FORMEC 2006

39th International Symposium on Forestry Mechanization

24-28 September 2006, Sofia, Bulgaria

PROCEEDINGS

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FORMEC – МЕХАНИЗАЦИЯ НА ГОРСКОТО СТОПАНСТВО – ИСТОРИЯ НА СИМПОЗИУМА ОТ 1966 ДО 2006

Йохан Виперман, Австрия

Симпозиумът по Механизация на горското стопанство, от 1994 наричан FORMEC, се провежда за 39-ти път, всеки път в различни страни от Централна, Северна и Източна Европа.

От основаването му Симпозиумът има за цел да събере водещите учени от областта на дърводобива и механизацията на горското стопанство. По-специално той има за цел да улесни и окуражи сътрудничеството на научните институции и научния обмен на идеи и резултати от последни изследвания и учебната дейност. Културното и историческо наследство на страната домакин също трябваше да обогати познанията на участниците по време на сесиите и екскурзиите.

Първоосновтелите – хора като Боянин, Хафнер, Калди, Кривец, Панкотай, Пестал, Платцер, Ронай, Турк и др. – успяха да осъществят симпозиума само на базата на безвалутния обмен – страната-домакин поемаше вички разноски, само пътните се поемаха от участниците. Всеки участник трябваше да прочете и представи в писмен вид доклад на немски език за текущи изследвания. Едва от няколко години се приемат и доклади на английски, за да се поощри участието на млади учени. Броят на участниците се колебае от 20 до 40 души.

Тематиката на симпозиума е, както следва:

- дърводобивна техника (технологии, инженеринг, производителност, влияние върху околната среда, биоенергия)
- горски трансторт (извоз и превоз на обла дървесина, материално-техническо снабдяване, усвояване на ресурсите)
- планиране и построяване на горски пътища; влияние върху околната среда
- научна организация на труда (организация на труда, нормативни проучвания, ергономика, рационализация на труда)

Председатели на FORMEC

Председател	Период	Институция
проф. д-р Еуген Ронай	1966 – 1993	Зволенски технически университет
проф. д-р Антон Тшесньовски	1993 – 1999	Виенски университет за земеползуване
проф. д-р Хуберт Дюрщайн	1999 – 2003	Виенски университет за земеползуване
проф. д-р Карл Щампфер	от 2003	Виенски университет за земеползуване

История на FORMEC

заседание №	год	страна
1	1966	Зволен/ЧССР
2	1968	Шопрон/Унгария
3	1969	Любляна/Югославия
4	1970	Познан/Полша
5	1971	Виена/Австрия
6	1972	Минск/СССР
7	1973	Мюнхен/ФРГ
8	1974	Куллаа/Финландия
9	1975	Зволен/ЧССР
10	1976	Пловдив/България
11	1977	Гарпенберг/Швеция
12	1978	Таранд/ГДР

13	1979	Залесие/Полша
14	1980	???
15	1981	Тесалоники/Гърция
16	1982	Осиах/Австрия
17	1983	Залесина/Югославияа
18	1984	Хоне/Норвегия
19	1985	Роден/ФРГ
20	1986	Бърно/ЧССР
21	1987	Хютиеле/Финландия
22	1988	Познан/Полша
23	1989	Таранд/ГДР
24	1990	Гарпенберг/Швеция
25	1991	Тесалоники/Гърция
26	1992	Виена/Австрия
27	1993	Бързия/България
28	1994	Лангнау/Швейцария
29	1995	Шопрон/Унгария
30	1996	Москва-Митишчи/Русия
31	1997	Бърно/Чехия
32	1998	Фрайзинг/Германия
33	1999	Загреб/Хърватско
34	2000	Рогов/Полша
35	2001	Бърно/Чехия
36	2003	Шлеглl/Австрия
37	2004	Gmunden/Австрия
38	2005	Любляна/Словения
39	2006	София/България

FORMEC – MECHANISIERUNG DER WALDARBEIT - GESCHICHTE DES SYMPOSIUMS 1966–2006

Dr. nat. techn. Jochen Wippermann, forstliche Arbeitstechnik

Das Symposium „Mechanisierung der Waldarbeit“ (ab 1994 FORMEC genannt) ist bisher 39. Mal an wechselnden Standorten in Mittel-, Nord- und Osteuropa durchgeführt worden.

Ziel des Symposiums ist seit seiner Begründung das Zusammenführen von Vertretern der Forstnutzung und Forsttechnik. Insbesondere soll die Kooperation dieser forstlichen Forschungsinstitutionen für den wissenschaftlichen Gedankenaustausch, beruhend auf aktuellen Forschungsergebnissen und Lehrerfahrungen, ermöglicht und gefördert werden. Dabei sollen kulturelle und historische Beiträge des jeweiligen Gastlandes das Programm der Tagung und der Exkursion bereichern.

Die „Männer der ersten Stunde“ – wie Bojanin, Hafner, Kaldy, Krivec, Pankotai, Pestal, Platzer, Ronay, Turk u.a. – haben ihre Idee zu einem solchen Symposium ursprünglich nur auf diese Weise realisieren können, dass die entstehenden Aufenthaltskosten von dem Land des jeweiligen Gastgebers getragen worden sind. Lediglich die Fahrtkosten zum Ort der Veranstaltung sind den anreisenden Kollegen entstanden. Jeder Teilnehmer ist verpflichtet worden, einen Vortrag in deutscher Sprache über fachliche Entwicklungen zu halten und darüber einen schriftlichen Beitrag abzuliefern. Erst seit wenigen Jahren gibt es auch die Möglichkeit englischer Präsentationen und Ausarbeitungen, um das Forum mehr jungen Wissenschaftern zugänglich zu machen. Die Teilnehmerzahlen schwanken zwischen 20 und 40 Personen.

Folgende Themenbereiche werden durch das Forum behandelt:

- Holzernte (u.a. Arbeitssysteme, Verfahrenstechnik, Produktivität, Umwelt-belastungen, Bioenergie)
- Holztransport (u a. Rücken und Ferntransport des Rundholzes, Logistik der Holzbereitstellung)
- Walderschließung (u.a. Planung und Bau von Forststraßen, ihre Auswirkungen auf die Umwelt)

Forstliche Arbeitswissenschaft (u.a. Arbeitsorganisation, Arbeitsstudien,.. Ergonomie, Rationalisierung)

FORMEC – Vorsitzende

Vorsitzender	Vorsitz (Zeiraum)	Institution
Prof. Ing. Dr. Eugen Rónay	1966 – 1993	Technische Universität Zvolen
Prof. DI Dr. Anton Trzesniowski	1993 – 1999	Universität für Bodenkultur Wien
Prof. Dipl.-Fw. Dr. Hubert Dürrstein	1999 – 2003	Universität für Bodenkultur Wien
Prof. DI Dr. Karl Stampfer	Seit 2003	Universität für Bodenkultur Wien

FORMEC – Bisherige Symposien

Meeting-Nr.	Jahr	Veranstaltungsort/-land
1	1966	Zvolen/CSSR
2	1968	Sopron/Ungarn
3	1969	Ljubljana/Jugoslawien
4	1970	Poznan/Polen
5	1971	Wien/Österreich
6	1972	Minsk/UdSSR
7	1973	Münchehof/B.R. Deutschland
8	1974	Kullaa/Finnland
9	1975	Zvolen/CSSR
10	1976	Plovdiv/Bulgarien
11	1977	Garpenberg/Schweden
12	1978	Tharandt/DDR
13	1979	Zalesie/Polen
14	1980	???
15	1981	Thessaloniki/Griechenland
16	1982	Ossiach/Österreich
17	1983	Zalesina/Jugoslawien
18	1984	Honne/Norwegen
19	1985	Rhoden/B.R. Deutschland
20	1986	Brünn/CSSR
21	1987	Hyytiälä/Finnland
22	1988	Poznan/Polen
23	1989	Tharandt/DDR
24	1990	Garpenberg/Schweden
25	1991	Thessaloniki/Griechenland
26	1992	Wien/Österreich
27	1993	Barsia/Bulgarien
28	1994	Langnau/Schweiz
29	1995	Sopron/Ungarn
30	1996	Moskau-Mytichi/Russland
31	1997	Brünn/Tschechische Republik
32	1998	Freising/B.R. Deutschland
33	1999	Zagreb/Kroatien
34	2000	Rogow/Polen
35	2001	Brünn/Tschechische Republik
36	2003	Schlägl/Österreich
37	2004	Gmunden/Österreich
38	2005	Ljubljana/Slowenien
39	2006	Sofia/Bulgarien

FORMEC – FORESTRY MECHANISATION – THE HISTORY OF THE SYMPOSIUM FORM 1966 TO 2006

Dr. nat. techn. Jochen Wippermann, forstliche Arbeitstechnik

The Symposium "Forestry Mechanisation" (since 1994 called FORMEC) has been held 39 times until now, in different countries of Central, North and East Europe.

Form its very beginnings the Symposium aims to bring together the leading scientists in forest harvest and forestry mechanisation. It aimed especially to facilitate and encourage the cooperation of the scientific institutions and the scientific exchange of ideas, obtained in recent investigations and education activities. The cultural and historical heritage of the host country should also enlarge the knowledge of the participants during the sessions and the excursions.

The "men of the first hours" – Bojanin, Hafner, Kaldy, Krivec, Pankotai, Pestal, Platzer, Ronay, Turk et alii – could realise the idea of such a symposium only on the base of the cash-free exchange – the host country undertook all expenses, only the travelling expenses were undertaken form the participants. Each participant had to present and read a paper in German about recent investigations. Since a couple of years, papers in English are also accepted in order to encourage the participation of younger scientists. The number of participants varied from 20 to 40 persons.

Following subject areas are covered by the panel:

- Harvesting systems (e. g. working systems, process engineering, productivity, environmental impacts, bioenergy)
- Wood transportation (e. g. skidding and transportation of roundwood, logistics, mobilization)
- Forest road network planning and construction; environmental effects

Forest work sciences (work organization, work studies, ergonomics, rationalization)

FORMEC – chairmen

Chairmen	Period	Institution
Prof. Ing. Dr. Eugen Rónay	1966 – 1993	Technical University in Zvolen
Prof. DI Dr. Anton Trzesniowski	1993 – 1999	Universität für Bodenkultur Wien
Prof. Dipl.-Fw. Dr. Hubert Dürrstein	1999 – 2003	Universität für Bodenkultur Wien
Prof. DI Dr. Karl Stampfer	Seit 2003	Universität für Bodenkultur Wien

FORMEC – history

Meeting-Nr.	Jahr	host country
1	1966	Zvolen/CSSR
2	1968	Sopron/Hungary
3	1969	Ljubljana/Yugoslavia
4	1970	Poznan/Poland
5	1971	Vienna/Austria
6	1972	Minsk/SU
7	1973	Münchehof/W. Germany
8	1974	Kullaa/Finland
9	1975	Zvolen/CSSR
10	1976	Plovdiv/Bulgaria
11	1977	Garpenberg/Sweden
12	1978	Tharandt/DDR
13	1979	Zalesie/Poland
14	1980	???
15	1981	Thessaloniki/Greece
16	1982	Ossiach/Austria
17	1983	Zalesina/Yugoslavia
18	1984	Honne/Norway
19	1985	Rhoden/ W. Germany
20	1986	Brünn/CSSR

21	1987	Hyytiälä/Finland
22	1988	Poznan/Poland
23	1989	Tharandt/DDR
24	1990	Garpenberg/Sweden
25	1991	Thessaloniki/Greece
26	1992	Vienna/ Austria
27	1993	Barsia/Bulgaria
28	1994	Langnau/Switzerland
29	1995	Sopron/Hungary
30	1996	Moskau-Mytichi/ Russia
31	1997	Brünn/ Czech Republic
32	1998	Freising/ W. Germany
33	1999	Zagreb/Croatia
34	2000	Rogow/Poland
35	2001	Brünn/Czech Republic
36	2003	Schlägl/ Austria
37	2004	Gmunden/ Austria
38	2005	Ljubljana/Slovenia
39	2006	Sofia/Bulgaria

ПОЧВОПОДГОТОВКА С ТЕЖКИ ДИСКОВИ ПЛУГОВЕ И ЕСТЕСТВЕНО ВЪЗОБНОВЯВАНЕ

Теодорс Блия, Латвия

От известно време почвоподготовката е актуален проблем на възобновяването, поради въвеждането на нова техника. Голяма част от заетите с почвоподготовка фирми закупиха произвеждани в Скандинавските страни тежки дискови плугове с активни предавки. Те са конструирани за подготовка за естествено или изкуствено възобновяване на каменливи почви или почви с почвена постилка. Съответно на това конструкторите са предвидили възможност за почвоподготовка с различна интензивност.

Чрез изследване влиянието на почвоподготовката върху естественото възобновяване са направени следните изводи: По отношение на резултатите от естественото възобновяване има разлика между пролетната и лятната почвоподготовка; При почвоподготовка с тежки дискови плугове не се използват възможностите за вариране на интензивността; Прокараните бразди са неустойчиви и подложени на ерозия.

Zusammenfassung

Seit längerer Zeit verursacht die Bereitung des Bodens für natürliche Verjüngung Probleme, weil in der Bereitung des Bodens der Wechsel der genutzten Mechanismen erfolgt. Ein großer Teil der in der Bereitung des Bodens einbezogener Firmen haben die in den skandinavischen Ländern produzierten schweren Scheibenpflüge mit aktivem Antrieb gekauft.

Die in den skandinavischen Ländern produzierten schweren Scheibenpflüge mit aktivem Antrieb sind für die Bereitung steiniger und verschrotteter (verstreuter? streubedeckter) Böden für die künstliche und natürliche Verjüngung konstruiert. Dessen ungeachtet haben die Konstrukteure die Möglichkeiten der Bodenbearbeitung in Regimen verschiedener Intensität vorgesehen.

Durch Bewertung des Einflusses der Bodenbearbeitung auf die natürliche Verjüngung im Laufe von mehreren Jahren kann man schlussfolgern, dass ein Unterschied zwischen der Bodenbereitung im Frühling und im Sommer und den Ergebnissen der natürlichen Verjüngung besteht. Bei der Bereitung des Bodens mit den schweren Scheibenpflügen werden Möglichkeiten der Variierung der Intensität für Bodenbearbeitung nicht genutzt. Außerdem sind die gezogenen Furchen unstabil und sie werden der Erosion ausgesetzt.

SOIL PREPARATION WITH HEAVY DISK TRENCHERS AND THE NATURAL REFORESTATION

Teodors Blija, Latvia

Facilitation of the natural reforestation is being practised in Latvia for more than ten years. A particularly high rate of the natural reforestation is characteristic to the dry-type forest growth conditions. The dry forests in Latvia are divided in 4 forest growth condition types, and they are as follows:

Cladinoso-callunosa – Sl,
Vacciniosa – Mr,
Myrtillosa – Ln
Hylocomiosa– Dm.

Forest stand

Sl – low productivity IV–V productivity index pinewood.

Mr - III productivity index pinewoods. Interbreeding of birch and spruce is possible in the first storey.

Ln - II productivity index pinewoods. Sometimes there is interbreeding of birch and spruce.

Dm - I productivity index pinewoods; interbreeding with spruce, birch or aspen.

Soil

Sl – very bare coastal or inland dune sand, horizons are shallow and weakly marked.

Detritus and humus layer is thin – 3 cm in average. Mineral soil and parent soil is formed of bare quartz sand, which contains a very little dust.

Mr - bare podzolic dune sand. Detritus layer is thin (approximately 4 cm). Mineral soil is formed of medium coarse quartz sand with a little admixture of dust matters.

Ln – quite deep, medium fertile podzolic sand. On the topsoil, there is a 4–5 cm thick humus layer. In elevated places the horizons are shallower.

Dm – Parent soil and mineral soil are formed of sandy loam, loamy soil and sometimes of dense loam. Soil is podzolic, quite nutrient-rich and deep (60 cm in average), with rust (ortstein) layer in some places. The thickness of humus layer is approximately 5 cm.

Reforestation

Sl – After cutting of the stand, heather *(Calluna vulgaris)* naturally spreads there. Pine in a natural way renovates slowly.

Mr - After the cutting of the stand, heather *(Calluna vulgaris)* naturally spreads there.

A medium thin sward develops instead that impedes the natural reforestation. From the pioneer tree species, the birch renovates. Pine in a natural way renovates slowly.

Ln – After the cutting of the stand, blueberries and moss sicken. Plants which more intensively destroy humus temporarily spread. A denser sward is formed by grass. From the pioneer trees, the birch renovates fast, becoming an undesirable dominant species, if people do not interfere. Pine in a natural way renovates slowly.

Dm – In cutting areas, the annual and biennial caulescent plants spread. During some years, the grass forms a dense sward. From the bush wood species, hazel-trees sometimes grow thick. Usually the birch stands and sometimes also the spruce and aspen stands develop. Pine in a natural way renovates slowly.

In order to intensify reforestation of the cutting areas with suitable and valuable tree species, an artificial reforestation has been done for a long time – the soil was prepared and the sowing performed, and later the pine was planted in the prepared furrows.

The sowing of pine in a prepared shallow furrow was refused, because it has not always provided good results. The reason was a delayed (the second or third ten-day periods of May) or too deep (15-20 cm) sowing as well as the big amount of seeds (0.7 kg/ha).

In different time periods, both biennial pine seedlings and pine plantings were planted in the dry-type forests. Reforestation quality of the cutting areas was satisfactory or even good, but the high expenditures 310 Ls/ha (440 EURO per ha) of the plants and the preparation costs 70 Ls/ha (100 EURO per ha) were not satisfactory.

Soil preparation

For a long time, the double-sided overturning forest ploughs (PKL – 70) were used for soil preparing in dry-type forests, which were cultivated by caterpillar forest tractors (TDT-55 un LHT-55). The soil preparing was carried out, making shallow furrows (5-10 cm) with even bottom. As several authors, such as M.Buðs, I. Mangalis, 1971, L.Gasiòð 1975, I. Mangalis, O. Cinîtis 1987, A.Aire 1988, I. Mangalis, 1989, I. Mangalis, 2004, have admitted, this was the most optimal depth of soil preparing in the dry-type forest growing conditions.

After the regain of independence of Latvia, a crisis was experienced in forest soil preparing. It was caused by termination of the delivery and purchase of the old forest technique from Russia. Another forest soil preparing mechanisms and the ways of their purchasing had to be founded. Use of different active and passive disk trenchers (TTS, Donaren, Bracke un TPF) was started in forest soil preparing in Latvia.

In Scandinavia. TTS, Donaren and Bracke are the heavy active and passive disk trenchers designed for Scandinavia conditions. They are intended for use in heavy circumstances. The most part of the soil layer covering the rocks of Scandinavia is quite thin, so the big disk grinders (up to 14 cm in length) of the trencher push aside the cutting remains during the processing and make oblique small furrows. The depth of furrows is 5-10 cm. They serve well for facilitation of the natural reforestation in Scandinavia conditions, as it is shown in Fig. 1.

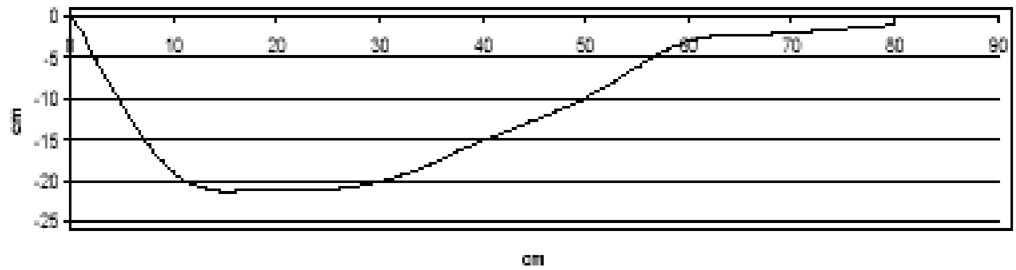
Fig.1. TTS Delta active disk trencher in work in the South of Finland.

In Latvia. With coming of the new techniques and technologies in timber cutting, the traditional forest ploughs could not be used any more, because the cutting remains are spread over the all cutting area. The use of TTS, Donaren, Bracke and TPF, as well as other active and passive disk trenchers was started in forest soil preparing. In more fertile forest growth condition types these soil preparing mechanisms have in general justified themselves, however, the use of them in different dry-forest types is still disputable. In areas, processed by the TTS, Donaren and Bracke active disk trenchers, the furrows of another depth and configuration are formed, as it is shown in the Fig. 2.

Fig. 2. Ploughs PKL -70 and TTS, Donaren and Bracke furrow types.

Such furrows are not stable in the sandy dry-type soils, and they re-form both in the lateral and lengthwise directions. If the soil in the cutting area is prepared in autumn, the re-formation of furrows takes place simultaneously with snow melting. In soil prepared in spring, the re-formation of furrows takes place the entire summer and depends on climate conditions, i.e. the dropped rainfall and its intensity.

Performing measures in the areas, where the soil has been prepared by means of Bracke- 321D, the situation is not gratifying. It follows from the obtained data that a slope forms from the first 10 cm of the furrow edge in the depth of 0 up to 20 cm, which continues approximately 20 cm. It is followed by a rise in about 50 cm. All these furrow parts are unstable and subjected to an intensive influence by weather conditions. The furrow parts from 0...10 up to 30...80 cm are subjected to a sand soil washing off, and the washed-off soil accumulates in the furrow part from 10 up to 30 cm.



Pict. 3. Bracke-321D A furrow, made in spring of 2006.

All the same could be related to the bottom of the furrow. In sandy soils the long grinders (14cm) of the active disks go deep without resistance and make a wavy bottom of the furrow (Pict. 4). So the conclusion follows that the area after the soil preparing is not ready for the natural reforestation process, because all the parts of the furrow during a longer or shorter period of time are under the re-formation process. The natural reforestation is practically impossible in such furrows. If the seed gets on the edge of the furrow, it does not sprout because of the lack of humidity, or it will be washed off; or, if the seed gets in the deepening of the furrow's bottom, most probably it will be covered by soil from the rise or by the slipped-down or washed-off soil from the edges.

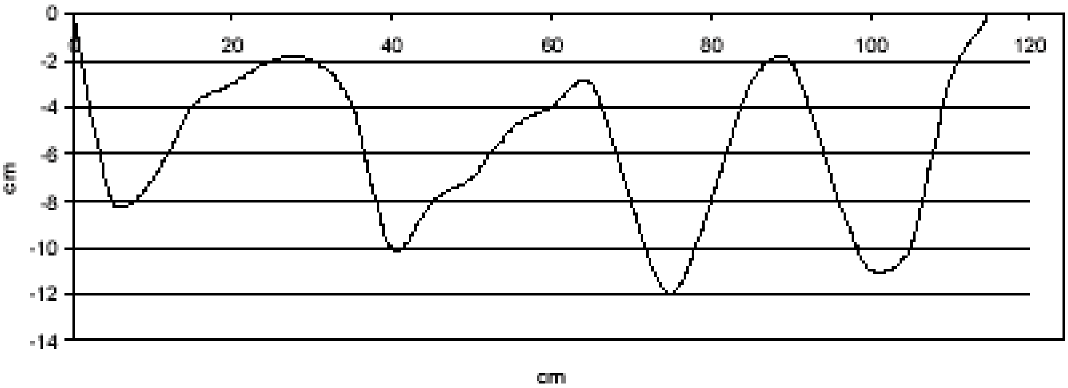


Fig. 4. Bracke- 321D Relief of the bottom of the furrow, made in spring, 2006

The area prepared by the active disk trencher is ready for a real natural reforestation process only after finishing of the furrow stabilization. Performing registration on the 1st of September in the area prepared by Bracke-321D in spring of 2006, natural reforestation was not detected.

Moreover, the depth of furrows is not equal; it hesitates to a great extent. The inspection confirms it (Table 1). One should be careful by the fact that in most cases the depth of the made furrows is too large for the natural reforestation. As shown in the Table 1, it is possible to make also shallower furrows by the Bracke-321D. The conclusion cold be that it is possible to make shallower furrows by the soil preparing mechanisms, but the problem is operators.

Table 1. Fluctuations of depth of the furrows made by Bracke-321D (data from 2004).

Forestry	KV	Time of preparing	Depth of the furrows (cm)	
			Max.	Min.
Iecava	6	2004.04	30...12	25...6
Iecava	280	2004.04	20...10	18...2
Vecumnieki	222	2004.04	30...10	19...3
Vecumnieki	344	2004.04	22...9	13...3
Vecumnieki	344	2004.04	22...9	12...2

While inspecting older areas, it was detected that the furrow profile has stabilized and the natural reforestation process has started successfully. The matter of worry could only be the fact that after stabilization the furrow is not of an equal depth at full length. At lower areas the furrows are shallower, but they could be very deep at slopes or rises. So, the natural reforestation process is more successful on flat areas, and it is not homogeneous on areas of a waved relief.

In areas, where the facilitation of natural reforestation has been performed, the number of pine seedlings (according to registration in 2004) hesitates from 3024 up to 13304 per 1 ha. By a big number of seedlings-13000 per 1 ha, the inspected Ln areas are remarkable. The situation in the Mr and Dm areas is similar (4000 ... 7000 seedlings per 1 ha). In Mr areas prepared in autumn, there is a comparatively large sward of heat*her (Calluna vulgaris).*

An interesting object is the 289th kv of Iecava forestry. The soil was prepared in April, 2004, and the pine was planted in spring, 2005, that is, a year after the soil preparing. In this area, the natural reforestation of pine has taken place alongside with the planted material. 5500 pine plantings (in average 55.6 cm long) and 9950 seedlings (in average 23.06 cm long) per 1 ha have been registered up to the 1st September 2006. No any seedlings of 2006 were detected. It could be explained by the extremely dry and hot spring and summer of 2006. Evaluating rates of the planting and the natural reforestation of pine by means of the dispersion analysis, we see that $F_{fact}=71.19 > F_{crit}= 4.24$, that is, the planted pine is considerably longer than the seedlings of natural reforestation. One is clear – the number of the little pine trees in the area is too big, and a treatment in order to reduce the number of them, shall be performed in the next coming years.

Data of this object confirm the conclusion that the maximum of the natural pine reforestation is not in the year of soil preparing. It starts the next year, when the soil has stabilized in the prepared furrows. It matches also the conclusions made by E. Bakūzis in 1959.

Conclusions

The furrows made in the dry-forest type areas by the heavy disk trenchers, in general, are too deep.

The inspections show that the depth of furrows to be made is practically controllable.

The bottom of furrows made by the heavy disk trenchers is not even, so it is subjected to the erosion process in a longer or shorter period of time.

In the dry-forest types, a more ecologically cautious soil preparing mechanism is advisable.

The natural reforestation in the areas, prepared by the heavy disk trenchers in spring, could start only after a year due to the furrow erosion.

The quality of furrows made by the heavy disk trenchers depends on the relief of the area.

It is possible to get a faster and more effective afforestation by planting in the areas prepared by the heavy disk trenchers.

The process of the natural reforestation is slow in the areas prepared by the heavy disk trenchers, and it could last for years.

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ОПТИМАЛНО СОРТИМЕНТИРАНЕ В СРЕДА НА EXCEL

Лео Бонт, Швейцария

Сортиментирането е от голямо значение за печалбата на горскостопанското предприятие. За системите с пълна механизация, предимно в Скандинавските страни, вече има инструменти за оптимизация. Тези инструменти имат обаче два недостатъка: (1) оптимизират според продажна цена, като пренебрегват добивните разходи, и (2) начинът на оптимизация е скрит в черна кутия. Като алтернатива се предлага разработен от автора способ за оптимизиране сортиментирането на отделното стъбло. Като целева величина се използва чистият доход (т.е. продажната цена, намалена с добивните разходи). Главни входни данни, характеризиращи дървото, са (1) кривата на стъблената форма (по данните на Швейцарската национална инвентаризация), (2) оценката на качеството на строителната дървесина и (3) размерите на короната. Изчисленията са формулирани като „мрежов проблем“ и решени чрез „алгоритъма на най-дългия път“ (динамично програмиране). Моделът е проверен в две насаждения, среднопредставителни за Швейцария, като бяха сравнени резултатите от окомерното сортиментиране от експерт с резултатите от оптимизацията. Беше показано, че при сортиментирането има значителен потенциал за повишаване на чистия доход от 10 до 80%. Решаващ момент при оптимизацията е оценката на качеството на отделните стъблени секции в стоящо състояние на стъблото, която остава окомерна.

A SPREADSHEET-BASED MARKING FOR BUCKING OPTIMISATION TOOL

Leo Bont, Switzerland

Marking for bucking decisions is the first step in the forestry value chain to create value-added. Fully mechanized cut-to-length harvesting systems that have been predominant in Nordic countries are equipped with computer tools that automatically identify optimal solutions for the marking for bucking problem. However, those systems have two disadvantages: (1) they optimize for value while neglecting harvesting cost, and (2) they consist of a black box that has been hiding the optimization procedure. Here, we report on the development of a "marking for bucking optimization tool" we have developed. We optimize for marginal profit (sales price minus harvesting costs) and characterize the geometric shape of a single stem by the taper equations used in the Swiss national Forest inventory. The user has to specify the shape parameters, wood quality, and crown dimension. We used a network formulation to represent the marking for bucking problem and solved it by using the longest route algorithm (dynamic programming). The tool was tested for two characteristic Swiss stand conditions, Norway spruce and beech. Compared with a rule of thumb solution the optimisation tool resulted in an increase in profit contributions of 10 to 80%. However, the model is quite sensitive to the estimation of wood quality of the different parts of the stem that is still based on expert judgment.

EIN TABELLENKALKULATIONS-BASIERTES OPTIMIERUNGSWERKZEUG FÜR DIE SORTIMENTS AUSHALTUNG

Leo Bont

Abstract

Die Sortimentsaushaltung, d.h. die Einteilung des Stammes in die verschiedenen Sortimente, ist ein wichtiger Wertschöpfungsschritt im Forstbetrieb. Für vollmechanisierte Systeme existieren dazu bereits, v.a. in nordischen Ländern, Optimierungswerkzeuge. Diese Werkzeuge haben jedoch zwei Nachteile: (1)

Sie optimieren nach der Zielgrösse Verkaufspreis und vernachlässigen dabei die Erntekosten, und (2) das Optimierungsverfahren ist in einer Blackbox versteckt. An dieser Stelle wird ein von uns entwickeltes Optimierungsverfahren zur Sortiments-Aushaltung am Einzelbaum vorgestellt. Als Zielgrösse wird der Erntekostenfreie Erlös (Verkaufspreis minus Erntekosten) verwendet. Wichtigste Eingangsdaten zur Beschreibung des Baumes sind (1) Schaftformkurve (Datengrundlage vom schweiz. Landesforstinventar), Schätzung der (2) Qualität des Schaftholzes und der (3) Kronenausmasse. Die Berechnungen wurden als Netzwerkproblem formuliert und mit dem „Longest Route Algorithmus" (dynamic programming) gelöst. In zwei Beständen, welche typischen schweizerischen Situationen entsprechen, wurde das Modell getestet und die gutachtliche mit der optimierten Aushaltung verglichen. Es zeigte sich, dass in der Sortimentsaushaltung noch ein beachtliches Potential zur Steigerung des Deckungsbeitrags, in unserem Fall um 10 – 80%, vorhanden ist. Der kritischste Punkt in der ganzen Optimierungskette ist die Abschätzung der Holzqualität der verschiedenen Teile des Stammes (am stehenden Baum). Diese basiert nach wie vor auf einem Expertenurteil.

1 Einleitung

Die dauernde Sicherung des Betriebserfolges hängt davon ab, ob auf der einen Seite die Kosten minimiert und auf der anderen Seite die Erlöse maximiert werden. Die Sortimentsaushaltung, d.h. die Einteilung des Stammes in die verschiedenen Sortimente, ist ein wichtiger Schritt in der ganzen Produktionskette eines Forstbetriebs. Auch hier gilt es möglichst die Kosten tief zu halten und gleichzeitig einen hohen Verkaufspreis zu generieren. In der heutigen Praxis erfolgen die Betrachtungen jedoch meist isoliert voneinander. Entweder werden die Kosten minimiert oder die Erlöse maximiert. Auf diese Weise wird keine optimale Lösung erzielt. Beispielsweise sind die gängigen Sortiments – Optimierungswerkzeuge, welche vorwiegend aus nordischen Ländern stammen, darauf ausgerichtet den Stamm so einzuschneiden, dass ein möglichst grosser Verkaufspreis erzielt wird. Für vollmechanisierte Holzerntesysteme (Harvestereinsatz) führt diese Vereinfachung durchaus zu einem guten Resultat, da für alle Sortimente die Produktionskosten in etwa gleich hoch sind. In Mitteleuropa und insbesondere in der Schweiz werden die Bäume jedoch oft noch in einem motormanuellen Verfahren (d.h. mit Motorsäge) geerntet. In diesem Fall müssen für den Aushaltungsentscheid die Erntekosten auch berücksichtigt werden, da je nach produziertem Sortiment unterschiedlich hohe Kosten anfallen. Dies ist besonders bei der Produktion von Hackschnitzeln wichtig, da für dessen Produktion die Erntekosten deutlich tiefer sind als diejenigen von Stamm- oder Industrieholz. In den bisher erschienen Arbeiten zu diesem Thema (Näsberg 1985; Gobakken 2000; Malinen 2004) werden die Produktionskosten nicht berücksichtigt.

Ein weiterer Nachteil der gängigen Sortimentsoptimierungstools besteht darin, dass sich die Optimierungsprozedur in einer „Blackbox" befindet und nicht eingesehen, nachvollzogen und überprüft werden kann.

Im Folgenden wird ein tabellenkalkulationsbasiertes Optimierungswerkzeug entwickelt, bei welchem das Holzernte-Verfahren frei gewählt werden kann und als Zielgrösse der Deckungsbeitrag (erntekostenfreie Erlös) verwendet wird (Bont 2005). Dieses wird in zwei Beständen getestet und mit einer gutachtlichen Lösung verglichen.

2 Modellentwicklung

2.1 Einflussfaktoren

Die Bestimmung des optimalen Einschnittmusters ist ein komplexes Problem, das von vielen Faktoren abhängt. Ein erster Faktorenkomplex umfasst die **Eigenschaften eines Baumes,** insbesondere die Baumart, den Brusthöhendurchmesser (BHD), den Durchmesser in 7 m Höhe (d7), die Baumhöhe, die Höhe des Kronenansatzes und die Qualitätsbeurteilung am stehenden Baum. Ein zweiter Faktor sind die **Marktpreise**. Ein dritter Faktor sind die **Eigenschaften des Produktionssystems** wie das gewählte Verfahren, eingesetzte Maschinentypen, waldbauliche Vorgaben und Bestandeseigenschaften. Ein vierter Faktorenkomplex sind **Kostensätze des Personals und der Maschinen**.

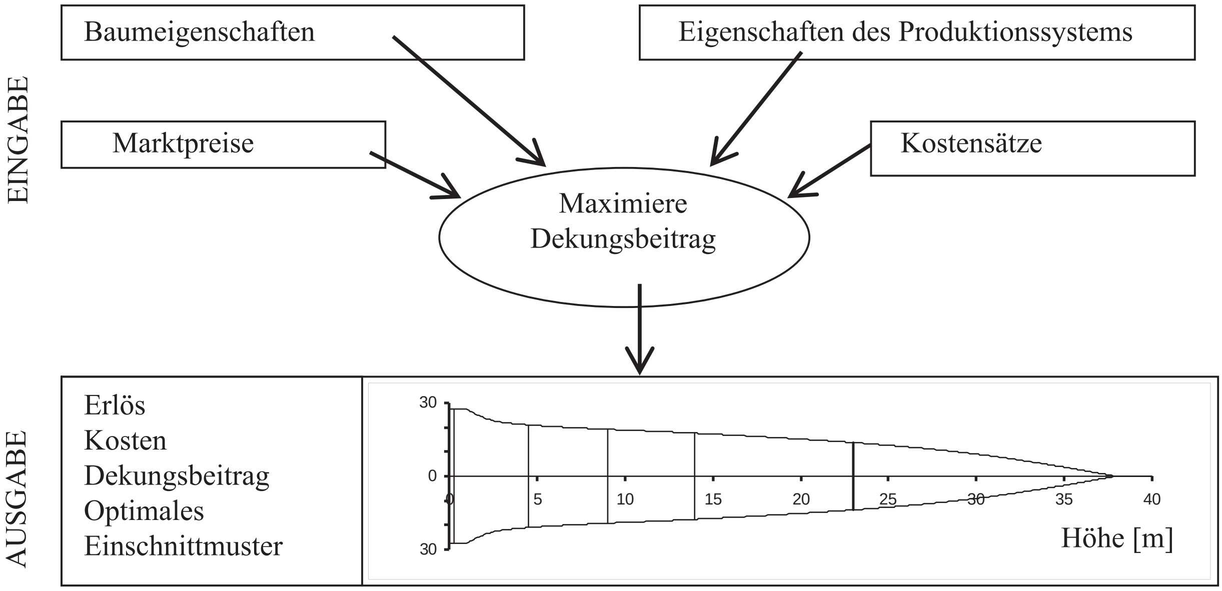


Abbildung 1: Die Einflussfaktoren wie Preise, Kosten, Holzernteverfahren und Baumeigenschaften fliessen ins Modell ein. Aus diesen Faktoren wird das optimale Einschnittmuster mit dazugehörigem Deckungsbeitrag berechnet.

1.1 Modellierung des Baumes

Den ersten Faktorenkomplex gibt es darum, da bei motormanueller Ernte die Kreation einer bestandesspezifischen Schaftkurve nur schwer möglich ist. Für unser Modell wurde die bereits vorhandene LFI Schaftkurve (NFI Taper Model) verwendet (Kaufmann 2001). Sie schätzt den Verlauf des Schaftes als Funktion des Brusthöhendurchmesser (BHD) des Durchmessers in 7 m Höhe (d7) und der Baumhöhe (H) (Abbildung 2). Die Schaftform kann mit der gewählten Methode sehr genau beschrieben werden. Im Weiteren muss die Qualität des Schaftes abgeschätzt werden. Diese kann in verschiedene Qualitätsklassen (WVS 2000) eingeteilt werden.

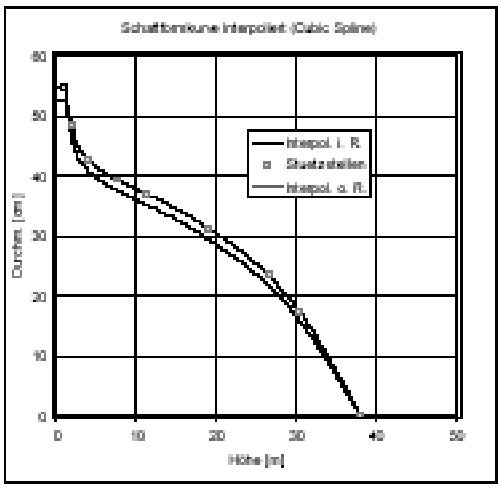


Abbildung 2: Schaftformkurve. Berechnet aufgrund der Höhe, des d7 und des BHD

1.1 Kostenrechnung

Da die Produktionskosten für die verschiedenen Sortimente unterschiedlich gross sind, ist es wichtig diesen bei den Berechnungen zu berücksichtigen. Bedeutend ist dies insbesondere bei der Energieholzproduktion, weil in diesem Fall die ganze Erntekette rationeller gestaltet werden kann. Im Vergleich zur Stamm- oder Industrieholzproduktion entfällt hierbei das Entasten und auch auf eine Schlagräumung kann verzichtet werden (gilt für die meisten Fälle).

Im Modell werden nur befahrbare Lagen mit Feinerschliessung durch Rückegassen und Hangneigung < 10 % berücksichtigt. Es wurden verschiedene Holzernte - Verfahren implementiert, welche dem Anwender zur Auswahl stehen. Die meisten Produktivitätsmodelle der einzelnen Arbeitsschritte basieren auf dem HEPROMO der WSL (Erni 2003). Einige Daten davon stammen aus den 70er Jahren und mussten, da keine neueren Untersuchungen verfügbar waren, mittels Korrekturfaktoren angepasst werden.

Die Kostenberechnung basiert auf Bestandesdaten. Wird in der Realität nur 1 Baum geerntet sind die Resultate unzulässig. Erst wenn dieser Baum im Rahmen eines (nicht zu kleinen) Holzschlages geerntet wird, sind die Resultate gültig.

Für das Entasten mit der Motorsäge wurde ein eigenes Produktivitätsmodell entwickelt, da die existierenden Modelle für unsere Fragestellung nicht brauchbar sind. Die existierenden Modelle schätzen jeweils den Entastungsaufwand für einen ganzen Baum. Es ist jedoch wichtig den Entastungsaufwand für einen Teil-Abschnitt des Baumes zu kennen, falls beispielsweise nur ein Teil der Krone entastet werden soll.

1.2 Berechnung des Erlös

Stammholz

Für die Berechnung des Erlös des Stammholzes wurden Klassen gemäss den schweizerischen Handelsgebräuchen für Rundholz (WVS 2000) gebildet. Der Preis wird durch den Mittendurchmesser, die Länge und die Qualität definiert.

Industrieholz

Da für das Industrieholz eine breite Palette an Sortimenten existiert, wurde ein fiktives Industrieholzsortiment eingeführt. Im Modell wird dieses durch einen individuell wählbaren minimalen Zopfdurchmesser und eine minimale Länge definiert. Für das Industrieholz wurde ein Einheitspreis pro Volumen angenommen.

Das Industrieholz wird als Teil des Stammholzsortimentes gehandhabt. Man kann sich das Industrieholz einfach als Stammholzsortiment mit geringen Dimensionen und Qualitäten vorstellen. Wird nachfolgend vom Stammholzsortiment gesprochen, ist immer auch das Industrieholzsortiment inbegriffen.

Energieholz

Unter dem Begriff Energieholz werden Hackschnitzel verstanden. Für dieses wurde ebenfalls ein Einheitspreis pro Volumen angenommen. Anders als beim Stamm- oder Industrieholz werden hier die Rinde und das anfallende Kronenmaterial (Äste) auch vermarktet. Eine Schwierigkeit bildete die Abschätzung der Menge und der Verteilung der Biomasse innerhalb der Krone. Dazu wurde eigens ein Modell geschaffen: Die Menge der Biomasse wurde mittels Grundlagenbericht zum LFI (Kaufmann 2001) und waldbaulichen Untersuchungen von (Burger 1950) und (Burger 1953) abgeschätzt. Für die Verteilung der Biomasse innerhalb der Krone liefern (Hagemeier 2002) und (Kramer 1988) Anhaltspunkte.

1.3 Optimierungstechnik

Wir haben es mit einem klassischen «Marking for bucking Problem» (MBP) zu tun, in dem es darum geht einen gegebenen Schaft so in kleinere Stücke zu unterteilen, dass der erntekostenfreie Erlös maximiert wird. Die Zielfunktion lautet folgenderweise:

$$\text{Max} \sum_{i}^{n} (P_i - C_i)$$

wobei:
Pi: Verkaufspreis des Sortiments i (Price)
Ci: Erntekosten für Sortiment i (Cost)
n: Anzahl der Sortimente aus einem Baum

Die häufigste verwendete Technik zur Lösung von MBP ist dynamisches Programmieren (DP). In

DP kann MBP als Netzwerkproblem formuliert werden, in welchem der längste Weg gesucht wird. Die Technik wird in (Näsberg 1985) beschrieben. Nachfolgend wird das Prinzip kurz erklärt:

Es sei δ der grösste gemeinsame Teiler der Standard Sortimentslängen. Bei ausgehaltenen Längen von 4, 5, 6, 7 und 8 ist δ = 1.

Nun wird die vermarktbare Schaftlänge (L) in N Segmente, jedes mit der Länge δ, eingeteilt. Danach wird ein Netzwerk mit N+1 Knoten kreiert, welche von 0 bis N nummeriert werden. Der Knoten i in diesem Netzwerk entspricht dabei der Schaftposition i*δ, welche eine potentielle Trennschnittposition darstellt. Knoten 0 symbolisiert die Stockhöhe und Knoten N entspricht der (vermarktbaren) Schaft Höhe.

Falls die Schaftpositionen iδ und δk mögliche Trennschnittpositionen sind und eine Standard Stammholzlänge lj = (k-i)δ existiert, wird nun ein Bogen (i, k) ins Netzwerk eingefügt. Der Wert, der dem Bogen (i, k) zugewiesen wird, entspricht dem entsprechendem Stammholzabschnitt, welcher durch das Volumen, die Qualität, die Länge und den Durchmesser bestimmt wird. Nun können weitere Bögen ins Netzwerk eingefügt werden. Um die möglichen Kombinationen und damit die Rechenzeit einzuschränken, wird vorgängig die maximale und minimale Länge (Lmin, Lmax) des Stammholzsortimentes festgelegt.

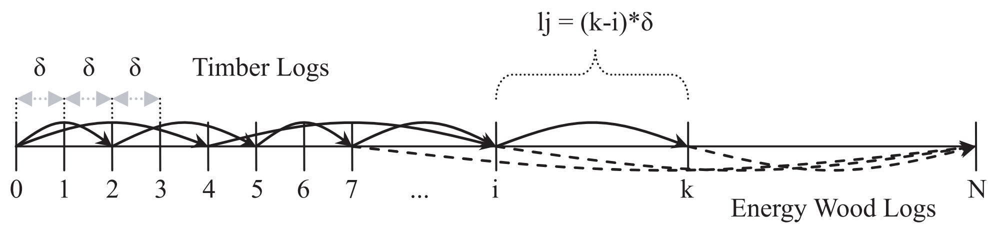


Abbildung 3: Mögliche Wege im Netzwerk Baum von 0 zur Baumhöhe N

Da das Optimale Einschittmuster Energieholz enthalten kann, werden extra Bögen eingefügt, ausgehend von allen möglichen Knoten (0 bis N) zu Knoten N. Diesen Bögen wird der Wert des entsprechenden Energieholzsortimentes zugewiesen. Nun wird ein Weg von 0 bis N gesucht, bei dem die Summe der Werte der durchlaufenen Bögen maximiert wird, oder mit anderen Worten ausgedrückt: Es wird der wertvollste (längste) Weg zwischen Knoten 0 und Knoten N gesucht (vgl. Zielfunktion).

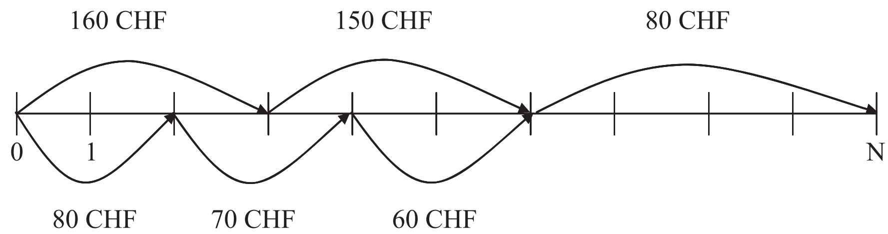
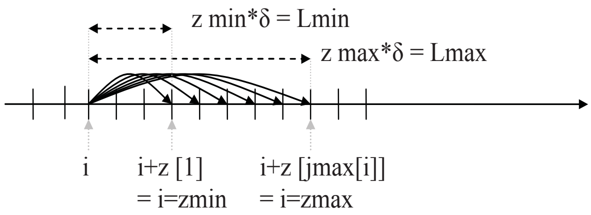


Abbildung 4: 2 mögliche Weg – Kombinationen von 0 bis N mit dazugehörigem Wert der einzelnen Abschnitte

Step 0	Initialisation	Festlegung der (Start-)Werte für diverse Konstanten und Variablen
Step 1	Hauptschritt	

Step 1a	Stammholzteil	Berechnung des optimalen Einschneidemusters für den Stammholzteil. Für jeden Knoten i+z wird jeweils der maximale Wert und der Vorgängerknoten der profitabelsten Kombination, welche im Knoten i+z enden, gespeichert. (Anwendung LRS - Algorithmus) 
Step 1b	Energieholzteil	Berechnung der optimalen Länge des Energieholzabschnittes. Vom Knoten N werden systematisch Bögen zu allen Knoten gelegt. Der beste Wert und die profitabelste Kombination werden gespeichert.
Step 2	Ausgabe	Ausgabe des optimalen Einschneidemusters und des dazugehörigen Erntekostenfreien Erlös / Deckungsbeitrag

Der LRS – Algorithmus ist sehr effizient. Währenddem beispielsweise zur Berechnung eines Baumes mit den Dimensionen H = 40m, L min = 4m, L max = 22m und δ = 0.5m 7‘666‘042 verschiedene Einschneidemuster möglich sind und dazu insgesamt 13‘488‘406 Abschnittslängen berechnet werden müssen, sind mit dem LRS – Algorithmus nur 2115 Abschnittslängen zu berechnen um die optimale Lösung zu erhalten. Ein Nachteil besteht allerdings darin, dass der Algorithmus nur fähig ist, die jeweils optimale Lösung zu berechnen. Lösungen die sich sehr nahe beim Optimum befinden, jedoch die Kundenbedürfnisse besser abdecken, können nicht berechnet werden.

1 Modellanwendung

1.1 Testgebiet

Das Modell wurde im Januar 2005 in 2 Beständen (Schweiz) getestet. In beiden Beständen fand eine Endnutzung statt, und es wurden Bäume in den Dimensionen von 40 – 65 cm BHD geschlagen. Das Gelände weist eine maximale Hangneigung von 10% auf. Die Feinerschliessung ist mit einer Dichte von 200m’/ha relativ hoch. Die Bäume wiesen mittlere bis schlechte Qualitäten auf (Stammholzklassen B bis D, gem. CH-Holzhandelsgebräuchen).

Das Fällen und Entasten erfolgte motormanuell (mit Motorsäge), das Energieholz musste nicht oder nur leicht entastet werden. Für das Rücken wurden Forwarder und Schlepper eingesetzt. In beiden Beständen wurde neben Stammholz auch Energieholz produziert. Vorausgesetzt wurde, dass sämtliche produzierten Sortimente auch abgesetzt werden können. Um den Ertrag zu berechnen wurden die Marktpreise des Winters 2004 / 2005 verwendet.

1.2 Ergebnisse

Um die Vorgehensweise anschaulich darzustellen, wird das Ergebnis zuerst anhand eines einzelnen Baumes (Fi) dargestellt. Die gutachtlich vorgenommene Aushaltung an der Fichte ergibt einen erntekostenfreien Erlös von 124 CHF / Baum. Das Modell liefert eine optimierte Variante mit einem EKFE von 208 CHF / Baum (+ 68 %). Zwei hauptsächliche Faktoren führen zu dieser Steigerung: Einerseits ist in der optimierten Variante der Anteil des Energieholzes von 12 auf 32 % gestiegen und andererseits setzt das Modell die Trennschnitte innerhalb des Stammholzes neu. (vgl. Abbildung 5)

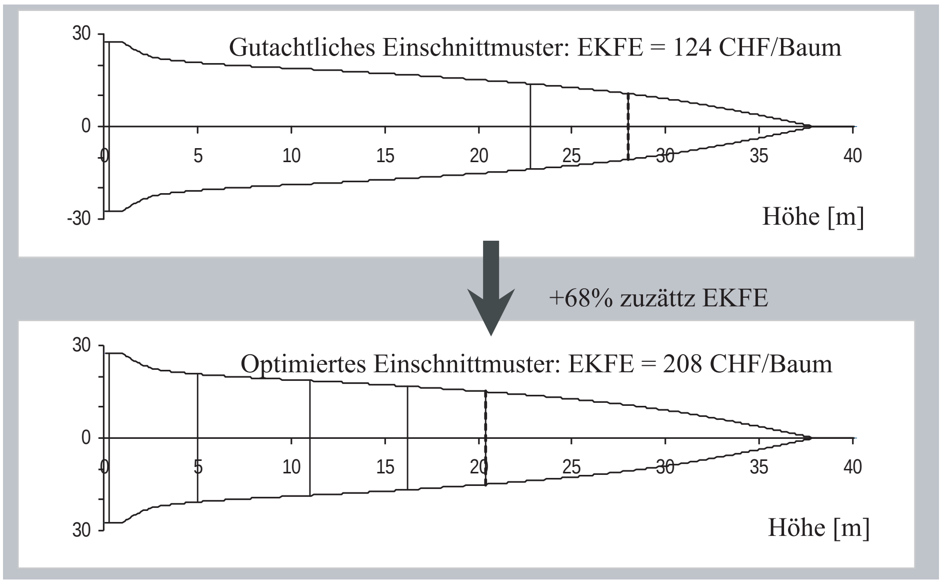


Abbildung 5: Vergleich der optimalen und der gutachtlichen Aushaltung eines Fichtenstammes. Annahmen: Höhe: 38m, BHD: 52cm, d_7: 40cm, Stockhöhe: 30cm, Höhe Beginn Grünkrone: 19m, Rückedistanz: 150m, Hangneigung: 0 - 10 %, Motormanuelle Ernte, Keine Schlagräumung, Keine Entastung des Energieholzes, Qualitätsbeurteilung Kl. B: 0 bis 23m Höhe, Kl. D: 23 bis 38m Höhe

Die Analyse (Abbildung 5) der einzelnen Faktoren zeigt, dass in unserem Fall die vermehrte Energieholznutzung ca. 1/3 (27 CHF) und die optimierte Aushaltung innerhalb des Stammholzabschnittes ca. 2/3 (57 CHF) der Steigerung des erntekostenfreien Erlös ausmacht.

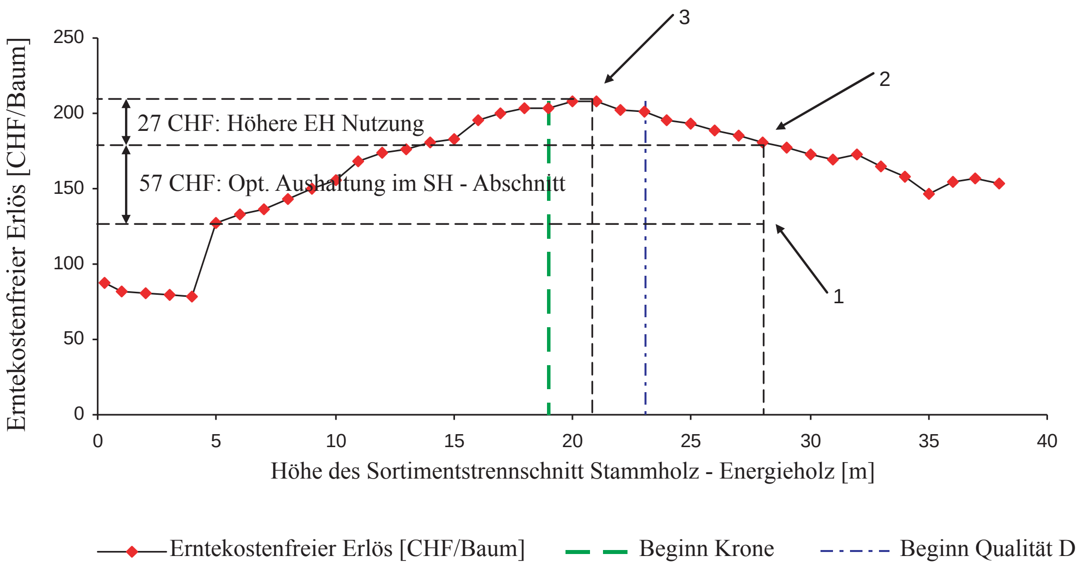


Abbildung 6: Erntekostenfreier Erlös in Abhängigkeit des Trennschnittes Stammholz – Energieholz, bei optimalem Einschneidemuster innerhalb des Stammholzabschnitt. Punkt 1 stellt die tatsächlich vorgenommene Aushaltung dar. Bei Punkt 2 wurde der Trennschnitt zum Energieholz noch unverändert bei 28m belassen, jedoch wurden hier die Trennschnitte innerhalb des Stammholzabschnitt optimiert und neu gesetzt. Der erntekostenfreie Erlös beträgt bei Punkt 2: 181 CHF. Wird nun beides, der Trennschnitt SH – EH und die Trennschnitte innerhalb des Stammholzes optimiert, erhalten wir Punkt 3 mit einem erntekostenfreien Erlös von 208 CHF.

Der gleichen Frage wurde in je einem hiebsreifen Fichten- und Buchenbestand nachgegangen. Vor allem im Fichtenbestand liesse sich durch eine Optimierung noch ein deutlich besseres Ergebnis erzielen: Hier kann der EKFE um durchschnittlich 85 % erhöht werden (vgl. Abbildung 7). Der Anteil des Energieholzes ist von 11 auf 29 % gestiegen.

Im untersuchten Buchenbestand lässt sich dagegen durch eine Optimierung das Ergebnis nur noch leicht, um 9 %, verbessern (vgl. Abbildung 8). Einerseits bleibt der Energieholzanteil bei 67 % praktisch unverändert und andererseits sind die Stammholzabschnitte nur kurz (< 10m) und lassen damit wenig Spielraum offen für eine neue Kombination der Trennschnitte innerhalb des Stammholzes.

Tabelle 1: Steigerung der Wertschöpfung nach den verschiedenen Optimierungsstufen (Fichten Winterthur)

	Durchschnittliche Erntekostenfreie Erlöse [CHF]	Durchschn. Mehrertrag gegenüber tatsächlicher Aushaltung [%]	Standard-Abweichung von Mehrertrag [%]
Tatsächliche Aushaltung	118.3	0	
Nur nach Stammholz (SH) optimiert	180.8	59.6	21.9
Nur nach Energieholz (EH) optimiert	139.5	25.2	21.9
Nach SH u. EH optimiert	202.0	84.8	31.0

Tabelle 2: Steigerung der Wertschöpfung nach den verschiedenen Optimierungsstufen (Buchen Warth)

	Durchschnittliche Erntekostenfreie Erlöse [CHF]	Durchschn. Mehrertrag gegenüber tatsächlicher Aushaltung [%]	Standard-Abweichung von Mehrertrag [%]
Tatsächliche Aushaltung	179.1	0	
Nur nach Stammholz (SH) optimiert	185.9	2.6	4.8
Nur nach Energieholz (EH) optimiert	186.0	6.9	4.8
Nach SH u. EH optimiert	192.8	9.5	14.5

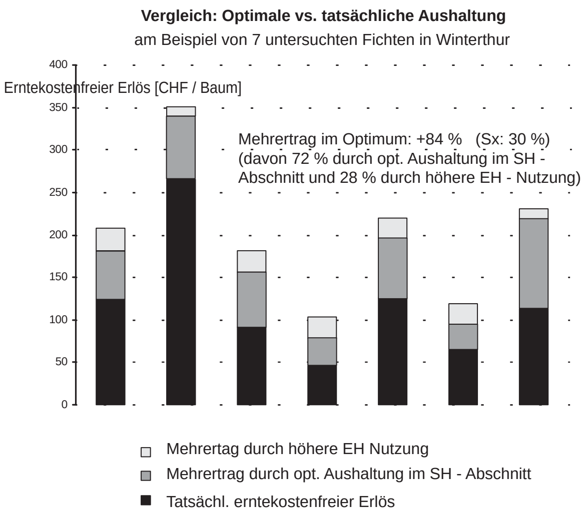


Abbildung 7: Vergleich von optimierter und tatsächlicher Aushaltung anhand des Fichtenbestand

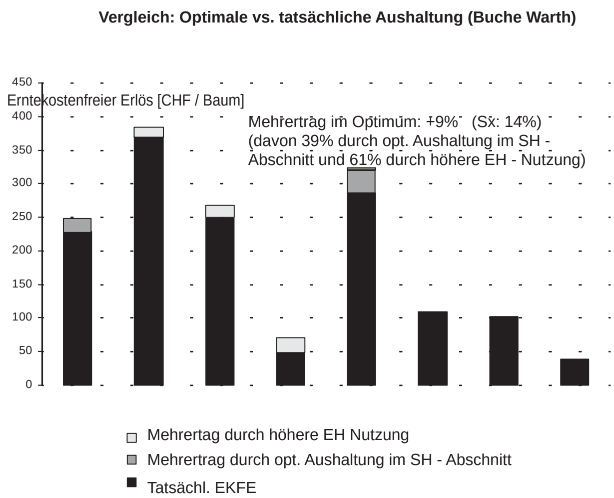


Abbildung 8: Vergleich von optimierter und tatsächlicher Aushaltung anhand des Buchebestand

1 Diskussion und Folgerung

Mit der vorgestellten Arbeit liegt ein Werkzeug vor, mit welchem das optimale Einschnittsmuster eines Baumes berechnet werden kann. Es zeichnet sich durch folgende Eigenschaften aus:

1. Einfache und breite Anwendbarkeit: Das Werkzeug basiert auf der Standardsoftware MS Excel und kann deswegen auf fast allen Computern eingesetzt werden. Die Datenein- und ausgabe erfolgt in einem gewöhnlichen Tabellenblatt und ist einfach zu handhaben.
2. Schnelle Rechenzeit: Die Auflösung (d.h. Abstand der Trennschnitte) kann frei gewählt werden und damit wird auch die Rechenzeit beeinflusst. Auch mit einer sehr hohen Auflösung von 1 cm (d.h. im Abstand von 1 cm ist ein Trennschnitt möglich), beträgt die Rechenzeit nur wenige Sekunden.
3. **Verknüpfung mit Produktivitätsmodellen**: Durch die Kombination von Produktivitätsmodellen mit Modellen der Aushaltungsoptimierung kann ein optimales Einschnittmuster mit der Zielgrösse Erntekostenfreier Erlös berechnet werden. Die eingesetzten Verfahren können aus einer breiten Auswahl von „Vollmechanisiert» bis „Motormanuell» ausgesucht werden und den individuellen Verhältnissen angepasst werden.
4. Publiziertes Optimierungsverfahren: Das Optimierungsverfahren ist publiziert und dokumentiert.

Im praktischen Einsatz ist das vorgestellte Modell jedoch nur ein Hilfsmittel, welches den Entscheidungsprozess bei der Sortimentseinteilung unterstützt. Dies hat folgende Gründe:

1. Die Optimierung erfolgt für den Einzelbaum ohne Berücksichtigung der Kundenbedürfnisse. Das Modell liefert also nur das optimale Einschnittsmuster bezüglich Deckungsbeitrags, unabhängig davon, ob die produzierten Sortimente auch verkauft werden können.
2. Einige zentrale Eingangsdaten beruhen auf Schätzungen. Im Modell muss beispielsweise die Holzqualität am stehenden Baum geschätzt werden, wobei dies mit einigen Unsicherheiten verbunden ist. Die Holzqualität lässt sich aber erst mit relativ hoher Sicherheit bestimmen, nachdem die Trennschnitte durchgeführt worden sind.

Der Einsatz des Modells in den Testflächen hat gezeigt, dass in der Sortimentsaushaltung noch ein enormes Potential zur Steigerung des Deckungsbeitrags versteckt ist. In unseren Beispielen konnten Steigerungen von 10 – 85% nachgewiesen werden. Dies ist vor allem auf 2 Faktoren zurückzuführen:

1. Anpassen des Sortimentstrennschnittes: In unseren Beständen konnte durch eine erhöhte Energieholzproduktion der Deckungsbeitrag deutlich gesteigert werden. Es hat sich gezeigt, dass der optimale Energieholzanteil eines Baumes von durchschnittlicher bis guter Qualität im Bereich von 30% (Fichte) bis 50% (Buche) liegt (Für schweizerische Verhältnisse). Bei qualitativ schlechten Bäumen liegt er deutlich höher.
2. Neukombination der Trennschnitte innerhalb des Stammholzabschnittes: Da der Stammholzabschnitt den wertvollsten Teil eines Baumes darstellt, ist mit dieser Massnahme auch das grösste Steigerungspotential verbunden. In unseren Beständen war die Neukombination der Trennschnitte innerhalb des Stammholzes für rund 2/3 der Steigerung des Deckungsbeitrages verantwortlich.

Um das vorgestellte Modell auch praxistauglich (d.h. für den täglichen Arbeitseinsatz brauchbar) zu machen, müssen die Kundenbedürfnisse berücksichtigt werden. Solche Ansätze sind bereits in Skandinavien oder auch in Chile etabliert, müssen aber noch für mitteleuropäische Verhältnisse angepasst werden. Ausserdem muss die Datenaufnahme vereinfacht werden. Denkbar wäre etwa, bei der motormanuellen Holzernte, der Einsatz einer elektronischen Kluppe mit einem integrierten Mikrocomputer und einer Datenverbindung zu einer zentralen Datenbank und einem zentralen Rechner, der die Arbeiten der verschiedenen Holzer - Teams koordiniert.

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Die Originalarbeit, sowie das Computerprogramm, können unter folgendem Link betrachtet werden: http://n.ethz.ch/student/bontle/Opt_Aushaltung.html

МОДЕЛ ЗА ОЦЕНКА НА ЕФЕКТИВНОСТТА НА ПРОТИВОПОРОЙНИТЕ МЕРОПРИЯТИЯ В МАЛКИ ВОДОСБОРИ В АЛПИТЕ

Йохен Брешан, Швейцария

Пороите нерядко предизвикват значителни материални щети в гъсто населените райони на Алпите и даже са вземали човешки жертви. Докато стойността на недвижимите имоти неотклонно расте, финансирането на защитните мероприятия от бюджета постоянно намалява. Затова предизвикателството е в рамките на бюджета да се определи портфейлът от мероприятия, който постига най-голяма ефективност при най-малки разходи.

Досега този проблем се решаваше предимно чрез експертни оценки и прост анализ на разходите и ефекта им. Ние формулираме проблема на търсене на оптимален портфейл от мероприятия като комбинаторен оптимизационен проблем, който търси за малките водосбори пространственото разпределение на мероприятията с най-голяма ефективност. Докато при количественото определяне на разходите е налице богат опит, познанията по измерване на ефективността на мероприятията се ограничават до водния отток и ерозията. За търсене на близки до оптимума пространствени решения е необходимо дискретно представяне на релефа. Ние предлагаме растер с разделителна способност 10 x 10 m. За всяка клетка съществува ограничен брой на алтернативите на защитните мероприятия.

За да се измери ефективността е необходим разпределен модел, който отразява промените на водния отток и седиментния пренос в зависимост от защитните мероприятия. В настоящата работа докладваме за оценката и регресията (Anpassung) на модела „FEST98mod“ за оценка на ефективността.

EIN MODELL DER SCHÄTZUNG DER KOSTENEFFIZIENZ DER WILDBACHSCHUTZMASSNAHMEN IN KLEINEN EINZUGSGEBIETEN IN DEN ALPEN

Jochen Breschan, Switzerland

Wildbäche verursachen wiederholt grosse Schäden an Gütern und Menschenleben in dicht besiedelten Regionen der Alpen. Während der Wert der Güter in der Vergangenheit sukzessive zunahm, nahm die Unterstützung für Schutzmassnahmen von Seiten der öffentlichen Hand stetig ab. Die Herausforderung ist nun, im Rahmen des Budgets das Massnahmen-Portfolio mit der besten Kostenwirksamkeit zu finden. Bis heute wird dieses Problem vor allem mithilfe von Expertenmeinungen und einfachen Kostenwirksamkeits-Analysen gelöst.

Wir formulieren das Problem der Suche nach einem optimalen Massnahmen-Portfolio als ein kombinatorisches Optimierungsproblem, das für kleine Einzugsgebiete die räumliche Verteilung von Massnahmen mit der höchsten Kostenwirksamkeit ermitteln soll. Während grosse Erfahrung bei der Quantifizierung der Kosten vorhanden ist, ist das Wissen zur Messung der Wirksamkeit von Massnahmen auf den Abfluss und die Erosion beschränkt. Für die Suche nach nahe-optimalen Lösungen im Raum ist die diskrete Repräsentation der Landschaft erforderlich. Wir schlagen ein Zellraster von 10 x 10 m Auflösung vor. Für jede Rasterzelle existiert eine beschränkte Zahl von Alternativen an Schutzmassnahmen.

Um die Wirksamkeit zu quantifizieren, ist ein verteiltes Modell von Nöten, das abhängig von der Schutzmassnahme die Änderungen im Abfluss und Sedimenttransport abbilden kann. In diesem Artikel berichten wir von der Evaluation und Anpassung des Modells „FEST98mod“ zur Quantifizierung der Wirksamkeit.

A MODEL TO ESTIMATE THE COST-EFFECTIVENESS OF TORRENT CONTROL MEASURES (TCMS) FOR SMALL CATCHMENTS IN THE ALPS

Jochen Breschan, Switzerland

Abstract

Flooding of torrents in the Alps through extreme precipitation can severely harm both assets and residents in densely populated areas. The values of those assets are constantly increasing while public funding for control measures is declining. The challenge has been to find the most cost-effective portfolio of measures subject to budget constraints. Until now, this problem has mainly been solved through expert opinion and, in some cases, by simplistic cost-benefit analyses.

The approach presented here involves formulating the best solutions to a combinatorial optimization problem, which identifies the spatial pattern of measures that are both feasible in small catchments and financially reasonable. Whereas much is known about calculating measure costs, knowledge is limited for quantifying the effectiveness on runoff and erosion. Performing the search for near-optimal solutions requires a discrete representation of the landscape. To do so, we use a regular grid of 10- X 10-m-resolution raster cells, each of which is assigned a finite set of possibilities.

To determine the effectiveness of specific measures, we require a distributed model that quantifies the associated changes in water and solid flux. Here, we report on the evaluation and adaptation of the "FEST98mod" model for effectiveness quantification.

1. INTRODUCTION

Protection against natural hazards is a vital challenge in Switzerland, particularly in the densely populated Alpine regions. One critical problem to be solved is maximizing safety with limited financial resources. Until now, that conflict has been assigned to experts, who often have relied on personal experience and rules of thumb. However, simultaneous developments in informatics and enhanced availability of digital geographic data have now facilitated the automatic design of optimal control measures.

The risk arising from flooding in small catchments during an extreme precipitation event serves as our example when devising a conceptual model for "Computer Aided Torrent Control Design", which enables planners to identify a near optimal-pattern of torrent control measures (TCM) on hillside slopes. Maximizing the cost-effectiveness of these TCM alternatives is the objective function in this optimization problem. Here, we present an evaluation of a model for spatial mapping of water- and sediment transport that can serve as a metric for estimating effectiveness.

2. THE TORRENT CONTROL MEASURE (TCM) DESIGN PROBLEM

Spatial arrangement of torrent control measures (TCMs) in a catchment is crucial because it affects 1) water and sediment flux that can promote flooding, and 2) investment costs. On that basis, we can formulate this design problem as one of optimization:

Maximize *cost-effectiveness* $\boldsymbol{C} = \frac{\textbf{\textit{effectiveness}}}{\textbf{\textit{investment cost}}}$; [1]

Subject to *investment cost < credit line;*
feasibility = true;

Cost-effectiveness sets a ratio of effectiveness gained to investment required, making it a suitable figure for assessing the performance of TCM alternatives. However, those alternatives also must fit within a given credit line and be feasible with regard to site properties.

Solving this problem necessitates a representation that both provides the spatial composition of various alternatives and spatially maps changes in water and sediment flux. A regular grid of raster cells matches these prerequisites. The feasibility of a TCM within a particular cell depends upon the state of the neighboring cells. This makes the TCM design problem one of combinatorial optimization, where traditional techniques fail while intelligent random-search methods (IRSMs) enable one to at least find near-optimal alternatives by screening the solution space via a search strategy. The general approach for an IRSM follows a cycle of consecutive steps:

(A) Create a preliminary best alternative.

(B) Create a neighbor alternative, which differs in one element from the preliminary best one.

(C) Apply acceptance criterion that compares objective function values to evaluate whether the neighbor alternative becomes the preliminary best.

(D) Apply a stop rule that assesses whether the search should be terminated.

(E) If the search is indeed stopped, then the preliminary best alternative is considered the solution; if not, return to Step (B).

The TCM design problem is fitted to an IRSM by splitting the duty into three tasks. The first task concerns Steps (A) and (B), where the alternative options are reduced to those that are feasible in order to save computational time. The second task addresses the formulation of the objective function in Step (C), the cost-effectiveness. In Task 3, all steps of the scheme are evaluated while implementing the IRSM search rules so that the near-optimal alternatives can be identified. Various types of IRSM are available, including SIMULATED ANNEALING, or TABU SEARCH. These and other techniques have been reviewed by Rayward-Smith et al. (1996).

Measuring cost-effectiveness is the backbone of this method. Although calculating TCM costs is simple, a gap has previously existed in designing a metric for this assessment. Therefore, the following model has been evaluated to close that gap.

3. EFFECTIVENESS MEASUREMENT

3.1 Model prerequisites

A suitable model for evaluating effectiveness must fulfill four prerequisites. First, it must be tailored to the object of the investigation. Here, the focus was on the fluxes of water and sediments that occur when extreme precipitation induces flood in pre-/alpine torrents. The scale was one of small catchments. Second, representation of the landscape must facilitate the use of an IRSM, i.e., through the use of raster cells. Third, the assignment of TCMs must influence model parameters, which then lead to changes in water and sediment fluxes that can be mapped effectively. And, finally, the choice of model must be practical so that it can incorporate and analyze the input data generally available.

3.2 The model *Fest98MOD + erosion code*

Using these prerequisites as a selection filter, we first investigated the model *Fest98MOD + erosion code*. *Fest98* was an events-based runoff model developed by Mancini (1998), that was later renamed Fest98MOD and adapted to pre-/alpine conditions by Kuntner (2002). Building upon this model, Hinz (2004) proposed an erosion code based on Fest98MOD, which was then formally introduced in 2006 as Fest98MOD + erosion code (Molnar et al., 2006). Fest98MOD has already been used to test the effects of land-use changes on runoff, particularly within the framework of an investigation of reforestation and windfall areas, as reported to the Federal Office for the Environment (FOEN; Burlando and Kirsch, 2005).

3.2.1 Main specifications

The catchment in Model Fest98MOD+erosion code is represented by a 25-m X 25-m cell-size raster (Hinz, 2004). The digital elevation model (DEM) as well as land-use and soil information serve as input data, which, for Switzerland, can be obtained at GEOSTAT, the Swiss agency for space-oriented data. In addition, data for precipitation events are needed, e.g., as a raster of rain depth per time unit. The DEM is further processed to 1) obtain flow directions for each cell by evaluating the direction to the steepest neighbor (D8-algorithm), and 2) to discriminate for slope and channel cells using a threshold for the contributing area assigned to each cell. Flow direction refers to flow passing from cell to cell, such that hill-slope and channel cells must be separated to adapt the flow calculation to hydrologically different reacting elements within a catchment.

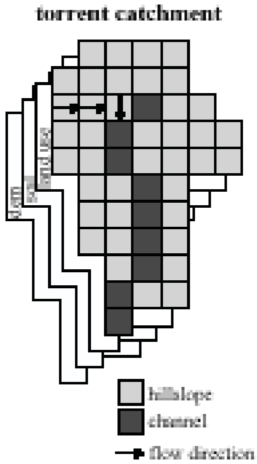

Fig. 1. Representation of the torrent catchment

The role of *Fest98MOD* is to provide planners with a simple model for predicting catchment behaviour. However, such events-based modeling of a torrent catchment (Fig. 1) must allow for simplifications:

Torrent-catchment modeling: The runoff produced by a precipitation event is defined by three contributing flows - overland flow, inter- (or subsurface) flow, and base flow (Fig. 2). The second factor represents the routing of infiltrated water through the soil. In contrast, base flow reacts very slowly to precipitation inputs, and is often considered instead as part of the groundwater. Although *Fest98MOD* calculates both overland and inter-flow, TCMs incorporate only the parameters associated with overland flow. Base flow is neglected, because the action of groundwater is not relevant to torrent catchments.

Events-based modeling: *Fest98MOD* is an events-based model. Flow routing is evaluated at 10-minute intervals, and involves a time window of only a few hours. This method neglects processes such as evaporation that influence water content in a catchment only over the long term. Therefore, *Fest98MOD* considers just the infiltration data when determining the proportion of rainfall available for surface runoff. When one also calculates values for erosion/detachment, the amount of runoff per cell that is produced by overland flow is then used to define the *erosion code.*

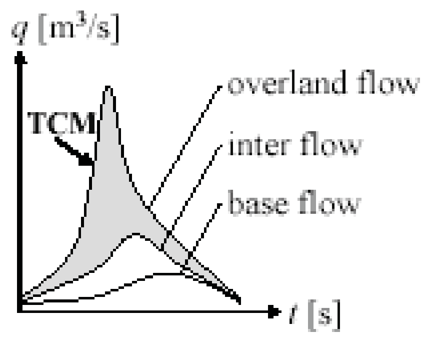

Fig. 2. Runoff during a precipitation event. The hydrograph can be separated in overland, inter-, and base flow. TCMs only affect overland flow in *Fest98MOD* (hatched area).

This simplification has led to *Model Fest98MOD + erosion code,* which assesses four components: 1) infiltration, for identifying the effective precipitation (q_p) that contributes to overland flow; 2) overland flow (q); 3) the inter-flow (q); and 4) erosion/detachment (q_s). The system illustrated in Figure 3 factors all the fluxes between those components in a precipitation event. Its output is a hydrograph of the water runoff q [$m^3 s^{-1}$] and the sediment transport rate q_s [kg $m^{-1} s^{-1}$]. Although most of the components are influenced by TCMs, and will be discussed later, the exception is inter-flow, represented by a linear reservoir. We refer to MANIAK (1997) for a close description of this concept.

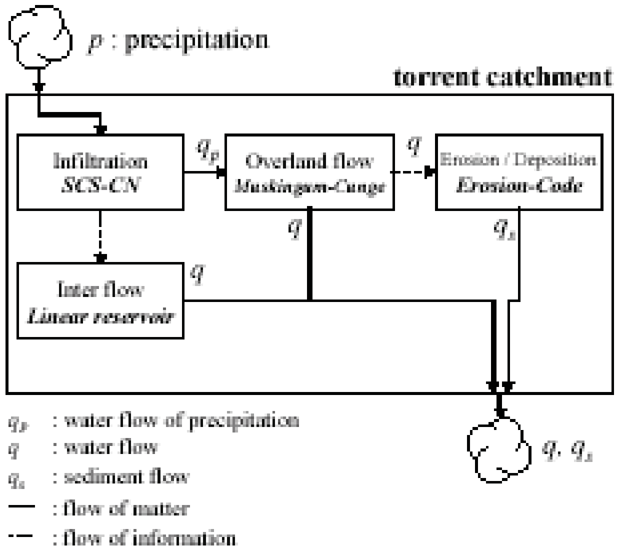

Fig. 3. System produced by *Model Fest98MOD + erosion code.*

3.2.2 Infiltration component

The objective of the infiltration component is to estimate the effective precipitation available for overland flow. *Fest98MOD uses the Curve Number Method (SCS-CN method)*, developed by the US Soil Conservation Service (SCS, 1986). It is a conceptual model that assumes that the ratio of cumulative infiltration F(t) [mm] to the amount stored in the soil S [mm] is equal to the ratio of cumulative effective precipitation $P_e(t)$ [mm] to accumulated precipitation P(t) [mm]. Simultaneously, some initial losses I_a [mm] - such as interception – are subtracted:

$$\frac{F(t)}{S} = \frac{P_e(t)}{P(t) - I_a}; \qquad [2]$$

where P(t) is the sum of F(t), $P_e(t)$, and I_a. By solving for $P_e(t)$, we arrive at:

$$P_e(t) = \frac{[P(t) - I_a]^2}{P(t) - I_a + S} \qquad [3]$$

In this way, the effective precipitation can be calculated with storage S as the only parameter that indicates soil behavior. That is then solved by using the CN-value specific to soil classification and land-use:

$$S = 254 \times (\frac{100}{CN} - 1) \qquad [4]$$

SCS provides a spreadsheet of CN-values that are associated with soil and land-use classes found in the US. Similar data are available for continental Europe from the Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DVWK, 1984).

In addition to the simple calculation of $P_e(t)$ that factors in soil storage, the SCS-CN method allows one to incorporate earlier moisture conditions when adjusting CN values that depend on three ranges of accumulated precipitation over the previous five days.

Effective precipitation must be calculated for each time step in *Fest98MOD*. Because $P_e(t)$ is the cumulation of effective precipitation at time t, one must subtract $P_e(t-\Delta t)$ to obtain the level of effective precipitation $P_{eff}(t)$ at any particular time step Δt:

$$P_{eff}(t) = P_e(t) - P_e(t-\Delta t) \quad [5]$$

The runoff that results from effective precipitation is then calculated by multiplying $P_{eff}(t)$ with the area of the cell Δx^2 [m^2], and dividing by the time step Δt:

$$q_p(t) = \frac{\Delta x^2}{\Delta t} P_{eff}(t) \quad [6]$$

Values for q_p (in $m^3 s^{-1}$) are calculated for each cell and at each time step.

3.2.3 Overland flow component

Fest98MOD determines overland flow by the Muskingum-Cunge method (CUNGE, 1969). This is a numeric solution of the kinematic wave, a simplification of Saint-Venant's impulse equation for waves (the starting point for any hydraulic method). Calculation works by a difference scheme. If one sets i as an index for the position of the cell on a hillside, with i+1 as the lower and i-1 as the upper neighbors, then the actual runoff in cell i+1 will depend on four factors: 1) the amount of runoff one time step previously, 2) the actual runoff from the upper neighbor cell(s), 3) the runoff from the upper neighbor cell(s) one step earlier, and 4) the runoff q_p that results from effective precipitation. Figure 4 and Equation 7 illustrate the calculation of runoff q from position i+1 at time step j+1.

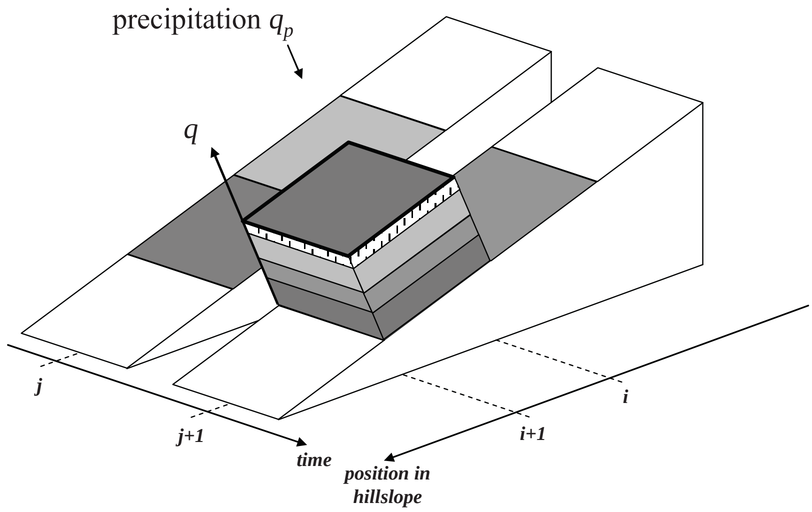

Figure 4: Visualization of the Muskingum-Cunge method.

$$q_{j+1}^{i+1} = c_1 q_j^{i+1} + c_2 q_j^i + c_3 q_{j+1}^i + q_{p\,j+1}^{i+1} \text{ [m}^3\text{ s}^{-1}] \quad [7]$$

The parameters c_1 through c_3 depend upon flow width B [m], the topographic slope I (m m^{-1}), the Strickler flow resistance coefficient k [$m^{1/3} s^{-1}$], hydraulic radius R [m], cell length Δx [m], and the steady-flow Q' [$m^3 s^{-1}$] at the outlet of the catchment prior to the event.

$$c_x = f(B, I, k, R, \Delta x, Q') \quad [8]$$

The difference between channel and hill-slope cells is represented by B and k. Flow width in the hill-slopes is equal to the cell size while a width smaller than that cell size is used for the channel cells. The former type receives k-values based on land-use while those of the latter are independent of that influence. The smallest k-values are assigned to forested areas, thereby indicating decelerated runoff.

3.2.4 Erosion component

The erosion code proposed by Hinz (2004) identifies the erosion depth z [m] at each time step by calculating the mass balance between incoming and outgoing sediment for each cell (Fig. 5). This parameter is expressed as the sediment transport rate q_s [kg m^{-1} s^{-1}].

$$z(t) = z(t-1) + \frac{\Delta t}{\Delta x}\frac{1}{\rho_s}\left[q_{s(in)}(t) - q_s(t)\right] \quad [9]$$

where ρ_s is the specific weight of the sediment in kg per cubic meter

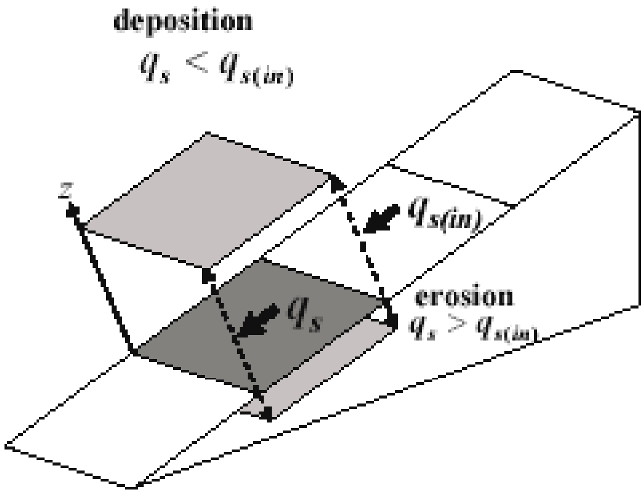

Figure 5: Relationship between erosion depth z and sediment transport rate q_s.

The procedure for these calculations differs between hill-slope and channel cells. For the former, no limitation of sediment is assumed, such that only the transport capacity T_c modulates erosion by overland flow ($q_s \approx T_c$). Here, T_c is a function of the bed shear stress $\tau = f(q, I, \rho_{soil})$. The critical shear stress for particle entrainment τ_c depends on the type of land-use. When $\tau < \tau_c$, no erosion occurs; in the opposite case, the following formula is implemented:

$$q_s = \frac{K}{\rho_s}(\tau - \tau_{cr})^{\mu} \quad \text{[kg m}^{-1}\text{ s}^{-1}\text{]} \quad [10]$$

where μ and K are coefficients

If sediment is transported in channels where no TCMs are planned, the Formula of Schoklitsch (1962) is used to calculate q_s.

3.2.4 Effect of torrent control measures

Measures to control torrents that alter land cover can affect infiltration and the hill-slope contributions to overland flow, as well as the erosion component (Table 1).

Table 1. Parameters susceptible to Torrent Control Measures

Component	Parameter	Source
Infiltration SCS-CN method	Storage, S Initial losses, I_a	(SCS, 1986), (DVWK, 1984)
Overland flow Muskingum-Cunge	Strickler roughness coefficient, k	(Chow, 1959)
Erosion Erosion code	Critical shear stress for particle entrainment, τ_c	(Bollrich, 1996)

3.2.5 Results from other studies

The first simulations that implemented FEST98mod to assess changes in land-use by afforestation in Switzerland demonstrated that peak flow (a key predictor of flooding) was reduced during a precipitation event, while the volume of water discharged remained relatively the same (Burlando and Kirsch, 2005). The authors attribute this to inherently low k-values for forests, which results in the slower allocation of precipitation. Likewise, because CN-values do not differ much between forest and meadow, the discharge volumes are similar.

In tests of the erosion code for this model, erosion was decreased on hillsides following afforestation, whereas an increase was measured in the channel (Hinz, 2004). A higher critical shear stress τ_c for those forested cells reduced that erosion on the hillsides, and the lower rate of incoming sediments combined with a fairly equivalent sediment transport rate caused greater erosion in the channel cells.

4. CONCLUSION

Our starting problem in this investigation was to use limited financial resources to maximize safety from natural hazards in the Alps. In the case of torrential flooding induced by extreme precipitation events, the objective was to develop a conceptual model for "Computer Aided Torrent Control Design". We based our solution on the elements of intelligent random search methods (IRSM), which include 1) reducing TCM alternatives to a feasible set, 2) formulating cost-effectiveness as the objective function, and 3) devising search rules. For the study presented here, we have evaluated the model FEST98mod + erosion code as a possible means for designing a metric that measures TCM-effectiveness in the objective function.

This solution utilizes a digital elevation model (DEM), land-use and soil information as input data on a 25- x 25-m cell resolution. Cells representing the channel are extracted from the DEM. TCMs influence parameters for soil storage S and initial losses I from infiltration, the Strickler roughness coefficient k for overland flow, and critical shear stress for particle entrainment τ_c to define the erosion component. Previous studies have shown that this model is capable of plausibly mapping changes in water and sediment fluxes that are induced by different land-use scenarios. Because one can interpret a Torrent Control Measure as a change in land-use, we believe that the effectiveness of TCM-alternatives can be evaluated adequately by this FEST98mod + erosion code model.

Our next challenge will be to integrate model components that are written in different computer languages in the MatLab in order to facilitate optimization calculations, because this model must also be verified under actual catchment conditions. Another challenge will involve improving the handling of model parameters that are affected by TCMs, perhaps through the use of fuzzy sets. To better represent a surface, the model may need to be refined to a 10- x 10-m cell raster.

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НОВ МОМЕНТ В ДОСТАВКИТЕ НА ТРЕСКИ – ИЗПОЛЗВАНЕ НА КАМИОН САМОТОВАРАЧ

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Резюме

Поради усилените мерки за стимулиране добива на биоенергия, търсенето на трески расте. В периода 2004-2007 г. се очаква допълнителен растеж на годишното потребление на енергийна дървесина от 1,6 до 5,0 млн. куб.m. Очакваното увеличение на търсенето предполага мобилизирането на допълнителен суровинен ресурс. Използването на отпадната маса от дърводобива по примера на Финландия може да буферира очертаващия се суровинен дефицит.

Добиването на трески от отпада на планинския дърводобив, извършван чрез извоз на цели дървета по въжена линия, поставя високи технологически изисквания. Досега използуваните технологии са неубедителни или имат съществени недостатъци. Засега най-често прилаганата технология е пряко дробене, при което то става на камионен път, като треските отиват направо в камиона, който ще го откара. Имайки предвид недостатъците на тази технология, един предприемач разви нова технология. Дробенето пак става на горския път, но треските се издухват на земята. Транспортът се извършва от самосвал с товарен кран с челюстен грайфер, който товари складираните трески. Тази технология позволява машините да работят независимо, с което се спестява времето за оперативно изчакване.

Настоящето изследване цели да изясни конкурентоспособността на новата технология в сравнение с по-старите – тези на прякото дробене и балирането. Снимката на работното време беше направена пооперационно от водача на камиона с преносим компютър с GPS-модул за засичане на маршрутите и разстоянията. Дробенето се протоколираше също от водача. Средната производителност на мобилната дробилна машина се получи от 30 до 52 прм/мч$_{15}$ (пространствени кубични метри на моточас, в т. ч. прекъсвания до 15 min). По данните беше изведено уравнение на производителността. Най-голямо влияние имат транспортното разстояние и курсовият товар. При 50 km разстояние и плътност на треските 370 kg/прм се получава изработка 11,1 прм/мч$_{15}$.

При транспортно разстояние 50 km до завода на потребителя, разходите възлизат на 9,0 EUR/прм, което означава, че са с 1,0 EUR/прм по-високи от тези при прякотото дробене. Балирането дава още по-високи разходи от 18,4 EUR/прм. Въпреки леко повишените разходи, разглежданата технология със самонатоварване може да се препоръча в планински условия поради гъвкавостта й и по-ниските логистични разходи.

A NEW APPROACH IN THE FUEL WOOD SUPPLY CHAIN USING A SELF-LOADING TRUCK FOR HAULING

Christian Kanzian, Franz Holzleitner, Austria

Abstract

The demand for forest fuel increases quickly, because of promotion activities for green electricity produced from biofuel. From 2004 to 2007 the yearly need of forest fuel will rise from 1.6 to 5.0 mil. m³. To fulfill the expected increase of demand new resources have to be used. Using harvesting residuals, as they actually do in large scale in Finland, can be a solution for the imminent shortage of resources.

From the logistical point of view supplying forest chips from logging residues after tree method in mountainous regions is a hard task. Applied supply chains do not precede satisfactory respectively have several open issues. Chipping at the landing and blowing them on a truck is currently the most common way. Knowing the issues of the employed systems an entrepreneur developed a new supply chain.

The chipping is done at the landing, blowing the chips on a pile. Afterwards the chips are picked and transported up with a self-loading truck. The loading is done by the truck-mounted loader equipped with clamshell bucked independent from the chipper. Work-flow related delays can be prohibited.

This study investigated if this chain is competitive in comparison to the direct chipping or the energy bundles system.

The data of the transport was divided into different working steps and recorded by the driver himself mostly using a standard PDA-GPS-device. The chipping was journalised by operators. The productivity of the mobile chippers reached 30 to 52 m³ loose/PSH_{15} in average. Based on the collected transport data a productivity model was developed. The highest influence to the transport productivity is given by the transport distance and the load volume. At a distance of 50 km and a bulk density of 370 kg/m³ loose a productivity of 11.1 m³ loose/PSH_{15} can be achieved.

The cost for the system for a transport distance of 50 km are 9.0 EUR/m³ loose, which means 1.0 EUR/m³ loose more than for the system direct chipping. The costs for system energy bundles are much higher with 18.4 EUR/m³ loose. Even than of a little bit higher costs compared to the system "direct chipping", the system using a self-loading truck can be recommended under mountainous conditions because of flexibility and the lower logistical expense.

WERTSCHÖPFUNGSKETTEN FÜR WALDHACKGUT - EINSATZ EINES SELBSTLADENDEN LKW FÜR DEN TRANSPORT

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Kurzfassung

Der Bedarf an Waldhackgut ist durch die verstärkten Maßnahmen in der Förderung von Energie aus Biomasse rasch im Steigen begriffen. Im Zeitraum von 2004 bis 2007 rechnet man mit einem zusätzlichen Anstieg des jährlichen Energieholzbedarfes von 1,6 auf 5,0 Millionen Festmeter. Die erwartete Bedarfssteigerung muss durch zusätzliches Rohstoffaufkommen gedeckt werden. Die Nutzung von Schlagrücklass, wie dies in Finnland praktiziert wird, könnte die drohende Rohstoffverknappung abfedern.

Die Bereitstellung von Waldhackgut aus Schlagrücklass bei der Holzernte im Gebirge im Anschluss an die Seilbringung im Baumverfahren stellt hohe Anforderungen an die Logistik. Bisher getestete Verfahren konnten nicht überzeugen bzw. weisen verschiedene Mankos auf. Direktes Hacken an der Forststraße in Transport-Lkw stellt derzeit die gebräuchlichste Kette dar. Mit Kenntnis der vorhandenen Nachteile hat ein Unternehmer eine neue Bereitstellungskette für Waldhackgut entwickelt. Der Prozess Hacken findet auf der Forststrasse statt, wobei das Hackgut auf den Boden geblasen wird. Anschließend erfolgt der Abtransport mit einem Schüttgut-Lkw mit aufgebautem Ladekran. Die Beladung mittels mitgeführtem Ladekran und Schalengreifer ermöglicht unabhängiges Arbeiten der Maschinen, wodurch ablaufbedingte Wartezeiten vermieden werden.

Diese Studie soll dieses System auf seine Konkurrenzfähigkeit gegenüber der Kette direkt Hacken und Energieholzbündel hin beleuchten. Die Datenerhebung für den Transport wurde getrennt nach Arbeitsschritten in Form von Selbstaufzeichnungen durch den Fahrer mittels PDA mit GPS-Modul durchgeführt. Das Hacken wurden mit Formularen durch die Fahrer protokolliert Die Produktivität der mobilen Hacker lag im Mittel bei 30 bis 52 Srm/$PSH_{15.}$ Aus den erhoben Daten wurde ein Produktivitätsmodell für den Transport entwickelt. Den größten Einfluss auf die Produktivität üben die Transportdistanz und die transportierte Menge pro Fuhre aus. Bei 50 km Distanz und einer Schüttdichte von 370 kg/Srm ergibt sich eine Produkttivität von 11,1 Srm/PSH_{15}.

Die Systemkosten frei Werk belaufen sich bei einer Transportdistanz von 50 km auf 9,0 EUR/Srm und sind damit nur um 1,0 EUR/Srm höher als beim vergleichbaren System direkt Hacken. Das System Energieholzbündel verursacht mit 18,4 EUR/Srm noch höhere Kosten. Trotz der etwas höheren Kosten kann das System Selbstbeladung vor allem unter Gebirgsbedingungen aufgrund seiner Flexibilität und des geringeren logistischen Aufwandes empfohlen werden.

Einleitung

Österreich erlebt derzeit eine Renaissance im Bereich des Energieholzes. Ausgehend vom Ökostrom-Gesetz 2002, welches 2006 novelliert wurde, entstand eine Planungs- und Baueuphorie bei den Energieversorgern. Die im Gesetz verankerten Einspeisetarife richten sich in ihrer Höhe nach den eingesetzten erneuerbaren Ressourcen. Neben der Förderung von Stromerzeugung aus Wind, Solar und Kleinwasserkraft, wird auch die thermische Stromproduktion unter Einsatz von Biobrennstoffen subventioniert. Ziel dieser Maßnahmen ist es, dass mit Ausnahme der Wasserkraft, bis 2010, 10% der Stromproduktion aus erneuerbaren Ressourcen stammen (Ökostromgesetz – Novelle 2006). Schätzungen sprechen von einer Zunahme des Energieholzbedarfs für Kraft-Wärme-Kopplungsanlagen (KWK) von 1,6 auf 5,0 Millionen Festmeter bis 2007. Der Brennstoffbedarf insgesamt lag im Jahr 2000 bei 10 Millionen Festmeter und soll sich aufgrund der Prognosen bis 2010 verdoppeln (Katzensteiner, Nemestothy, 2006).

Der Brennstoffverbrauch von bestehenden Biomasseheizwerken wird vielfach durch Sägenebenprodukte wie Hackgut, Sägespäne und Rinde gedeckt. Waldhackgut spielte bisher eine geringe Rolle, weil die Kosten im Vergleich zu hoch sind (Stockinger, Obernberger, 1998; Kanzian et al., 2006). Effiziente Logistikketten für Waldhackgut konnten sich aus mangelnder Nachfrage nicht entwickeln. Sägenebenprodukte und Rinde sind nicht ausbaufähig, daher ist in Zukunft mit Engpässe in der Rohstoffversorgung zu rechnen. Zusätzliche Quellen für Energieholz müssen erschlossen werden.

Schlagrücklass, welcher bei der Holzernte als Nebenprodukt anfällt, könnte einen Teil des Bedarfs abdecken. Finnland setzt bereits seit einiger Zeit auf diese Ressource (Hakkila, 2004). Waldbauliche Strategien zur Vermeidung von Kahlschlägen und dass ca. 2/3 des österreichischen Waldes auf Hängen mit einer Neigung von über 30% stocken, lassen den Einsatz in Skandinaven erprobter Verfahren zur Nutzung von Schlagrücklass kaum zu. Im Gegenzug dazu hat sich vor allem in der Durchforstung im steilen Gelände das Baumverfahren trotz massiver Kritik wegen des Nährstoffentzuges (Krapfenbauer, 1983) aus wirtschaftlichen Gründen etabliert. Bei der Aufarbeitung an der Forststraße fällt Schlagrücklass in konzentrierter Form an. Dieser bietet sich für die energetische Verwertung an.

Die rapide steigende Nachfrage und vor allem die Versorgung größerer KWK-Anlagen erfordert effiziente Bereitstellungsketten. Steigende Anlagengröße führt zwangsläufig zu höheren Transportkosten, da die Energieholzbeschaffung größere Einzugsgebiete erfordert (Asikainen et al., 2001). Die bisher in Österreich untersuchten Ketten weisen Schwachpunkte in den Bereichen Kosten, Organisationsaufwand und Einsetzbarkeit unter Gebirgsbedingungen auf. Da bei diesen Studien meist Verbraucher im lokalen Bereich bis 30 (50) km versorgt wurden, spielten die Transportkosten eine untergeordnete Rolle (Stampfer et al, 1997; Rohrmoser, Stampfer, 2003).

Die spezifischen Transportkosten von Biomassebrennstoffen erweisen sich im Vergleich zu fossilen aufgrund der geringen Energiedichte als bis zu viermal teurer (Stockinger, Obernberger, 1998). Unverdichteter Schlagrücklass hat gegenüber Rundholz oder Hackgut die niedrigste Ladedichte mit 0,08 bis 0,10 m^3/Raummeter (Patzak, 1981; Frey, 1996). Die Nutzlast der Transportfahrzeuge kann nicht ausgeschöpft werden, da das Ladevolumen limitierend wirkt (Ranta, Rinne, 2006). Eine Verdichtung des Schlagrücklass zu einem frühest möglichen Zeitpunkt in der Kette ist daher anzustreben. Dazu bietet sich einerseits die Möglichkeit an, das Material mechanisch zu verdichten, oder zu hacken. Hacken würde nach Frey (1996) die Ladedichte um den Faktor vier steigern.

Eine Alternative zum Hacken stellt die Technologie der Energieholzbündel dar, wo ähnliche Ladedichten wie beim Transport von Hackgut erreicht werden (Hakkila, 2004). Das Material wird dabei über ein Presssystem zu runden Bündeln mit einem Durchmesser von 70 bis 80 cm und einer Länge von üblicherweise 3 m verarbeitet (Hakkila, 2004; Cuchet et al., 2004). Die Technologie wurde ursprünglich in Schweden entwickelt, wird dort aber kaum eingesetzt. Finnland bedient sich dieser Technologie und versorgt über die Kette Energieholzbündel große Heizwerke. Die Bündel haben im Vergleich zu Hackgut aus Schlagabraum den Vorteil, dass sie lagerfähig sind. Bei frischem Hackgut beginnt sofort ein Abbau der Substanz. Die Selbsterwärmung des Materials kann bis zur Selbstentzündung führen (Johansson et al, 2006). Energieholzbündel, vorausgesetzt sie werden abgedeckt, zeigen ein gutes Trocknungsverhalten (Kanzian, 2005)

Die Produktion von Waldhackgut wird neben den Kernprozessen Hacken (Bündeln) und Transportieren von den Prozessen Fällen, Aufarbeiten und Rücken geprägt. Aus den genannten Prozessen lassen sich verschiedene Ketten erstellen. Unterschiede zwischen den Ketten ergeben sich einerseits durch die

Art des Hackmaterials und andererseits durch den Ort des Hackens. Dessen Festlegung determiniert den Zustand des Brennstoffes beim Transport. Potenzielle Hackorte stellen der Bestand, die Forststraße, der Lagerplatz oder das Werk dar.

Bei der Nutzung von Schlagrücklass unter Gebirgsbedingungen scheidet der Bestand aus, da die Voraussetzung der Befahrbarkeit nicht gegeben ist. Ein Transport zum Werk erscheint aufgrund der geringen Ladedichte von losem Schlagrücklass unwirtschaftlich. Hacken an der Forststraße direkt in Transport-Lkw in einer geschlossenen Kette bietet sich an (SC 1 – Abbildung 1). Als problematisch haben sich aber die Nachteile des hohen Logistikaufwandes und Platzbedarfs erwiesen. Ablaufbedingte Wartezeiten sowohl des Hackers als auch der Lkw können die Folge sein und zusätzliche Kosten verursachen. Aufgrund der geringen Wurfweite der in Österreich eingesetzten mobilen Hacker auf Lkw müssen die Transport-Lkw parallel zum Hacker aufgestellt werden, welche dementsprechend Platzbedarf in Anspruch nimmt. Ein Vortransport des losen Materials zu einem geeigneten Hackort mit ausreichenden Platzverhältnissen ist in den meisten Fällen daher unumgänglich. Dazu werden Rundholz-Lkw mit eingesetzten Bordwänden verwendet.

In Schweden werden jährlich über 4 Millionen Festmeter Waldhackgut im Bestand bzw. großteils an der Forststraße gehackt. Der Transport wird mit Abrollcontainern abgewickelt (Johansson et al, 2006). Der Einsatz von Abrollcontainer hilft, ablaufbedingte Wartezeiten zu vermeiden. Um die Vorteile der Container nutzen zu können, muss der Hacker die Container jederzeit beladen können. Das erfordert allerdings den Einsatz von mobilen Hackern mit aufgebauten, kippbaren Containern (Hakkila, 2004) oder einen Hacker, welcher selbst die Abrollcontainer aufnehmen kann (Neff et al, 2003). Beide Varianten kommen in Österreich kaum zum Einsatz. Hohe Investitions- und Überstellungskosten bei geringen Einsatzmengen je Ort sind ein Grund dafür.

Eine Alternative zum Hacken im Wald stellt das Bündeln dar (SC 2 - Abbildung 1). Das Hacken kann mit mobilen oder stationären Hackern beim Werk erfolgen, wo durch hohe Auslastung, Mengen und Produktivitäten die Hackkosten niedrig gehalten werden können. Die in Schweden entwickelte Technologie wurde in Finnland Anfang 2000 eingeführt und weiterentwickelt. Knapp 30 Bündler standen im Frühjahr 2005 in Finnland im Einsatz (Kärhä, Vartiamäki, 2006). Am Markt befinden sich zwei Systeme für die Bündelproduktion. Der Valmet WoodPac arbeitet schrittweise, das heißt ein Presssystem wird solange befüllt bis ausreichend Material für ein Bündel vorhanden ist. Danach wird das Bündel mit Polypropylen- oder Sisalschnüren umwickelt. John Deere (vormals Timberjack) und Pinox setzten auf ein kontinuierliches System mit vier Einzugswalzen. Pinox verwendet einen sich verengenden Kanal mit Stachelbändern, wo das Material sukzessive verdichtet wird. Beim Energieholzbündler 1490 D von John Deere arbeiten nach den Einzugswalzen zwei Hydraulikpressen tangential. Durch alternierendes Öffnen und Schließen sowie durch die Längsbewegung wird das Material durch das Aggregat gedrückt und zugleich verdichtet. Beide Maschinen erzeugen so einen Strang, welcher anschließend mit einer Schnur umwickelt wird. Am Ende wird das Bündel mittels Kettensäge vom Strang abgetrennt. Im Vergleich zum Valmet WoodPac ist die Bündellänge variabel einstellbar. Üblicherweise werden in Finnland Bündel mit 3 m Länge, passend zu den Rungenabständen der Lkw, hergestellt. Die Stabilität der Bündel nimmt allerdings mit zunehmender Länge ab. Die genannten Bündelaggregate werden üblicherweise auf Forwarder aufgebaut. Wird jedoch im Baumverfahren genutzt, bleibt nach der Aufarbeitung an der Forststraße der Schlagrücklass in Form von Haufen liegen. Da kleinflächige Nutzungen in Österreich vorherrschen, fallen pro Einsatzort nur geringe Mengen an. Um die anfallenden Überstellungskosten niedrig zu halten, hat ein Schweizer Unternehmer das Bündelaggregat Timberjack 1490 D auf einen Lkw aufgebaut. Die Verwendung des Lkw als Trägerfahrzeug anstatt eines Forwarders soll dieses System für die Nutzung von Schlagabraum unter den skizzierten Bedingungen konkurrenzfähig machen.

Um die Nachteile der geschlossenen Kette zu umgehen, kann die Beladung der Transport-Lkw getrennt vom Hacken, entweder fremd durch ein Ladegerät oder selbst mittels mitgeführten Ladekrans, erfolgen. Aufgrund des geringen Mengenanfalls kommt eine Fremdbeladung nicht in Frage. Aus praktischen Erfahrungen und mit dem Wissen der Schwächen der genannten Systeme, hat ein Unternehmer einen Rundholz-Lkw mit Schüttgut-Aufbau entwickelt. Die Holzzange des Ladekrans wird durch einen Schalengreifer mit Schnellwechselkupplung ersetzt. Durch die Fähigkeit des Lkw sich selbst zu beladen, können das Hacken und der Transport unabhängig voneinander erfolgen (SC 3- Abbildung 1). Systembedingte Wartezeiten können vermieden werden.

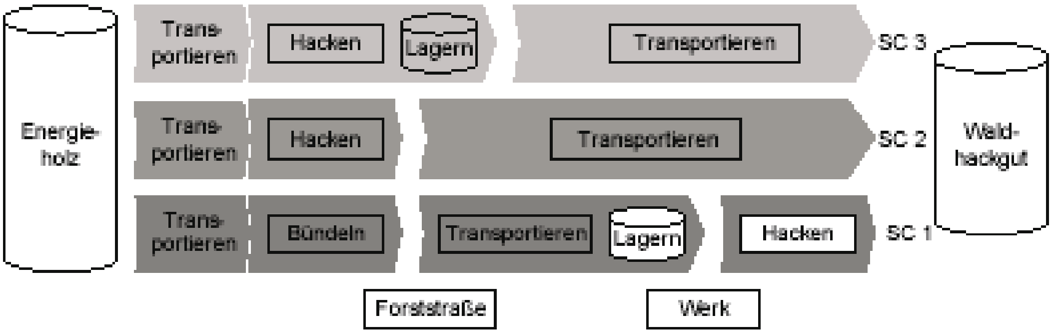

Abbildung 1: Bereitstellungsketten zur Erzeugung von Waldhackgut aus Schlagrücklass nach einer Nutzung im Baumverfahren. SC 1 – Bündeln auf der Forststraße und Hacken im Werk. SC 2 – Direktes Hacken auf der Forststraße in Transport-Lkw. SC 3 – Hacken auf der Forststraße und anschließendes Transportieren durch einen Schüttgut-Lkw mit Ladekran.

Die Bereitstellungsketten SC 1 und SC 2 sind durch Feldstudien in Kanzian (2005) und Kanzian et al. (2006) dokumentiert. Diese Studie zielt darauf ab, die Systeme SC 1 und SC 2 für die Bereitstellung von Waldhackgut aus Schlagabraum unter Gebirgsbedingungen mit dem System SC 3 zu vergleichen und Einsatzempfehlungen abzugeben.

Methodik

Systembeschreibungen

Das Hacken erfolgte mit mobilen Großhackern des Typs Starchl U-1250 oder Jenz HEM 35D. Als Trägerfahrzeug kommt in beiden Fällen ein Lkw zum Einsatz. Die Hacker werden von einem eigenen Dieselmotor und nicht über den Lkw-Motor angetrieben. Die Beschickung des Hackers erfolgt mittels Ladekran, montiert am Trägerfahrzeug, durchgeführt (Tabelle 1).

Zum Transport des Waldhackgutes kommt ein adaptierter Rundholz-Lkw mit 6x6-Antrieb zum Einsatz. Die Rungen werden durch einen kippbaren Aluminiumaufbau für Schüttgut ersetzt. Die Holzzange des Ladekrans wird durch einen Schalengreifer mit 500 Liter Fassungsvermögen ersetzt. Aus Platz- und Gewichtsgründen kann der Schalengreifer mittels Schnellwechselkupplung demontiert und am Beladeort abgelegt werden. Die Kranreichweite beträgt 10 m. Die gesetzlichen Rahmenbedingungen erlauben bei einem Leergewicht von 20,8 t eine Nutzlast von 17,2 t. Der Motorwagen fasst 34 m³ und der mitgeführte Anhänger 47 m³, womit pro Zug insgesamt 81 m³ transportiert werden können (Tabelle 1).

Der Ablauf der einzelnen Fahrten beginnt üblicherweise mit der Leerfahrt zum Ladeort. Dort wird zuerst der Schalengreifer mittels Schnellkupplung in ca. 3 Minuten an den Ladekran fixiert. Nach dem Ladevorgang und Abkoppeln der Ladeschaufel wird das Waldhackgut zum Abnehmer transportiert. Nach dem Entladen, durch Abkippen am Werksgelände, beginnt eine neue Fahrt.

Tabelle 1. Technische Beschreibung der eingesetzten Maschinen Transport-Lkw und mobile Großhacker.

Schüttgut-Lkw mit Ladekran			Trommelhacker auf LKW			
Type	MAN 33-430 TGA				STARCHL U-1250	JENZ HEM 35
D						
Leergewicht	20,8	[t]	Gesamtgewicht	[t]	28,0	32,0
Nutzlast	17,2	[t]	Kranreichweite	[m]	9,0	10,0
Antrieb	6x6	[ ]	Stationärer	[PS]	400	408
Leistung	430	[PS]	Dieselmotor			
Ladevolumina			Einzugsöffnung	[bxh mm]	1250x800	
1000x500						
Motorwagen	34	[m³]				
Hänger	47	[m³]				
Gesamt	81	[m³]				

Abbildung 2: Transport-Lkw mit Ladekran beim Laden einer Fuhre (rechts) und mobiler Großhacker auf Lkw beim Hacken von Schlagrücklass (links).

Zeitstudie

Die Produktive Systemstunde inklusive Unterbrechungen bis 15 min (PSH_{15}) wird als Zeitkonzept herangezogen. Die PSH_{15} ergibt sich aus der Produktiven Arbeitszeit (PSH_0) und den Unterbrechungen bis 15 min. Die Umrechnung von PSH_0 auf PSH_{15} erfolgt über den Faktor k, welcher entweder aus den aufgezeichneten Daten berechnet oder aus der Literatur entnommen wird (Stampfer, 2002).

Der Prozess Hacken wird über schriftliche Selbstaufzeichnungen durch den Fahrer dokumentiert. Unterbrechungen bis 15 min werden bei Selbstaufzeichnungen nicht erfasst, da der zusätzliche Arbeitsaufwand bei schriftlichen Aufzeichnungen durch den Fahrer für diesen nicht zumutbar ist. Eine Untergliederung in Ablaufabschnitte entfällt. Beobachtungseinheit bildet der Holzschlag, wobei die Produktivität über das anfallende Hackgutvolumen (Schüttraummeter) berechnet wird.

Die Datenerhebung für den Transport wurde mittels elektronischer Selbstaufzeichnung begleitet. Als Beobachtungseinheit beim Transport wird die Fuhre definiert. Basis für das Zeitgliederungskonzept ist die Produktive Systemstunde ohne Unterbrechungen (PSH_0), welche in die Ablaufabschnitte Laden, Fahren, Entladen und Warten auf die Übernahme im Werk unterteilt wird. Unterbrechungen bis 15 min und größer als 15 min werden ebenfalls aufgezeichnet, wobei alle Angaben über die Produktivität auf die PSH_{15} umgelegt werden. Die Berechnung des Faktor k erfolgt aus den Zeitstudiendaten.

Transport

Für den Transport wird ein Produktivitätsmodell entwickelt. Das Transportmodell (1) setzt sich aus den Teilen Laden, Fahren (Leer-Last), Warten und Entladen zusammen. Die Teilmodelle berechnen über die unabhängigen Variablen den Zeitbedarf für die Arbeitsschritte (Teilprozesse). Für die Schätzung der Fahrzeit wird das Modell zur Berechnung der Durchschnittsgeschwindigkeit von Asikainen (1995) auf seine Eignung getestet (2). Über diese Funktion erfolgt die Kalkulation der Fahrzeit aus Distanz und Durchschnittsgeschwindigkeit.

(1) $$\Pr oduktivit\ddot{a}t = \frac{Fuhrvolumen}{\sum(Lade-, Fahr-, Warte-, Entladezeit, Unterbrechungen < 15\,\mathrm{min.})} * \frac{60}{k}$$

(2) $$Durchschnittsgeschwindigkeit = a + b * \log(Dis\tan z)$$

Datenerhebung und -analyse

Als Hardware diente ein Personal Digital Assistant (PDA) mit Windows Mobile 3.0. Dieser ist zusätzlich mit einem GPS-Empfänger zur Fahrtrouten- und Distanzerfassung ausgestattet. Als Software kommt eine Eigenentwicklung zum Einsatz, bei welcher sowohl die Arbeitsschritte als auch die Position protokolliert werden. Entsprechend des zu erwartenden Arbeitsablaufes werden die benötigten Arbeitsschritte inklusive der entsprechenden Parameter im Vorfeld definiert. Der Fahrer muss während der Aufzeichnungen den Arbeitsschritt auswählen und eventuell erforderliche Parameter eingeben. Diese Informationen speichert die Software in ein XML-File (Extensible Markup Language) auf einem Datenträger ab. Das Aufbereiten und Auswerten der Daten wird nach der Datenübertragung auf dem PC durchgeführt.

Die Zeitstudiendaten werden mit Standardwerkzeugen verarbeitet (Tabellenkalkulation MS-Excel, Statistikpaket SPSS). Der Prozess Hacken wird deskriptive ausgewertet. Die Selbstaufzeichnung lässt einen höheren Detaillierungsgrad nicht zu.

Ergebnisse

Die Datenerhebung erstreckte sich von Mitte Juni bis Anfang September 2005. Aufzeichnungen für das Hacken liegen für 9 Einsatzorte vor, wobei eine Menge von ca. 2200 Srm aufbereitet wurde. Der Jenz HEM 35 erreichte Produktivitäten von ca. 20 bis 47 Srm/PSH_{15} und der Starchl U-1250 39 bis 73 Srm/ PSH_{15} (Abbildung 3). Im Mittel lag die Produktivität für den Jenz Hacker bei 30 Srm/ PSH_{15} und für den Starchl Hacker bei 52 Srm/ PSH_{15}. Erfahrungen aus Zeitstudien mit dem Starchl U-1250 beim direkten Hacken von Schlagrücklass in Lkw zeigen ähnliche Produktivitäten mit ca. 55 – 60 Srm/ PSH_{15} (Kanzian et al., 2006). Die Produktivität des Hackers wird einerseits durch die technischen Merkmale selbst und andererseits durch das Hackmaterial bestimmt. So beeinflusst sinkender Wassergehalt und Verschmutzung des Ausgangsmaterials die Produktivität von Hackern negativ (Asikainen et al., 2001). In dieser Studie wird unterstellt, dass die Produktivität beim selben Ausgangsmaterial und Gerät in der untersuchten Kette eine geringe Variation aufweist. Die Produktivität und die resultierenden Kosten für das Hacken werden daher für die weiteren Kalkulationen als konstant angenommen.

Die Datengrundlage für die statistische Auswertung des Transportes umfasst 83 Fuhren. Die transportierte Menge betrug 4560 Srm bzw. 1680 t. Für diese Menge war der Lkw 400 h im Arbeitseinsatz und legte eine Strecke von insgesamt 9250 km zurück, was in etwa ein Fünftel der durchschnittlichen Jahresleistung entspricht. Das Fuhrvolumen der Lkw-Züge betrug im Mittel 56 Srm. Das Entladen im Werk dauerte in 90% der Fällen zwischen 10 und 30 Min, wobei hier die Übernahme und das Aufsuchen der Entladestelle im Werk inkludiert sind.

Die mittlere Ladeeffizienz beträgt 1,2 min/Srm. 90% der Werte liegen in einem Bereich von 0,72 bis 2,19 min/Srm. Dies entspricht einer Produktivität von 27 bis 83 Srm/h bzw. im Mittel von 50 Srm/PSH_0 für das Beladen.

Tabelle 2: Deskriptive Statistik der aufgezeichneten Daten des Transportes.

	Mittelwert	Standardabweichung	Min.	Max.	5. Perz.	95. Perz.
Leerfahrt [km]	53,07	16,57	9,63	96,78	25,27	80,86
Leerfahrt [min]	88,59	27,83	18,27	164,87	47,65	143,96
Lastfahrt [km]	53,34	19,03	13,00	100,27	24,12	92,20
Lastfahrt [min]	92,53	31,58	20,03	141,82	49,90	136,01
Warten [min]	9,06	15,63	0,00	79,25	0,00	45,99
Entladen [min]	18,31	5,66	4,47	33,08	10,31	30,17
Fuhrvolumen [m³]	56,02	7,22	23,96	72,80	47,56	67,57
Trockengehalt [%]	55,43	9,00	33,61	78,86	40,17	77,57
Schüttdichte [kg/Srm]	372,45	61,63	197,07	588,35	280,37	483,63

Aufgrund der aufgezeichneten Daten nimmt die Fahrzeit, rund 66,0% der PSH_{15} in Anspruch. Auf das Beladen fällt ein Anteil von 23,6%, der Rest verteilt sich auf den Übernahmevorgang mit 3,3% Warten und 6,7% Entladen. Unterbrechungen kleiner 15 min fallen nur in einem Ausmaß von 0,3% an (Abbildung 4).

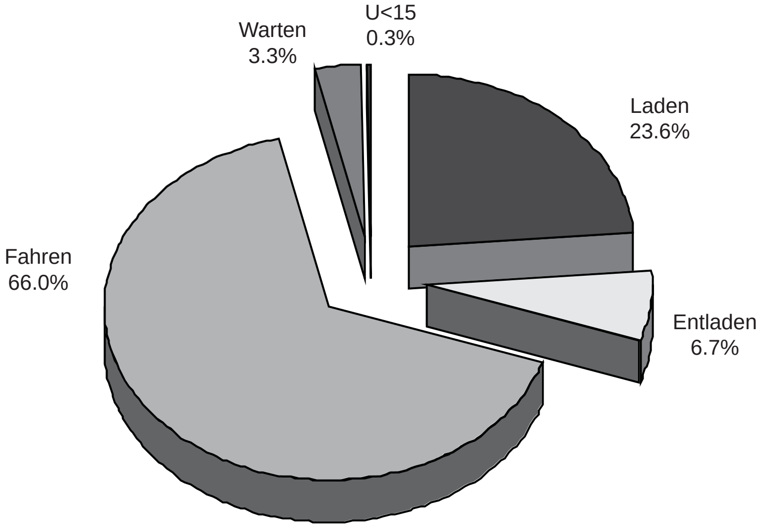

Abbildung 4: Aufteilung der einzelnen Arbeitsschritte für einen Lkw-Zug mit Waldhackgut.

Die Ladeeffizienz fließt als Konstante in das Transportmodell ein. Die Ladezeit ergibt sich aus dem Quotient von Fuhrvolumen und mittlerer Ladeeffizienz (3). Das Entladen wird als konstant betrachtet, dass heißt unabhängig vom Fuhrvolumen, weil das Waldhackgut abgekippt wird. Als Wert wird die mittlere Entladezeit von 18,3 min aus den Aufzeichnungen ins Modell aufgenommen.

(3) $$Ladezeit[\min] = \frac{Fuhrvolumen[Srm]}{Ladeeffizienz[\min/Srm]}$$

Eine Regressionsanalyse der aufgezeichneten Daten mit dem Modell (2) von Asikainen (1995) zur Vorhersage der mittleren Fahrgeschwindigkeit ergibt keine gute Anpassung und ein sehr niedriges Bestimmheitsmaß. Die Darstellung der Fahrzeit über der Distanz lässt auf einen linearen Zusammenhang schließen (Abbildung 5). Die abhängige Variable „Dauer Lastfahrt" bzw. „Dauer Leerfahrt" kann durch die Distanz erklärt werden (4 und 5). Pro Kilometer braucht der Lkw im Schnitt also 1,63 bzw. 1,67 min, was einer mittleren Geschwindigkeit von 36,8 bzw. 35,9 km/h entspricht. Zusammengesetzt ergeben die Teilmodelle das Produktivitätsmodell Transport (6). Der Faktor k fällt mit einem Wert von 1,0032 aufgrund des geringen Anteils an Unterbrechungen bis 15 min sehr niedrig im Vergleich zu anderen forstlichen Zeitstudien aus (Stampfer, 2002).

(4) $Dauer\_Lastfahrt[\min] = 1{,}67 * Distanz\ [km]$ R^2=0,937

(5) $Dauer\_Lastfahrt[\min] = 1{,}63 * Distanz\ [km]$ R^2=0,949

(6)
$$\Pr oduktivität[Srm / PSH_{15} = \frac{Fuhrvolumen[Srm]}{\frac{Fuhrvolumen[Srm]}{Ladeeffizienz[\min/Srm]} + (1{,}67 + 1{,}63) * Distanz[km] + Enladezeit[\min]} * \frac{60}{k}$$

Die Untersuchungen haben gezeigt, dass das vorhandene Fuhrvolumen von 81 m³ aufgrund der hohen Schüttdichte des waldfrischen Hackgutes nicht ausgelastet werden kann. Zur Berechnung der Produktivität wird in Abhängigkeit von der Schüttdichte das maximal zulässige Fuhrvolumen eingesetzt. Bei 50 km Transportdistanz und einer mittleren Schüttdichte von 370 kg/Srm ergibt sich eine Produktivität von 11,1 Srm/PSH_{15} (Abbildung 6). Durch eine Erhöhung des gesetzlich höchstzulässigen Gesamtgewichtes von 38 auf 42 t für Waldhackguttransporte, was eine gesetzliche Gleichstellung mit dem Rundholztransport bedeuten würde, könnte eine Steigerung der Produktivität erreicht werden. Bei einer mittleren Schüt-

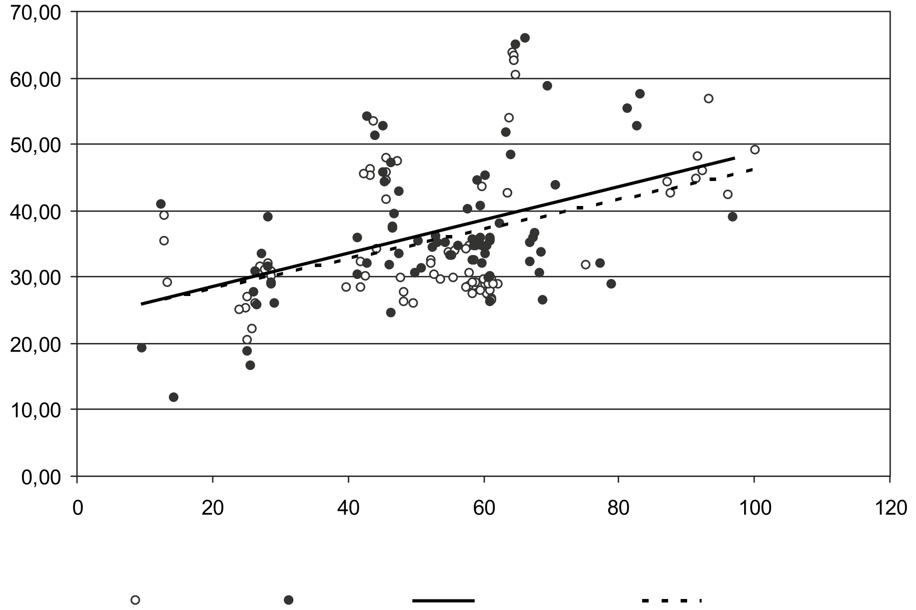

Abbildung 5: Zusammenhang von Dauer Lastfahrt bzw. Dauer Leerfahrt und Distanz.

tdichte von 370 kg/Srm und Transportdistanz von 50 km würde dies zu einer Produktivitätserhöhung von 2,0 Srm/h bzw. 18 % führen. Die Trockung des Energieholzes bzw. Hackgutes reduziert die Schüttdichte, welche sich auf die Produktivität weitaus stärker niederschlägt als eine Erhöhung des Gewichtlimits. So steigt die Produktivität bei einer Schüttdichte von 210 kg/Srm um 50% auf 16,7 Srm/h bei einer Distanz von 50 km.

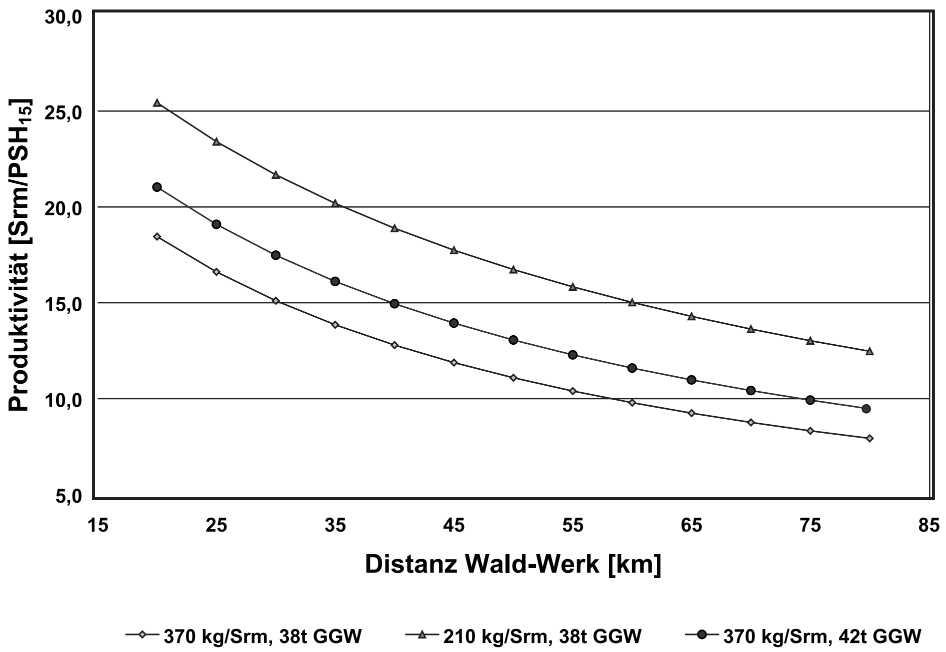

Abbildung 6: Produktivitäten des Systems Schüttgut-Lkw mit Selbstbeladung auf Basis des erstellten Modells bei unterschiedlichen Schüttdichten des Waldhackgutes und höchstzulässigen Gesamtgewichten.

Die Berechnung der Systemkosten wird über die ermittelten Produktivitäten und den von den Unternehmern angegebenen Stundensätzen durchgeführt. Der Schüttgut-Lkw mit Ladekran kostet inklusive Fahrer 57 EUR/h und der Hacker 180 EUR/h. Üblicherweise werden von den Hackunternehmern keine

Überstellungskosten verrechnet, wenn die Einsatzzeit pro Ort einen Tag erreicht bzw. überschreitet. Deshalb werden keine Überstellungskosten für den Hacker kalkuliert. Die Kosten für den Vortransport stammen aus Erfahrungswerten und wurden von den Unternehmern mit ca. 2 EUR/Srm beziffert. Die Kosten der Systeme SC 1 und SC 2 sind den Fallstudien von Kanzian (2005) und Kanzian et al. (2006) entnommen. Um die Vergleichbarkeit zu gewährleisten wird den drei Ketten dieselbe Transportdistanz von 50 km unterstellt.

Für das System SC 3 entstehen inklusive eines Vortransports des Hackmaterials Kosten von 9,0 EUR/Srm (Abbildung 7). Das bedeutet im Vergleich zum System SC 2 Direktbeladung Mehrkosten von 1,0 EUR/Srm bzw. 12,5%. Dabei muss festgehalten werden, dass im System SC 2 außer den ablaufbedingten Wartezeiten keine Risikokosten für einen Maschinenbruch inkludiert sind. Das System SC 1 Energieholzbündel hat sich aus Sicht der Kosten im Feldversuch nicht bewährt, da sich diese frei Werk auf 18,4 EUR/Srm belaufen (Kanzian, 2005). Einzig die Kosten für das Schreddern der Bündel am zentralen Lagerplatz sind um bis zu 40% günstiger als das Hacken im Wald. Die durch den zusätzlichen Prozess Bündeln verursachten Kosten konnten durch die erwarteten Kostensenkungen beim Transport und beim Aufbereiten der Bündel nicht annähernd ausgeglichen werden (Kanzian, 2005).

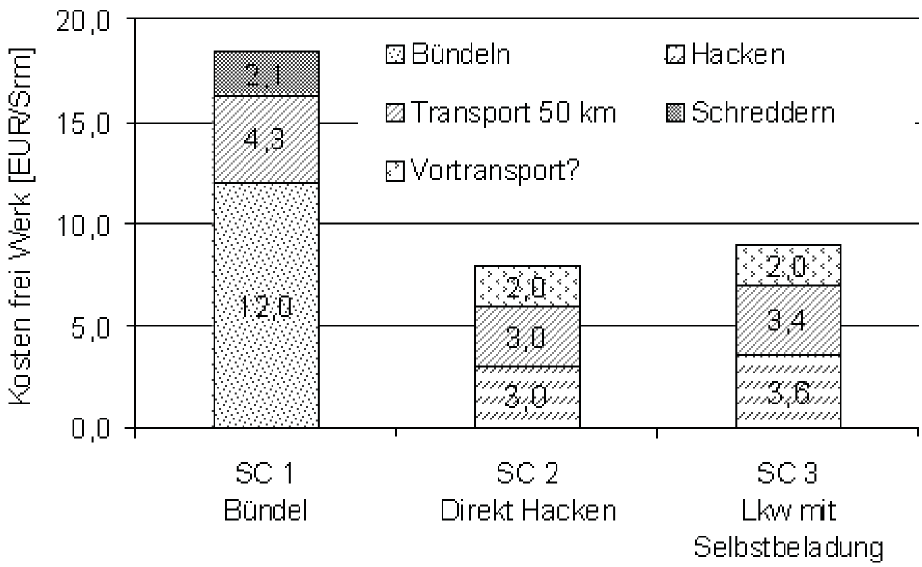

Abbildung 7: Vergleich der Bereitstellungskosten [EUR/Srm] für Waldhackgut mit drei unterschiedlichen Systemen.

Diskussion

Die gebrochene Bereitstellungskette von Waldhackgut mit Schüttgut-Lkw mit aufgebautem Ladekran kann auf Basis der vorliegenden Daten als konkurrenzfähig gegenüber den hier vorgestellten Systemen bezeichnet werden. Die Ergebnisse zeigen nur geringfügig höhere Kosten als bei der Direktbeladung. So ergeben sich bei einer Transportdistanz von 50 km Bereitstellungskosten von 9,0 EUR/Srm im Vergleich zum System Direktbeladung mit 8,0 EUR/Srm. Als Haupteinsatzgebiet wird aufgrund der technischen Ausstattung des Schüttgut-Lkw mit Ladekran die Nutzung von Schlagabraum nach der Nutzung im Baumverfahren im Seilgelände gesehen, wo mit eingeschränkten Platzverhältnissen und geringen Mengen pro Einsatzort zu rechnen ist. Das System zeichnet sich, aufgrund der gebrochenen Arbeitsweise, durch hohe Flexibilität aus. Der logistische Aufwand reduziert sich und ablaufbedingte Wartezeiten können nicht auftreten.

Nachteile ergeben sich durch das höhere Eigengewicht in Folge des Ladekrans. Durch die reduzierte Nutzlast kann das Ladevolumen bei waldfrischem Waldhackgut nicht ausgelastet werden. Ein Abdecken des Schlagrücklasses und somit eine bessere Trocknung wäre zu überlegen. Die Einsparungen bei den Transportkosten müssen aber den Aufwand für das Abdecken übersteigen.

Der Einsatz des Systems Energieholzbündel hat sich wegen der hohen Kosten nicht bewährt. Als besonders problematisch hat sich auch die Verschmutzung des Schlagrücklasses herausgestellt, was zu einem hohen Verschleiß an der Kette der Kappsäge führt. Beim Transport besteht die Gefahr, dass sich Teile aus den Bündeln lösen, weshalb aus Gründen der Ladungssicherheit die Bündel abgedeckt werden müssen.

Direktes Hacken in Schüttgut-Lkw scheitert meist aufgrund der Platzverhältnisse. Die in Österreich eingesetzten mobilen Hacker weisen eine geringe Wurfweite auf. Die Transport-Lkw müssen deshalb beim Laden sehr nahe am Hacker bzw. parallel dazu aufgestellt werden. Die verwendeten Transport-Lkw sind für den Ferntransport ausgelegt und haben Probleme beim Befahren von Forststraßen (Reifenausstattung, kein Allrad-Antrieb, große Wendekreise). Diese Nachteile und das Problem der zeitlichen Abstimmung von Hacker und Lkw müssen beim Einsatz dieser Kette beachtet werden.

Zu wenig Aufmerksamkeit wird hier den Überstellungskosten und der Maschinenkostenrechnung gewidmet. Die notwendigen Mindestmengen je Einsatzort hängen von den anfallenden Überstellungskosten ab. Durch konsequentes Aufzeichnen der Fahrtenrouten der Lkw und Hacker mittels GPS (Tracking) über einen längeren Zeitraum, wären Aussagen über den tatsächlichen Zeitaufwand ableitbar. Die Kostenkalkulation beruht auf Unternehmersätzen. Vor allem die für die Kalkulation des Hackers notwendigen laufenden Kosten für Betriebsmittel (Treibstoff, Klingen) sind nicht dokumentiert.

СЪВРЕМЕННИ СРЕДСТВА ЗА МЕХАНИЗАЦИЯ НА ГОРСКОСТОПАНСКИЯ КОМПЛЕКС

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В съвременните условия, във връзка с изострянето на екологичната обстановка и поскъпването на енергоносителите, лесокултурното производство трябва да премине към еколого- и ресурсощадящи технологии.

Предложените средства за механизация осигуряват минимално въздействие върху естествения състав на горния слой на почвата, създават оптимални условия за почвеното хранене на култивираните дървесни видове, съхраняват екологията на сечищата и намаляват разходите на материално-технически и финансови ресурси.

Данните по оценката на еколого- и ресурсощадящите технологии и средства за механизация потвърждават високата им ефективност. Прихващането на 3-годишните култури, създадени в сечищата, достига 95%.

MECHANISIERUNG DER WALDBEGRÜNDUNG UNTER BERÜCKSICHTIGUNG DER ANFORDERUNGEN DER GEGENWART

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Für unsere Gegenwart sind sowohl die Verschärfung der ökologischen Probleme als auch die Verteuerung der Brennstoffe ausschlsggebend. Unter diesen Umständen werden in Russland umweltfreundliche und energiesparende technische Lösungen sowohl für die Baumschulen, als auch für den Anbau im Wald entwickelt.

Die vorgeschlagenen Maschinen sichern eine minimale Störung der oberen Bodenschicht und eine optimale Nährstoffversorgung der gesetzten Pflanzen, erhalten die ökologischen Eigenschaften der Verjüngungsfläche und verringern den Material- und Geldaufwand.

Die Auswertungsergebnisse bestätigen die Vorteile der umweltfreundlichen energiesparenden technischen Lösungen. Der nach dem 3. Jahr ermittelte Erfolg der gegründeten Kulturen erreicht 95%.

СОВРЕМЕННЫЕ СРЕДСТВА МЕХАНИЗАЦИИ ДЛЯ ЛЕСНОГО КОМПЛЕКСА

С. А. Родин, В.И. Казаков, И. В. Казаков

В настоящее время, в связи с обострением экологической обстановки, удорожанием энергоносителей, лесокультурное производство должно быть переведено на эколого-ресурсосберегающие технологии, охватывающие период от выращивания крупномерного посадочного материала до формирования насаждений, обеспечивающих получение планируемого целевого конечного результата искусственного лесовосстановления. Решение этой проблемы должно идти по пути оптимизации почвенной экологии питомников, применения крупномерного посадочного материала, максимального сохранения экологических условий лесокультурных площадей, уменьшения энергоемких технологий и переход на эколого-ресурсосберегающие.

РЕЗУЛЬТАТЫ И ДИСКУССИЯ

Для успешного создания лесных культур наиболее целесообразно использовать укрупненный посадочный материал, который требует меньше агротехнических уходов и дает более интенсивный прирост на лесокультурной площади.

Наиболее перспективным направлением производства укрупненного посадочного материала хвойных пород является более длительное (до 4 лет) его выращивание в посевном отделении без перешколивания при условии выполнения определенных агроприемов и условий. Для посева необходимо использовать только семена с высокой грунтовой всхожестью и при посеве их необходимо разместить равномерно в посевной строчке с нормой высева около 0,5 г на 1 м. Для получения компактной и хорошо развитой корневой системы растений на 3-ом году роста необходимо подрезать их корневые системы.

Предпосевная обработка в питомниках включает выравнивание поверхности поля, рыхление посевной ленты и в ряде случаев – нарезку гряд. Для выравнивания поверхности поля и поделки гряд в питомниках предназначен выравниватель-грядоделатель ВГ-3,6. Этот выравниватель состоит из рамы с опорными колесами, спаренных выравнивателей из неравнобокого уголка и двух грядообразующих рабочих органов. При поступательном движении агрегата выравниватели срезают неровности почвы на ширине 3,6 м, перемещают ее в стороны и засыпают имеющиеся впадины (углубления, ложбины).

Для предпосевной обработки почвы в питомниках разработана бесприводная ротационная машина МРБ-1,6. Особенностью конструкции этой машины являются рабочие органы, выполненные в виде двух катков с вырезными планками, расположенными последовательно один за другим и связанных между собой цепной передачей. Кроме того, на переднем брусе машины установлены долотообразные зубья и грядообразующие рабочие органы. В процессе работы долотообразные зубья рыхлят почву на глубину до 15 см, грядообразующие рабочие органы производят нарезку гряд глубиной 10…15 см с расстоянием между ними 1,5…1,6. Передний каток при взаимодействии с почвой рыхлит верхний слой почвы на глубину 4-6 см и одновременно обеспечивает вращение заднего с удвоенной частотой вращения. При этом обеспечивается более интенсивное воздействие его на почву и достигается необходимая степень рыхления почвы на глубину до 8 см. при рабочей скорости не менее 7 км/ч.

Для посева мелких сыпучих семян хвойных пород применяется сеялка лесная навесная СЛН-5/9. Эта сеялка обеспечивает посев семян с равномерно-разреженным размещением их в посевной строчке как по общепринятой норме (около 2 г на 1 м), так и минимальной (около 0,5 г на 1 м). Сеялка СЛН-5/9 снабжена девятью штифтовыми высевающими аппаратами и производит посев 4 или 5 строчек через 22,5 см и 9 строчек через 11,2 см. Заделку семян обеспечивают загортачи, выполненные в виде сходящихся полозков. Сеялка имеет прикатывающий каток для уплотнения верхнего слоя почвы.

Мульчирование посевов и присыпка семян субстратом производится мульчирователем сетчатым навесным МСН-1. Этот мульчирователь имеет сетчатый барабан шириной 1 м и емкостью 1 м^3, приводимый во вращение от опорно-приводных колес через цепную передачу. Полное освобождение барабана от субстрата происходит через 250-350 м.

Для агротехнического ухода за растениями широко применяется культиватор комбинированный ККП-1,5. Этот культиватор монтируется на самоходное шасси Т-16М и представляет собой поперечный брус с рабочими органами. Культиватор имеет набор сменных рабочих органов, включающий игольчатые диски, узкозахватные полольные лапы, долотообразные зубья и подкормочные ножи, кроме того, по следу колес шасси установлены универсальные стрельчатые лапы. Культиватор снабжен туковыми банками для внесения минеральных удобрений.

Для подрезки корней растений при выращивании укрупненных сеянцев без перешколивания применяется оборудование для их подрезки ОПК-1,3. Это оборудование обеспечивает подрезку как вертикальных, так и горизонтальных корней растущих сеянцев лиственных и хвойных пород. Глубина подрезки регулируется от 8 до 16 см, рабочая скорость составляет около 2 км/ч.

Выкопка посадочного материала проводится вибрационной выкопочной машиной ВМ-1,3. Особенностью конструкции этой машины является наличие активных отряхивателей с приводом от ВОМ трактора. В процессе работы пласт почвы после схода с лемеха подвергается интенсивному разрушению и отделению почвы от корней.

Затраты труда на выращивание 1000 шт. укрупненных сеянцев ели по предлагаемой технологии на базе комплекса машин снижаются в 3 раза, при существенном улучшении качества посадочного материала.

Комплекс машин, применяемый при создании лесных культур на вырубках по эколого-ресурсосберегающей технологии, включает следующие средства механизации.

Полосная расчистка вырубок от пней и порубочных остатков проводится орудием для расчистки вырубок ОРВ-1,5. Это орудие представляет собой клинообразный отвал, передняя часть которого выполнена поворотной и имеет вертикальный нож для раскалывания пней, а боковые поверхности отвалов снабжены горизонтальными ножами для срезания поросли. Ширина захвата орудия составляет 1,5 м.

Для обработки почвы под посадку лесных культур после полосной расчистки вырубок применяется плуг дисковый ПДВ-1,5. Плуг имеет два лево- и правообрабатывающих дисковых корпуса. В процессе работы формируется микроповышение высотой до 15 см, шириной 1,5 м. и глубиной рыхления почвы 12…18 см.

Посадка саженцев высотой до 60 см на полосах после их расчистки проводится лесопосадочной машиной МЛК-1. Машина снабжена резиновыми посадочными дисками. Глубина хода сошника до 40 см. Шаг посадки 1-1,5 м.

Для агротехнического ухода за культурами, созданными на вырубках по бороздам и полосам, а также для осветления культур путем уничтожения в междурядьях нежелательной древесной растительности применяется каток универсальный лесной КУЛ-2. Каток состоит из двух ножевых барабанов. Общая ширина захвата составляет 2,2 м. Степень уничтожения нежелательной растительности достигает 90 %.

ЗАКЛЮЧЕНИЕ

Данные по оценке эколого-ресурсосберегающей технологии и средств механизации подтверждают ее высокую эффективность. Приживаемость 3-летних культур, созданных на вырубках достигает 95%.

Таким образом, предложенные средства механизации обеспечивают минимальное воздействие на естественное сложение верхнего слоя почвы; создают оптимальные условия почвенного питания культивируемых древесных пород; сохраняют экологию вырубок; снижают затраты материально-технических и финансовых ресурсов.

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ИЗСЛЕДВАНЕ НА ФАКТОРИТЕ, КОИТО ОКАЗВАТ ВЛИЯНИЕ ВЪРХУ ПАЗАРА НА ШИРОКОЛИСТНИ ДЪРВА В БЪЛГАРИЯ

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Резюме

Изследвани са зависимостите между факторите на търсенето и предлагането на широколистните дърва, продавани от горски камионен път през 2004 г. от държавния горски фонд. Главният извод е, че производителите и купувачите са вземали решенията си въз основа на пределната полезност на широколистните дърва.

INVESTIGATION OF THE FACTORS INFLUENCING THE MARKET OF BROADLEAVED PILED WOOD IN BULGARIA

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Dependences between supply and demand factors and broadleaved piled wood, sold from forest road in 2004 by Bulgarian State Forests, are investigated. The main conclusion drawn from research is that producers and customers made their decisions on the basis of broadleaved piled wood's marginal utility

In 2004 the incomes of National Forestry Board (NUG) from sales of broadleaved piled wood on forest road reached 31 382 808 BGN (19 862 536 USD) [1]. This sum is nearly 30 % of National Forestry Board total revenues. The importance of broadleaved piled wood, sold from forest road, is obvious for state forest administration's financial policy. Because of that the object of this research are the factors that influence supply and demand of broadleaved piled wood, sold from forest road in 2004 by the Bulgarian State Forests.

Methodology

First: Supply is an economic category, which expresses complicated links and relations between market and those economic subjects, whose goal is the production and sale of goods and services. The function is comprised by many factors and can be presented in the following way:

Qs = f (P, R, Pa, T), where:

Qs – quantity from a product supplied to market; P – product's price; R – prices of row materials; Pa – prices of alternative products; T – technology.

Second: Demand is an economic category, which expresses relation between prices and quantity of goods and services as a result of the realized solvent necessities on the market. The function is also comprised by many factors, i.e.:

Qd = f (P, I, Pa, T, N), where:

Qd – quantity from a product demanded on market; P – product's price; I – customers' income; Pa – prices of alternative products; T – wishes of customers; N – number of population.

Third: Based on the presented above demand and supply functions the following tasks are put for resolution:

- By means of statistical analysis define functions, which describe most properly demand and supply of broadleaved piled wood.
- Evaluate the influence of each factor on the supply function of broadleaved piled wood.
- Evaluate the influence of each factor on the demand function of broadleaved piled wood.

Statistical measurement of dependences

According to Mishev, Tzvetkov (1998) the measurement of correlation between the components of two samples is connected with the solution of two consecutive tasks. The first one is related to the dependence form modeling. Through it a quantitative characteristic about the influence of independent variable (x) on dependent variable (y) is obtained. **The second** task is connected with the measurement of closeness of correlative dependence by means of a correlative analysis [3].

The coefficient of determination is the statistical characteristic of correlation. The higher its value, the better the chosen regression model describes the investigated connection. The coefficient of determination is calculated by the formula:

$r^2 = \frac{\sigma_y^2 - s_y^2}{\sigma_y^2} = 1 - \frac{s_y^2}{\sigma_y^2}$ (1), where r^2 – coefficient of determination; σ_y^2 - common dispersion, s_y^2 - standard error of estimation [3].

Usually the coefficient of determination is written in percentages. Then it points out the variations in dependent variable (y) as a consequence of independent variable (x) influence. After computing a root square from the coefficient of determination, the coefficient of correlation is established [3].

$r = \sqrt{1 - \frac{s_\eta^2}{\sigma_\eta^2}}$ (2). The last one characterizes the extent of dependence between the variables. For its estimation, table 1 is used.

Table 1. Defining the extent of dependence [3]

Value of coefficient of correlation	Extent of dependence
to 0.3	poor
over 0.3 to 0.5	moderate
over 0.5 to 0.7	significant
over 0.7 to 0.9	high
over 0.9	very high

Evaluation of dependences between the variables which define supply function of piled wood from forest road

As basic factors predetermining supply of piled wood from forest road[1] can be outlined:

- Value of timber harvesting costs[2] (R);

Reported values[3] of broadleaved piled wood sold on road and prices of alternative products (Pa). In this research as alternative prices are used reported values of standing broadleaved piled wood[4] sold from territories of 16 Regional Forestry Boards.

[1] In the following exposition under supply of broadleaved piled wood we will understand broadleaved piled wood sold from forest road.

[2] The value of timber harvesting costs (BGN/m^3) is computed after dividing total timber harvesting cost (BGN) by broadleaved piled wood's quantity (m^3).

[3] We introduce category "reported value" as it is different from the category "market price". The category "reported value" is calculated after dividing revenues (BGN) from sale of broadleaved piled wood on forest road by broadleaved piled wood's quantity (m^3).

[4] Because of the reasons pointed in footnote No 3 we use again the category "reported value", but this time regarding piled wood sold as a standing timber.

Table 2. Factors of supply

Regional Forestry Boards (RUG)	Number of un-employed	Sale of broadleaved piled wood from forest road			Reported value of standing piled wood, BGN/м^3
		Realized quantity, м^3	Reported value BGN/м^3	Value of timber harvesting costs BGN/м^3	
1. Berkovitza	47 413	29587	42.3	20.2	7.56
2. Blagoevgrad	14 833	32879	35	20.04	9.33
3. Burgas	17 945	93621	39.81	15.8	9.66
4. Varna	36 800	112012	32.93	12.5	11.47
5. V. Tarnovo	24 096	56887	36.96	14.13	10.87
6. Kardzhali	28 495	26638	42.74	21.23	8.68
7. Kyustendil	16 022	31474	43.75	24.54	3.72
8. Lovech	35 077	36082	39.77	24.7	7.43
9. Pazardzhik	23 968	7458	44.81	21.25	12.38
10. Plovdiv	34 365	29628	33.23	18.97	8.46
11. Russe	41 976	118914	26.53	10.77	8.38
12. Sliven	29 735	130886	37.24	20.41	5.27
13. Smolyan	12 219	922	48.21	29.92	6.38
14. Sofia	32 990	35556	39.85	19.65	8.68
15. Stara Zagora	18 694	48183	43.94	22.48	8.01
16. Shumen	35 938	62007	32.49	12.6	8.64
TOTAL	**450 566**	**852733**			

Sources: National Forestry Board, Statistical Yearbook 2005

Dependence between supply of broadleaved piled wood from forest road and value of timber harvesting costs

In the investigated dependence broadleaved piled wood sold from storage is dependent variable (y) while timber harvesting costs are independent variable (x). From the point diagram of the variables is chosen the compound regression model: $\hat{y} = 1020319.(0,841^{x})$, where $\hat{y}$ is broadleaved piled wood under influence only of timber harvesting costs (x). The chosen model is verified by means of F – test [2].

$$Fem = \frac{\sigma_{\hat{y}}^{2} /(p-1)}{s_y /(n-p)}$$ (3), where: $\sigma_{\hat{y}}^{2}$ - explicable dispersion; n – scope of the sample, i.e.

16 Regional Forestry Boards, p – number of evaluated model's parameters.

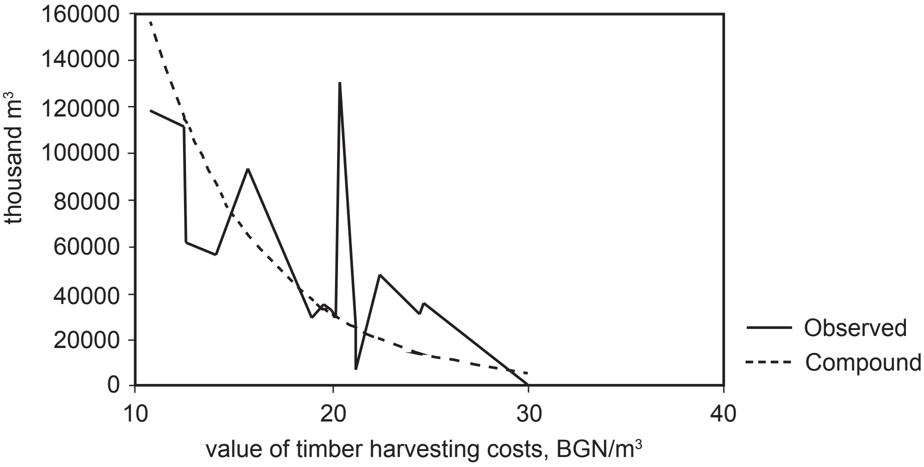
$$Fem = \frac{\sigma_{\hat{y}}^{2} /(p-1)}{s_y /(n-p)} = \frac{11.89/(2-1)}{10.08/(16-2)} = \frac{11.89}{0.72} = 16.50$$

The theoretical characteristic (F_T) is taken from the table of F – distribution with critical level $\alpha = 0.05$, and extents of freedom v = p-1 = 2-1=1 and w = 16-2=14, $F_T = 4.60$. When $F_{EM} > F_T$, the zero hypothesis (Ho) is rejected and the alternative hypothesis is accepted (H_1). In this case $F_{EM} = 16.50$ and the alternative hypothesis is accepted. This means that the compound regression model describes the dependence correctly.

The coefficient of determination is $r^2 = 0.541$. It is bigger than the coefficients of determination of other regression models[1] (verified with F – test): LIN 0.450; LOG 0.464; INV 0.462; QUA 0.459; CUB 0.476; POW 0.463; S 0.389; GRO 0.540; EXP 0.540; LGS 0.540. Because of this it is accepted that compound regression model describes best the correlation as 54.1 % in the variation of broadleaved piled wood

[1] In current research are verified next models: Linear, Logarithmic, Inverse, Quadratic, Cubic, Compound, Power, S, Growth, Exponential, Logistic.

supplied was due to changes in timber harvesting costs. At the same time the coefficient of correlation (r = 0.735) defines the dependence as high (see Table 1). Graphically this dependence is presented on Fig. 1. The curve is similar to the demand law, i.e.: when timber harvesting costs are decreasing there is an increase in broadleaved piled wood supply. This is natural as many producers are stimulated by the low production costs to harvest and supply piled wood. At the same time in the point of average costs (15 BGN/m^3) the shape of the curve suggests high angular coefficient. The low cost price of broadleaved piled wood sold on road can be changed because of increase in the value for the owner (value of the standing piled wood). According to us, the reported values permit nearly two times increase in the stumpage price of broadleaved piled wood, which is obvious from the data in Table 2.



Sources: National Forestry Board

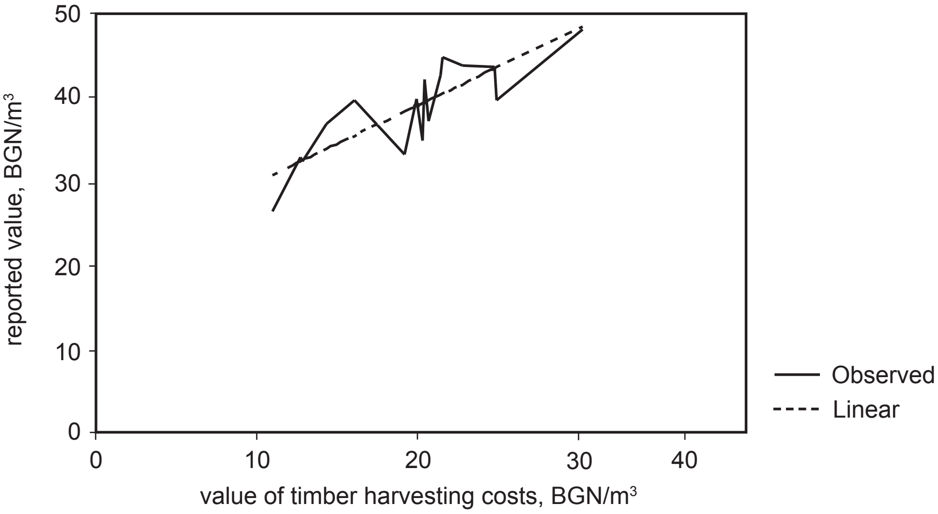
Fig. 1. Dependence between value of timber harvesting costs and supply of broadleaved piled wood from forest road

Because of the high correlative dependence between the supply of broadleaved piled wood from forest road and the value of timber harvesting costs of high interest for research is the correlation between timber harvesting costs and reported value of broadleaved piled wood. If the curve is similar to the supply law and its angle coefficient is high there will be another confirmation of the conclusions, which were made above.

Dependence between reported value of piled wood sold from forest road and value of timber harvesting costs

It is established that the linear regression model describes best the dependence between the variables: $\hat{y} = 20{,}985 + 0{,}917.x$, where $\hat{y}$ is reported value of broadleaved piled wood sold from road under influence of independent variable timber harvesting costs (x). The coefficient of determination (r^2= 0.686) means that 68.6 % in the changes of reported value were due to changes in the value of production costs. The coefficient of regression before x (value of timber harvesting costs) means that reported value increased with 0.92 BGN when timber harvesting costs rised with 1 BGN. **The coefficient of correlation r = 0.82 defines the dependence between variables as high.** Graphically this is presented on Fig. 2.

The curve expresses a real relation, which has been imposed as a practice in our forest sector namely: the decisions for participation in the market of piled wood are taken when a rate of profit is 100 % on the basis of timber harvesting cost. At the same time the value of the free member of the linear regression model (20.985) means that hypothetically when the timber harvesting costs (x) are zero, the reported value starts from 20,985. The last one confirms the conclusion about the necessity of increasing the share of the forest owner.

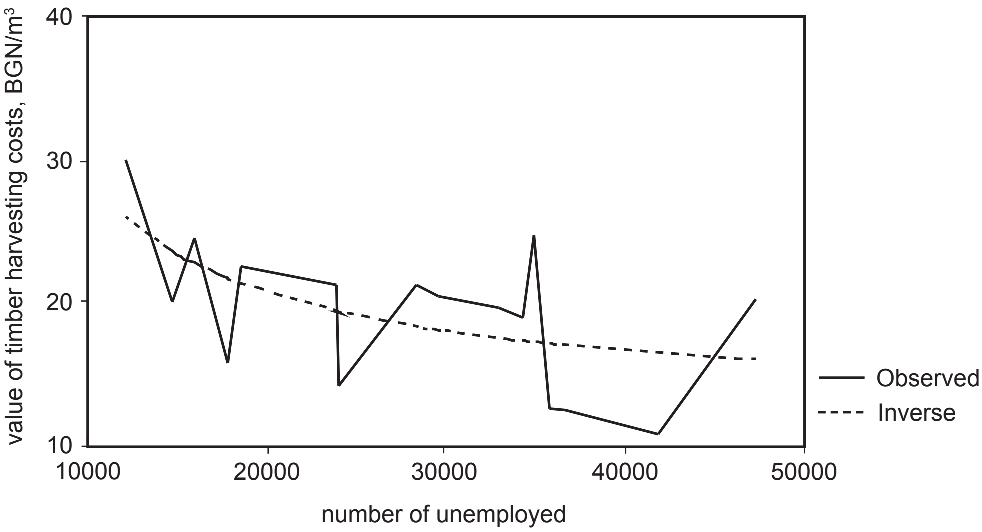


Sources: National Forestry Board

Fig. 2. Dependence between the value of timber harvesting costs and the reported value of broadleaved piled wood sold from forest road

Dependence between value of timber harvesting costs and number of unemployed on the territory of 16 RUG

The mechanization in Bulgaria is not on a high level. Forest net road is not maintained and animals are used for hauling. Because of that, it is logically to be presumed that the labour market has an influence on timber harvesting costs. The best explanation of this connection is given with the inverse regression model: $\hat{y} = 12{,}58 + (163322 / x)$, where $\hat{y}$ is value of timber harvesting costs under the influence of factor - number of unemployed (x). The coefficient of determination is $r^2 = 0.323$, i.e. 32.3 % in the variation of costs can be explained with unemployment. The coefficient of correlation ($r = 0.57$) defines the dependence between the variables as significant (see Table 1). Graphically the dependence is presented on Fig. 3.



Sources: National Forestry Board, Statistical Yearbook 2005

Fig. 3. Dependence between the value of timber harvesting costs and the number of unemployed

Dependence between quantity of broadleaved piled wood supplied from forest road and prices of alternative products, in private reported value of broadleaved piled wood sold as standing timber

By the shape of the correlative field it is not possible to choose a regression model. Through the F-test eleven models[6] are checked for adequacy. No one of them is suitable; therefore the reported value of standing broadleaved piled wood does not influence the broadleaved piled wood supply from forest road.

Evaluation of dependences between variables which define the demand function of piled wood from road

The main factors predetermining broadleaved piled wood demand (Qd)[7] from road are:

- Reported value of broadleaved piled wood sold from forest road on territory of 16 Regional Forestry Boards;
- Number of population;
- Average annual income on head of household.

Table 3. Factors of demand

Regional Forestry Boards	Number of citizens	Demanded quantity broadleaved piled wood from road, m^3	Reported value, BGN/m^3	Average annual income per head of household, BGN
1. Berkovitza	503 065	29 587	42.3	2466
2. Blagoevgrad	334 907	32 879	35	2599
3. Burgas	418 925	93 621	39.81	2450
4. Varna	665 285	112 012	32.93	2322
5. V. Tarnovo	423 138	56 887	36.96	2985
6. Kardzhali	428 213	26 638	42.74	2273
7. Kyustendil	296 719	31 474	43.75	2599
8. Lovech	471 639	36 082	39.77	2496
9. Pazardzhik	300 062	7458	44.81	2273
10. Plovdiv	709 861	29 628	33.23	2273
11. Russe	535 617	118 914	26.53	2322
12. Sliven	358 911	130 886	37.24	2450
13. Smolyan	133 015	922	48.21	2273
14. Sofia	1 483 189	35 556	39.85	2599
15. Stara Zagora	362 090	48 183	43.94	2273
16. Shumen	336 383	62 007	32.49	2322
TOTAL	7 761 019	852 733		

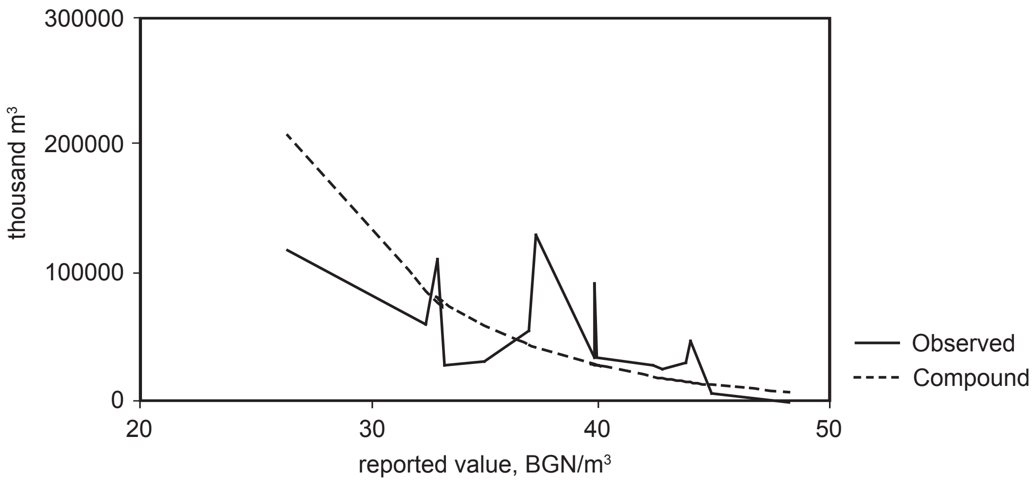
Sources: National Forestry Board, Statistical Yearbook 2005

Dependence between broadleaved piled wood demand and their reported value

The dependence is described best with the compound regression model: $\hat{y} = 9920360.(0,86)^x$. The coefficient of determination $r^2 = 0.465$ means that 46.5 % in changes of broadleaved piled wood demand (y) can be explained with their reported value (x). The coefficient of correlation r = 0.68 defines the dependence as significant. Graphically it is shown on Fig. 4.

[6] Linear, Logarithmic, Inverse, Quadratic, Cubic, Compound, Power, S, Growth, Exponential, Logistic

[7] Because of lack of information about broadleaved piled wood demand from road is accepted that the sold quantity coincides with demanded, i.e. the market of broadleaved piled wood from forest road is in equilibrium.



Sources: National Forestry Board

Fig. 4. Dependence between the demanded quantity broadleaved piled wood from forest road and their market price

Dependence between demanded quantity broadleaved piled wood from forest road and the number of citizens

From correlative field's shape it is not possible to be chosen a regression model. Through F-test are checked for adequacy eleven models (LIN, LOG, INV , QUA, CUB, COM, POW, S, GRO, EXP, LGS). No one of them is suitable therefore there are not dependence between demand of piled wood and citizens' number.

Dependence between demanded quantity broadleaved piled wood from forest road and average annual income per head of household

From the correlative field's shape it is not possible to choose a regression model. Through F-test the models pointed above are checked for adequacy. No one of them is suitable, therefore there is not dependence between the broadleaved piled wood demand and the average annual income.

Summary

- The supply of deciduous piled wood from forest road is predetermined by the value of timber harvesting costs. Nearly 54 % in the changes of broadleaved piled wood supply are due to variation in production costs. The extent of dependence is high (r = 0.737). The compound function is descending. When timber harvesting costs increase, supply of deciduous piled wood slopes down.
- There is a high correlation (r = 0.82) between broadleaved piled wood's reported values and timber harvesting costs' value. The linear function which describes this connection is growing. When value of timber harvesting costs increases with 1 BGN broadleaved piled wood's reported value increases with 0.92 BGN.
- There is a significant dependence (r = 0.57) between timber harvesting costs's value and the number of unemployed. Nearly 32 % in the changes of timber harvesting costs are explained with the unemployment. The inverse function, which describes this relation, is descending. Its slope could be outlined better if the hidden unemployment was taken into account.
- Broadleaved piled wood supply from forest road does not depend on reported values of standing piled wood, which means that there is reserve for their increase with nearly 2 times.
- There is a significant relation (r = 0.68) between broadleaved piled wood demand and their reported value. Nearly 46.5 % in variation of broadleaved piled wood demand is due to changes in their reported value. The compound function, which describes the dependence, is decreasing. With the rise in the reported value, demand decreases.
- Demand of broadleaved piled wood from forest road does not depend on number of population and its income.

From the summaries above, the main conclusion is drawn: the average market value of broadleaved piled wood on the territories of all Regional Forestry Boards was formed as a relation between the production costs and the broadleaved piled wood's utility. The utility was defined by piled wood demand both on regional markets and national market. Production costs were formed as a consequence of competition between timber harvesting companies. Values derived from this market model make us believe that customers were making their decisions on the basis of broadleaved piled wood's marginal utility, whereas the producers were making their decisions on the basis of marginal costs. The last was proven by means of the linear regression model: $\hat{y} = 20{,}985 + 0{,}917.x$, where on 1 BGN costs corresponded 0.92 BGN increase in the reported value. Something more, from the approximate equality between the marginal costs and the marginal increse in the reported value follows that the supply of broadleaved piled wood from forest road in 2004 was done in conditions similar to those of free competition. In this situation, to some extent, the forest owner in the face of the state is not compensated on the account of the entrepreneurs, who are benefited. The market shows that entrepreneurs can bear nearly two times increase in the price for the right of use if the prices of broadleaved piled wood on road in 2004 stay on the same level.

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ЛОГИСТИЧНО ПЛАНИРАНЕ НА ГОРСКАТА БИОМАСА ЗА ЕНЕРГИЙНИ ЦЕЛИ ЧРЕЗ ПРОСТРАНСТВЕН АНАЛИЗ

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Пространственият анализ е многообещаващо средство за проучване на ресурсите от горска биомаса за добиване на енергия и за вземане на логистични решения.

Проучването трябва да включва терена, пътната мрежа и характеристиката на горските насаждения, т.е. главните характеристики на местността, които са променливи в пространството и времето. Те определят добивните разходи, тъй като разходите са пряко свързани с разположението на биомасата, състоянието на пътната мрежа и машинната й достъпност.

За да се оцени възможният добив на горска биомаса (дърводобивен отпад и непродаваеми трупи) и добивните им разходи, беше извършен пространствен анализ по GIS-методика.

Тъй като GIS методиката първоначално беше развита за растерен анализ, за целите на настоящата работа впоследствие беше доразвита за векторен анализ, с цел да се повиши качеството на данните за транспортното разстояние.

За разпределяне на доставките на биомаса по басейни беше развита първа версия на системата за вземане на решения, която държи сметка за пътната мрежа и на количеството на достъпната суровина.

PLANNING FOREST BIOMASS SUPPLY CHAIN FOR ENERGETIC USE THROUGH SITE ANALYSIS

Raffaele Cavalli, Beatrice Emer, Stefano Grigolato, Italy

Abstract

To support investigations on availability of forest biomass for energetic use and consequently to support decisions on the supply chain logistic, a spatial analysis study should be an interesting approach.

The study could consider terrain, road network and forest stand characteristics, as these main site features change in space and in time. In fact, consequently these factors influence supply cost that are straight connected to biomass localisation, quality of road network and machine accessibility.

In order to evaluate the feasibility of supplying forest biomass (logging residue or un-merchantable logs) and consequently to estimate forest biomass amount and its supplying cost, a site analysis was carried out by GIS methodology.

Since GIS methodology was previously developed for supporting raster analysis, in this case study a network study based on vector analysis were consequently developed in order increase the transport supply distance data quality.

With the aim to define a forest biomass for energetic use supply basin a first rough Decision Support System was drafted considering road network and amount of logging residues available at forest roadside.

INTRODUCTION

Forests and forestry management can contribute to mitigate climate changes towards substitution of fossil fuels and towards sequestration of carbon. The conclusion of a multi-disciplinary working group of the European Commission (European Commission, 2005) stated that wood will “play a major role in mitigation of climate change”. Consequently, European interest on forest biomass is growing.

Due to its particular characteristics and its spatial distribution, forest biomass for energetic purpose is a complex subject. Its quantification, supply planning and conversion in solid biofuels require deep investigations.

Considering that biomass sources such as logging residues or sawmill residues are more often than fossil fuels depended on local conditions, logistic has a fundamental role in order to develop the supply chain. Therefore, the cost of forest biomass supply strongly depends on operating environments in which available biomass is located.

Comparing the environment conditions of southern Europe and especially of its alpine area to the environment conditions of Nordic countries, recovering of logging residues marks to be not so cost-effective and surely not high productive. As well, considering the supply chain at regional scale, the low productive working system of recovering logging residues results in many Southern countries secondary if it is compared to other woody biomass supply chains for energetic use (Grigolato et al., 2005; Gronalt and Rauch, 2005; Sanchez et al., 2005).

By considering that production of forest wood biofuels follows a logical progression from forest to heating or cogeneration heating plants (CHP) (Richardson et al., 2002), basic considerations are needed. Wood as local energetic resource is geographically constrained in part by biomass feedstock and in part by energy demands. For this reasons, geographical dispersion, transporting and working systems play an important role in developing forest biomass supply logistic. In the same time not only supply logistic and all the related machines can influence the final productivity, but other complicating factors has to be considered such as seasonally availability, forest and public road density, terrain characteristics (steepness and ground roughness) and moisture contents of biomass.

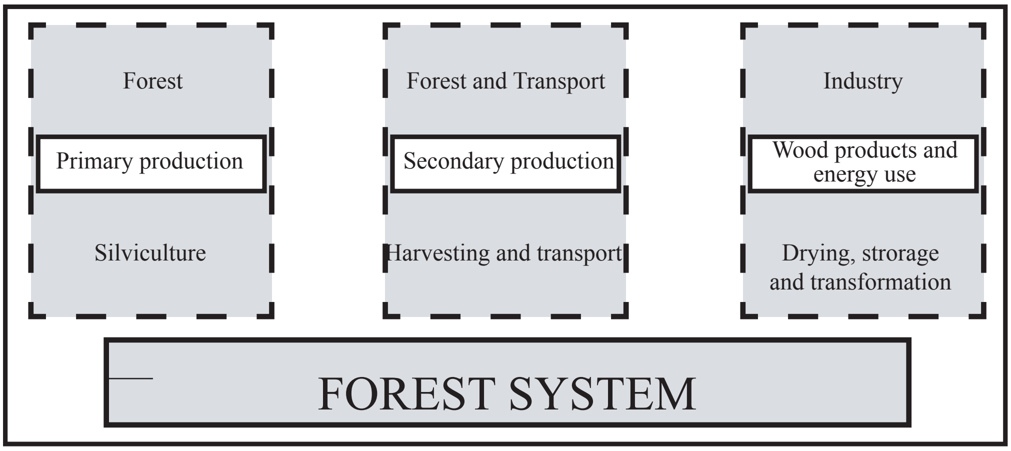

Fig. 1. Forest System (derived from Richardson, 2002)

Present developed research method is an empirical quantitative and in part qualitative analysis on available forest biomass for energy purpose. In particular woody chips from logging residues were investigated.

Objective

The main task is to develop a methodology to define the availability of logging residues for woody biofuel production in alpine condition.

By a further cost calculation, working site cost, productivity and transport distance are involved in order to define and optimize chips supply logistic.

Subsequently a decision support model is drafted in order to evaluate the feasibility of a heating plant by considering the availability of local forest resources (in this model logging residues), local harvesting operational level and local heating district system demand.

MATERIALS AND METHODS

Study area

Logging residues availability and the practicability of a woody biomass local supply chain were investigated in the area of Baselga highland (Fig. 2). The Baselga district is covered by 5 400 ha of high forest which growing stock corresponds to 1.16 M m^3 with an annual prescribed yield of 11 800 m^3 of wood. The real felled amount corresponds to 7000 m^3. This depends mainly by roundwood price that is mainly connected to the combination with periodical fluctuations between local, Austrian and German market.

Norway spruce (Picea excelsa Link) is the predominant tree species, European Larch (Larix decisua L.), Scotch pine (Pinus sylvestis L.) and Silver fir (Abies alba L.) are commonly spread. Beech (Fagus sylvatica L.) and other broadleaved are rare because of the continental climate and men's action, which have always favoured spruce for its most valuable timber.

Productive forest has both an even aged structure and uneven aged, even if irregular stands are mostly limited to the higher elevation. The management type on the productive forest can be clear strip system (around 5000 m^2 with a width from 1/3 to 1/2 of the stand height) or patch and group cutting. Selection cutting is also present but usually is limited to the most irregular stands in higher elevation. For what concerns forest ownership, in Baselga district forests are mainly public owned, seeing as the public forest land is the 80% of the total. The public forest is owned by different institutions, which forest plans present different prescribed yield and different amount of firewood assigned as rights of wood use (about 1400 m^3/year).

It is important to highlight that public forest of Baselga highland, as in many other part of Italy suffers for fragmentation of forest estate both in area and allowable cut. This effects timber supply chain and consequently logging residues supply logistic. In fact, the prescribed yield as wood rights can influence the availability of logging residues both as woody biomass amount and as supply logistic since available forest biomass could be enough but located in area too much far from heating plant sites and so not economically suitable. For this reason is recommended to know both amount of residues as their location.

Consequently, by integrating data from field surveys, Master Forest Plan and Local Forest Plans and by interviewing local logging companies and local forest service operators, a GIS based model was drafted and thus developed. Consequently, theoretical, technological and economical quantification of logging residues were estimated.

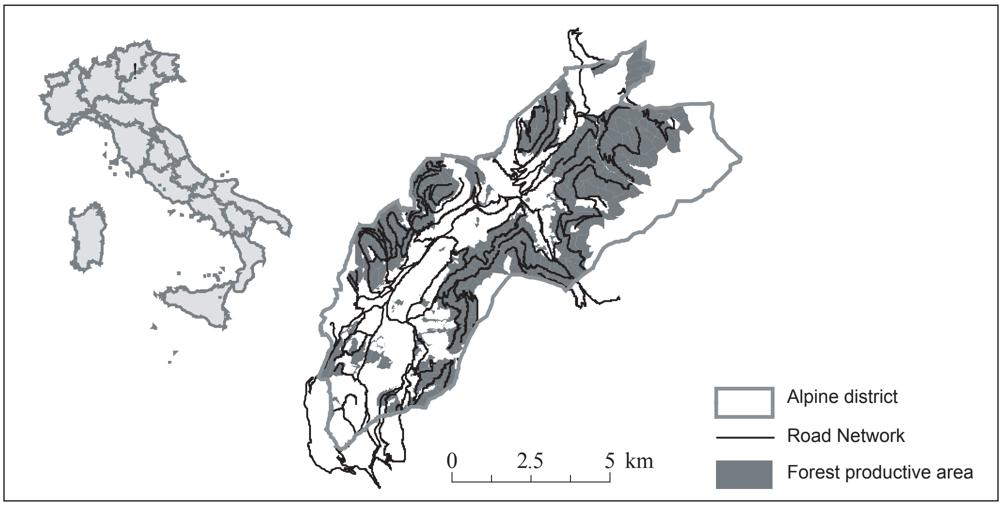

Fig. 2. Baselga district and its forest productive area

Logging residues quantifications

Using GIS methodology for understanding geographic context of the wood biomass accessibility is the first step in estimating the potential stock available for an energetic use. At a general level, this methodology is based on integrating geographical data, derived from forest management plans and specific stand volume data (Stand Volume Table, SVT), with administrative geographical data. local public and forest road network, logging systems and local rules on forest biomass removal.

Different GIS approaches to quantify logging residues or agriculture residues for energetic use were developed during the last few years (Graham et al., 2000; Rossi et al, 2001, Voivontas et al, 2001, Van Belle et al., 2003; Ranta, 2002, Bernetti and Fagarazzi, 2003, Grigolato et al, 2005). Often the precedent GIS methodologies developed were often concentrated on evaluating the potential availability of forest biomass. Quality aspects were also observed even if theses analysis remained at a general level of investigation.

In the present work, the identification and estimation of potential biomass is integrated by theoretical and technical quantifications.

Theoretical quantification: it is a based on an simple series of calculation to determine the total amount of logging residues and/or un-merchantable logs that could be use for local energetic requirements. Theoretical quantification identifies the maximum potential offered by forest area without any consideration of the logging and extraction system used, spatial relationship like distance, adjacency and supply cost. Rights of forest use are instead considered. The result will be identified as Potential Wood Fuel Resource (PWFR).

Calculation of PWFR is based on gaining data from the local forest management plans database and volumetric tables (Table 1). The main GIS algorithmic for logging residues calculation was based on the following formula:

$$LR_t = \sum_{i=1}^{n} SV_{sp} \times \left(B_{sp} + SL_{sp} + BT_{sp}\right)$$

where

LR_t = logging residue, m^3

SV_{sp} = stem volume, m^3

B_{sp} = bark, %

SL_{sp} = sawing loss, %

BT_{sp} = branches and tops, %

$$LR_{t\text{-}cml} = \left(\sum_{i=1}^{n} SV_{sp} \times \left(B_{sp} + SL_{sp} + BT_{sp}\right)\right) \times cf$$

where

$LR_{t\text{-}cml}$ = logging residues, m^3 loose

cf = volume coeficient factor (2.5 - 3.0)

Table 1. Percentage of logging residues specific for each tree species (sp)

Logging residue		Tree Species					
		Picea abies	Abies alba	Larix decidua	Pinus nigra	Pinus sylvestris	Pinus cembra
Bark on SV	%	10	10	20	15	15	15
Sawing loss on SV	%	5	5	5	5	5	5
Branches and tops on SV	%	14	14	14	14	14	14
Total on SV	%	29	29	39	34	34	34

Results were explained in loose cubic meter (m^3_{loose}) as commonly used for measuring wood chips. Conversion factors from solid cubic meter to loose cubic meter depends on chips size and therefore chipping process and machine. The size of chips is related to wood density, growth-ring orientation, moisture content and chipper cutting system (drum or knife cutting system). In this context a conversion factor (cf) of 2.7 was applied.

Technical quantification: it is evaluated according to extraction systems. Where trees could technically be extracted by skidding with tractors and winch, skidded trees are considered delimbed, cross-cut and bucked (Cut to Length System, system A); as an alternative, where trees technically could be extracted with cable system, consequently, they are supposed to be topped and limbed at roadside by processor (Full Tree, System B). Only system B was considered useful to heap logging residues at roadside and consequently considered useful for energetic request (Cavalli et al, 2003; Mao and Spinelli, 2004). Technically, System B could support biomass supplying chain from forest. as all logging cost and extraction cost can be supported by commercial assortments.

For defining area suitable for system A or system B a GIS methodology was developed. The specific site analysis was supported by field surveys and specific geodatabase. Considering that steepness of the topography and the fragmented nature of the woodland influence logging methods, a GIS based investigation become a fine tool for mapping forest area according to one system rather than the another one.

GIS elaborations were based on logging system characteristics and limits as reported on Table 2:

Table 2. extraction system characteristics that were considered in GIS application

System	Felling	Hauling	Extraction distance		Extraction slope	
			down hill	up hill	up hill	down hill
			m	m	%	%
System A	manual	CtL	50	50	35	25
System B	manual	FT	0 – 1000	0 – 1000	100	100

In addition, taking into account that logging systems and logging methods depend on terrain slope, terrain aspect and road network characteristics, a first elaboration was based on necessary conversion analyses in order to carry out geographically distributed fundamental factors and organised them into a geodatabase.

Once forest area was characterised according to the most suitable extraction system, theoretical logging residues amount layer (cell grid 20x20m) was overlaid to the extraction system layer. In this way technical logging residues amount was evaluated (Fig. 3).

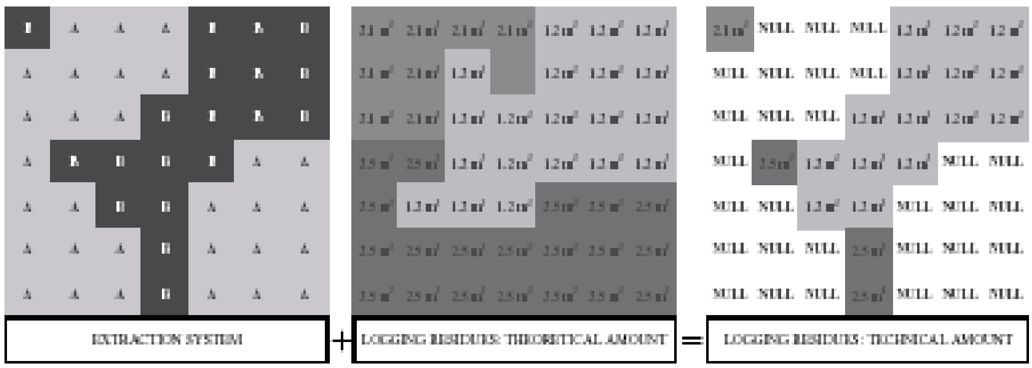

Fig. 3. Grid calculation on logging residues technical quantification

Supply basin

By considering extraction systems and road network characteristics and density, a geometric network study was developed in order to define a logging residues supply basin.

A geometric network study was considered the most appropriate tool to define supply basin edges in according to effective logging residues processing (chipping) and transporting cost. As a result, forest road network was represented by edges and junctions. Edges are connected by junctions and therefore flows (logging residues, chips, logs) can be transferred from one edge to another edge.

Once landings have been identified in relation to extraction area type (System A or System B) and in relation to primary and secondary forest road network, a geometric network was build by Arc-GIS™ ver.8.2. Network was developed by connecting different features: landings, primary or secondary forest road network, and biomass terminal or heating plant. The network connectivity was obtained by geometric coincidence. Consequently the geometric network, or logical network, presented sources and sinks all together topologically connected. In this way all the movements through road network are well-defined. Consequently in according to its steepness and width, different weights, I was possible to highlight transporting barriers and critical point along the same road network.

Using geometric road network allows getting ahead of straight-line distance or winding factor distance calculation approaches. In fact, as the project regarded a small alpine basin, it was considered not useful to calculate distance by approximate methods.

A supply cost model was successively developed to determine supply (chipping and transporting) costs. It was based on a calculation spreadsheet and it was set in order to import results from the geometric network. The model was developed in order to allow for multiple what-if scenario explorations.

The model, called with the following acronym Bio.Su.M (Biofuel Supply Model), covers the costs of all the single operations and processes between landings and terminals or heating plants, including costs for loading and unloading, chipping of logging residues and transportation.

Resulting supply costs were well geographically defined as computations are based on road network between landings, terminals and logging residues availability within forest.

The end-user can define different scenarios by defining maximum transporting distance between landings and heating plants (from 1 to 20 km), and minimum economic volume of logging residues required at a landing (user defined up to 15 m^3_{loose}).

The combination of volume of available logging residues at a landing and distance between landings sites and heating plant define number of landings available for calculation of final cost.

Supply operations and process cost calculations were based on an algorithm derived on contractors data and on field surveys (Mao and Spinelli, 2004; Grigolato and Raise, 2005). Different inputs (Table 3), subdivided in logging residues, chipping worksite and transporting, were considered in order to model scenarios (Table 4) in according to logging residues and supply chain characteristics.

Table 3. Model inputs and their value range

Features	Unit	Value		Note
	-	minimum	maximum	
<u>Basic input</u>				
logging residues at landing	m^3	15	∞	minimum amount required
supply distance	m	1000	20 000	maximum supply distance
<u>Logging residues</u>				
moisture content	%	0	100	on dry weight
heat net value	kcal/kg	3700	4700	depending on the tree species
basic density	kg/m^3	380	560	depending on the tree specie
coefficient m^3/m^3_{loose}	-	2.5	3.0	depending on chips size
<u>Chipping worksite</u>				
hourly cost	€/h	65	210	based on contractor tariff
productivity	m^3_{loose}/h	15	70	based on field surveys
<u>Transporting</u>				
tractor/trailer cost	€/h	45	100	based on contractor tariff
average speed	km/h	5	40	based on field surveys

The following steps concerned to define the supply area in order to evidence the logging residues that economically could be supplied at the gate of the heating plant.

On Bio.Su.M it is possible to screen all the landings that can provide chips under a cost settled by the user. In this way only the woody biomass considered under a fixed cost will be summed and reported.

The final result will consider all the energy held at a heating plant as chips and consequently compare cost value of chips (€/MJ) with cost value of other fuel (diesel fuel and methane). Exporting the results of the Bio.Su.M model into a suitable format for a following analysis in a GIS environment, a new spatial analysis can be created. As final step, in fact, it can be possible to highlight the landings resulting suitable to be sources of logging residues and consequently evidence the economical limit of the supply basin. After that, summing the relative logging residues as volume of chips, it can be possible to estimate the economical amount of chips at the heating plant.

Table 4. scenarios setting applied to the model

		scenario 1	scenario 2	scenario 3
Chipper power	kW	314	270	80
Chipping	€/m^3_{loose}	4.5	4.0	3.6
Chipping hourly cost	€/h	180	160	65
Vehicle	-	truck	truck	tractor & trailer
Transport	€/m^3_{loose} per km	0.19	0.17	0.15
Transport hourly cost	€/h	50	40	38

RESULTS AND DISCUSSION

Logging residues quantification: theoretical and technical amount

Considered the methodology presented, the total amount of logging residues available for energetic purpose inside the Baselga highland was calculated. On first the results presented the woody biomass recoverable by mature cut subdivided into forest plan area (Table 5).

Then, the technical quantification was based on evaluating harvesting and hauling system since the amount of logging residues technical availability depends if they are located at roadside or at stump area. In the following calculations, only the logging residues located at roadside were valuated available for energetic use, therefore the alpine district was mapped according to the possibility to apply extraction of full trees (FT) by cable systems or extraction of cut to length hauling (CtL) by ground skidding systems. In fact only by extraction of FT methods (in this case whole tree extraction by medium size mobile cable system and topping and bucking at roadside by processor) there will be the possibility to pile logging residues at roadside (or at landing). In Baselga alpine district 76% of the whole forest area planed for wood production resulted suitable for FT extraction by mobile cable system. The results of calculation of technical availability of logging residues is reported on Table 6 according to the area suitable for FT logging methods and extraction methods based on cable system but also considered that trees had been partially bucked before to be extracted.

Table 5. Logging residue theoretical quantification and technical quantification according to suitable FT extraction system area

Quantification		theoretical							technical	
Forest Plan	Yield									
	-	Ar	Ab	L	Ps	Pc	Pn	Chips	FT area	Chips
	m^3	%	%	%	%	%	%	m^3_{loose}	%	m^3_{loose}
160	455		4.0		4.2	0.5	0.0	374	65	206
42	757		8.0	3.2	0.3		0.0	615	83	449
51	805		8.0	3.2	0.3		0.0	654	81	464
331	879		1.9		0.7	0.6	0.0	717	74	459
330	600		1.7		4.3	0.4	0.3	503	73	317
31	60		7.0			0.3	0.0	53	77	36
121	242		6.8		1.8	0.1	0.0	201	70	120
115	193			1.6	0.9	0.1	0.0	152	20	15
114	171		1.0			0.0	0.0	155	69	91
30	123		2.8			0.0	0.0	107	68	62
113	325		2.2			0.1	0.0	288	70	173
32	108		1.5	9.2		0.0	0.2	101	80	71
118	1732		6.1	7.6	0.6		0.0	1425	69	841
Total	**6450**	**-**	**-**	**-**	**-**	**-**	**-**	**5345**		**3304**

Quantification by geometric network: economical amount

By considering road network transport distances and minimum amount of logging residues left at the landing or roadside (15 m^3) and consequently by according to the three different scenarios (Table 6) results are presented as follows:

Table 6. Economical quantifications result according to the applied scenarios

Scenario	Technical chips	Economical chips amount	Involved landings	Run road network	Chips cost average	Energetic amount
-	m^3_{loose}	m^3_{loose}	n°	km	€ m^{-3}_{loose}	MJ
01	3381	1175	37	598	10.38	3 630 750
02	3381	1765	56	1060	10.18	5 453 850
03	3381	2744	88	1956	9.19	8 478 960

Results represent the amount of logging residues as chips that can be supplied at a cost inferior than 18 €/m^3_{loose}. The cost for supplying one loose cubic metre correspond to the average cost between all the loose cubic meter within the maximum cost that the model has assumed to be economical. The road network amount (km) is the total distance (two-way) that a truck or tractor run for transporting chips from forest to plant, while involved landings correspond to the amount of source point within the defined economic supply cost. All the results are sorted out by the supply cost model Bio.Su.M. The resulting supply cost was consequently defined geographically and over time as the computations were based on the transportation network between landings and plants and the availability of logging residues within the forest.

CONCLUSIONS

The rising interest on verifying the possibility of use forest biomass for energetic use had determined the development of different assessment approaches.

On this project a specific assessment methodology was developed only for determining the feasibility of use logging residues for supplying a potential district heating system located in and alpine district. Alpine terrain characteristics (mainly terrain steepness) influence logging systems applications. Considering the high cost that logging requires in mountains area and the difficulty on extracting logs from the stand area, the Full Tree logging system by cable system may be one of the most cost effective solution in most of the alpine condition. Where the Full Tree solution by cable system is practicable, the generated logging residues by processing could be chipped to energetic purpose. Integrating logging system by chipping operation can be considered one of most cost effective solution to supply chips from forest. In this way the supply cost is charged only by chipping operation and by successive transporting cost between yard areas to heating plants or storages. For this reason the feasibility of procurement chips from forest operations has been based only by considering the amount of the available logging residues at cable yard.

Concerning one heating plants location, the three set scenarios evidenced that in an alpine district where forest productive area is sizeable and where road network density is substantial, the feasibility to supply a heating plant exclusively by logging residues can be confirmed. In order to guarantee the feasibility of a district heating system, the size of the plant has to be compatible to the cost-effective amount or in the case it requires a larger a woody biomass amount, a local integration by recovering un-merchantable roundwood, small trees from thinning operations or wood industry slash must be considered.

The dispersed geographical distribution of forest biomass, both as volume stock and as logging residues, required the interest of using GIS for the evaluation of the same availability of biomass as well the supply chain cost. In this case the vector analysis (geometric network analysis) presented a more precise level than a precedent project that it was based on raster analysis (Grigolato et al, 2005), but evidenced a more accurate investigation on the involved data and a strict adaptation of the same data to the geometric network database in order to be suitable for the GIS model. The vector analysis can be more adapted on local investigation where the precision of the outputs results fundamental for determining effective cost of forest biomass supply chain for energetic use.

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ВЪПРОСИ НА РАЗПРЕДЕЛЕНИЕТО И КАЧЕСТВОТО НА ДЪРВЕСИНАТА ПРИ ДЪРВОДОБИВА И ТРАНСПОРТА (СЪОБЩЕНИЕ ЗА МОДУЛ 3 НА EFORWOOD)

Диана Фьотер, Германия

EFORWOOD е четиригодишен проект, финансиран по дейност „Глобални промени и екосистеми" на Шеста Рамкова Програма. Целта на проекта е да разработи за първи път методика за интегрална оценка на въздействието на веригата горско стопанство–дървопреработване (FWC) върху устойчивостта в Европа въз основата на индикатори за трите аспекта на устойчивостта: екологическия, икономическия и социалния. Проектът ще даде метод за оценка на въздействието на промените във веригата в следствие на измененията на политиката, пазара и технологията. Разработената методика ще влезе в така наречената ToSIA – „Методика за оценка на въздействието върху устойчивостта".

Модул 3 на EFORWOOD "Взаимодействие на гората и промишлеността" обхваща всички дейности от добиването и транспорта на дървесината до подаването на обли материали в преработващите предприятия. Въпросът за разпределението и качеството на дървесината се решава чрез моделиране като 5-step allocation approach. Това означава подходящото насаждение да се добие по подходящия метод като се използува най-добрият метод за разкройване и сортиране. Това ще позволи трупи с оптимално количество и качество да се доставят в най-подходящия завод, където да бъдат подадени за преработка на най-подходящата линия. Накратко, моделират се процесите по протежение на верига горско стопанство–дървопреработване, което ще позволи предприятията да получават подходящата за тях суровина, спазвайки изискванията на екологическата, икономическа и социална устойчивост.

EFORWOOD FOREST TO INDUSTRY INTERACTIONS - ALLOCATION AND WOOD QUALITY ISSUES DURING HARVESTING AND TRANSPORT

Diana Vötter, Germany

Abstract

EFORWOOD is a four-year Integrated Project, funded under the EU "Global change and ecosystems" research activity of the Sixth Framework Programme. The aim of the project is to provide methodologies and tools that will, for the first time, integrate Sustainability Impact Assessment of the whole European Forestry-Wood Chain (FWC), by quantifying performance of FWC, using indicators for all three pillars of sustainability: environmental, economic and societal. The project will provide methods to assess the sustainability impacts of modifications of Forestry -Wood Chains as influenced by policy changes, market drivers, or technological innovations. This output will be implemented in a "Tool for Sustainability Impact Assessment", ToSIA for short.

EFORWOOD's Module 3: Forest to Industry Interactions encompasses all activities from tree harvesting and wood transport to the provision of pre-processed materials fed into industrial processes. The topic of material allocation and wood quality is reflected in the modelling of those processes as a 5-step allocation approach. This means that the right stand will be harvested with the appropriate method using the best suitable bucking and segregation method. This will ensure that the logs will arrive in the optimal quality and quantity at the best suitable mill, where it will be fed to and processed in the most applicable product line. In short: A modelling of processes along the Forest-Wood-Chain (FWC) which provides that the industry gets the raw material which is best suited for the range of products in terms of environmental, economical and social sustainability.

BACKGROUND

Ever since the Brundtland report (1987) was presented by the Norwegian minister president at the World Commission on Environment and Development (WCED), the most acknowledged global description of sustainable developments clearly defines those as such that “meet the needs of the present without compromising the ability of future generations to meet their own needs” (UN, GENERAL ASSEMBLY, A/RES/38/161, 1983). The European Union pledged themes elves to transfer this principle of sustainability to all economic sectors. Europe’s forestry’s and wood industry’s growth chances and competitiveness are particularly linked to the aspect of sustainability: only if forests, which are a natural and renewable resource, are managed sustainable at all levels (ecologic, economic and social), they yield great future chances in a regional perspective as well as in a global context. The pre -condition is that also the downstream parts of the FWC, i.e. wood industry including consumption and recycling, are managed according to the principles of sustainability.

DEFINITION OF TERMS AND METHODS

Within the project of EFORWOOD the module M3 deals with sustainability issues along the processes of harvesting and transport operations as well as in terms of wood quality and raw-material allocation. The Institute of Forest Utilisation and Work Science is coordinating this module and deals, in addition, with the module-specific integrated partial chain modelling, which means the description, modelling and optimisation of processes in the before-mentioned fields, in order to complement and integrate those into ToSIA.

The definition of processes – as it is also given in the scientific literature (see for instance the following books: NIESTRASZ: “Object-Oriented Software Composition”; FORBRIG: “Objektorientierte Softwareentwicklung mit UML”; BERNROIDER ET AL.: ”Grundzuge der Modellierung”) – signifies that a “process (lat. processus movement) is a naturally occurring or designed sequence of operations or events, possibly taking up time, space, expertise or other resources, which produces some outcome. A process may be identified by the changes it creates in the properties of one or more objects under its influence” (WIKIPEDIA, 10/05/2006). The EFORWOOD strategy sticks to this definition, with the only specification that “immaterial processes” such as decisions, considerations, and similar are not included as stand-alone processes in ToSIA but have to be linked to physical processes. At M3 level, however, those “immaterial processes” like planning or material allocation are implemented, especially if they take up time, money and other resources. A process has also a time dimension, which is important for EFORWOOD. In terms of “business process”, for example, this is defined as “a collection of related structural activities that produce something of value to the organisation”, being marked by “inputs, method and outputs”, whereas it “can be part of a larger, encompassing process and can include other business processes that have to be included in its method” (WIKIP EDIA, 09/03/2006).

Generally, EFORWOOD ToSIA-processes are structured following this philosophy, and have a starting point and an end point and contain classes with e.g. objects, attributes and methods. Furthermore, processes are modelled in a formal structure, so that they can be computerized. Hereby in module M3 UML (Unified Modelling Language, an object oriented programming approach) is used, which can be applied for all future calculations, quantitative modelling, etc.

The operations of harvesting and transport are interlinked with material allocation processes at several levels. “Allocation (“allocare” from Latin in its colloquial form of “ad locus” =”to a place” it means “to set aside for a purpose” or “to distribute according to a plan” in its original meaning) is an assignation of an amount of elements to elements of a different amount. In economic science, an assignation of limited resources to possible usage alternatives is called ‘resource allocation’. A certain production factor (raw material, pre-product, energy, manpower, funds, privilege), which is used for the production of good x, can not be used simultaneously for the alternative production of good y. While ‘allocation’ deals with the assignment of production factors, the assignment of consumption products is called ‘distribution’” (SOURCE: http://de.wikipedia.org/wiki/Allokation; last update: 16:31, 5. Mai 2006). As within the Forest-Wood-Chain several products are created, it is necessary to work with a strict usage of terms in question.

WORKING PLAN, FIELD OF WORK

M3 deals with the partial integrated chain modelling of all processes encompassing all activities dealing with harvesting, transport and wood quality in the European wood chain. During harvesting operations the standing trees are felled and cross-cut to different assortments of logs. In the further process these logs are further processed and refined to become pre-products as well as end products. The term raw-wood already implies that this is a raw-material as well as a pre-product in comparison to end-product. In the consequence, getting the optimal volume of raw-wood or pre-products to the right mill clearly deals with allocation, whereas getting the end-product to the customer is a distribution of goods.

Within this paper the main focus is on allocation. During the processes of harvesting, transport, wood quality and wood allocation, five main stages of allocation are defined (compare Fig. 1) according to their sequence of occurrence Allocation 1 to 5:

Allocation 1: Pre-harvest (at stand level)
Allocation 2: Harvesting and forwarding (at tree level)
Allocation 3: Stacking (at forest road stack level)
Allocation 4: Delivery (at truck-pile level)
Allocation 5: Pre -product (at log level)

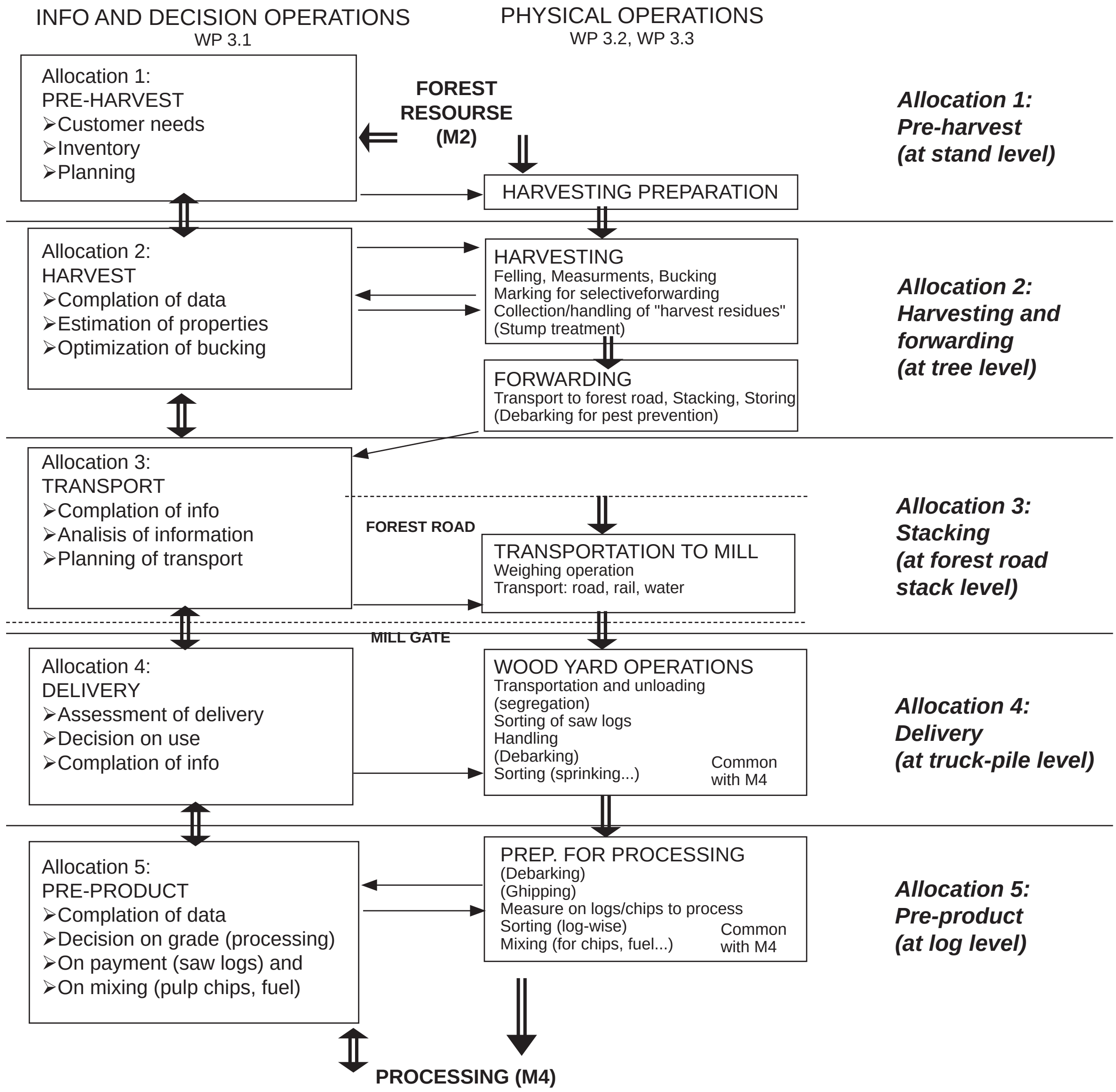

Fig. 1. M3 processes with highlighted Allocation 1 to 5; by D. Votter, S-O. Lundqvist, March 20, 2006 with WP3.1 emphasized

This means that starting from a forest stand at a certain stage of age which leads to pre-commercial thinning(s), thinning(s) and final cut, different stages of allocating wood to optimal ways of bucking, cross-cutting, storing and transporting do occur.

a) Allocation 1: Each stand grows on a specific site and has undergone specific forest management regimes and consequently shows significant dimensional and spatial features and wood structures. Thereby it is, in the consequence, suited for a different assortment of timber to be harvested, e.g. long/short saw logs, pulpwood and collected bio fuel, depending on its age, diameter, height, quality, silvicultural treatment and applicable harvesting method restricted by site and terrain. Therefore, the starting point of pre-harvest processes is a set of stands to be harvested with a description of site and genetic material as well as with a prescription of silvicultural treatment, taking into account raw materia l demands from wood industry, i.e. mill and customer side. These stands to-be-harvested have attributes (size and geographical location of the stand, terrain, species, number and size of trees, wood quality, …). On the other hand, the ordered raw materials, which are to be delivered, have certain attributes as well (demanded tree species, timber quality, chips, boles, length and diameter of trunks, etc.). This information is used by M3 for the allocation process; taking into account the location (transport distance) and specific product needs of the industry. The result of the optimal allocation process is the distribution of all stands and products out of these stands to the respective industries (compare Fig. 2), which can make the best use of this material.

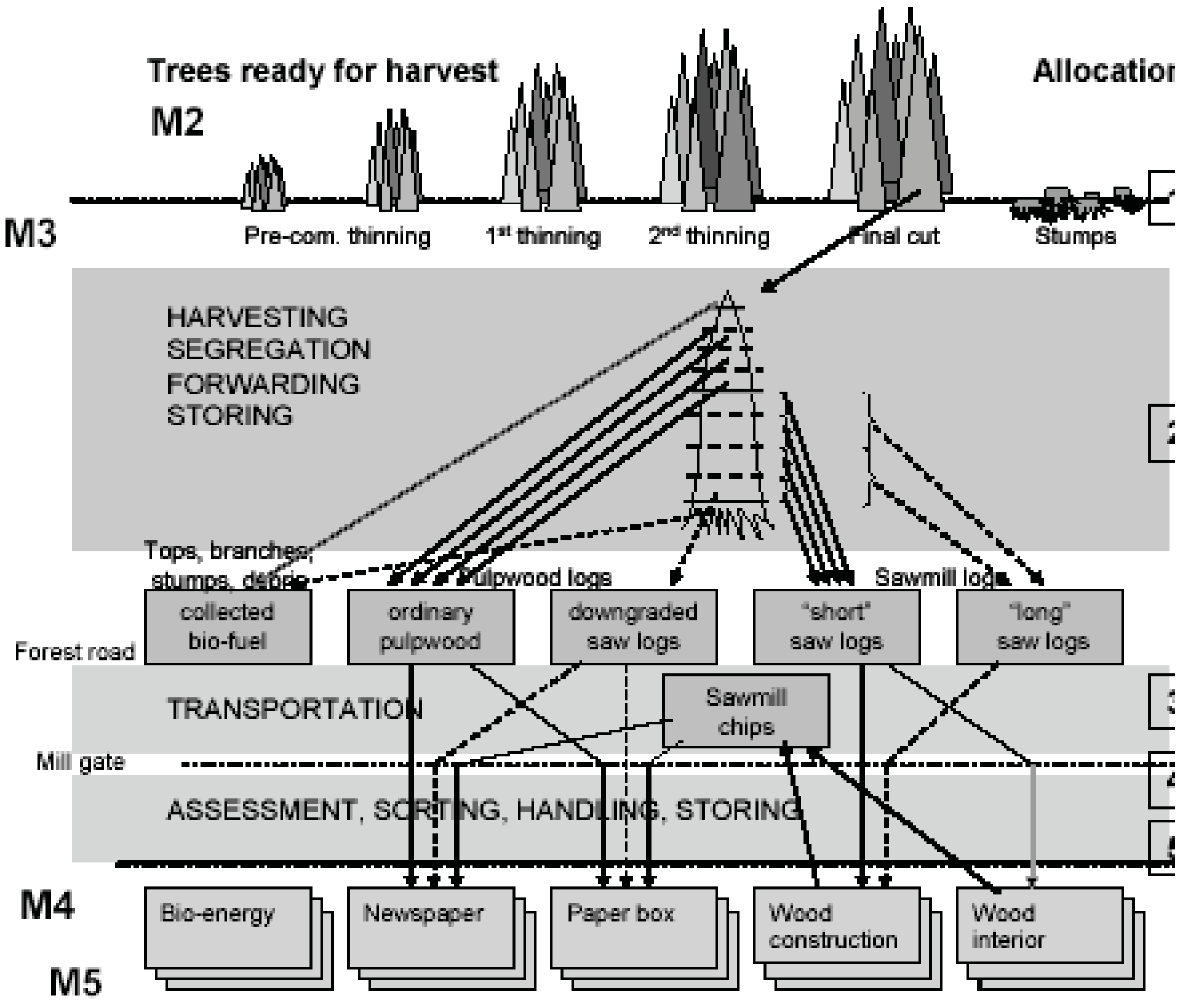

Fig. 2. Feedstock of M3 (stand at different age levels); by S-O. Lundqvist, April 06, 2006

(For example: bottom logs from a spruce thinning go to a saw mill for furniture, top logs go to paper mill, branches and residues go to an energy plant). As wood quality of trees in these stands differ widely according to genetics, altitude, stand development, etc., this allocation decision has also to take into account specific quality requirements from the industry, because the down-stream industrial processes are influenced by this and consequently, there are different impacts on sustainability (e.g. by different harvesting/transport and processing costs according to the chosen method, which also influences environment and society via its amount of used fuel, emissions, duration of the operation, and similar). Furthermore, the geographic location has an influence on the transport distance, and this again means different impacts on sustainability. The result (end point of the process) of this optimal allocation process is a matrix of distribution, which stand, which timber respectively, of this stand goes to which industry (expressed in quantities, qualities, distances). Stands, selected according to the result of the allocation process are prepared for harvesting; the decision about the appropriate technique (harvester, motor manual, short wood, tree length etc.) of harvesting and forwarding is taken.

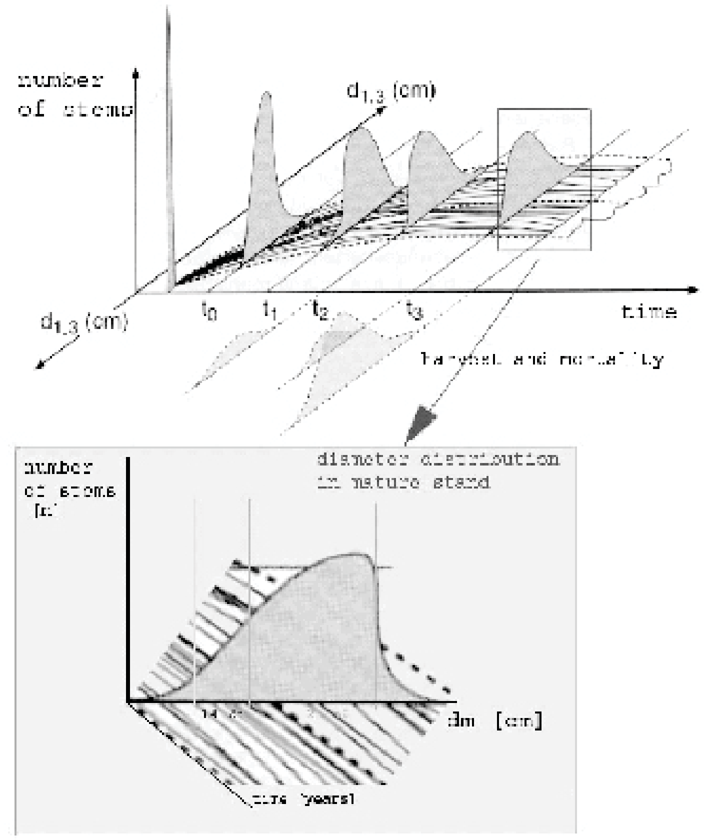

Fig. 3. In the course of stand development the distribution of stem diameters within the stand increases with age. In the consequence, the mature harvesting stand offers an increase in variability, and thus a wider range of assortments to be cut. Harvesting and cross-cutting at stand level therefore also depends on this allometry. (figure from H. Pretzsch, "Grundlagen der Waldwachstumskunde", adapted by D. Votter)

b) Allocation 2: Incorporated into the harvesting, processing and forwarding process is an allocation of pieces of logs to the respective assortments (to be delivered to the industries, defined by the allocation process). This allocation is done on a tree by tree basis and is part of the harvesting process.

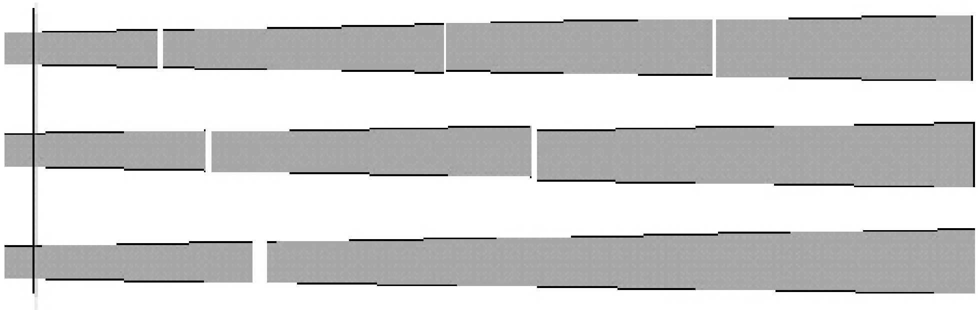

Fig. 4. Allocation at tree level during harvesting, where each tree is cross-cut according to its growth in order to obtain the best possible results for log grading. This optimization contains elements of economic sustainability (creation of value), ecologic sustainability (optimized harvesting in relation to product with smallest energetic input) and social sustainability (transformation of tree into useful product). (Figure by D. Votter)

c) Allocation 3: Sensible stack management renders a third allocation possibility. Apart from concentrating timber at the forest road side in some form of heap, there is also an improvement possibility in organising transport of stacks to the mill according to assortment, volume quality, owner, mill. In combination of RFID technology and/or geographical coordinates this information could be sent from the forest enterprise to the transport operator electronically and thus ease and speed up the process of finding timber stacks and delivering them to the mill in question.
d) Allocation 4: At the mill gate, when the truck is getting unloaded, a further rough measuring and grading takes place in form of weighing the truck (loaded minus unloaded) and a rough quality estimation. Even though it may be only a rough grading, its importance can be found as it includes the decision

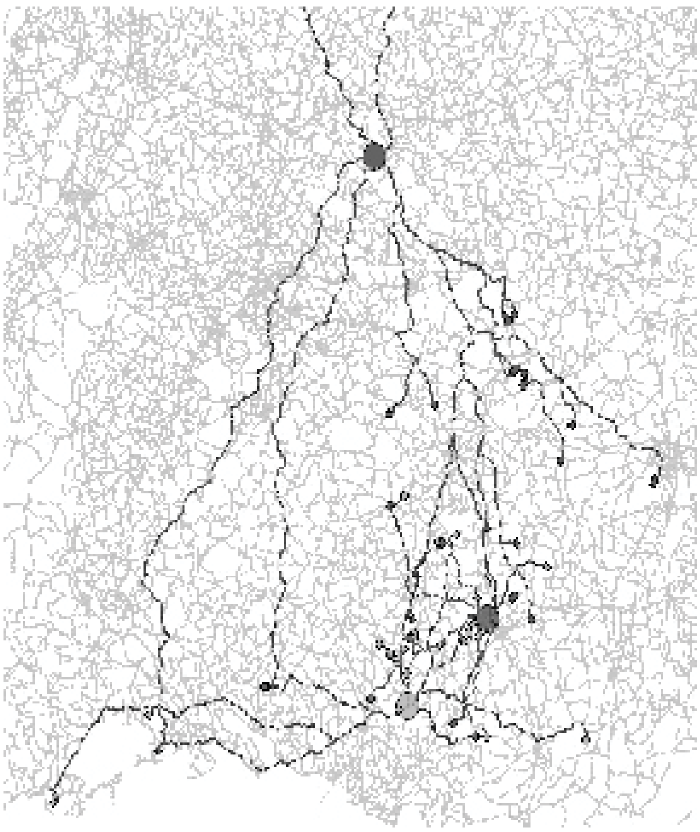

Fig. 5. Stack management with reference to destined mill, assortment and truck loads. (Figure by T. Schmaltschinski)

whether the truck load of logs is accepted at the mill or not. Furthermore, logs are not only unloaded off the truck but also assigned to certain uses, alias product-lines. At this time timber can be either immediately enter the processing, or first be separated and stored according to its designed production line.

e) Allocation 5: Last but not least, the one of the most important forms of quality grading takes place when the timber enters the production line. It includes the standard metal detection and a measuring, quality grading and assignation according to the given production lines and purposes. In the case of pulp wood the quality allocation encompasses a mixing proposal of deciduous and coniferous wood shares.

OUTLOOK

Modelling and optimising these processes of the FWC with respect to economical, environmental and social sustainability has a huge benefit potential for regional, national and global forestry and wood industry. This can be explained easily at the sub-example of timber transport from Allocation 4 (Transport and Wood yard operations): planning truck loads and directing trucks to tagged stacks – for example via GPS – makes timber transports, in the consequence, economically and environmentally more competitive. The less time and fuel is spend on un-necessary driving in search of wood stacks across the individual forest districts and in transporting half-loads, the better productivity becomes which manifests itself in monetary values (e.g. working hours and fuel). And the less fuel is used by driving optimised routes and loads, the better transport becomes from an environmental point of view. Social aspects are taken heed of by relieving the truck driver from an unnerving procedure of searching stacks and/or waiting for a forester to lead the way towards there and/or hitting dead-ends or not-truck-driveable forest roads.

In the course of the next three years the above mentioned processes will be modelled with UML, integrating existing models and completing given gaps to form a partial chain or stand alone model which can be integrated into ToSIA. This partial chain model will have all its processes and optimisation scenarios connected with indicators for economical, environmental and social sustainability in order to find the most suitable action alternative at a given real-world situation within the forest-wood-chain.

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ДЪРВОДОБИВЪТ В БЪЛГАРИЯ - СЪСТОЯНИЕ И ПЕРСПЕКТИВИ

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Общата горска площ на България възлиза на 4,076 млн. ха или 34% от територията на страната, от които 3,651 млн.ха са покрити с гори. Дървесните запаси надвишават 590,781 млн. $м^3$, при среден годишен прираст на 1 ха от 3,9 $м^3$ или общия годишен прираст е 14,12 млн. $м^3$. От залесената площ 30% е заета от иглолистни насаждения и култури и 70% от широколистни. Почти 55% от тях са млади гори, близо 30% са на възраст от 40 до 80 години, а вековните насаждения са 9,2%. През последните 50 години са залесени около 1,5 млн. ха горски култури.

През последните години средногодишният добив на обла дървесина (лежаща маса) от горския фонд е около 5,5 млн. $м^3$ от които 72% са за промишлен дърводобив, а 28% за местното население. Това ползване е под годишният прираст на горите.

Отчитайки тези фактори, ползването от горите, по експертни оценки, може да достигне 8 млн.$м^3$ (3.5 млн.$м^3$ от отгледни и 4,5 млн.$м^3$ от възобновителни сечи) към 2010 г. и 10 млн.$м^3$ (5 млн. $м^3$ от отгледни и 5 млн. $м^3$ от възобновителни сечи) към 2020 г. Разпределението на предвидената за сеч дървесина, се очаква да бъде - 35 % от иглолистните и 65 % от широколистните гори.

Условията, при които се осъществява добивът на дървесина, са доста разнообразни, като по-голяма част (около 59%) от горите са в планински райони, друга значителна част (около 29%) от горите са разположени в хълмисти райони и останалата част (около 12%) от горите са равнинни. Това води до голямо разнообразие в технологиите и трудности с обезпечаването им с необходимите средства за усвояване на дървесината. Делът на широколистните гори е 68% от залесената площ. Най-разпространените дървесни видове при тях са дъбът, букът, церът и габърът. Общо 34 на сто от залесената територия на страната са заети от иглолистни видове, като бял и черен бор, смърч, ела, атласки кедър и мура.

Към 01.01.2006 г. държавният горски фонд заема 76,5% от общата площ, общинският – 11,4%, частният - 9,9% и други – 2,2% (фиг.3). Държавният горски фонд се управлява от Национално управление по горите (НУГ) – 72,6% и Министерство на околната среда и водите (МОСВ) - 3.9 % (изключителна държавна собственост). Към настоящия момент, основните приходи за горския сектор се формират от продажбата на дървесина.

Технологията на дърводобивния процес включва прокарване на извозни пътища и трасета на въжените линии с различни разстояния между тях и ширина, избор на посока на поваляне на дърветата съобразена с разположението на подраста в насажденията, кастрене на клоните и разкройване на стъблата в сечището или извън него, подвоз и извоз на дървените материали изцяло по терена, полувъздушно и въздушно положение. Едновременно с добива на дървесина са извършва почистване на сечищата в зависимост от вида на сечта чрез равномерно разпръскване на лесосечните отпадъци, събирането им във вид на купчини или ивици и др.

В зависимост от реда и мястото на изпълняване на операциите в технологичния процес, от начина на използване на отсечената дървесна биомаса и разновидността на предлаганата продукция, са познати три метода на добив: "метод на сортиментите", "метод на цели стъбла" и "метод на цели дървета.

Сортиментната технология, т.е. добива на сортименти в сечищата през периода 1960 г. е била 94,2%. През 1990 г. по тази технология са обработени 21,8% от добитата дървесина. Втората технология, включва отсичане на дърветата и кастрене на клоните в сечищата и извозване на цели стъбла или дълги стъблени секции на временен склад, където се добиват сортиментите. През 1990 г. по тази технология са обработени около 74% от добитата дървесина. По третата технология с добив и извоз на цели дървета на временен склад, през 1990 г. са обработени около 4,2% от дървесината, като в последствие добитите цели стъбла и дългите стъблени секции са обработени на постоянни централни складове. През 2005 г. отново добивът на сортименти е най-широко застъпен с относителен дял от 77,4%, т.е. връщане назад до положението от 1960 г., когато процентът на използване на ръчния труд и животинската теглителна сила в дърводобива е бил също много висок.

При избора на най-подходящия от посочените методи, се имат предвид конкретните размери на подлежащите за сеч дървета, количествата на добиваната от единица площ дървесина, теренните условия, биологичните и лесовъдските съображения. Оценката отчита голям брой различни фактори, като производителността и ефективността на работа на машините, минималния обем ръчен труд, максималното и рационалното използване на биомасата на дърветата, достигането на минимална себестойност на продукцията и др. Значително влияние върху избора на технологичен процес оказва начинът за преработка на добиваната дървесина и териториалното разположение на предприятията, които я извършват.

Технологиите с добив на сортименти в сечището са подходящи за долната лесорастителна зона, но при определени условия могат да намерят приложение и в други райони на страната. Технологиите с извоз на цели дървета изискват най-малък брой работници, но все още няма условия за тяхното внедряване. В бъдеще по всяка вероятност те ще се наложат за сметка на сега използваните технологии с извоз на цели стъбла.

На базата на използването главно на моторните триони при сечта и първичната обработка на дърветата, което още дълго време ще бъде преобладаващият начин за извършване на тези операции у нас, като най-подходящи и реално изпълними за нашите условия се явяват следните системи от машини: моторен трион за поваляне и кастрене + трактор или въжена линия за извоз на цели стъбла + моторен трион за разкройване на временен склад; моторен трион за поваляне и първична обработка в сечището + сортиментна машина за извоз до временния склад и моторен трион за поваляне + трактор или въжена линия за извоз на цели дървета + процесор за първична обработка на извозените дървета.

Първата система от машини е най-достъпна и се препоръчва за масово внедрявяне понастоящем. Втората осигурява по-висока производителност и по-добри екологични показатели в случаите, когато условията позволяват влизане на сортиментните машини в сечищата. Препоръчва се водене на главни или възобновителни сечи в насаждения с такива условия. Третата схема се препоръчва при водене на ранните отгледни сечи, особено при прилагане на схематичните методи за тяхното извеждане.

В по-далечна перспектива, при по-голям обем на добива (50 и повече хил. m^3/год.) трябва да се препоръча технологията за добив и извоз на сортименти на основата на харвестер и форвардер. Преимуществата на тази система е високата производителност на труда в резултат на високата степен на механизация на процесите.

Въз основа на проведените научни изследвания и дългогодишния опит от решаване на задачите пред горския сектор, могат да се направят следните по-важни обобщения:

1. В резултат на недостига и лошото състояние на дърводобивната техника и утежнените условия за нейното поддържане и ремонт, намалява обемът на добиваната с тях продукция и нараства относителния дял на работата с животинска теглителна сила и ръчния труд. В социален аспект се понижава нивото на работите в дърводобива, тъй като се влошават условията на труда и се намалява неговата производителност.

2. Анализът на сегашното състояние на дърводобивната техника у нас обуславя необходимостта от почти пълна подмяна на използваните машини. Като се вземат предвид сериозните икономически затруднения, пред които е поставен понастоящем отрасъла, решаването на тази задача е изключително трудно и не може да стане наведнъж. Трябва да се набележат приоритетни насоки за нейното поетапно решаване, които да осигурят постепенно навлизане на съвременни машини и технологии в дърводобива, подходящи за разнообразните условия на нашата страна.

3. Обновяването на дърводобивната техника и преди всичко на извозните машини и съоръжения е първата и най-важна задача на фирмите за добив на дървесина, ако искат производствената им дейност да бъде ефективна и рентабилна. Снабдяването с нова техника може и трябва да се стимулира с облекчени кредити, продажба на изплащане и др. Освен вносна техника, могат да се използват и нови български машини, които имат много по-ниска цена при добро качество. В последно време у нас научни работници и машиностроителни фирми създадоха някои нови машини, които успешно преминаха изпитанията и могат да се внедряват в дърводобива.

4. Реорганизацията на дърводобива изисква продажба на дървесината от склад, с оглед цялостна обвързаност с пазара; подпомагане на насърчителни мерки за модернизиране на дърводобивната

техника и приложението на съвременни технологии в дърводобива; приемане и реализиране на национална програма за развитие на горско-пътната мрежа; насърчаване ползването на дървесната биомаса за енергия и др. цели; въвеждане на съвременна система за борсова търговия с ценни дървесни сортименти; изграждане на действаща система за маркетинг на пазара на дървесина и др.

LOGGING AND THINNING IN BULGARIA - STATE AND OUTLOOKS

Dinko Dinev, Konstantin Asparuchov, Stoyan Kanev, Bulgaria

INTRODUCTION

As a result of both the political and economic changes occurred in our country after 1989, the forestry sector in Bulgaria passed over a period of reforms directed to a functioning in the conditions of the market economics and the pluralism in property. That transition was complicated, and it was also predetermined by the strained social and economical situation, which it was passing in. Due to what above said, a number of negative changes in the development of the whole society and the economics affected the forestry sector, as well, according to the data provided by the National Forestry Board (NFB) in Sofia. Within that period, it came to that, the logging was not considered so much as a natural completion of the forestry operations, as a necessary activity for the forest itself, but merely as a field of exploitation, being realizable with not too clear intentions, methods and means.

The total woodland area in Bulgaria amounts at 4,076 mill. ha or at 34% of the home territory, where 3,651 mill. ha are covered with forests. The wood resources surpass 590,781 mln.m^3, at an average annual growth as of 3,9 m^3 at 1 ha, or being the total annual growth as of 14,12 mill.m^3. Of the afforested area 30% is being covered with coniferous plantations and cultures, and 70% of it with deciduous ones. Almost 55% of those ones are coppices (young forests), nearly 30% being at the age as from 40 up to 80 years old, while the secular plantations are of 9,2%. During the last 50 years, about 1,5 mill. ha of wood cultures were afforested.

In the last years, the average annual procurement of round timber (lying mass) of the wood stock was about 5,5 mill. m^3, from which ones 72% being designed for industrial timber production, while the rest 28% for local population. That utilization is below the annual growth of the forests. Moreover, there is no report, given by the official statistics, as on timber true use: e.g. no report on that timber, which is illegally being procured, and which annual amount is being come up to 800 thousand m^3, approximately (s. Figure 1).

Taking into account the above mentioned factors, the utilization of the materials obtained from wood, as according to experts` assessments, can get up to 8 mill. m^3 (3,5 mill. m^3 of thinning and 4,5 mill. m^3 of regeneration felling) ones by 2010, and up to 10 mill. m^3 (5 mill. m^3 of thinning and 5 mill. m^3 of regeneration felling) ones by 2020. The distribution of the timber is expected to be as of 35% of the coniferous and 65% of the deciduous forests, as according to data provided by the National Forestry Board (NFB).

The reasons for such a failure in utilization are, as following below: the scarce road net (being its average density as of 7,9 m/ha), and due to that factor, there are about 500 thousand m^3, annually, of wood designed for felling, that remains out of reach; a number of prolonged law suits conducted for restitution of property on forests, freezing the utilization of about 200 thousand m^3 of timber annually; a jumpy market for technological timber and others.

The conditions, which the logging is being obtained under, are rather various, being the greatest part of the forests (about 59%) located in the uplands, another significantly large part of them (about 29%) in hilly areas, while the rest one (about 12%) lies in flat countries. It leads to a great variety of the technologies applied to, and to difficulties, as regards to providing for the necessary means and funds for timber utilization. The percentage of the deciduous forests amounts at 68% of the afforested area, being the most widely distributed tree species, as following ones: oak (quercus), beech (fagus), moss-capped (cerris) and horn beam (carpinus). There are 34% , totally, of home afforested territory, covered with coniferous species as: white (pinus silvestris) and black (pinus nigra) pine, spruce (picea abies), pine spruce (abies alba), Atlas cedar and fir (pinus peuce) (s. Figure 2).

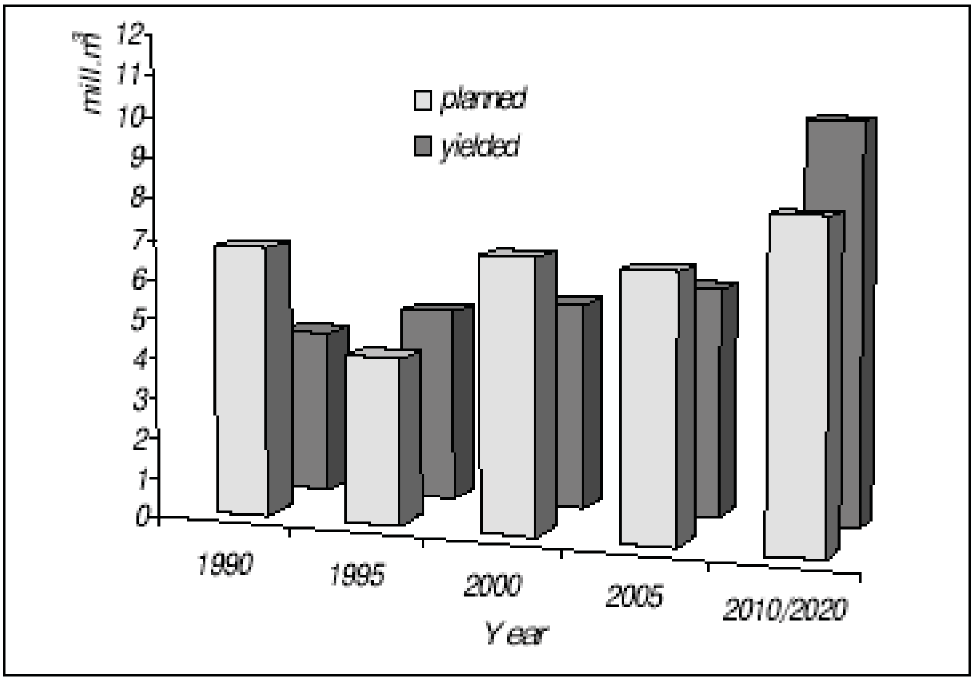

Fig. 1: Planned and real timber use within the period 1990 – 2020

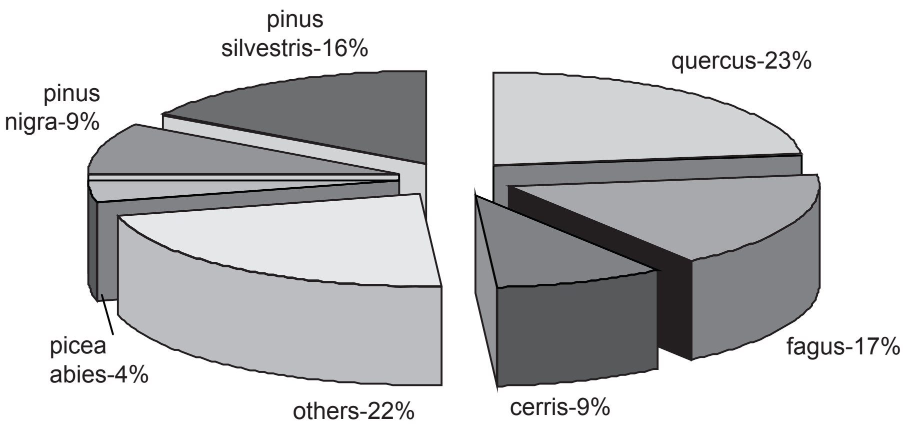

Fig. 2: Distribution of the main forest tree species

By 01.01.2006, the State wood stock covers 76,5% of the total area, the municipal one: 11,4%, the private one: 9,9% and the others: 2,2% (s. Figure 3). The State wood stock is managed by the National Forestry Board (NFB) - 72,6% and by the Ministry of Environment and Waters (MEW): 3,9 % (being an exclusive state property). By the present moment, the main incomes for the forestry sector are being formed by timber sale.

Most of the forests, belonging to private owners, are of a small area, being even less than 1 ha. There are 150 individual plots only, of more than 50 ha, while the municipal forests usually have an area of several hundred hectares.

By the moment, there are 4700 firms registered, approximately, for timber production and sale, but about 1500 ones of them do not exercise the above mentioned activity. These firms are small and large scale ones, as depending on the volume of their work.

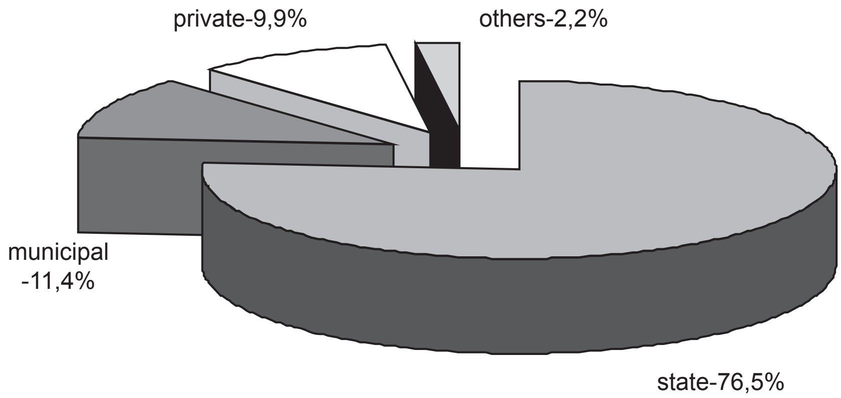

Fig. 3: Distribution of the property on forests

The large scale firms have from 10 up to 15 working groups, being provided of tractors, 1-2 short cable ways for timber haulage, and of cranes and trucks. A small part of the above said companies disposes of workshops for machinery repair, and deals with road building, - where no more than 60-80 thousand levs (30-40 thousand Euro), annually, are being invested in, - and possesses shops for timber processing by siding it in beams, boards, planks and others.

TECHNOLOGIES STATE

The technological processes in our country have not been strictly differentiated yet. These technologies, which have been applied to, are not in a full conformity with the forestry conditions. Speaking in the broadest terms, the technologies, used by the moment, do not correspond either to the cutting types and methods, or to the forest stands density, the terrain slope, the soil strength capacity to erosion, the average volume of the stems, the undergrowth available of the main tree species, taking into account the modern machines use and other factors.

In the course of the operation, some injuries are being caused in the plantations, most often due to: a non-coordinated direction of the trees felling to that one of the haulage; a bad manage when the materials are dragged on and the loads are to be arranged; a primary transport of full tree logging and half-delimbed stems; a dragging of the materials wholly along the ground without uplifting their front section; a large number of single loads, etc.

The number of the machines has been decreasing for these last years. A greater part of them is amortized, being both morally and physically outdated and worn out. In the greatest extent, it concerns the main machinery for logging, as the cable skidder tractors, where there are 11% of them only to have some residual resource. The state of the loaders is not better, being about 90% of those ones amortized.

The chain saws are the only technical means of not reduced application, guaranteeing a 100% mechanization both of the felling operation and of the main initial handling of the cut trees.

A high influence on the logging mechanization is being exerted by the parameters of the wooded country, especially the terrain slope, the relief type (roughness and other factors). Tractors and animal hauling power are used on flatter lands, while cable ways and animal hauling power, too, are applied on steeper ones. Multipurpose machines are not used, for now. A number of trials have been carried out for introduction of delimbing-bucking machines“ Steyr KP 40 ” and “ Stripper III ”, but they have not gained prevalence, due to the above mentioned changes occurred in our country (s. Figure 4).

Primary transport is made by tractors and cable ways, as well as by animal (horses and oxen) hauling power. Till 15-20 years ago, there was a strenuous work of making such kinds of specialized tractors and cable systems, which to be applicable in our country (s. Figure 5).

Fig. 4: Delimbing-bucking machine “ Steyr KP 40 ”

Small cable skidder tractor “ШТ - 40 (Shipka-40)“

Small cut-to-length tractor “Б - 1203 (B-1203)“

Cable way system “ТВС - 500 (TVS-500)“

Light cable way “Витоша - I (Vitosha-I)“

Fig. 5: Some of the machines, constructed and introduced in Bulgaria

The most widespread means of primary transport are the skidder tractors equipped of a cable line unit, as the following: “Universal - 651“ - type modified agricultural tractors or “TAF – 654“ and “LKT - 81/82“ - type specialized ones for forestry, are (s. Figure 6).


Fig. 6: The most widespread tractors for tree-length, long-length and full-tree skidding

Much more suitable result to be the cut-to-length trailers, able to haul timber, not dragging it across the ground, and at a much greater distance to the motor ways of permanent covering (s. Figure 7). One of the greatest advantages of these machines is that they can reach the clearing itself on the grounds, accessible to tractors, and if there is a steep sloped or broken terrain, these trailers may pass even on not covered tractor roads. Thus, it becomes possible, a desirable shortening of the primary transport distances, by dragging the materials across the ground up to 300 - 400 meters, to be realized by the building of a dense net of tractor roads, instead of motor ways. The latter ones are much more expensive than the former, affecting much worse and harder the environment. The difference between the values of one kilometer of motor way and one kilometer of tractor road amounts at 50 - 60 thousand levs (25-30 thousand Euro), which means that by a saving, realizable in case, some 5 kilometers of a motor way should be replaced by tractor road, instead, a high efficient forwarder may be bought, that would be able to operate within a rather large area, for a couple of years. The experience of that prototype model of "МСИ - 100(MSI-100)" forwarder (s. Figure 7), produced in our country, years ago, showed quite good results, regardless of its significant technical imperfections. In the very first years of its use, an annual productivity was achieved by it, as of 8 - 10 thousand cubic meters, at an average haulage distance of about 2 kilometers.

In our country, for the last 30 - 40 years, the percentage of utilization of the tractors, as compared to that one of the cable systems, has increased. The reasons for such a reduced use of the cable systems are as following: the lack of a qualified personnel who could be able to cope well enough with the operation of the cable ways, used in forestry; the low concentration of timber and the wide spread clearings, being the result from, a raising frequency of the cable ways re-basing and an increase of the working expenses for assembling-disassembling; the lack of suitable kinds of cable lines and systems, due to the fact, they are expensive or not produced in our country; and so on.

For many years, complete groups of workers have been used to operate with tractors, equipped of cable way units for transport through the air. It should be proceeded from the regulation: that a maximum utilization of the productive capacities of the most expensive means, which ones being the tractors, in this concrete case, has to be provided for, to precise what optimum number of members of a working group could be appropriate. According to some data, excerpt from our studies, when heavy stems of coniferous trees are being hauled along a road in a good state, of both direct and reverse slopes, the shift productivity of the "Universal - 651" type tractor, at an average haulage distance of 750 m, achieves 15 - 16 m^3, while on a road of predominant direct slopes (down slopes), it may reach 20 m^3. The above indicated shift productivity of that class of tractors can be achieved, when for main (regenerative) cuttings, along with the tractor-driver, there have to work, with the tractor, other four workers-cutters, as well, who could be able to provide for a monthly logging as of 350 m^3.

Fig. 7: Primary transport by a "ТП - 50Г(TP-50G)" cut-to-length trailer and "МСИ - 100(MSI-100)" forwarder

Examining any single way of primary transport, it is to be considered, the labor consumption results the lowest when a transport by tractors is used, followed by a cable lines, and the highest, when there is by animal power.

The mechanized methods and operating technologies cannot replace everywhere the traditional primary transport where animal power is utilized. It is used to apply, in our country, technologies, requiring a lot of manual work, for logging haulage, as these ones by packsaddle horses or by carts. There is not only the uploading of the assortments onto a packsaddle horse, or into a cart, to be done, in the cutting area, but also a stacking in figures, after transport to the temporary timber-yard. Regardless of all that, such technologies are widely spread and preferred because of the cheaper manpower. And besides, these mechanized transport means, which are being used in our country nowadays, are designed for a haulage of long-lengths and tree-lengths, and not for short sized materials, got in the clearings, which materials are used, when a packsaddle horse or a cart haulage is provided.

The animal hauling power is also utilized for a haulage of long-lengths, being the load attacked to, in its front section, by a chain and steel wedges, and being wholly dragged across the ground, when a packsaddle horse haulage is used, or being uploaded, in its front section, on wheeled or hauling carts (s. Figure 8).

Fig. 8: Long-length haulage by horses and oxen

The problems, referred to a proper way of transporting, both by horses and oxen, include cares of animals breeding and keeping of their health in a good status, as well as a provision of a suitable farm equipment and the indispensable forage. Another problem to be added to is the lack of qualified workers - haulers.

Building timber is used to be hauled by animal power, and more precisely, by oxen pulled wheeled or hauling carts. The technology of the haulage by oxen is prevailing for small quantities of wood materials scattered all over the different sites. The shift productivity of one hauler depends both upon the haulage distance and the haulage direction towards the terrain slope. When the materials are down hauled, i.e. down slope, and at short distances of haulage, as up to 400 - 500 m, the shift productivity reaches 2,5 - 3 m^3, while if there are distances of haulage of more than 1000 m, it drops to less than 2 m^3. If the materials are up hauled, i.e. up slope (in such a case when there is a reverse slope), the shift productivity is sensibly reduced, as there shall be less quantity of load to be used. In that case, it is obligatory, wheeled carts to be used, for the purpose, while in a case of a down slope haulage, hauling carts would be preferable, instead.

The technology of the haulage by horses is applied to in cases when cut-to-length logging. The shift productivity, at a distance of 300 m, in very bad conditions, reaches 2,7 m^3, while if there are more favorable conditions, it may achieve 9-10 m^3. The materials are fasten with chains, being the latter ones also used to ensure an increase of resistance, when a down slope haulage is to be done.

When efficiency is to be raised, exploiting the machines, a number of factors shall be taken into account, as the forest-road net, the plantations density, the transport distance and others, which ones exert their influence onto, affecting the work in the stands. For that purpose, a data bank of the forest exploiting conditions shall be created, by all means, where such data can be reliably saved.

In our country, the development of the logging is not based either on the social factors, or on the economic, as the following ones are, for example: availability of various specialists; requirements for wood environment protection; price formation and others, i.e., it is not dependant upon the existing conditions. As an illustration to what above said, some data have been pointed out, as about the labour productivity change in a moderately representative working group, in our country (s. Figure 9).

The averaged daily natural workmanship of a worker, being a member of a working group operating with an agricultural tractor, adapted to logging, was of 3,25 m^3 in 1990, 2,84 m^3 in 1995, 2,20 m^3 in 2000 and 2,31 m^3 in 2005. As for working groups, operating with a specialized tractor, in all those same years, the values are, as following: 3,65 m^3, 3,25 m^3, 2,52 m^3 and 2,77 m^3, respectively. As evident, there is to be considered a significant drop of the productivity of labour up to 2000, and a slight increase in 2005. The reasons for that are complex, being the greatest one the prolonged idle time for repair of the machinery, that affects to productivity of labour (s. Figure 10).

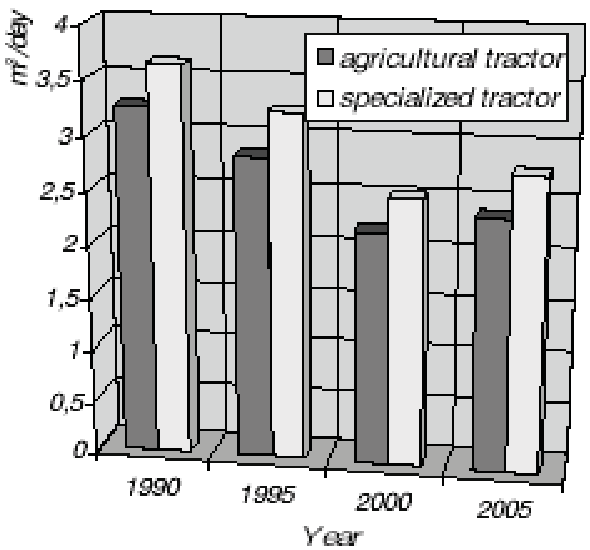

Fig. 9: Daily productivity per worker in logging

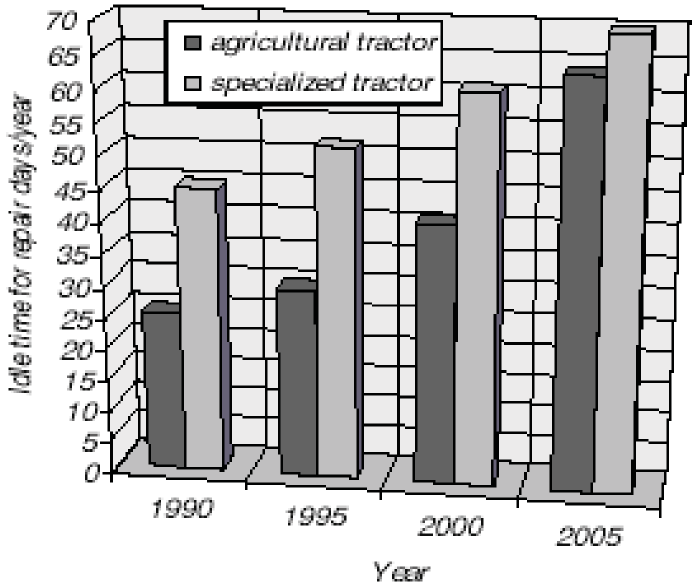

Fig. 10: Idle time of tractors which are to be repaired

It is not better the state of the loaders, being 86% of those ones amortized. “Shipka” hydraulic cranes, produced in our country, to be mounted on tractors and trucks, are considered to be of the widest use (s. Figure 11).

Fig. 11: *“Shipka”* hydraulic cranes mounted on a tractor and a truck

If all, what was previously mentioned herein, is summarized, a conclusion may be drawn out: that available machinery which is at our forestry enterprises disposal, is not only insufficient, but also significantly worn out, being in many cases almost unfit to be used. It comes to confirm, - taking into account the present state of the machinery, - no good results could be achieved either, as regards to labor productivity.

The motorway net in forests is poorly developed. There are about 3 m/ha of asphalt covered roads, and as a whole, the gravel ones included, the roads are not over 7-8 m/ha, very often being of a unsatisfactory state. Circumstances demand uncovered (strip) roads to be built and used, passable only in dry days, but even these roads included, the road net density is seldom over 10 m/ha. For that reason, the average haulage distances are of 700-800 m, and there are not rare such cases when the distances are even more than 1000 m (s. Figure 12).

Fig. 12: Making of forest truck roads for timber transporting

No good results would be achieved without a building of a modern forest road net in the wood massifs, without a mechanization of the technological processes in the stands. The importance of the forest road net density is great, but in our country that same net is rather poor because of the upland nature of our forests. That is why new roads should be made, providing that the machines come as nearer as possible to each cut-to-length material prepared to be loaded. Otherwise, due to the long distances of transport, economic inefficiency will result from, because of comparatively high costs of delivery of the forestry machines.

Among all the kinds of thinning, the clearances and the first thinning are of a great importance, as being related to a positively orientated development of the plantations, thus permitting, later on, and in short times that maximum economic and social advantages should be derived from.

The problems of the technological aspect appear as the most obvious ones in the clearances and the first thinning, as the plantations are very dense and provide a low material yield. That is why, in their thinning out, a technological clearing-out of the plantations should be provided, being the requirements for, as following: 1) a high-grade growth; 2) a free access to the plantations, to make use of it in further penetrations into; 3) a minimization of the injuries occuring in the plantations, and so on.

The technological schemes, in clearance, are made under the plantation canopy or after the final phase (s. Figure 13). The clearances are thinned out, using all the three methods for: of area, corridor and nest, as in dependence of the respective tree species, its structure, origin, state and so on. Undesired species are eliminated by tools as axes, cutters and knives, shears and others, and by mechanized means as motor saws and brush cutters.

Under the canopy of the stands *After the final phase*

Fig. 13: Clearance in young plantations

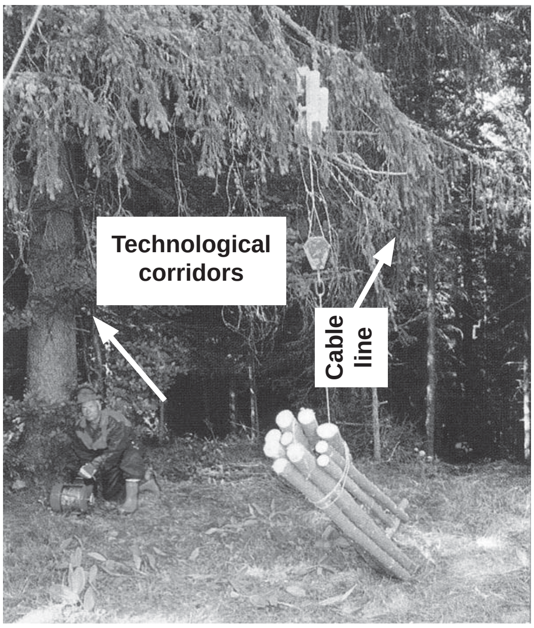

Fig. 14: Schemes of tracing out of strip roads and technological corridors for operations made by winches and light cable lines equipped tractors

In the first thinning, the technological schemes are made, providing or not, a previous tracing out of rides, which width is as of 2-3 m, through 20 or 40 m area, as in dependence with the plantations density and the primary transport means. When second thinning out by tractor cable skidder or "Pioner" type light cable systems are provided, rides can be made through 40-70 m, and technological corridors at an angle of 45°, through 10 -15 m area (s. Figure 14). The technological corridors serve for trasportation up to the ride or the trace, using a winch for the greatest part of the materials, which, after it, will be hauled by the tractor or the cable way, respectively.

Thinning are to provide a non material or a material logging. If there is no material logging, the cut trees remain within the plantation, while if there is a material one, the boles, or the cut-to-lengths obtained from, will be dragged to the ride or to the technological corridor (when a winch is used for), where by animal hauling power (packsaddle horses or a cart), or by a tractor, the stems or the cut-to-lengths will be hauled away, up to a temporary timber-yard.

Main (regenerative) cuttings are thinned out when the forest growth conditions are to be considered, as following below: the forest type, the biological characteristics of the tree species, the regularity in the growth and the development of the plantations, the utilization of the possibilities, provided by nature, for regeneration after the cutting of the plantations. When a choice of methods and technologies is to be made, there are the specific biological characteristics of the tree species, the terrain slopes, the availability and the state of the undergrowth of the main tree species, that shall be taken into account.

The logging technology includes a tracing of strip roads, and a making of cable lines, being the distances among differed; and the width and the choice of the tree felling direction, appropriate and correponding to the growth location in the stands; so does it include a delimbing of the branches and a bucking of the stems, both within - or out of - the cutting area; a transportation and a haulage of wood materials, wholly along the ground; a through the semiair and air position. Simultaneuosly with wood procurement, the first thinning - of the cutting area is being made, as depending upon the type of cutting, by a uniform scattering of the logging residues, after cutting, or by collecting them in piles or strips or others.

One of the classical methods applied to improve the economic indices is the raise of production concentration. That can be solved, in logging, by technologies improvement only, when recent and more productive machinery is applied to. In that relation, the use of various kinds of machines, in dependence with the forest exploitation conditions, the terrain ones included, will lead to achievement of good results.

The process of production, when logging is to be done in areas of a hard access, is distinguished by a prevailing importance and significance of the shift moving operations over the cutting ones. The relative weight, at the labor costs, when cutting operations are realized, is of 25-30%, while, in cases, when shift moving ones are provided, it is of 70-75%.

In such difficult conditions, the process of production is characterized by some pecularities as following below: the management should be conducted, taking into account the great water and soil protective importance of the forests; there should be also considered the terrain slope and broken relief and the complicated conditions for the realization of the shift moving operations, determining a necessity of a complex initial haulage by different means of transportation and haulage; the fact that the forest machinery is not too fit for operations in such unfavorable conditions; the extremely limited number of specialized machinery and accessories, suitable for the purpose. The utilization of the mechanized means of haulage, available in our country, is very difficult to be realized in such plantations; the possibiity of the haulage of tree-lengths has lowered; and the haulage of the cut-to-lengths by animal power causes a significant drop in labor productivity, thus affecting on tecnological processes efficiency.

The hard access to the terrain depends not only upon the slope, but also upon the uneven relief and the strength-lacking soils. Usually, there are two types of haulage means to be used across such grounds: a transportation and a haulage of materials at short distances, across uneven and hard broken grounds, by light portable winches, and a haulage of timber at longer distances, up to temporary timber-yards or sites of loading, by short cable ways and other cable-roll systems.

The cutting areas, as in dependence with the primary transport, the terrain slope and relief, can be subdivided into four groups: cutting areas exploitable by using high negotiable specialized tractors for; cutting areas exploitable by winches and cable ways only; cutting areas of a combined assimilation where both machinery and animal hauling power are used; cutting areas exploitable by using a gravitational method of material lowering.

The graviest injuries are caused when a tractor primary transport of tree-lengths is used; less injuries occur when a combined cable systems haulage and tractor or animal power transportation is utilized. It is the terrain slope that is considered to be if a great importance for the preservation of the plantations. Higher is the slope: as from 20° to 30°, higher results the percentage of injuried plantations: up to 2,2 times. The gravest are the injuries of the large undergrowth. It is the undergrowth of a height as from 20 up to 80 cm that remains the best preserved.

That is the soil covering, too, which gets injured and even destroyed when the undergrowth is injured. If the cuttings are of low intensity, the main part of the soil covering sustains only a touch of injuries. The gravest destruction is caused by a systemless free dropping of materials onto the ground and by the use of the chain tractors as compared to all the rest means of haulage.The best preservation of trees, soil and undergrowth results when a cable line is used.

Substantial changes occur in the forest stands, in their vital process, and in the soil structure (that is being destroyed) when main (regenerative) cuttings are thinned out. It has to be considered, the influence extent depends upon the type of cutting, the technological processes and the methods of work, applied to. That is the working technology used in plantations, which influences substantially on the preservation of the trees remaining on root after cutting, and on the undergrowth available, as well as on the alteration of the water - physical properties of the soil superficial horizon. The gravest injuries occur on trees, undergrowth and soil covereing when a haulage of full trees and, in part, of tree-length skidding, is made by winches equipped tractors.

Sometimes, the replacement of the animal hauling power, in timber production, is provoked more by the idea, that same kind of activity ought to be mechanized, rather than innovated. The point is that innovation does not always pass through mechanization of the processes. Thus, for example, the animal hauling power use is often imposed by a permanent raise of prices: of machinery, equipment, fuel, production costs; by some increase of the machinery repair costs and expenses; by the enhanced requirements of plantation protection.

In our country, a number of the studies, conducted on the most widely spread methods of horse utilization for timber haulage, have shown an efficient haulage of timber, by packsaddle horses or carts, depends upon the plantation age, and upon the terrain slope and relief. Generally, the main advantage of the haulage by horses becomes evident in the first thinning of material logging, in plantations of a high density, where the minimum distance among the trees is no more than 2-2,5 m, during the period of vegetation, and so on.

OUTLOOKS FOR DEVELOPMENT

When an assessment of the state is made, and the methods and the technological processes, applied to the cuttings, are prognosticated, the following stages, qualitatively differing one from other, of the cuttings development, are to be pointed out: methods and technologies where tools and animal hauling power are used; methods and technologies where mechanized means and hauling machinery are used, auxiliary manual operations included; mechanized methods and technologies where no auxiliary manual operation are applied to.

Our country is in the initial stage of a gradual mechanization of the production process, where the manual operations and the animal power percentages are still high enough, while in countries, where there is an advanced logging and timber production, new and more rational working methods and technologies are applied to, grounded onto a complex mechanization of timber obtaining and trasportation.

As in dependence with the sequence and the position of the operations, which the technological process consists of, with the way of using the wood biomass by the cut trees and with the variety of the offered production, there are three methods of logging, known by the moment: “ the cut-to-length method “, “ the tree-length method “, and “ the full-tree method “ (s. Figure 15).

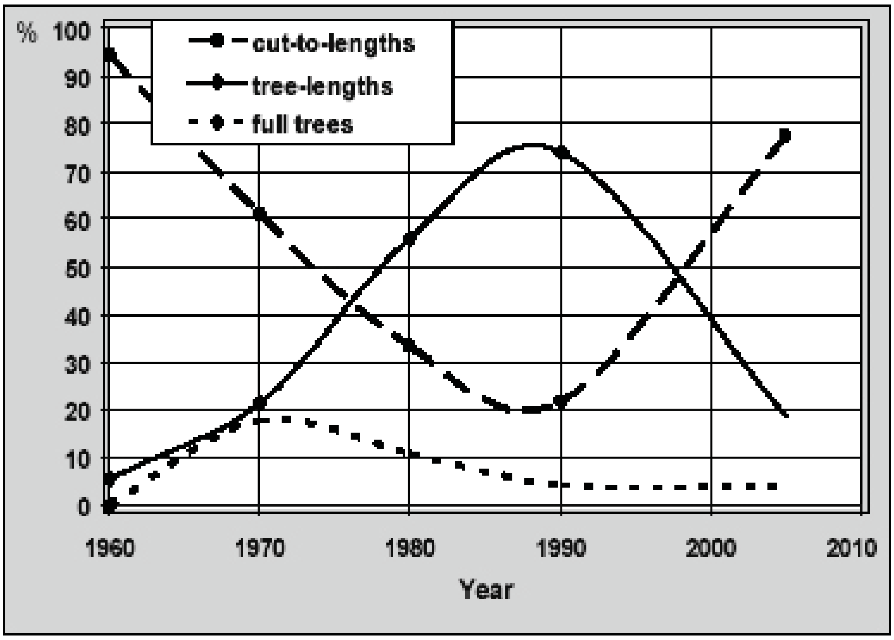

Fig. 15: Methods of logging, used in Bulgaria

The cut-to-length technology, i.e. the cut-to-lengths obtaining in the cutting areas in 1960 was 94,2%. In 1990, that same technology was used for the processing of 21,8% of the timber that was obtained. The second technology comprises trees felling and branches delimbing, within the cutting area, and a haulage of tree lengths or long-lengths to a temporary timber-yard where cut-to-lengths are obtained. In 1990, that same technology was used for the processing of about 74% of the obtained timber. Using the third technology, including both logging and full trees haulage to a temporary timber-yard, in 1990, there were about 4,2% of timber processed, and, subsequently, the tree-lengths and the long-lengths were processed in forest-yards. In 2005, again, the cut-to-lengths obtained were the largest one, being the percentage as of 77,4%, i.e., it was not else but a bark-back situation, to that one, observed in 1960, when the percentage of the manual operations and animal hauling power in the logging had also been too high.

When it is aimed at a choice of the most appropriate method among all that were indicated above, the following factors should be taken into account as the concrete size of the trees to be cut; the quantity of the timber obtained by a unit of area; the terrain conditions; the biological and forestry considerations. The assessment shall report on a number of different factors, as the machinery productivity and efficiency; the minimum volume of the manual operations used; the maximum and rational utilization of the wood biomass; the achievement of a minimum cost price of the production and others. There are also the method of timber processing and the territorial location of the enterprises (dealing with timber processing) to influence significantly on the choice of a given technological process.

When means of haulage are to be chosen, it is the tractor that is usually preferred, as being efficient even in cases, where small quantities of timber are available in the logging areas. The cable ways, and especially, the short ones, designed to uplifting, can be used in greater slopes, even more than 70%. The same is also valid for the mini-winches used as light cable lines.

The technologies, comprising cuts-of-length obtaining within the cutting area, in the cutting area, are appropriate for the lower forest area, but if some determined conditions are available, these technologies may be applied to in other areas of our country, for example, in the Rhodope Mountains. For that purpose, it is necessary, in the forthcoming years, an enlarged use to be provided, being, perhaps, not that one of specialized forwarders, due to their higher prices, but, at least, of cuts-to-length trailers equipped of self-loading manipulators.

The technologies, comprising a haulage of full trees, require the most reduced number of workers, but there are no conditions, yet, for introduction. In the future, it is more probably, these technologies might gain ground, instead of those ones where a haulage of tree-lengths is practiced, taking into account the fact. The labor consumption operations as delimbing and bucking are done out of plantation, being concentrated in the timber-yard, where it is possible to be mechanized.

There are the machines for cut-to-lengths haulage, which are considered both perspective and suitable means of wood haulage, where no dragging of the materials along the ground is provided. When the forest-road net is less dense, these machines are able to move across the ground, even if there is no road traced in the logging area, even if such a terrain is of a very low carrier capacity. It is obvious, where a too steep terrain and a broken relief are available, these machines should only proceed on tractor roads, made before. The choice of an appropriate type of cut-to-length machine depends mainly upon the size and the quality of the materials and upon the nature of the terrain.

The access of the cut-to-length machines to the logging area and the wood material uplifting onto wheels in that same site, are considered the best ways to achieve the purposes of the step-by-step cuttings. And moreover, if the trees felling and initial operation are made by a harvester, there will be really granted the most efficient environment protection. But even when there are thinning out of cuttings and initial operations made by chain saws, the haulage of the materials, got by such machines (as the above said ones), may be efficient enough, as to provide for very high ecological indices of use.

The machinery systems, as following below, being considered the most appropriate and realizable, in our conditions, on the basis of the chain saws use for cutting, and of the initial processing of the cut trees (taking into consideration, that use will be considered the prevailing way of carrying out these operations in our country, for a rather long time, in future), are indicated herein, as consisting of:

- a chain saw for felling and limbing + a tractor or a cable system for a primary transport of tree-length + a chain saw for bucking (cross-cutting) in the temporary timber-yard;
- a chain saw for felling and initial operation, within the logging area + cut-to-length machine for a haulage to the temporary timber-yard;
- a chain saw for felling + a tractor or a cable system for a haulage of full trees + a processor for a primary processing of the hauled trees.

The first machinery system is the most accessible one, being recommended for a mass introduction nowadays. The second one guarantees a higher productivity and better ecological indices in such cases, when the conditions allow an unimpeded penetration of the cut-to-length machines into the cutting area. It is recommended, main or regenerative cuttings to be thinned out in plantations where such conditions are available. The third scheme is recommended for thinning out of early cuttings, especially when the methods, provided for by the schemes, are to be applied to thinning out of such cuttings.

In a farther prospective, - when a greater volume of logging (as of 50 and more than 50 thousand m^3/year) is to be foreseen, - it will be the technology for cut-to-length obtaining and haulage, grounded on the use of a harvester and a forwarder, that should be recommended. The advantage of such a system is a high labor productivity resulting from the high grade mechanization of the processes.

The machines for cut-to-length technology are light, easy movable, being of high speed indices and improved ergonomic and ecological qualities.

CONCLUSIONS

On the basis of a number of researches, carried out for years, and of the long experience in solving the problems concerning the forestry sector, the following general conclusions can be summarized, being of a greater importance:

- As a result of the lack and the bad state of the logging and thinning machinery, and of the aggravated conditions for its maintenance and repair, the volume of the production, obtained by, drops, while the percentage of that work, where animal hauling power and manual operations are used, increases. As for its social aspect, the level of the logging operations lowers, as the working conditions get worse, and consequently, the work productivity drops.
- The analysis of the present state of the logging and thinning machinery in our country emphasize a necessity of almost a total change of the machinery, used till now. Taking into account the grave economic difficulties standing to that branch nowadays, such a problem shall be solved extremely hard, and not at once. Guidelines of priority are to be traced out for its step-by-step solving, as to guarantee a gradual introduction of modern machines and technologies into the logging, which ones to be approved as appropriate for the various conditions existing in our country.
- The renovation of the logging machinery, to begin with the skidding machines and accessories, is the very first and the most important task to be fulfilled by the companies dealing with timber production, if they aim at reaching an efficient and profitable production activity. A supply of new machinery can and must be stimulated by credit facilities, sale in installments and in other ways. Along with imported machinery, Bulgarian machines of a recent production can be used, as well, having a much lower price and a good quality. Lately, some new machines were created in Bulgaria, by our scientists and engineering companies, and being the tests come off, the introduction of these machines into the logging sector can be realized.
- The re-organization of the logging sector requires: a timber stock sale, as to be entirely bound with the market; a timely assistance of stimulating measures for updating of the logging machinery, and the application of recent technologies to the logging; the approval and the realization of a national program for development of the forest-road net; the incitement of the utilization of the wood biomass as a source of energy and for other purposes; the introduction of a modern system for exchange trade with high-grade cut-to-lengths, much in demand; a creation of an operative marketing system at the timber market, and so on.

HOLZERNTE IN BULGARIEN – ZUSTAND UND AUSSICHTEN

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ZUSAMMENFASSUNG

Die gesamte Waldfläche Bulgariens macht 4,076 Mio. ha aus, d. h. 34 % der Gesamtfläche des Landes. Davon sind 3,651 Mio. ha mit Wäldern bedeckt. Die Holzvorräte betragen 590,781 Mio. m^3, und zwar bei einem jährlichen Zuwachs von 3,9 m^3 pro ha oder einem Gesamtzuwachs pro Jahr von 14,12 Mio. m^3. Von der bewaldeten Fläche sind 30 % mit Nadelanpflanzungen und –kulturen bewachsen. Fast 55 % davon sind junge Wälder, beinahe 30 % sind 40 bis 80 Jahre alt, während die jahrhundertealten Anpflanzungen 9,2 % der Flächen einnehmen. Und in den letzten 50 Jahren wurden ca. 1,5 Mio. ha aufgeforstet.

In den letzten Jahren beträgt die durchschnittliche Gewinnung von Rundholz (liegende Masse) aus dem Waldbestand etwa 5,5 Mio. m^3, von denen 72 % für die Holzindustrie bestimmt sind und 28 % für die Bevölkerung. Diese Nutzung liegt unter dem jährlichen Waldzuwachs.

Im Hinblick auf diese Faktoren kann die Waldnutzung laut Experteneinschätzungen um 2010 8 Mio. m^3 erreichen (3,5 Mio. m^3 aus Verjüngungsschlag und 4,5 Mio. m^3 aus Erneuerungseinschlag) und um 2020 10 Mio. m^3 (5 Mio. m^3 aus Verjüngungsschlag und 5 Mio. m^3 aus Erneuerungseinschlag). Dabei werden wohl 35 % des vorgesehenen Einschlags auf Nadelwälder entfallen und 65 % auf Laubwälder.

Die Voraussetzungen, unter denen die Holzgewinnung realisiert wird, ist recht unterschiedlich, wobei der größere Teil (etwa 59 %) aus Wäldern in Gebirgsgegenden kommen, ein anderer bedeutender Teil (ca. 29 %) der Wälder liegt in hügligem Gelände und der Rest, also ca. 12 % der Wälder sind in Ebenen. Das führt dazu, dass auch unterschiedliche Verfahren und Schwierigkeiten bei der Abdeckung der dafür erforderlichen Mittel für Nutzbarmachung des Holzes vorhanden sein müssen. Der Anteil der Laubwälder beträgt 68 % der bewaldeten Flächen. Die am weitesten verbreiteten Holzarten sind dabei Eiche, Buche, Zerreiche und Weißbuche. Auf insgesamt 34 % der bewaldeten Territorien des Landes wachsen Nadelholzarten, wie Schwarz- und Weißkiefer, Fichte, Tanne, Zeder und Bergkiefer.

Mit Stand vom 01.01.2006 haben die staatlichen Wälder 76,5 % der Gesamtfläche ausgemacht, während 11,4% Gemeindeeigentum, 9,9% Privateigentum und 2,2% sonstiges Eigentum waren (Abb. 3). Der staatliche Waldbestand wird von der Landesverwaltung der Waldbestände (LW) verwaltet (72,6 %) und vom Ministerium für Umweltschutz – 3,9 % (alleiniges Staatseigentum). Derzeit kommen die Haupteinkünfte für die Forstwirtschaft aus dem Holzverkauf.

Der Holzgewinnungsprozess erfordert das Anlegen von Transportwegen und Trassen für Drahtseilbahnen unterschiedlicher Länge und Breite dazwischen; ausgewählt werden muss die Fallrichtung der Bäume, und zwar unter Berücksichtigung des Unterholzes in den Anpflanzungen, ferner das Abschlagen der Äste und das Zerteilen der Stämme im Einschlaggebiet selbst bzw. außerhalb dessen. Dazu müssen das Zubringen des Holzmaterials bedacht werden und der Abtransport aus dem gesamten Gebiet, und zwar halb oder ganz in der Luft. Einhergehend mit der Holzgewinnung erfolgt die Säuberung der Einschlaggebiete je nach Einschlagart durch gleichmäßiges Verteilen der Forstabfälle, deren Zusammenkehren zu Haufen oder in Reihen.

Abhängig von Verfahrensweise und Ort der Ausführung der Operationen im technologischen Prozess, von der Nutzungsweise der eingeschlagenen Holzbiomasse und der Art der angebotenen Produktion sind drei Holzgewinnungsverfahren bekannt, nämlich Sortimentsverfahren, Ganz – Stamm – Verfahren und Ganz – Baum – Verfahren.

Das Sortimentsverfahren, d. h. das Einschlagen von Sortimenten machte 1960 noch 94,2 % aus, während 1990 nur noch 21,8 % der Holzgewinnung nach dieser Technologie erfolgt sind. Das zweite Verfahren beinhaltet Einschlagen der Bäume und Entästung im Einschlaggebiet, sowie anschließenden Abtransport ganzer Stämme bzw. langer Stammteile zu einem vorläufigen Lagerplatz, wo dann die Sortimente zusammengestellt werden. 1990 wurden auf diese Weise 74 % der Holzgewinnung vorgenommen. Auf die dritte Art und Weise, also dem Einschlagen und Abtransport ganzer Bäume zu einem vorläufigen Lagerplatz wurden 1990 4,2 % des Holzes gewonnen, wobei dann in der Folge die gewonnenen ganzen Stämme und langen Stammteile in ständig unterhaltenen Zentrallagern bearbeitet wurden. 2005 war wiederum die Sortimentgewinnung mit einem Anteil von 77,4 % am meisten verbreitet, mit anderen Worten eine Rückführung der Situation von 1960, als der Prozentsatz der Nutzung menschlicher Arbeitskraft und tierischer Transportkapazität in der Holzgewinnung sehr hoch gewesen ist.

Bei der Wahl der günstigsten Einschlagverfahren sind die konkreten Abmessungen der dem Einschlag unterliegenden Bäume zu berücksichtigen, ferner die Mengen des pro Flächeneinheit gewonnenen Holzes, Geländevoraussetzungen und ebenso die biologischen und fortwirtschaftlichen Belange. Bei der Bewertung werden sehr viele unterschiedliche Faktoren begutachtet, wie z. B. Produktivität und Effektivität der Arbeit der Maschinen, Mindestvolumen an Handarbeit, maximale und rationelle Verwendung der Biomasse der Bäume und das Erreichen der geringsten Selbstkosten für die Produktion. Einen wesentlichen Einfluss auf die Wahl des technologischen Prozesses haben die Art und Weise der Weiterverarbeitung des gewonnenen Holzes und die territoriale Lage der Weiterverarbeitungsfirmen.

Die Verfahren zur Sortimentgewinnung im Einschlaggebiet sind für den unteren Waldgürtel geeignet, finden jedoch unter bestimmten Umständen auch in anderen Regionen des Landes Anwendung. Die Verfahren, bei denen ganze Bäume abtransportiert werden, brauchen am wenigsten Arbeitskräfte, allerdings bestehen für deren Einführung noch keine guten Voraussetzungen. In Zukunft werden sie aller Wahrscheinlichkeit nach den derzeit angewendeten Verfahren mit dem Abfahren ganzer Stämme den Rang ablaufen.

Aufgrund der hauptsächlichen Nutzung von Motorsägen beim Einschlagen und der Erstbearbeitung der Bäume, die wohl noch sehr lange die vorherrschende Art und Weise für die Ausführung dieser Arbeiten sein wird, sind folgende Maschinensysteme die geeignetsten und real ausführbaren unter unseren Bedingungen: Motorsäge zum Fällen und Entästen + Traktor bzw. Seilbahn zum Abtransport ganzer Stämme + Motorsäge zum Zersägen auf einem vorläufigen Lagerplatz; Motorsäge zum Fällen und zur Erstbearbeitung auf dem Einschlagplatz + Sortimentmaschine zum Abtransport bis zum vorläufigen Lagerplatz und Motorsäge zum Fällen + Traktor bzw. Seilbahn zur Abfuhr von ganzen Bäumen + Prozessor zu einer ersten Bearbeitung der abtransportierten Bäume.

Die erstgenannte Kombination von Maschinen ist am günstigsten und wird derzeit fast überall zur Einführung empfohlen. Die zweite gewährleistet eine höhere Produktivität und bessere ökologische Kennzahlen in den Fällen, wo die Voraussetzungen gegeben sind, dass Sortimentmaschinen in die Einschlaggebiete hineinfahren können. Empfehlenswert ist das Führen von Haupt- oder Erneuerungseinschlägen in Anpflanzungen mit derartigen Voraussetzungen. Die dritte Form wird bei der Vornahme von Verjüngungsschlag empfohlen, insbesondere bei der Anwendung von schematischen Methoden für deren Herausführung.

In fernerer Zukunft sollte bei einem größeren Volumen an Holzgewinnung (50 m^3/Jahr oder mehr) das Verfahren der Sortimente auf der Grundlage von Harvester und Forwarder für die Gewinnung und den Abtransport von Holz vorrangig sein. Die Vorzüge dieses Systems liegen in der hohen Arbeitsproduktivität, und zwar aufgrund des hohen Grades der Mechanisierung der einzelnen Arbeitsschritte.

Auf der Grundlage der durchgeführten wissenschaftlichen Untersuchungen und der langjährigen Erfahrungen bei der Lösung der Aufgaben in der Forstwirtschaft können folgende wesentlichere Verallgemeinerungen getroffen werden:

- Infolge nicht ausreichender Holzgewinnungstechnik und deren schlechtem Zustand, sowie der erschwerten Bedingungen für deren Wartung und Reparatur verringert sich der Umfang der damit gewonnenen Produktion und der relative Anteil der Arbeit mit Tiergespannen und Handarbeit wächst an. Vom sozialen Aspekt aus betrachtet verringert sich das Niveau der Arbeiten in der Holzgewinnung, da sich die Arbeitsbedingungen verschlechtern und die Produktivität abnimmt.
- Die Analyse des derzeitigen Zustandes der Holzgewinnungstechnik in unserem Land lässt die Notwendigkeit erkennen, dass die verwendeten Maschinen fast vollständig ausgetauscht werden müssen. Im Hinblick auf die ernsthaften wirtschaftlichen Schwierigkeiten, in denen dieser Zweig im Augenblick steckt, erweist sich die Lösung dieser Aufgabe als ausgesprochen kompliziert, und vor allem kann das nicht auf einmal geschehen. Abgesteckt werden müssen etappenweise Lösungen mit Prioritätsangaben, die ein allmähliches Einbringen moderner Maschinen und Technologien in die Holzgewinnung gewährleisten, die noch dazu für die unterschiedlichen Bedingungen in unserem Lande geeignet sind.
- Die Erneuerung der Holzgewinnungstechnik und vor allem der Abtransportfahrzeuge und Ausrüstung dafür ist die erste und wichtigste Aufgabe der Holzgewinnungsfirmen, wenn sie wollen, dass ihre Produktionstätigkeit effektiv und rentabel sein soll. Die Versorgung mit neuer Technik kann und muss durch Erleichterungen bei der Kreditaufnahme stimuliert werden, durch Leasingkauf u. a. m. Neben importierter Technik können auch bulgarische Maschinen genutzt werden, deren Preis bei dennoch guter Qualität niedriger ist. In letzter Zeit haben Wissenschaftler und Maschinenbaufirmen in unserem Lande zusammen einige neue Maschinen geschaffen, die die Prüfungen erfolgreich bestanden haben und die in die Holzgewinnung eingeführt werden können.
- Die Reorganisation der Holzgewinnung verlangt den Holzverkauf ab Lager, und zwar im Hinblick auf die vollständige Einbindung in den Markt; ferner die Unterstützung von Fördermaßnahmen für die Modernisierung der Holzgewinnungstechnik und die Anwendung zeitgemäßer Technologien bei der Holzgewinnung; Annahme und Realisierung eines nationalen Programms zum Ausbau des Wegenetzes in der Forstwirtschaft; Förderung der Nutzung von Holzbiomasse für die Energiegewinnung und zu anderen Zwecken; Einführung eines modernen Systems für den Börsenhandel mit wertvollen Holzsortimenten; Schaffung eines gut gehenden Systems für ein Marketing auf dem Holzmarkt und vieles andere mehr.

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НОРМИРАНЕ НА ХАРВЕСТЕРНАТА ТЕХНОЛОГИЯ ПРИ ПРОБИРКИТЕ И ОПРЕДЕЛЯНЕ НА ОПТИМАЛНИТЕ ПРОИЗВОДСТВЕНИ УСЛОВИЯ

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Извършено е нормативно проучване на харвестерната технология за харвестери от средния клас на мощност (71–140 kW), които имат 25-процентен пазарен дял от дърводобива в Чехия. Най-висока производителност на харвестера беше получена при маса 0,451–0,500 m³ на средното добито стъбло. Беше добиван смърч на проходим терен с наклон до 10%. Форвардерът показа най-висока производителност при извозно разстояние 200–400 m, средно стъбло 0,451–0,500 m³, проходим терен без препятствия и наклон 11 – 20 %.

ARBEITZEITAUFNAHME VON DER HARVESTERTECHNOLOGIE IN DER DURCHFORSTUNG UND DER VORSCHLAG DER OPTIMALEN ARBEITSBEDINGUNGEN

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Die analytische Zeitaufnahmeuntersuchung von Harvestertechnologien wird mit den Maschinen mit mittlerer Leistung (71–140 kW) gemacht, die einen 25% Anteil auf dem Arbeitsmarkt in Tschechien bilden. In Hinsicht auf die erzielte Leistung ist die durchschnittlichen Holzmasse der Stämme für die Arbeit des Harvesters 0,451–0,500 m³/St. Die Fichte sollte im Durchfahrterrain bearbeiten; bei einer Neigung bis zu 10 %. Ein Forwarder hatte die maximale Leistung bei der Abfuhrentfernung 200–400 m und bei der Holzmasse der Stämme 0,451–0,500 m³/St.; im Durchfahrterrain ohne Hindernisse; bei der Neigung 11 – 20 %.

TIME SNAPSHOT OF HARVESTER TECHNOLOGY USED FOR ADVANCE FELLING AND PROPOSAL OF OPTIMAL PRODUCTION CONDITIONS

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Abstract

Analytical analysis of time snapshots regarding harvester technology is carried out by medium-scale machines, which part of the harvester market is about 25 % in the Czech Republic. With respect to the reached efficiency in examined conditions as the optimal tree-volume was found the range 0.451 – 0.500 m³/tree. Spruce should be processed on accessible terrain with no obstacles, on terrain slope up to 10%. Forwarder reached maximum performance during the work within the distance interval 200-400 m and a mean volume of felled stems 0.451 – 0.500 m³/tree, on accessible terrain with no obstacles and on 11-20% slopes.

Einleitung

Am Anfang des Jahres 2005 arbeiteten 116 Harvestoren und 213 Forwarder in der Forstwirtschaft der Tschechische Republik. Die größte Bedeutung haben Kranvollerntern und Rückzügen von der mittleren Leistungsklasse (71–140 kW), die sich immer mehr attraktiv für eine Verwendung zu einen Nutzungen von den 4. altersmäßigen Stufen bis zu einer Endnutzug geschehen. Ein Grund ist dafür der einheitliche Rückegassenabstand während den allen Forstnutzungen. Die Entwicklung der Maschinenanzahl dupliziert die Entwicklung westeuropäischen Staaten. Bisher wurden keine Leistungsnormen von den Nutztransportmaschinen für einen Forstwirtschaftbetrieb und seine Bedingungen in Tschechien formiert. Das führt zu Einführung der Maschinen in ungeeignete Betriebsbedingungen und ein Betrieb hat geringere Gewinne bei der Nutztransporttätigkeit.

Ziel und Methodik

Das Ziel der Studie ist ein Vorschlag der Vornormen für die Harvestertechnologie und eine Festsetzung den optimalen Produktionsverhältnissen für die Erziehlung einer maximalen Leistungsfähigkeit.

Für eine Experimentalmessung wurden Nadelbeständen im Naturwaldgebiet (NWG) „Sudetské středohoří“ gewählt. Vornormen waren für die mittleren Leistungsklassen von den Maschinen erstellt. Der Vollernter war vom Typ Valmet 911.1 und die Rückzug Valmet 860. Die spezifische Natur- und Nutztransportfaktoren gestattet keine allgemeine Ausnutzung der gegenwärtigen Ergebnisse. Die Ergebnisse sind eindeutlich nur im oben genannten NWG.

Unter grundlegende konstante Faktoren waren eingereiht:

- Nutzung – die planmäßige Zwischennutzung,
- Nutztransportmaschinen – ein Harvestor und ein Forwarder von der mittleren Leistungsklasse (Valmet 911.1 und Valmet 980),
- Gehölz – die Fichte; die Vertretung mindestens 90 % an der Einschlagsfläche,
- Bodentragfähigkeit – die Tragfähigkeit mehr als 200 kPa,
- Geländegängigkeit – ein Durchfahrtsterrain (Hindernisse sind niedriger als 50 cm oder in einer Entfernung weiter als 5 m).

Variable Faktoren, die während der Untersuchung ausführlich erfassten werden:

- Durchschnittliche Holzmasse der Stämme,
- Neigung des Geländes,
- Abfuhrentfernung.

Eine Arbeitseinsatzuntersuchung wird zwischen zwei Gruppen zerteilt, d.i. die Zeitaufnahme der Arbeitstage und die Zeitaufnahme der Arbeitsvorgänge.

Eine Zeitaufnahme des Arbeitstages von einem Operator des Harvestors oder des Forwarders beinhaltet:

a) Zeit für die Arbeitsvorbereitung und die Jobbeendingung (T_{pz}),
b) Maschinenarbeit - operative Zeit (T_{o})
c) Pausenzeit und Zeit für die Hygiene (T_{opp})
d) Zeit für die Reparatur und Maschinenwartung (Tu)
e) Zeit für weitere Arbeit (T_{d})

Obengenannte Bestandteile von der Zeit bilden die Zeitaufnahme des Arbeitstages:

$$T = T_o + T_{pz} + T_{opp} + T_u + T_d \quad \text{(s)}$$

Aufgabe der Zeitaufnahmen von einem Arbeitstag ist die Entdeckung des Arbeitszeitverlustes und die Suche der Ursachen, damit wir organisatorische und technische Maßnahmen realisieren könnten, die zur Eliminierung des Zeitverlustes führen. Die Zeitaufnahmen des Arbeitstages helfen zum besseren Arbeitszeitbewirtschaftung. Zahlenmäßige Angaben von Zeitaufnahmen sind die Unterlagen für die Festsetzung der Bestandteile von den Zeitnormen. Die Zeiten werden während den Experimentalmessungen präzise auf die Sekunde genau.

Die Struktur von den Arbeitsoperationen des Harvestores

In diesem Teil sind einzelne Arbeitsvorgänge beschrieben, die den Arbeitszyklus von dem Harvester bilden.

1) Maschinenfahrt in eine neue Position (t_1),
2) Zuschiebung des Einschlagskopfs und die Klemmung des Baumes (t_2),
3) Baumeinschlag und die Bearbeitung des Baumes (t_3).

Ein Arbeitszyklus des Harvesters besteht aus obengenannteren Bestandteilen:

$$t = t_1 + t_2 + t_3 \quad \text{(s)}$$

Die Struktur von den Arbeitsoperationen des Forwarders

In diesem Teil beschrieben wir die Arbeitsoperationen des Arbeitszyklus von dem Rückzug. Wir bringen die Grenzpunkten bei, die die anfängliche Bewegung bestimmen, mit der wir die Arbeitsoperationen messen beginnen.

1) Fahrt der Maschine ohne Sortimente aus dem Abfuhrplatz im Bestand (t_1),

2) Bildung der Fuhre (t_2),
3) Fahrt der Maschine mit einer Fuhre aus dem Bestand auf einen Abfuhrplatz (t_3),
4) Ablagerung auf einem Abfuhrplatz (t_4).
Ein Arbeitszyklus des Forwarders besteht so aus oben genannten Bestandteilen:

$$t = t_1 + t_2 + t_3 + t_4 \quad (s)$$

Die Zeitaufnahme des Arbeitstages und des Arbeitsvorganges werden zusammen ergänzt. Sowohl die Aufnahme des Arbeitstages als auch des Arbeitsvorganges verbessert die Arbeitsorganisation und gibt die Unterlagen für die Vornormen.

Ergebnisse und Diskussion

Kranvollernter

Wir haben die Maschine von dem Typ Valmet 911.1 verfolgt. Messungen wurden in einem tragfähigen Terrain und in einem Durchfahrtgelände gemacht, wobei die Neigung in den Intervallen 0 – 10 % und 11 – 20 % geändert wurde. Ein Arbeitszyklus wird in drei Operationen aufgeteilt, d.i. eine Maschinenfahrt in der neue Position, eine Zuschiebung des Aggregates + eine Klemmung des Baumes und ein Baumeinschlag + eine Bearbeitung des Baumes. Der Zeitaufwand von Arbeitsoperationen des Harvesters wird in der Tabelle 1 angeboten.

Tabelle 1. Zeitaufnahme der Arbeitsoperationen des Harvesters in Abhängigkeit von der Neigung

Arbeitsoperationen	Neigung (%)			
	<= 10 %		11 – 20 %	
	Durchsch-nittszeit der Arbeitsoperation	Zeitan-teil von der Operati-on	Durchschni-ttszeit der Arbeitsoperation	Zeitan-teil von der Operati-on
	(Sek.)	(%)	(Sek.)	(%)
Maschinenfahrt in eine neue Position	15,0	13,7	13,6	11,1
Zuschiebung des Aggregates und eine Klemmung des Baumes	10,9	10,0	13,4	11,0
Baumeinschlag und eine Baumbearbeitung	83,6	76,4	94,6	77,8
Gesamtszeit eines Arbeitszyklus	109,5	100,0	121,6	100,0

Wir können eine unbedeutende Zunahme des Zeitverbrauchs im höheren Neigungsintervall sehen. Es ist 12,1 Sek. für einen Arbeitszyklus. Die Fahrt der Maschine zur neuen Position dauert bei einer Neigung von 0 – 10 % längere Zeit als im Terrain von 11 – 20 %. Andere Arbeitsoperationen werden bei einer steigenden Neigung verlängert - die Zuschiebung des Aggregates um 2,5 Sek., der Baumeinschlag und die Baumsbearbeitung um 11,0 Sec. Die statistische Analyse bestätigt keine statistische Signifikanz unter Zeitaufwand der Arbeitszyklen bei unterschiedlichen Neigungen (Tabelle 2).

Der Herstellungsvorgang beinhaltet nicht nur die operative Zeit, aber auch die andere allgemeine notwendige und unnützliche Zeiten, die in der Tabelle 3 sind. Wir haben die Harvesters- und Forwarderszeitaufnahmen der Arbeitstage gemacht. Dafür haben wir 21 Tage der Harvestersarbeitstage. Wir haben um diese Zeit die primäre Herstellungszeit verbreitet, weil sie unvermeidlich für Produktionstätigkeiten sind.

Tabelle 2. T-Test der Durchschnittszeit der Arbeitsoperationen in Abhängigkeit von der Neigung.

Durchschnittliche Arbeitszeit für eine Neigung von 0–10 %	Durchschnittliche Arbeitszeit für eine Neigung von 11 - 20 %	T-Wert	Signifikanzniveau
T-Test der Durchschnittsfahrzeiten in der neue Position			
15,0	13,6	0,60	0,548
T-Test der Durchschnittszeiten für eine Zuschiebung des Aggregates und eine Klemmung des Baumes			
10,9	13,4	-2,60	0,010
T-Test der Durchschnittsfahrzeiten für einen Baumeinschlag und eine Baumbearbeitung			
94,6	83,6	0,91	0,365

Der Durchschnittseinsatz des Harvesters ist 13,9 Stunden bei dem Einschichtbetrieb. Der größte Anteil hat die operative Zeit (78,4 %), an zweiter Stelle steht die Zeit für die Maschinenwartung und Reparatur (10,5 %), Pause (5,7 %), Zeit für die andere Tätigkeit (3,2 %) und der kleinste Anteil hat die Zeit für die Arbeitsvorbereitung und für die Jobbeendigung 2,0. Dieser Zeitbedarfe hatten keine nachweisbare Abhängigkeit von der Natur- und Geländebedingungen.

Für weitere Analysen und praktische Verwendung wird die vorgeschlagene Leistungsnorm des Harvesters im Hinblick auf die Holzmasse der Stämme präsentiert. Die Holzmasse wird in vier Intervallen im Bereich von 0,300 bis 0,500 m^3 verteilt. Die kürzte Zeit für den Arbeitszyklus ist bei dem durchschnittlichen Holzmasse des Stammes 0,300-0,350 m^3. Ein Zeitverbrauch führt zum dritten Intervall 0,401-0,450 m^3 hinauf. Danach folgen eine Stagnation und ein Sinken zum Intervall 0,451-0,500 m^3 auf 119,3 Sek. Der Grund ist wahrscheinlich eine niedrigere Baumästigkeit und die Homogenität von den produzierten Sortimenten. Der prozentuale Anteil von den Arbeitszeiten der Operationen ist in den verschiedenen Holzmasseintervallen fast konstant (ein Baumeinschlag und eine Baumbearbeitung 72,9 - 77,1 %, eine Maschinenfahrt in einer neue Position 12,0 – 16,2 %, eine Zuschiebung des Einschlagskopfs und die Klemmung des Baumes 9,6-11,1 %).

Tabelle 3. Arbeitsaufnahme des Arbeitstages

Arbeitschicht	Harvester		Forwarder	
	Durchsch-nittszeit	Zeitanteil	Durchsch-nittszeit	Zeitanteil
	(Min.)	(%)	(Min.)	(%)
Arbeitsvorbereitung und eine Jobbeendingung	17	2,0	15	1,7
Maschinenarbeit – operative Zeit	655	78,4	665	75,7
Pause und Zeit für eine Hygiene	48	5,7	40	4,6
Maschinenwartung und eine Reparatur	88	10,5	122	13,9
Weitere Zeit	27	3,2	36	4,1
Gesamtschichtzeit	835	100,0	878	100,0

Große Bedeutung hat Zeit für die Arbeitsvorbereitung und eine Jobbeendingung, Zeit für die Pause und Hygiene, Zeit für die Maschinenwartung und Reparatur usw. Die Summe ist aus der Gesamtschichtszeit 21,6 %. Weil diese Zeit erforderlich im Herstellungsvorgang ist, muss man darüber die Zeit für die eine Baumbearbeitung verbreiten (Tabelle 4). Ein Bearbeitungsnormativ von dem Nadelbaum bewegt sich dann im Intervall 0,035-0,045 NS in Abhängigkeit von der Holzmasse der Stämme (Tabelle 5).

Tabelle 5. Die Vornorm von der Nadelbaumbearbeitung

Holzmasse	Operative Zeit	Gesamtzeit für die Nadelbaumbearbeitung bei einer Zwischennutzung	
(m^3/Baum)	(Sek./Baum)	(Sek./Baum)	(NS/Baum)
0,300 – 0,350	103,3	125,6	0,035
0,351 – 0,400	130,5	158,7	0,044
0,401 – 0,450	134,0	162,9	0,045
0,451 - 0,500	119,3	145,1	0,040

Vorleistungsnormen sind in den ausgewählten konstanten Bedingungen vorgeschlagen. Nur die Geländeneigung (0-10 % und 11-20 %) war variabel. Der Einfluss der Neigung ist nicht statistisch bestätigt. Die Leistungsnormen kann man in der Forstwirtschaft von der Tschechische Republik beim motormanuellen Einschlagen regeln, wenn die Neigung des Terrains mehr als 35 % ist [1]. Die Experimentalmessungen wurden bei der planmäßigen Nutzungen durchgeführt. Die Leistungsfähigkeit bei den Zufallsnutzungen sinkt um 20 %. Der Einfluss klimatischer Bedingungen hat keine Arbeitsleistung beeinflusst, weil die Arbeit von dem Operator aus der klimatisierten Kabine gesichert ist. Wir können auch keinen Einfluss der Baummerkmale bestätigen (z.B. Ästigkeit, Fäulnis).

Tabelle 6. Zeitaufnahme für eine Bildung der Fuhre von dem Forwarder in Abhängigkeit von der Neigung

Arbeitsoperation - Bildung der Fuhre	Neigung (%)			
	<= 10 %		11-20 %	
	Durchschni-ttszeit der Arbeits-operation	Zeitanteil von der Operation	Durchschni-ttszeit der Arbeits-operation	Zeitanteil von der Operation
	(s)	(%)	(s)	(%)
	1809	54,9	1228	59,2
T-Test der Durchschnittszeit für eine Bildund der Fuhre				
Die Durchschnitt-liche Arbeitszeit für eine Neigung von 0 – 10 %			(Sek.)	1809
Die Durchschnitt-liche Arbeitszeit für eine Neigung von 11 - 20 %			(Sek.)	1228
T-Wert			(-)	3,45
Signifikanzniveau			(-)	0,001

Forwarder

Arbeitsoperationen des Rückzuges beinhalten eine Maschinefahrt ohne Sortimente aus dem Abfuhrplatz im Bestand, eine Bildung der Fuhre, eine Maschinefahrt mit einer Fuhre aus einem Bestand auf einen Abfuhrplatz und eine Ablagerung auf einem Abfuhrplatz. Primäre Faktoren sind die Abfuhrentfernung und durchschnittliche Holzmasse der Stämme. Weil wir den Einfluss von den Bestandsbedingungen verfolgen, in denen die Maschinen arbeiten, orientieren wir uns vor allem an die Zeit für die Bildung der Fuhre. Die statistische Analyse zeigt die bedeutende Differenz (das Signifikanzniveau 0,05) zwischen den durchschnittlichen Zeiten im ebenen Terrain (0–10 %) und auf der Neigungsfläche (11–20 %). Der Unterschied ist 32 % zugunsten der höheren Neigung. Markante Zeitdifferenzen von dem Arbeitszyklus (Tabelle 7) sind nicht für die Geländeneigung aber für variable Abfuhrentfernung.

Tabelle 7. Zeitaufnahme den Arbeitsoperationen des Forwarders

Arbeitsoperation	Durchschnittszeit für die Operation	Anteil der Zeit für ein Arbeitszyklus
	(Sek.)	(%)
Fahrt der Maschine ohne Sortimenten aus dem Abfuhrplatz im Bestand	251	9,6
Bildung der Fuhre	1481	56,9
Fahrt der Maschine mit einer Fuhre aus dem Bestand auf einen Abfuhrplatz	261	10,0
Ablagerung auf einem Abfuhrplatz	611	23,5
Gesamtzeit des Arbeitszyklus	2604	100,0

Die durchschnittliche Auslastung des Forwarders beträgt 14,6 Stunden. Die Arbeitszeit ist 75,7 % aus dem Gesamtschichtzeit, regelmäßige Maschinewartung und Reparaturen 13,9 %, Pausen und eine Zeit für eine Hygiene 4,6 %, eine Arbeitsvorbereitung und eine Jobbeendingung 1,7 %/ und weitere Tätigkeit 4,1 %.

Der Zeitverbrauch ist abhängig von der Abfuhrentfernung und von der durchschnittlichen Holzmasse der Stämme (Tabelle 8). Bei der höheren Holzmasse der Stämme wird der Anteil von dem Sägerundholz (Länge des Sortimentes 6 m) erhöht und der Anteil von dem Faserholz (Länge des Sortimentes 2 m) ist niedriger. Die Zeit für die Bildung der Fuhre wird erniedrigt. Die Arbeitszeit ist länger mit der wachsenden

Abfuhrentfernung. Die Maschine fuhr bei der Durchschnittsgeschwindigkeit 7,4 km/S im Bestand und 6,8 km/S zurück auf einen Holzlagerplatz.

Tabelle 8. Zeit für einen Arbeitszyklus des Forwarders – (Sek./Fuhre)

Abfuhrentfernung (m)	Durchschnittliche Holzmasse der Stämme (m^3)			
	0,300 – 0,350	0,351 – 0,400	0,401 – 0,450	0,451 – 0,500
200 – 400	2935	2563*	2426	2123
401 – 600	3213	2762	2571*	2296
601 – 800	4157	3827	3645*	2447*

* Daten von diesem Intervall waren nicht im Betrieb bewährt, das Ergebnis ist von der Approximation festgelegt.

Die Vornorm des Forwarders ist für eine Fuhre der Mittelleistungsmaschine 0,85-1,41 NS/Fuhre. Der Normativwert steigt mit niedrigeren Holzmassen und mit höheren Abfuhrentfernungen. Die mathematische Analyse empfiehlt die Normreglung, wenn die Ladung nicht gefüllt ist, und zwar die Abrechnung 5 % auf ein Viertel der Fuhre. Die Zeit der Arbeitsvorgänge wird um 36 % erniedrigt bei einer höheren Neigung. Gesamtzeit und auch das Normativ wird dann um 18 % erniedrigt. Die Experimentalmessungen wurden im tragfähigen Durchfahrtsterrain (ohne Hindernisse oder eine Schneedecke max. 20 cm) durchgeführt, wann das Normativ keine weitere Bearbeitung hat.

Tabelle 9. Vornorm für eine Fuhre des Forwarders (NS/Fuhre)

Abfuhrentfernung (m)	Durchschnittliche Holzmasse der Stämme (m^3)			
	0,300 – 0,350	0,351 – 0,400	0,401 – 0,450	0,451 – 0,500
200 – 400	1,08	0,97	0,93	0,85
401 – 600	1,15	1,03	0,97	0,90
601 – 800	1,41	1,32	1,27	0,94

Zusammenfassung

Die Zeitdaten werden Harvestoren mit mittlerer Klasse in Abhängigkeit von den durchschnittlichen Holzmaßen der Stämme in Normen gestaffelt. Die Vorleistungsnormen sind für die Durchfahrfläche und tragfähige Fläche mit maximaler Neigung bis 20 % (Geländetyp 11 und 12). Hindernisse sind max. 50 cm hoch oder sie haben den Abstand mehr als 5 m. Der Vorschlag ist für die Nadelwälder. Die Vornorme kann man nicht für die Nutzung den Randbäumen verwenden, weil sie keinen Bestandenschluss haben. Die Norm kann bei einer Zufallsnutzung applizieren werden, wenn es ähnlich von einer planmäßigen Nutzung ist. Die Normativen beinhalten keine anderen Tätigkeiten als tabellarisch sind (z.B. einen Jungholzschutz oder einen Ansamungschutz bei der Nutzung). Die niedrigste Leistung ist 11,2 m^3/ha bei der durchschnittliche Holzmasse der Stämme 0,300 - 035 m^3/St im Terraintyp 11. Maximale Durchschnittsleistung 12,2 m^3/St. war bei den gleichen Terrain- und Naturbedingungen im höchsten Intervall.

Der Forwarder hat die Vornorm für gleichen Natur- und Betriebsbedingungen wie die Harvestoren. Das Normativ ist abhängig an der Abfuhrentfernung, die wir im Bereich 200 - 800 m analysieren und an der durchschnittliche Holzmasse der Stämme, die im Bereich 0,30 - 0,50 m^3 ist. Die maximale Leistung haben wir, wenn die Abfuhrentfernung 200 - 400 m, die Holzmasse 0,451 - 0,500 m^3/St. und die Neigung 11 - 20 % sind. Die Maschine muss im tragtätigen und Durchfahrtsterrain arbeiten.

Die Normen bearbeiteten wir für die Aktiengesellschaft betreffs:

- Produktionsvorbereitung,
- Arbeitszeitschätzung,
- die Schätzung der optimalen Bedingungen für die Erreichung der maximalen Produktion bei dem Einsatz der Harvestertechnologie.

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ОТГЛЕДНИ СЕЧИ В ПЛАНТАЦИИ ОТ ЦЕННИ ШИРОКОЛИСТНИ

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В Италия на земеделски земи се създават смесени плантации от ценни широколистни (главно орех и череша), чиято техника на създаване благоприятства присъствието и на второстепенни видове. Целта на настоящата работа е да се изследват отгледните сечи в смесените плантации. Бяха проучени две орехови култури (с топола и други подходящи видове) в Ломбардия в Северна Италия. В плантацията в Казал Бутано орехът е насаден по схема 10×14 m и е комбиниран с топола (5×14 m). Между двата вида има два реда храсти (леска и бъз) и един ред елша. В редовете на ореха главният вид се редува с храсти *Eleagnus umbellata.* В плантацията в Сан Матео деле Киавике разстоянието между дърветата е 3×3,5 m. Дървесните видове са орех, топола, елша и храстът *Eleagnus umbellata.* При отгледната сеч тополата трябва да се поваля без повреди по оставащия орех. Поради различното разстояние между различните видове в двете плантации, бяха приложени различни технологии на сеч.

Бяха проведени нормативни проучвания, за да се анализират двете различни технологии. В Казал Бутано храстите от леска се режеха с резачка-дробилка, която дава стърготини за горене. При изваждане на тополата работник с моторен трион поваляше дърветата, подпомаган от багер, оборудван с товарен кран; след това дърветата бяха извозвани с тракторно ремарке. В плантацията в Сан Матео деле Киавике работник с моторен трион извършваше насочено поваляне на тополата с помощта на работник с лост за поваляне; дърветата се извличаха с трактори. Бяха изчислени производителността и разходите при двете технологии.

И при двете технологии нямаше повреди по оставащите орехови дървета. Първата технология е подходяща, когато редовете на тополата и ореха са разделени с второстепенни видове, за да се избегнат повредите, предизвиквани от багера. Втората е препоръчителна за насаждения, в които редовете на тополата и ореха следват непосредствено, без междинни редове от второстепенен вид.

LOGGING OPERATIONS IN HIGH VALUE HARDWOOD MIXED PLANTATIONS

Cavalli Rafaele, Emer Beatrice, Zuccoli Bergomi Luka, Italy

Objectives

In Italy some agricultural areas have been planted with high value hardwood mixed plantations (mainly walnut or cherry trees) realized with a technique that provides benefits also for the presence of accessory species. The purpose of this work is to study intermediate cutting operations in mixed plantations. Two different plantations of walnut (with poplar and other fitting trees), situated in Lombardia region (Northern Italy), were investigated. In Casal Buttano plantation walnut has a planting distance of 10×14 m and it is combined with poplar (5×14 m distance). Between the two species there are two shrub rows (cob hazel and elder) and a common European alder row. In walnut rows, the main species is alternated with *Eleagnus umbellata* shrubs. In San Matteo delle Chiaviche plantation the planting distance between trees is 3×3,5 m. Trees species are walnut, poplar, common European alder and a shrub *(Eleagnus umbellata).* During intermediate cutting operation poplar needs to be felled providing no damages to standing walnuts. Because of the different distance between species in the two stands, different logging methods were needed.

Methodology

Time studies were carried out to analyse two different logging methods. In Casal Buttano plantation cob hazel shrubs were cut with a cutting-chipper machine that provided biomass for heating. During poplar logging an operator with chainsaw felled the trees assisted by an excavator equipped with a loading grapple; the trees were then forwarded on a tractor bunk. In San Matteo delle Chiaviche plantation a chainsaw operator felled poplar in the right direction supported by an operator with felling lever; the trees were skidded by tractors. Productivity and costs of the two methods were calculated.

Results

Both adopted logging methods did not cause any damage to the standing walnuts. First method might be suitable when rows of poplar and walnuts are separated by an accessory species row, in order to avoid damages caused by the excavator. Second method is advisable in stands where rows of poplar and walnuts are adjacent, without any accessory species in the middle.

INTRODUCTION

In Italy cultivations of high value hardwood plantations during the last years have increased their importance because they allow diversification of the agricultural production and decrease of the surplus production together with landscape and environmental benefits. With those plantations is also possible to decrease the import of high value wood material for the furniture industries. Unfortunately it is not rare that some diseases and insects attach single-species hardwood plantations. There is also an economical disadvantage with monoculture when their assortments are not required by the market due to changes in the public demand.

The best chance to obtain high value wood is to plant hardwood mixed plantation (mainly with walnuts or cherry trees) (Buresti et al., 2001). Accessory species are planted together with the principal species. Accessory species, also called ancillary or auxiliary species or fitting trees, can be species of less value than the principal one, but useful in assisting the development of the latter and likely to influence in some degree the method of treatment. The principal species can grow in a better shape and with better wood technological characteristics if helped by ancillary species that are mainly nitrogen-fixing trees enriching the soil with nitrogen. In plantation planning is necessary to think about species that can grow together without too much competitiveness. The competitiveness varies with the environmental conditions, the distance between trees, the percentage of species and their distribution inside the planting scheme (ISS, 2006).

To obtain high value walnut trees is necessary to perform some intermediate cuttings on ancillary and principal trees that have already completed their training task on the main species and that can give some economic return to the landowner. Logging operations of accessory species should be done providing no damages to the standing trees, and especially to the principal species.

The aim of this paper is to present different intermediate cutting operations in mixed plantations, especially on poplar trees. In the study two mixed plantation of poplar and walnut with ancillary species, situated in Lombardia region (Northern Italy), were investigated. Logging operations in the two stands are different, chosen according to the different tree spacing plantation layout.

MATERIAL AND METHODS

Casal Buttano (Cremona province) plantation

In Casal Buttano plantation the principal species are walnut *(Juglans regia)* and poplar *(Poplulus sp.)*, the accessory species are common European alder (Alnus glutinosa) and three shrub species: cob hazel *(Corylus avellana)*, elder *(Sambucus nigra)* and *Eleagnus umbellata.* In this case accessory species perform the task to foster the stem lengthening with a good shape. When they finish their task they can be used as chops or chips firewood. The plantation was established in 1998 and it is made up of single species alternate rows of poplar, cob hazel, common European alder, elder, walnut, elder, common European alder, cob hazel, poplar going on subsequently. In the walnut row, walnut trees are alternated with the shrub *Eleagnus umbellata (*figure 1). The tree spacing plantation layout is 5 m on the rows and 1.75 m between rows.

The aim of the three clones (Villafranca, I 214 and BL) poplar is to produce high value assortments and to protect sideways walnuts. In 2006 cob hazel and I 214 and BL poplar clones were ready to be cut.

Poplar clones were mixed planted on the row. Time studies were carried out during their logging.

After cutting the cob hazel shrubs, the distance between poplar and common European alder rows was 3.5 m and the distance between poplar and walnuts was 7 m. So there was enough space to drive a machine in between rows. Poplar logging operations, because of space limits, should be carried out providing no damages to the walnuts. Common European alder rows acted as a protective barrier if poplar was fallen not in the proper direction.

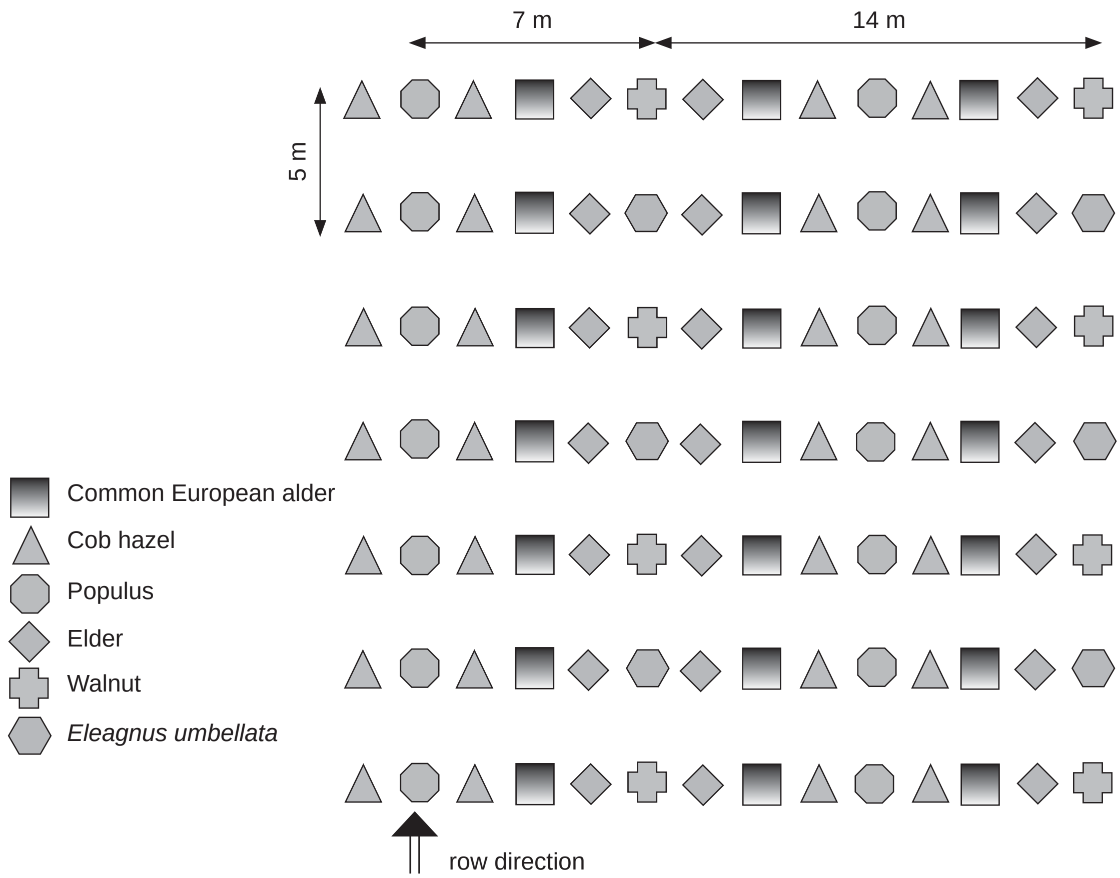

Fig. 1. Tree spacing plantation layout in Casal Buttano plantation

Time studies

In Casal Buttano plantation cob hazel was cut with a cutting-chipper machine mounted on the rear of an agricultural tractor with reversible drive. The tractor driving backwards, was going on the cob hazel long-line cutting the stems with a circular saw, chipping the wood and conveying chips directly on the trailer hooked to the tractor.

Time studies were carried out on poplar logging operations following Berti et al. (1989) methodology, consisting in separated working phases time survey.

In the first part of poplar logging a chainsaw and a tracked excavator with a loading grapple were used.

In the first passing on the row an operator with chainsaw cut trees while the excavator directed their fall with its grapple. When the tree was on the ground branches and top were delimbed. Excavator grasped and dragged the stem along the row as far as the next poplar to be fallen, laid it on the ground and helped the chainsaw operator in felling the tree. After then the two stems were dragged until the third tree, and the operation was repeated until 5 stems were piled up on the right side of the row. Stems were so piled five to five on the corridor.

The second passing on the row was backwards. The operator with chainsaw cut the butt of the stems and selected and cut the paper-mill logs from the top of the stems helped by the excavator. The machine was also moving the branches on one side of the corridor, ready to be chipped. In this way the strip was ridded.

With the third passing on the row the operator with chainsaw cut the logs into assortments and the excavator piled them.

In the second part of the logging, a tractor with a trailer was used to forward logs. The excavator loaded the same assortments of the same clone on the trailer passing on the corridor.

Villafranca clone, not ready to be cut was left on the rows. This means machine and tractor had to pass sideways, in a narrower corridor 3.5 m wide (and not 7 m).

In the productivity study the yield was calculated according to the yield table that refers to the commercial timber (timber with bark and branches up to 10 cm of diameter).

San Matteo delle Chiaviche (Mantova province) plantation

The principal species of this plantation are poplar *(Populus I 214)* and walnut *(Juglans regia)* and the ancillary species are common European alder *(Alnus glutinosa)* and the shrub *Eleagnus umbellata.*

The plantation, of about one hectare, was established in 1996. The tree spacing plantation layout is composed by hexagonal shapes with distance between two poplar trees of 12.1 m. For walnut the layout is made by two hexagonal shapes (distance 12.1 m) and combined together with the poplar layout originates hexagonal shape layouts with distance between principal species of 7 m. Considering also the accessory trees (common European alder and *Eleagnus umbellata*), the tree spacing plantation layout has a rectangular shape with a distance of 3 m on the row and 3.5 m between rows (figure 2).

The study considered only the poplar logging. Tree felling must be done very carefully because in this plantation poplar row is in between two walnut rows. Actually there were no protective barrier rows.

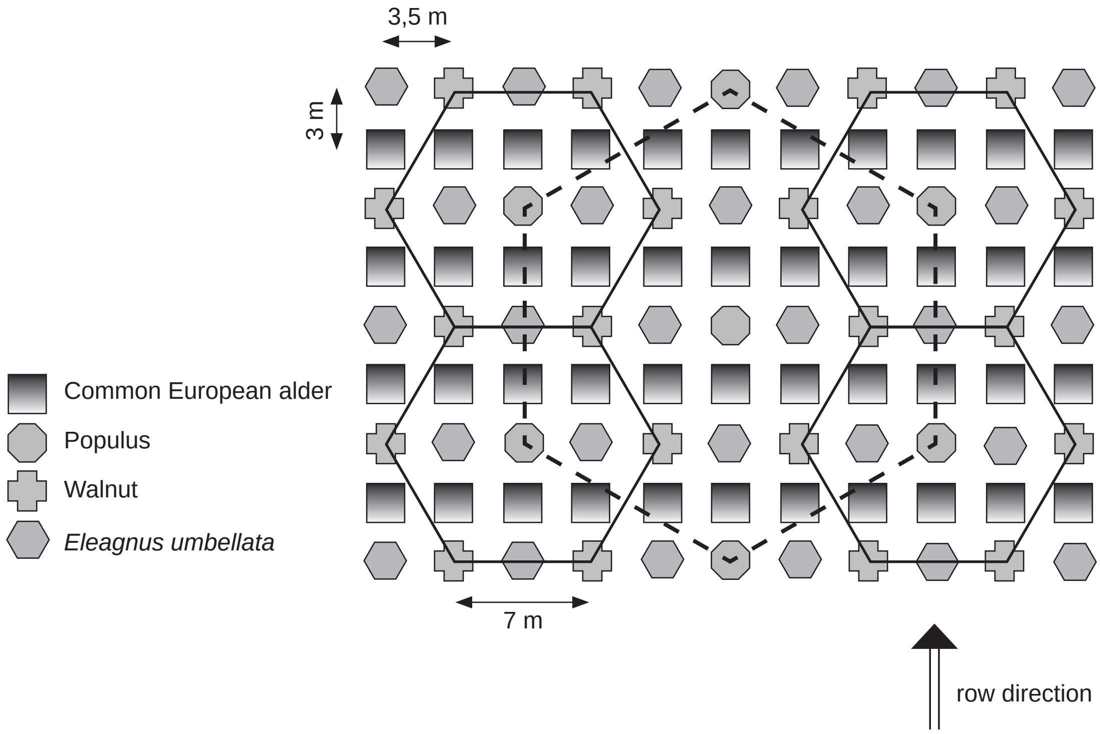

Fig. 2. Tree spacing plantation layout in San Matteo delle Chiaviche plantation

Time studies

Time studies were carried out on poplar logging operations. In the first part an operator with chainsaw felled the poplar trees in the right direction supported by an operator with a felling lever. When the tree was felled at stump, the operator with chainsaw delimbed it and cut the top. Stems (not cut into assortments) were then attached on a notched bar mounted on a tractor skidding them out of the field. Operator with felling lever provides his help also in hooking the stems. Branches and tops were left on the corridors.

The second part of the logging, considering the timber skidding was done at the same time as the cutting operations. In skidding operation three tractors equipped with notched bar on the lower arms of the three-point hitch and chains were used. Stems were hooked on the butt side and were skidded at landing, where they were measured and crosscut into assortments. Minimum forwarding distance was of 196 m and maximum was of 318 m.

The bottom part of some standing walnut was carefully protected with plastic protection to avoid accidental touching with the stems during skidding.

In the productivity study, the yield was calculated according to the yield table that refers to the commercial timber (timber with bark and branches up to 10 cm of diameter).

RESULTS

Casal Buttano plantation

Productivity of the cutting-chipper machine used on cob hazel rows was 3.8 t oven dry/hour and the machine cost was 41.65 €/t oven dry (Anonymous, 2004).

Productivity and logging costs of poplar exploitation divided into the different passes on the row are presented in table 1. For calculating the hourly cost of chainsaw and excavator used in logging the costs presented in Table 2 and 3 were used.

Table 1. Productivity and logging costs of poplar in Casal Buttano plantation. PMH means productive machine hour and SMH means scheduled machine hour

			Productivity		Logging cost	
			t/hr	trees/hr	€/t	€/tree
First step of the logging	Felling and delimbing	SMH	21.69	32.5	2.9	2.0
		PMH	26.93	40.4	2.4	1.6
	Corridor cleaning and paper-mill logs selection	SMH	20.12	28.8	3.2	2.2
		PMH	27.66	39.6	2.3	1.6
	Logs crosscutting	SMH	22.55	29	2.8	2.2
		PMH	31.51	40	2.0	1.6
Second step of the logging	Forwarding	SMH	8.2	158	9.3	0.5
		PMH	8.42	163	9.0	0.5

Table 2. Calculation of chainsaw hourly cost. The chainsaw considered is a Stihl 036, considering it is commonly used in poplar plantations. All prices are without taxes.

Costs voice	Symbol	Unit	Calculation formula	Value
Purchase price	P	€		1012
Salvage value	S	€		0
Estimated life	n	years		1.2
Daily utilization	DSH	hr		8
Yearly utilization	DY	days		210
Scheduled operating time	SH	hr	DSH*DY	1680
Average value of yearly investment	AI	€/year	P*(n+1)/2n	928
Interest rate	R	%		4
Fuel consumption rate	Fc	l/hr	0.379*power	1.288
Fuel cost at 2%	Fp	€/l		1.169
Chain lubricant consumption rate	Lc	l/hr	Fc/2	0.250
Chain lubricant cost	Lp	€/l		2.4
Operator labour and benefit cost	WB	€/hr		15.68
Fixed cost				
Annual depreciation	Depr	€/year	(P-S)/n	843
Interest cost	In	€/year	AI*R	37
Fixed cost per scheduled machine hour	OC	€/h	Depr+In/SH	0.52
Operating cost				
Maintenance and repair cost	RM	€/hr	P*0.0005	0.51

Fuel consumption cost	FC	€/hr	Fc*Fp	1.51
Oil and lubricants cost	LC	€/hr	Lc*Lp	0.60
Operator labour and benefit cost	Pc	€/hr	= WB	15.68
Operating cost per scheduled machine hour	OpC	€/hr	RM+FC+FO+FL+Pc	18.29
Total cost per scheduled machine hour		€/hr	OC+Opc	18.82

Table 3. Calculation of tracked excavator with grapple hourly cost. The hourly cost derives from the sum of the excavator, the tracks and the grapple costs. All prices are without taxes.

				Escavator	Grapple	Tracks
				Hitachi ZX 130	Tizmar TM 550	
Costs voice	Symbol	Unit	Calculation formula	Value	Value	Value
Purchase price	P	€		80000	3000	3400
Salvage value	S	€	20% P	16000		
Estimated life	n	year		7	4	3.5
Daily utilization	DSH	hr		8	8	8
Yearly utilization	DY	days		210	210	210
Scheduled operating time	SH	hr	DSH*DY	1680	1680	1680
Average value of yearly investment	AI	€/year	(P-S)*(n+1)/2n+S	52571	1875	2186
Maintenance rate	RMr	%		70		
Interest rate	R	%		7	7	7
Taxes and insurance rate	ITGr	%		8		
Fuel consumption rate	Fc	l/hr		12		
Oil consumption rate	Lc	l/hr		0.35		
Fuel cost	Fp	€/l		0.9		
Oil cost	Lp	€/l		2.08		
Operator labour and benefit cost	WB	€/hr		18.08		
Fixed cost						
Annual depreciation	Depr	€/year	(P-S)/n	9143	750	971
Interest cost	In	€/year	AI*R	3680	131	153
Taxes and insurance rate	ITG	€/year	AI*ITGr	4206		
Fixed cost per scheduled machine hour	OC	€/hr	Depr+In+ITG/SH	10.1	0.5	0.7
Operating cost						
Maintenance and repair cost	RM	€/hr	(Depr*RMr)/SH	3.8		
Fuel consumption cost	FC	€/hr	Fc*Fp	10.8		
Oil and lubricant cost	LC	€/hr	Lc*Lp	0.73		
Operator labour and benefit cost	Pc	€/hr	= WB	18.08		
Operating cost per scheduled machine hour	OpC	€/hr	RM+FC+LC+Pc	33.4		
Total cost per scheduled machine hour		€/hr	OC+OpC	43.6	0.5	0.7

During the poplar logging no walnut tree was damaged. In the loading operation a lot of time was devoted for moving. The excavator was loading first one assortment and then the other one, so the productivity was not so high.

San Matteo delle Chiaviche

In Table 4 are presented results of productivity and logging costs of the two steps of the poplar logging.

Table 4. Productivity and logging costs of poplar in San Matteo delle Chiaviche plantation. PMH means productive machine hour and SMH means scheduled machine hour

			Productivity		Logging cost	
			t/hr	trees/hr	€/t	€/tree
First step of the logging	Felling and delimbing	SMH	11.18	25	3.4	1.5
		PMH	15.13	34	2.5	1.1
Second step of the logging	Skidding	SMH	6.01	16	7.4	2.8
		PMH	6.72	18	6.6	2.5

CONCLUSIONS

Different logging systems are adapted to different tree spacing plantation layouts. Logging costs in the phases of felling and delimbing show not too different values. The choice of one or the other method must not consider logging cost but only the plantation layout.

If the poplar row is next to one with walnut, is recommended to do not use the excavator. On the contrary the machine can be used in plantation with a protective row in between walnut and poplar.

In Casal Buttano plantation, some poplars fell down on alder trees, probably because of lack of skill of the chainsaw operator, but they did not cause any damage to the walnuts. In San Matteo delle Chiaviche plantation no poplars caused damages to the walnuts, probably because of the skilfulness of operators. If poplar and walnut rows are close to each other employing skilled operators is essential.

In Casal Buttano plantation poplar clones were mixed in the rows and this caused waste of time in loading and forwarding timber. Moreover where Villafranca clone (which was not cut) was present it was necessary to pass slower in a narrower corridor. This problem can be avoided just planting the same clone on the row.

Skidding whole stems with tractors in San Matteo delle Chiaviche plantation was a good solution because it would have been much more difficult to forward assortments considering the lack of space to manoeuvre machines. Less operations in the plantation means less risk causing damages.

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ПРОУЧВАНЕ НА ПОВРЕДИТЕ ПО ПОЧВАТА И РАСТИТЕЛНОСТТА ПРИ ИЗВОЗ С КАТЪРИ В СЕВЕРЕН ИРАН (НОУШАХР)

Мохамад Реза Гафариян, Хушанг Собхани, Мохамад Реза Марви Мохаджер, Иран

Използването на катъри в дърводобива се практикува в Иран от незапомнени времена. Извозът с работен добитък се смята за една от технологиите с ниско равнище на повредите. За да определим повредите от извоза с катъри, на един представителен извозен път бяха измерени повредите по младите растения преди и след извоза, както и уплътняването и pH на почвата. От разположените на пътя млади растения 27% се оказаха повредени, 31% бяха напълно унищожени. Относителната плътност на почвата се оказа увеличена с 14 %, но pH не показа значима разлика. В 218 подотдела в района на изследванията беше определена общата площ на извозните пътища, местата за първична преработка и временните складове, което показа, че 5,72% от площта беше с повреди от дърводобива.

STUDY OF SOIL AND SEEDLINGS DAMAGES BY MULE LOGGING – A CASE STUDY IN NORTHERN FORESTS OF IRAN (NOWSHAHR)

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Abstract

Animal logging is one of the low impact logging systems. Mule logging has been in use many years ago in Iran. In order to estimate site damages by mule logging, in a sample skid trail, seedlings, soil compaction and pH were measured pre- and post-harvesting. 27% of the seedlings were damaged, 31% were completely destroyed and relative soil compaction increased by 14.14% but pH did not have significant difference. In 218 compartment of research area, the area of total skid trails, processing areas and landings of mule logging were surveyed, 5.72% of the compartment area was damaged by mule logging.

Introduction

Animal logging is a traditional forest harvesting system. There are an estimated 300 million draught animals in the world such as oxen, horses, mules, elephants and lamas [2].

Mule logging was studied in the east of Alabama in the mixed stands, the results showed that damages to skid trails was low and approximately 2 inches of the soils was disturbed and some of trees were damaged. The most damages to the residual trees included broken branches by tree felling [9].

Residual stand damages in selective cutting by two skidding systems were studied in the Missouri Ozark. The area of mule skid trails was 1% of the area of the logging unit, for the skidders was 4.6% [3].

The results indicated that the physical soil properties mostly depend on the amount of disturbance. The soil disturbance was higher in machine skidding [10].

Another research was carried out about "Production Study Horse and Mule Logging ", the results showed that the soil disturbance was low in horse logging in the mineral soils [7].

The logging damages were studied by Ahmadi H. in the forests of Northern Iran (Lavidj, Amol), 27.1% of total damages to the stands was occurred by Mule Logging [1].

Mule logging damages including damages to seedling and standing trees was studied in Rouyan forests, 5.14 % of seedlings were grazed, 4.2 % of saplings were curved, 7.4% of the stems of the saplings were wounded and 4.2% of the seedlings and yearlings were destroyed. 5.1% of the samples had first grade wound, 8.29% second grade and 7.59% third grade [8].

Production- cost of mule logging in Iran was studied [4], production in firewood hauling was 2.135

m^3/h, firewood hauling with special equipment 3.275 and pulpwood hauling 1.246 m^3/h, costs according to contract were; 1.67 US dollar/ m^3, 1.09 US dollar/ m^3 and 3.58 US dollar/ m^3 .

The site damages by mule logging have not been studied in the study area. This study presents the changes in soil properties, seedlings damages and amount of disturbed area cased by mule logging which would be helpful in logging planning to reduce site disturbance.

Method of Study

Sites of study:

The first study site was 218 compartment of Namkhaneh district of Research and Training Forest Center of Nowshahr in the Northern Iran. The harvest area was 31.5 ha. Minimum and maximum elevations above sea level were 1100 and 1260 meters, respectively. General slope was 30% and the aspect was west. Soil was washed brown and forest type was fageto-carpinetum. Standing volume per hectare was 441.8 m^3 [6].

The second study site was 114 compartment of the Patom district .The area was 38.4 ha, min. and max. height above sea level was 650 and 750 m . General slope was 35%, general aspect was north, soil brown, forest type fageto-carpinetum and standing volume/ha was 324 m^3 [5].

Climate of Study site:

There is no climate data available in these forestlands, but according to the meteorology station in Nowshahr, the warmest month was July with average temperature about 24.6 $^{\circ C}$ and coldest month was February with an average temperature of about 7.5 $^{\circ C}$. The greatest monthly rainfall was 237.6 mm in October, and lowest rainfall was 475 mm in June.

Work Organization

The work team includes a mule, a worker for loading with hand and a teamster. The pulpwood, lumber or firewood is fasten with a rope to the saddle of mules (Fig. 1). For firewood extraction, special V-shape woody instrument may be also used (Fig. 2). Sometimes, two or three mules may be connected by a rope. The important point in mule logging in Iran is that firewood and pulpwood are hauled over the mule saddle, the woods are not skidded. The maximum payload is about 120 kg. The mules are not as strong as horses or mules used in the other countries.

The mule logging is used in these situations; when no skid trail is available for using skidders or tractors, when the cut volume is not so high or timber is scattered in the compartments, when the logging area is too steep and using tractors is not possible, also after extracting the sawlogs by mechanized systems, firewood or pulpwood are extracted by mules.

Fig. 1. Extraction of pulpwood by mules

Fig.2. Using Vshape instrument to extract firewoods

Data Collection

In order to determine damaged area caused by mule logging, in the 218 compartment all of the skid trails, processing sites and landings were surveyed.

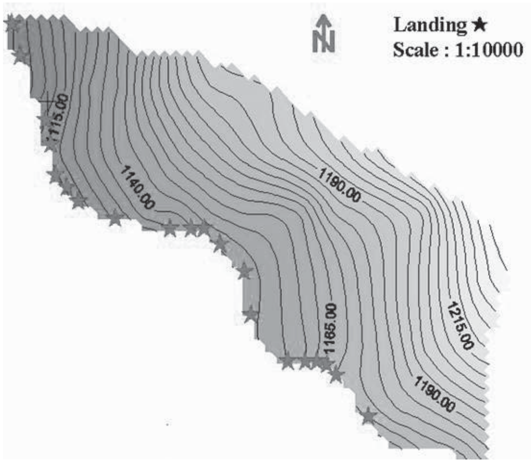

Fig. 3. Map of 218 compartment and location of landings of mule logging

The results of surveying of skid trails and landings are showed in the Table 5.

In the 114 compartment before skidding, in a distinct skid trail with 45 m length and 5 m width, all of the seedlings were inventoried and classified according to height ($h<30$ cm, $30<h<130$ cm, $h>130$ cm). This inventory of seedlings in pre- and post- hauling was carried out in November (autumn).

After the pulpwood and firewood were extracted by mules (post-hauling), seedlings in the skid trail were inventoried and classified again according to mentioned classifications; furthermore, the seedlings were characterized by wound type such as health, wound (less than 30% of the height of stem and some leaves were damaged), semi- wound (from 30% to 50% of the height of stem and most of leaves were damaged), broken top (the crown of sapling was broken), crushed (the stem and crown of saplings were completely damaged and crushed) and grazed by mules.

In order to determine the degree of soil compaction based on a random systematic sampling method, the soil samples were collected in 5 m distance from each other. 10 soil samples were collected for

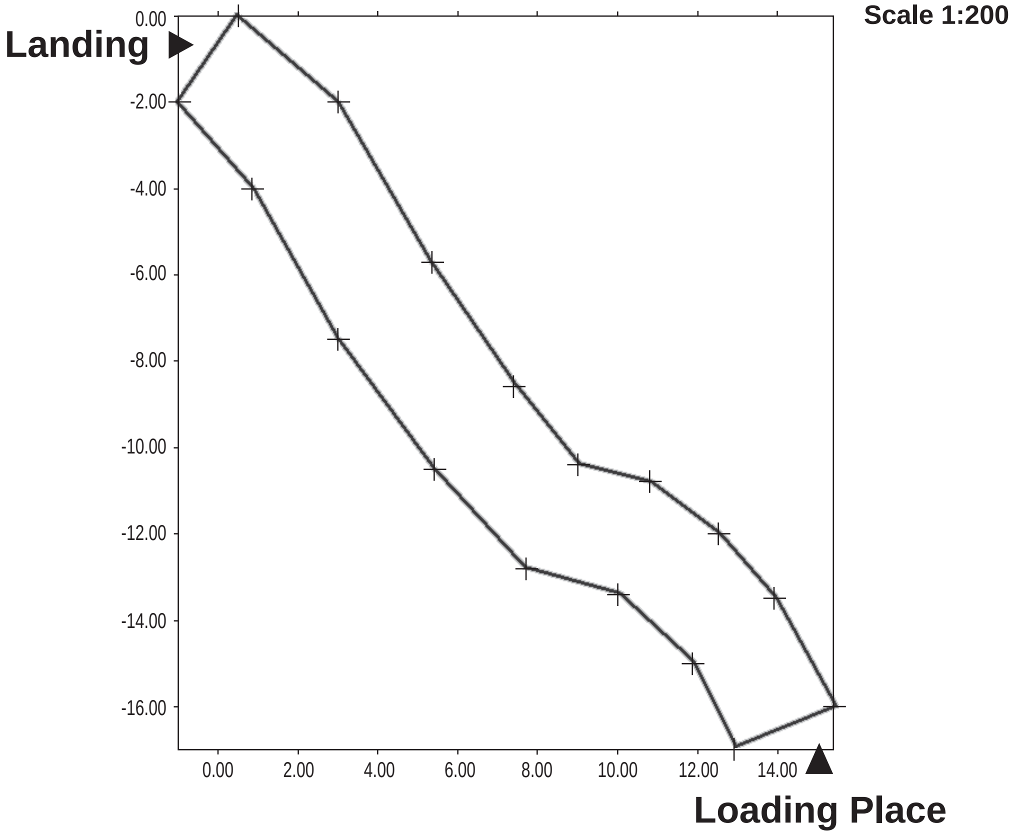

Fig. 4. Skid trail of mule logging in 114 compartment

compaction tests and 5 samples for determining pH changes in pre-hauling and post-hauling period. The number of trips was 28 in the skid trail.

To determine relative compaction, dry density (g/cm^3), moisture content percentage, optimal water and maximum dry density were measured in the 10 soil samples, then using this formula, relative compaction was calculated:

$$RC = \frac{\gamma_d}{\gamma_{d\max}} \times 100$$

RC : Relative Compaction (%)

γd : dry density (gr/cm^3)

$\gamma d max$: maximum dry density(gr/cm^3)

It should be noted that we could not determine the actual soil compaction by mule logging because the harvesting area was not completely undisturbed.

Results

All skid trail, processing sites and landings in 218 compartment were surveyed. The results of surveying of skid trails and landings are showed in this table.

Table 5. The information of damaged areas by mule logging in 218 compartment

Total damaged area (m^2)	Damaged area (%)	Mean area of the skid trails (m^2)	Mean area of processing site (m^2)	Mean area of landings (m^2)	Mean width of the skid trails (m)	Mean length of the skid trails (m)
18018.12	5.72	291.08	298.9	291.08	4.58	54.38

The disturbed area is 5.72% of logging block; also the average of skid trail is more than skid trail width of skidders which is about 3.5 m.

Table 6. Pre-hauling (harvest) regeneration results in the skid trail (114 com.)

Percentage of class h>130 cm	Percentage of class 30<h<130 cm	Percentage of class h<30cm	Number of seedlings
1.28	47.8	50.9	546

Table 7- Post- hauling (harvest) regeneration results in the skid trail (114 com.)

Percentage of class h>130 cm	Percentage of class 30<h<130 cm	Percentage of class h<30cm	Number of seedlings
9.02	40.3	50.66	377

The skid trail in 114 compartment had the area of 239.5 m^2. Number of seedlings decreased from 546 to 377 which means 30.95% of the seedlings were destroyed by mule logging in this skid trail.

Table 8- Number and Percentage of damaged seedlings in the skid trail in 114 com.

Damage type	crushed	Broken top	Semi-wound	wound	grazed
number	10	9	36	71	15
%	1.38	1.65	6.59	13	2.75

The results of table 8 indicate that most of damages cased by mule logging are related to wound and Semi-wound classification.

Table 9. Soil properties in the skid trail in 114 compartment (for 28 cycles of hauling by one mule)

	pH	Mean of dry density (gr/cm^3)	Percentage of Moisture	Maximum of dry density (gr/cm^3)	Percentage of optimal water	Mean of relative compaction
Pre-harvest	5.512	1.135	21	1.61	16	70.49
Post- harvest	5.49	1.371	21.55	1.62	18	84.63

Mean of relative compaction was increased by 14.14% after hauling, and using Two-Sample Analysis method by Statgraph Software the mean of relative compaction in pre and post- harvest had significant increase at $\alpha=0.01$. But pH did not change significantly after mule logging.

Discussion

Disturbed sites including skid trails, processing sites and landings are so scattered, 5.72% of the logging area was disturbed although in Missouri Ozark, only 1% of site damages cased by mule logging [3]. There was 20 landings and a lot of skid trails in 218 compartment, so it is necessary to plan skid trails and landings for mule logging to decrease the soil and stand damages, the width of skid trails should be more limited and mule loggers must use the planed trials.

The results of the comparison of soil compaction and pH in Pre and Post harvesting period indicated that relative compaction increased by 13.8% but pH did not have a significant difference. Because the dry density of soil depends to the soil genus and the soil moisture, we proposed to study the other logging sites with different soils in order to determine physical, mechanical and chemical changes, the number of hauling cycles to determine maximum soil compaction should be appointed.

It is needed to carry the research plans on the comparison of mechanized logging systems (ground based systems and cable systems and animal logging systems) based on economical and environmental issues.

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ПОЛЗВАНЕ НА ДЪРВА В БЪЛГАРИЯ

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Дървата са значителна част от ползването в горите в България. От тях близо половината се използва за енергийни цели, предимно като дърва за горене в домакинствата. Промишленото добиване на енергия от дърва се ограничава с оползотворяването на кората и технологичния отпад в дървопреработвателната индустрия. Коефициентът на полезно действие на печките и отоплителните агрегати на населението е сравнително нисък – до 60%. Въпреки че някои от тях са доста усъвършенствани, те дават топлина само за домакински цели, но не за стопански. Въз основа на тези факти може да се прогнозира появата и динамичното развитие на пазар за битови и промишлени агрегати, работещи със стърготини. Това развитие ограничава зависимостта на България от внос на енергия и употребата на невъзобновяеми енергоизточници и ще срещне енергичната потреба на Европейския съюз.

DIE BRENNHOLZNUTZUNG IN BULGARIEN

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Abstrakt

Mit seinen 110 000 km^2 ist Bulgarien etwas größer als Bayern. Es ist ein Land mit vielen Gebirgen und einer Bevölkerung von 7,5 Mio. Über 60% der Befölkerung wohnt in den Städten. Seit etwa 1980 erlebte das Land eine wirtschaftliche Stagnation, gefolgt in den 90-er Jahren von einer tiefen Rezession, die sich unter allem durch die indirekten Folgen des jugoslawischen Krieges ergab (allerlei Exporterschwernisse, keine Investitionen). Nach 2007 wird sich das Investitionsklima vermutlich radikal verbessern.

Bulgarien hat 4 Mio. ha Wald, davon 1,3 Mio. ha Nadelwald. Der Gesamtvorrat beträgt 526 Mio. Vfm, der jährliche Zuwachs 4,03 Vfm/ha/j, die jährliche Nutzung beträgt 4.6 Mio Vfm. 78% der Waldfläche gehören dem Staat. Die Forstwirtschaft ist rentabel.

In den letzten 5 Jahren wachsen die Brennholzpreise in Bulgarien mit 5 BGN (=2,5 EUR) jährlich. Die Brennholz-Preiserhöhung ist überdurchschnittlich – die Brennholzpreise wachsen schneller als die Preise der anderen Treibstoffe. Trotzdem bleibt Brennholz die billigste Energie (Abb. 2). Daraus ergibt sich die Prognose: weitere Preiserhöhung und verstärkter Holzeinsatz für die Energiegewinnung. Das Holz dafür ist da. Bulgarien nutzt nur etwa 1/3 vom jährlichen Zuwachs (Abb. 3). Das ergibt sich aus der ungünstigen Altersstruktur des bulgarischen Waldes (Abb. 5), aber auch durch die Ausrichtung der Forstwirtschaft auf das Stammholz (Abb. 4). Brennholz wird als Nebenprodukt des Stammholzes betrachtet. In dieser Denkweise macht sich ein Wandel bemerkbar. Aus Abb. 5 ist ersichtlich, dass die bulgarischen Vorräte ganz überwiegend im Vornutzungsalter sind und daher für Stammholz zu jung. Eine Schwerpunkt-verlagerung in Richtung Energie könnte jedoch das Urteil anders fallen lassen.

Der Einsatz von Energieholz wird anjetzt von der Technologie gehemmt. Es wird vorwiegend für Haushaltszwecke eingesetzt, abgesehen von den Holzabfällen in den holzverarbeitenden Betrieben. Die verwendeten Öfen können ziemlich sophistiziert sein. Der Ofen auf Abb. 8 dient als Küchenherd, heizt 2 Wohnräume und einen Warmwasser-speicher. Sein Nutzeffekt ist jedoch nur 60%. Die weiteren Energiebedürfnisse eines Familienbetriebes kann er nicht befriediegen.

Das Verhältnis Nutzung : Zuwachs besagt, dass Bulgarien seine Nutzung dramatisch erhöhen kann, wenn das Energieholz eine Vorrangigkeit erlangt. Die Brennholzpreise steigen schon dramatisch seit einigen Jahren. Ein Einsatz von besseren Technologien (Hackschnitzelaggregate u.ä.) kann diesen Vorgang nur beschleunigen.

Allgemeines

Mit seinen 110 000 km^2 ist Bulgarien etwas größer als Bayern. Es ist ein relativ kleines Land mit vielen Gebirgen und einer Bevölkerung von 7,5 Mio., d.h. nicht so dicht besiedelt wie Mitteleuropa. Trotz seiner südlichen Lage hat es ein gemäßigtkontinentales Klima mit heißem Sommer und kaltem Winter und einem Jahresdurchschnitt der Temperaturen von 9,2°C. Bei diesem Klima müssen Wohnräume und Arbeitsräume 5 bis 6 Monate im Jahr geheizt werden. Die Bauernbevölkerung hat immer vorwiegend mit Holz geheizt. Steinkohle kommt seit der Nachkriegszeit auch in Frage. Das Stadtvolk (etwa die Hälfte der Bevölkerung) rechnet dagegen auf Dampfheizung und elektrischen Strom. In den letzten Jahren wird jedoch die Dampfheizung zunehmend zugunsten dem Brennholz aufgegeben ? sie ist teuer geworden. Man schätzt ein, dass 40?50% der bulgarischen Stadtbevölkerung schon mit Brennholz heizt.

Das Brennholz ist eines der sehr wenigen naturfreundlichen Brennstoffe, die unsere Umwelt nicht belasten. Sein Schwefelgehalt ist praktisch Null und sein Stickstoffgehalt beträgt weniger als 1% seiner Masse. Dementsprechend entstehen bei seiner Verbrennung sehr wenig schädliche Schwefel- und Stickstoffoxide. Letzteres ist besonders wichtig angesichts der Verpflichtung, die sich aus der bulgarischen Unterschrift unter dem Kyoto-Protokoll ergibt, die anthropogenen Emissionen von Treibhausgasen um 8% zu verringern, bezogen auf ihr Niveau im Jahre 1988.

Ein weiterer wichtiger Umstand ist, dass Bulgarien nach der offiziellen Statistik über 70% seiner primären Energieressourcen importiert. Nach wie vor rechnet Bulgarien auf russische Brennstoffimporte – Erdöl, Erdgas, hochwertige Steinkohle und Kerntreibstoff. So eine Struktur der Energiebilanz ist besorgniserregend hinsichtlich der Sicherheit der Energieversorgung. Deswegen richtet die "Energetische Strategie der Republik Bulgarien", die auf Antrag der Regierung vom Parlament am 17. Juni 2002 angenommen wurde, eine besondere Aufmerksamkeit auf die wiederherstellbaren Energiequellen des Landes, d.h. auf das Brennholz und Wasserkraftwerke.

Der Energiewert des bulgarischen Waldes

Nach der Forststatistik des Jahres 2005 beträgt die gesamte Waldfläche Bulgariens 3.900.000 ha oder 35% der Landesfläche, davon 1.300.000 ha Nadelwald, 800.000 ha Laubhochwald, 1.000.000 ha Überführungswald, 700.000 ha Umwandlungswald und 100.000 ha Niederwald. Überführungswald sind die in Hochwald zu überführenden Stockausschlagbestände. Umwandlungswald sind die verlichteten oder aus anderen Gründen als minderwertig eingestuften kurzfristig abzutreibenden und künstlich zu verjungenden Bestände. Unter Niederwald versteht man in Bulgarien die Robinienplantagen, die durch Stokausschlag verjüngt werden.

Von der ganzen Waldfläche sind 3.400.000 ha bestockt mit einem Vorrat von 526.000.000 Fm. Der jährliche Zuwachs beträgt 13.700.000 Fm. Der durchschnittliche Hektarvorrat beträgt 154,8 Fm/ha und der jährliche Zuwachs 4,03 Fm/ha/j. Der nachhaltige Hiebssatz nach den Betriebswerken beträgt 6.800.000 Fm/J, oder 1,3 % vom Gesamtvorrat, oder 49,7% vom jährlichen Zuwachs. Die tatsächliche Nutzung beträgt 4.629.000 Fm oder 0,88% vom Gesamtvorrat und 33,8% vom jährlichen Zuwachs. Daraus ist ersichtlich, dass Bulgarien über 66% vom Zuwachs nicht nutzt, oder 2.200.000 Fm jährlich. Das ist ein Ergebnis der ungünstigen Altersstruktur (wenig hiebsreife Bestände, viele junge und mittleren Alters). Die üblichen Umtriebszeiten sind 100-120 Jahre, 80 bei den Überführungsbeständen, 15 bei der Pappel.

Von der gesamten bestockten Fläche von 3.400.000 ha gehören 78% dem Staat, 9% den privaten Waldbesitzern, 7,5% den Gemeinden und 5,5% gehören anderen juristischen Personen oder Körperschaften.

Die Wälder der unteren Wuchszone (Ebenen, Hügelland und Gebirgsfüße unter 600 m) sind 46% aller Wälder. Das sind vorwiegend Stockausschlagbestände der Eiche und künstliche Nadelwälder. Charakteristisch für die Wälder der unteren Wuchszone ist ihre besondere Bedeutung für die Umwelt (weil sie im dicht besiedelten Raum gelegen sind), ihre besondere Bedeutung für die Brennholzversorgung (weil Brennholz in der Regel lokal verbraucht wird) und ihr schlechter Zustand. Der schlechte Zustand ergibt sich zuerst aus ihrer Zugänglichkeit, die mit Übernutzungstendenzen, Waldfrevel und Waldbrandschäden verbunden ist. Darauf folgen die klimatischen Faktoren: die untere Wuchszone ist in Bulgarien zugleich die untere Kampfzone des Waldes, wo er überdurchschnittlich an Trockenjahren, Insektenkalamitäten und Pilzinfektionen leidet. Die Auswirkungen der klimatischen Faktoren werden zusätzlich durch die Eigentumsstruktur verstärkt (viel Privat- und Gemeindewald und daher Durchforstungsrückstände, Schnee- und Eisbruchschäden).

Nach der offiziellen Statistik werden jährlich ca. 2 Mio. Fm Schichtholz veräußert, die Hälfte davon in der unteren Wuchszone. Die zweite Hälfte des Schichtholzes kommt aus den Gebirgswäldern, bei denen vorwiegend Stammholz aufgearbeitet wird, aber auch Schichtholz als Koppelprodukt. Der jährliche Absatz von Industrieholz beträgt weitere 1 Mio. Fm pro Jahr. Die Exporte von Schichtholz und Industrieholz nach den benachbarten Ländern (Türkei, Griechenland und Mazedonien) belaufen sich auf 0,4 Mio. Fm. Weitere 0,1 Mio. Fm (geschätzt vor der Pyrolyse) werden in der Form von Holzkohle nach manchen EU Ländern exportiert. Schließlich beläuft sich die gesamte Produktion von Schicht- und Industrieholz auf 3,5 Mio. Fm jährlich.

DIE ENERGETISCHE VERWERTUNG DES HOLZES IN BULGARIEN

Brennholzverwertung durch die Bevölkerung

Der größte Teil des Holzes, das in Bulgarien für Energiegewinnung verbraucht wird, wird als Brennholz verbrannt. Dazu werden einfache Heizöfen (Küchenherde) mit einem horizontalen Rost und manueller Ladung verwendet. Auch die vertikalen “Schützengrabenöfen,” die von oben geladen werden, sind bekannt (Abb. 1, Bilder 1 und 2).

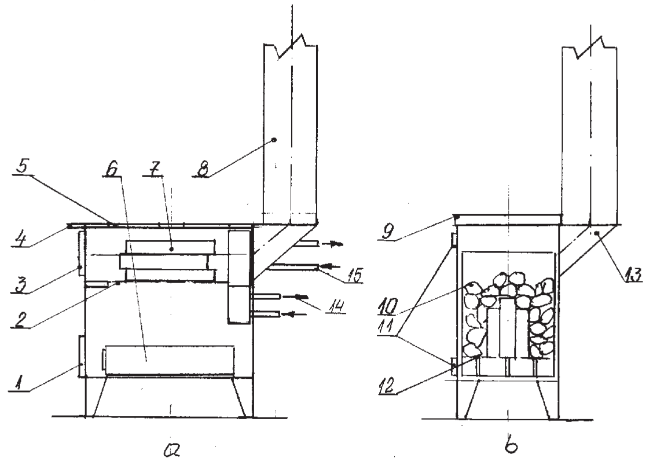
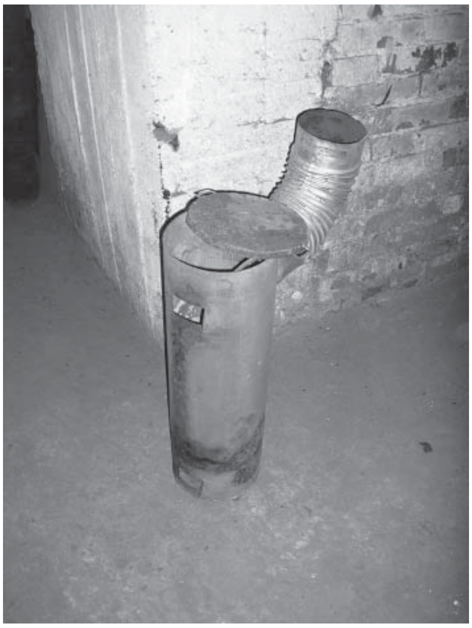


Abb.1

Herkömmliche eiserne Heizöfen, verwendet in Bulgarien.
a) Küchenherd mit horizontalem Rost b) vertikaler Ofen.

(Bild 1) Küchenherd



(Bild 2) Vertikaler Ofen

Die Küchenherde mit horizontalem Rost (Abb. 1a und 2) bestehen aus einem Metallkasten, der von einem Rost aus Gusseisen in zwei Räume eingeteilt wird: Verbrennungskammer und Aschenbehälter. Von oben ist der Ofen von einer Gusseisenplatte abgedeckt. In der Seitenwand gibt es zwei Öffnungen, die mit den Gusseisentüren (1) und (3) zugedeckt werden. Die Türen haben Belüftungsöffnungen, die die Steuerung des Brennvorganges durch Veränderung ihrer Fläche ermöglichen. Durch die Türe (3) wird manuell das Brennholz (7) geladen. Die durch seine Verbrennung entstehende Asche fällt in den Aschenbehälter (6) heraus. Der Wärmeaustausch erfolgt über die Gusseisenplatte (5), auf welcher die thermische Bearbeitung der Nahrung erfolgt. Die Abgase werden durch das Gasrohr (8) und den Schornstein abgeleitet. Zur thermischen Bearbeitung der Nahrung ist auch die Seitenkammer bestimmt. Die meisten Modelle sind mit Rohrschlangen aus gerüstet; eine größere, die über elektrische Pumpen (Bild 3), eine Rohrleitung (Bild 4) und einen Heizkörper einen Wohnungsraum durch einen Wasserkreislauf heizt und eine kleinere, die einen Warmwasserspeicher zum Waschen versorgt.

(Bild 3) Kuchenherd, elektrische Pumpe

(bild 4) Kuchenherd, Rohrleitung

Mit seiner Verbrennungskammer von 0,03 m^3 und seinem Gasrohrdurchmesser von 0,20 m ermöglicht der Ofen die Heizung einer Wohnung mit einer Wohnfläche von 45 m^2 und einem Volumen von 112 m^3, d.h. der Wohnung einer durchschnittlichen Familie aus 4 Personen, die Zubereitung ihrer Nahrung und die Versorgung mit Warmwasser für die Zwecke des Alltags. Im Herbst und im Winter verbraucht so ein Herd 8 bis 10 Fm trockenen und halbtrockenen Holzes.

Die vertikalen Öfen (16) bestehen aus einem Blechzylinder mit einer Gasableitungsöffnung (13). Das Heizmaterial – Holz, Steinkohle oder beides, kommt in eine zylindrische Kassette. Die Asche fällt durch das Gitter (12). Die Verbrennung wird durch Veränderung der Fläche der Belüftungsöffnungen (11) gesteuert. Die Heizkammer wird mit dem Deckel (9) zugedeckt.

Die vertikalen Öfen werden hauptsächlich für die Heizung von Arbeitsräumen verwendet.

Charakteristisch für die herkömmlichen Heizgeräte ist ihr geringer Nutzeffekt ? nicht höher als 60%. Er hängt hauptsächlich vom Heizmaterial – Feuchtigkeit, Aschenbildung und chemische Zusammensetzung. Optimal ist die Feuchtigkeit von 28?30% und der Aschengehalt unter 5%. Die optimale Feuchtigkeit erzielt man im Alltag, indem man feuchte und trockene Holzstücke mischt. Sie sind in der Regel gelichzeitig vorhanden. Eine Familie besorgt 8 bis 12 Fm Brennholz, das sie einschneiden, spalten und bis zum nächsten Jahr troknen lässt (Bild 5 und 6). Man lagert das Holz in Wandnischen oder in Stößen (Abb. 2). Günstiger sind die Stöße (Abb. 2b, Bild 8), bei welchen für die Austrocknung sowohl die Sonne als auch der Wind beitragen. Die Nischenlagerung, die weniger Platz beansprucht, ist für die Stadtbevölkerung typisch (Abb 2a, Bild 7).

Bild 5. Eingeschnittenes Brennholz (30cm Stücke)

Bild 6. Spalten des eingeschnittenen holzes

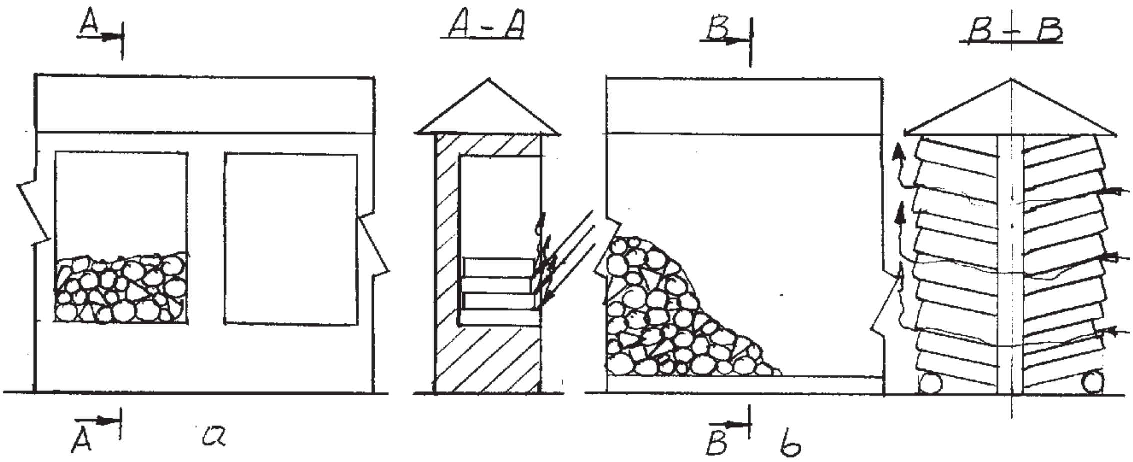


Abb.2

Holzlagerung. a) Nischenlagerung b) Stoßlagerung

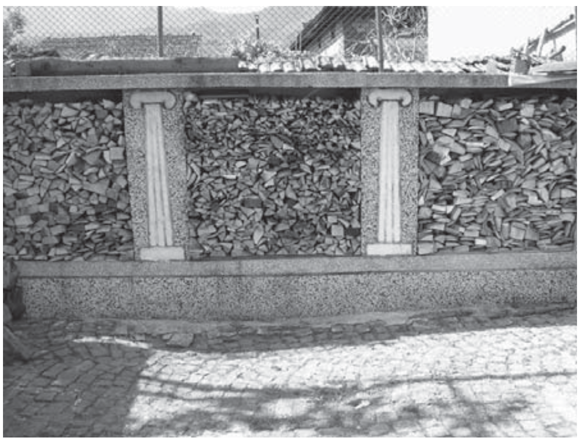


Bild 7. Nischenlagerung

Bild 8. Stoßlagerung.

2.2. Verwendung des Brennholzes für industrielle Zwecke

Die Verwendung von Holz und Holzabfällen zur Energiegewinnung hatte ihre Anfänge vor 25 Jahren, nachdem die Versorgung mit russischen Treibstoffen zunehmend problematisch wurde. Damals wurden die ersten Kessel zur Verbrennung von Rinde, Holzspänen und Holzabfällen konstruiert, durch welche die holzverarbeitenden Betriebe ihre Energiebedürfnisse teilweise decken konnten. Zu diesem Zweck untersuchte das Institut für Holzverarbeitung in der Stadt Pasardshik den Bestand an Holzabfällen und die Energiebedürfnisse der Betriebe. Aufgund dieser Untersuchung wurde eine Reiche von Anlagen verschiedener Konstruktion und Leistung gebaut, die Wasserdampf für die Trockenanlagen und für die Heizung von Arbeits- und Wohnränmen lieferten. Sie haben sich gut bewährt und sind in ihrer Mehrzahl noch immer in Betrieb. Es folgt die Beschreibung einiger davon:

Dampfkessel für Baumrinde: Ein Kessel mit Ï-förmiger Komposition, zylindrischer Verbrennungskammer mit Durchmesser 2 500 mm und gesamte Rostfläche 4,9 m^2. Treibstoff ist die zerkleinerte Baumrinde der Stückgröße von 40-50 mm. Druckluftzufluss in 3 Verbrennungszonen. Leistung 6,5 t/h Dampf mit einem Druck von 1.3 MPa. Nutzeffekt 80%. Verbrennungswärme 1 500 kcal/kg. Der Dampf kann zu technologischen Zwecken oder Heizung verwendet werden.

Wasserheizerkessel für Holz und Holzabfälle KOT – 350: Ein klassischer Wasserheizerkessel mit Wärmeleistung 350 kW. Verbrennt Holz und Holzabfälle mit einer Länge bis 1 m und einem Durchmesser bis 3,0 cm. Nutzeffekt 75-80%. Nominale Verbrennungswärme 2000–2500 kcal/kg. Findet Anwendung in mittelgroßen Holzverarbeitungsbetrieben sowie für die Heizung von Gasthäusern in den Gebirgskurorten.

Wasserheizerkessel für Holz und Holzabfälle KW – 150: Wärmeleistung 150 kW. Ähnliche Konstruktion wie der KOT–350, aber kleiner. Bewährt für kleinere Betriebe.

Diese Kesselmodelle wurden bis ins 1990 produziert. Auch heute produzieren einige bulgarische Firmen Anglagen zur Verwertung von Holz und Holzabfällen, vorwiegend Wasserheizerkessel. Ein Beispiel wäre Erato-Holding in Haskovo, die nach Lizenz der tschechischen Firma Viadrus eine breite Skala pyrolytischer Kessel mit einem Nutzeffekt über 80% und mit Einzelleistung bis 100 kW produziert. Es werden zunehmend auch die Kessel der Firmen Buderus aus Deutschland, Windhager aus Österreich und Passat aus Dänemark importiert.

TECHNOLOGISCH-ÖKONOMISCHE WEISER DER BRENNHOLZNUTZUNG.

Die Aufarbeitung von Brennholz

Die Aufarbeitung und die Bringung von schwachem Holz und Schichtholz gehören zu den arbeitsintensiven und aufwendigen Tätigkeiten, viel aufwendiger als die Gewinnung von Stammholz. Dieses Verhältnis ergibt sich aus der relativ kleinen Stückmasse sowie aus den zusätzlichen Operationen Vorrücken, Spalten und Setzen.

In Bulgarien werden Schwach- und Schichtholz motormanuell mit Motorsägen der mittleren Klasse aufgearbeitet. Schichtholz wird zu 1m-Stücken geschnitten. Rollen ab eta 20cm Stärke werden gespalten. Spalten ist die aufwendigste und inattraktivste Operation der Holzernte. Zwei Arbeiter mit Keilen und Spaltäxten spalten 2,5 bis 3,5 Fm pro Tag. Die Bringung erfolgt mechanisiert (54%) oder mit Pferden und Oxen (46%). Bei Hangneigungen unter 20° werden vorwiegend landwirtschaftliche Schlepper eingesetzt, bis 40° – Raupenschlepper und forstliche spezialisierte Radschlepper, und über 40° - Seilanlagen. Zum Beispiel erfolgen in der mit Buche bewachsenen Hochlagen des Balkans 78% der mechanisierten Holzbringung mit Radschleppern (landwirtschaftliche und forstliche), 15% mit Raupenschleppern und 7% mit Langstrecken-Seilanlagen. Die durchschnittliche Leistung eines Schleppers erreicht 3200 Fm bei einer durchschnittlichen Rückestrecke von 1140 m. Es werden vorwiegend entastete Stämme gerückt, aber auch unentastete. Nach der Rückung des Stammholzes werden die Äste und die Wipfelteile zu Schichtholz geschnitten. Schichtholz wird zu Stößen gesetzt, auch in sehr steilem Gelände, wo die Holzernte ihre Kosten kaum deckt (Bild 9). Ein Stoß hat 1,5 bis 3,5 Rm. Danach wird das Schichtholz mit Pferden auf dem Tragsattel bis zum Holzlagerplatz gerückt. Die Ladung eines Pferdes kann 0,25 Rm erreichen. Die optimale Anzahl der Pferde ist 3 Pferde pro Arbeiter. Eine Mannschaft aus 3–4 Arbeitern mit 10–15 Pferden rückt 22–28 Rm Schichtholz täglich, bei einem Arbeitstag von 10 Stunden und einer durchschnittlichen Rückestrecke von 1100 m. Der Holzlagerplatz ist i.d.R. eine weniger geneigte Waldwiese an der befahrbaren Straße. Auf dem Holzlagerplatz wird das Schichtholz zu 1m hohen Stößen gesetzt und die Stöße werden gemessen. In der unteren Waldzone unter 600 m, wo die Hangneigungen gemäßigt sind, kann das Schichtholz auch mit Pferdewagen gerückt werden. Ein Wagen mit Pferden bringt 4,5 bis 5,2 Rm täglich. Der Wagen wird von 2 Arbeitern bedient.

Die Holzbringung mit Zugtieren ist im europäischen Südosten eine alte Tradition. Wegen dem steilen

Gelände ist sie vielfach die einzige kostendeckende Lösung und wird auch in der Zukunft eine Bedeutung haben.

Die Selbstkosten des Brennholzes

Die Jahrespreise für Brennholz werden in den ersten Sommermonaten bekannt – etwa in Juni. Sie unterscheiden sich zwar nach Gegenden, aber nicht viel. Im Sommer 2006 sind die Marktpreise für Brennhobz loco Wald (d.h. ab Holzlagerplatz), wie folgt: 45 BGN/Rm für Eiche und Hainbuche, 42 für Buche und 26 für Nadelholz. BGN, gesprochen Lewa (!), heisst die bulgarische Währung, 2 BGN = 1 EUR.

In Tab. 1 sind die mit dem Brennholz verbundenen Kosten aufgeführt.

No	Kostenstellen	Kosten pro Rm		Kosten pro Tonne	
1	Nutzungsrecht + 20 % Mehrwertsteuer	14,41		30,27	
2	Aufarbeitung	7,51		15,77	
3	Bringung	15,02		31,53	
4	Sa.1+2+3, Kosten des Unternehmers	36,94		77,57	
5	Marktpreis loco Wald	Ei	Bu	Ei	Bu
		45,00	42,00	94,50	88,20
6	Reinertrag des Unternehmers, 5 – 4	8,06	5,06	16,93	10,63
7	Rentabilitität, 6/4	22%	14%	22%	14%
8	Holzlieferung (Transport mit LKW, Laden und Abladen)	10		21,0	
9	Einschneiden mit Kreissäge	4		8,4	
10	Spalten (manuell), Rücken (mit Schubkarren) und Setzen	5		10,5	
11	Gesamtkosten des Abnehmers	Ei	Bu	Ei	Bu
		64	61	134,40	128,10

Das Nutzungsrecht ist ein Geldbetrag, der in den staatlichen Haushalt einfließt. Diesen Betrag bezahlt der Unternehmer (wenn das ausgezeichnete Holz auf Stock versteigert wird) oder das Forstamt (wenn es in Eigenregie wirtschaftet). In diesem zweiten Fall wird diese Summe nach einem Tarif erhoben, etwa analog der „severance" in einigen Staaten der USA. Egal wie die Holzernte geschieht, werden die Kosten der Kostenstellen 1, 2 und 3 vom Anbieter (ein Forstamt oder ein Unternehmer) getragen, der das Holz in der Regel ab Holzlagerplatz verkauft. Aus der Tabelle ist ersichtlich, dass die Profite der Brennholzanbieter momentan sehr hoch sind. Das ergibt sich aus der hohen Nachfrage, aber auch aus der Quasi-Monopolposition der Anbieter: Brennholz wird lokal verbraucht und die Anbieter in einer Siedlung sind nicht viel.

Die restlichen Zeilen der Tab. 1 ergeben den Gesamtpreis des Brennholzes für den Abnehmer. Die nachfolgende Tab. 2 vergleicht die Preise der verschiedenen Treibstoffe auf dem bulgarischen Markt und verfolgt ihre Entwicklung in den letzten 5 Jahren. Aus der Tabelle ist ersichtlich, das der Einsatz von Brennholz viel günstiger ist in allen Fällen, in welchen er technologisch möglich ist.

Treibstoff	Preis, 2001	Preis, 2006	Preisindex	Kalorien–gehalt	Kalorienpreis
	BGN/t	BGN/t		kcal/kg	BGN/kcal
Diesel	984	1988	2,02	10000	199
Gasöl	770	1819	2,36	10000	182
Masut	405	722	1,78	9500	76
Erdgas	757	1530	2,02	8000	191
Brennholz, Eiche	54	134,4	2,49	2480	54
Brennholz, Buche	48	128,1	2,67	2140	60

Quellen

Die Daten für diese Aufführung entstammen der öffentlichen Statistik der Nationalen Forstverwaltung. Wir haben das Schrifttum erspart, um den Leser nicht mit einer Vielzahl von Titeln in einer anderen Schrift zu belasten. Die Daten aus dem Jahre 2006 stammen aus freundlichen Gesprächen in den Forstämtern, Schlagflächen und Werkstätten des Balkans und des Rhodopengebirges.

Schlussfolgerungen

Das Verhältnis Nutzung : Zuwachs besagt, dass Bulgarien seine Nutzung dramatisch erhöhen kann, wenn das Brennholz eine Vorrangigkeit erlangt. Die Brennholzpreise steigen schon dramatisch seit einigen Jahren, mit 2,5 EURO pro Jahr. Ein Einsatz von besseren Technologien (Hackschnitzelaggregate u.ä.) kann diesen Vorgang nur beschleunigen. Der Nutzeffekt der bisher eingesetzten Heizgeräte ist gering.

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СОФТУЕРЪТ DMED ЗА ОПРЕДЕЛЯНЕ НА СРЕДНОТО ИЗВОЗНО РАЗСТОЯНИЕ НА ГОЛЕМИ ЗАЛЕСЕНИ ПЛОЩИ

Еуджен Йордаке, Румъния

Настоящата работа е посветена на софтуер за пресмятане на средното извозно разстояние на определена територия. Благодарение на възможностите на компютъра софтуерът определя средното извозно разстояние, като държи сметка и за релефа. Използвахме тримерен модел на земната повърхност (Digital Elevation Model - DEM), като предполагахме, че дървесината се извозва до долинен камионен път, а се добива на по-висока кота на разстояние до 50 m от извозен път. Като първа стъпка софтуерът определя центъра на тежестта на всеки подотдел. Втората стъпка се състои в пресмятане на наклонените разстояния от центъра на тежестта до най-близкия път, след което се пресмята средната аритметична на тези разстояния. Софтуерът позволява визуализиране на получените данни.

USING OF AN ORIGINAL SOFTWARE PROGRAMM DMED FOR DETERMINATION OF AVERAGE SKIDDING DISTANCE OF LARGE FOREST AREAS

Eugen Iordache, Romania

This article is about a model for the calculation of the average distance of skidding, on a well-defined territory. Thanks to the facilities, given by the PC, our model is able to obtain the average skidding distance, taking into account the orography of the territory as well. To obtain this distance, we used the three-dimensional model of the surface (Digital Elevation Model, DEM). This way we could impose some restrictions referring to the harvest of the wooden/ligneous material, which is collected only on the valley roads, respectively on short distances (50 m) where it is harvested on the roads, characterized by a higher quota. Our model is based on the determination of the mass-centre of each lot/parcel, with the aid of PC's. The second step consists of calculation of the inclined distances from the points to the nearest road, and than it is calculated the arithmetical mean of these distances. The model makes also possible to see the obtained data.

BENUTZUNG DES DMED PROGRAMMS BEI DER BERECHNUNG DER MITTLEREN RÜCKEENTFERNUNG AUF GROSSE WALDFLÄCHEN

Eugen Iordache, Romania

VORWORT

Das unter der Matlab 7.01 Platform entwickelte Programm, durch die Benutzung dessen Vorteile, hilft den Spezialisten in Walderschließung bei der Berechnung der mittleren Rückeentfernung. Um diese Kennzahl zu berechnen, benützt das Programm die Datenbank GIS (Geographic Information System). Die GIS Datenbank ermöglicht eine relativ leichte Berechnung der mittleren Rückeentfernung durch einfache mathematische Berechnungen. Die Datenbank wurde im ArcView 3.2a erstellt und setzt sich aus der digitalen Karte der Wege, der Waldflächen (in *.shp Format), beziehungsweise aus dem digitalen Geländehöhenmodell (Digital Elevation Model, DEM, in GeoTiff Format, *.tif), (Abbildung 1).

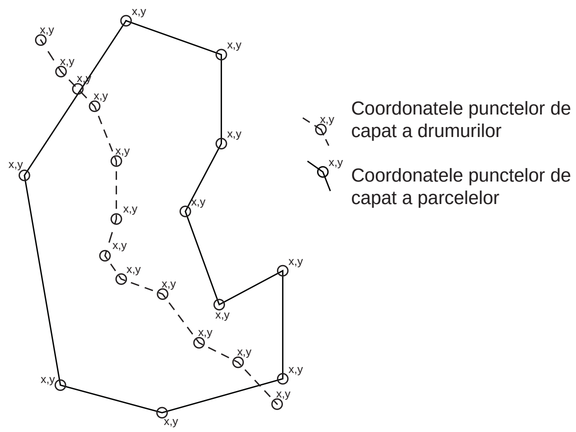

Abb1.Schematische Darstellung der Vektorendaten

Diese Daten werden durch unser entwickeltes Programm Dmed (GUI) importiert und dann verarbeitet. Das Importieren wird durch spezielle Befehle des Programms Matlab gemacht: mit shaperead werden die digitalen Karten der Waldflächen und Strassen importiert, und mit dem Befehl geotiffread erzeugen wird die Importierung des digitalen Modells.

Die Daten werden im spezifischen Format Matlab gespeichert und werden Matlab Strukturen genannt. Diese Strukturen beinhalten alle in Arcview genannten Eigenschaften und zusätzlich die Koordinaten jedes Punktes.

Die Straßenkoordinaten (xd, yd) und die Koordinaten der Waldflächen (xp, yp) werden aus den Matlab Strukturen übernommen und sind Ausgangspunkt für die ersten Berechnungen des Programms. Um das Programm leichter zu handhaben, haben wir eine Benutzermaske/Graphical User Interface, GUI genannt, entwickelt.

ARBEITSWEISE DES PROGRAMMS

Das Programm basiert auf einfache mathematische Berechnungen. In diesen Berechnungen benützen wir die x, y und z Koordinaten der Strassen und der Waldflächengrenzen. Dieses ist möglich weil sich jedes Element (Fläche oder Strasse) aus kleinen Geradensegmenten zusammensetzt, egal wie kurvenreich der Umfang der Fläche ist (Abbildung 1). Die Berechnungen können sich so auf Niveau von Koordinaten einschränken, ohne aber eine erlaubte Toleranz einzuhalten. Die Daten dieser Type werden Vektorendaten genannt.

Die Flächenkoordinaten (x und y aus der Abbildung) werden bei der Berechnung des Schwerpunktes verwendet und in den Matlab Strukturen gespeichert. In der nächsten Phase werden dieser Koordinaten auch die z Quote zugeordnet, Mass das sich aus dem digitalen Geländemodell ergibt und das unter der Form einer n x m Matrix importiert und gespeichert wird und wo jedes Element h (Höhe) der Quote der Mitte eines Quadrates mit Seiten von 10 m entspricht. Diese Zuschreibung wird auch für die Koordinaten der Strassen gemacht. Es ist also ergeben, dass sowohl die Strassen als auch die Schwerpunkte sehr präzise im Raum definiert sind. Der nächste Schritt ist praktisch die Berechnung der mittleren Rückeentfernung, danach erfolgt die graphische Darstellung der Entfernungen. Der Datenfluss und der zeitliche Ablauf der Berechnungen sind in der nächsten Abbildung dargestellt (Abb.2).

Berechnung der Schwerpunktkoordinaten

Die Berechnung des Schwerpunktes für jede Fläche ist für uns wichtig weil wir von der Voraussetzung ausgegangen sind, dass sich hier die Holzmasse konzentriert. Um nun die mittlere Rückeentfernung zu berechnen, ist es ausreichend, wenn man den Abstand von dem Schwerpunkt der Fläche bis zum nächsten Rückeweg berechnet.

Hat man in der Matlab Platform die Grenzen der Flächen in Vektorenform, so hat man auch die x und y Koordinaten der Flächengrenzen. In der Ebene wird die Berechnung des Schwerpunktes einer Fläche zu einer analytischen Berechnung zurückgesetzt, usw. durch die Bestimmung des arithmetischen Mit-

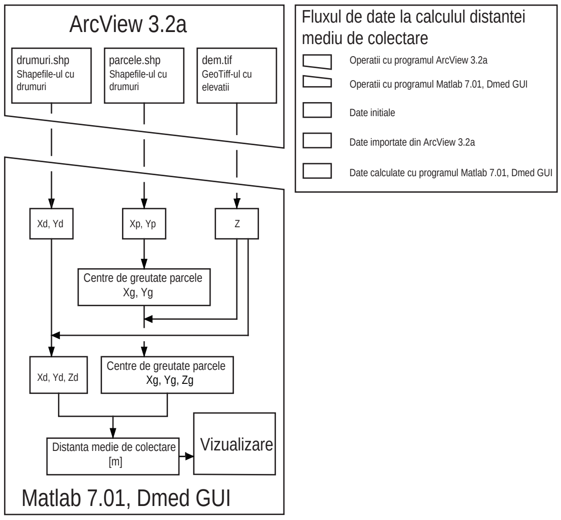

Abb2.Datenfluss

telwertes der x Koordinaten und separat der arithmetische Mittelwert der y Koordinaten der Punkten auf den Flächenumfang mit folgender Formel:

$Xc = \sum X_i / n;\ \ Yc = \sum Y_i / n,$
wobei:
Xc – x Koordinate des Schwerpunktes
Yc – y Koordinate des Schwerpunktes
Xl, Yl – Koordinaten der Flächengrenze
N – Gesamtanzahl der Koordinaten

Die Koordinaten der Schwerpunkte werden als eine 2 x Anzahl der Flächen Matrix gespeichert.

Zuschreibung der z Quote für die x und y Koordinaten der Strassen und Schwepunkte der Waldflächen

Wenn wir die x und y Koordinaten der oberen linken Ecke des digitalen Geländemodells kennen, sowohl auch die Größe der Zellen (Auflösung – in unserem Fall 10 m) kennen, so können wir für jedes x,y Paar eine Quote zuschreiben. In der Abbildung 3 ist ein einfaches digitales Geländemodell dargestellt auf dem Flächen zusammenfallen, mit schwarzen Linien und Punkte gekennzeichnet.

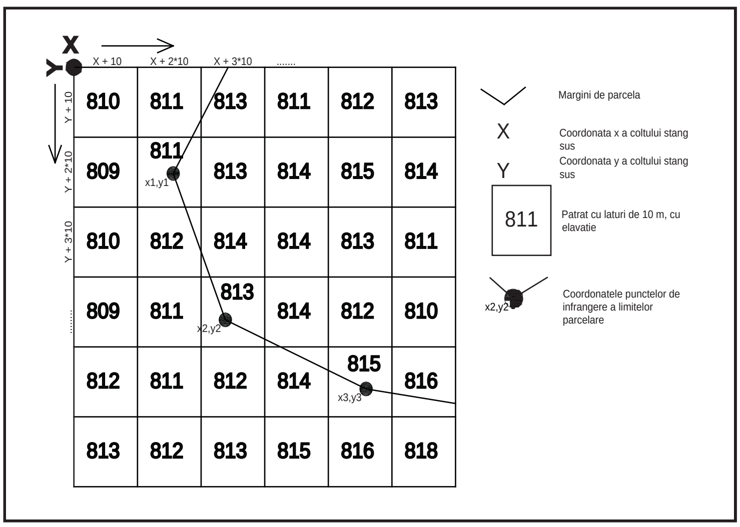

Abb3.Berechnung für die Zuschreibung der z Quote

Jeder Schnittpunkt hat x und y Koordinaten. Als erstes werden die x und y Koordinaten der Quadratschnittpunkte berechnet. Kennt man die Koordinaten der oberen linken Ecke und die Größe jedes Quadrates (cellsize), können wir für jeden Schnittpunkt die x und y Koordinaten mit folgendem Algorythmus bestimmen:

Xp , Xp1 = Xp + 10, Xp2 = Xp + 2*10, Xp3 = Xp + 3*10, ... Xpi = Xp + i*10;
i > = 1, i€ N
Yp , Yp1 = Yp + 10, Yp2 = Yp + 2*10, Yp3 = Yp + 3*10, ... Ypj = Xp + j*10;
j > = 1, j€ N

Die Anzahl der erhaltenen Werte wird weiterhin für die Berechnung und Zuschreibung der z Koordinaten zu den x,y Paare. Für dieses haben wir eine logische Bedingung gestellt. Das Programm nimmt die Koordinaten des ersten Punktes (x1,y1) und überprüft die nächsten Bedingungen bis diese wahr werden:

Xpi <= x1 < Xp(i+1), Ypj <= y1 < Yp(j+1), .., i > = 1, i€ N, j > = 1, j€ N

Sind diese Bedingungen wahr, so wird neben x1 und y1 auch die z1 Koordinate zugeschrieben, Koordinate die aus der Zelle ij gelesen wird für die die oben genannte Bedingung wahr ist. Im nächsten Schritt nimmt man x2 und y2 und wiederholt die Berechnungen etc.

Berechnung der mittleren Rückeentfernung

Diese Berechnung basiert auf der Voraussetzung der Suche eines minimalen Abstandes von jedem Schwerpunkt zu den benachbarten Strassen.

Mit folgender Formel wird theoretisch der Abstand zwischen zwei Punkte mit bekannten Koordinaten berechnet:

$$d_i = ((xci - xdi)^2+(yci - ydi)^2+(zci - zdi)^2)^{1/2}$$

Nachdem der Abstand von jedem Schwerpunkt zu allen Straßenpunkten berechnet wurde, nimmt man von jedem Punkt i den kleinsten Abstand (di) und speichert ihn in einer Wertfolge. Sind alle minimalen Abstände berechnet wird der arithmetische Mittelwert der Folge gemacht und erhält so den durchschnittlichen Rückeabstand. Diese Berechnungen sind aber sehr zeitraubend, darum wird in unserem Programm zuerst eine topographische Festlegung der Straßenkoordinaten gemacht. Es wird so verhindert dass bei einem Schwerpunkt alle Kombinationen mit den Strassen überprüft werden, sondern das Programm nimmt nur die Kombinationen mit den benachbarten Strassen.

TESTEN DES PROGRAMMS

Das Programm Dmed,GUI wurde auf der Fläche des Forstamts Tarlung gemacht, usw. auf den Produktionseinheiten U.P.6 und U.P. 7. Das digitale Modell wurde durch Digitalisierung aller Geländehöhen der Basisebenen gemacht, Mass 1:5000. Für jede Kurve wurde eine Höhe im ArcView 3.2a zugeschrieben. Im selben Programm wurde auch das GeoTiff hergestellt, wobei die Auflösung bei 10 m war. Ebenfalls durch Digitalisierung wurden die Flächendateien, bzw. die Straßendateien gemacht und im Format SHP gespeichert. Wir möchten nun eine Vorführung der bis jetzt vorgestellten Theorie machen. Um dem Datenpfleger zu helfen haben wir eine Benutzermaske (Graphical User Interface, GUI) hergestellt (Abbildung 4).

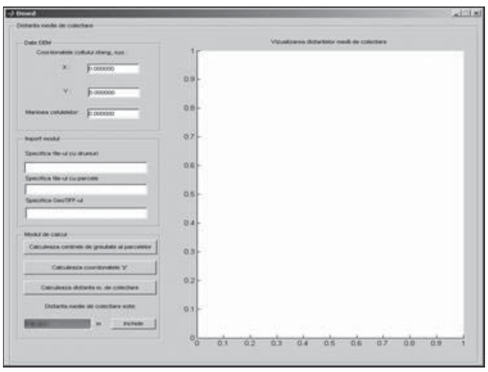

Abb4. Benutzermaske

Diese Maske ist aus drei Module und eine Datenansicht zusammengestellt. Das erste Modul nennt sich Date DEM und hier werden die Daten für das digitale Geländehöhenmodell gepflegt. Diese Daten sind die Koordinaten der linken oberen Ecke der Fläche und die Größe der Zellen (Abbildung 5). Auf der Abbildung sind die Daten des digitalen Modells der Produktionseinheit 6 eingegeben. Das nächste Modul wird Import Modul genannt. Mit seiner Hilfe gibt der Benutzer die Spezifikation der Dateien die in der Matlab Plattform importiert werden müssen, an. Erstens wird das shapefile mit Strassen und Flächen angegeben und danach das GeoTiff des digitalen Geländehöhenmodells. (Abbildung 6).

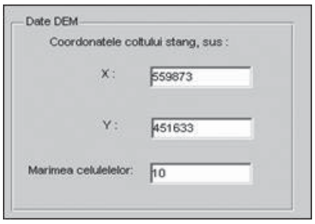

Abb5. Modul für die Dateneinfürung

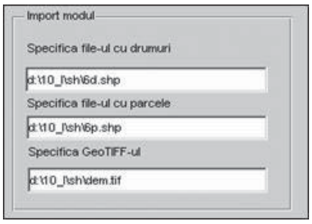

Abb6.Daten Importmodul des digitallen Gelendemodels

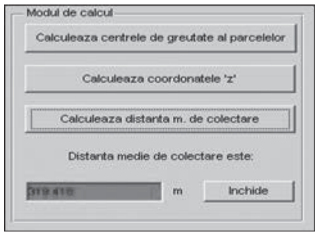

Abb7.Berechnungsmodul

Das letzte ist das Berechnungsmodul das sich aus drei Dialogfelder zusammensetzt. Bei der Verwendung dieser Felder muss der Benutzer beachten dass diese verbunden sind. Deswegen wird zuerst auf dem oberen Feld gedrückt, nachdem die Berechnungen gemacht wurden auf dem nächsten Feld und so weiter. Bei der Beendung der Berechnungen muss in der rot markierten Fläche der Wert der mittleren Rückeentfernung erscheinen. In diesem Fall ist dieser für die Produktionseinheit UP6 gleich mit 319,418m und für UP7 Tarlung 342,291m, Werte die sich nicht maßgebend von denen mit der Hand bestimmten Werten unterscheiden (Abbildung 6). Nachdem die Berechnungen korrekt gemacht worden sind erscheint folgendes Fenster (Abbildung 7).

SCHLUSSFOLGERUNGEN

Hat man alle bis jetzt genannten Daten zur Verfügung kann das von uns entworfene Programm leicht benutzt werden. Besitzt man diese Daten wird die Berechnung der mittleren Rückeentfernung in etwa 10 Minuten gemacht, die Methode ist also viel leistungsfähiger als jede bis jetzt übliche Methode. Zusätzlich können die mit Dmed,GUI erhaltene Daten im ArcView 3.2a exportiert werden und können somit visualisiert und in anderen Berechnungen benutzt werden. Weiterhin wird unser Program mit neuen Einschränkungen und neuen Berechnungsmethoden verbessert und wir

möchten eine genauere Einschätzung der mittleren Rückeentfernung erhalten. Diesen Faktor möchten wir bei der Lösung für eine optimale der Standortplanung des Wegenetzes benutzen.

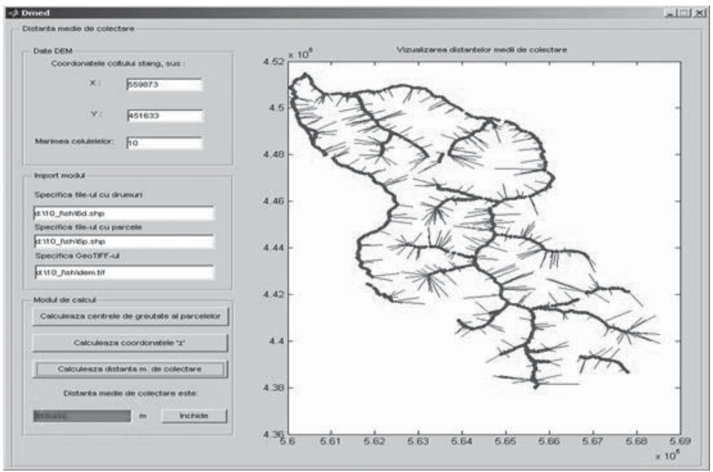

Abb8.Visualisierung der Ergebnisse in DMED

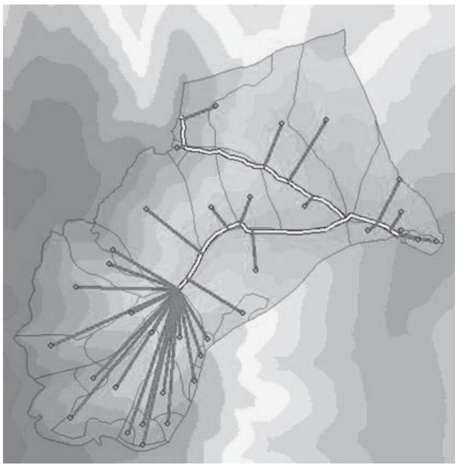

Abb9.Visualisierung der Ergebnisse in GIS

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МРЕЖАТА ОТ ИЗВОЗНИ ПЪТИЩА В ПЛАНИНИТЕ НА РУМЪНИЯ

И. Опря, Р. Дерцени, Е. Йордаке, Румъния

Горските пътища в Румъния са почти изключително долинни и много рядко минават по склон. Вследствие на това извозните разстояния надхвърлят 1500 m. От друга страна, фирмите предпочитат да работят с трактори, а не с въжени линии, чийто брой в последно време е намалял. Изхождайки от това, в настоящата работа анализираме възможностите за развитие на мрежата на извозните пътища в зависимост от наклона на терена, теренните форми и ползуването на 1 ha. Направено е сравнително изследване на различните геометрични модели на мрежата на извозните пътища по отношение на параметрите дължина, гъстота и извозно разстояние. Изследвана е и икономическата ефективност.

NETZE VON RÜCKEGASSEN IN DER GEBIRGSZONE RUMÄNIENS

I. Oprea, R. Derczeni, E. Iordache, Romania

Zusammenfassung: Das Forststraßennetz in Rumänien erstreckt sich meist auf Tälern und sehr selten auf Hängen, so dass die Rückeentfernungen 1500 m überschreiten. Anderseits bevorzugen die Firmen mit Traktoren zu arbeiten und nicht mit Seilbahnen, deren Anzahl in letzen Zeit gesunken ist. Ausgehend von diesen Bedingungen analysiert die Arbeit die Entwicklungsmöglichkeiten der Rückegassennetze abhängig von der Steilheit des Hanges , Geländemodell , Holzernte pro Hektar. In diesem Sinne wurde ein Vergleichstudium der unterschiedlichen geometrischen Modelle der Rückegassennetze anhand von den Parametern : Länge, Dichte, Wegeabstand durchgeführt und mit einer Wirtschaftsanalyse ergänzt.

TRACTOR SKIDDING NETWORKS ON THE MOUNTAINSIDES

I. Oprea, R. Derczeni, E.Iordache, Romania

Abstract: The paper presents an analysis of the development variants of the tractor skidding networks in connection with the slope gradient, terrain morphology, exploited timber quantity per hectare. Also, the methodology to establish the optimum variant is described, also taking into consideration two equivalently skyline solutions.

Skidding Tracks Types and the Optimal Density of the Network

In case of cutting areas from uneven relief, generally with slopes till 40-50%, the timber skidding it is possible by developing a skidding tractor network along the thalwegs and mountainsides, existing also, equivalently solutions with skylines.

Regarding the tractor usage on mountainsides, the modalities of development the skidding tracks are differentiated by slope gradients categories, in comparison with the danger of the soil erosion level and with the affection of the slopes instability and also with the economical usage possibilities of the other basic skidding mean, respectively the skyline [2]. Thus, on the grounds with prevailing declivity under 20...25%, the tracks are orientated on the higher declivity line (obligatorily on slopes with more de 10%), orientation which is the most favourable from the tractors stability point of view, the transversal inclination being practically insignificant. These tracks are mostly natural, special arrangements not being necessary.

On grounds with prevailing declivity between 20…25% and 40…45%, both from an ecological point of view, as well from a technical point of view, especially from labour protection point of view, it is no more allowed that the tractors circulation to be made on the higher declivity line; therefore roads are constructed, by embankment works. The tractor track costs increase in comparison with the declivity, therefore a comparative analysis of skyline is imposed.

On grounds with declivity more than 45%, the tractors are not running any longer for upstream yarding (the loads to slip free), and the embankments could be expensive and could affect the mountainside stability; so the skyline is used exclusively.

Thus, on grounds with prevailing declivity between 20…25% and 40…45%, there is a technical tractor - skyline interference zone, where the adoption of the solution must be analysed from an economical point of view.

Generally, it is known that the skylines assure the skidding on the shorter distance and have a superior ecological performance. But the skylines have acquisition prices and, implicitly, the redemption expenses per m^3 higher than tractors and the skyline movement from a track to another procure a call-off of the technological works. On the other side, the increasing of the ground declivity, the tractor tracks are more sinuous and need higher embankment works, which increase the works costs and, in addition, negative technological implications interfere. All these conflicting aspects impose a study of solutions.

The modalities of tractor skidding networks development are various, a selection of the optimum variant being necessary, respectively of the most economical variant, which will be compared, if it is necessary, with a contra-variant with skyline [3].

In a theoretical tackling, a mathematical calculation could establish relations which will allow the selection of the optimum variant for tractor skidding network development. For example, the forest area from Fig. 1 which will be harvest, for which n variants of tractor skidding network (V_i, i = 1…n) are planned. At the n variants, the parameters variation are ascending concerning the network length (L), the thickness of the network (d) and the medium distance for forwarding with tractor (l_2) and descending with de medium distance for yarding to the tractor track (l_1). The optimum solution, corresponding to the most economical variant, depends on the d, l_1, l_2 variables. Between these statistical - mathematical correlations could be established which permit to express the cost functions in comparison with one independent variable. In these meaning, the regression equations adopted by Arnautovici [1] for the up mentioned elements will be take up:

$$l_1 = A\,\mathrm{e}^{-cd} \quad (1)$$

and

$$l_2 = a_0 - b_0\, l_1\,, \quad (2)$$

where: l_1 is the medium yarding distance, in m; l_2 - medium forwarding distance, in m; d - the tickness of the skidding network, in m/ha; A, c, a_0, b_0 - coefficients.

The economic function which has to be minimized is:

$$C = C + C_2 + C_3\,, \quad (3)$$

where: C are the total expenses, per m^3; C_1 - yarding expenses, per m^3; C_2 - forwarding expenses, per m^3; C_3 - expenses for construction and maintenance of the skidding tracks, per m^3, or:

$$C = (a_1 + b_1 l_1) + (a_2 + b_2 l_2) + \frac{t\,L}{Q}\,, \quad (4)$$

where: t is the construction and maintenance cost of the tractor track network per length unit, in m; L - network length, in m; Q - wood mass, in m^3; a_1, b_1, a_2, b_2 - coefficients of the regression equation of the yarding and forwarding expenses, in connection whit the work distance.

The expenses for construction and maintenance the skidding tracks could by expressed in relation whit the medium yarding distance, whit the relation:

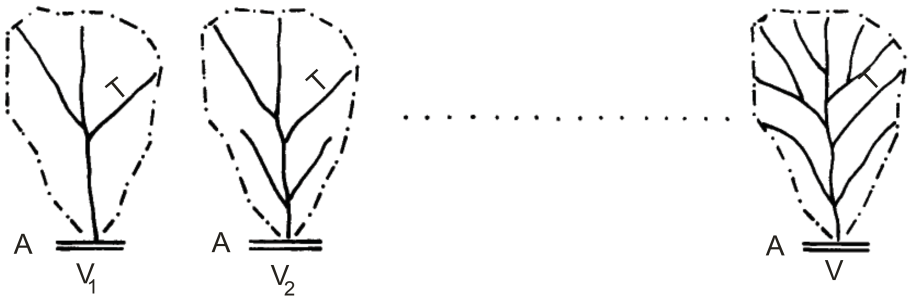
$$\frac{t\,L}{Q} = t\,\frac{L}{S\,q} = \frac{t\,d}{q}\,, \quad (5)$$

where: q is the harvested wood mass at ha, in m^3/ha; S - surface of the cutting area, in ha, and in which, taking into account the relation (1):

$$d = \frac{\ln A - \ln l_1}{c}\,. \quad (6)$$

Thus, the formula of the minimised total cost will be:

$$C = (a_1 + b_1 l_1) + (a_2 + b_2 a_0 - b_2 b_0 l_1) + \frac{t(\ln A - \ln l_1)}{qc} \quad (7)$$



Parameters	Variation
	V_1 ... V_2 ... V_n
L	L_1 ↗ L_2 ... ↗ ... L_n
S	Constant
$d = \frac{L}{s}$	d_1 ↗ d_2 ... ↗ ... d_n
l_1	$l_{1.1}$ ↘ $l_{1.2}$ ... ↘ ... l_{1n}
l_2	$l_{2.1}$ ↘ $l_{2.2}$ ... ↗ ... l_{2n}

Fig. 1. Development variants of a tractor skidding network:
V - variant; T - tractor track; A - road; L - network length; S - ground surface;
d - the thickness of the network; l_1 - de medium distance for yarding; l_2 - the medium distance for forwarding

C being a function having l_1 as argument.

The optimum value of the medium yarding distance (l_{1e}), corresponding to a minimum cost (C), result by minimizing the function (7), being:

$$l_{1e} = \frac{t}{(b_1 - b_2 b_0)\, qc} \quad . (8)$$

Introducing the value of the optimum yarding distance l_1, calculated with the relation (8) in relation (6), will result the optimum thickness of the skidding network for the studied case, according as will be decided the network variant which must be adopted.

Network Types and Characteristic Parameters

On grounds with prevailing declivity under 20…25%, a complete tractor skidding network assumes tracks on higher declivity line

,on the stint axis, laterally realising yarding with the winch mounted on tractor. The geometrised model from Figure 2, relieve that, apart from little windings in the real case, the tractor tracks are relatively straight and ensure, as the skyline, the shorter forwarding distance, with up mentioned advantage that the tractor tracks do not need arrangements, in comparison with those for skylines.

The significance of the notations from figure 2 – 9 are: A - road; T - tractor track; F - skyline line; V - mountainside; Tg - thalweg; C - summit; N - dimension for contour line; P - stint; 10%, 20% a.s.o - tracks or ground declivities.

On grounds with prevailing declivity between 20…25% and 40…45%, the skidding tracks could be managed in different ways; ascending at the declivity limit, ramifications in gentle slope, combinations [4]. To put in evidence the implications of these modalities to the skidding network parameters, a study on geometrised models (Fig. 3 - 9) was conducted in the two geomorphological situations of placing the cutting areas: cutting areas placed on mountainsides having at the base a road and cutting areas from the lateral basins without road. For the same geometrical models, for comparison, were take into account also the skylines diagrams. All the diagrams have in view a total skidding network, to realise a full skidding with the tractor, using at yarding the winch mounted on tractor and respectively with the skyline and resorting at lateral yarding with skyline.

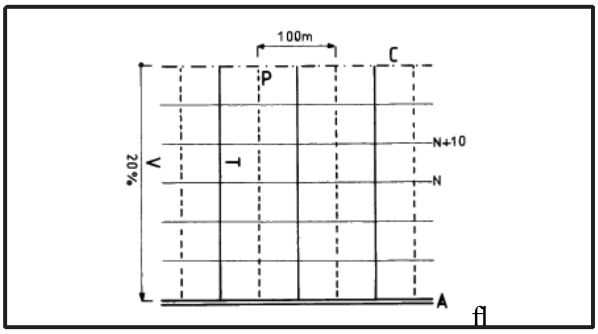


Fig. 2. Geometrised model for a tractor skidding network, on ground whit declivity under 20 …25%

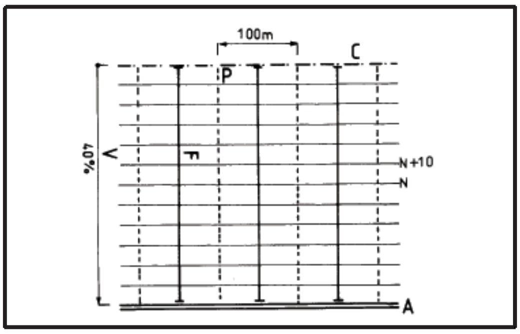


Fig. 3. Geometrised model for a skyline skidding network on mountainside (F_1 variant)

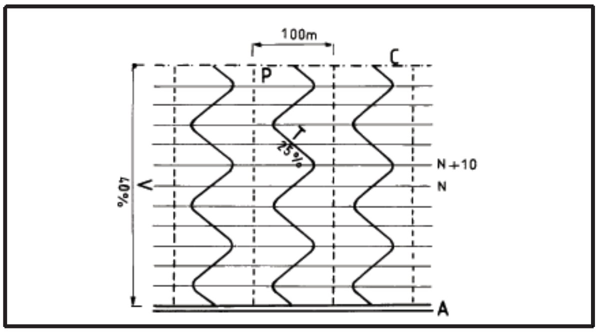


Fig. 4. Geometrised model for a tractor skidding network on mountainside ($T_{1.1}$ variant)

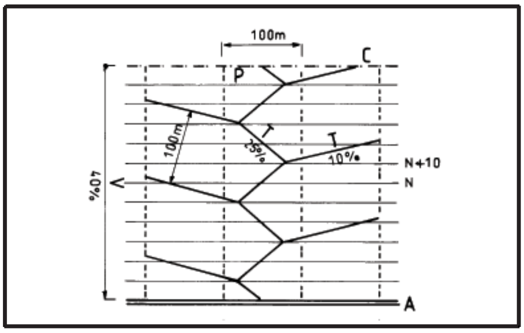


Fig. 5. Geometrised model for a tractor skidding network on mountainside ($T_{1.2}$ variant)

The main characteristics of the studied skidding networks variants, supposing a 40% declivity of the mountainside and 20% declivity of the basin thalweg are presented in Table 1.

From this table, it is noticed that in case of mountainsides having at the base a road, in comparison with the variant with parallel skylines lines (F_1 variant), where the network parameters were considered 100%, for the variant with accessional sinuous skidding tracks, with 25% declivity ($T_{1.1}$ variant), the network length and implicitly his thickness, as the forwarding distance also, increase with 48% and, supplementary appear a lot of curves of the tracks (2 curves per hectare) where are necessary considerable super enlargements of the tractor tracks, to ensure the load entry into the curve.

Similarly, at the variant with lateral tracks in gentle slope ($T_{1.2}$ variant), although the network length and thickness, and the number of curves also are smaller than at $T_{1.1}$ variant, however in this case the medium forwarding distance increase substantially, which is with more than 91% higher than the one for skyline forwarding. In the same manner the variants for the felling areas located in lateral basins by the road are analysed (F_2, $T2_{.1}$, $T_{2.2}$, $T_{2.3}$), presented in figure 9, 6, 7, 8.

All these variations of the network parameters are given back in the works cost (cost to realise the skidding network, production costs), according to which the most economical variant will be adopted. Although, the analysed technical parameters are disadvantageous in case of the skidding networks depend on tractor, in concrete situation the skyline could have cost elements higher than the tractor (redemption, mounting - dismounting expenses a.s.o), thus only a specific economic analyse could point out the economical solution for a specific case.

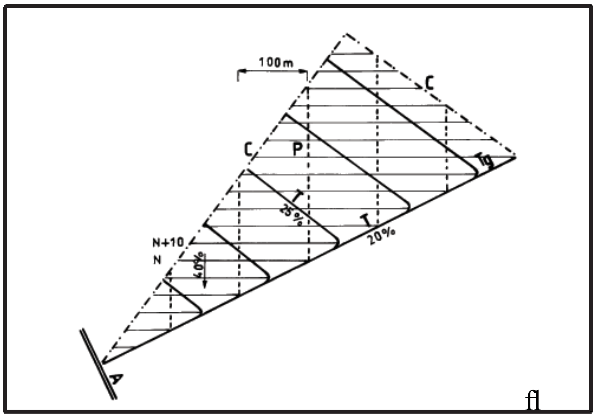


Fig. 6. Geometrised model for a tractor skidding network on basin ($T_{2.1}$ variant)

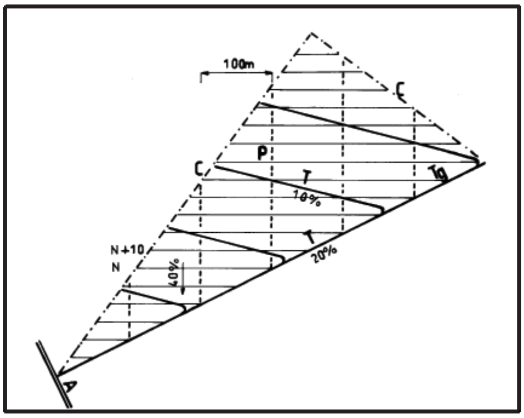


Fig. 7. Geometrised model for a tractor skidding network on basin ($T_{2.2}$ variant)

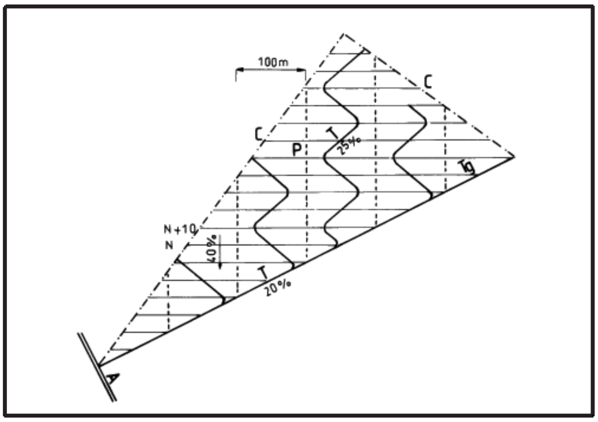


Fig. 8. Geometrised model for a tractor skidding network on basin ($T_{2.3}$ variant)

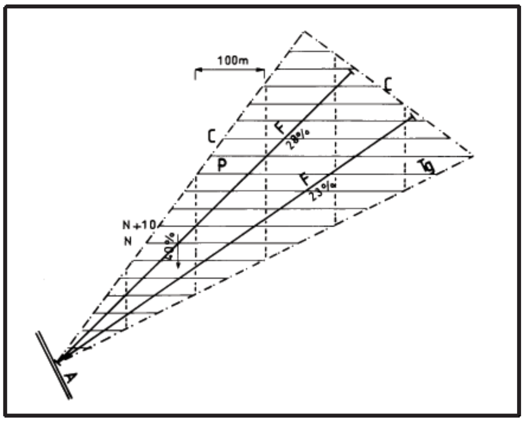


Fig. 9. Geometrised model for a skyline skidding network on basin (F_2 variant)

Table 1. Characteristics of the skidding networks variants, evolved on ground with declivity from 20…25% to 40…45%

The felling area geomorpho-logi-cal position	**Development variants of the skid-ding network**	**Percentage rapport between the vari-ants for 40% mountainside declivity and 20% thalweg declivity, regarding:**			**Number of curves of tracks per hect-are**
		Networks length	Networks thickness per hectare	Medium forwarding distance	
Mountainsides having at the base a road	Parallel skyline lines (F_1 variant)	100	100	100	-
	Sinuous tractor tracks, ascencionals, whit 25% declivity ($T_{1.1}$ variant)	148	148	148	2.00
Mountainsides having at the base a road	Main tractor track, sinuous, acces-sional, with 25% declivity and lateral tracks with 10% declivities ($T_{1.2}$ variant)	127	127	191	0.67
Basin mountain-side	Skyline lines disposed in fan (F_2 variant)	100	100	100	–
	Main tractor track along the thalweg and rectilinear tracks on mountainside, whit 25% declivi-ties ($T_{2.1}$ variant)	125	125	133	0.56
	Main tractor track along the thalweg and rectilinear tracks on mountainside, whit 10% declivi-ties ($T_{2.2}$ variant)	136	136	158	0.56
	Main tractor track along the thalweg and sinuous, accessional tracks on mountainside, whit 25% declivities ($T_{2.3}$ variant)	134	134	129	1.44

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ОЦЕНКА НА ВЛИЯНИЕТО ВЪРХУ ОКОЛНАТА СРЕДА НА ГОРСКИТЕ ПЪТИЩА ЧРЕЗ СЪВРЕМЕННИ ИНФОРМАЦИОННИ ТЕХНОЛОГИИ

Н. Карандзидис, В. Янулас, К. Дукас, Гърция

Една от най-значителните намеси на човека в живота на горската екосистема е пътното строителство, т.е. планирането и построяването на мрежа от камионни и тракторни пътища и технологични просеки, които служат за извоз на дървесина, но също така и за туристически и лесозащитни цели.

Бързото развитие на компютърната техника и софтуера на географските информационни системи (GIS) дава възможност за обективна проверка и оценка на влиянието върху околната среда без големи разходи.

Целта на настоящата работа е да се задълбочи анализът на въздействието на строителството на горски пътища върху околната среда въз основа на измерими интензитетни и абсорбционни критерии и използуване на възможностите на модерните технологии.

Приложението на предлагания от нас метод предполага наличието на подходяща база данни. В сравнение с класическите методи, обработката на голям обем данни става за много кратко време и без методически грешки, понеже потребителят вече не взема участие в изчисленията. Дава се възможност за произвеждане на множество разнообразни дигитални карти и диаграми за различни варианти на пътя, които спомагат за вземане на оптимално решение.

EVALUATION OF E.I.A. BY THE FOREST ROAD CONSTRUCTION USING MODERN INFORMATION TECHNOLOGY

N. Karantzidis, V. Giannoulas, K. Doukas, Greece

ABSTRACT

Forest opening up is one of the most important interventions in a forest Ecosystem and is carried out by planning and constructing a transport network (forest roads, skidding tracks etc.), satisfying not only the need for skidding and transporting of forest products, but also forest protection and recreation activities.

The fast development of pc technology and GIS software provides an objective and effective evaluation of the Environmental Impact Assessment (E.I.A.). The present research focuses on E.I.A. concerning forest road construction, using measurable Intensity and Absorption criteria and exploiting the above mentioned modern technologies.

The implementation of this method requires an existing Database of geographical data. Spatial analysis and processing are carried out in an efficient and reliable way in comparison to classical methods.

Many various digital maps and diagrams were produced, examining different road variables. All these digital products contribute significantly to choose the most compatible for the environment solution.

DIE ABSCHÄTZUNG DER UVP IN EINZELNEN FORSTWEGEN DURCH ANWENDUNG MODERNER INFORMATIONSTECHNOLOGIE

N. Karantzidis, V. Giannoulas, K. Doukas, Griechenland

ZUSAMMENFASSUNG

Ein der bedeutendsten Eingriffe der Menschen in ein Waldökosystem ist seine Erschließung durch die

Planung und den Bau eines Netzes von Transportanlagen (Wald-, Schlepper-, Rückwege usw.), das zur Rückung und Bringung von Waldprodukten, touristischen Entwicklung und zu seinem Schutz effektiv beiträgt.

Die rasche Entwicklung der PC-Technologie und der GIS -Software bietet die Möglichkeit zur objektiven und wirtschaftlichen Untersuchung der Umweltverträglichkeitsprüfung.

Ziel dieser Arbeit ist die Erweiterung der Umweltverträglichkeitsprüfung im Forstwegebau aufgrund messbarer Intensitäts- und Absorptionskriterien und Ausnutzung der Möglichkeiten der modernen Technologien.

Die Durchführung der Methode setzt das Vorhandensein einer geeigneten Datenbasis voraus. Die Verarbeitung einer großen Menge von Daten wird in einem sehr kurzen Zeitraum, im Vergleich zu den klassischen Methoden, ohne methodische Fehler ausgeführt, da der Benützer in der Berechnung nicht mehr teilnimmt. Es gibt die Möglichkeit zur Herstellung von vielen und verschiedenartigen digitalen Karten und Diagrammen, für verschiedene vorgeschlagene Wegevarianten, die zur Entscheidung der bestmöglichen Lösung beitragen.

EINLEITUNG

Die Entwicklung der Berggebiete erschafft das Hauptziel der Waldpolitik, die heute in unserer Heimat angewandt wird. Diese Entwicklung setzt jedoch menschliche Eingriffe in die Naturumwelt voraus, die zu ihrer Verfälschung, Beschädigung und oft ihrer Degradierung führen. Ein der bedeutendsten Eingriffe des Menschen in ein Waldökosystem ist seine Erschließung durch die Planung und den Bau eines Netzes von Transportanlagen (Wald-, Schlepper-, Rückwege usw.), das zur Rückung und Bringung von Waldprodukten, touristischen Entwicklung und zu seinem Schutz effektiv beiträgt (Sedlak, 1993, Becker, 1995). Dennoch, außer dieser oben erwähnten positiven Auswirkungen, belastet die Erschließung die Umwelt und ruft Schäden an der Landschaft hervor, die zum Teil bedeckt werden, aber nicht wiederhergestellt werden können. Es ist sehr schwierig, diese Einwirkungen mit wirtschaftlichen Größen einzuschätzen, im Rahmen der bekannten Auswertungs- und Entscheidungsmethoden, wie die Kosten-Nutzen Analyse und andere mathematische Methoden. Unter Umweltverträglichkeitsprüfung (UVP) versteht man die Bestimmung, Beschreibung und Auswertung der Auswirkungen eines Werkes auf die Umwelt und die Maßnahmen für seinen Schutz. Demgemäß soll Hauptaufgabe eines Forstingenieurs die Forschung der Verträglichkeit des Forstwegebaus mit der Umwelt sein. Deswegen werden Kriterien der forsttechnischen Werke angewandt, die die Auswertung der Auswirkungen der vorhandenen Werke auf die Naturumwelt erlauben und die Möglichkeit zur Wahl der bestmöglichen umweltverträglichen Lösung unter vielen Alternativen vor dem Bau der Wege anbieten (Bürger et al., 1987, Doukas, 2004).

Die rasche Entwicklung der PC-Technologie und der GIS -Software bietet die Möglichkeit zur objektiven und wirtschaftlichen Untersuchung und Prüfung dieser Kriterien (Doukas, Akça, 1990).

Ziel dieser Arbeit ist die Erweiterung der Umweltverträglichkeitsprüfung im Forstwegebau aufgrund messbarer Intensitäts- und Absorptionskriterien und Ausnutzung der Möglichkeiten der modernen Technologien.

METHODEN UND MATERIALIEN

Die Untersuchung wurde im gebirgigen Gelände des Gesellschaftswaldes von Pisoderi im Florina-Bezirk durchgeführt. Das ist ein Wirtschaftswald, wo man Vielzweck-Forstwirtschaft übt. Zwei Forstwegen wurden untersucht im Rahmen der Umweltverträglichkeitsprüfung.

Zur Erreichung der Forschungszwecke im Rahmen der vorliegenden Arbeit wurde folgendes verwendet:

1. Digitale Orthophotokarte des Forschungsgebietes, die sich aus der photogrammetrischen Verarbeitung eines Luftbilderpaares in einer digitalen photogrammetrischen Station und der späteren Verarbeitung der Orthophotokarte im GIS- Software ergab. So wurden die Digitalisierung der Landnutzungen und des forstlichen Wegenetzes und schließlich die Durchführung von sicheren Messungen möglich, die die genaue Berechnung der Flächen für jede Landnutzung und die Länge des vorhandenen Wegenetzes betreffen (Doukas, 1995).

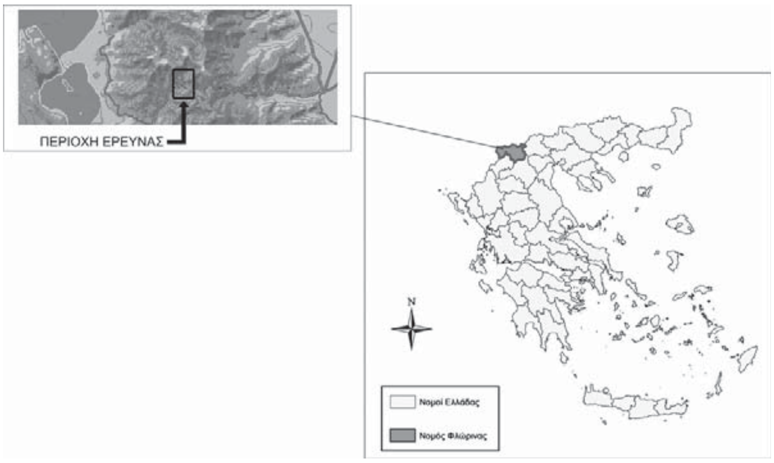

Abbildung 1 : Untersuchungsgebiet

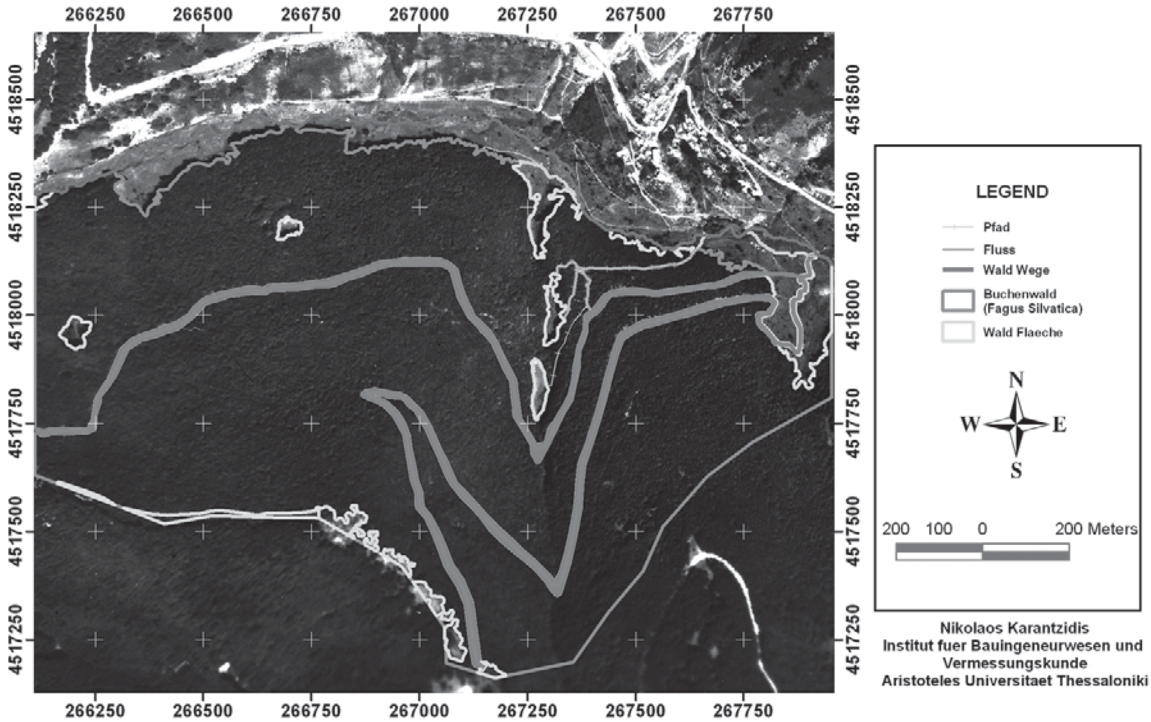

Abbildung 2 : Orthophotokarte des Forschungsgebietes

2. Der letzte Einrichtungsplan des Waldes, woraus Angaben wie Hiebsatz, Einrichtungsform, die vorhandenen Baumarten usw. ausgenutzt wurden.

3. Zur Bestimmung der Intensität des menschlichen Eingriffes in die natürliche Umwelt wegen des vorhandenen Forstwegebaus und der Waldausnutzung wurden die entsprechenden Kriterien (Buwal, 1990, Mader, 1990, Heinimann, 1994, Doukas, 2004) bestimmt. Parallel wurden Gewichtigkeitskoeffizienten bestimmt, die den Intensitätsgrad jedes Kriteriums aus Meinungen der Fachleute aussprechen.

Ausführlicher wurden folgende Intensitätskriterien angewandt:

Tabelle 1. Intensitätskriterien

Intensität				
	Kriterien	Grad E	Gewichtigkeit BE	Ingesamt E×BE
1	Erdmassenausgleich			
1.1	Kehren		2,1	
1.2	Gradienten		2,01	
1.3.	Querschnitt		2,25	
2.	Querprofil-Fahrbahnbreite		2,04	
3	Längsneigung		2,52	
4	Kehren (Serpentine)		2,13	
5	Lage der Trasse im Gelände			
5.1	Entfernung zu Wasserläufen		1,83	
5.2	Entfernung zur Waldgrenze		1,65	
5.3	Flächeninanspruchnahme		2,4	
5.4	Wegabstand		2,0	
6	Optische Erschließúng			
6.1	Geländemorphologie		1,83	
6.2	Vegetation		1,8	
6.3	Aussichtswirkung		(1,7)	
6.4	Störende Bauwerke		1,6	
6.5	Ansicht auf Wasserflächen		(1,65)	
7	Visuelle Absorptionsfähigkeit		1,77	
	Insgesamt			
	Mittelwert $GE= G\ (E{\cdot}B_E)/GB_E$			

4. In der Folge untersuchte man die Fähigkeit des Waldökosystems Absorption die Forstwegebauten zu absorbieren. Spezieller unter Absorption versteht man in wie weit die Auswirkung im Laufe der Zeit vom Ökosystem absorbiert wird, wie auch die Anzahl der Auswirkungsempfänger (Doukas, 2004). Die nachgeprüften Absorptionskriterien wie auch die vergleichbaren Gewichtigkeitskoeffizienten sind folgende:

Tabelle 2. Absorptionskriterien

Absorption				
	Fall	Grad A	Gewichtigkeit BA	Insgesamt A×BA
	Bodenzustand			
1	Bedeckungsart			
2	Baumart			
3	Forsteinrichtungsform			
4	Alter			
5	Baumhöhe			
6	Produktivität			
7	Geländeneigung			
8	Exposition			
9	Relief			
10	Entfernung von			
10.1	Touristischem Erholungsgebiet			
10.2	Nationalem Wegenetz			
10.3	Eisenbahn			
10.4	Archäologischem Platz			
10.5	Nebenliegender Großstadt			
10.6	Nebenliegender Gemeinde			
10.7	Europäischem Pfad			
10.8	See oder Fluss			
	Insgesamt			
	Mittelwert $GA = G\ (A{\cdot}B_A)/GB_A$			

Die endgültige Abschätzung der Intensität (E) für jedes Kriterium ergibt sich aus dem Produkt des Wertes jeden Kriteriums mal seinem Gewichtigkeitskoeffizienten (B_E), um den Mittelwert zu finden GE = G ($E \cdot B_E$)/GB_E. Die Absorption (A) des Waldökosystems wird mit dem Produkt des Wertes jeden Kriteriums mit dem entsprechenden Gewichtigkeitskoeffizienten (B_A) kalkuliert und schließlich ergibt sich der Mittelwert GA = G ($A \cdot B_A$)/GB_A.

Diese Mengen (GE, GA) bilden die Indexe, die den Absorptionsgrad der Erschließungswerke mit der Umwelt betreffen.

ERGEBNISSE

In den nachfolgenden Tabellen werden die Prozente der Intensitäts- und Absorptionskriterien wie auch die Werte GE und GA angegeben:

Tabelle 3. Intensitätskriterien des 1es Weges (näher dem Bach, als der zweite).

Intensität				
	Kriterien	Grad E	Gewichtigkeit BE	Ingesamt E×BE
1	Erdmassenausgleich			
1.1	Kehren	90	2,10	189,00
1.2	Gradienten	100	2,01	201,00
1.3.	Querschnitt	90	2,25	202,50
2.	Querprofil-Fahrbahnbreite	100	2,04	204,00
3	Längsneigung	100	2,52	252,00
4	Kehren (Serpentine)	100	2,13	213,00
5	Lage der Trasse im Gelände			
5.1	Entfernung zu Wasserläufen	100	1,83	183,00
5.2	Entfernung zur Waldgrenze	100	1,65	165,00
5.3	Flächeninanspruchnahme	100	2,40	240,00
5.4	Wegabstand	100	2,00	200,00
6	Optische Erschließúng			
6.1	Geländemorphologie	100	1,83	183,00
6.2	Vegetation	100	1,80	180,00
6.3	Aussichtswirkung	100	1,70	170,00
6.4	Störende Bauwerke	100	1,60	160,00
6.5	Ansicht auf Wasserflächen	100	1,65	165,00
7	Visuelle Absorptionsfähigkeit	90	1,77	177,00
	Insgesamt	1570	31,28	3066,80
	Mittelwert GE= G ($E \cdot B_E$)/GB_E	3066.80/31,28 = 98,04%		

Tabelle 4. Intensitätskriterien des 2es Weges.

Intensität				
	Kriterien	Grad E	Gewichtigkeit BE	Ingesamt ExBE
1	Erdmassenausgleich			
1.1	Kehren	90	2,10	189,00
1.2	Gradienten	75	2,01	150,75
1.3.	Querschnitt	70	2,25	157,50
2.	Querprofil-Fahrbahnbreite	80	2,04	163,20
3	Längsneigung	90	2,52	226,80
4	Kehren (Serpentine)	100	2,13	213,00
5	Lage der Trasse im Gelände			
5.1	Entfernung zu Wasserläufen	100	1,83	183,00
5.2	Entfernung zur Waldgrenze	100	1,65	165,00
5.3	Flächeninanspruchnahme	100	2,40	240,00
5.4	Wegabstand	6	2,00	12,00
6	Optische Erschließúng			
6.1	Geländemorphologie	100	1,83	183,00
6.2	Vegetation	100	1,80	180,00

6.3	Aussichtswirkung	100	1,70	170,00
6.4	Störende Bauwerke	90	1,60	144,00
6.5	Ansicht auf Wasserflächen	100	1,65	165,00
7	Visuelle Absorptionsfähigkeit	75	1,77	132,75
	Insgesamt		31,28	2675,00
	Mittelwert GE= G ($E \cdot B_E$)/GB_E	2675/31,28 = 85,51%		

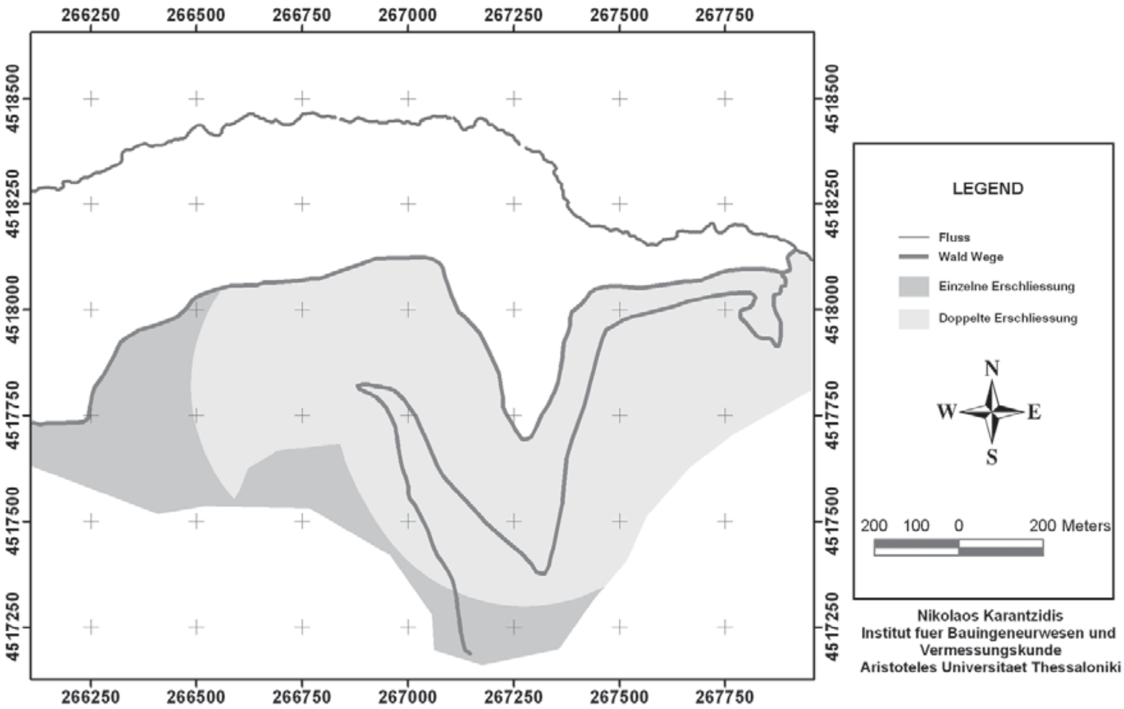

Abbildung 3 : Wegabstand

Tabelle 5. Absorptionskriterien

	Absorption			
	Fall	Grad A	Gewichtigkeit BA	Insgesamt AxBA
	I. Walbauliche Kriterien			
1	Bedeckungsart	93,00	3	279,00
2	Baumart	75,00	3	225,00
3	Forsteinrichtungsform	85,00	3	255,00
4	Alter	100,00	3	300,00
5	Baumhohe	75,00	3	225,00
6	Standortbeschaffenheit	100,00	3	300,00
7	Produktivität	100,00	3	300,00
	II. Topographische Kriterien			
1	Geländeneigung	22,60	2	45,20
2	Exposition	83,40	2	166,80
3	Relief	15,00	2	30,00
	III. Gesellschaftliche Kriterien (Empfängeranzahl): Entfernung von			
1	Touristischem Erholungsgebiet	30	1	30
2	Nationalem Wegenetz	50	1	50
3	Eisenbahn	Es befindet nicht im Gebiet		
4	Archäologischem Platz	Es befindet nicht im Gebiet		
5	Nebenliegender Grosstadt	Es befindet nicht im Gebiet		
6	Nebenliegender Gemeinde	70	1	70
7	Europäischem Pfad	70	1	70
8	See oder Fluss	-	-	-
	Insgesamt		31	2346,00
	Mittelwert GA = G ($A \cdot B_A$)/GB_A	2346/31=75,68%		

Die Kriterien I1, I2, II1, II2 und II3 können digital berechnet werden (Abb.4 bis 6), die I3, I4, I5, I6 und I7 aus den Forsteinrichtungsplan oder im Ort, während die Gesellschaftliche Kriterien (III) mit speziellem Software (Entfernung), das im Computerscreen die von einem Punkt von DTM Beobachteten aufweist.

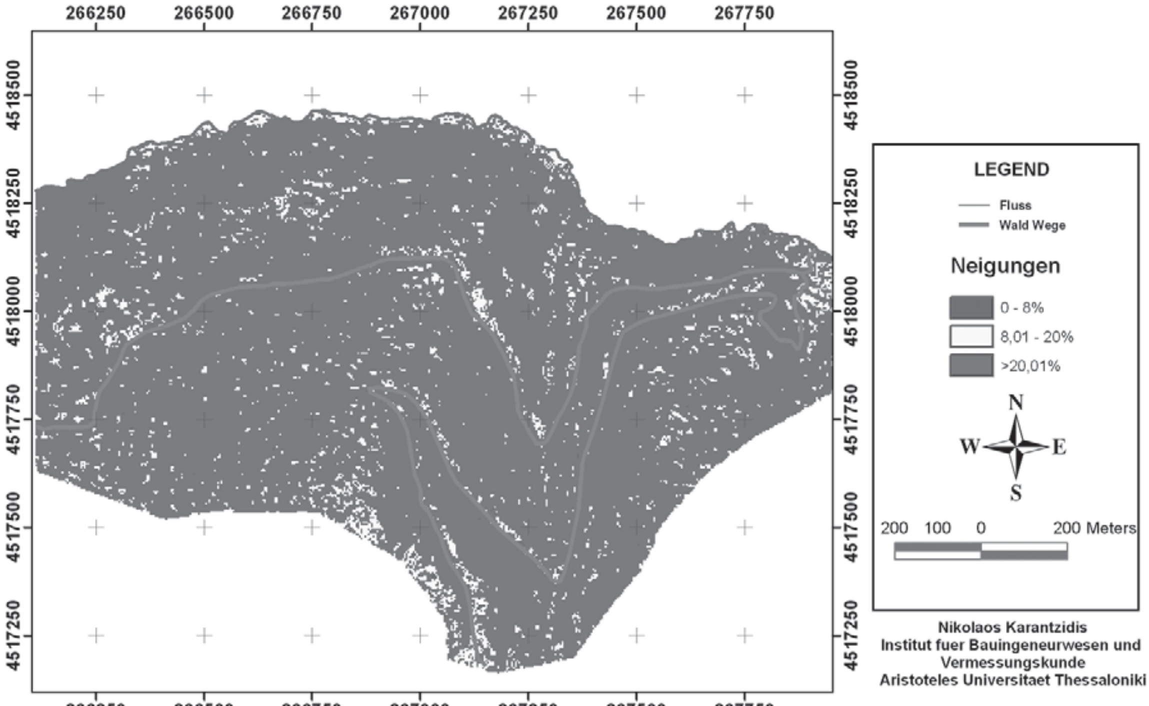

Abbildung 4 : Geländeneigung

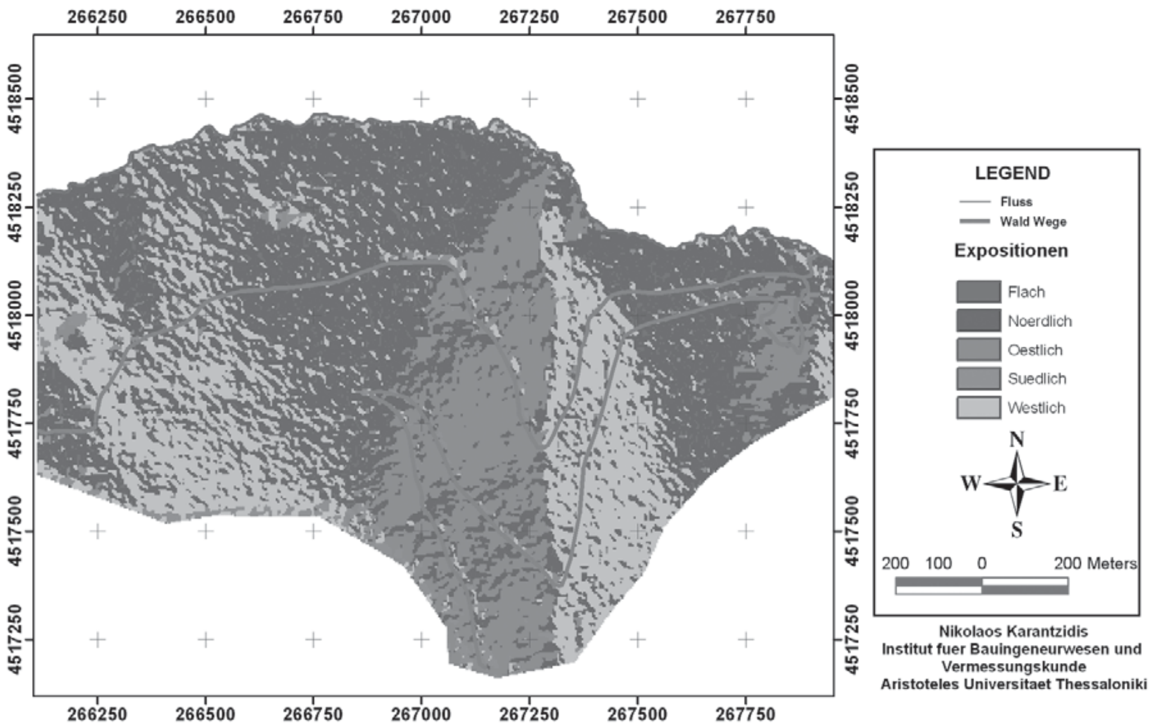

Abbildung 5 : Expositionen

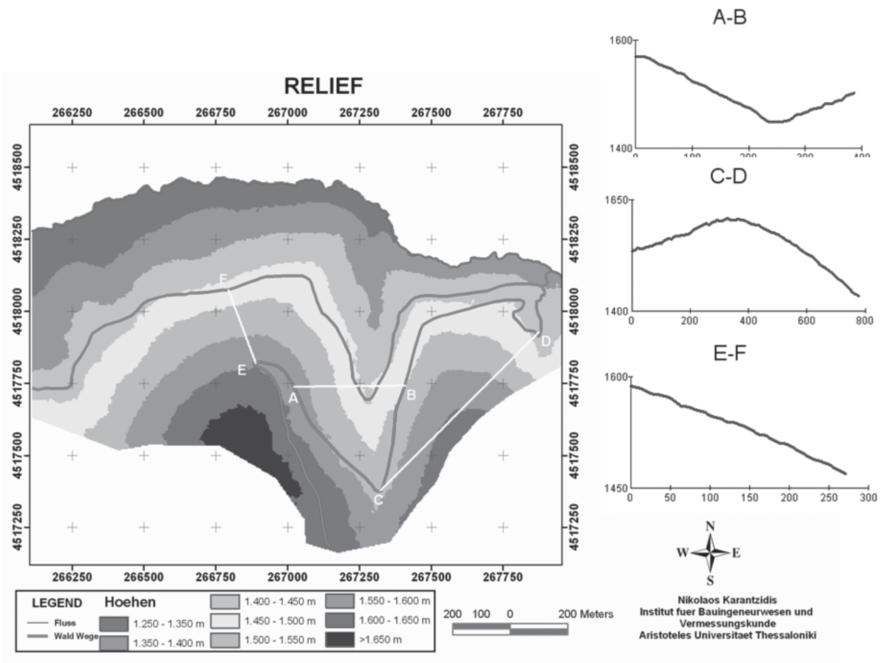

Abbildung 6 : Relief

SCHLUSSFOLGERUNGEN

- Die Herleitung der oben angeführten Werte basiert sich auf objektiven und messbaren Größen, die Indexe von Umweltauswirkungen sind, deren Studie die angewandte Methode zuverlässig macht. Ihre Anwendung ist notwendig nicht nur zur Auswertung der in einem Wald vorhandenen Forstwege, sondern auch vor dem Bau von neuen, um ihre Auswirkung auf die Umwelt zu erforschen und die bestmögliche Lösung zu wählen. Vorhandene Datenbasis erleichtert und vermindert wesentlich die Arbeitskosten.
- Die Zuverlässigkeit der Ergebnisse, wenn es sich um Intensitätskriterien 1,2,3,4 handelt, ist nutzbar nur bei der Voruntersuchung der UVP beim Forstwegebau, wenn das DGM aus Photogrammetrie mit kleinen Maßstabes Luftbildern hergeleitet ist. Bei der Evaluierung der optischen Erschließung braucht man spezielle Software.
- Diese Berechnungsmethode der Werte der meisten Intensitätskriterien und fast aller Absorptionskriterien ist leicht anzuwenden, mit der Verwendung von digitalen Kartographie und GIS-Technologien. Die Durchführung der Methode setzt das Vorhandensein einer geeigneten Datenbasis voraus. Die Verarbeitung einer großen Menge von Daten wird in einem sehr kurzen Zeitraum, im Vergleich zu den klassischen Methoden, ohne methodische Fehler ausführt, da der Benutzer in der Berechnung nicht mehr teilnimmt. Es gibt die Möglichkeit zur Produktion von vielen und verschiedenartigen digitalen Karten und Diagrammen, für verschiedene vorgeschlagene Wegalternativen, die zur Entscheidung der bestmöglichen Lösung beitragen.
- Die Anwendung der oben genannten Methode kann auch in Wäldern mit anderer Einrichtungsform möglich sein, wie degradierte, nicht produktive Wälder, Schutzwälder usw., aber mit noch strengeren Kriterien.

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ЗАВИСИМОСТ МЕЖДУ БРУТНИЯ НАЦИОНАЛЕН ПРОДУКТ И ПОЛЗВАНЕТО НА ДЪРВЕСИНА В БЪЛГАРИЯ

Константин Колев, България

Резюме

Изследвана е статистическата зависимост между брутния национален продукт и ползването на дървесина от горския фонд в България. Главният извод, който може да се направи е, че развитието на националната икономика има силно влияние върху дърводобива.

DEPENDENCE BETWEEN GROSS DOMESTIC PRODUCT AND FELLED TIMBER IN BULGARIA

Konstantin Kolev, Bulgaria

Summary

Statistical dependence in time between gross domestic product and felled timber by the Bulgarian forest territories is investigated. The main conclusion drawn from the research is that national economy development has a strong impact on timber harvesting.

Timber harvesting is of great significance for the Bulgarian forestry sector as it provides 2/3 of the financial funds for its development [4]. According to Forest surveying project the average quantity of felled timber for the period 1996 – 2005 should have been 5 200 000 m^3. However the average felled timber was only 4 400 000 m^3, which is nearly 85 % from the planned [3]. The failure in Forest surveying project fulfillment can be explained with three main reasons: insufficient forest net road (7.9 m/ha); restitution of forest lands; unstable demand for some sort classes timber. In relation to the last one (unsteady demand of timber) it is logical to suppose that it depends on terms of boom and stagnation in national economy. This assumption can be verified by means of a correlative analysis. In this connection the goal of research is to measure the extent of dependence between the Gross Domestic Product (GDP)[1] and felled timber for the period 1996 – 2005.

In order to realize the research's goal the following tasks have to be accomplished:

1. Measurement of dependences in time series.
2. Measurement of dependence between GDP and timber harvesting for the period 1996 – 2005.

Measurement of dependences in time series

Measurement of dependences on the basis of time series is connected with autocorrelation. This means that each variable in the time series is dependent on previous one. This phenomenon reflects unfavourably on correlation's characteristics. Coefficients of correlation (r) calculated from autocorrelated data exceed real ones [2].

In current research verification of autocorrelation is done through the first rank coefficient of autocorrelation.

[1] Gross Domestic Product (GDP) is main macroeconomic indicator. It measures general market value of goods produced for consumption in economy for a definite period of time (usually) one year.

$$r_{y_t y_{t-1}} = \frac{\sum_{t=2}^{N} y_t y_{t-1} - \frac{\sum_{t=1}^{N-1} y_t \sum_{t=2}^{N} y_t}{N-1}}{\sqrt{\left[\sum_{t=1}^{N-1} y_t^2 - \frac{\left(\sum_{t=1}^{N-1} y_t\right)^2}{N-1}\right]\left[\sum_{t=2}^{N} y_t^2 - \frac{\left(\sum_{t=2}^{N} y_t\right)^2}{N-1}\right]}}$$

(1), where $r^*_{y_t y_{t-1}}$ is coefficient of autocorrelation; N – number of variables in time series; y_t–size of variable in year t.

The calculated empirical coefficient of autocorrelation, is compared with theoretical coefficient ($r^*_{y_t y_{t-1}}$) [2].

If $r_{y_t y_{t-1}} \leq r^*_{y_t y_{t-1}}$, in time series does not have autocorrelation.

If $r_{y_t y_{t-1}} > r^*_{y_t y_{t-1}}$, in time series has autocorrelation.

When in time series there is autocorrelation, implementation of correlative analysis is possible only after some transformations. They aim to eliminate autocorrelation.

Measurement of dependence between GDP and timber harvesting for the period 1996 – 2005

In this research GDP (x) is an independent variable. It is measured in thousand USD by reason of eliminating inflation's influence. Felled timber (y), in thousand solid m^3, is dependent variable (Table 1).

Table 1. Gross domestic product and felled timber 1996 – 2005

Years	GDP in thousand USD (x)	Felled timber in thousand solid m^3 (y)
1996	9 900 621	4869
1997	10 364 983	4784
1998	12 736 680	4495
1999	12 945 459	4258
2000	12 596 286	3733
2001	13 598 103	3362
2002	15 568 502	4341
2003	19 936 751	5389
2004	24 130 348	5892
2005	26 435 888	5768

Sources: National Forestry Board, Bulgarian National Bank, Statistical Yearbook 2005

The coefficients of autocorrelation for GDP and felled timber calculated by means of formula 1 are presented in Table 2. The empirical coefficients of autocorrelation are bigger than the theoretical coefficients[2]. This means that in both time series there is autocorrelation.

Table 2. Empirical and theoretical coefficients of autocorrelation

Time series	Empirical coefficient, $r_{y_t y_{t-1}}$	Theoretical coefficient, $r^*_{y_t y_{t-1}}$
GDP	0.967	0.360
Felled timber	0.751	0.360

[2] The theoretical coefficient of autocorrelation is taken from Anderson's table.

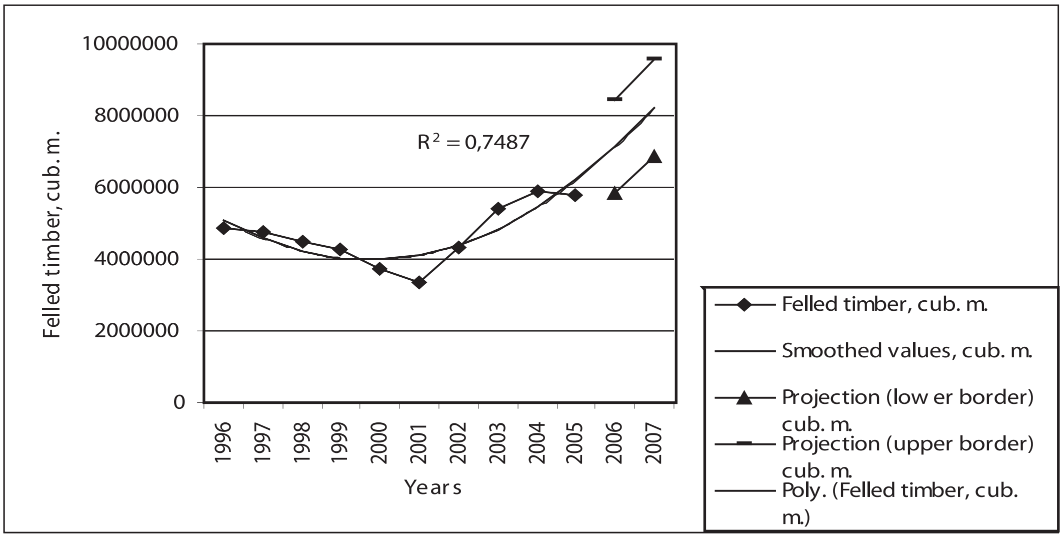
For elimination of autocorrelation, the method correlation of residual elements around trend lines was used. It is supposed that the residual elements around the trend line are with casual character and are not autocorrelated [2]. The chosen method was carried out in following order:

First: The tendency of development in the investigated time series is modeled through the analytical method. Concerning the felled timber, its trend is best described by quadratic regression model[3]: $\hat{y} = 5775715 - 757493.t + 79988.t^2$. In this model the coefficient of determination is the highest r2=0.7486 i.e. 75 % in the changes of timber harvesting can be explained with the tendency of development. The trend of gross domestic product is best described also by the quadratic regression model: $\hat{x} = 11487891 - 909512.t + 242488.t^2$. The coefficient of determination r2 = 0.964 means that 96.4 % in the changes of GDP are due to steady reasons, which form the tendency of development. Both regression models can be used for projections. After extrapolation it can be forecasted that in 2006 timber harvesting will reach 7 121 840 m3 and in 2007 – 8 204 071 m3. Regarding GDP it is expected that in 2006 it will reach 30 824 302 thousand USD and in 2007 – 35 492 013 thousand USD. Taking into account projections' stochastic errors with probability 0.95 are determined confidential intervals. They are presented in Table 3

Table 3. Borders of confidential intervals

Variables	Confidential interval 2006		Confidential interval 2007	
	Lower border	Upper border	Lower border	Upper border
Felled timber, thousand m³	5834	8409	6854	9554
GDP, thousand USD	27 442 199	34 206 404	31 946 167	39 037 859

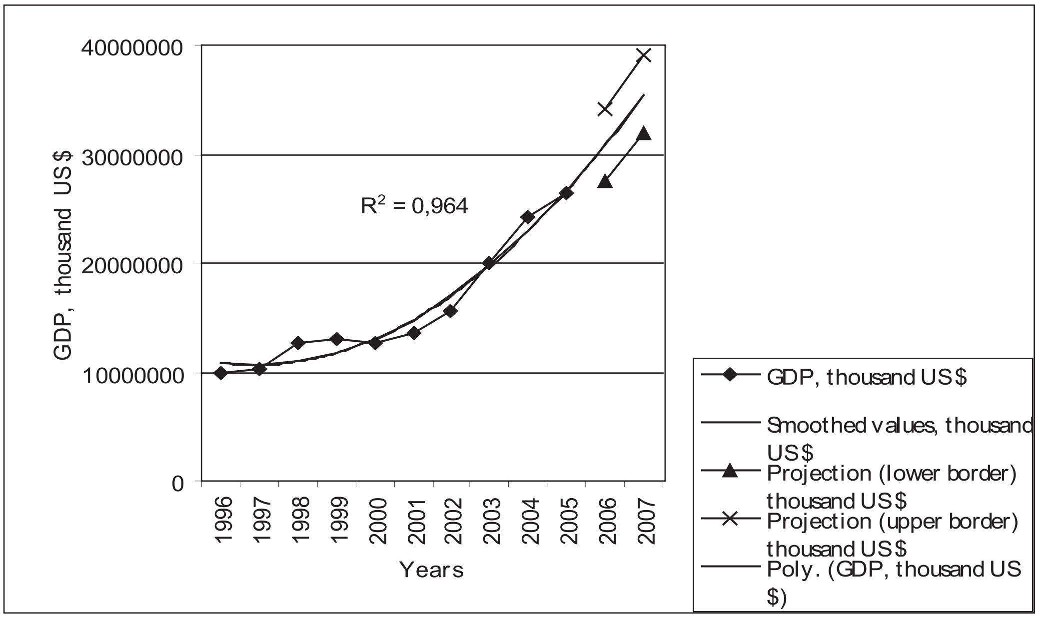
Smoothed time series, projections and borders of confidential intervals for 2006 and 2007 are presented graphically on Fig. 1 and 2.



Sources: National Forestry Board

Fig. 1. Trend of timber harvesting, m³

[3] In this research are verified for adequacy through F - test 11 models: Linear, Logarithmic, Inverse, Quadratic, Cubic, Compound, Power, S, Growth, Exponential, Logistic.



Source: Statistical Yearbook, 2005

Fig. 2. Trend of GDP, thousand USD

Second: Deviation around the trend line are calculated.

$\eta_t = y_t - \hat{y}_t;\ \varepsilon_t = x_t - \hat{x}_t.$ It is supposed that η_t and ε_t are with casual character and are not autocorrelated.

Table 4. Calculation of deviations (residual elements) around the trend lines

Years	Felled timber, m³ (y)	Smoothed values, m³ ($\hat{y}$)	Residual elements felled timber(η_t)	GDP, thousand US $ (x)	Smoothed values, thousand US $ ($\hat{x}$)	Residual elements GDP (ε_t)
1996	4 869 434	5 098 210	-228 776	9 900 621	10 820 867	-920 245
1997	4 783 694	4 580 681	203 013	10 364 983	10 638 818	-273 835
1998	4 495 084	4 223 128	271 956	12 736 680	10 941 746	1 794 934
1999	4 257 858	4 025 551	232 307	12 945 459	11 729 649	1 215 810
2000	3 732 643	3 987 950	-255 307	12 596 286	13 002 529	-406 242
2001	3 361 838	4 110 325	-748 487	13 598 103	14 760 384	-1 162 281
2002	4341261	4392676	-51415	15568502	17003216	-1434714
2003	5388594	4835003	553591	19936751	19731023	205728
2004	5891837	5437306	454531	24130348	22943807	1186541
2005	5768000	6199585	-431585	26435888	26641566	-205678

Third: Establishment of regression model, which describes the dependence between the residual components (deviations). The most adequate model is the linear: $\hat{\eta}_t = 0.254\varepsilon_t - 17.66$. Its suitability is checked with F- test.

$$F_{em} = \frac{\sigma_{\hat{\eta}}^{2/}/(p-1)}{s_{\eta}/(n-p)}$$

(2), where: $\sigma_{\hat{\eta}}^2$ - explicable deviation; s_{η}^2 - standard error of evaluation; n – number of variables in time series; p – number of evaluated parameters.

$$F_{em} = \frac{\sigma_{\hat{\eta}}^{2/}/(p-1)}{s_{\eta}/(n-p)} = \frac{689596408082/(2-1)}{859267926600/(10-2)} = \frac{689596408082}{107408490825} = 6.42$$

The theoretical characteristic F_T=5.32 is taken from F – distribution's table with critical level α = 0.05

and extents of freedom v = p-1 = 2-1=1 and w = n-p =10-2=8. When Fem > Fт the zero hypothesis (H_o) is rejected and the alternative one (H_1) is accepted. In this case the alternative hypothesis is the right one i.e. the linear regression model describes correctly the dependence between the variables.

The coefficient of determination $r^2 = 0.445$, is calculated through the formula $r^2 = \frac{\sigma_\eta^2 - s_\eta^2}{\sigma_\eta^2} = 1 - \frac{s_\eta^2}{\sigma_\eta^2}$ (3), where σ_η^2 is common deviation. The value of the coefficient of determination means that 44.5 % in the changes of timber harvesting are due to changes in GDP. After computing a root square from the coefficient of determination, the coefficient of correlation was established: $r = \sqrt{1 - \frac{s_\eta^2}{\sigma_\eta^2}} = 0.67$ (2). The last one characterizes the extent of dependence between the two variables. For its estimation, table 5 was used.

Table 5. Defining the extent of dependence [2]

Value of the coefficient of correlation	Extent of dependence
to 0.3	poor
over 0.3 to 0.5	moderate
over 0.5 to 0.7	significant
over 0.7 to 0.9	high
over 0.9	very high

After comparing the calculated coefficient of correlation (r= 0.67) with the data in table 5, it can be concluded that timber harvesting from the Bulgarian forest territories depends significantly on national economy development.

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ИЗВОЗ НА ДЪРВА С ВЪЖЕНА ЛИНИЯ НА СТРЪМЕН ТЕРЕН В УСЛОВИЯТА НА АЛПИТЕ

Рафаеле Кавали, Даниеле Лубело, Италия

Ползването на издънковите насаждения в Алпите расте бавно, но неотклонно поради търсенето на дърва за горене за населението, които се използват индивидуално или в кооперативни топлоцентрали. За стопанисване на издънковите насаждения на стръмни терени са необходими въжени линии. За да се оценят производителността и експлоатационните разходи на извоза на дърва за горене с въжена линия, беше изследвана въжена линия, разположена в буково издънково насаждение.

Дължината на линията беше 650 m при среден наклон на трасето около 60%. Беше приложен извоз на цели дървета, като се извозваха частично окастрени повалени дървета и по-нататъшната преработка се извършваше на временния склад.

Всички операции, от първоначалния оглед до демонтирането на линията, включително сечта, се включваха в измерванията и времето им се засичаше. При всеки курс се измерваше товарът, за да се определи производителността. Бяха определени общите разходи и разходите за единица продукция.

Определените разходи бяха сравнени с пазарните цени. Изводът е, че ако дървата се добиват за нуждите на местното население, цените са твърде ниски, така че рентабилност може да се постигне само с получаване на европейски субсидии.

FIREWOOD CABLE YARDING ON STEEP TERRAIN IN ALPINE CONDITIONS

Cavalli Raffaele, Lubello Daniele. Italy

Abstract

The utilisation of coppice in the Alpine area is slowly but constantly raising, in order to satisfy the firewood requirements of the populations, both for individual and co-operative heating plants. To exploit also the coppice growing on steep terrain cable crane extraction should be envisaged. In order to evaluate the productivity and the operating costs of firewood cable yarding, a cable crane based on a sledge yarder has been tested in a beech coppice.

The length of the line was 650 m and the average slope was about 60%. The full tree system, in which the stems were felled, only partially delimbed and yarded, was adopted (the stems being processed at the landing site).

All the working operations (from survey to dismounting the line, including also manual felling) were considered and different times were measured. For each run the load was assessed in order to calculate the productivity of the system. The total and unit operating costs were estimated.

Total and unit costs were compared to market costs: when firewood has to be cut only for inhabitants requirements, the value is too low and the only way to operate economically is using European grants.

INTRODUCTION

In last years, the use of wood to produce heat or energy is increasing after a period of low production. In Italy, firewood reached 60% in volume of total cuttings (Istat, 2002). This comes mostly from the regions in the south or in the centre of Italy where coppice is spread. In alpine conditions there are two kind of coppice woods: the first is a mixed wood where different species like alder, oak, hornbeam, poplar, ash and others appear; the second is a pure beech forest.

The energy use of wood is growing and increased the value from the availability on market of technological plants with high yield which are competitive, also in cheap terms, with respect to the conventional heating systems based on fossil or not renewable fuels (diesel oil, methane). This tendency has been accentuated in the last few years following the engagements accepted at international level about the reduction of the gas emissions (mostly CO_2), culminated with the approval of the Kyoto protocol. This gave impulse, also in Italy, to the greater diffusion of thermal plants of small, middle and big dimensions (from few kW to plants of some MW) which produce energy using vegetable biomassa (Verani, Sperandio 2005).

Specific reductions on taxes and regional contributions promote and support the private ones in the purchase of new plants burning firewood, chips or pellet.

In Trentino region, where the study has been carried out, coppice woods are 69 183 ha (1/5 of the total forestry area) and an average of 1344 ha are cut every year for a total amount of about 80 000 m^3. Public and private properties are equally distributed. People living in the Region have the right to use public wood for heating the house. Usually a forester gives to them every year a small area (Fig. 1) where to cut, but in 2006 the town council decided to ask European grants to cut in a steep area where beech was getting too much older. They decide to give this wood to inhabitants at a symbolic price (180 EUR per 4.5 tons). Current beech price is from 15 to 30 EUR/t standing inside the forest and about 120 EUR/t for market firewood. Cuttings have been done by a private enterprise instead of logging operations, equipments and crew provided by the regional forest office.

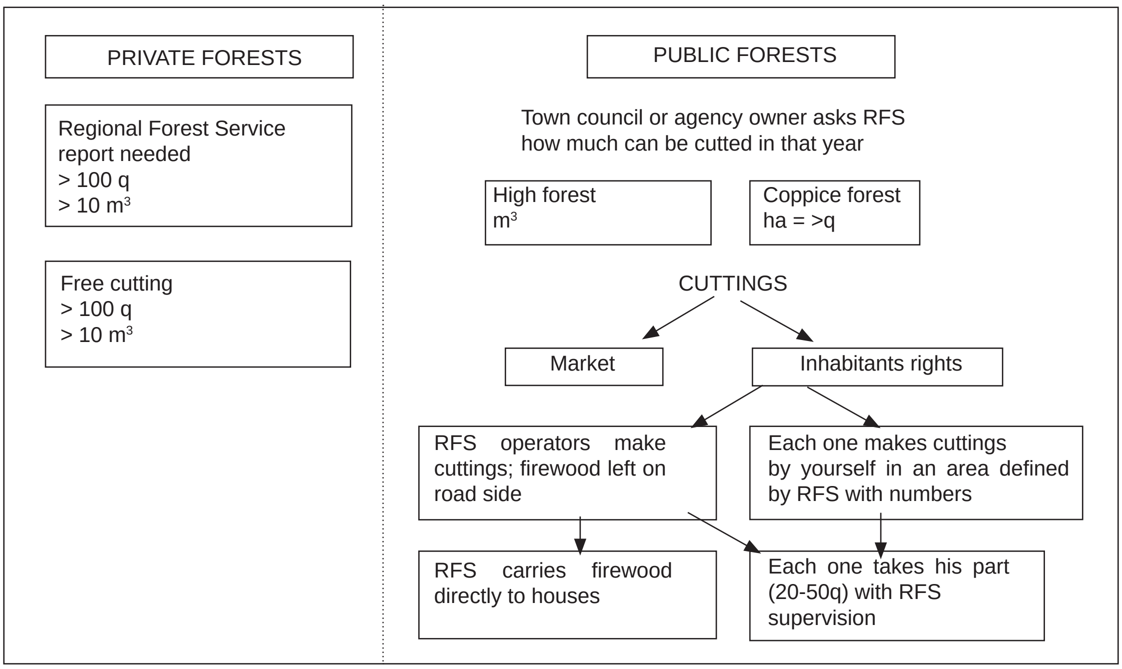

Fig. 1. Forest rules in Trentino region

In mountainous area beech forests usually grow on steep terrain where people have not supported softwood. Harvesting on steep slopes is a difficult operation requiring special technology. While tractor or harvester-forwarder system represent the state-of-the-art in trafficable terrain, log extraction on steep slopes has to be achieved by cable or helicopter yarding (Heinimann et al., 1998).

This study was carried out on a very steep and difficult terrain. The cutting area, situated at the top of the slope, can be reach only by a 4wd vehicle. This means that a traditional long-distance gravity system and downhill extraction is required (Eker et al., 2001). Trees partially delimbed at felling site are manually processed at landing site.

MATERIALS AND METHODS

Machines

Yarder Gantner HSW 50

Gantner HSW 50 is a versatile fully hydrostatic sledwinch. It can be used with all carriage systems, it is easy to handle because of its light weight and it has controls that make the work safe (Table 1).

Table 1. Yarder technical data (www.gantner-cableways.com)

Gantner HSW 50 NB	
Drum capacity Ø 8 mm Ø 9 mm Ø 10 mm Ø 12 mm	1400 m 1040m 855m 565m
Weight with full tanks without lines	1100 kg
Dimensions (lenght x widht x height)	215 cm x 113 cm x 120 cm
Max. line pull Bare drum Full drum	 33 kN / 3300 kp 18 kN / 1800 kp
Maw. line speed Bare drum Full drum	 4.6 m/s 8.5 m/s
Engine	Air cooled Hatz-Diesel engine with electric starter, approx. 26 kW/35hp at 3000rpm, oilbath ari filter, V-belt control
Consumption	3.7 l/h
Power transmission	Linde variable displacement pump and motor for a large range of torque and speed combinations
Brakes	Band brake integrated in drum; downhill braking by wearless hydraulic brake; multiple disk brake (safety brake – automatic stop)
Controls	Charging control, oil pressure control, temperature control, high and low pressure gauges
Attachments	Sled frame, closed bottom plate, roller fairlead, slope holding brakes, overroll guard with load-hook eye, remote control, electric power 12V
Drum dimensions	Core Ø 24 cm, Flange Ø 44 cm, width 800 mm

Carriage Greifenberg CRG15

Greifenberg CRG15 is a light carriage with integrated electro-hydraulic system (Table 2). It is a safe item because of the radiocontrol and of a particular system that closes brakes on skyline in case of mainline breaks.

Table 2. Carriage technical data (www.greifenberg.it)

Greifenberg CRG 15	
Dimensions (lenght x widht x height)	120 cm x 24 cm x 90 cm
Weight	145 kg
Max load	1.5 t
Working temperature	from –15°C to +60°C
Skyline	from Ø 16 mm to Ø 22 mm
Mainline	from Ø 8 mm to Ø 13 mm
Pulleys and ropes	2
Minimum line slope	15%
Maximum speed	14 m/s
Controls	radiocontrol

Ropes and supports

Skyline is a 20 mm Seale - fiber core; minimum breaking load is 234 kN and weight is 1.45 kg/m.

Mainline is a 9 mm compacted Warrington-Seale; minimum breaking load is 53 kN and weight is 0.41 kg/m.

Mounting the line, two artificial supports were needed: an intermediate support with a typical L-support shape and a tail support at landing site. The tail support was mounted perpendicular under the line, the skyline lying on a jack over the head (Fig. 2).

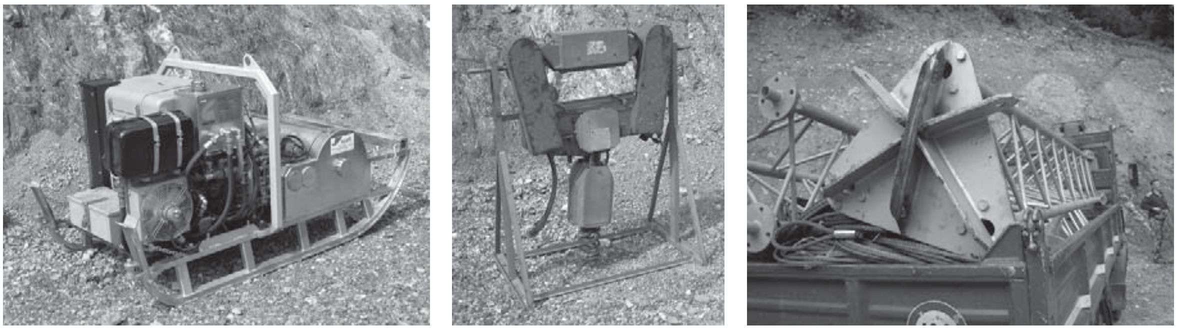

Fig. 2. Gantner sledge-yarder, Greifenberg carriage and the head of artificial tail support

Working site

Working site took place in northern Italy in mountain Alps near Garda Lake. Property is of Tenno council, a town in Trento district. Mountain shoulder, were cuttings took place, has an average steepness of 90%. There is only a truck forest road reaching the lower part where an escavator enlarged a small place preparing landing site. From landing site, a tractor road went up near cutting area, but steep slope reached 22% and it was not possible to skid wood down the road with tractor and trailer. Sledge yarder could be reached only by 20 min walking.

The average slope of the line was 56.6%. Skyline lenght between anchor trees was 772 m; maximum hauling distance was 658 m from landing site. Loading area was concentrated in the upper part of the line. Fig. 3 shows the profile of ground and cable line.

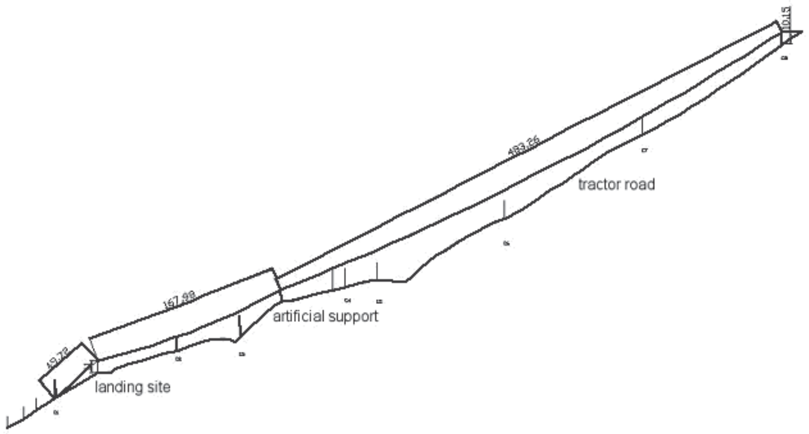

Fig. 3. ground and cable crane profile.

Due to height of skyline, hauling corridor is narrow: maximum lateral skidding distance is 15 m. After cuttings, operators had to move wood under the line by hand and by PVC timber-slides.

Time and productivity study

The aim of the research is a good estimation of unit costs when cutting coppice wood in steep slope conditions.

The analysis of working site calendar times and all costs operations gives unit costs and it is a basis to improve productivity and reduce costs (Klun et al., 2005). Total times are divided in big chapters (Bortoli, Solari 1996):

1- Survey and project of the line
2- Cuttings
3- Mounting and dismounting the line
4- Yarding times

Much information was recorded about general data on locality and workers, daily monitoring of the work's structure and efficiency (for example the number of workers), machine maintenance, petrol and lubricant consumption, data on working site, sketch of the line and terrain's profile, data from felling and logging distances. In first two steps, total times and quantities were recorded. According to Bortoli, Solari (1996), Kosir (2001) and Stampfer et al. (2006), times for setting and taking down the line were divided in:

- supports a) artificial downhill tailtree

b) uphill tailtree

c) artificial intermediate support

- positioning the machine
- mainline
- telephone
- skyline
- carriage
- cutting trees
- move materials
- extra times

During yarding, time studies were necessary to know the average daily productivity of the sistem. The productivity model was based on protocols well-known in literature (Heinimann et al., 1998; Visser, 1998; Tunay, 2001). The working cycle of the cable crane was divided into the following steps:

- carriage out (coming up unloaded)
- rope out and hooking up
- skidding
- carriage return (coming down loaded)
- unhooking turn
- delay times
- total time

For every trail, the distance from landing site and lateral skidding were recorded.

To test the effect on total time and productivity, one or two operators were involved in hooking up operations.

Time for pile logs at landing site has been recorded to evaluate the tractor cost.

The yarding efficiency was expressed in “ton-metres” (t/cycle) and simply calculated for average data (Medved et al., 2004).

Two people collected all the data during a thirteen days period in August and September 2006. During yarding, one person was constantly following hooking up operations, the second, at landing site, was following unloading and piling operations. Times and average volumes relative to 50 extraction cycles were gathered. Statistical analysis was performed with SPSS 13.0 for Windows (2006) software. Applying linear (simple or multiple) and non-linear regression techniques parameters of the models were estimated, by which is possible to quantify the productivity of the sledge yarder under specific work conditions.

RESULTS AND DISCUSSION

Setting the line analysis

Total corridor installation operations took eleven days of work. Seven days were spent on setting-up and four days for taking-down the line. Every day, two trainer operators and three or four simple operators were working. Working site was every time in order and well organised taking care of safety of workers. In each operation, from two to five people were occupied, the others doing something else or waiting. It would be useful to divide crew in two teams of three. Actually, mounting the line took a lot of time. The length of the line and steepness has also influence.

20% of mounting time, more than one day, was spent cutting trees along the corridor (figure 4): after previous cuttings, a lot of trees had many branches over the corridor. If this operation would have well done before, mounting times had been near to 5.6 days as reported in Bortoli, Solari (1996). Spreading mainline and skyline was difficult for the presence of two little streams were walking was hard because of steep slopes and slippery. The intermediate support had to be built just in between the two streams. In that place no useful trees were growing and an artificial support was needed: this is why constructing intermediate support took 15% of total mounting time.

Taking-down the line, four operations take together 62% of total time (Fig. 5): coming down with yarder is slower than coming up and mainline has to be rolled up by hand on a drum for safe transporting;

artificial intermediate support has to be hoisted uphill to the road were it was dismounted; skyline coming down is helped using mainline and tractor power force to move storage drum; checking, ordering and stacking materials (move materials) is an important operation for saving time in the next working site.

Tractor and yarder have been used respectively 3 h 50’ and 20 h 20’ during all operations.

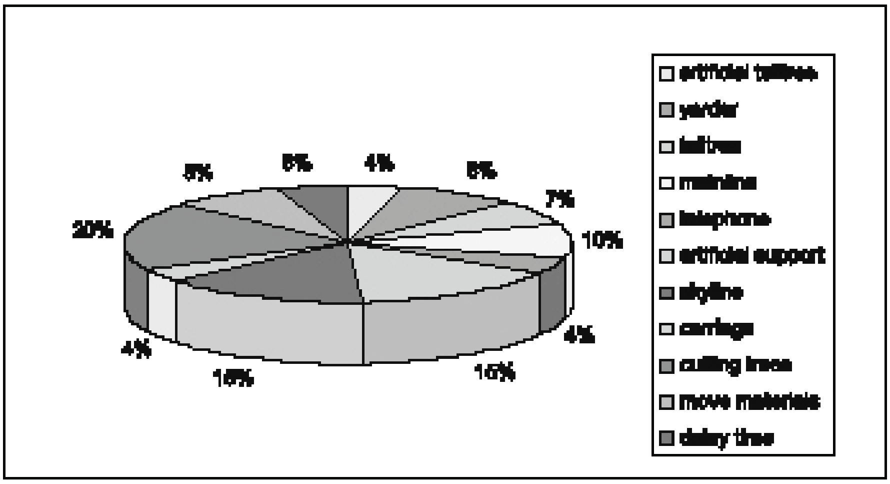

Fig. 4. Operations and times mounting the line

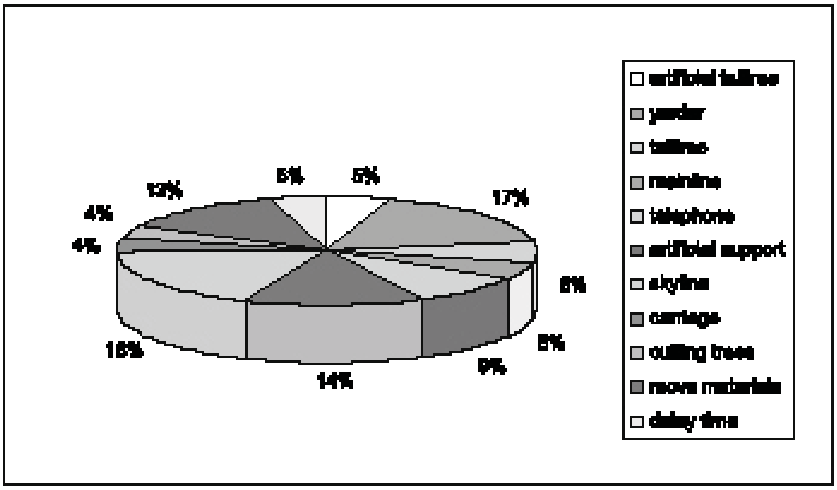

Fig. 5. Operations and times dismounting the line

Productivity analysis

During cuttings logs were stacked in heaps of 0.5-0.8 tons to be easily tied up in yarding operation. Operators were only occupied in tying logs or cutting with chainsaw. Delay times depend on sawing operations: some trees did not fall during cleaning the corridor so the hook was used as winch to help trees falling down. Others delay times occur when skidding heaps under the line an obstacle caused the opening of chains and operators had to recover the load.

A good estimation of daily productivity and productive times were needed to correctly calculate unit costs. During time studies two situations were tested: the first with only one operator hooking up loads, the second with two operators (as usual the system works). As shown in Fig. 6 and 7, when only one operator is working, 45% of total time is affected by his skill; when the same operation is done by two, the percentage decreases to 30%. Tying becomes 24% faster. Daily productivity is also affected increasing from an average of 10.4 t/day to 14.9 t/day with two operators; 28 carriage trails and 22 t/day are maximum values. Carriage running times also increase from 39% to 53% of total productive time.

Lateral skidding distance and times (“log”) were recorded, but they do not seem to be correlated (R^2=0.026).

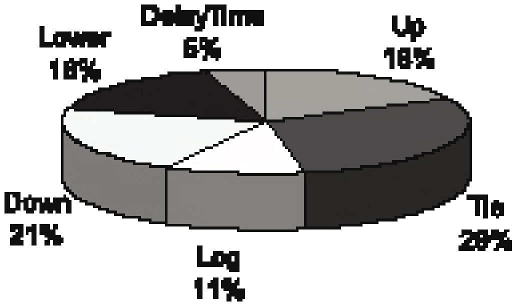

Fig. 6. 1 operator ties logs

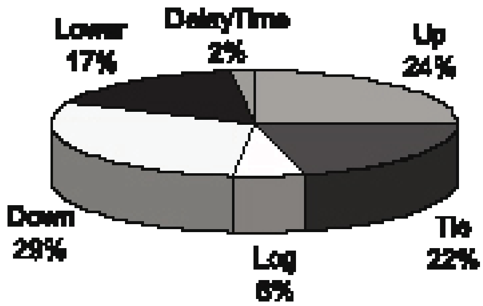

Fig. 6. 1 operator ties logs

Sledge yarder productive time has an average of 385.5 min/day. K conversion factor equals 1.38. Oil (0.02 l/h) and fuel consumption (3.7 l/h) have been recorded for calculating operative costs.

To evaluate the efficiency of the system, productivity has been compared to others time studies data (Fig. 8). Fanari's (1999) data refers to cuttings in mature softwood stands while Klun's (2005) data to both pure softwood and mixed with deciduous beech trees stands. No examples were found investigating only deciduous stands with these skidding distances. Even if data refers to only 50 complete trails, R^2 equals 0.48, it is possible to say that times are three times higher, and consequently productivity lower, when skidding beech firewood than softwood. This is good information in forest management when utilisations have to be planned in different stands. A good knowledge of times for cutting and skidding operations allows the respect of management plan prescriptions about the yearly wood amount to be cut.

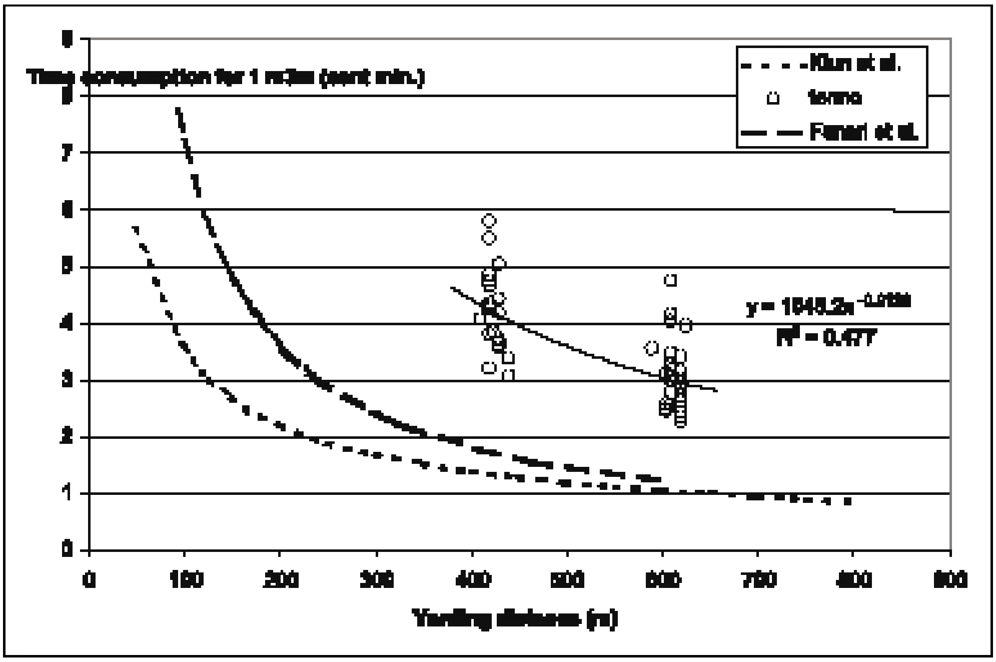

Fig. 8. Data comparison: time used for the load of 1 m³/m in view of yarding distances

Times for piling logs at landing site were also recorded. This is contemporary with cable crane working and has been monitored for the use of tractor with winch and for the estimation of its costs. Tractor works an average of 141 min/day.

Cost analysis

All recorded time studies and unit costs data were used in cost analysis.

Costs (Table 3) have been recorded mostly checking invoice elements as cutting by private enterprise, machines translocation, firewood transport, grants and selling firewood to inhabitants.

Regional forest operators have different daily costs according to their instruction level: trainer operators cost 152.48 EUR/day, special operator 120.65 EUR/day and simple operators 115.81 EUR/day including all employer costs.

Machines hourly costs have been obtained by operating data and calculated with Miyata (1980) model. The cars cost is 1.29 EUR/km and operative costs have been estimated considering a trip of 40 km per day to reach working site. Yarder and tractor (120 hp) costs are 17 EUR/h and 14 EUR/h (without operator).

Table 3. Costs

Phase	people/operators	hours (tot)	total cost (EUR)	notes
Surveying	4	20	315.00	
Line project	1	2	60.00	
Cutting	3	170	19 000.00	private enterprise (500 t)
Cutting	4	160	2428.00	regional forest operators (65 t)
Escavator	2	70	7634.00	enlarge landing site
Move machines	2	12	600.00	2 trucks coming and back
Mounting the line	5.5	308	4853.49	regional forest operators
			614.62	tractor + yarder + cars
Logging	5	1200	17 890.80	regional forest operators
			2805.00	yarder
			4083.00	tractor + cars
Firewood transport	2	276	6000.00	92 trails
Dismounting	5	161	2468.46	regional forest operators
			338.87	tractor + yarder + cars
Total cost			69 091.24	
European grants			8430.00	
Selling income			22 600.00	
Total income			31 030.00	
Total firewood				565 t
Unit cost			67.4	EUR/t
Unit cost without grants			82.3	EUR/t

CONCLUSIONS

In last ten years, the interest on bioenergy increased, in Italy in particular the use of biomasses for heating like firewood. There are many coppice forests taken in advantage of this purpose, but often wood lies in difficult situations. This was the case of this research which had the aim to evaluate economically the use of a sledge yarder in firewood skidding.

Mounting and dismounting the line are long lasting operations and depend on the working site organization, the operators number and problems connected to forest road infrastructures and ground steepness. Well done cuttings, including cleaning the line corridor, and small teams of operators working at the same time could be time saving solutions.

Daily and hourly productivity is one third lower than studies carried out on high forests. Unit costs raise 82.3 EUR/t: if we consider selling price of standing coppice forest (15-20 EUR/t), cuttings will not be cheap for private enterprises (no economic gain). With the help of European grants, obtained in this case for changing management from coppice to high forest, unit costs get lower to 67.4 EUR/t and symbolic price paid by inhabitants (40 EUR/t) can be reasonable.

The fact that all operations have been provided by regional forest service, firewood transport to each inhabitant included, allows to reduce traffic on public and forest roads and cuttings have been done by professional operators reducing risks for others people.

Accurate estimation of yarder corridor installation time is not only important for harvest planning and costing of operations, it can also help assess cost increases associated with silvicultural recommendation (Stampfer et al., 2006). With these results forester will plan utilisations according to slope, skidding distances and costs that can be obtained. Next management plans will consider if cuttings on a determined area are cheap or not for supplying firewood.

AKNOWLEDGEMENT

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ИНТЕГРИРАНЕ НА СТАРИТЕ ТРУПЧИЙСКИ ПЪТИЩА В МОДЕРНИТЕ СИСТЕМИ ЗА ИЗВОЗ

Мануела Бахер-Винтерхалтер, Германия

През последните десетилетния дърводобивни машини навлязоха в повечето насаждения в Германия. Машините станаха големи, мощни и тежки. Още при първо влизане те предизвикват уплътняване на почвата. Способността на извозните пътища да се възстановят още не е проучена. Много почви в Германия обаче са чувствителни. По тази причина опазването на почвата е с предимство за германското горско стопанство. То изисква създаването на постоянни извозни пътища, които да се използват при всички извозни операции.

Институтът по дърводобив и научна организация на труда и Институтът по почвите към Фрайбургския университет, Университетът за приложни изследвания в Хиледсхайм/Гьотинген и Институтът за гората на провинция Баден-Вюртемберг работят по проекта 'TESTKIT', финансиран от германското Федерално министерство на образованието и научните изследвания. Проектът започна в края на 2005 г. Първата му цел е да се разработят методи и тестове за откриване на старите трупчийски пътища. След това те трябва да бъдат включени в мрежа от постоянни извозни пътища, каквато е необходима по икономически и екологични причини за модерните извозни операции.

Институтът по дърводобив и научна организация на труда към Фрайбургския университет работи по следните задачи:

- Разработват се първите рационални методи за разпознаване на старите трупчийски пътища в горите. Изпробват се възможностите и на модерни технологии като лазерното сканиране. Тези технологии допринасят за предварително определяне на местоположението на старите трупчийски пътища и за рационално използване на почвените проби при разпознаването им.
- Като следващ етап ще бъде определен и оптимизиран потенциалът на старите трупчийски пътища за включването им в постоянна система от извозни пътища, която да отговаря едновременно на икономическите, екологичните и съвременните технически изисквания.

За тези изследвания бяха избрани 6 обекта в Южна Германия. Те се различават по почвени условия и горскодървесна растителност. Избрани са обекти с чувствителна почва, заети от млади и стари иглолистни и широколистни насаждения.

Настоящата статия е посветена на методиката на горното изследване, както и на обсъждане на първите резултати.

INTEGRATION OF HISTORICAL SKID LINES IN MODERN SKID TRAIL SYSTEMS

Manuela Bacher-Winterhalter, Germany

In the last decades harvesting machines have crossed the most part of the stands. The machines became larger and more powerful with higher weights. They cause soil compaction by crossing the first time. There is no knowledge about potentials of regeneration of skid lines. In Germany there are lot of sensitive soils. For this reason soil protection is a priority objective for German forest management. Soil protection means permanent skid trail systems which are used for all harvesting operations.

In cooperation with the Institutes of Soil, University of Freiburg, University of Applied Supplies in Hildesheim/Göttingen and the Forest Research Institute of Baden-Württemberg, there is the project 'TESTKIT' sponsored by BMBF (Federal Ministry of Education and Research of Germany). The project started at the end of 2005. The main objective of it is to develop suitable methods and tests for identify historical skid lines. Moreover these identified historical skid lines should be integrated in permanent skid trail systems necessary for modern harvesting operations with regard to site adaptation, economy and ecology.

The Institute of Forest Utilization and Work Science, University of Freiburg, is dealing with the following objectives:

- First rational methods are developed for recognising historical skid lines in the forests. Potentials of modern technology like laser scanning are also tested. These methods are contributing to a pre-localisation of historical skid lines and a rational utilisation of soil tests for identifying such lines.
- Then for the study areas the potentials of these historical skid lines are tested and optimized for integrating in a permanent skid trail system which meets economical, ecological and modern technical requirements of harvesting at the same time.

For the studies six sites have been selected in Southern Germany. They differ in soil and stand conditions. The sites consist of sensitive soils, in old and young softwood and also hardwood stands. This paper refers on a presentation of the study methods and on a discussion of the first results.

СРАВНЕНИЕ НА НОРМИТЕ НА ДЪРВОДОБИВА

Ивайло Марков, Индржих Неруда, Клаус Клугман, Сотир Глушков

През 2004 г. Националното управление по горите (НУГ), след конкурс по Закона за обществените поръчки, натовари Института за гората – БАН със задачата да актуализира трудовите норми на дърводобива. С това НУГ целеше преди всичко да получи надежден инструмент за извършване на техническите разчети, които се правят при подготовка на търговете и преговорите с дърводобивните фирми.

Работната група пристъпи към работа с убеждението, че действащите у нас трудови норми на дърводобива имат съществени методически недостатъци. По-специално, те не държат достатъчно сметка за закона за единичната маса, и то от времето на възникването си през 50-те години. В следствие от това едрата дървесина се товари със себестойността на дребната. По тази причина беше предприето сравнение на нашите норми с известните Европейски такива – тези на Германия и Чехия и в по-малка степен на Русия и Полша.

Сравнението показа, че нормите на време на изследваните страни са близки по стойност. За разлика от разценките, които са национални и даже регионални, нормите на време са международни и поне в Европа би трябвало да се изработват и актуализират съвместно. Сравнението потвърди средното ниво на разходите на време в действащите норми от 1991 г. Както обаче очаквахме, те се оказаха твърде непрецизни по отношение на размерите на добивания материал и бяха прецизирани по изчислителен път и литературни данни.

COMPARISON OF LOGGING PERFORMANCE STANDARDS

Ivailo Markoff, Jindřich Neruda, Klaus Klugmann, Sotir Gluschkov

Abstract

In the present paper, a comparison between Bulgarian, Czech and German standard time tables of logging operations is made. For the traditional technologies (without harvesters ans forwarders) quite similar standard times have been stated. It was also found that the Bulgarian standard does not take sufficiently account of the timber size (the mean diameter or the mean log volume) and should therefore be duly improved.

VERGLEICH DER LEISTUNGSNORMEN DER HOLZERNTE

Ivailo Markoff, Jindřich Neruda, Klaus Klugmann, Sotir Gluschkov

In 2004 beauftragte die bulgarische Nationale Forstverwaltung das Sofioter Institut für Forstwissenschaften (FRI o. Forest Research Institute) mit der Aktualisierung der Normen der Holzernte. Die dementsprechend benannte Arbeitsgruppe ging von der Überzeugung aus, daß die gültigen bulgarischen Normen aus dem Jahre 1991 wesentliche methodische Mängel aufweisen. Es geht hauptsächlich darum, dass sie das Stückmassengesetz (Speidel, 1967, Klouda, 1988) schlecht berücksichtigen, d.h. inkonsequent oder zu grob. Die wichtigste Folge davon ist, daß das starke Holz mit den Selbstkosten des schwachen Holzes belastet wird. Dies hat die Jahresplanung der Forstwirtschaft immer gestört, besonders in den letzten Jahren, die sich mit massivem Einsatz von Holzernteunternehmern kennzeichnen (Roček, 2007). Es ist zu vermerken, daß das besprochene Problem bekanntlich seit der Entstehungszeit der bulgarischen Normen der Holzernte in den 50-er Jahren besteht. Dabei geht es nicht um Unwissenheit, sondern um eine Entlohnungspolitik. Auf jeden Fall ist der Fehler tief verwurzelt. Aus diesem Grund wurde der Vergleich unternommen, von welchem hier berichtet wird.

Materialien und Methoden

Es wurden bulgarische, deutsche und tschechische Leistungsnormen für die Holznutzung verglichen (Anonymus, 1980, Anonymus 1991, Anonymus 1994, Anonymus, 2001, Anonymus, 2005, Anonymus, 2007). In den nachfolgenden Aufführungen werden sie oft mit den Abkürzungen „bg“, „dt“ bzw. „cz“ bezeichnet.

Als Entscheidungskriterium wurde der graphische Vergleich gewählt. Kompliziertere mathematische Auswertungsverfahren sind in diesem Fall überflüssig.

Ein Problem war die Vergleichbarkeit. Die bulgarischen Normen sind anders strukturiert, als die mitteleuropäischen, insbesondere hinsichtlich der Ausmaßen der Holzsorten. Als Beispiel sollen zwei Auszüge aus den obengennnten Normen (Tab. 1 und Tab. 2). Der Beispiel repräsentiert die zwei Hauptbereiche der Holzernte – die Aufarbeitung (Tab. 1) und die Bringung (Tab. 2).

Tab. 1. Holzaufarbeitung, Nadelholz, unentrindet

BHD	Stärkeklasse	Vorgabezeit
cm		h/Fm
über 20	starkes Stammholz	0,60
	mittleres Stammholz	0,80
	schwaches Stammholz	1,14
11 − 20	mittleres Stammholz	1,63
	schwaches Stammholz	1,40
bis 10	schwaches Stammholz	3,10

Die Begriffe starkes, mittleres und schwaches Stammholz in Tab. 1. werden im Sinne der bulgarischen Sortentafeln verwendet. Starkes Stemmholz muß am Zopf mindestens 18 cm stark sein, mittleres − 8 cm und schwaches − 3 cm. Ausnahmen aus dieser Regel gibt es, wenn das Stück eine minimale Länge nicht hat, zB. 4 m beim starken Holz. Dann wird das ganze Stück der nächsten Klasse zugeordnet, zB. zum mittelstarken Holz. BHD ist der Brusthöhendurchmesser des Kreisflächenmittelstammes.

Die Klassifikation des Rundholzes nach Tab. 1 erfolgt hauptsächlich nach der Zopfstärke. Diese Klassifikation wird beim Fällen und Aufarbeiten verwendet. Bei der Bringung richtet man sich dagegen nach dem starken Ende der gerückten Stücke oder Bäume (Tab. 2).

Tab. 2. Holzrückung mit landwirtschaftlichen Traktoren, 1 Arbeiter, Nadelholz

Rückeentfernung	Durchmesser am starken Ende	
m	D > 20 cm	D ≤ 20 cm
	Vorgabezeit	
	h/Fm	
100	0,239	0,505
500	0,324	0,585
1000	0,424	0,698
2000	0,622	0,912
3000	0,820	1,131

Aus Tab. 2. ist übrigens ersichtlich, daß in Bulgarien die Rückeentfernungen sehr groß sein können.

Aufgrund von Sortentafeln und statistischen Daten, die die Frequenz einzelner Holzsorten und Baumarten angeben (Krastanov et alii, 2004), konnten die Stärkeklassen nach Tab. 1 und 2 in die üblichen Weiser Stückmasse und Mittendurchmesser übersetzt werden (Tab. 3 und 4), was dann den Vergleich mit den mitteleuropäischen daten ermöglicht hat.

Tab. 3. Stärkeklassen der motormanuellen Holzaufarbeitung

BHD	Stärkeklasse	Stückmasse	MDM
cm		Efm o.R.	cm
	starkes Stammholz	0,229	27
über 20	mittleres Stammholz	0,095	17*
	schwaches Stammholz	0,026	9*
	mittleres Stammholz	0,063	14
11 – 20	schwaches Stammholz	0,021	8
bis 10	schwaches Stammholz	0,017	7

Die Abkürzung MDM bezeichnet freilich den mittleren Durchmesser der Mitte. Die mit einem Stern * gekennzeichneten MDM sind scheinbar zu groß. Sie erklären sich durch die Nichteinhlatung der obigen Zopfstärenregel bei kürzeren Stücken.

Tab. 4. Stärkeklassen der Holzbringung

Stärkeklasse	Stückmasse	MDM
	Efm o.R.	cm
D ≤ 20 cm	0,108	12
D > 20 cm	0,706	21

Ergebnissse

Die Ergebnisse des Vergleichs werden in den nachfolgenden Abbildungen 1 bis 7 dargestellt. Abbildung 1 zeigt ein ziemlich gutes Übereinstimmen der bulgarischen Normen mit dem EST. Der zackige Verlauf der BG-Kurve ist ein Mangel bulgarischen Zeittafeln. Er egibt sich dadurch, sie in einigen Fällen das schwache Holz für weniger aufwendig als das mittelschwache halten (siehe z.B. Tab. 1, die Zeitwerte 1,14 und 1,63).

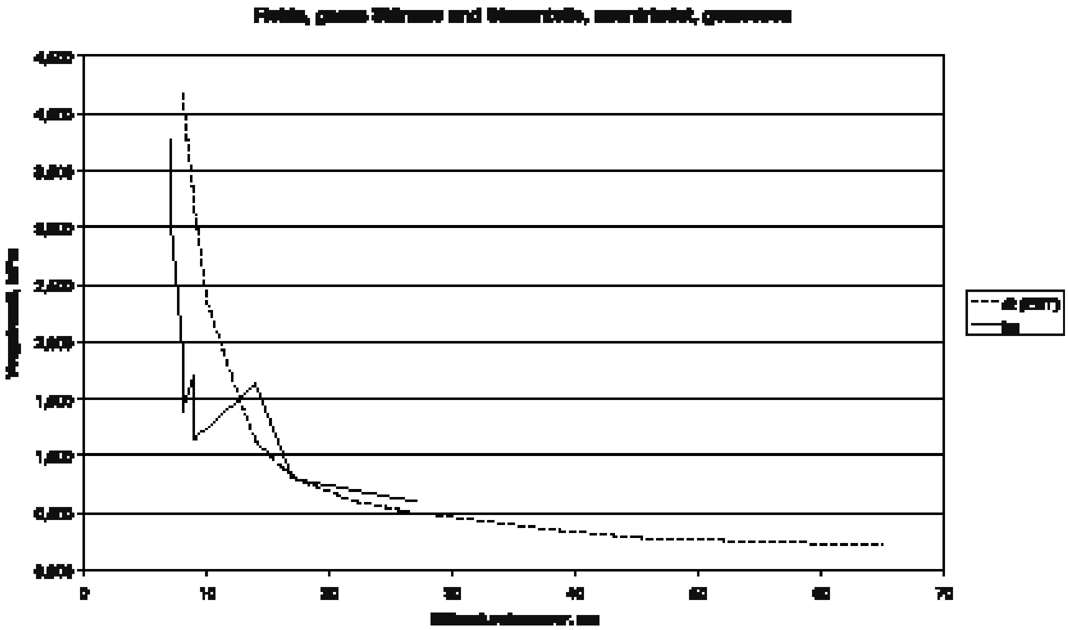

Abb. 1

Abbildung 2. zeigt wiederum eine ziemlich gute Übereinstimmung der bulgarischen Normen mit den tschechischen. Es werden die durch schwellenartige Kurven dargestellten Mittelwerte der Kurven verglichen. Auf der Abbildung ist auch der stetige Verlauf der tschechischen Kurve gezeigt. Die zackige bulgarische Kurve haben wir der Lesbarkeit halber erspart, es ist nur ihr schwellenartiger Mittelwert (punktiert) angegeben.

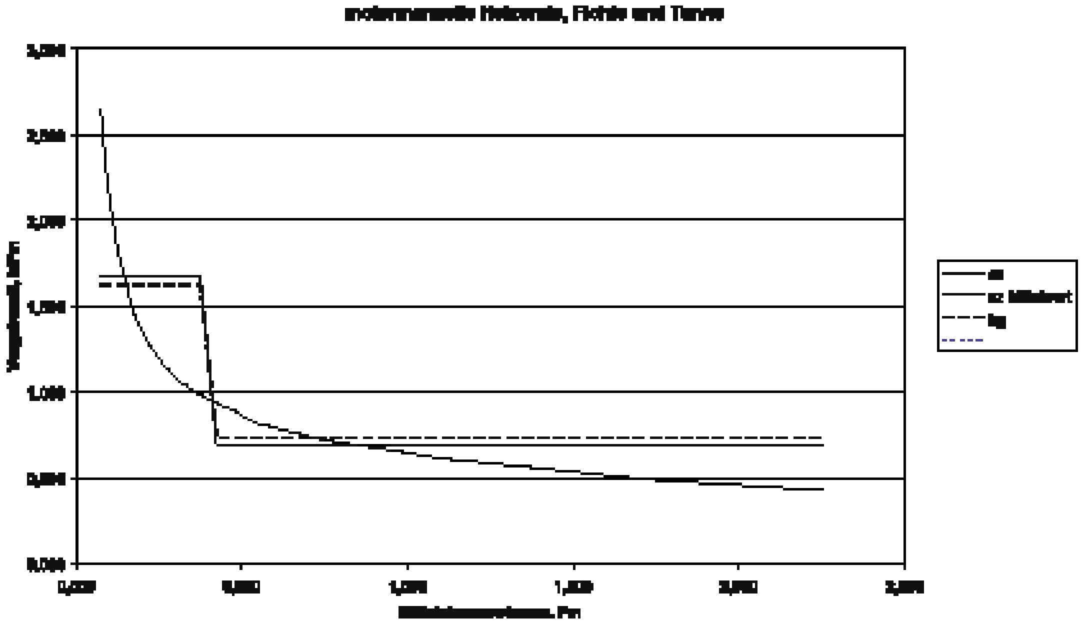

Abb. 2

Abbildung 3 bezieht sich auf die Produktivität der landwirtschaftlichen Schlepper bei der Holzbringung. Es werden tschechische und bulgarische Vorgabezeiten verglichen. Die tschechischen Kurven entsprechen der Summe der Vorgabezeiten für Rückung und Polterung. Der Vergleich der aufgeführten Kurven (sowie der Vielzahl derjenigen, die wir nicht aufführen) zeigt eine ungefähre Übereinstimmung.

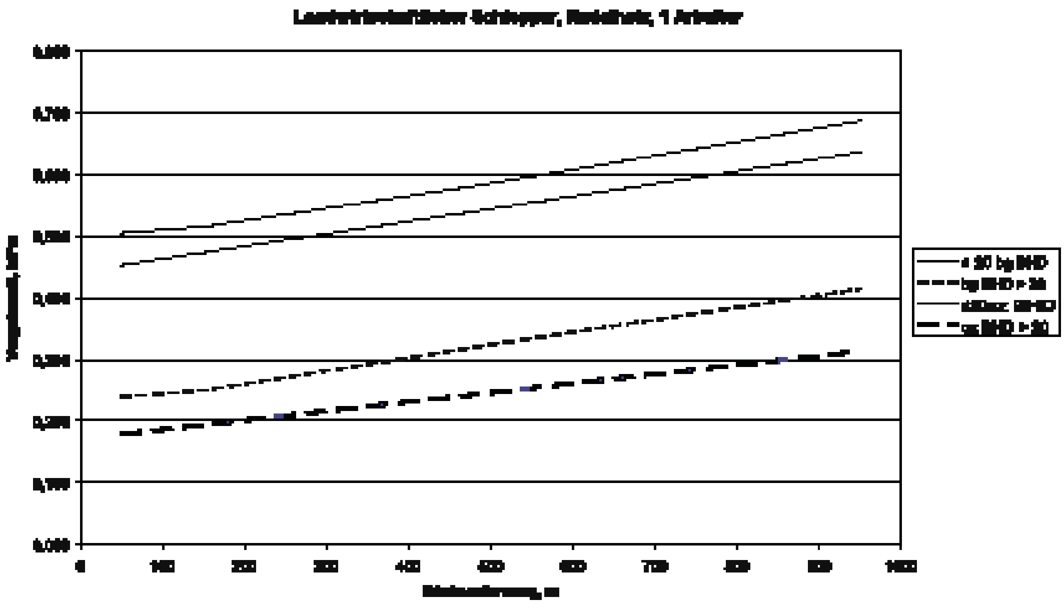

Abb. 3

Abbildung 4 ist ein Vergleich der Vorgabezeiten für die Holzernte mit spezialisierten forstwirtschaftlichen Schleppern. Die Vorgabezeiten für spezialisierte Schlepper sind in Prozenten von der Vorgabezeit für landwirtschaftliche Schlepper ausgedrückt. Die Abbildung zeigt eine wesentliche Abweichung in den Auffassungen der bulgarischen und tschechischen Autoren der 80-er Jahre: nach den tschechischen normativen Daten muß die Vorgabezeit eines forstwirtschaftlichen Schleppers 67% von der Vorgabezeit eines landwirtschaftlichen Schleppers betragen, während sie nach den bulgarischen ganze 95% beträgt. Da es um diegleichen Schlepper LKT handelt, müßte das ein Misverständnis sein. Allerdings bestätigen einige bulgarischen Autoren die geringe Produktivität der forstwirtschaftlichen Schlepper unter den Bedingungen Bulgariens. Für uns bleibt der Fall anjetzt unklar.

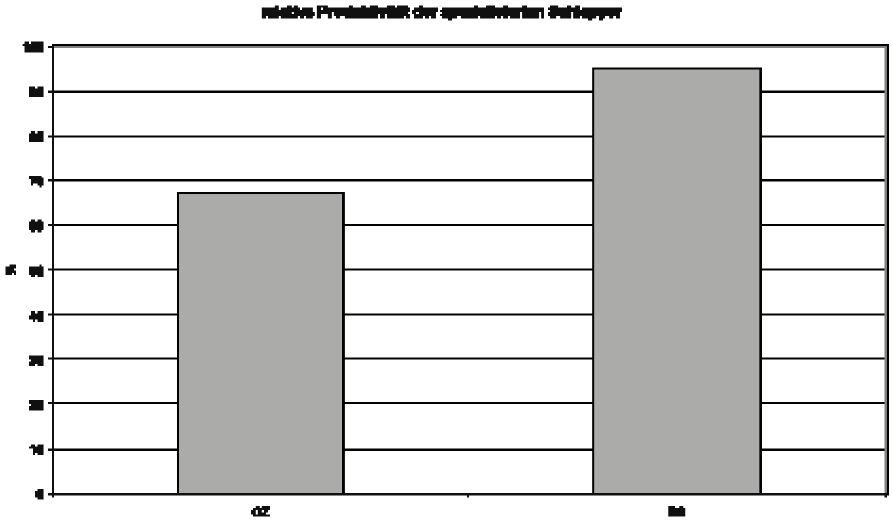

Abb. 4

Es ist zu vermerken, dass die mitteleuropäischen Normen hisichtlich der Produktivität der spezialisierten forstwirtschaftlichen Schlepper miteinander einverstanden sind. Abbildung 5 vergleicht die tschechischen Normen (Bringung + Polterung) mit den Richtsätzen des Forstamtes Entenpfuhl in Rheinland-Pfalz.

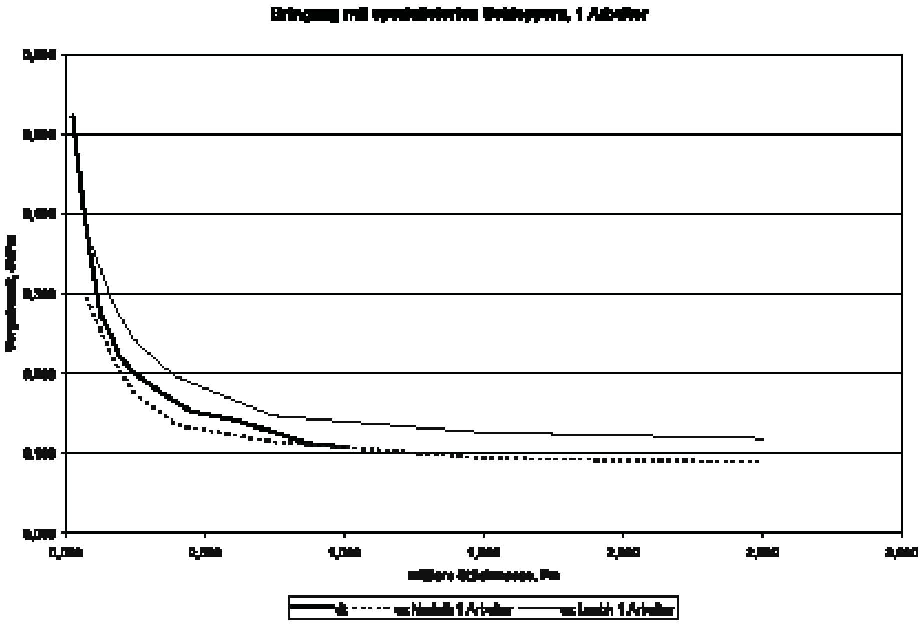

Abb. 5

Die Pfälzer Kurve, die keinen Unterschied sowohl für Nadelholz als auch für Laubholz gilt, hat eine Zwischenstellung zwischen den tschechischen Kurven für Rückung von Laubholz und Nadelholz. Das Gesamtbild ist als eine gute Übereinstimmung der Vorstellungen dieser zwei Normen zu deuten.

Abbildung 6 stellt den Vergleich der Normen für Holzbringung mit Pferden dar. Unter CZ sind tschechische und unter BG sind bulgarische Vorgabezeiten aufgeführt. Um Vergleichbarkeit zu erreichen, sind die tschechischen Daten entsprechend der Annahme umgerechnet worden, daß der Pferdeführer seine Pferde selbst betreut. Die Übereinstimmung ist befriedigend, wenn man dazu in Betracht nimmt, daß es bei den bulgarischen Vorgabezeiten um einen kleinen Teil ihres Definitionsgebietes geht, der sich entsprechend den Gebräuchen der Halbinsel von 100 Metern zu 3000 m und mehr erstreckt.

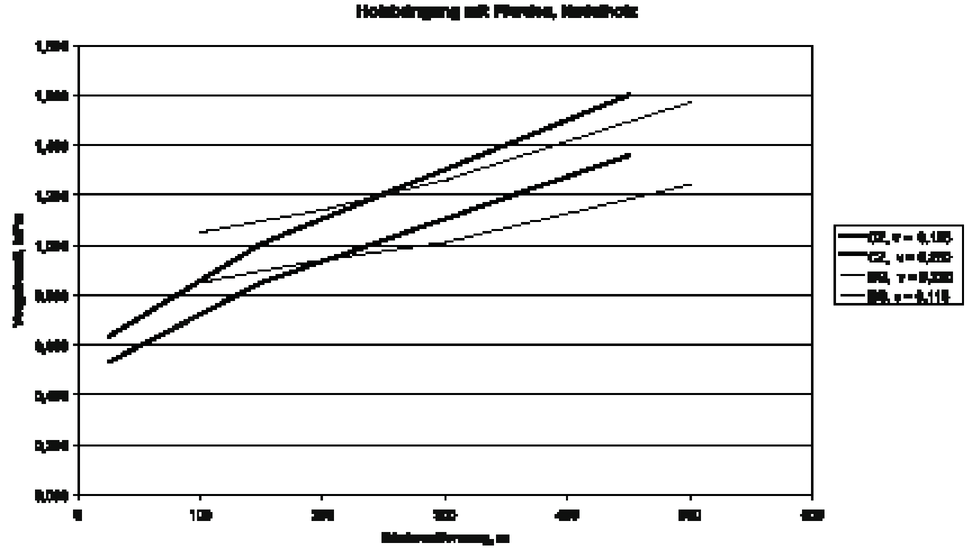

Abb. 6

Abb. 7 betrifft die Bringung mit Seilkrananlagen. Es werden tschechische und bulgarische Normen verglichen. Die tschechschen Vorgabezeiten beziehen sich auf die Bringung selbst + Montage und Demontage je 100 m Holz. Dabei wurde gutachtlich geschätzt, daß die Seilkräne Koller etwa um 50% schneller montiert und demontiert werden als die tschechischen VLU der 80ßer Jahre.

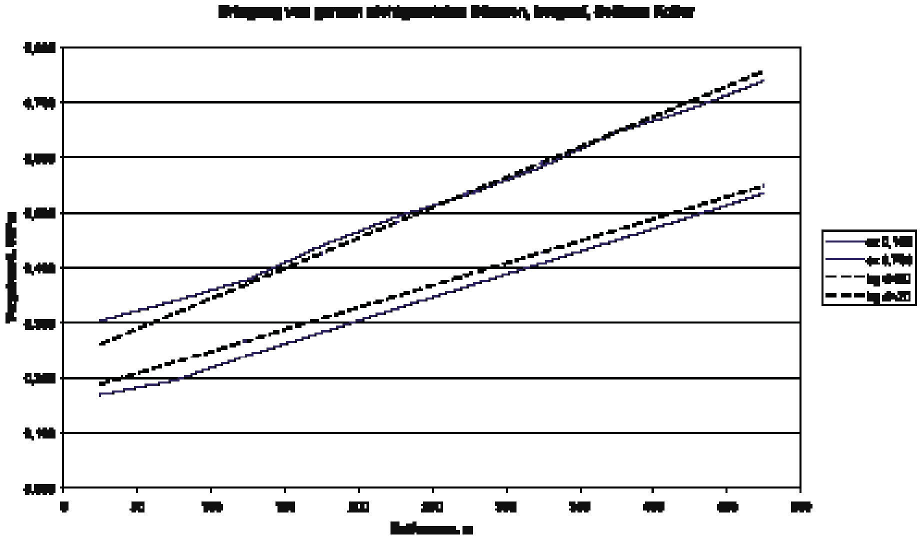

Abb. 7

Schlußfolgerungen

Hinsichtlich des gesamten Niveau des Zeitaufwandes bestätigen die verglichenen Normen einander, mit Ausnahme des Falles der Holzbringung mit forstwirtschaftlichen Schleppern.

Die bulgarischen Normen sind hinsichtlich der Stückmasse zu grob und müßten kalkulatorisch oder experimental verbessert werden.

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ОПОЛЗОТВОРЯВАНЕ НА ДЪРВОДОБИВНИЯ ОТПАД ЧРЕЗ ДРОБИЛНАТА МАШИНА BRUKS 800 CT

Тадеуш Москалик, Ярослав Садовски, Полша

До средата на XIX век дървесината се използва широко като енергиен ресурс. Промишлената революция, която започва тогава, предизвиква бързо нарастване на потреблението на енергия. Затова хората се обръщат към нови, по-ефективни енергоизточници като въглищата, петрола и природния газ. Тези горива обаче започнаха да се изчерпват. През последните двадесет години все по-голямо значение придобиват възобновимите енергоизточници. Като такъв източник може да бъде оползотворена значителна част от горската биомаса (дърводобивният отпад). Важно е да се подчертае, че като член на Европейския съюз през 2010 г Полша трябва да постигне 7,5 % дял на възобновимите ресурси от енергодобива си.

Дърводобивният отпад е сравнително лесно достъпен за преработващите машини при гола сеч. През 2005 г. площта на голите сечи в полските държавни гори възлезе на 25 000 ha. От тази площ се очаква да се получат 1,0 милион m^3 дърводобивен отпад.

Целта на настоящата работа е да се представи ефективността на дробилната машина Bruks 800 CT при дробене на дърводобивния отпад. Изследването беше проведено на пробни площи с бял бор. Постигнатата производителност беше 5,7 m^3/ч дървесни трески. Разходите за единица продукция възлязоха на 18,6 EUR/m^3.

UTILISATION OF LOGGING RESIDUES BY BRUKS 800 CT CHIPPER

Tadeusz Moskalik, Jarosław Sadowski, Poland

Abstract

Wood as an energy resource had been used very often until the middle of the nineteenth century. The industry revolution, which began at that time, caused a rapid increase in demand for energy. Consequently, people have searched for new, more effective energy sources, like coal, oil and natural gas. But these types of fuels have been running off. For the last twenty years bigger and bigger importance has had a renewable energy. A significant part of biomass coming from forest (logging residues as well) can be utilized this way. It is important to emphasize that Poland as a EU member has to reach 7.5% energy from renewable sources by year 2010.

Logging residues are relatively easy to reach for processing machines on the clear cuts. The area of clear cuts amounted last year in the Polish State Forests to 25,000 ha. It is estimated that on this area about 1.0 million m^3 of logging residues can be harvested.

The aim of this paper is to present a work efficiency of the logging residues chipping by the Bruks 800 CT. The research was carried out on the forest plots with Scots Pine. The achieved work productivity came to 5.7 m^3/h of wood chips. Unit costs reached 18.6 EUR/m^3.

Introduction

In the all world, to the middle of the nineteenth century only renewable sources of energy (mainly wood) had been used. In the aftermath of the industry revolution appeared a rapid demand for energy. On the larger scale were exploited coal, oil and natural gas. But in not so long time it turned out that these fossil fuels, characterized by a high net calorific heating value are not unlimited on the earth. Besides, their use causes definite changes in natural environment, connected with the global climate warming up, greenhouse effect and acid rain.

The concern for environment conditions and prospects of the running low of fuel reserves aroused again interest in renewable energy sources.

Popularity of the renewable energy sources and problem with the atmosphere pollution were the initiation point of many international meetings and conferences. One of the first, very important for the future activities, was the Earth Summit - the United Nations Conference on Environment and Development (UNCED), which took place in Rio de Janeiro, 1992. One of the accepted guiding principles for business and governments was that alternative sources of energy are being sought to replace the use of fossil fuels which are linked to global climate change. Great importance was the Kyoto Protocol to the United Nations Framework Convention on Climate Change (1997), in which are included agreements concerning of the emission reduction of carbon dioxide and five other greenhouse gases.

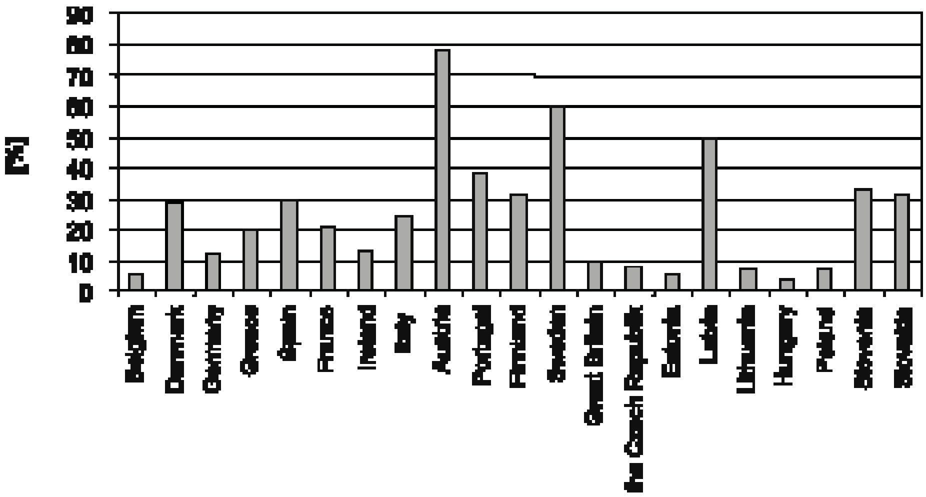

Fig. 1. Assumed minimal share of renewable energy sources in the total production of electric energy in some European countries.

In accordance with the established documents, there were made appropriate decisions on the EU level. Among other things, the next strategic documents were accepted: Energy for the Future: Renewable Sources of Energy White Paper for a Community Strategy and Action Plan (1997), Green Paper: Towards an European Strategy for the Security of Energy Supply (2002), White Paper European Transport Policy to 2010: Time to Decide (2001). The first document defines a strategy and action plan to promote the market penetration of renewable energy sources, with a target of doubling their use by 2010, from 6% of total consumption in 1996 to 12% in 2010 (Oniszk-Popławska, 2003).

Fig, 1 presents assumed minimal share of renewable energy sources in the total production of electric energy in some European countries. Poland in year 2010 should achieve 7.5% (Jabłoński, Różański, 2003). One of the most important renewable energy sources is a wood biomass. It includes fuel wood for residential heating, fuel chips from forest operations (wood and forest residues chips), residues from sawmills and residues from paper mills.

This paper presents results of work of Bruks 800 CT chipper in Polish conditions.

Material and methods

Research was carried out on the 5 forest plots. The material processed in the experiments consisted of logging residues collected from Scots Pine harvesting sites (clear cuts). At all harvesting sites cutting was done by a chain saw operator. Merchantable timber was skidded by LKT-81. Logging residues were left scattered on the whole area. The volume of collected forest residues from each plot is presented in Table 1. On average, 58.9 m^3/ha of forest residues were harvested.

The chipping of clear cut residues was carried out by Bruks 800 CT chipper mounted on the Timberjack 1210 forwarder. It is a combination of the chipper and integrated chips container. The chipper can move to the harvesting site even if it is located “off road”. After the container filling with made chips, the machine drove to the forest road where ensued the dumping of chips load into the truck container. Next this material was transported to heating plants. Basic technical details of the chipper are presented in Table 2.

Table 1. Volume of harvested forest residues on the analysed plots in m^3/ha

Forest plot number	Harvested forest residues (m^3/ha)
1	61.7
2	57.3
3	65.8
4	58.6
5	51.2
Average	58.9

Table 2. Technical data for Bruks 800 CT chipper

Chipper drum diametre	800 mm
Number of knives	2 st
Motor type	Diesel V8 Caterpillar 3280
Motor power	250 KM
Chips container capacity	6.7 m^3
Forwarder type	Timberjack 1210

There was relatively an old machine. Use in this way of logging residues utilisation in Poland has been known for more than twenty years, but practically it has been applied in more scale in the last two years when burning of forest residues at the harvesting site was forbidden.

A time study was carried out using a continuous-timing method. The work time was divided into following parts:

- processing,
- driving to landing and chips dumping,
- refuel,
- delay,
- lunch break.

Data were collected by the hand- held computer Psion Workabout. For the cost calculation a method presented by Sessions (1992) was applied.

RESULTS AND DISCUSSION

Utilisation of logging residues is necessary for a good preparation of the soil for a new forest generation. In Poland, burning of this material is carried out very rarely because since 2004 in the State Forests that way of utilisation has been forbidden. Nowadays many types of crumbling machines are in use. In the last few years has been growing interest in an exploitation of logging residues as an energy source.

This study presents results of Bruks 800 CT chipper mounted on the Timberjack 1210 forwarder. The achieved productivity results are not so high. It reached on average 5.7 m^3/h.

The structure of working day, presented in Fig. 2, shows that the highest share of work time has been spent on chipping and gathering of raw material from the site. It is necessary to emphasize that residues were not earlier collected in piles, but were scattered on the whole area. About 9% of working time was taken for driving to the landing and chips dumping.

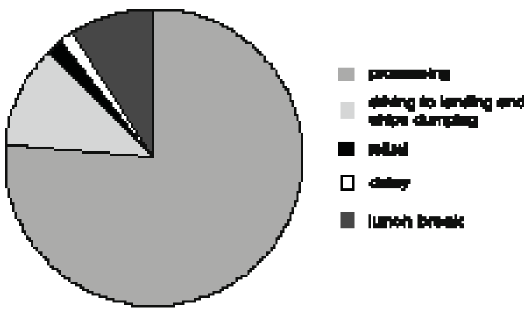

Fig. 2. Structure of working day by forest residues chipping with Bruks 800 CT

Cost calculation for logging residues chipping is presented in Table 3. Total hourly costs reached 106.2 EUR/h. Calculation was made with prices, as the machines were new. Unit costs amounted to 18.6 EUR/m^3.

Table 3. Cost calculation for logging residues chipping by Bruks 800 CT

Type of costs	Unit	Forwarder Timberjack 1210	Bruks 800 CT chipper
Ownership costs	EUR/h	24.2	23.6
Operating costs	EUR /h	27.1	27.1
Labour costs	EUR /h	4.2	
Total costs	EUR /h	55.5	50.7
Total costs together	EUR/h	106.2	

In Poland the total area of clear cuts in state forests (Fig. 3) varied from 42 thousand ha in year 1980 to 25 thousand ha in 2005. In the future it should be expected that the share of clear cuts could be smaller. It is connected with sustainable forest management, where other forms of cutting, especially complex felling are promoted. According to calculation made by Jabłoński (2003), in Poland about 432 thousand m^3 of branches and 472 thousand m^3 of brushwood can make up a potential logging residues for energy purposes.

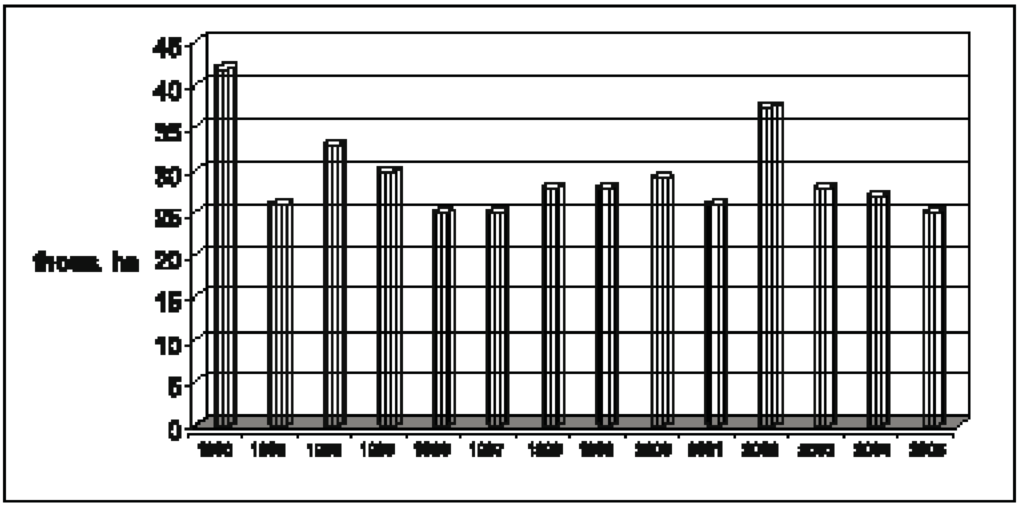

Fig. 3. Total area of clear cuts in Polish state forests “Lasy Państwowe” (PGL LP 2005)

The technological problem is in transport of chips. When they are made at the harvesting site, they need containers with the big capacity, and efficiency of the whole process is depending on the transportation distance form the forest to the heating plant. 1 m^3 of logging residues chips averages 2.38 bulk-m^3 of logging residue chips (Angus-Hankin et al., 1995).

Fig. 4 presents net calorific value of fuels. Heating value of logging residues is very similar to wooden raw material and amounts from 2.4 MWh/t (by 50% moisture) to 3.6 MWh/t (by 30% moisture).

Taking out of logging residues from the forest has many opponents because this practice is not sustainable in the long-term period as too much nutrient is removed from the ecosystem. In branches and brushwood are accumulated about 2/3 of all nutrients. The most losses are observed by N and Ca. For that reason, in forest where soils are poor, taking out of the biomass should be done very carefully, Fig. 5, (Kowalkowski, 1983).

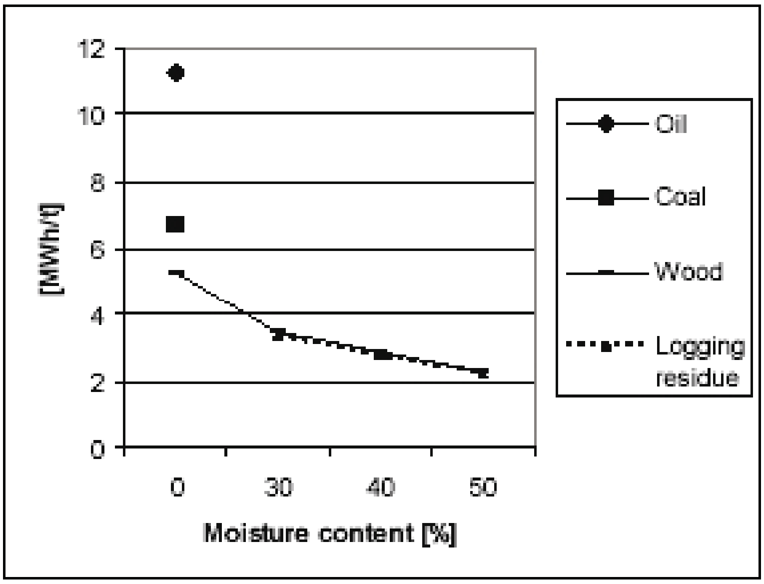

Fig. 4. Net calorific heating value of fuels for different moisture percentages (Kalliola, Paananen, 2003)

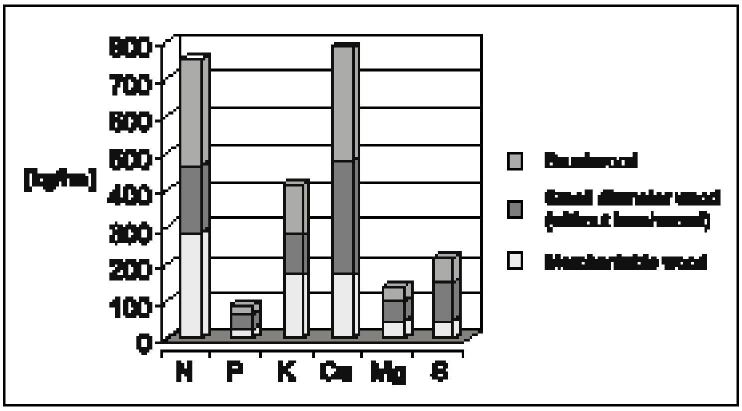

Fig. 5. Average loss of nutrients as a result of forest harvesting in Scots Pine stand (Kowalkowski, 1983)

CONCLUSION

In connection with EU requirements the share of renewable energy resources in Poland and other European countries has to increase. One of the possibilities in this sphere is the utilisation of forest residues which can be chipped and transported to heating plants.

In the structure of working day, by Bruks 800 CT chipper work, the most time share (77%) has been destined for processing – chipping and gathering of forest resides from the harvesting site.

Calculated hourly cost of the machine use reached 106.2 EUR. By the chipper work productivity coming to 5.7 m^3/h, unit cost is running at 18.6 EUR/m^3.

The main problems with utilization of forest residue chips as an energy source are:

- comparatively lower calorific value in comparison with fossil fuels,
- considerable diversity of calorific value in one batch of produced chips,
- there is a need to prepare a big space for chips store at a power plant,
- relatively high work intensity of chips preparing processes,
- susceptibility to the changes of transport costs, what needs a specific localization nearby forest areas,
- organic material is removed from the nutrient cycle,
- they can be burn in fluidized-bed furnace.

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ГЕОГРАФСКА БАЗА ДАННИ ЗА ПОДОБРЯВАНЕ УПРАВЛЕНИЕТО НА ДАННИТЕ В ГИС-СРЕДА С МНОГО ПОТРЕБИТЕЛИ

Рикардо де Филипи, Бернт Хебел, Швейцария

В последно време количеството географски данни расте драматично. Тази тенденция се дължи на по-ефективните сензори, усилията на агенциите да направят двуразмерната и триразмерната информация достъпна в дигитален формат и увеличената достъпност на комуникационната инфраструктура.

Увеличаването на достъпността на данните доведе до диференциация на ГИС-приложенията и до значително разширяване на кръга на потребителите на ГИС. Опитът показва, че при пълен цикъл на живота на данните, разходите за управление на данните се равнява на 10-кратната цена на софтуера и на 100-кратната цена на хардуера. Подобряването на ефективността на управлението на данните изисква мощна система за управление на данните.

Има обща тенденция да се използват централизирани системи за управление на данните, свързани със сървър за географски данни, който дава достъп до тях чрез конфигурация от тип client/server. За търсене в централната база данни клиентът използва традиционен GIS-софтуер, стандартните Web-браузери, мобилни компютри и т.н.

В настоящата работа докладваме за развитието и приложението на сървър за географски данни, който ще се използува както за изследване, така и за обучение.

GEO-DATABASE TO IMPROVE DATA MANAGEMENT IN MULTI-USER GIS-ENVIRONMENTS

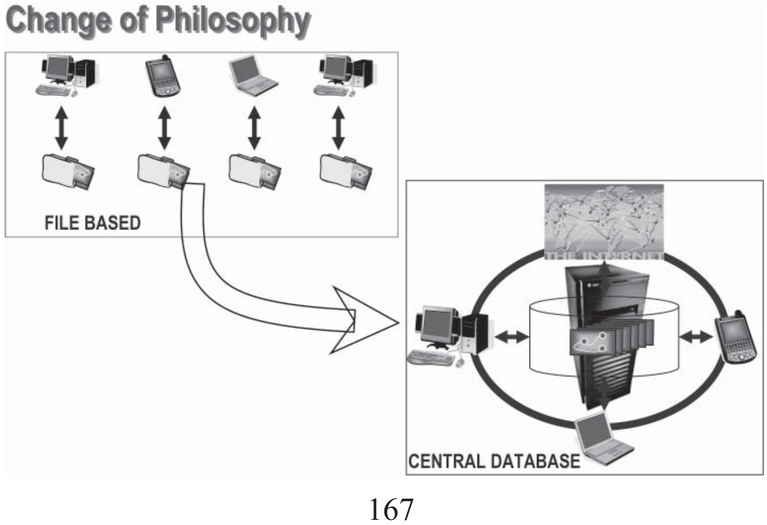
Riccardo de Filippi, Bernd Hebel, Switzerland

Recently, the amount of geographic data has been increasing tremendously. This trend has been triggered by more efficient sensors for data gathering, agency efforts to make 2D and 3D map information publicly available in digital format, and increasing availability of communication infrastructure.

The improvement of data availability led to a differentiation of GIS applications and to a significant growth of the GIS user community. Experience demonstrates that - for a whole data life cycle - cost for data management equals about 10 times the cost of software and about 100 times the cost of hardware. Improvements in both data management effectivity and efficiency requires a powerful data management system.

There is a general trend to use centralized database management systems that are linked with a geo-data server to provide access to geographic data by a client/server configuration. Clients can use traditional desktop GIS-software, standard Web browsers, mobile computing devices etc. to query the central database.

Here, we report on the development and implementation of a geo-data server that will be used for both, research and teaching activities.

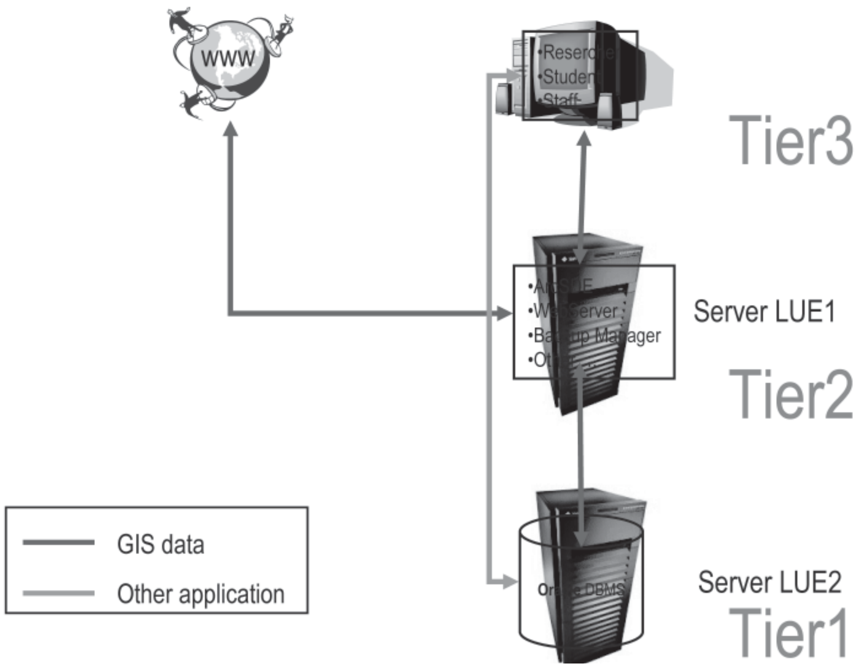


GDS Concept

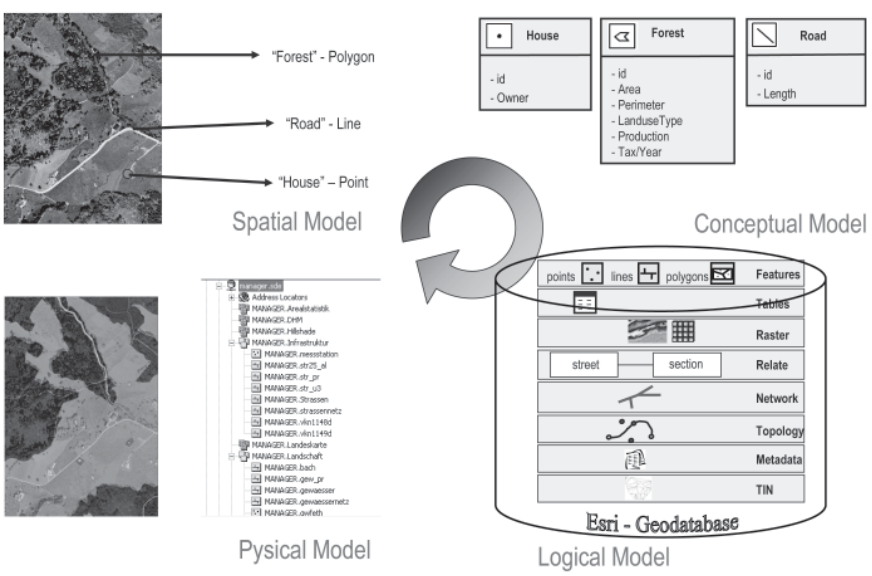
- DB — " **different types** of data organised according to a **structure** that **minimizes redundancies** and facilitates the **manipulation** of the data."

- GDB? — A Database of geographic datasets

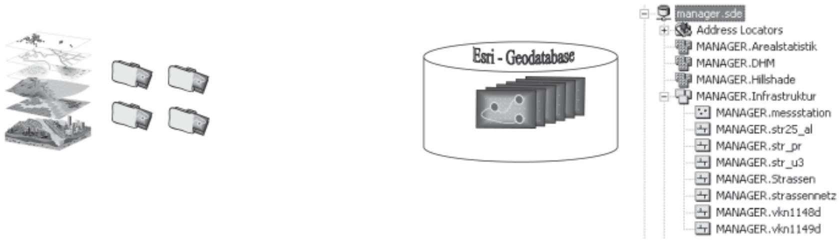
GDS Architecture



Data Modelling



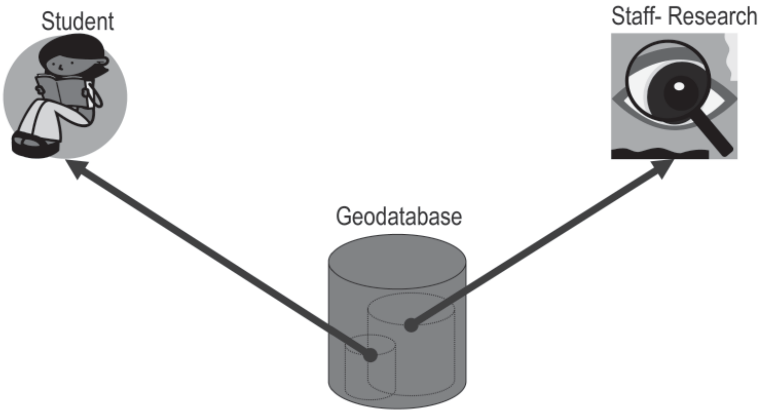
Data Migration



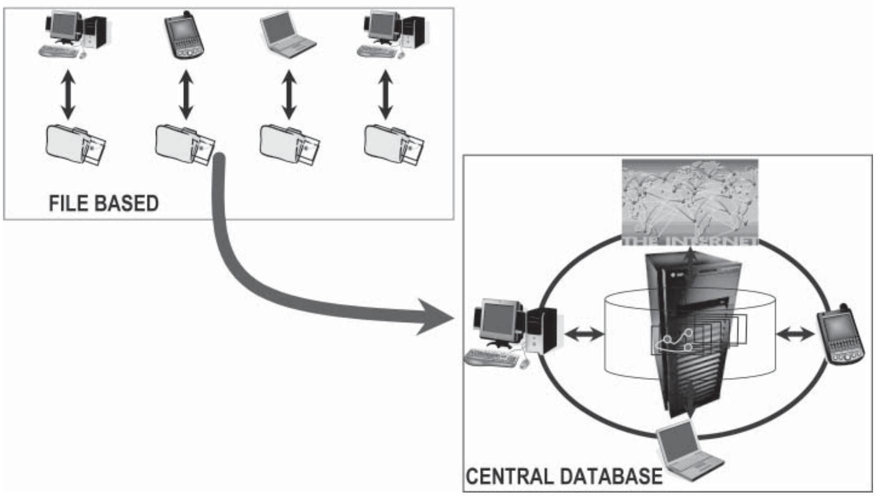
- Close look to the existing data
- Data model refinement
- Metadata catalogue
- Interoperability (foreign data format)

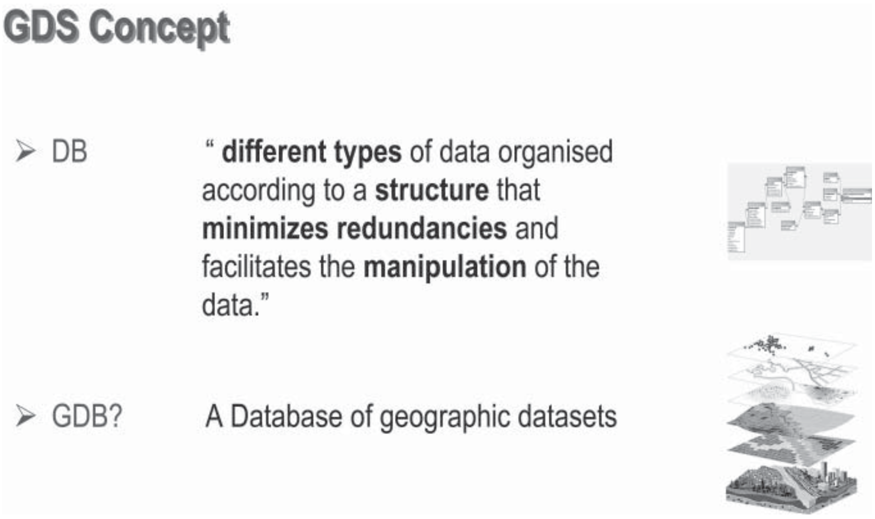
GDS Administration

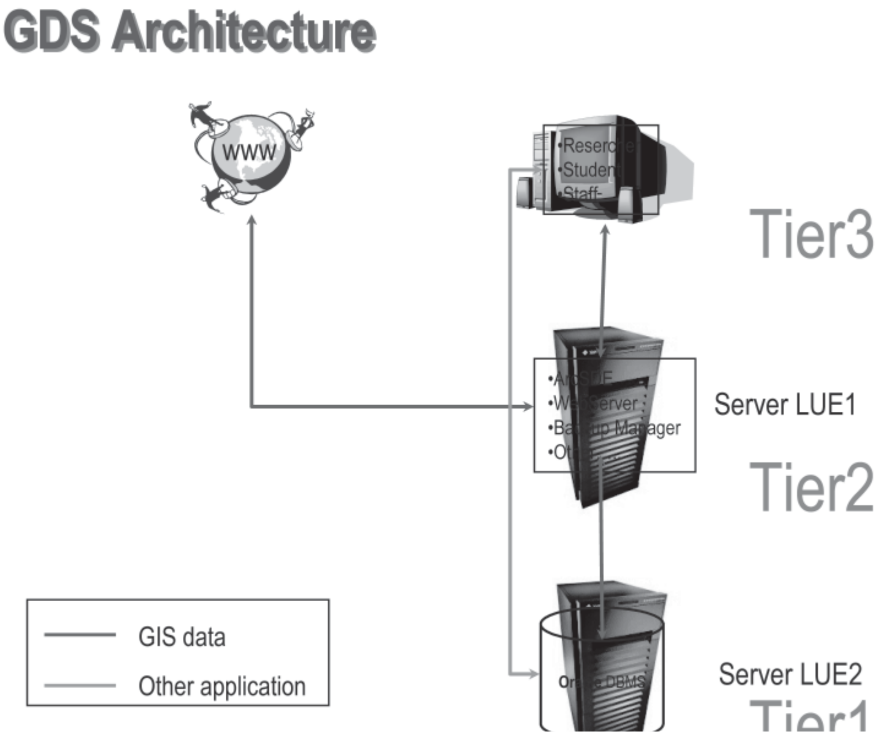
- Definition of user and of version
- DBMS and Geodatabse administration and tuning
- Backup strategies

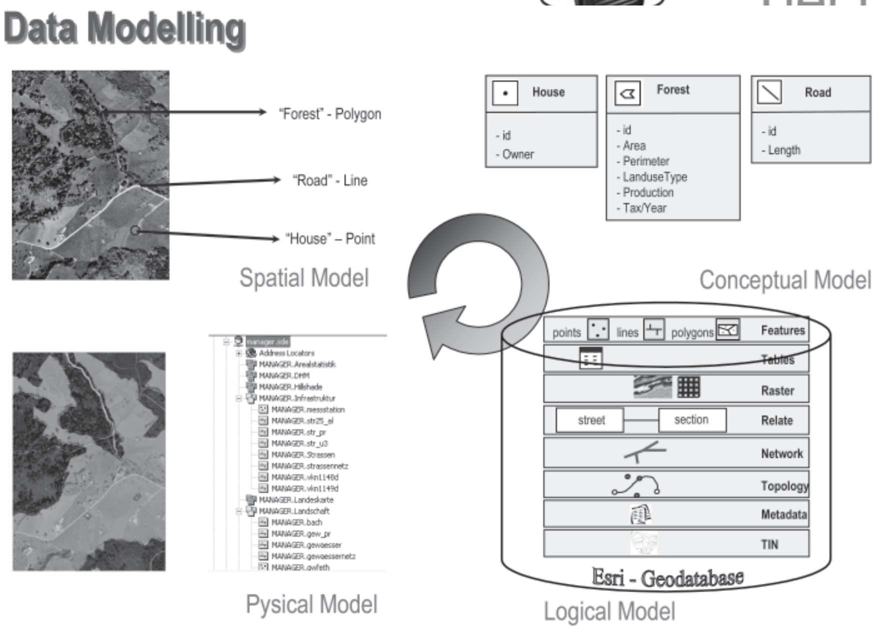


Change of Philosophy

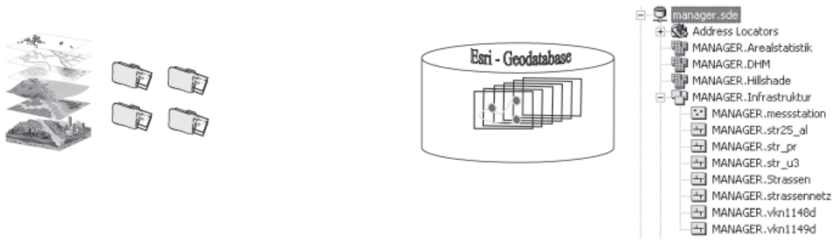



GDS Concept
DB
" **different types** of data organised according to a **structure** that **minimizes redundancies** and facilitates the **manipulation** of the data."
GDB?
A Database of geographic datasets


GDS Architecture
WWW
Tier3
Server LUE1
Tier2
GIS data
Other application
Server LUE2
Tier1


Data Modelling
"Forest" - Polygon
"Road" - Line
"House" – Point
Spatial Model
House
- id
- Owner
Forest
- id
- Area
- Perimeter
- LanduseType
- Production
- Tax/Year
Road
- id
- Length
Conceptual Model
points
lines
polygons
Features
Tables
Raster
street
section
Relate
Network
Topology
Metadata
TIN
Esri - Geodatabase
Pysical Model
Logical Model

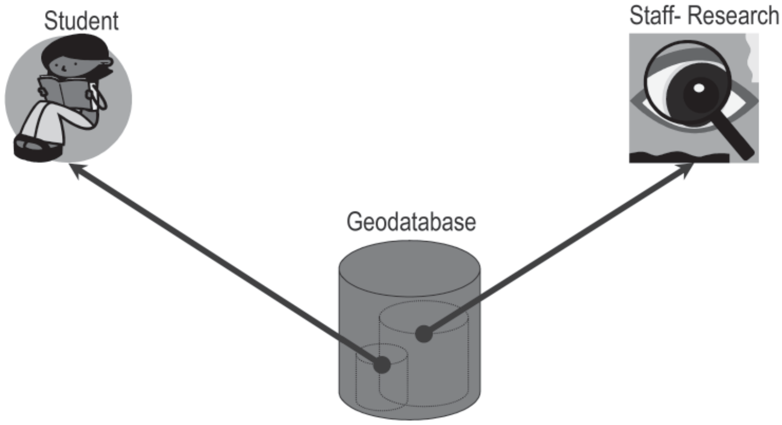
Data Migration



- Close look to the existing data
- Data model refinement
- Metadata catalogue
- Interoperability (foreign data format)

GDS Administration

- Definition of user and of version
- DBMS and Geodatabse administration and tuning
- Backup strategies



Conclusions

- Design specification – data modelling – data migration – user administration → logical sequence to master complexity
- Common DBS platform (Oracle) provides high data integrity and cuts software formats
- Data modelling and migration techniques special know how, high computational power and high cost

ПОВРЕДИ ПО ОСТАВАЩИТЕ ДЪРВЕТА ПРИ ИЗВОЗА В ПЛАНИНСКИ ГОРИ

Ярослав Садовски, Дариуш Застоцки, Полша

Целта на настоящата работа бе да се провери въздействието върху някои елементи на околната среда и да се направи оценка на избрани методи и технологични процеси, прилагани от частните горски компании. Бяха подробно проучени степента на повреда на останалите след извоза дървета при главни и отгледни сечи. За целта бяха заложени пробни площи в букови насаждения за пробирка на възраст 71-80 г., както и в 101-120-годишни насаждания за главна сеч на широколистни месторастения с преобладание на бука, чийто площен дял е над 80%. Дървесината беше добивана по сортиментния метод (SWS, short wood system) със специализирана техника (в т.ч. специализирани горскостопански трактори).

Въз основа на проучванията бяха направени следните изводи:

1. Размерът на повредите по оставащите дървета след извоза зависи съществено от приложената технология за извоз.
2. Най-голям дял на повредените дървета се наблюдаваха в сечищата, където за извоз беше използван специализираният трактор Kockums. Той достигна 31,2% от общия брой на оставените дървета.
3. Най-нисък дял на повредените дървета имаше при извоз с камион ЗИЛ в насаждения за пробирка, който възлизаше на 9,8% от оставените след пробирката дървета.
4. Трета степен на повредата и най-висок процент повредени дървета беше установен при отгледните сечи, което в бъдеще ще има последици за състоянието на насажденията и качеството им.
5. Повредите на насажденията при извоза са неизбежни поради характера на тази дейност и специфичното работно място – гората. Въпреки това целта трябва да бъде свеждането на повредите до минимум със всички възможни средства, в т. ч.: използването на обучени работници, надзор на извоза от страна на горските власти и осигуряване на необходимия достъп до насажденията с подходящи извозни пътища.

DAMAGES OF THE TREES DURING SKIDDING PROCESSES IN MOUNTAIN FOREST STANDS

Jarosław Sadowski, Dariusz Zastocki, Poland

ABSTRACT

The aim of this work was to examine the effects and to make an evaluation of selected methods and technological processes used by private forest companies on selected elements of the forest environment. The damage degree of the trees remaining after skidding during thinning and final cutting processes have been analysed in detail. The research plots were set in 71-80 years old thinning beech stands and in 101-120 years old cutting tree stands, on broadleaved mountain forest sites where beech is a predominant species (area share of over 80%). Wood has been harvested using the short wood system (SWS) method by means of specialist equipment (skidders in particular).

INTRODUCTION

Forestry in mountain forests is characterised by specific activities resulting from varying shape of the terrain and irregular spatial division network, which enforces a different character of forest management. Unlike lowland areas, where clear cutting is applied, here the main forest management methods are shelterwood cutting and stepwise cutting. This results in some difficulties in wood harvesting and skidding, starting from setting up of skidding roads through to the individual approach to cutting every single tree. Wood is usually logged in a whole to the valleys where the manipulation is done. Such a system of wood harvesting increases damage to the trees remaining in the tree stands. Technologies applied during harvesting should minimise damages caused in the ecosystem (injured trees, thickening of soil, exhaust and noise emissions), (Putkiso, 1986, Laurow, 1990, Fröding, 1992, Gierfing, 1992, 1995a). The amount and types of damage caused to the trees in the harvesting and skidding processes depend on the technology and type of machinery employed.

The selection of technology also into a significant extent depends on private forest companies, rendering services to State-owned Forests. Such technologies should be characteristic for their great efficiency, low production costs and minimal influence on the forest environment. The research results show that during wood harvesting damage is caused to the trees remaining in the tree stand, the results of which are visible for a long period of time. Damage to the trees during wood harvesting in thinning tree stands affect technological quality of large-sized timber and special wood, being the main production purpose.

The research explained in this study was limited to an assessment of the level of damage to the trees remaining on the surface after wood harvesting in cutting and thinning tree stands.

Purpose and methodological assumptions

Field work was executed in mountain areas in cutting and thinning tree stands in the Regional Management of State Owned Forests (RDLP) of Krosno – Cisna and Komancza forest inspectorates. In the individual forest inspectorates the research areas were selected on the basis of the mandatory felling plan, and located in beech tree stands (thinning – approx. 80 years) and cutting (101-120 years) on a mountain forest site where beech is a predominant species (minimum 80%).

In the research the following factors were determined:

- the degree of damage to the tree stands,
- the number of trees damaged along the skidding roads.

The degree of damage was determined using the percentage of trees damaged in relation to the number of trees remaining. The structure of damage, taking into consideration the size and depth of injuries, was presented using the following three-level scale of damage:

- damage level I, which includes trees damaged up to 1/8 of the circumference of their stem in the place of injury,
- damage level II, which includes trees damaged above 1/8 of the circumference of their stem in the place of injury,
- damage level III, which includes trees damaged to the wood layer and including damage to the wood itself.

In this classification the rule has to be applied that a damaged tree can only be classified to one of the above categories, and this is decided by an injury creating the greatest hazard to the appropriate growth and life of a tree.

The number of damaged trees at a distance of up to 5 m from the skidding road was determined through the observation of trees remaining in the tree stand on either side of the skidding road.

As a result of the field research it has been stated that in mountain beech tree stands in Poland predominate the simplest, classical technologies of wood harvesting, based on the short wood system method, and manual and mechanical technological level, with a low level of technical equipment such as chainsaws used for felling and cutting into length, as well as specialist tractors used for skidding. Felling and crosscutting of wood were done by means of chain saws, and debranching was done using chain saws and axes. Felling of trees was done by single workers or in two-person teams, where the assistant helped in debranching and stacking of wood. Skidding was done by means of a specialist tractor Kockums 812 and a truck ZIL, which are the basic pieces of equipment employed in difficult mountain conditions.

RESEARCH RESULTS & DISCUSSION

The research did not include damage to the trees occurring in the process of felling which were only limited to breaking the remaining single branches. During the process of skidding, the majority of injuries occurred on tree stems up to the height of one metre and on the root collars, and primarily entailed damage to the bark. The greatest number of trees was damaged in cutting stands in which for skidding of wood a specialist Kockums tractor was employed. The participation of damaged trees in this stand amounted to 31.2% of the total number of trees remaining in the stand. Whereas the lowest participation of trees in cutting stands where skidding was done by means of a ZIL truck, and it amounted to 15.9% of the trees remaining in the stand (Table 1.) The observed circumstance may be explained by haste in harvesting activities, dictated by economic factors. Another very important cause of such significant damages were the skidding roads being too narrow for the skidding equipment employed, as well as the necessity of protecting the undergrowth and brush wood. In pre-cutting stands the participation of damaged trees remaining in the stand as a result of thinning activities was the lowest when for skidding a ZIL truck was employed. The participation of damaged trees amounted to 9.8% of the trees remaining after thinning. Whereas in the tree stands where skidding was done using a specialist Kockums tractor, the participation of damaged trees was on a similar level, amounting to 17.9% and 19.5% of the total number of measured trees respectively (see Table 1.) Deep injuries, exposing or damaging the surface of wood are the easiest places where infections by fungi may occur causing rotting of wood and creating places for potential attacks of xylophageous insects. Therefore, it seems necessary to carry out an analysis of damages created during technological processes. Through the analysis of damages on the individual research surfaces the greatest number of damaged trees classified as damage level III was observed in pre-cutting tree stands. This results from the smaller sizes of the individual trees in comparison with the trees growing in cutting stands.

Table 1
The effects of the types of skidding on damages to the tree stands

	Type of skidding Harvesting technology	Age (type of cut)	Damage level I (%)	Damage level II (%)	Damage level III (%)	Total damage (%)
58c	Skidding with a ZIL truck short wood system	74	2.0	0.6	7.2	9.8
187Af	Skidding with a Kockums tractor short wood system	79	6.8	2.1	10.6	19.5
226g	Skidding with a tractor short wood system	76	6.4	2.9	8.6	17.9
92b	Skidding with a ZIL truck short wood system	120	6.2	7.1	2.6	15.9
19a	Skidding with a Kockums tractor short wood system	105	12.3	8.6	4.5	25.4
117d	Skidding with a Kockums tractor short wood system	105	14.7	10.1	6.4	31.2

The number of trees damaged in the nearest neighbourhood of the skidding roads was determined only in the pre-cutting stands. In the examined areas the number of trees damaged up to a distance of 5 m from the skidding roads was the smallest in branch 58c and amounted to 12 trees per 100 m of the operational road. The number of trees damaged up to a distance of 5 m from the skidding roads in branches 187Af and 226g was at a similar level and amounted to 17 and 19 per 100 m of the skidding road respectively. In these branches the skidding was done by the same working team, thus the greater number of damaged trees may be explained by haste in the skidding activities (see Table 2.)

Table 2. Number of damaged trees at the skidding roads

Branch	Sum of damaged trees (pieces)	Sum of measured roads (m)	Number of damaged trees (pieces/100m)
58c	368	3050	12
187Af	529	3100	17
226g	882	4640	19

The above results clearly show that we are unable to eliminate damages to the remaining tree stands. The amount of damage mainly depends on the age of a tree stand, the number of trees per 1 hectare, the shape of the terrain, and the presence and width of skidding roads. Large damages are cause by technological conditionings such as the radius of turning of a loaded tractor or the amount of a single load. Observed during the examination, the directions of increase of the number of damages to the trees along with the increased technological level of the skidding activities are consistent with the observations made by the other observers (Paschalis, Porter, 1994, Porter, 1997, Suwala, 1999), and are mainly caused by poor quality of the executed skidding work and by the equipment employed not being adjusted to the type of a tree stand (the number of trees, type of short wood, and so on), as well as poor qualifications of the workers operating the vehicles. Nonetheless, it has to be highlighted that the economic factors will enforce the application of higher level technological methods in skidding activities. If the technology is improved as well as quality of the executed work, then it will have positive effects on the condition of the trees remaining in a stand after such activities. Currently the costs of wood harvesting are not being fully calculated, only including the costs borne by the owners on particular activities. In the wood harvesting processes in sustainable forestry, such costs should include the effects of environmental damage, negative effects of the activities on the health of the workers, losses caused by decreased growth, and some other factors. The observed circumstance may be explained by haste in harvesting activities, dictated by economic factors.

CONCLUSIONS

The amount of damage of the trees remaining in a stand during skidding work is significantly influenced by the type of skidding applied.

The greatest participation of damaged trees remaining in a stand was observed in cutting areas where skidding was done by means of a specialist tractor Kockums. In this case it amounted to 31.2% of the entire number of trees remaining in a stand.

The lowest number of damaged trees was during skidding activities done using a ZIL truck in pre-cutting stands, and it amounted to 9.8% of the trees remaining after thinning activities.

The third level of damage (damage to and of the wood), the greatest percentage participation was observed in pre-cutting stands, which in the future will affect the condition of the tree stands and technological quality of wood.

Damage to the tree stands caused by skidding is unavoidable because of the character of such activities which take place in a specific place such as forest. It is however necessary to aim to the maximum reduction of damage by all possible means, such as ordering experienced personnel to do the skidding, monitoring work by forest service, and providing the appropriate access to the tree stands through proper skidding roads.

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ИЗСЛЕДВАНЕ НА ФАКТОРИТЕ НА РАБОТНОТО МЯСТО ПРИ ИЗВЪРШВАНЕ НА ПРОБИРКИ С МОТОРЕН ТРИОН

Януш Сова, Кшищоф Лешчински, Полша

Цел на настоящата работа е да се анализират факторите на работното място, които въздействат върху работника при извършване на пробирка с моторен трион. Проучени бяха два технологични варианта:

1. Индивидуална работа – поваляне от един работник с моторен трион и извоз с конски впряг;
2. Групова работа – поваляне с моторен трион, извоз с лебедка Multi FKS.

Извършените изследвания установиха подобрение на производствените условия при вариант 2 (групова работа), което се дължи на намалено физическо натоварване (от 9500 kJ/8h на 7800 kJ/8h), многократно намаление на превишението на допустимите вибрации (¼ срещу 1,23), съкращение на въздействието на шум (от 85 dB(A) на 48%) и по-ниска емисия на въглероден окис.

ANALYSIS OF OPERATOR WORK ENVIRONMENT FACTORS DURING MOTOR-MANUAL TIMBER HARVESTING WHILE THINNING

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Abstract

The purpose of this study was to analyse elements of the work environment of operators involved in motor-manual cutting during thinning. Two technological variants were studied: i) one-man felling with a power chain saw, horse skidding – individual work; ii) cutting with a power chain saw, felling, dislodging hanging trees, skidding with the Multi FKS cable winch - group work. The improvement of the work environment conditions was found in the case of variant 2 (group work) resulting from a smaller physical work load (decrease from 9500 kJ/8h to 7800 kJ/8h), decreasing of the multiplication factor of exceeding the level of admissible vibration by ¼ to 1.23, reduction of the time of exposure to noise above 85 dB(A) to 48%, and decreasing of carbon monoxide emission.

UNTERSUCHUNG DER FAKTOREN DER ARBEITSUMGEBUNG BEI MOTOR-MANUELLER HOLZERNTE BEI DER DURCHFORSTUNG

J. M. Sowa, K. Leszczyński, Poland

Ziel der Untersuchung ist die Analyse der Faktoren der Arbeitsumgebung für Arbeiter, die mit der Holzernte bei der Durchforstung mit motor-manuellen Methoden beschäftigt sind. Die Untersuchungen wurden in zwei technologischen Varianten durchgeführt:

1^0 Fällen durch eine Person unter Einsatz einer Motorsäge, Holzrücken mit Pferdegespann – Einzelarbeit;

2^0 Fällen unter Einsatz einer Motorsäge, Beseitigung von Hängern, Holzrücken unter Einsatz einer Kabelwinde Multi FKS – Gruppenarbeit.

In den vorgenommenen Untersuchungen wurde eine Verbesserung der Arbeitsumgebung in der Variante 2^0 (Gruppenarbeit) festgestellt, die aus einer geringeren Belastung durch physische Arbeit (Verringerung von 9500 kJ/8h auf 7800 kJ/8h), eine Verringerung des Vielfachen der Überschreitung der zulässigen Schwingungen um ¼ auf 1,23, einer Verkürzung der Lärmausgesetztheit auf über 85 dB(A) auf 48% und einer geringeren Kohlenmonooxydimmission resultiert.

Schlüsselwort: Arbeitssicherheit, Durchforstung, Ergonomie, Motorsäge, Seilwinde

Einleitung

In letzter Zeit lassen sich die begrenzten Möglichkeiten der Gewinnung von Sägewerksholz sowie ein Anstieg des Bedarfs an mittelgroßem Holz bemerken (Kubiak Laurow 1994). Die Umsetzung von Pflegemaßnahmen im polnischen Forstwesen zeichnet sich häufig durch den Einsatz von einfachen und nicht selten arbeitsintensiven Technologien aus. Die Motorsäge ist weiterhin eines der wichtigsten Werkzeuge und als Zugkraft werden weiterhin Pferde eingesetzt oder auch Schlepper, die für die Feld- und nicht die Forstwirtschaft vorgesehen sind. Der schrittweise Rückgang der Anzahl der Zugtiere sowie die fehlenden Investitionsmöglichkeiten der zahlreichen kleinen Firmen, die häufig genug nur aus einer Person bestehen, bedingen die Suche nach geeigneten technologischen Lösungen. Die am Lehrstuhl für Forst- und Holzwirtschaft der Landwirtschaftsakademie Krakau durchgeführten Untersuchungen zeigen, dass eine Durchforstungstechnologie unter Einsatz einer kleinen Kabelwinde, die mit dem Motor einer leistungsstarken Motorsäge angetrieben wird (Sowa Stańczykiewicz 2003), das Niveau der Humanisierung der Arbeit erheblich verbessern würde. Außerdem zeichnet sich diese Methode durch eine größere Umweltverträglich aus (Sowa Stańczykiewicz 2005).

Aufgrund der spezifischen Arbeitssituation im freien Raum und bei großer Verteilung im Gelände werden die ergonomischen Aspekte der Forstwirtschaft häufig vernachlässigt. Dennoch haben die am Arbeitsplatz auftretenden Faktoren (Lärm, Schwingungen, Abgase) sowie die belastende körperliche Arbeit einen wesentlichen Einfluss auf die Gesundheit der Arbeiter. Nicht selten verursacht die Arbeitsbelastung eine Verringerung der Abwehrkräfte des Organismus, und diese negativen Folgen kumulieren mit der Zeit.

Ziel der Arbeit und Forschungsbereich

Das Ziel der Untersuchung ist die Analyse der Elemente der Arbeitsumgebung von Arbeitern, die motor-manuell Durchforstungsarbeiten durchführen. Die Untersuchung wurde in zwei technologischen Varianten durchgeführt:

1^0 Fällung durch eine Person unter Einsatz einer Motorsäge, Holrücken mit Pferdegespann – Einzelarbeit;

2^0 Fällung unter Einsatz einer Motorsäge, Beseitigung von Hängern, Holzrücken unter Einsatz einer Kabelwinde Multi FKS – Gruppenarbeit.

Der Forschungsbereich umfasste die Früh- und Spätdurchforstung von Kiefern-, Fichten-, Tannen-, und Buchenbeständen. Die Untersuchungen wurden auf dem Gebiet von drei Forstämtern durchgeführt, die in zwei verschiedenen Regionen der staatlichen Forstverwaltung liegen (Kraków und Katowice). Alle Ergebnisse der durchgeführten Arbeiten wurden festgelegt: Lärmbelastung, die Überschreitung zulässigen Schwingungen, CO-Kohlenmonooxydkonzentration (CO), Stickstoffmonooxydkonzentration (NO) sowie die Energieabgabe der Arbeiter.

Untersuchungsmethode

Die Untersuchungen wurden in drei Wiederholungen auf 0,5 ha Versuchsfläche für die beiden angenommenen technologischen Varianten, durchgeführt:

1^0 Die herkömmliche Technik unter Einsatz einer Motorsäge und eines Pferdegespanns. Der Fäller führt die Fällung durch, die Astung und eine erste Manipulation des Rohmaterials auf der Haufläche, anschließend wird das Holz mit einem Pferdegespann zum Rückweg gerückt (Abb. 1).

2^0 Durchforstungstechnik unter Einsatz einer Motorsäge zum Fällen und einer Kabelwinde Multi FKS zum Rücken des Holzes zum Waldweg. Die Arbeiten verlaufen prinzipiell in den folgenden Etappen: Fällen (Fäller), mechanische Beseitigung von Hängern (Bediener der Kabelwinde), Astung und erste Manipulation des Rohmaterials (Fäller), Holzrücken zum Rückweg (Abb. 2).

Die Gewinnung wurde nach dem Langholzsystem LWS (Lenght Wood System) durchgeführt mit einer ersten Manipulation des Rohmaterials in Abschnitte von 6-12 m. Die durchschnittliche Entfernung des Holzrückens betrug 25 m. Eine schematische Darstellung der Arbeitsorganisation zeigen Abb. 3 und Abb. 4. Die Kabelwinde Multi FKS wurde von dem Motor einer Motorsäge Stihl 064 mit einer Leistung von 4,8 kW angetrieben. Das technische Schema für die beiden Methoden des Holzrückens zeigen Abb.

5 und Abb. 6. Insgesamt wurden die Arbeiten auf 48 Versuchsflächen durchgeführt. Die Untersuchungen wurden unter verschiedenen Wetter- und Geländebedingungen bei einer Umgebungstemperatur von 0^0 C bis 25^0C durchgeführt.

Abb.1. Arbeitsplatz bei Holzrücken mit Pferd (Foto: G. Szewczyk)

Abb. 2. Arbeitsplatz des Bedieners der Kabelwinde Multi FKS (Foto: G. Szewczyk)

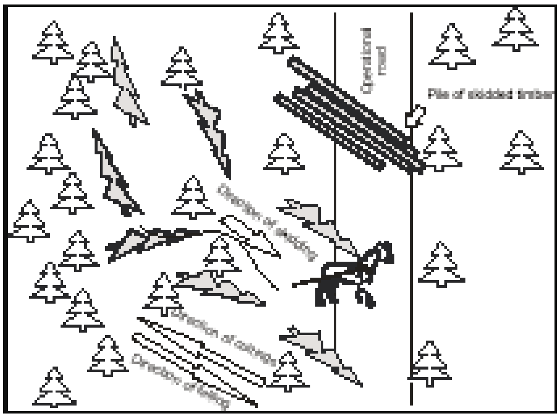

Abb. 3. Schema der Arbeitsorganisation bei Holzrücken mit Pferd

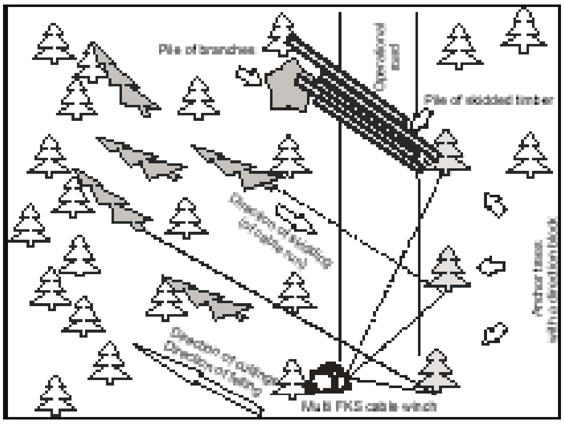

Abb.4. Schema der Arbeitsorganisation bei Holzrücken mit Kabelwinde Multi FKS

Abb. 1. Raumordnung nach Holzrücken mit Pferd (Foto: G. Szewczyk)

Abb. 2. Raumordnung nach Holzrücken mit einer Kabelwinde Multi FKS (Foto: D. Kulak)

Die Messung des Geräuschpegels wurde nach der direkten Methode nach den Vorgaben PN-ISO-1999: 2000 unter Einsatz eines Lärmdosimeters DM-50 durchgeführt. Als Ergebnis der durchgeführten Arbeiten wurde der ausgeglichene Geräuschpegel $L_{A,eq,Te}$ ermittelt sowie eine Messgeschichte erstellt. Bei der Berechnung wurde der Schalldruckpegel, bezogen auf einen Achtstundentag (Formel 1) sowie die entsprechende Lärmexposition (Formel 2) ermittelt.

$$L_{EX,8h} = L_{A,Te} + 10\log\frac{T_e}{8h} \text{ dB(A)} \qquad (1)$$

$$E_{A,T_e} = 1.15 \cdot 10^{-5} \cdot 10^{0.1L_{EX,8h}} \cdot 3600^{-1} \text{ Pa}^2\text{h} \qquad (2)$$

Die Bestimmung der Gesundheitsgefährdung der Arbeiter durch mechanische Schwingungen wurde anhand von chronometrischen Daten und die Messung der Beschleunigung von mechanischen Schwingungen mithilfe eines integrierenden Vibrationsmessers der dänischen Firma Brüel & Kjaer vom Typ 2513 durchgeführt. Zur Bestimmung des Niveaus der Gesundheitsgefährdung durch Schwingungen wurde das Vielfache des überschrittenen Äquivalenzwerts der Schwingungen im Verhältnis zum zulässigen Wert berechnet, nach der Formel:

$$K_{aw,eq} = \frac{a_{weq,8h}}{a_{wdop,8h}} \qquad (3)$$

$$a_{weq,8h} = \sqrt{\frac{D}{T}} \qquad D = \sum_{i=1}^{n} (a_{w,zm})_i^2 \cdot t_i$$

wo: $K_{aw,eq}$ – Vielfaches der Überschreitung des zulässigen Grenzwerts für mechanische Schwingungen, $a_{wdop,8h}$ – Grenzwert der zulässigen mechanischen Schwingungen mit örtlicher Wirkung, 2,8 m/s^2, a_{wzm} – gewogener Wert der Schwingungsbeschleunigung, m/s^2 , t_i – Zeit der Schwingungseinwirkung, T – Zeit der Schwingungseinwirkung (Zeit einer Arbeitsschicht), 480 min., D – Schwingungsdosis, m^2/s^3,

Die CO- und NO-Messung wurde nach einer direkten Methode unter Verwendung von individuellen Dosimetern der Firma Dräger durchgeführt. Die Untersuchungen umfassten eine ständige Messung der Gaskonzentration in der Atemzone der Arbeiter (bis zu 30 cm von Mund und Gesicht der Arbeiter). Infolge der durchgeführten Arbeiten wurden folgende Werte ermittelt: die durchschnittliche Konzentration mit einem Konfidenzintervall von 95% sowie der Wert der maximalen Kurzzeitkonzentration als Mittel aus den Messergebnissen von 15 Min.

Die energetischen Kosten der ausgeführten Arbeiten wurden auf der Grundlage der vereinfachten Lehmann-Methode bestimmt, außerdem wurden chronometrische Untersuchungen durchgeführt. Die gewählte Methode erlaubt (im Vergleich zur Respirationsmethode) die Vermeidung von Fehlern, die sich aus unterschiedlichen Sauerstoffaufnahmevermögen der Arbeiter sowie einer unterschiedlichen Intensität der ausgeführten Arbeiten ergibt (Koradecka Bugajska 1998).

Untersuchungsergebnisse

Die Untersuchung der akustischen Arbeitsumgebung wurden mit der dosometrischen Methode durchgeführt. Die in Abb. 7 dargestellten Daten zeigen, dass die Fäller in der Variante 1^0 während 65 % der Arbeitszeit einer Lärmbelastung über dem zulässigen Grenzwert von 85 dB(A) ausgesetzt waren, in der Variante 2^0 hingegen war diese um ¼ kürzer. Der auf der Grundlage der chronometrischen Untersuchungen berechnete Wert der täglichen Lärmausgesetztheit $L_{EX,8h}$ für den Fäller betrug 99 dB(A) in Variante 1^0 und 95 dB(A) in Variante 2^0. Der niedrigste Wert $L_{EX,8h}$ von 93 dB(A) wurde am Arbeitsplatz des Bedieners der Kabelwinde Multi FKS ermittelt (Tab. 1).

Das Vielfache der Überschreitung der zulässigen mechanischen Schwingungen $K_{aw,eq}$ schwankte zwischen 1,23 am Arbeitsplatz des Bedieners der Kabelwinde und 1,56 während der Holzfällung nach Technologie 1^0 (Abb. 8). Die Inkonstanz der ermittelten Werte betrug 6–11 %.

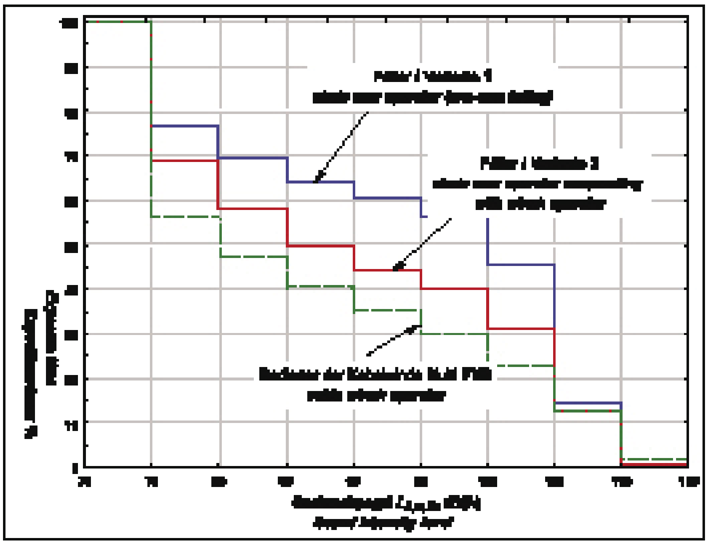

Abb. 7. Expositionsdauer in Klassen von Geräuschpegeln
Fig. 7. Exposure time in noise level class

Tab. 1. Das Niveau der täglichen Lärmausgesetztheit $L_{EX,8h}$
Table 1. The daily level of exposure to noise

Arbeitsplatz Workplace	$L_{EX,8h}$ dB(A) ($v_{\% LEX,8h}$)	$E_{A,8h}$ Pa^2h	L_{AeqTe} dB(A)
Fäller / Variante 1⁰ chain saw operator (one-man felling)	98,78 (0,54)	24,12	102,0
Fäller / Variante 2⁰ chain saw operator cooperating with winch operator	95,35 (0,97)	10,95	100,3
Bediener der Kabelwinde Multi FKS cable winch operator	93,30 (1,05)	6,83	100,9

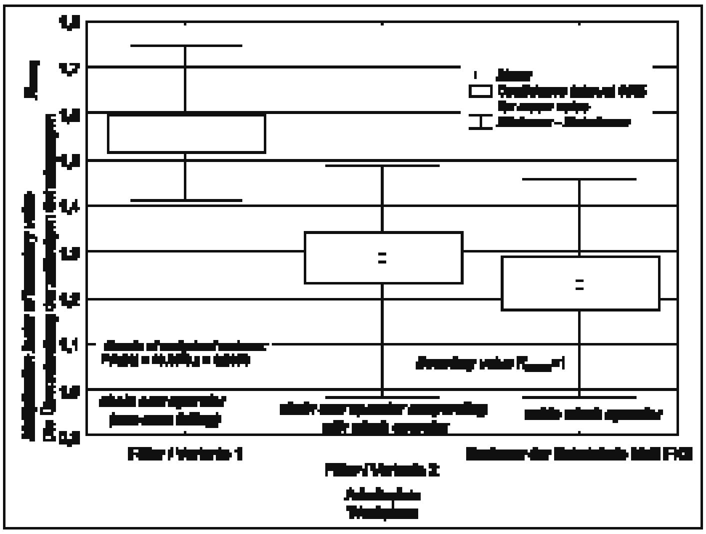

Abb. 8. Die Überschreitung der zulässigen mechanischen Schwingungen $K_{aw,eq}$
Fig. 8. Multiplication factor of boundary value

Die Analyse der Kohlenmonooxydimmission zeigte, dass am Arbeitsplatz des Fällers in der Variante 1^0 es zu einer Überschreitung des zulässigen Grenzwerts kommt. Die mittlere Konzentration (Tab. 2) betrug dabei 39,5 mg/m^3 und lag um 23 mg/m^3 höher als an dem selben Arbeitsplatz in Variante 2^0. Außerdem wurde an beiden genannten Arbeitsplätzen eine Überschreitung der höchsten zulässigen zeitweisen Konzentration notiert. Am Arbeitsplatz des Bedieners der Kabelwinde wurde hingegen keine Überschreitung der zulässigen Grenzwerte festgestellt.

Die festgestellten Stickstoffmonooxydwerte in der Atemzone der Arbeiter waren wesentlich niedriger als die zulässigen Grenzwerte (Tab. 3). Das spricht dafür, dass keine Gesundheitsgefährdung für die Arbeiter in dieser Hinsicht vorliegt.

Die Energieabgabe der Arbeiter ist in Tab. 4 dargestellt. Die größte durchschnittliche Energieabgabe (9487 kJ/8h) und die größte Inkonstanz (21%) wurde bei der Arbeit des Fällers in Variante 1^0 festgestellt. Die energetischen Kosten eines Fällers, der mit dem Bediener einer Kabelwinde zusammenarbeitet, waren um ca. 1650 kJ geringer (7833 kJ/8h).

Auf der Grundlage einer dreistufigen Skala für die Einschätzung der Arbeitsbelastung, die von Konarska und Roman-Liu im Jahr 1997 vorgeschlagen wurde (Koradecka Bugajska 1998), können wir feststellen, dass die Arbeit des Fällers in Variante 1^0 zu der Kategorie der sehr schweren Arbeit zu rechnen ist. Der Einsatz einer Kabelwinde bei Durchforstungsarbeiten bewirkt eine wesentliche Verringerung der Arbeitsbelastung, die aber auch weiterhin als schwer zu qualifizieren ist. Die Energieabgabe der Arbeiter, die mit dem Holzrücken beschäftigt sind, beläuft sich auf 5200–5600 kJ/8h, was auf leichte und mittelschwere Arbeit hinweist.

Tab. 2. Statistik der CO-Konzentration am Arbeitsplatz, mg/m^3
Table 2. Statistics of CO concentration at workplaces, mg/m^3

Arbeitsplatz Workplace	S_{CO} 1)	$P(S_1<S_{CO}<S_2)=0,95$	S_{COch} 2)
Fäller / Variante 1^0 chain saw operator (one-man felling)	39,5	(37,2; 41,8)	422,6
Fäller / Variante 2^0 chain saw operator cooperating with winch operator	16,3	(15,3; 17,3)	264,8
Bediener der Kabelwinde Multi FKS cable winch operator	27,3	(26,6; 27,9)	28,2
Hinweise: 1) S_{CO} – durchschnittliche Kohlenoxydkonzentration (MAK-Wert$_{CO}$= 30 mg/m^3, Maximale Arbeitsplaz-Konzentration, highest allowable concentration); 2) S_{COch} – Kohlenoxydkonzentration in 15 Minuten Messzeit (ZZAK-Wert$_{CO}$= 180 mg/m^3, Zeitweise Zulässige Arbeitsplatzkonzentration, highest allowable instantaneous concentration)			

Tab. 3. Statistik der NO-Konzentration am Arbeitsplatz, mg/m^3
Table 3. Statistics of NO concentration at workplaces, mg/m^3

Arbeitsplatz Workplace	S_{NO} 1)	$P(S_1<S_{NO}<S_2)=0,95$	S_{NOch} 2)
Fäller /Variante 1^0 chain saw operator (one-man felling)	0,036	(0,032; 0,040)	0,42
Fäller / Variante 2^0 chain saw operator cooperating with winch operator	0,026	(0,014; 0,037)	0,153
Bediener der kabelwinde Multi FKS cable winch operator	0,024	(0,014; 0,034)	0,153
Hinweise: 1) S_{NO} – mittlere Stickoxydkonzentration (MAK-Wert$_{NO}$= 5 mg/m^3, Maximale Arbeitsplaz-Konzentration, highest allowable concentration); 2) S_{NOch} – mittlere Stickoxydkonzentration in 15 Minuten Messzeit (ZZAK-Wert$_{NO}$=10 mg/m^3, Zeitweise Zulässige Arbeitsplatzkonzentration, highest allowable instantaneous concentration)			

Tab. 4. Statistik der durchschnittlichen Energieabgabe in einer Arbeitsschicht, E kJ/8h
Table 4. Statistic of mean energy expenditure at the work stand, E kJ/8h

Arbeitsplatz Workplace	E	$P(E_1<E<E_2)=0,95$	min	max	$v_{\%}$
Fäller / Variante 1^0 chain saw operator (one-man felling)	9487	(8645; 10330)	5704	13562	21
Fäller / Variante 2^0 chain saw operator cooperating with winch operator	7834	(7442; 8225)	6324	9996	12
Pferdeführer Hors skidding	5607	(5139; 6076)	2864	7179	20
Bediener der Kabelwinde Multi FKS cable winch operator	5201	(4741; 5661)	3118	7548	21

Diskussion

Die vorgestellten Untersuchungsergebnisse zeigen, dass an den untersuchten Arbeitsplätzen (mit Ausnahme des Holzrückens mit Pferd) eine Lärmbelastung auftritt, die eine Gesundheitsgefährdung für das Gehör des Arbeiters bedeutet. Das Risiko einer Gehörschädigung im Alter von 50 Jahren bei einer 30-jährigen berufsbedingten Lärmausgesetztheit nach der Norm ISO beläuft sich auf 40–60 % (Sowa Leszczyński 2005b). Eine wirksame Gegenmaßnahme ist der Einsatz von selektivem Gehörschutz, die den Lärm auf einen Pegel von 75–80 dB reduzieren.

Die ermittelten Werte des Vielfachen des äquivalenten Schwingungspegels weisen auf eine sehr hohe Gesundheitsgefährdung für die Arbeiter hin. Zwecks Verringerung der auftretenden Gefährdung auf ein zulässiges Niveau ist die Arbeitszeit auf der Arbeitsfläche auf 2,5 Stunden (Fäller in Variante 1^0) bis ca. 5,5 Stunden (Bediener der Kabelwinde Multi FKS) zu beschränken. Dabei ist jedoch zu bedenken, dass die Gefährdung durch mechanische Schwingungen durch eine unangemessene Arbeitstechnik oder einen schlechten Zustand der Motorsäge vervielfacht werden kann (Sowa 1995). In Anbetracht der relativ niedrigen Schwingungsemission und der hohen Zerspanungseffizienz schlägt Wójcik (2004) den Einsatz von Motorsägen mit einer Leistung von ca. 2,3 kW vor.

Bei Durchforstungsmaßnahmen haben wir es mit einer deutlich erkennbaren Gefährdung durch Kohlenmonooxyd zu tun. Eine vielfache Einatmung einer geringen Dosis kann zu chronischen Vergiftungen führen, die allerdings keine erkennbaren Langzeitschäden oder -folgen für den Organismus haben. Die Vergiftungen können sich in Kopfschmerzen, Schwindelgefühl, Muskelschwäche, Übelkeit, Appetitlosigkeit, Schlafstörungen äußern (Valentin et al. 1985). Eine Langzeituntersuchung, die am Lehrstuhl für Forst- und Holzwirtschaft der Landwirtschaftsakademie Krakau durchgeführt wurde, zeigt ebenfalls, dass keine permanente (tägliche) Gefährdung durch Kohlenmonooxyd besteht (Komuński 1995, Sowa Leszczyński 2005a). Während der Holzgewinnung in Kiefernbeständen, die durch Kahlschlag bewirtschaftet werden, beträgt die durchschnittliche CO-Konzentration 25 mg/m^3, und eine Überschreitung der gesundheitlichen Normen ist als ausgesprochen unwahrscheinlich anzusehen (Komuński 1995). Den größten Einfluss hat hierbei der Wind. Schon eine Windgeschwindigkeit von 3 m/s verhindert praktisch eine CO-Konzentration in der Atemzone des Arbeiters.

Der Einsatz einer Kabelwinde eliminiert die Notwendigkeit des manuellen Herunterdrehens von Hängern, einer Tätigkeit, die einen Energieaufwand von ca. 37 kJ/min (Józefaciuk Nowacka 1993) beinhaltet. Außerdem wird das Arbeitstempo der gleichzeitig durchgeführten Holzrücken untergeordnet (Sowa Leszczyński Szewczyk 2006). Deswegen wurde in Variante 2^0 ein wesentlich geringerer Energieaufwand der menschlichen Arbeitskraft verzeichnet.

Die physische Belastung des Fällers in Variante 1^0 (Einzelarbeit) überschreitet den zulässigen Grenzwert, 17 kJ/Min. Eine derartige Intensität der Arbeit verursacht eine negative Energiebilanz des Arbeiters und infolgedessen das Fehlen einer Möglichkeit der Regenerierung des Organismus. Der

Arbeitsprozess ist also auf eine solche Art und Weise zu organisieren, dass es in der Arbeitswoche nicht zu einer permanenten Notwendigkeit der Kräfteregenerierung in der Freizeit kommt (Löffler 1990).

Der Einsatz einer Kabelwinde zur Holzgewinnung verringert das Risiko von riskanten Tätigkeiten, wie sie häufig durch Einsatz, von vereinfachten, unzulässigen Methoden der Beseitigung von Hängern auftreten. Die Arbeit in einer Zweipersonengruppe unter Einsatz einer Kabelwinde ermöglicht eine Rotation an den Arbeitsplätzen und dadurch eine Verringerung der Arbeitsbelastung und der Monotonie der Arbeit. Ihr Einsatz gewährleistet die Einhaltung der Ordnung im Gelände und die Konzentration des Rohmaterials am Manipulationsweg, was die weitere Bearbeitung erleichtert und die Notwendigkeit eines manuellen Transports von Sortimenten aus dem Baumbestand bei angenähert identischer Arbeitseffizienz ermöglicht (Sowa Szewczyk 2005).

Feststellungen und Schlussfolgerungen

1. Die durchgeführten Untersuchungen ergaben eine Nichtübereinstimmung der Arbeitsbedingungen mit den gesundheitlichen Normen in den Bereichen Kohlenmonooxydkonzentration, Lärm, mechanische Schwingungen oder energetische Abgabe an den untersuchten Arbeitsplätzen.
2. Der größte Wert der Kohlenmonooxydimmision wurde während der Fällung durch eine Person mit der Motorsäge festgestellt, und der berechnete Konzentrationswert betrug etwa das doppelte im Verhältnis zur Holzernte mit einer Durchforstungstechnik, bei welcher der Fäller mit dem Bediener einer Kabelwinde zusammenarbeitet. Am Arbeitsplatz des Bedieners der Kabelwinde wurde keine Überschreitung der Maximale Arbeitsplatzkonzentration-Werts für Kohlenmonooxyd festgestellt, dagegen muss mit einer zeitweiligen Überschreitung der Zeitweise Zulässige Arbeitsplatzkonzentrat ion-Werts gerechnet werden.
3. Die durchgeführten Untersuchungen haben ergeben, dass der Lärmpegel auf der Ebene der täglichen Lärmausgesetztheit $L_{EX,8h}$ für den Fäller 99 dB(A) in Variante 1^0 beträgt und 95 dB(A) in Variante 2^0. Der geringste Wert $L_{EX,8h}$, nämlich 93 dB(A), wurde am Arbeitsplatz der Kabelwinde Multi FKS festgestellt.
4. Eine Analyse der Gesundheitsgefährdungen durch Schwingungen zeigt, dass eine höhere Gefährdung auf dem Arbeitsplatz des Fällers in Variante 1^0 auftritt als in Variante 2^0, bei welcher der Wert der Gesundheitsgefährdung durch Schwingungen um 25% niedriger liegt.
5. Die Unterschiede der energetischen Abgabe des Fällers in beiden untersuchten technischen Varianten beruhen auf dem unterschiedlichen Charakter des aufgebrachten Krafteinsatzes durch die verschiedenen Arbeiter. Die Energieabgabe sowohl des Fällers als auch des Bedieners der Kabelwinde Multi FKS (Variante 2^0) übersteigt die zulässigen physiologischen Normen nicht. Dagegen betrug in Variante 1^0 die Energieabgabe um die 9.500 kJ7/8h, was als nicht normgerecht zu werten ist.
6. Die Arbeitsbelastung auf dem Arbeitsplatz eines Fällers, der mit einem Pferdeführer zusammenarbeitet (Holz rücken mit Pferd) ist um 21% größer als die eines Fällers in Zusammenarbeit mit dem Bediener einer Kabelwinde Multi FKS. Der Einsatz der Kabelwinde verringert also die Arbeitsbelastung bei der Durchforstung.
7. Die vorliegenden Untersuchungen haben gezeigt, dass durch den Einsatz einer Kabelwinde die Sicherheit und das Niveau der Humanisierung der Arbeit deutlich verbessert werden kann. Darüber hinaus ermöglicht diese Form der Zusammenarbeit eine Rotation der Arbeitsplätze und infolgedessen die Belastung.

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БЕНЧМАРКИНГ (СРАВНЕНИЕ НА ПОКАЗАТЕЛИТЕ) НА ГОРОВЛАДЕЛСКИ КООПЕРАЦИИ В ГЕРМАНИЯ, АВСТРИЯ И ШВЕЙЦАРИЯ

Томас Щайнмюлер, Австрия

Дребното горовладение е от голямо значение за австрийското горско стопанство – половината от годишното ползуване е от дребните частни горски имоти. Ефективното стопанисване на дребните частни гори в повечето случаи е невъзможно поради малката им площ, разпръснатото им положение и други структурни недостатъци. Допълнителни затруднения произтичат от недостига на машини или тяхната износеност.

Горовладелските кооперации би трябвало да послужат за преодоляване на тези слабости, но те засега ограничават дейността си главно до съвместна продажба на добития материал и до общо ползуване на машини при дърводобива. Спешно е необходимо тези кооперации да се развият в пълноценни предприятия с всестранна дейност.

При настоящето изследване въз основата на разработен от нас списък от показатели бяха анализирани 12 горскостопански сдружения в Германия, Австрия и Швейцария и равнището на организационното им развитие беше проучено посредством аналитичен йерархичен процес (AHP).

Освен че се различават много по размер (по площ, брой на членовете и добита маса), резултатите показаха големи разлики между показателите на бенчмаркинг-партньорите. Като фактори на успеха бяха идентифицирани мениджментът, техническата въоръженост, готовността за коопериране, работа с обществеността, образованието и квалификацията на персонала и членовете, както и спектърът на дейността и работата с кооператорите; същите показатели са основа и за дизайна на моделното горско стопанство “Modellbetrieb 2010”.

BENCHMAKING OF CO-OPERATIONS AMONG FOREST OWNERS IN GERMANY, AUSTRIA AND SWITZERLAND

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Abstract

Small forests are of great importance to Austria’s forestry; approximately half of the entire annual harvest originates from small, private properties. In many cases, professional management is not possible due to the very small and often fragmented parcels. Old and insufficient machinery makes small forests even more difficult to manage.

To overcome these weaknesses and to increase competitive ability, co-operations between the forest owners have been established. So far, the activities of these co-operations are predominantly limited to wood marketing and machine sharing. In the future, an advancement of these unions to enterprises with a wide range of services will be necessary.

This project is a benchmarking study for 12 forest co-operations in Austria, Germany and Switzerland. Furthermore the current development status will be demonstrated with an Analytic Hierarchy Process (AHP).

The results are showing big differences, due to different operational areas, number of forest owners, annual cuts and many other reasons. As the most important critical success factors have been identified: management, configuration, co-operations, public relations, continuing education and management of the members.

Keywords: Forest Engineering; Co-Operations; Small Scale Forestry; Organisation Development

KURZFASSUNG

Im Kleinwald ist eine effektive Bewirtschaftung aufgrund von sehr kleinflächigen, nicht arrondierten Einheiten und strukturellen Hemmnissen in vielen Fällen nicht möglich. Weitere Erschwernisse ergeben sich durch veraltete und unzureichende Maschinenausstattungen.

Kooperationen zwischen Waldbesitzern sollen diese Schwächen überwinden, jedoch beschränken sich die Aktivitäten bisher vorwiegend auf eine gemeinsame Rohholzvermarktung und den überbetrieblichen Maschineneinsatz bei Holzerntemaßnahmen. Eine Weiterentwicklung dieser Zusammenschlüsse zu Dienstleistungsbetrieben mit umfangreichem Leistungsangebot ist dringend notwendig.

Im Rahmen einer Benchmarking Studie wurden auf Basis eines entwickelten Kennzahlenkataloges 12 forstliche Zusammenschlüsse in Deutschland, Österreich und der Schweiz analysiert und der Stand der Organisationsentwicklung mittels AHP untersucht.

Die Ergebnisse zeigen – neben verschiedenen Dimensionen betreffend Operationsgebiet, Mitgliederanzahl und Gesamteinschlag – große Unterschiede zwischen den Benchmarkingpartnern. Als Erfolgsfaktoren wurden u. a. die Geschäftsführung, Ausstattung, Kooperationsbereitschaft, Öffentlichkeitsarbeit, Aus- und Weiterbildung von Personal und Mitgliedern sowie das Dienstleistungsangebot und Mitgliedermanagement identifiziert.

Schlagwörter: Forstliches Ingenieurwesen; Forsttechnik; Kooperationen; Kleinwald; Organisationsentwicklung

AUSGANGSSITUATION

In Österreich kommt rund die Hälfte des jährlichen Gesamteinschlags aus dem Kleinwald. Aus diesem Grund ist diese Besitzkategorie für die Forstwirtschaft von großer Bedeutung. Momentan stellen sehr kleinflächige (und nicht arrondierte) Einheiten zusammen mit unzureichenden und veralteten Maschinenausstattungen Erschwernisse für eine effektive Bewirtschaftung dar. Zusätzlich führen gesellschaftliche Entwicklungen und der Strukturwandel in der Landwirtschaft zu einem ständig abnehmenden Bezug der Eigentümer zu ihrem Waldbesitz (Von Bodelschwingh et al., 2005).

Forstliche Zusammenschlüsse sollen strukturell bedingte, einzelbetriebliche Nachteile ausgleichen. Die Positionierung zwischen Waldbesitzern und der Holz- und Papierindustrie ist eine wichtige Aufgabe. Dies v. a. vor dem Hintergrund, dass die Anforderungen der Holzabnehmer an Menge, Qualität und zeitliche Konstanz bei der Lieferung deutlich zugenommen haben (Suda und Warkotsch, 2002).

In der Vergangenheit haben sich die Kooperationen zwischen Waldbesitzern in erster Linie auf die gemeinsame Holzvermarktung und überbetriebliche Maschineneinsätze beschränkt. Die Weiterentwicklung in Richtung Dienstleistungsbetriebe mit umfangreichem Leistungsangebot ist zur Steigerung der Wettbewerbsfähigkeit in vielen Fällen notwendig.

Bisher kaum untersucht ist die Situation der Aus- und Weiterbildung des Personals forstlicher Zusammenschlüsse bzw. der Schulungsbedarf der einzelnen Waldbesitzer. Je nach Größe und Lage des Waldbesitzes besteht unterschiedlicher Beratungsbedarf (Raupach, 2002).

In dieser Benchmarkingstudie für forstliche Zusammenschlüsse in Österreich, Deutschland und der Schweiz sollen Leistungslücken identifiziert und Verbesserungspotenziale aufgezeigt werden. Im Detail sind folgende Ziele zu verfolgen:

- Darstellung von ausgewählten Ergebnissen des Benchmarkingprozesses
- Ableitung der Erfolgsfaktoren für forstliche Zusammenschlüsse und Darstellung der maßgebenden Einflussparameter
- Ranking der Benchmarkingpartner aufgrund ihrer Organisationsentwicklung

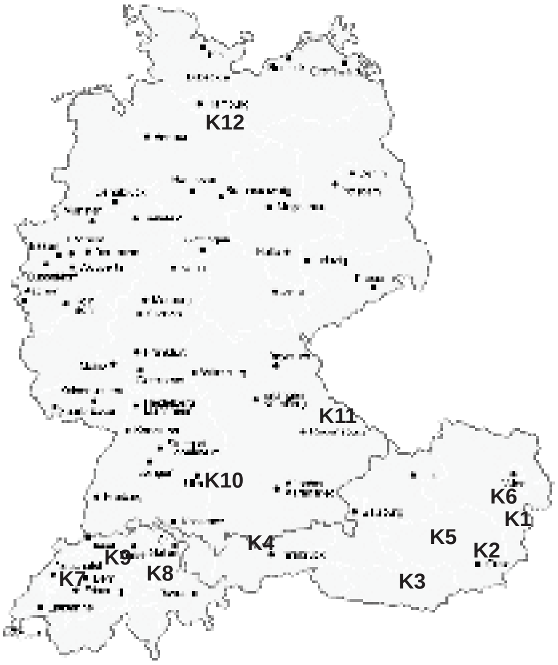
BENCHMARKING – PARTNER

Erfolgreiche Kooperationen mit ausreichend verfügbarer Datengrundlage sind in die Untersuchung einbezogen worden. Folgende Gesichtspunkte waren bei der Auswahl wesentlich:

- geografische Lage (Österreich, Schweiz und Deutschland),
- Form der Zusammenschlüsse (z. B. Urbarialgemeinde, Waldwirtschaftsgemeinschaft, Agrargemeinschaft, Waldbesitzervereinigung),
- Strukturen (z. B. Besitzerzusammensetzung, Personal- und Maschinenausstattung),
- Prozesse,

- Strategien,
- Zweck der Kooperationen (z. B. gemeinsame Holzvermarktung).

Abbildung 1 zeigt die regionale Verteilung und wichtige strukturelle Daten (Gesamtwaldfläche und Anzahl von Waldbesitzern) der forstlichen Zusammenschlüsse.



Nummer	Land	Gesamtwaldfläche [ha]	Waldbesitzer [n]
K1	Österreich	2.000	45
K2		27.444	2.400
K3		17.000	350
K4		405	30
K5		9.930	282
K6		400	141
K7	Schweiz	10.000	2.000
K8		800	145
K9		12.000	1.500
K10	Deutschland	8.634	1.452
K11		10.600	1.750
K12		57.000	2.600
Summe		156.200	12.695
Mittelwert		13.018	1.058
Durchschnittsfläche		17 ha/Waldbesitzer	

Abbildung 1: Struktur der Benchmarkingpartner (Stand: Dezember 2003).

Von den 15 erhobenen Kennzahlengruppen (Grunddatenerhebung, Organisation/Struktur, Subventionen, Waldbau, Forstschutz, Holzernte, Holzvermarktung, Holztransport, Holzbearbeitung, zusätzliche Wertschöpfung, Naturschutz, Soziale Aktivitäten, Öffentlichkeitsarbeit, Erschließung, Aus- und Weiterbildung) im Rahmen des zugrunde liegenden Forschungsprojektes werden ausgewählte Ergebnisse analysiert.

HOLZVERMARKTUNG

Die gemeinsame Holzvermarktung wird nach wie vor als eine zentrale Aufgabe von forstlichen Zusammenschlüssen gesehen. Dabei wird die gesamte vermarktete Holzmenge in Vor-, End- und Katastrophennutzungen aufgegliedert (Abbildung 2).

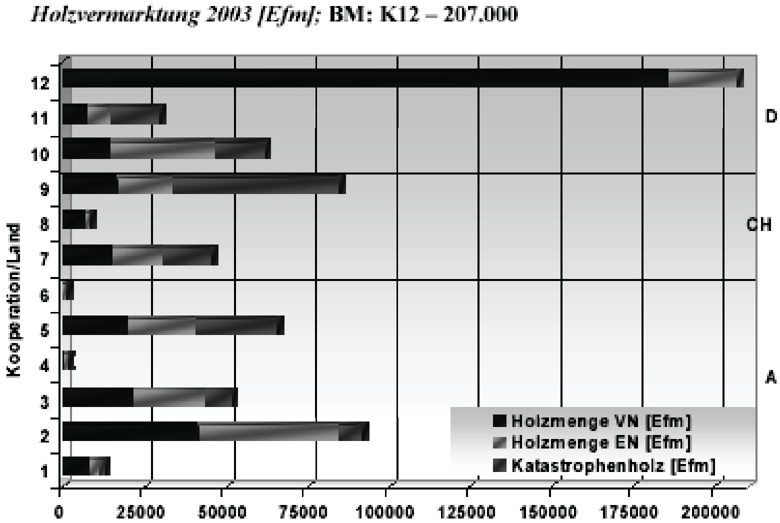


Abbildung 2: Holzvermarktung 2003 [Efm].

Die 12 Benchmarkingpartner haben im Jahr 2003 eine Holzmenge von 664.858 Efm vermarktet. Die größte Menge (207.000 Efm) erreichte K12; gefolgt wird sie von K2 (92.000 Efm) und K9 (85.000 Efm). Der Mittelwert über alle Zusammenschlüsse liegt bei 55.405 Efm.

- Vornutzungen: Der VN-Anteil schwankt zwischen 0 (K6) und 90% (K12); der Mittelwert liegt bei 43%.
- Endnutzungen: Der EN-Anteil variiert zwischen 10 (K12) und 100% (K6); Mittelwert: 37%.
- Katastrophennutzungen: Es gibt Unterschiede von 0 (K6, K8 und K12) bis 60% (K9), Mittelwert: 20%. Katastrophennutzungen sind Nutzungen nach forstlichen Kalamitäten (Borkenkäfer, Windwurf, Schneebruch usw.).

Die ungleichen Anteile von Vor-, End- und Katastrophennutzungen der forstlichen Zusammenschlüsse resultieren aus verschiedenen Bewirtschaftungskonzepten und unterschiedlichen Schadholzmengen im Untersuchungszeitraum. Die durchschnittliche Losgröße im Jahr 2003 schwankt zwischen 17 (K2) und 70 (K3) Efm; der Mittelwert aller Vereinigungen liegt bei 24 Efm.

VERWALTUNGS- UND BERATUNGSEFFIZIENZ

Die Kennzahl Verwaltungs- und Beratungseffizienz ergibt sich durch Division des Arbeitsaufwandes (Arbeitszeit der Angestellten, keine Arbeitszeiten von Forstarbeitern) einer Kooperation für das Jahr 2003) durch die vermarktete Holzmenge (ohne Waldhackgut) in diesem Zeitraum (Abbildung 3).

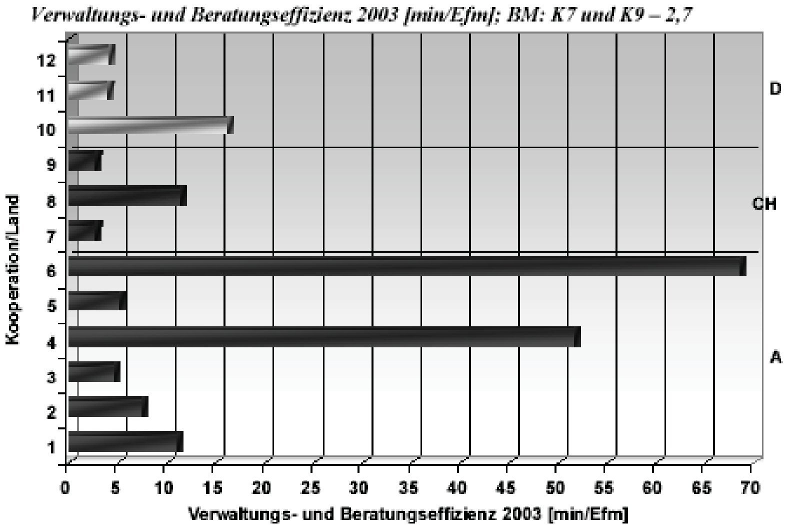


Abbildung 3: Verwaltungs- und Beratungseffizienz 2003 [min/Efm].

Die beste Verwaltungs- und Beratungseffizienz erreichen die schweizerischen Kooperationen K7 und K9, gefolgt von den deutschen K11 und K12. Die schlechteste Effizienz erreichen aufgrund der geringen Holzvermarktungsmengen im Jahr 2003 K4 und K6. Der Mittelwert aller Kooperationen beträgt 16 min/Efm; somit wurde im Durchschnitt aller Zusammenschlüsse pro Arbeitsstunde eine Holzmenge von 3,75 Efm vermarktet.

Eine von Rauch (2003) durchgeführte Kennzahlenanalyse von 3 steirischen Waldwirtschaftsgemeinschaften (Soboth, Leoben und Bruck/Mur) und einem Waldverband (Hartberg-Fürstenfeld) bringt nur teilweise vergleichbare Ergebnisse: Er kommt auf Arbeitsproduktivitäten (durchschnittlich von der Waldwirtschaftsgemeinschaft vermarktete Holzmenge in Efm pro aufgewendeter Arbeitsstunde) in einer Bandbreite von 10 bis 25 Efm/h. In dieser Studie befinden sich K3 (13 Efm/h), K5 (12 Efm/h), K7 und K9 (jeweils 22 Efm/h) in diesem Bereich; die anderen liegen darunter. Die Hauptursache für den Unterschied sind verschiedene Strukturen von den Kooperationen der beiden Studien.

FLÄCHENNUTZUNG

Für die Berechnung der Flächennutzung werden die Holzvermarktungsmengen 2003 mit dem Operationsgebiet in Beziehung gesetzt (Abbildung 4).

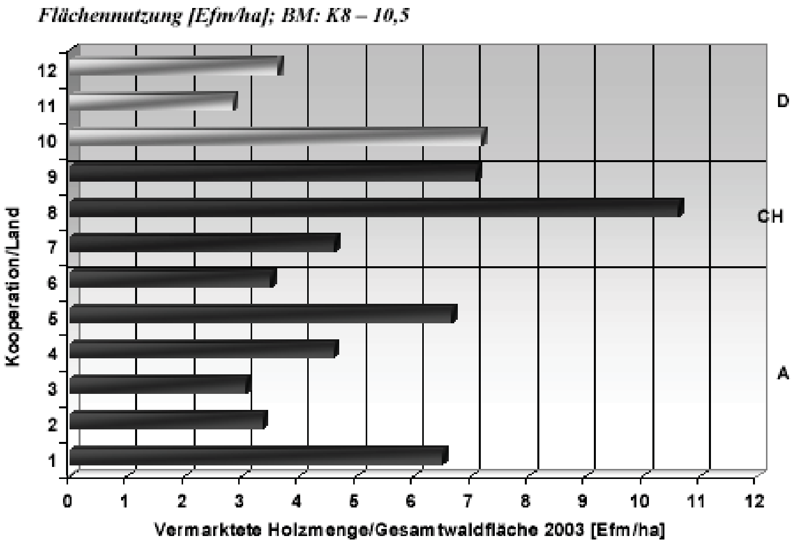


Abbildung 4: Zusammenhang Holzvermarktung und Gesamtwaldfläche [Efm/ha].

Die Vergleichsobjekte haben im Mittel 5 Efm/ha im Jahr 2003 genutzt. Die beste Flächennutzung im Jahr 2003 verzeichnet K8 mit rund 11 Efm/ha. Über dem Durchschnitt mit rund 7 Efm/ha befinden sich außerdem die K1, K5, K9 und K10.

In 50% der Fälle sind Bewirtschaftungspläne als Planungsgrundlage vorhanden; in den Kooperationen K4, K6, K7, K8, K10 und K12 sind Hiebssätze (nachhaltig jährlich einschlagbare Holzmengen, welche durch die Forsteinrichtung geplant und festgesetzt wurden) verfügbar. Die Werte reichen von 1.400 (K6) bis 210.900 (K12) Efm/Jahr (Bayerische Staatsforstverwaltung, 2006).

AUS- UND WEITERBILDUNG – PERSONAL

Laufende Aus- und Weiterbildungsaktivitäten werden für forstliche Zusammenschlüsse als Erfolgsfaktor gesehen. Aus diesem Grund wurde der derzeitige Stand getrennt nach Personal und Waldbesitzer erhoben.

Das Personal der Benchmarkingpartner nimmt im unterschiedlichen Ausmaß an Weiterbildungsvera nstaltungen in Form von Kursen, Seminaren und Tagungen teil (Abbildung 5).

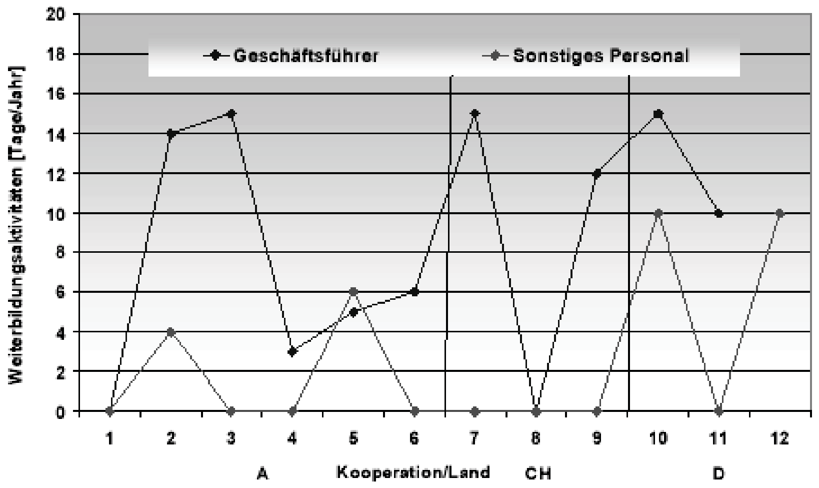


Abbildung 5: Umfang von Weiterbildungsmaßnahmen des Personals

Geschäftsführer von 10 Kooperationen (K2, K3, K4, K5, K6, K7, K9, K10, K11 und K12) nehmen an bis zu 15 (Mittelwert: 11) Tagen im Jahr an Kursen, Seminaren und Tagungen teil; der Schwerpunkt liegt derzeit bei forstfachlichen und kaufmännischen Veranstaltungen. Seminare zur Förderung von Managementkenntnissen und Sozialkompetenz werden zukünftig verstärkt besucht.

Sonstige Angestellte von 4 Zusammenschlüssen (K2, K5, K10 und K12) nützen Weiterbildungsmaßnahmen im Ausmaß bis zu 10 (Mittelwert: 8) Tagen im Jahr. Bei den Forstberatern stehen forstliche Themen im Vordergrund, vom Verwaltungspersonal wird je nach den Anforderungen kaufmännische Kompetenz verlangt, die durch Ausbildungs- und Weiterbildungsmaßnahmen (z. B. Lohnverrechnungs-, Bilanzbuchhaltungs- und EDV-Kurse) aufgebaut wird.

In 2 Kooperationen (K10 und K12) werden Fortbildungsreisen zu forstlichen Themen im Ausmaß von je 2 Tagen veranstaltet und vom Personal in Anspruch genommen.

Aus- und Weiterbildung – Waldbesitzer

Für die Mitglieder der forstlichen Kooperationen (Waldbesitzer) wurden – neben der Intensität – die Möglichkeiten der Informationsbeschaffung erhoben (Abbildung 6).

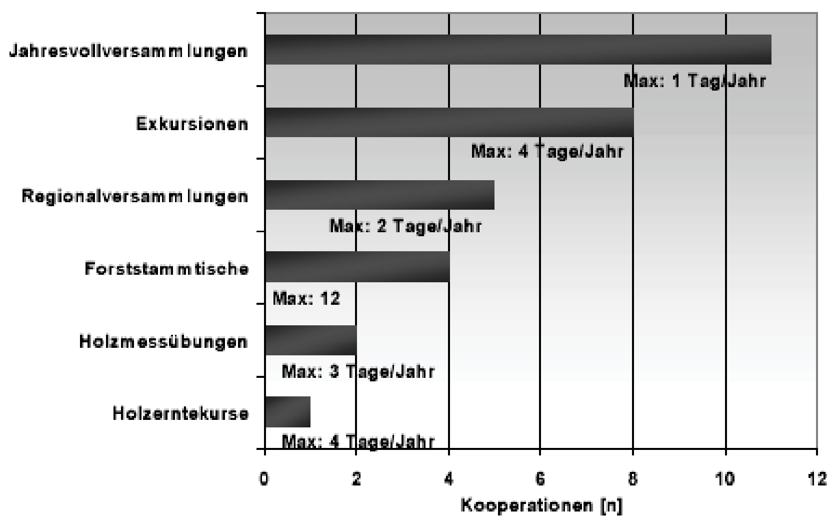


Abbildung 6: Informationsveranstaltungen für Waldbesitzer.

In allen Vereinigungen (mit einer Ausnahme – K9) findet einmal jährlich eine Jahresvollversammlung mit Fachvorträgen zu aktuellen forstlichen Themen statt. Exkursionen und Waldbegehungen im Ausmaß bis zu 4 Tagen werden von zwei Drittel der Zusammenschlüsse (K1, K2, K5, K8, K9, K10, K11 und K12) angeboten und von ihren Mitgliedern in Anspruch genommen.

In 5 Fällen (K2, K4, K5, K10 und K12) leistet das Personal aktiv Beiträge bei regionalen Versammlungen und ist in der Organisation beteiligt. Regelmäßige Forststammtische (bis zu 12/Jahr) werden von einem Drittel der Kooperationen (K2, K3, K4 und K5) für die Waldbesitzer abgehalten. Bei dieser Gelegenheit werden in erster Linie Themen der Holzvermarktung besprochen. Holzmessübungen (bis zu 3 Tage) bzw. Holzerntekurse (4 Tage) werden nur in 2 Fällen (K7 und K10) organisiert.

- Bäuerlichen Waldbesitzern soll zukünftig verstärkt ein permanentes Weiterbildungsprogramm mit forstfachlichen und kaufmännischen Inhalten geboten werden. Als Anbieter können die forstlichen Ausbildungsstätten, Landwirtschaftskammern, Bezirks- und Landesforstdirektionen fungieren.
- Bei den aktiven hoffernen Waldbesitzern wird der Schwerpunkt auf Waldbau und Holzernte gelegt.
- Für passive hofferne Waldbesitzer sind permanente Informationsstellen (u. a. die Landwirtschaftskammern) einzurichten. Aktuelle Themen und Probleme überwiegen bei ausgesendeten Informationen.

Organisationsentwicklung forstlicher Kooperationen

Die Bewertung der Entwicklungsphasen der 12 forstlichen Kooperationen wird mittels Analytisch Hierarchischem Prozess (AHP) durchgeführt. Dazu werden 5 Bewertungskriterien und 14 Indikatoren definiert, die aus den erhobenen Kennzahlen abgeleitet werden. Als erster Schritt erfolgt die Formulierung eines hierarchischen Zielsystems. Das Entscheidungsziel lautet: „Darstellung der Organisationsentwicklung der 12 forstlichen Zusammenschlüsse“ (Abbildung 7).

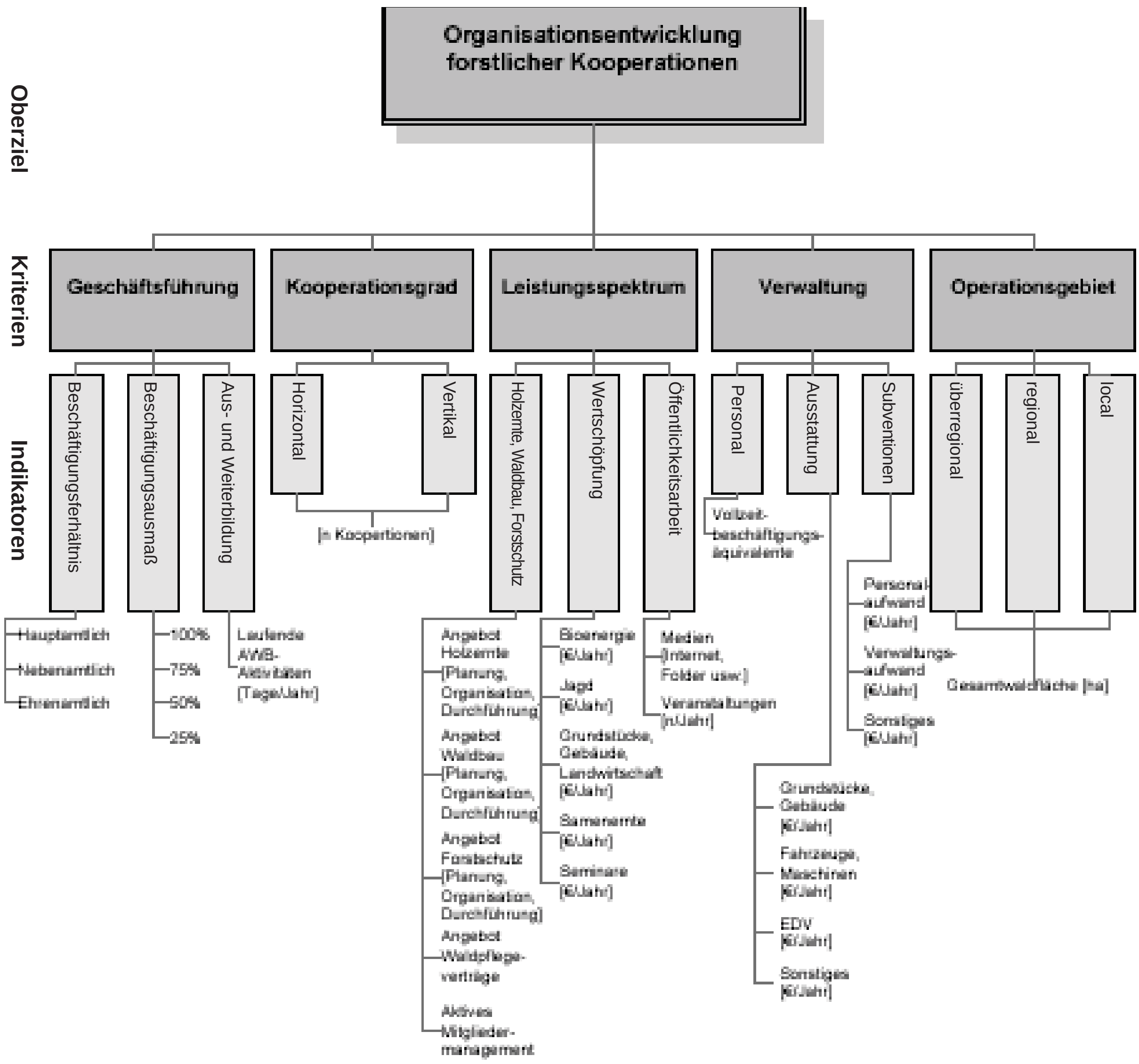


Abbildung 7: Oberziel, Kriterien und Indikatoren.

Die Gewichtung der Kriterien beruht auf Einschätzung von Kleinwaldexperten. Jeweils 2 Kriterien werden mittels „Paarweisen Vergleich" miteinander verglichen; den qualitativen Vergleichen werden quantitativen Größen zugeordnet. Das Resultat sind 5 12 x 12 Matrizen, bei denen mit der Eigenvektormethode die subjektive Präferenz für eine Kooperation bestimmt wird.

Zuletzt werden die einzelnen Ergebnisse zu einer Gesamtpriorität zusammengeführt; dazu werden die Eigenvektoren der Entscheidungskriterien ermittelt. Durch die Synthese ergibt sich eine Reihenfolge der forstlichen Zusammenschlüsse hinsichtlich ihrer Organisationsentwicklung (Abbildung 8).

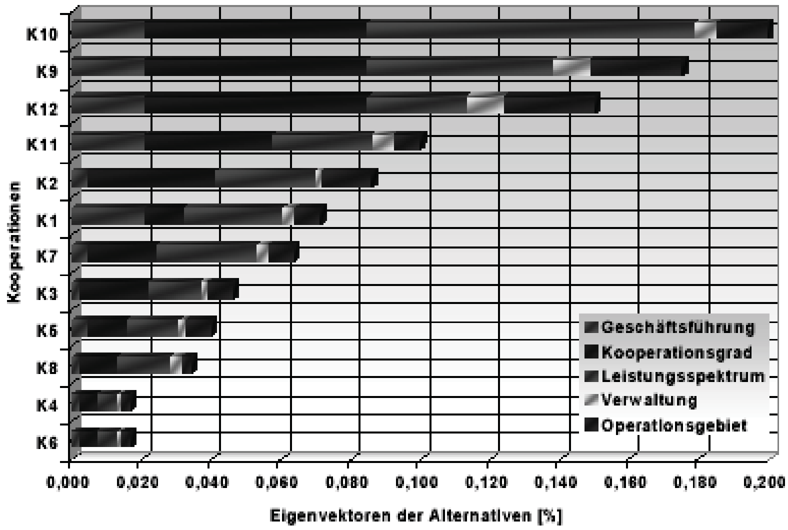


Abbildung 8: Reihenfolge der forstlichen Zusammenschlüsse.

Die Kriterien Kooperationsgrad und Leistungsspektrum haben sich als die wichtigsten Entscheidungskriterien herausgestellt. Beide sind mit jeweils ca. 35% für den Gesamtnutzen einer Alternative verantwortlich. Je 13% sind die Anteile von der Geschäftsführung und vom Operationsgebiet. Den geringsten Einfluss (5%) hat das Entscheidungskriterium Verwaltung.

Den höchsten Eigenvektor erreicht K10 mit rund 20% des erreichbaren Maximalwertes, gefolgt von K9 und K12. Entscheidend für das gute Abschneiden dieser Kooperationen sind v. a. das umfangreiche Dienstleistungsangebot und die vielseitigen horizontalen bzw. vertikalen Allianzen. Die geringsten Eigenvektoren (jeweils 1,7%) liegen bei K4 und K6.

ZUSAMMENFASSUNG

Ziele der vorliegenden Studie sind das Identifizieren von Leistungslücken, die Ableitung der Erfolgsfaktoren und Darstellung der Organisationsentwicklung von forstlichen Zusammenschlüssen in Deutschland, Österreich und der Schweiz.

Die methodische Vorgangsweise beinhaltet – nach einer Literaturrecherche – die Auswahl der Benchmarkingpartner, Kennzahlenerhebung, Identifizierung der Benchmarks und den Vergleich der Organisationsentwicklung mittels analytisch hierarchischen Prozess (AHP). Zusätzlich wurde ein Workshop („Aus- und Weiterbildung forstlicher Kooperationen – Definition des zukünftigen Bedarfs") durchgeführt.

Die Ergebnisse zeigen – neben verschiedenen Dimensionen betreffend Operationsgebiet, Mitgliederanzahl und Gesamteinschlag – große Unterschiede zwischen den Zusammenschlüssen. Die Kriterien erfolgreicher Kooperationen sind die Geschäftsführung, der Kooperationsgrad, das Leistungsspektrum, die Verwaltung und das Operationsgebiet.

Den höchsten Reifegrad erreicht K10, gefolgt von K9 und K12. Hauptgründe dafür sind die wertmaximalste Sortimentsverteilung (96% Rundholzanteil), dreistufige Waldpflegeverträge, 12.000 Srm vermarktete Hackschnitzel im Jahr 2003 und eine hohe vertikale und horizontale Kooperationsbereitschaft.

Für die Weiterentwicklung forstlicher Kooperationen zu Dienstleistungsbetrieben mit umfangreichem Leistungsangebot sind u. a. eine Forcierung der Aus- und Weiterbildungsmaßnahmen von Personal und Waldbesitzern, ein aktives Mitgliedermanagement, eine Erhöhung des Repräsentationsgrades (Zielgröße:

60%), die Anhebung der Mindestlosgröße auf 28 Efm und die Vermarktung von Waldhackgut als konkrete Maßnahmen identifiziert worden.

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ОЦЕНКА НА ВЛИЯНИЕТО ВЪРХУ ОКОЛНАТА СРЕДА НА ГОРСКИТЕ ПЪТИЩА В ПЛАНИНСКИ УСЛОВИЯ

В. Г. Стергиаду, П. Х. Ескиоглу, Гърция

В настоящата работа е развит метод за оценка на антропогенното въздействие върху природата при строителството на горски пътища. Главните съображения са: а) Строителните работи често водят до повреди на околната среда, така че при усвояване на дадена гора трябва да се държи сметка не само за себестойността на пътя, но и за размера на екологичните щети, който трябва да се добави към себестойността. б) Съществуването на човека изисква експлоатация на природата, но човешката намеса понякога има отрицателни последици.

Метод, който ще се прилага на практика, трябва да бъде практичен, ефективен и приложим преди построяване на пътя. За целта : 1) трябва да се прилагат практични критерии за оценяване на интензивността на въздействието и последиците му. Степенуването на тези критерии по важност става на следния принцип: Приемаме ситуацията за идеална (=100%), ако строежът не поврежда горите. Тази идеална ситуация ще се описва по определени критерии, 2) относителната тежест на тези критерии ще се определи чрез анкетиране на научни работници. Ще бъдат обхванати следните параметри: времетраенето на отрицателния ефект, засегнатата площ, чувствителността на общественото мнение към ефекта, социалното му значение и политическата воля. Комплексната оценката на тези параметри е трудна, което налага оценка на въздействието върху околната среда (ОВОС) да се представи под формата на „профил". 3) Екологично оптималното трасе на пътя ще бъде определено с използване на аналитичната фотограметрия (аерофотоснимки) и GIS. 4) ОВОС на съществуващи пътища в района на изследването ще установи отрицателните влияния по протежение на пътищата. Тази информация ще се използува за оценка на въздействието на проектираните бъдещи горски пътища.

Изследването е от практически интерес за горското стопанство. Определянето и степенуването по важност на критериите за ОВОС на пътното строителство и определянето на възможното смекчаване на ефектите чрез абсорбиране на въздействието, ще позволи изчерпателни оценки на всеки горски път по стандартите на новите директиви на ЕС. ОВОС е може да се използва при сравняване на различни технически възможни трасета на пътя на стадия на проектирането. Освен оценката им с оглед транспортната достъпност на ресурсите, ще бъде възможно да се държи сметка и за въздействието върху горските екосистеми. Това ще оптимизира вертикалната и хоризонталната проекции на пътя и ще доведе до решение, което е приемливо и в техническо, и в екологично отношение. Въз основата на рамките на ОВОС ще се извърши едновременно оптимизиране както на серпантините, така и на дрениращата система на пътя. За картиране на промените в околната среда ще се използват аерофотоснимки и GIS. Комбинацията на различните методи заедно с параметрите на ОВОС, разходите, действуващото законодателство и политика по въпросите на околната среда ще доведат до решение за или против построяване на пътя.

UMWELTVERTRÄGLICHKEITS-PRÜFUNG (UVP) DER WALDWEGE IM GEBIRGE

V. G. Stergiadou, P. Ch. Eskioglou, Greece

ABSTRAKT

In dieser Studie wurde eine Methode entwickelt, um den menschlichen Einfluss, insbesondere die Effekte der Waldwegkonstruktion auf die Natur zu untersuchen. Die Hauptüberlegungen sind; a) Umweltschäden sind oft als Konsequenzen von Konstruktionsarbeiten festzustellen; bei der Planung von Zugang in Waldflächen ist die Berücksichtigung von Wegkonstruktions- wie auch Umweltschadenkosten erforderlich. Die Gesamtkosten werden als die Summe verschiedener Teilkosten berechnet, b) Die Natur wird vom Mensch genutzt, allerdings oft mit negativen Konsequenzen.

Die angewendete Methode soll praktikabel, effektiv und schon vor der Wegkonstruktion einfach verwendbar sein. Aufgrund dessen: 1) Praktische Kriterien müssen eingesetzt werden, um die Einflussintensität der Eingriffe und Einflussaufnahme zu schätzen. Die Kriterien werden nach dem folgenden Prinzip eingestuft: Wir akzeptieren eine Situation als ideal (=100%) für den Waldschutz während der Konstruktion. Diese ideale Situation wird nach bestimmten Kriterien beschrieben, 2) die Einstufung dieser Kriterien erfolgt nach einer Umfrage von Forstwissenschaftlern. Folgende Parameter werden berücksichtigt: a) die Dauer von negativen Effekten, b) die beeinflusste Fläche, c) die Sensibilität der Bevölkerung wie auch die soziale Konsequenzen und politische Wille. (Die Evaluierung der oben genannten Parameter ist eine schwierige Aufgabe und deshalb wird die Beschreibung von UVP als Ergänzung benötigt), 3) Luftaufnahmen und GIS werden benutzt, um die Wege umweltfreundlich in der Landschaft zu lokalisieren, 4) UVP von existierenden Wegen, in der Versuchsregion werden negativen Effekten entlang des Weges unterschiedlich aufgenommen. Diese Information wird benutzt, um die Umweltbelastung der geplanten Wege einzuschätzen.

Das Ergebnis dieser Arbeit ist von praktischem Interesse für die Forstwirtschaft. Die Festlegung and Beurteilung von Kriterien für die Einschätzung von Umweltbelastungen wegen Waldwegkonstruktionen in Zusammenhang mit strafmildernden Effekten durch Effektaufnahme wird eine übergreifende Bewertung von allen Waldwegen erlauben. Diese Bewertung wird gemäß festgesetzten EU-Standards erfolgen. UVP ist beim Vergleich von technisch ausführbaren Waldwegen in der Planungsphase sehr wichtig. Neben ihre Beurteilung in Abhängigkeit von ihrem Zugang in der Planungsphase werden zusätzlichen Kriterien zur Verfügung gestellt. Diese Kriterien werden die Einflüsse auf Waldökosysteme berücksichtigen, welche wiederum die horizontale und vertikale Wegausrichtung beeinflussen werden. Daraus wird ein Vorschlag gemacht, der technisch umsetzbar und umweltfreundlich ist. Im Rahmen der UVP sollen Verbesserungsm öglichkeiten bez. Serpentine und Straßenabflusssysteme vorgeschlagen werden. Luftaufnahmen und GIS werden zur Darstellung von ökologischen Veränderungen angewendet. Die Kombination der verschiedenen Methoden wird zusammen mit UVP- Parameter, Kostfaktoren, Gesetzgebung und Umweltpolitik zur Entscheidung für oder gegen eine Wegkonstruktion führen.

ENVIRONMENTAL IMPACT ASSESSMENT FOR EVALUATION OF FOREST ROADS IN MOUNTAINOUS CONDITIONS

V. G. Stergiadou, P. Ch. Eskioglou, Greece

This research develops a method of anthropogenic impact on the natural environment especially the impacts by the forest road construction. The key issues are: a) Construction work in the field often results in environmental damage, to be more specific to get access to a forested is necessary to take into consideration the net cost of road construction as well as the cost arising from to the environment. The total cost is the sum of partial cost. b) Human presence demands exploitation of the natural environment. Yet it causes interference some times with a negative effect.

The method, which will be applied, should be practical, effective and easy to use before the road construction. For this reason: 1) Practical criteria must be held in order to evaluate the intensity of the impact and absorption. The grading of these criteria depends on the following principle: We accept a situation as ideal (=100%) for the forest protection by construction. This ideal situation will be described by criteria, 2) the rating of those criteria will result from a survey of forest scientist by questionnaires. The following parameters will be considered: duration of the negative effect; the influenced area; the sensitivity of the general public to the effect as well as social impact and political desire. (The evaluation of the later parametres will be difficult and therefore the description of an E.I.A. in a profile form will be a necessary addition), 3) Analytical photogrammetric method and GIS will be used to evaluate the road location on the landscape level and with respect to the environment, 4) E.I.A. of existing roads, in the research area will reveal different forms of absorption of negative impacts along the roads. This information will be used to assess the impacts of the planned forest roads.

The research is of practical interest for forest management. The identification and the rating of criteria for E.I.A. of road construction combined with revealing possible mitigating effects through impact absorption will allow for comprehensive evaluations of every forest road according standards set by new EU directions. The E.I.A. is of special interest when comparing different technically doable road alignments at the planning stage. Besides assessing them against the objectives of the access planning additional criteria will be available to include impacts on the forest ecosystems. The latter will affect the road alignment in horizontal and vertical perspective and result in a solution, which is technically and environmentally acceptable. The criteria of E.I.A. of forest roads will be analysed by using methods of conditions and protection of forest ecosystems. Based on the framework of the E.I.A. we must find a compatible solution in order to improve the road on the level both on the serpentine and the road draining system. Analytical photogrammetry and GIS will be used for drawing up the environmental changes. The combination will be used as a decision – support tool together with the: E.I.A. parameters, cost, existing legislation and environmental policy.

INTRODUCTION

The term Environmental Impact Assessment (E.I.A.- UVP) means an assessment of impact on the environment caused by anthropogenic interference. This paper deals with the impacts on the natural environment by road construction. In Greece this terminology used for the first time in the Law Nr.743/77 and same years later in the Law Nr. 1650/86, articles 3 to 6, which were referred to as the environmental protection in order to be compatible to the Greek legislation with the European directions that was given to Greece.

Despite the legislation about E.I.A. all constructions are rarely undertake by them, because constructors couldn't estimate the use of them (Stergiadou e.t.all, 2003, Stergiadou et all, 2004). For a successful forest opening up project it is necessary to take into consideration the net cost of road construction as well as the cost arising from the Environment (Doukas, 1994, Becker, 1995, Doukas et all 1998). The total cost is the sum of partial cost (Warner 1973).

The key issues are: a) Construction work in the field often results in environmental damage, to be more specific to get access to a forested area it is necessary to take into consideration the road net cost as well as the cost arising from the landscape and the natural environment. b) Human presence demands exploitation of the natural environment. Yet it causes interference some times with a negative effect (Stergiadou, 2006).

The area of the National Park of southern Pindos spreading over 6.8 acres, it is the biggest and most important national park of Greece and it is held as the research area. It is situated at the mountain range of Pindos, around 25km north of Metsovo, at the borders of Ioannina and Grevena. Among the developing forestry plants and trees there can be found beech trees, black pine trees, white pine trees, fir trees, maple trees, elms etc. The existing fauna is equally rich and comprises of wild bores, deer, wolves, rabbits, squirrels and various kinds of eagles and hawks. The geology and the flora of the national park are remnants of the ice age, as are twin lakes Flega at the centre of the park (http://menoumeellada.ert.gr/en/tourdetails.asp?id=657).

The road network is old, but every year the office of forestry improves the network and works on opening up of the forest, in order to be easily visited. The roads that have been chosen are two of the main forest roads in the heart of the National Park of Southern Pindos. The first forest road is ahead from the village Perivoli to the Warerfalls (Photo1) and it is the central road of the National Park. The second forest road is a secondary road that connects the E6 path with the village Pades. Both of the roads used only for tourist reasons and only sometimes are used by cars or tracks of the office of forestry. So the intensity isn't really enormous.

Photo 1. First Forest road between the village Perivoli and the Waterfalls

Photo 2. Second Forest road between international pathway E6 and village Pades

METHODOLOGY

The methodology that was followed was practical, effective and easy to use before or after a road has been constructed (OECD, 1994). For this reason:

- Practical criteria have been held in order to evaluate the intensity of the impact and absorption (Trzesniowski, 1993). The grading of these criteria depends on the following principle: We accept a situation as ideal (=100%) for the forest protection from construction. This ideal situation will be described by criteria.
- The rating of these criteria came as a result from a survey of forest scientists by using questionnaires. The following parameters have been considered: a) the duration of the negative effect, b) the influenced area, c) the sensitivity of the general public to the effect as well as the social impact and political desire. (The evaluation of the later parameters will be difficult and therefore the description of an E.I.A. in a profile form will be a necessary addition) (Eskioglou, 1994, Koutsopoulos et al., 1984, Mousiopoulos, 1999).
- Analytical photogrammetric method and GIS will be used to evaluate the road location on the landscape level and with respect to the environment.
- E.I.A. of existing roads, in the research area will reveal different forms of absorption of negative impacts along the roads (Heinimann, 1992, Sedlak, 1993, Weiss, 1986). This information will be used to assess the impacts of the planned forest roads.

The equation that gives the compatibility with the natural environment is:

$C(\%) = MA(\%) \times ME(\%)$,

Where C (%): Compatibility, MA(%): Mean Absorption, ME(%): Mean Intensity.

The identification and the rating of criteria for assessing environmental impacts of road construction combined with revealing possible mitigating effects through impact absorption will allow for comprehensive evaluations of every forest road according standards set by new EU directions. The E.I.A. is of special interest when comparing different technically dual road alignments at the planning stage. Besides assessing them against the objectives of the access planning additional criteria will be available to include impacts on the forest ecosystems. The latter will affect the road alignment in horizontal and vertical perspective and result in a solution, which is technically and environmentally acceptable. The criteria of assessing environmental impacts of forest roads will be analysed by using methods of conditions and protection of forest ecosystems. Based on the framework of the E.I.A. we must find a compatible solution in order to improve the road on the level both on the serpentine and the road draining system.

RESULTS

Based on questionnaires which have been given to the office of forestry of National Park of Southern Pindos area we composed a table (table 1) where all the criteria of absorption and intensity with their weights and the evaluation of forest roads have been presented $F.R.C_1$ and $F.R.C_2$.

Table 1. Criteria of absorption and Intensity on forest roads at Southern Pindos

CRITERIA OF ABSORPTION					
1. Terrain conditions	Weights	$F.R.C_1$		$F.R.C_2$	
		Grade %	Sum	Grade %	Sum
1.1 Forest	3	100	300	70	210
1.2 Mixed forest	3	65	195	65	195
1.3 High forest	3	100	300	100	300
1.4 Selection forest	3	50	150	50	150
1.5 Mean height	3	75	225	75	225
1.6 Side quality	3	50	150	50	150
1.7 Productivity	3	-	-	-	-
1.8 Slope	2	25	50	25	50
1.9 Exposition	2	85	170	85	170
1.10 Relief	2	100	200	100	200
2. Distance from					
2.1 Tourist places	1	100	100	100	100
2.2 Highway	1	100	100	100	100
2.3 Railway	1	-	-	-	-
2.4 Archaeological Sites	1	-	-	-	-
2.5 Town	1	100	100	100	100
2.6 Village	1	90	90	90	90
2.7 Path way	1	100	100	100	100
SUM	29		2230		2140
Avarege clause			76,9%		73,8%

CRITERIA OF INTENSITY					
1. Terrain allocation	Weights	$F.R.C_1$		$F.R.C_2$	
		Grade %	Sum	Grade %	Sum
1.1 Curve radius	2,1	100	210	80	168
1.2 Gradient	2,01	80	161	70	141
1.3 Gross section	2,25	90	202	80	180
2. Road width	2,04	70	143	70	143
3. Road gradient	2,52	100	252	90	227
4. Serpentine	2,13	100	213	90	192
5. Position of road					
5.1 Distance of water flow	1,83	100	183	80	147
5.2 Distance of forest boundary	1,65	100	165	70	116
5.3 Area with construction problems	2,40	80	192	70	168
6. Picture of landscape					
6.1 From terrain	1,83	100	183	100	183
6.2 Vegetation	1,8	100	180	100	180
6.3 View effect	1,7	100	170	100	170
6.4 Compatible constructions	1,6	100	160	90	144
6.5 View of water flow	1,65	100	165	100	165
7.Visual absorption capability	1,77	90	160	100	177
8. Forest road construction (only for existing road)					

8.1 Earth works machinery	2,16		151	70	151
8.2 Material	2,08	70	208	100	208
8.3 Seeding and mulching of side slope	1,38	100	124	80	110
8.4 Road drainage system	2,31	90	162	50	116
SUM	37,21		3384		3086
Avarege clause			90,9%		82,9%

The equation that gives the compatibility with the natural environment is:

C(%) = MA(%) X ME (%),

Where C (%): Compatibility,
MA (%): Mean Absorption,
ME (%): Mean Intensity

a. First forest road C_1 Category (F.R.C_1) – (Perivoli– Warerfalls):
C(%) = MA(%) X ME (%) => C(%) = (76,9 X 90,9)% = 69,9%,
So the coefficient of compatibility C with the natural environment is almost 70%.

b. Second forest road C_2 Category (F.R.C_2) – (E6-Pades):
C(%) = MA(%) X ME (%) => C(%) = (73,8 X 82,9)% = 61,2%
So the coefficient of compatibility C with the natural environment is almost 61%.
It is obvious that both the forest road is compatible with the natural environment.

CONCLUSIONS

Based on the above results we came out with the following conclusions:

1. The first forest road shows compatibility almost 70%, so it is over than the 50% which is necessary in order to accept the existing road as a compatible road with the natural environment.
2. The second forest road shows compatibility nearly 61%, so it is also over than the 50% which is necessary in order to accept the existing road as a compatible road with the natural environment.

So both the forest roads are accepted and there are no suggestions for technical specifications of the staking grade line in order to be improved.

According to the research results it is suggested:

1. The proposed research is of practical interest for forest management.
2. A list of criteria (table 1) and their weights to evaluate the intensity of the impact from road construction and the absorption ability will be very useful and practical for the assessment by the Environmental Impact Assessment. Such a profile form based on European Union directions, will be useful to every office of forestry.
3. It could be very useful to have alternative road construction solutions for comparison based on the new planning technique according to the aims of opening up the forest, terrain conditions and the protection of forest ecosystem, before the forest road is constructed.
4. The staking grade line of one road in a Digital Terrain Model will be easiest to use for the comparison of more than one road alternative, in order that the best solution be taken.
5. Road segments exceeding this threshold will be identified for re-design purposes to minimize negative impacts on the environment.
6. It is of maximum importance in sensitive ecological systems such as Mediterranean forest areas, to have a realistic concept by designing the opening up of forests.

7. The uses of Environmental Impact Assessment as a decision tool it is of a major importance for having a Sustainable Development of a forest.
8. The existence of a profile form based on European Union directions for Environmental Impact Assessment can be used also as a tool, for re-design purposes of existing roads.

The existing legislation and the local environmental policy which held in Greece can give new directions to the offices of forestry in the section of construction works. The ministry of Environment, Physical Planning and Public Works is trying these days to reform a law that concerns for the Environment from the Public Works, using European Union directions. Last but not least is the usage of Environmental Impact Assessment as a powerful decision tool of a major importance; in order to maintain a Viable Development at mountainous areas.

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АНАЛИЗ НА ПРЕДВИДЕНОТО ПОЛЗВАНЕ ОТ ДЪРВЕСИНА

Даниела П. Георгиева, България

Резюме

В настоящата работа се изследват добивът и продажбата на дървесина, в т.ч. годишен добив, добита строителна дървесина и дърва за огрев по видове гори. Прави се анализ на предложеното, договорено и добито количество дървесина, на очакваните и получени приходи от проведените продажби на дървесина в страната за периода 2000-2005 г. Въз основа на изследването се правят изводи и краткосрочна прогноза за екологосъобразно ползване от горите.

ANALYSIS OF THE PROVIDED USAGE OF TIMBER

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Abstract

In the present paper, the harvest of wood, sale of timber, including the annual wood harvest, wood harvested for construction and fuel wood, according to types of forests, are researched. An analysis of the offered, contacted and harvested amount of wood is made, as well as the anticipated and realized incomes from the timber sales in the country in the period 2000-2005. Based on this research, conclusions are made, and a short term forecast for the environmentally friendly utilization of forests is driven.

Under the conditions of a market economy, limited resources and growing needs of the people, each economic organization aims to satisfy the needs of the individuals, transforming the limited resources into the respective goods. The producers and consumers, on their part, interact through the market. The market is the interesting point of supply and demand. The market is the mechanism which unites the consumers and producers in one organism with definite proportions. In the sphere of exchange, the demand is the market expression of consumption and the supply – the market expression of production. In the timber market the supply is expressed through the planned volume of the forest management projects and the timber offered from the State Forestry Fund, and the demand – through the volume of harvested timber.

In order to be competitive on the market, each economic organization should know and follow the changes in supply and demand. It is not by chance that it is stated that the laws of marketing are as strong as the natural ones. That is why in the branch of forestry it is necessary to carry out a permanent analysis of the offered and actually harvested timber, both on a national and regional level. On its part, in the estimation of the effectiveness of the provided usage of timber, natural and value points could be used, including the offered contracted and harvested amount of wood, as well as the expected and realized incomes from the timber sales made in the State Forestry Fund. On the other hand, through the analysis valuable information could be received as to the future development of the timber market and hence to build the right strategy and tactics connected with the provided usage of timber.

The aim of the present paper is to analyze the supply and demand of timber for the period 2000-2005 and on this basis to make a short term forecast for the harvest and usage of timber till 2007.

The object of research is the planned and harvested from main and selective cuttings timber in the country, and the provided usage of timber from the State Forestry Fund in the period 2000-2005.

The research is made according to data, provided by the National Forestry Board. In order to define the tendencies for change in the 6^{-th} year period of research, the methods of the comparative regressive and correlative analysis are used. Through the comparative analysis, the tendencies are delineated, and in consequence on the defined experimental models through the regressive and correlative analysis the theoretical models and the forecast for development of the object of research are defined.

In the definition of the theoretical models, different types of functions for delineation of the tendencies for change are used. The criterion for choice of a trend function is the coefficient of correlation to have the value close to 1 and the forecasted volume of timber to be realistic.

On the basis of the so delineated tendencies, an attempt has been made to forecast the possible supply and demand of timber in a short-term horizon till 2007.

In the form of questions and figures the results from the harvest and the timber usage provided for the period 2000-2005 are shown.

What is the volume of the planned according to the forest management projects and actually harvested timber in the state and non-state forests?

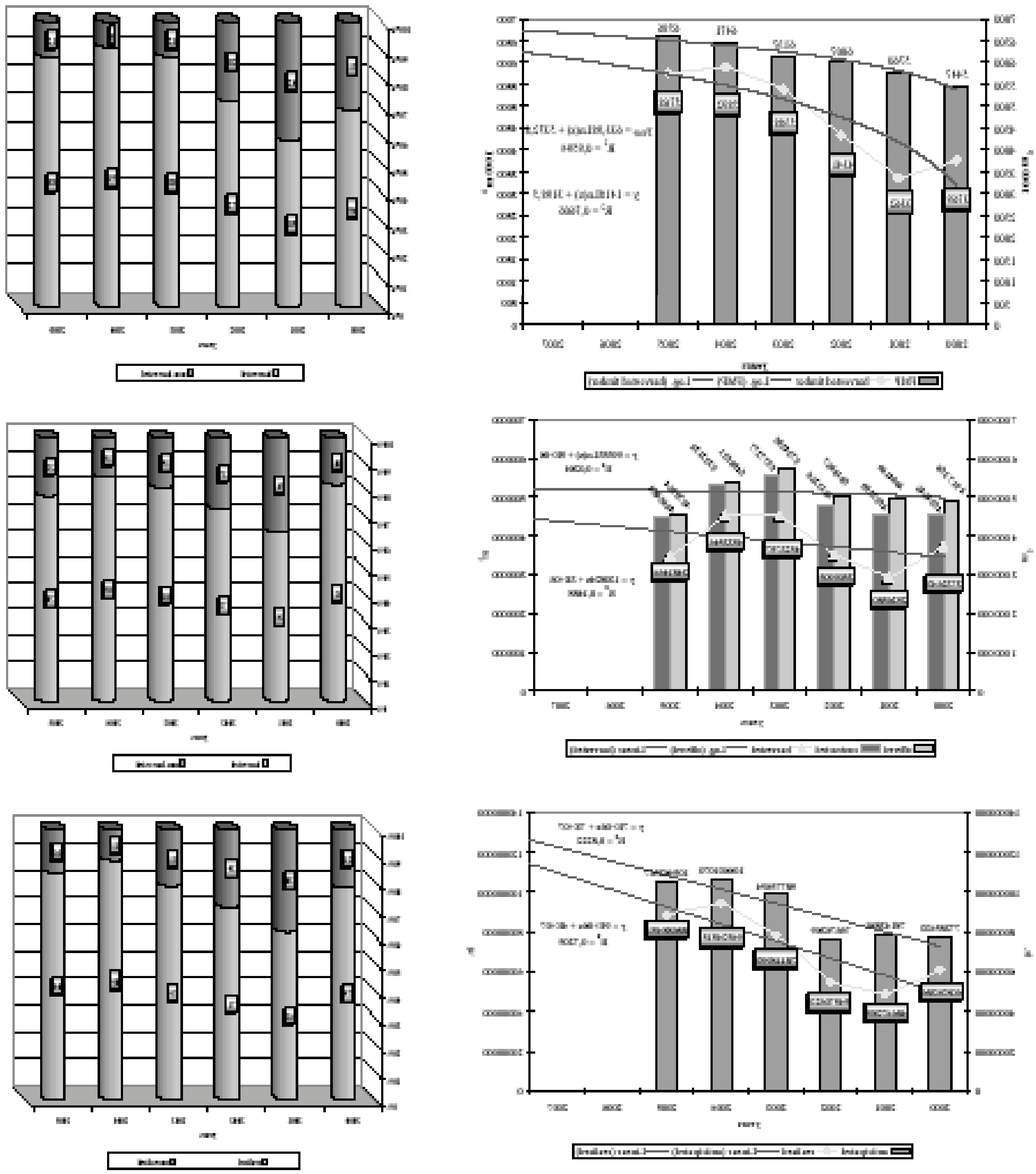

Fig. 1. Dynamics and forecast for the provided and harvested timber in the period 2000-2007.

a) - the planned according to the forestry management plans and the actually harvested timber in the state and non-state forests;

b) - the index of the harvested and non- harvested timber in the state and non-state forests;

c) - the offered, contracted and harvested timber in the State Forestry Fund;

d) - the index of the harvested and non-harvested timber in the State Forestry Fund;

e) - the anticipated and realized incomes from the provided usage in the State Forestry Fund;

f) - the index of the realized and unrealized incomes from the provided usage in the State Forestry Fund.

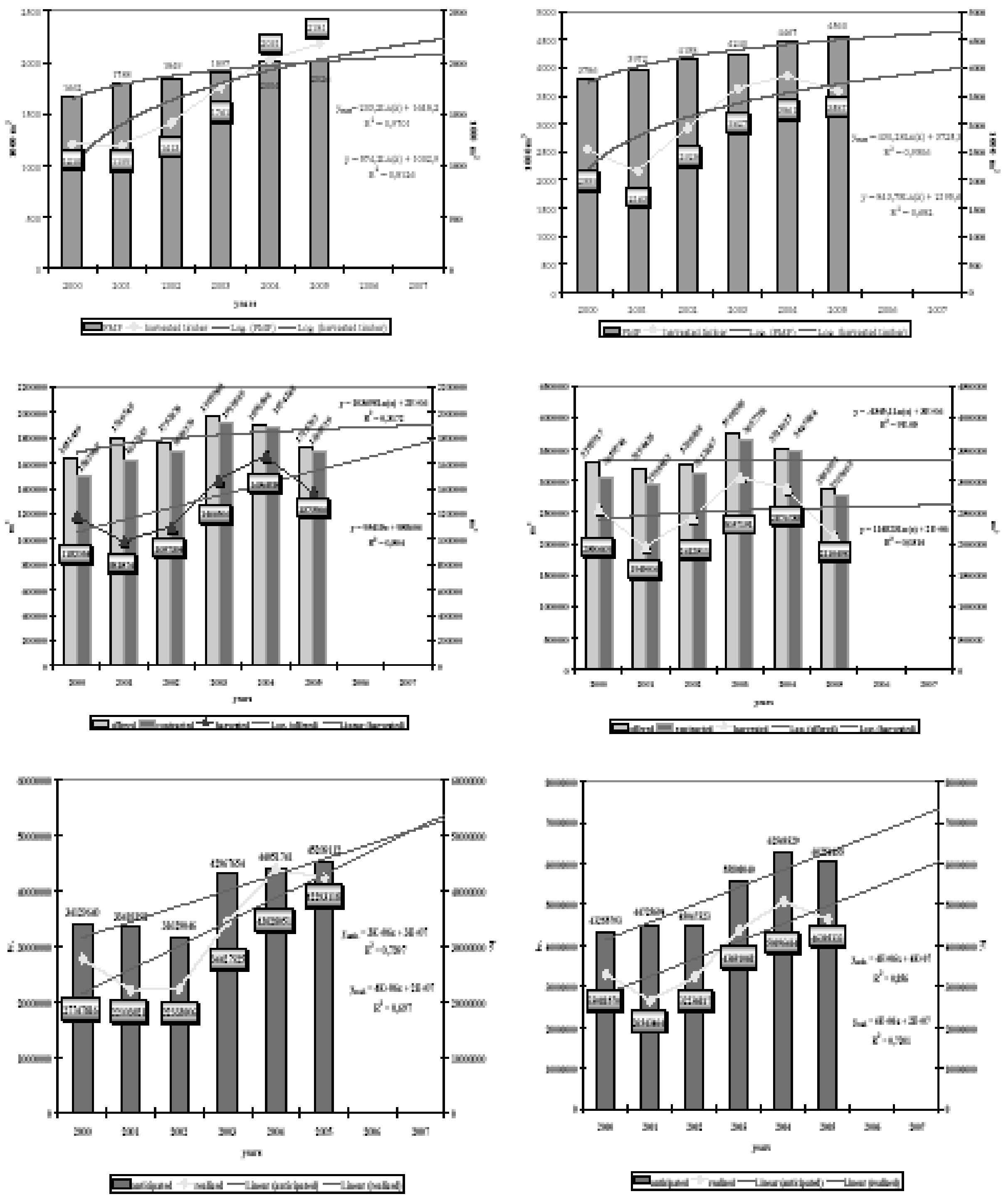

Fig. 2. Dynamics and forecast for the conifer and broadleaved timber in the period 2000-2007.
a) - the planned according to the forest management plans and the actually harvested timber in the state and non-state forests;
b) - the offered, contracted and harvested timber in the State Forestry Fund;
c) - the anticipated and realized incomes from the provided usage in the State Forestry Fund.

For the period 2000-2005 the planned according to the forest management projects timber is average in the volume of 6 068 000 m^3 (Fig.1a) from which 1 870 768 m^3 conifer and 4 196 920 m^3 - broadleaved (Fig.2a). For the whole period of research the provided for usage conifer woods are 31 % and broadleaved – 69% from the total amounts of woods.

From the planned woods for the period the average harvested is 4 881 880 m^3 (Fig.1a) from which 1 632 614 m^3 – conifer and 3 120 763 m^3 - broadleaved (Fig.2a).

The efficacy of execution according to natural points – harvested/non-harvested timber as a whole for the country is 78%:22% (Fig.1b), conifer – 87%:13%; broadleaved – 74%:26%. The weakest year is 2001 in the execution of natural points in the amount of 58%:42%, whereas the most successful is 2004 in the ratio 91%:9%.

The first half of the researched period 2000-2002 is delineated with a bigger difference between the forecasted for usage timber according to the forestry management plants and the actually harvested timber – on the average 33% non-harvested, 27% - conifer and 36% - broadleaved.

In the second half of the period 2003-2005, the efficacy of execution according to natural points is higher – on the average 11% non-harvested timber for the country, out of which 16% for the broadleaved.

In the conifer woods for the period 2003-2005 an overexecution of the plan in comparison with the volume according to the forestry management plan with the average of 1% is registered, in which – 1% for 2004 and 8 % for 2005. This points out that there is over demand of conifer and at the same time sources for the bigger demand of such timber should be found.

What is the amount of the offered, contacted and harvested timber from the State Forestry Fund?

For the period 2000-2005 the average offered timber is in the volume of 5 102 697 m^3 (Fig.1c), from which 1 791 858 m^3 - conifer and 3 310 840 m^3 - broadleaved (Fig.2b).

The total volume of the offered timber from the State Forestry Fund represents 84% of the production capacities of the branch or of the planned quantity according to the forest management plans – 96% for the conifers and 79% for the broadleaved.

For the period 2000-2002, the average contracted timber is 93% which is on offer, whereas for the period 2003-2005 this amounts to 98%.

From the contracted timber for the period the average harvest is 3 784 649 m^3 (Fig.1c), from which 1 292 557 m^3 - conifer and 2 492 092 m^3 - broadleaved (Fig.2b). The total amount of the harvested timber represents 75% of the total harvest of timber in the branch.

The efficacy of the provided usage of timber expressed by the correlation harvested/non-harvested timber on the average for the period amounts to 77%:23% (Fig.1d). In the conifers this correlation is 75%:25%, whereas in the broadleaved it is 78%:22%.

The provided usage of timber in 2004 is the best. The total non-harvesting timber for the country is 15% from the contracted, the conifer is 12% and the broadleaved - 17%.

From the calculated natural points and the figures shown, the positive effect of the changes made in the legislation is registered in connection with the provided usage of timber, and more concrete the introduced mechanisms for the delegation of timber harvest and later the organization of procedures for the sale of stored timber, both in the absolute and the relative rise in the wood harvest.

What is the size of the anticipated and actually realized incomes from the provided usage of timber in the State Forestry Fund?

For the period 2000-2005 the incomes from the contacted timber or the so called incomes which are anticipated (planned) to be received from the provided usage of timber are in the amount of 90 507 670 BGN on the average (Fig.1e) from which 38 567 564 BGN from the conifer and 51 940 106 BGN from the broadleaved (Fig.2c).

From the expected incomes for the period on the average 70 897 709 BGN are received (Fig.1e) out of which 32 122 423 BGN from the conifers and 38 775 286 BGN from the broadleaved (Fig.2c).

The effectiveness of the provided usage of timber according to value points, expressed by the ratio realized/unrealized incomes for the period amounts on the average to 77%:23% (Fig.1f) in 77%:23% - harvested/non-harvested timber (Fig.1d). All this points out that the factor which influences the amount of incomes is the volume of harvested timber and not the prices which determine the timber usage.

Both in natural and value aspect the year 2001 is unsatisfactory. The non-realized incomes are 38% of the anticipated, from which 34 % in the conifers and 41% in the broadleaved.

The realized incomes from the usage of timber in 2004 are the biggest for the researched period and amount to 89% of the anticipated. In the conifers 99% execution is registered as concerning the anticipated incomes, whereas in the broadleaved - the difference between the anticipated and realized incomes is 19%. All this points out to the fact that there is full demand of conifer and fall in the demand of broadleaved. In other words – in order to improve the effectiveness of timber usage, measures should be taken to encourage the consumption of broadleaved and the utilization of enclosed basins.

On the basis of the delineated tendencies in naturals and values an attempt has been made to forecast the possible timber harvest in the short-term horizon up to 2007.

What is the forecast for timber harvesting?

From the delineated theoretical models, it is found that the offered amount of timber from the state and non-state forests according to the forest management plans in 2007, will reach 6 750 000 m^3 (Fig.1a), from which 2 100 000 m^3 for the conifers and 4 650 000 m^3 for the broadleaved (Fig.2a).

As concerning the total harvest in the country, 6 250 000 m^3 are forecasted (Fig.1a), out of which 2 250 000 m^3 for the conifers and 4 000 000 m^3 for the broadleaved (Fig.2a).

In a short-term plan up to 2007, it is forecasted that the timber which is offered by the State Forest Fund will amount to 5 200 000 m^3 are forecasted (Fig.1c), from which 1 900 000 m^3 for conifer and 3 300 000 m^3 for the broadleaved (Fig.2b).

It is forecasted that the harvest from the state forests will rise up to 4 400 000 m^3 (Fig.1c), from which 1 750 000 m^3 for conifer and 2 550 000 m^3 for broadleaved (Fig.2b).

What is the forecast for the incomes from the utilization of timber in the state forests?

In a short term up to 2007, it is forecasted that the contracted incomes from the utilized timber from the State Forest Fund will amount to 126 million leva (Fig.1e), from which 53 million BGN from the conifer and 73 million BGN from the broadleaved (Fig.2c).

It is forecasted that the incomes from the harvested timber will be around 113 million BGN (Fig.1e), from which 53 million BGN from the conifer and 60 million BGN from the broadleaved (Fig.2c).

It should be stated here that the pointed quantities are just navigators, concerning the supply and demand of timber because they are received solely on the basis of the delineated tendencies from the harvest of timber.

By taking into consideration the definite resource potential, measures should be taken in the time for the recovery of the deficit of conifer, as well as the creating of a market of the average, small and technological timber and fuel wood.

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ЕКОЛОГИЧНА ОЦЕНКА НА ФОРВАРДЕРИТЕ ЧРЕЗ ВЪЗВРАЩАТЕЛНО ДВИЖЕНИЕ

Мариян Шушняр, Томислав Поршински, Дубравко Хорват, Тибор Пентек, Желко Томашич, Хърватия

Настоящата работа представя изследване на възможностите за използване на възвращателно движение като задоволителен параметър, който дава екологична оценка на взаимодействието между колелата на транспортното средство и почвата при извоз на дървесина.

Възвращателното движение е безразмерна величина, която характеризира взаимодействието между натовареното колело и почвата. Този параметър лесно може да се определи или пресметне, като се измери на място индексът на почвения конус и се приложат полуемпиричните формули за определяне на контактното налягане.

Анализът на частното между възвращателното движение и дълбочината на следите от гумите, която лесно се мери и е най-очевидната проява на вредното въздействие върху почвата, показа, то е добра характеристика на това въздействие и оттук достатъчен критерий за екологическа оценка.

За по-добро разбиране на проблема основните компоненти на възвращателното движение и начините му на пресмятане според различни автори са показани за 17-тонен форвардер Timberjack 1710B.

Недостатъците на полуемпиричните изрази като средство за пресмятане на контактното налягане между колелата и почвата, както и недостатъчното разбиране на динамичното разпределение на вертикалния товар на горските транспортни средства при различни теренни условия, в това число при извоза на дървесина, изискват допълнителни изследвания на третирания въпрос.

ASSESSMENT OF ENVIRONMENTAL ACCEPTABILITY OF FORWARDER BY WHEEL NUMERIC

Marijan Šušnjar, Tomislav Poršinsky, Dubravko Horvat, Tibor Pentek, Željko Tomašić, Croatia

Abstract

This paper presents the research of possibilities of use of wheel numeric, as a satisfying parameter that describes the environmental acceptability of interaction between vehicle wheels and soil in timber extraction.

The wheel numeric is a non-dimensional parameter, which describes the interaction between the loaded wheel and soil. This parameter can be easily measured/calculated by simple on-site measurement of soil cone index and by use of semi-empiric expressions for contact pressure.

The analysis of the ratio between wheel numeric and rut depth, which can be easily measured and represents the most conspicuous consequence of the vehicle's adverse effects on soil, showed that the wheel numeric is a sufficiently good parameter for its assessment and therefore also for the assessment of the environmental acceptability.

In order to get a better understanding of this problem, the basic components of the wheel numeric as well as models of different authors for their calculation are exemplified by a 17-ton forwarder Timberjack 1710B.

The deficiency of the use of semi-empiric expressions for the calculation of wheel/soil contact pressure, as well as insufficient level of understanding of the dynamic distribution of vertical loads of a forest vehicle in different terrain conditions, especially in timber skidding, require further research in this direction.

Introduction and scope of research

Forest soil compaction is one of the criteria in assessing environmental acceptability of forest vehicles. Wästerlund (1994) defines the term soil trafficability as "soil capability of bearing the passage of vehicles". Bekker (1960) considers that soil trafficability cannot only be determined by bearing capacity and traction capacity without taking into account physical and geometric features of the vehicle. He also states that soil trafficability has no general physical meaning unless it contains the indicators of both soil and vehicle. Such approach to the research of the vehicle-soil system corresponds fully to the meaning of vehicle mobility as defined by Horvat (1993) in searching for the term that would describe the impact of vehicle on soil.

With the development of the empiric method of research of the complex wheel-soil or vehicle-soil system, known in the reference literature as WES method (Waterways Experimentation Station, US Army Corps of Engineering Research), wheel numeric came into use so as to connect the vehicle's traction capacity and soil bearing capacity.

The wheel numeric is a non-dimensional parameter (factor), which describes the interaction between the loaded wheel and soil. This parameter is defined by the ratio between the contact pressure at the wheel-soil contact point and the soil bearing capacity measured by penetrometre. Generally the wheel index shows the level of soil capability of bearing the wheel load.

The resistance of cone penetration into soil, determined as the ratio between force required for inserting the cone into soil and the cone basis is often used as the quantitative indicator of soil strength (bearing capacity). The measuring devices used for the determination of soil penetration characteristics are called penetrometres, and the measurement result is expressed in SI units of pressure (kPa or MPa). Cone penetration resistance changes with the depth of soil penetration. Penetration curve of soil characteristics contains detailed data on the assessment of soil strength depending on the depth of cone penetration, caused by soil layers – (sub) horizon layers of certain types of soil. The impact of granulometric content and momentary moisture content of soil on soil penetration characteristics is shown in Fig. 1.

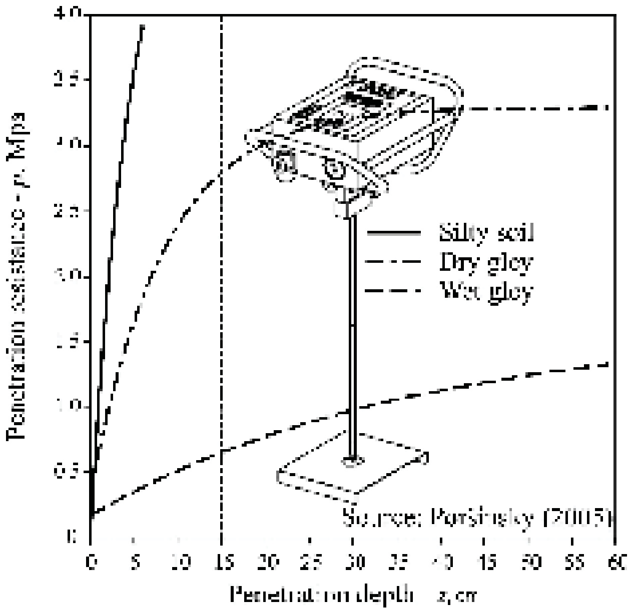

Fig. 1. Penetration curves

Many authors express the wheel numeric as the function of soil cone index, wheel load and dimensions of wheel tyres (diameter, width, profile height and deflection). The review of wheel numeric developed by different authors clearly shows differences among them with respect to the impact of deflection and width of a loaded wheel tyre on the soil-tyre contact area (Table 1). Most formulas for the calculation of wheel numeric are intended for use in gley soils, because the problem of vehicle mobility is connected with wet coherent soil.

Fig. 2 shows that the increase of wheel numeric or soil cone index, in case of a wheel under specific vertical load, also means more favourable tractive characteristics (higher factors of gross and net traction and lower rolling factor) and lower rut depth. Due to wheel numeric contents tractive and environmental characteristics, it seems to be a suitable parameter for the assessment of the suitability of forest vehicles.

In practice, standardised measurement of cone penetration resistance is used at soil depth of 15 cm (ASAE EP542 1999), called cone index (CI). The same standard recommends the use of cone index in estimating the soil trafficability and vehicle mobility, as well as the parameter that can be used in WES models for tractive characteristics of vehicles.

General form $N_w = \frac{CI}{p} = \frac{CI}{\frac{G_w}{A}} = \frac{CI \cdot A}{G_w}$		
Freitag (1965) $N_w = \frac{CI \cdot b \cdot d}{G_w} \cdot \sqrt{\frac{\delta}{h}}$	Wismer i Luth (1973) $N_w = \frac{CI \cdot b \cdot d}{G_w}$	Symbols: N_w – wheel numeric; CI – cone index, kPa; p – contact pressure, kPa; G_w – wheel load, kN; A – contact area, m^2; b – tyre width, m; d – tyre diameter, m; h – section height, m; δ – tyre deflection, m
Turnage (1972) $N_w = \frac{CI \cdot b \cdot d}{G_w} \cdot \sqrt{\frac{\delta}{h}} \cdot \frac{1}{1 + \frac{b}{2 \cdot d}}$	Brixius (1987) $N_w = \frac{CI \cdot b \cdot d}{G_w} \cdot \left(\frac{1 + 5 \cdot \frac{\delta}{h}}{1 + 3 \cdot \frac{b}{d}} \right)$	
Rowland (1972) $N_w = \frac{CI \cdot b^{0.85} \cdot d^{1.15}}{G_w} \cdot \left(\frac{\delta}{h} \right)^{0.5}$	Maclaurin (1997) $N_w = \frac{CI \cdot b^{0.8} \cdot d^{0.8} \cdot \delta^{0.4}}{G_w}$	Source: Saarilahti (2002c)

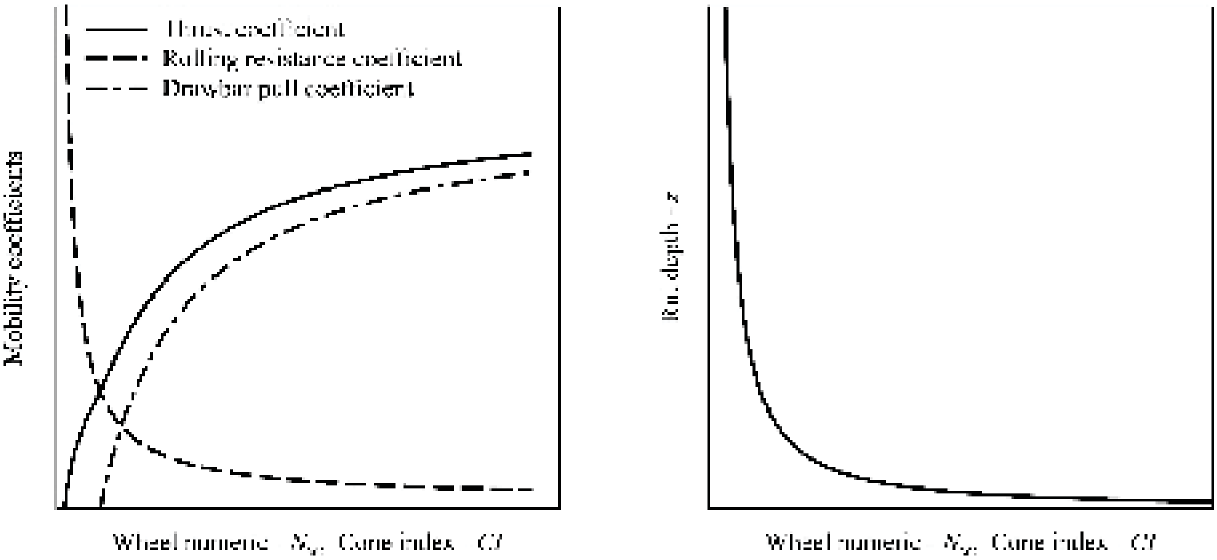

Fig. 2. Dependence of mobility coefficients and rut depth on wheel numeric and cone index

While it is simple to measure the soil cone index, which makes it suitable for the determination of very complex wheel numeric, the measurement of wheel-soil contact pressure is a complex and difficult procedure under field conditions.

The contact pressure between the vehicle and soil is the ratio between the weight and vehicle-soil contact area. It is very difficult to determine the wheel-soil contact area because it depends on the characteristics of the soil and tyre. Tyre-soil contact area differs in its size and form depending on tyre dimensions, tyre pressure, wheel load, tyre deflection as well as deformability of soil. The tyre deflection depends on the tyre pressure, ply rating and structure. At low tyre air pressure, the deflection causes the increase of the contact area.

There are different methods for measuring the contact area, based on inserting the wheel into soil of known characteristics under different loads. In doing so, after lifting the wheels, the contact edges are marked by colour signs, and the contact area is usually determined by planimetering method.

Theoretical wheel-soil contact area as the product of multiplication of wheel radius (r) and tyre width (b) is used by Mellgren (1980). This approach identifies the length of the contact between the wheel and plastic basis (l_C) with the wheel radius (r) at wheel sinking of 30 cm or 15 % of the wheel diameter (Mellgren, 1980). The length of wheel-soil contact, under the said wheel sinking, is equal to the wheel radius only in case when the angle between the beginning and the end of the wheel-basis contact is 1 Rad (≈ 57.3°), which means that this approach is only restricted to the case when the wheel radius is 0.653 m (Poršinsky, 2005) and hence it cannot be widely applied in practice.

Abbels (1994) considers that the actual form of the contact area differs from the theoretical one on soft soils. When moving on hard soils, the contact between the tyre and the ground is only made on ribs, which highly increases the contact pressure (Fig. 3).

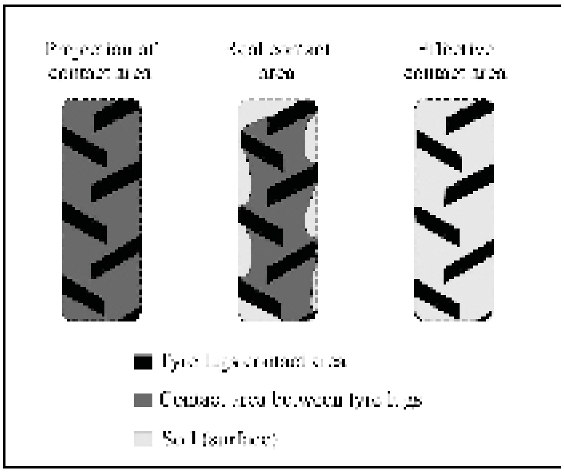

Fig. 3. Tyre contact area on soft soils (Abels 1994)

Another problem is the determination of the wheel-soil contact area under dynamic loads. Sharma and Pandey (1996) introduce the idea of dynamic contact area and conclude that the most commonly determined static contact area under loaded wheels differs significantly from the dynamic contact area on both hard and deformable grounds.

In order to improve forwarder's mobility in crossing terrain surface obstacles and due to unfavourable distribution of axle loads of loaded vehicles, forwarder manufacturers have been designing for some time now vehicles with bogie axle set up, instead of traditional axle. Such vehicles have two wheels put together in the so-called tandem distribution. Six-wheel forwarders are manufactured with the rear bogie axle, while the eight-wheel forwarders are equipped with both front and rear axles in bogie style. In case of limited bearing capacity of forest ground, the bogie axle wheels are equipped with semi-tracks in order to improve forwarder's mobility and so as to decrease contact pressure on forest soil for environmental reasons.

In establishing the model for the determination of wheel-soil contact area, many researchers make correlation between the size of the contact area and tyres dimensions, deflection, tyre pressure and wheel load (Dwyer, 1984, Silversides, Sundberg, 1989, Maclaurin, 1997, Larminie, 1988). Based on formulas for calculating contact areas along with the information on wheel load, the said authors develop formulas for determining the wheel's contact pressure on soil (Table 2).

Nominal Ground Pressure - NGP was used for a long time for determining soil features with respect to its compaction (Mellgren, 1980). Actually, NGP represents the limit wheel's contact pressure on soil that can be developed by the wheel under conditions of lower soil bearing strength, and hence it cannot be used for comparing the suitability of two different wheels in different soil conditions. The advantage of this parameter is its simplicity, and the disadvantage is that the following elements are not taken into account: effects of tyre deflection of loaded wheel, tyre pressure, independence on soil features and estimate of the impact of use of wider tyres (Saarilahti,2002d).

Due to the significance of the effects of tyre deflection on the size of wheel-soil contact area, when calculating forest vehicles contact pressure on soil Saarilahti (2002d) recommends the use of the formula containing tyre deflection.

Table 2 . Review of formula commonly used for calculating vehicle's contact pressure on soil

<table>
<tr><td>Mellgren (1980) - Nominal ground pressure
Wheel nominal ground pressure
$NGP = \frac{G_W}{r \cdot b} \Rightarrow A = r \cdot b$
Semitrac nominal ground pressure
$NGP = \frac{G_B}{b \cdot (1.25 \cdot r + l)} \Rightarrow A = b \cdot (1.25 \cdot r + l)$</td><td rowspan="5">NGP - nominal ground pressure, Pa
MMP - mean maximum pressure, Pa
G_B - wheel load, kN
G_B - bogie axle load, kN
G_V - vehicle weight, kN
r - wheel radius, m
l - bogie wheel base distance, m
p_i - tyre inflation presszre
m - number of vehicle axles
b_p - semitrack plate width, m
c - semitrack link profile factor
K - factor of axles driven proportion

All other symbols correspond to symbols in the table 1.</td></tr>
<tr><td>Dwyer (1984) -Wheel contact pressure
$p = \frac{G_W}{b \cdot d} \cdot \sqrt{\frac{h}{\delta}} \cdot \left(1 + \frac{b}{2 \cdot d}\right) \Rightarrow A = \frac{b \cdot d}{\sqrt{\frac{h}{\delta}} \cdot \left(1 + \frac{b}{2 \cdot d}\right)}$</td></tr>
<tr><td>Larminie (1988) - Mean maximum pressure
Wheeled vehicle on fine-grained cohesive soil
$MMP = \frac{K \cdot G_V}{2 \cdot m \cdot b^{0.85} \cdot d^{1.15} \cdot \sqrt{\frac{\delta}{h}}} \Rightarrow A = b^{0.85} \cdot d^{1.15} \cdot \sqrt{\frac{\delta}{h}}$
Tracked vehicle on fine-grained cohesive soil
$MMP = \frac{1.26 \cdot G_V}{2 \cdot m \cdot c \cdot b \cdot \sqrt{d \cdot b_P}} \Rightarrow A = b \cdot \sqrt{d \cdot b_P}$</td></tr>
<tr><td>Silversides i Sundberg (1989) - Wheel contact pressure
$p = 1.111 \cdot p_i \Rightarrow A = \frac{0.9 \cdot G_W}{p_i}$</td></tr>
<tr><td>Maclaurin (1997) - Limited cone indeks for wheeled vehicle
$p = \frac{1.85 \cdot G_V}{2 \cdot m \cdot b^{0.8} \cdot d^{0.8} \cdot \delta^{0.4}} \Rightarrow A = b^{0.8} \cdot d^{0.8} \cdot \delta^{0.4}$</td></tr>
</table>

Contact pressure on soil surface can be directly measured by pressure measuring devices attached to the tyre (Horvat, 1993). It is also possible to measure directly the depth of pressure effects on the soil by use of load cells, which are inserted into soil at different depths (Sever, Horvat, 1990).

Mean Maximum Pressure - MMP is determined by measuring the actual pressures in the central zone of the loaded wheel tyre or semi-track of the vehicle. (Larminie, 1988). Models designed based on MMP are better adapted for estimating soil damage and for decision making on the choice of the means of work, because the peak values of maximum pressures under wheel can be determined for each wheel of a differently loaded vehicle.

AIM OF RESEARCH

Data on load distribution between axles and wheels of vehicles used for timber extraction cannot usually be directly found in manufacturers' brochures. The research of vehicle-soil interaction imposes the need for their measurement and calculation.

It should be emphasised that the dynamic load distribution of axels is quite different for the vehicles extracting timber with one end on the ground (skidders, adapted farm tractors with winch) and for the vehicles carrying timber off the ground (forwarders, tractor assemblies). Due to higher load complexity of skidder's driving axels caused by the manner of tying the load and higher terrain diversity caused by different ways of construction of strip roads, uneven areas and slopes, in this case (Šušnjar, 2005) we can justly talk about the vehicle-load-terrain system. For these reasons, forwarder has been chosen for this analysis, as its dynamic distribution of vertical loads is somewhat simpler – it mostly travels on level ground and its load distribution only depends on timber load size, and just partly on the manner of load piling into forwarder loading space.

The aim of this paper is a critical review of wheel numeric and of the problem of measurement of its basic components. The basic components of wheel numeric and models for their calculation developed by foreign authors will be shown on the example of a 17-ton Timberjack 1710B forwarder.

Research results

Using KWF methodological approach (Weise, 2002, Weise, Nick 2003), based on measurement data of axle loads of unloaded Timberjack 1710B forwarder (Horvat et al. 1999) and measurement of the basic vehicle dimension, Poršinsky (2005) calculates the distance of the centre of gravity from the front and rear axle of unloaded forwarder, i.e. the distribution of axle loads depending on weight and dimensions of roundwood loaded in forwarder's loading space (Fig. 4) while the vehicle is resting on level ground.

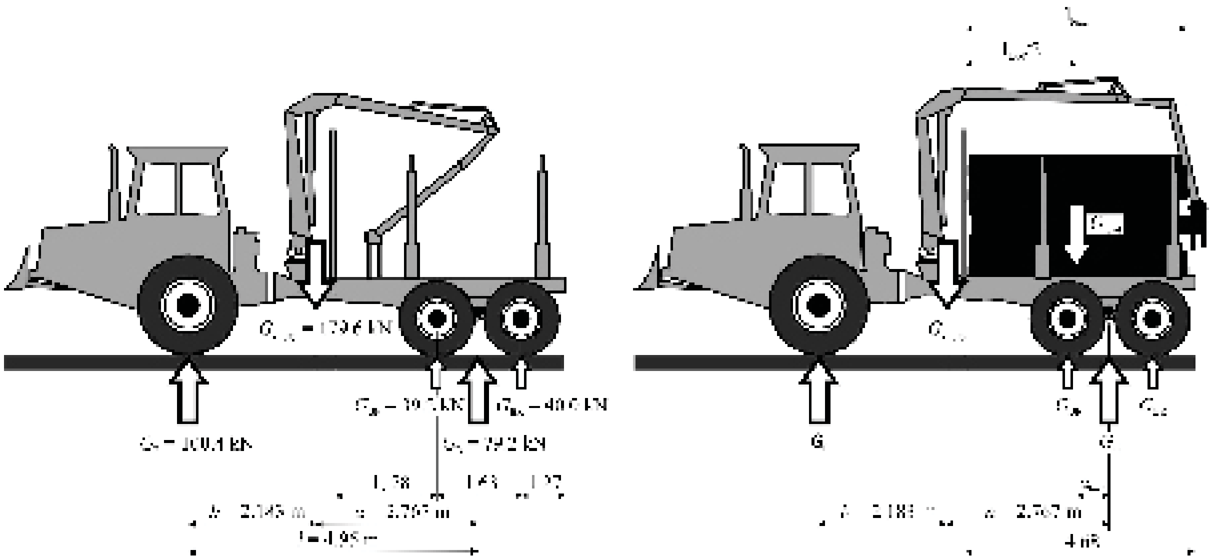

Fig. 4. Axle load calculation of loaded forwarder

When determining axle loads of a loaded forwarder, the following restrictions were set: the load weight G_{load} must not exceed 17 000 kg, which is the approximate carrying capacity of Timberjack 1710B forwarder, and maximum length of the load must not exceed 6 m, which is the length of the forwarder's loading space. Under assumption that the forwarder's load (roundwood) is a regular prism of weight (G_{load}) and length (l_{load}), the distance between the load centre of gravity and the rear axle is as follows:

$|a_{load}| = [4.68 - (1.63/2) – 1.27] - l_{load}/2$

As total wheel load corresponds to the sum of an empty forwarder and load weight ($G_F + G_B = G_{empty} + G_{load}$) under equal load of the front and rear wheels of rear bogie axle, momentum equations were set around the rear axle $\Sigma M_B = 0$.

$G_{empty} \cdot a \pm G_{load} \cdot a_{load} - G_F \cdot l = 0$

$G_{empty} \cdot a \pm G_{load} \cdot a_{load} = G_F \cdot l$

Load momentum around the rear axle acquires the following direction:

$+ G_{load} \cdot a_{load}$ in case $l_{load} < 5.2$ m or

$- G_{load} \cdot a_{load}$ in case $5.2 \text{ m} < l_{load} < 6$ m

Based on momentum equations, the axle loads of a loaded forwarder are as follows:

Front axle load $\quad G_F = (G_{empty} \cdot a \pm G_{load} \cdot a_{load}) / l$

Rear axle load $\quad G_B = G_{empty} + G_{load} - G_F$

By the application of equations, axle loads and wheel loads of Timberjack 1710B forwarder were estimated depending on the mass of the loaded timber of 5 m in length (Fig. 5).

Total mass of the vehicle increases depending on the weight and length of roundwood loaded in the forwarder's loading space. The load increase on the rear axle is significant and the increase on the front axle is negligible, which leads to the transfer of the centre of gravity from the front to the rear axle. The comparison between the distribution curve of axle loads and wheel loads show the same pattern.

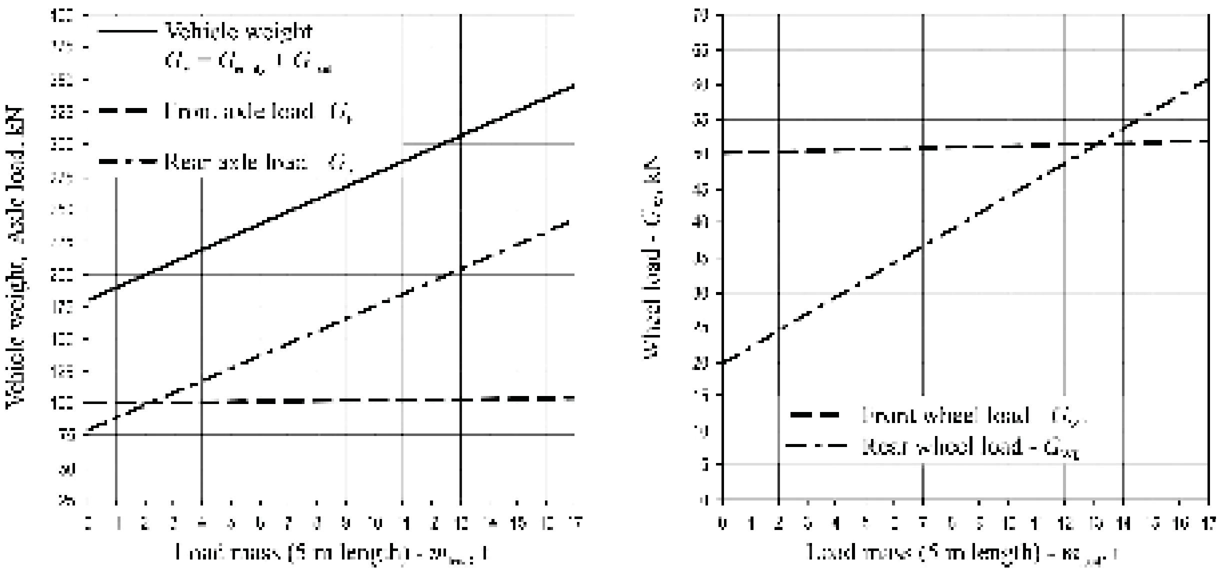

Fig. 5. Dependence of axle and wheel load on loaded mass – Timberjack 1710B Forwarder

When the morphological features of Timberjack 1710B forwarder are known as well as the characteristics of front and rear tyres (dimensions, air inflation pressure), dimensions of used semi-tracks, and data on the assessment of load distribution between forwarder's axles and wheels and tyre deflection, depending on the change of loaded roundwood, it becomes possible to calculate the contact area and contact pressure between this forwarder and soil. For this purpose stochastic formulas developed by the said authors (Table 2) were used for the assessment of suitability of application of individual formulas during forwarding operations. The knowledge of contact pressure against mass of roundwood loaded in the forwarder provides the possibility of selecting the vehicle for timber extraction and planning the load, which should finally eliminate the reasons of excessive soil compaction (Sever, Horvat 1990).

The analysis of the influence of roundwood mass loaded into the forwarder's loading space on the values of the contact area and contact pressure under the front and rear wheels of the vehicle, i.e. under semi-track of tandem wheels of the rear bogie axle are shown in Fig. 6. It can be seen that the values of the contact area and contact pressure under the front forwarder's wheel are independent on the increase of loaded roundwood mass, which is the effect of distribution of axle loads of Timberjack 1710B forwarder. Unlike front axle wheels, contact area under forwarder's rear wheels, calculated by formulas containing tyre deflection, increases with the increase of loaded roundwood mass, while the values of semi-track contact area are constant. The increase of contact pressure under rear wheels and semi-tracks, respectively, is the effect of complete redistribution of roundwood loads on the forwarder's rear axle.

By comparative survey of formulas for contact pressure developed by the said authors, the changes have been calculated of contact area and contact pressure depending on the loaded roundwood mass on the example of a Timberjack 1710B forwarder. They show as follows:

L The impact of tyre air pressure in the model Silversides, Sundberg (1989) results in underestimating contact area under the wheel or overestimating the values of contact pressure,

L Nominal pressure model (Mellgren, 1980) overestimates the wheel-soil contact area and consequently it underestimates the values of contact pressure,

L The values of contact area and contact pressure according to Dwayer (1984) and Maclaurin's (1997) models are more or less equal and close to mean values of maximum vehicle pressure calculated by use of Larminie's (1988) model,

L With semi-tracks, the contact area is overestimated by nominal pressure model (Mellgren 1980) due to the use of semi-track surface projection on soil, by which the model of mean maximum pressure of semi-track vehicles (Larminie, 1988) becomes more suitable for use, because the contact area is calculated based on the width of individual semi-track plate and track link pitch, respectively.

WES method of vehicle mobility assessment is based on wheel index, i.e. interaction between one wheel of the vehicle and soil, by which the WES method is only restricted to the case of equal tyre dimen-

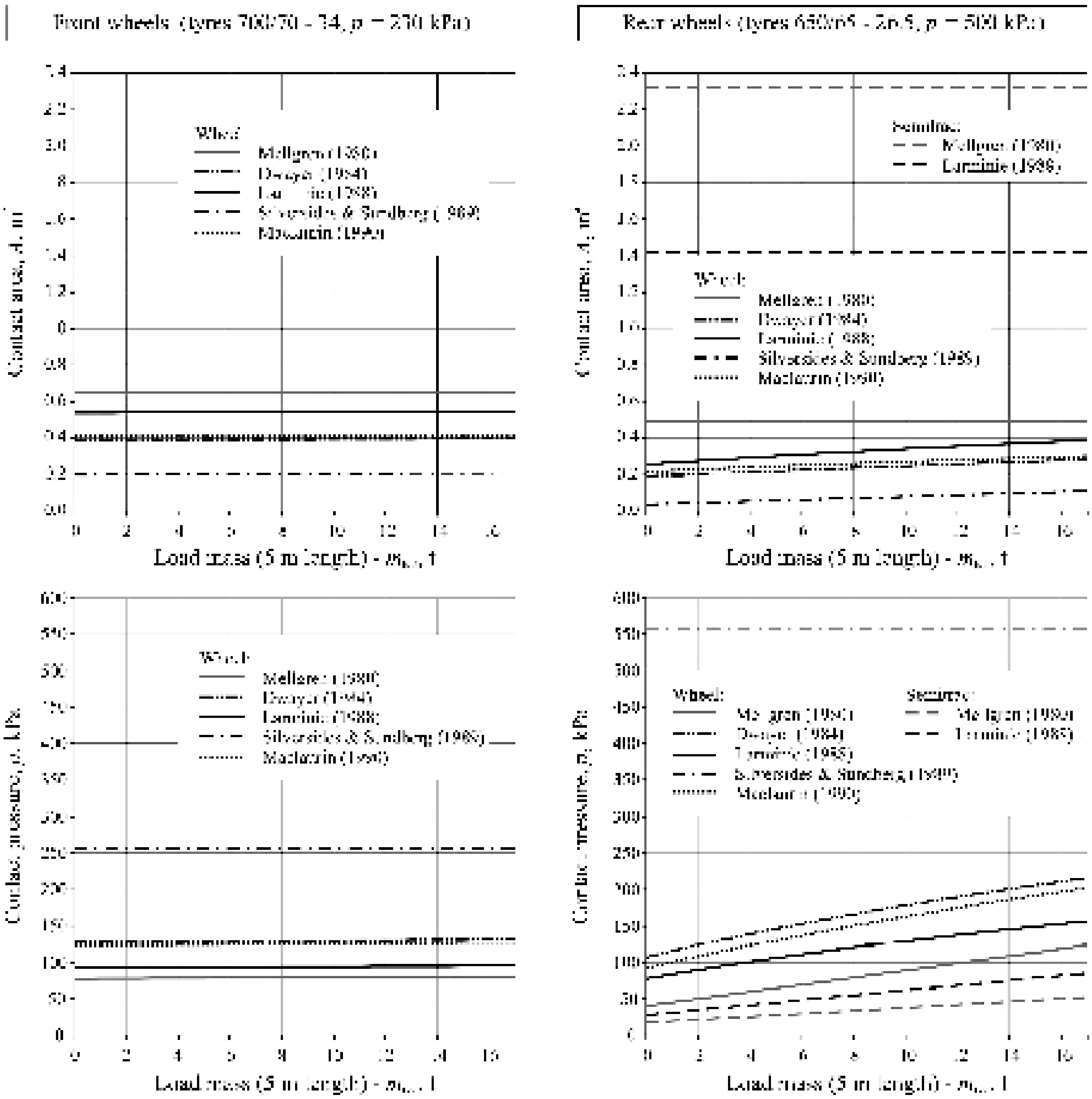

Fig. 6. Influence of loaded roundwood mass on contact area and contact pressure – Timberjack 1710B Forwarder

sions and equal wheel load distribution. In case of different dimensions between front and rear wheels, i.e. unequal load distribution between front and rear axle of the vehicle, the so-called reference wheel is used for the assessment of vehicles mobility by WES method. Saarilahti (2002b) defines the reference wheel as the wheel of the vehicle with the lowest wheel numeric value.

Dependence of wheel numeric of the front and rear axle of Timberjack 1710B forwarder in case of unloaded (m_T = 0 t) and nominally loaded (m_T = 17 t) vehicle on soil cone index is shown in Fig. 7. The analysis of the said dependence clearly shows that the front wheels are referential in case of unloaded forwarder, while the rear wheels become referential with nominally loaded forwarder.

Based on wheel numeric Saarilahti (2002c) estimates the quality of vehicle mobility, by dividing it into three classes (Fig. 8). If the limit wheel numeric 3 is selected as the lowest value of good mobility, then it is observed that in this case the soil should have the cone index of minimum 0.7 Mpa (Fig. 7). The question is whether such assessment of vehicle mobility should be the target guideline from the standpoint of sustainable forest management, as it fails to express clearly the effects of timber extraction.

However, a firm correlation between wheel numeric and rut depth (Fig. 2) provides possibility of use of wheel numeric as the parameter that describes environmental acceptability of timber extraction.

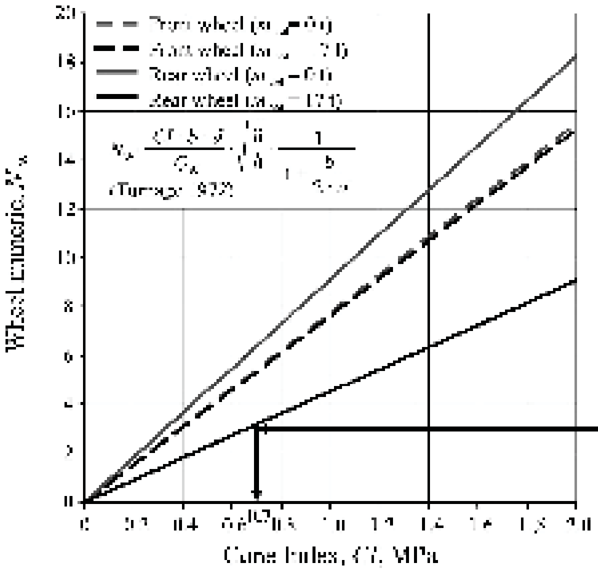

Fig. 7. Dependence of wheel numerics on cone index

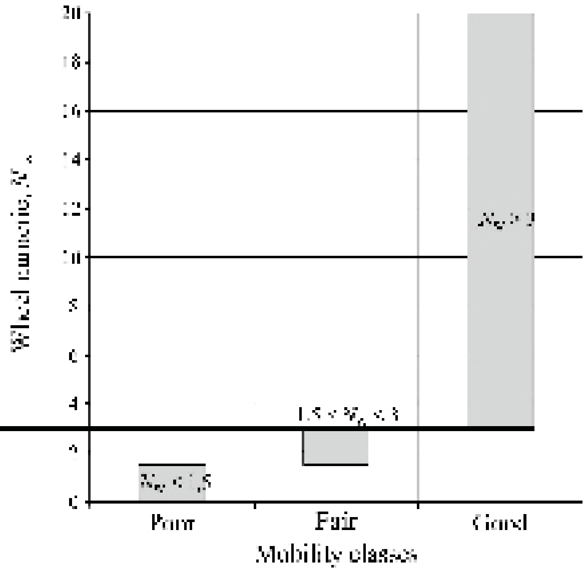

Fig. 8. Vehicle mobility classification according to wheel numeric

In doing so, EcoWood Protocol recommends the rut depth of 10 cm as environmentally acceptable for achieving an efficient forest harvesting on sensitive forest soils (Owende et al.,. 2002).

Rut depth dependence model, which uses Turnage's wheel numeric (Maclaurin, 1990) as the input parameter was used for the assessment of environmental acceptability of timber extraction by Timberjack 1710B forwarder. Dependencies are shown with respect to wheel numeric and soil cone index, respectively (Fig. 9). The interaction between vehicle and soil (wheel numeric) and soil bearing strength (cone index), respectively, are set as the criteria of environmental acceptability, by which indexes the curves of the assessment of rut depth are crossed with the environmentally referential rut depth (10 cm).

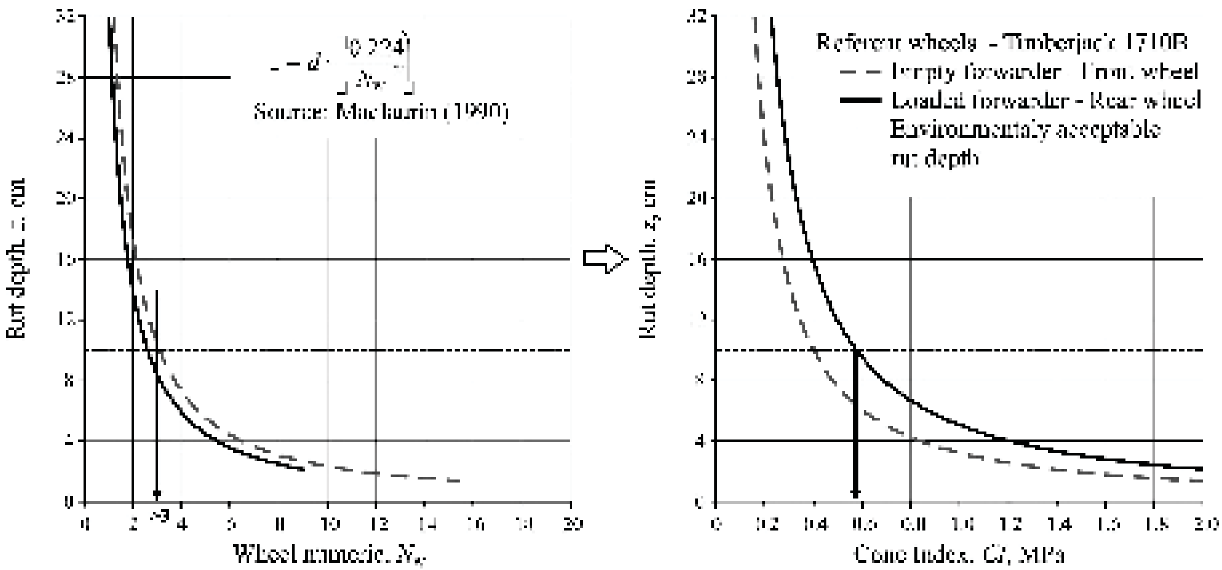

Fig. 9. Influence of wheel numeric and cone index on rut depth

Figure 10 shows that with the unloaded Timberjack 1710B forwarder, whose referential wheels are the front axle wheels, the wheel numeric must be 3.1 and the soil cone index must be 400 kPa. With a nominally loaded forwarder (17 t of roundwood), whose rear axle wheels become referential, the wheel numeric must be 2.6, and the cone index must exceed 575 kPa.

Consequently, it can be concluded that the limit values of wheel numeric, which define mobility, are good enough – they require the soil of cone index of minimum 0.7 MPa, which is a more strict criteria than the one obtained according to the limit rut depth of 10 cm, when it is sufficient to meet the limit soil bearing strength defined by cone index of 0.6 MPa

CONCLUSIONS

Wheel numeric, defined as the ratio between soil cone index and pressure under wheels, i.e. defined as the factor including soil bearing capacity, wheel loads and wheel dimensions and elasticity characteristics, is a good starting point for the assessment of environmental acceptability of wheeled forest vehicles for timber extraction.

The limit value of wheel numeric, which defines good vehicle mobility proved to be a “stricter” criterion than the one defining the limit rut depth.

The basic measuring problem in the determination of wheel numeric – measuring pressure under the vehicle wheel – can be solved with satisfaction by use of a semi-empirical formula.

Consequently, the environmental acceptability of a wheeled forest vehicle can be assessed relatively quickly by simple measurement of cone index and use of not exceedingly complicated semi-empirical formulas.

The analysis of wheel numeric, as the parameter used for the assessment of environmental suitability of forest vehicles for timber extraction, should be continued by establishing quantity correlation between the research of the effects of vehicle on soil and stand, as well as of wheel numeric.

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НАПАДЕНИЕТО НА КОРОЯДА *IPS TYPOGRAPHUS (L.)* (COLEOPTERA: SCOLYTIDAE) И СЪХНЕНЕТО НА СМЪРЧА ВЪВ ВИТОША

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През май 2001 г. ветровал повали 20 000 m^3 зряла дървесина от смърч *Picea abies* (L.) Karst. на площ от 62 ha в биосферния резерват във Витоша. Повалените и прекършени дървета създадоха благоприятни усовия за развитието на един от най-опасните вредители по смърча – корояда *Ips typographus* L. (Coleoptera: Scolytidae). За две години видът се намножи масово и през 2003 г. нападна прилежащите смърчови насаждения, в резултат на което заселените дървета загинаха върху площ от 35 ha в ивица от 50-250 m около ветровала. През същата година се появиха и първите миграционни огнища на *I. typographus* в зрели насаждения от смърч извън резервата. През 2004 г. съхнението обхвана 100 ha, а през 2005 г. достигна до 200 ha. От 2006 г. се наблюдава затихване на градацията на *I. typographus* в резултат на действието на абиотични и биотични фактори.

OUTBREAK OF IPS *TYPOGRAPHUS (L.)* (COLEOPTERA: SCOLYTIDAE) AND DRYING OF NORWAY SPRUCE ON VITOSHA MOUNTAIN

Georgi Georgiev, Plamen Mirchev, Georgi Tsankov, Boyan Rossnev, Peter Petkov, Bulgaria

In May 2001, a tornado broke down about 20 000 m^3 mature timber of *Picea abies* (L.) Karst. on an area of 62 ha in Bistrishko branishte biosphere reserve in Vitosha Mountain. The wind-fallen and broken trees caused favourable conditions for development of one of the most dangerous pests of Norway spruce – *Ips typographus* L. (Coleoptera: Scolytidae). During 2 years the species developed massively and in 2003 infested the nearest *Picea abies* stands and as a result these trees died on an area of 35 ha along 50-250 m stripe. During the same year appeared the first migration spots of *I. typographus* in mature Picea abies plantations out of the reserve. In 2004the wilting covered 100 ha and in 2005 reached 200 ha. Since 2006 decreasing of *I. typographus* gradation was observed as a result of abiotic and biotic factors' influence.

Vitosha is one of the first Nature Parks in Bulgaria and Europe. Two reserves are located within its boundaries – Bistrishko branishte and Torfeno branishte. The first one is designated in 1934 in order to protect the natural spruce (*Picea abies* L. (Karst.) stands in the region. The reserve territory has been enlarged two times, and currently it covers an area of 1061.2 ha spruce stands, sub-alpine herbal associations, and rock and stone landscapes. In 1977 Bistrishko branishte was included in the Global Network of Biosphere Reserves, part of UNESCO's Biosphere Programme.

In May 2001, a tornado passed trough Vitosha and broke down about 20,000 m^3 mature spruce timber on an area of 62 ha in Bistrishko branishte (10 % of its forest territory). The wind thrown and broken trees caused favourable conditions for development of one of the most dangerous insect pests in spruce forests – Spruce bark beetle, *Ips typographus* (L.) (Coleoptera: Cerambycidae).

Due to lack of legislative base for human intervention as the damaged territory was less than 25%, and under a strong press by ecological NGOs a decision was taken not to offence the status of the biosphere reserve but to realise monitoring on the insect pests in the windbreak. To follow the decision permanent observations were carried out in three sample plots in the lower, middle and upper part of the windbreak – SP 1 (1550 m a.s.l.), SP 2 (1650 m) and SP 3 (1850 m.).

Spruce health condition before the windfall was very good – an average 83.3% of the trees were without any damages (Rossnev et al., 2005).

In 2002, 15 xylophagous insect species were established in the windfall. Among them, *I. typographus* was the most abundant. The population density of the pest exceeded 3-4 times the critical minimum, with which infestations of alive trees should be expected.

The ministry of environment and water was alerted that the enormous insect value will surely pass from the fallen to alive trees in the neighbouring stands.

After exhausting the trophic resources in the windbreak in spring 2003 the first infestations by *I. typographus* in adjusted plantations were registered. The climatic conditions of 2003 were extremely favourable to overcome trees' resistance towards the pest:

- Early and warm spring contributed to the develpoment of two generations of *I. typographus*;
- Poor precipitations predetermined the wilting of the major part of the infested trees.

Up to the end of 2003 about 35 ha infested spruce stands were killed by the pest (Fig. 1).

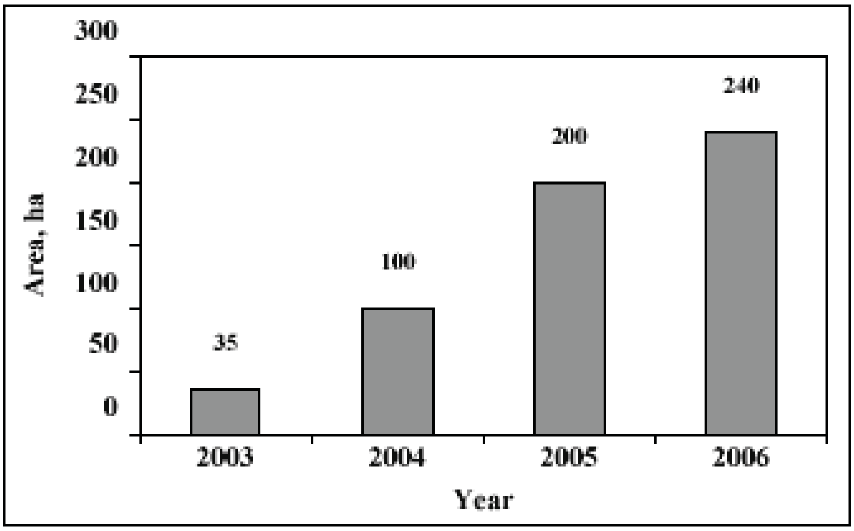

Fig. 1. Total area of killed spruce stands by *Ips typographus*

In 2004 infested area was mainly enlarged to Pogledets place and Northwestern slopes of Yanchovska and Bistritsa Rivers. In the same year first migration outbreaks of *I. typographus* appeared in spruce stands out of Bistrishko branishte – in the region of Vitoshko lale ski track and Moreni Hut path (Georgiev, 2006; Georgiev et al., 2006). Up to the end of the year the drying covered about 100 ha spruce stands, and in 2005 and 2006 – distributed on an area of about 200 and 240 ha, respectively (Fig. 1).

Frequent and abundant precipitations during the vegetation period of 2005 contributed to increasing the spruce resistance to *I. typographus* infestations. On the other hand the climatic conditions had significantly negative on the survivance of the wintering and new generation of the pest. Low temperatures and the high air humidity provoked the development of pathogenic microorganisms.

Towards beginning of the overwintering the mortality of *I. typographus* caused by predators, parasitoids, and pathogens, etc. reached up 58-85 % (mean 74.3 %) (Fig. 2).

The fungal pathogen which caused mortality of *I. typographus* most probably is Beauveria bassiana (Balsamo) Vuillemin (Deuteromycotina: Hypomycetes). In Bistrishko Branishte this and other entomopathogenic fungi were found to kill an average of 1.4% of the scolytid but in some cases the infection reached up to 7.3-13.6% (Takov et al., 2006).

In Bistrishko Branishte five parasitoids of *I. typographus* were found – Ropalophorus clavicornis (Wesmael) (Hymenoptera: Braconidae), Tomicobia seitneri (Ruschka), Dinotiscus eupterus (Walker), Rhopalicus tutela (Walker) and Roptrocerus xylophagorum (Ratzeburg) (Hymenoptera: Pteromalidae) (Georgiev, Takov, 2005; Georgiev, Stojanova, 2007). R. clavicornis and T. seitneri parasitized adults, and the remaining species – host larvae.

High mortality of *I. typographus* population will lead to decreasing of the infestation intensity and gradually extinguishing of the pest calamity. Although there is a significant possibility all the adult spruce stands in the reserve to die within following few years.

Reasonable are the questions related to the adequacy of the former decisions and advisability of taking measures to limit the damages by *I. typographus* in Vitosha. Our opinion is that it is necessary to follow a differentiated approach for Bistrishko branishte reserve and the rest of park's territories.

We are sure that if in 2001 the fallen timber was removed from the reserve we would not be eyewit-

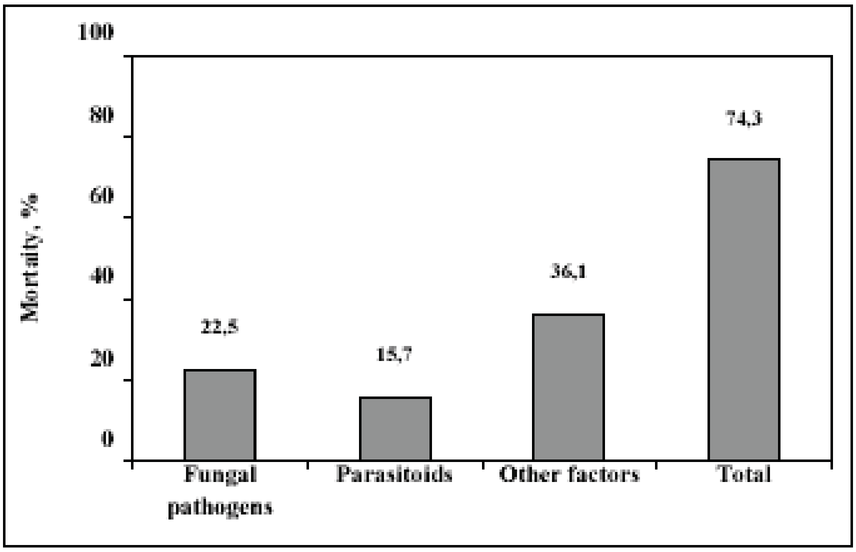

Fig. 2. Mortality of *Ips typographus* caused by different factors in 2005

nesses of the scale and forms of pest outbreak. In managed spruce stands in Bulgaria never until now there were not similar calamity appearances of *I. typographus*.

Now the died plantations overcome 40% of the forest area and 25% of the total area of Bistrishko branishte reserve but in the condition of huge pest volume density and presence of large number of infested spruce trees any anthropogenic interventions in the reserve are not welcome.

The current affairs in Vitosha rise up serious doubts about the correctness for choosing biosphere reserves in relatively small forests with recreation functions mainly.

Out of the reserve territory the outbreaks of *Ips typographus* have to be under maximally intensive control. If it would be not done the drying could cover 30-70% of the old spruce stands in Nature Park Vitosha.

The best effect would have the usage of trap trees in the infested spots. After completing the role their timber could be used in the most prestigious productions. It is necessary to know that to be effective this type of control the number of trap trees should be not less than the died in the previous year.

This approach not only will contribute to faster decreasing of Spruce bark beetle's outbreaks in Vitosha but will also lead to formation of uneven aged dendrocoenosis being those more productive and more resistant to pest and disease attacks.

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МАЛКИТЕ ТРАКТОРИ И ДРЕБНОТО ГОРОВЛАДЕНИЕ

Юрий Маренче, Бощян Кошир, Словения

Словенските гори се характеризират със сложен строеж по собственост. Има и обширни държавни гори, но повечето (71% от горската площ) са дребни частни имоти. Средният им размер е 2,3 ha, разделени на няколко отделни парцела. Годишното ползване на дървесина от един собственик е малко. Тези обстоятелства определят предпочитанието на горовладелците към маломерни машини. Предпочитат се по-малки (до към 40 kW) и по-евтини трактори, допълнително оборудвани за случайна горска работа. В настоящата работа са представени някои измервания и анализи за възможното използване на два малки трактора: колесния трактор AGT 835 T и верижния трактор Айрънхорс (Ironhorse). Колесният трактор беше изпитан при контролирани условия. Товари до 1 m^3 бяха извозвани нагоре по стръмен извозен път с наклони най-много до 27 %. Верижният трактор още не е изпитван в практиката, но характеристиките му показват твърде широк работен диапазон на умерен терен и при малък товар.

KLEINTRAKTOREN UND KLEINWALD

Jurij Marenče, Boštjan Košir, Slovenia

ZUSAMMENFASSUNG

Das Charakteristikum slowenischer Wälder ist eine komplexe Eigentumsstruktur. Einerseits gibt es große staatliche Waldgebiete, andererseits besteht die Mehrheit der Wälder (71% der Waldfläche) aus Kleinwäldern. Die durchschnittliche Waldfläche der kleinen Privatwälder beträgt 2,3ha, wobei die Waldfläche stark zerstreut ist. Diese Umstände, stark beeinflusst durch den geringen Holzeinschlag pro Waldbesitzer, tragen dazu bei, dass die Waldbesitzer sich für kleinere Maschinen und Ausrüstung entscheiden. Die Eigentümer wählen kleinere (bis zu 40 kW) und billigere Traktoren, die ausreichend für gelegentliche Waldarbeiten ausgerüstet sind. Dieser Artikel stellt einige Messungen und Überlegungen über die mögliche Nutzung zweier Kleintraktoren vor: des AGT 835 T Radtraktors und des Ironhorse Raupentraktors. Der Radtraktor wurde unter kontrollierten Bedingungen getestet. Lasten bis zu 1m^3 wurden eine steile Rückegasse mit einer maximalen Neigung von 27% bergauf gezogen. Der Raupentraktor wurde noch nicht in der Praxis gebraucht, doch seine Fähigkeiten zeigen einen weiten Einsatzbereich auf mäßigem Terrain, wo kleinere Lasten zu erwarten sind.

SMALL TRACTORS AND SMALL-SCALE FOREST PROPERTY

Jurij Marenče, Boštjan Košir, Slovenia

ABSTRACT

Slovenian forests are characterised by a complex ownership structure. On the one hand, there are large areas of state owned forests, and on the other hand, the majority of forest holdings (71% of the forest area) are small-scale. The average woodlot size of small-scale forest holding owners is 2.3ha, with the holding scattered on several individual parts. These conditions importantly influenced by low annual timber cut per forest owner contribute to the decision of forest owners to choose from the range of smaller machines and equipment. Owners choose smaller (up to 40 kW) and cheaper tractors, sufficiently equipped for occasional forest work. This paper presents several measurements and considerations about the possible use of two small tractors: the AGT 835 T wheeled tractor and the Ironhorse tracked tractor. The wheeled tractor has been tested under controlled conditions. Loads up to 1m^3 have been skidded uphill along a concave skid trail with a maximum slope of 27%. Tracked Ironhorse tractor has not been put in practice

yet, but its capabilities show a considerably broad working range on moderate terrain where small loads can be expected.

INTRODUCTION

The majority of forests in Slovenia are privately owned. The structure of forest property, most of it small scale, is highly fragmented. It is not surprising that forest owners usually do little work in their forests, and only occasionally. In forest operations, they use machines which are primarily intended for agricultural use, but given proper forestry equipment they could also be used in forests (Marenče, 1997). The tractors used for this purpose have different technical characteristics, engine power levels and are available in a variety of versions.

Mostly for economic reasons, smaller and therefore cheaper machines are more suitable for work on small-sized agricultural lands where the quantity of work to be done is relatively low. Such machines can also be used in forestry operations provided the working conditions are suitable. In forest areas where the gently sloping terrain makes working conditions easier, even small machines, otherwise rarely used in forest work, can be used. Understandably, such machines are interesting for all forest holders who undertake occasional forestry work in addition to farming operations. Small machines, however, have several limitations imposed by their technical capability. If these technical limitations are taken into consideration, however, the use of these machines in forest work can become efficient and sensible. The issue of forestry machines is of particular relevance in Slovenia as 71% of all forests in the country that otherwise boasts a high 58% forest cover are in private ownership (Slovenian Forest Service, 2005). Forest property is typically small, measuring an average of 2.3ha, and highly fragmented (average annual cut 2.4 m^3/ha). Given these facts, forest owners have little interest in forest work, in particular as the rural population in Slovenia in gradually decreasing.

Slovenia, located at the meeting point of the Alpine, Mediterranean and continental climate zone, is known for its diversity of growth conditions. Partly, this is a result of diverse historical and social development in various parts of the country. At higher altitude the land is overgrown with state-owned forests, whereas private forests prevail in low-altitude areas and in the surroundings of large urban centres. As in certain areas agricultural use is being abandoned, farmland is increasingly lost due to overgrowing, which contributes to a further increase in the share of forests. In fact, it has been established that the size of forest property and the socio-economic status of forest owners have a marked influence on the intensity of land management (Medved, 2000).

Forest owners are rather poorly equipped with tractors, although not so much in terms of number of machines as in terms of their quality. Most tractors are rather old, poorly utilized, with implements inappropriate for work on farms and in forests. The tractors are ergonomically deficient and their safety equipment is often outdated and insufficient. The purpose of the research was to present the characteristics of the present use of tractors and to outline the possible utilization of these machines in forest operations in small-scale forest holdings. Primarily, the study was aimed at determining the types of tractors which could be used in forestry operations under certain limitations imposed by the special forestry conditions in Slovenia. The research was based on the assumption that forest owners were motivated to manage their forest holdings efficiently despite their small size. As our primary interest was the technical characteristics of small tractors at work, we did not study in detail the economic efficiency of individual tractor types on small scale forest property. Therefore, our main aim was to show the capacity of small machines and to apply in practice the methods for testing tractors in timber skidding.

TRACTORS IN SMALL AGRICULTURAL AND FOREST HOLDINGS

As a result of all the abovementioned conditions, primarily the small size of forest holdings, the quantity of forest operations to be undertaken in these forests is low. The analyses conducted to date (Marenče, 1997) have shown several characteristics of these forest operations. They focused mainly on studying the effect of the type of mechanisation used on the time spent on forest work. In order to obtain the desired results, we analysed tractors with different rated engine powers which are normally used by forest owners. The computation considered data on forest work in a holding of average size, in undemanding working conditions, for designated trees of medium thickness 0.50 m^3, with the working period of the machine estimated at 12 years, as used by agricultural workers for similar computations (Žibrik, Golež, 1991). Similar values for the period of one year were also obtained by the Agricultural Institute of the Republic of Slovenia (Jejčič et al., 2003) – Fig. 1.

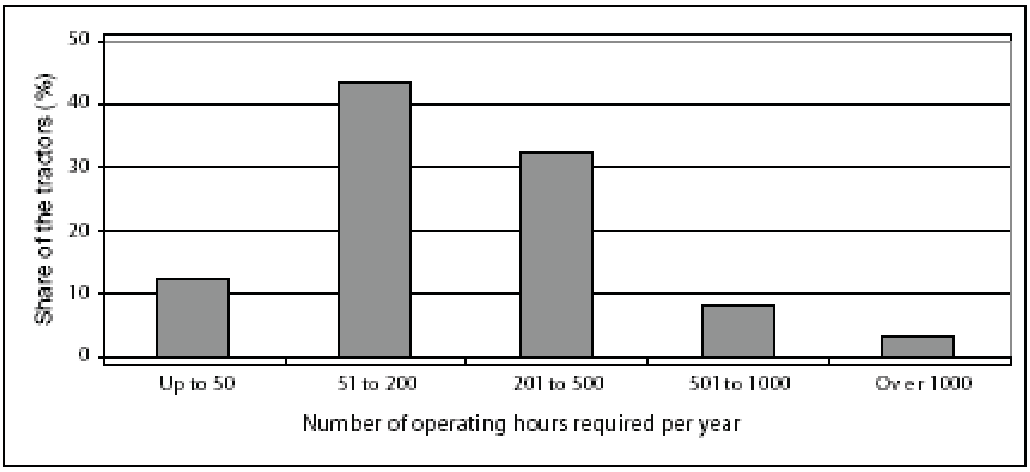

Fig. 1. Cumulative number of operating hours required per year for agricultural lands and woodlots

The required number of operating hours refers to the year-round work on agricultural land and forest land. Most tested tractors actually performed fewer operating hours than normally expected for their depreciation period, mainly due to a low quantity of work.

In terms of engine power, forest owners use different tractors, most of them in the power range between 19 and 37kW (Jejčič et al., 2002, Fig.e 2).

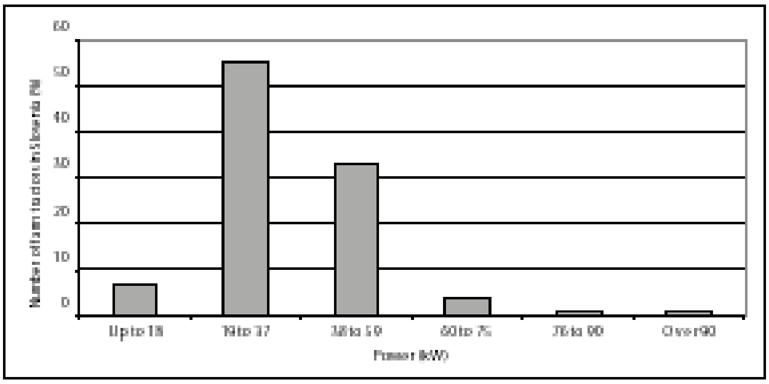

Fig. 2. Most frequently used tractors by power

The questionnaire included wheeled tractors which are commonly used in agriculture and forestry. Tracked tractors, however, are better adapted for use in special forestry conditions. Ever since tractors were introduced into forestry operations in Slovenia, tracked tractors have been used in skidding, whereas the use of tracked harvesters has increased over the recent years. Purpose-built tracked tractors, classified among tracked harvesters, were developed years ago (Košir, Medved, 1988) to suit the needs of small forest holders and for extraction of small diametre timber. These machines can be compared with small wheeled tractors, although their size is actually lower than the size of tractors included in this research (Fig. 2).

Small tracked tractors are commonly known as »iron horses« as they have actually replaced the role of horses in skidding. The advantage of these small machines is their flexibility on uneven and densely overgrown terrain and their ability to drive across soft surface. Their smaller size also means lower price, and, understandably, lower output. The machine can be fitted with various options to be better suited to different purposes, including ground skidding and transport of timber from the forest. The shortcomings of these machines, however, are substantial as a machine weighing approximately 400kg cannot efficiently be used in skidding of heavy loads. Certain problems may also arise in bunching and stacking, and in the loading of logs onto the trailer, provided the tractor has one. All in all, these tractors are less efficient in skidding than in transporting wood on tractor-trailers. The power of these dwarf tractors is between 5kW and 10kW, which still serves their basic purpose – downhill skidding of small diametre timber along terrains of moderate and medium difficulty. The performance of »iron horses« may be low when compared with larger tractors specially adapted for forestry use, but on the other hand, the pressure related to working time efficiency of these tractors is much lower than is often the case with larger and more expensive machines. With some modifications, they can be used in limbing, yarding (7kN) and loading of small diametre timber with a mechanical loader onto a semi-trailer. Another plus of these small tractors is that their impact on the forest floor is minimal and they cause little residual stand damage, which makes them environment-friendly.

There is also a possibility of skidding small loads in wintertime using tractors with motor sleighs and semi-trailers with sleighs, but this form of skidding is restricted to extraordinary circumstances (Košir, 1985).

Given all the above mentioned characteristics of forestry operations, easy and moderately difficult conditions warrant the use of small machines which may not be originally intended for professional forestry use but can, provided they are outfitted with the necessary options, prove very useful in arable as well as forest operations. The other possibility which was not studied in the research is the use of various implements and attachments in tractors with high engine power and weight and are mainly used in extensive arable operations. A single-drum logging winch with a blade is such an implement, especially if the tractor is to be primarily used in skidding, or a semi-trailer with a loading crane which can be – in cheaper versions – non-powered, with a mechanical lift. Tractors can be fitted with a selection of implements and attachments available, although specific and more powerful implements such as processors, hydraulic cranes, powered trailers and harvesters are not suitable for small forest holdings.

METHODOLOGY

In the group of tractors with net power of 19-37 kW, to which most tractors belong (Fig.e 2), we have selected the AGT 835 T tractor with a mechanical transmission system, which falls into the category of machines that could, if equipped with proper forestry implements, be used in forestry operations (Fig. 3). Nevertheless, the use of the selected tractor would remain limited to easy and moderately difficult working conditions and skidding of small loads. The tractor has an all-wheel drive, which makes it suitable for driving along trail less terrain, especially if the wheels are chain-mounted. The hydrostatic version of AGT 835 T, better for travelling on soft terrain, is also available. In order for the tractor to be better equipped for forestry operations, it should be modified to ensure better protection (cab and safety frame) and a front blade should be added. At the back, the tractor can be outfitted with a logging winch with a deck (this option was studied in the research), a semi-trailer or any other proper attachment. One should, however, bear it in mind that the power of the adapted tractor is low.

Fig. 3. AGT 835 T during a test on a skid trail

Table 1. Technical characteristics – farm tractors AGT 835 T

Manufacturer: AGROMEHANIKA Kranj, Slovenia
Engine: Lombardini LDW 1503, 4 cylinders diesel
Displacement: 1,551 cm^3
Power: 26.4 kW
Transmission: mechanical
Tyres: 750 X 16
Mass: 1,085 kg
Safety frame, front blade, 30 kN winch Krpan, wheel chains
Price with complete adaptation as described (without VAT): 13,546 EUR

In the course of the test, tractor performance was measured when travelling empty and in uphill skidding of spruce logs with an average length of 8 m and approximate volume of 0.25 m^3, 0.50 m^3, 0.75 m^3 and 1.00 m^3. Only one log was skidded at a time and the orientation of the load was often changed from butt-end forward to top-end forward. Wheel slip and wheel pressure were measured (Košir et al., 2005). All loads were weighed to the nearest kilogram.

The 191-metre-long skid trail was concave in shape and in its upper part reached the maximum slope of 27% (Fig. 4). The focus of the research was to determine tractor slip, limiting slope steepness and the maximum load the tractor is able to transport, as well as the effect of load orientation on the values obtained.

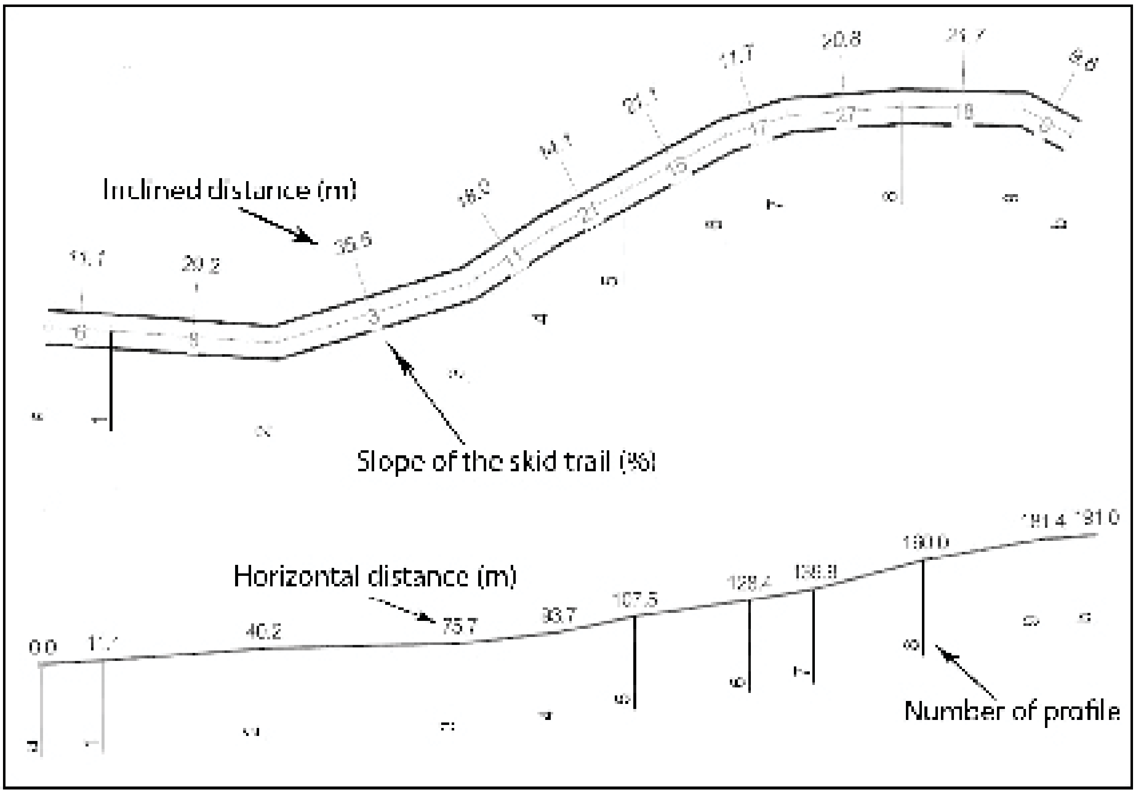

Fig. 4. Test skid trail

RESULTS AND DISCUSSION

The highest longitudinal gradient of the skid trail and the highest load were selected on the basis of previous experience in performing forest work. It was expected that the tractor would stop in uphill skidding under the most difficult working conditions. The skid trail with its concave form and increasing longitudinal gradient set the frame within which the difficulty of skidding was changed, slowly growing towards the top of the trail. By gradually increasing the volume of the load, the load rate of the tractor and the difficulty of operation also increased.

The research was aimed at determining the capacity of the chosen tractor under working conditions which represent different load rates of the tractor. Fig. 2 gives a part of the answer. The skid trail with the highest gradient of 27% does not cause any problems in the skidding of load up to 0.75 m^3. Regardless of load orientation (butt-end or top-end forward), the tractor managed to transport the load along the entire skid trail. To conclude, the tractor performed well at the selected difficulty of skidding (longitudinal gradient up to 27% and load up to 0.75 m^3).

Table 2. Skidding performance with regard to the longitudinal gradient of skid trail, load size and load orientation in uphill skidding

	Slope of the skid trail (%)		
	Up to 10 %	11 to 20 %	Over 20 %
No load	+	+	+
0.25 m3 butt-end	+	+	+
0.25 m3 top-end	+	+	+
0.50 m3 butt-end	+	+	+
0.50 m3 top-end	+	+	+
0.75 m3 butt-end	+	+	+
0.75 m3 top-end	+	+	+
1.00 m3 butt-end	+	+	STOP 139.6 m, at 27 %
1,00 m3 top-end	+	+	STOP 138.5 m, at 27 %

where:
+ means that the tractor travelled the entire length of the skid trail
STOP means that the tractor stopped at a certain point and slope gradient due to overload

At larger loads (1.00 m^3) the tractor stopped at the longitudinal skid trail gradient of 27% as the skidding conditions became to difficult for the tractor to overcome because of the combination of the slope (27%) and size of the load (1.00 m^3). That was the load rate which the selected tractor with its technical characteristics could no longer overcome.

It needs to be pointed out that the stopping of the tractor occurred regardless of the load orientation. However, when the load was transported butt-end forward, the length of the skid trail travelled by the tractor was longer. The finding was both expected and relevant as it indicates that the right orientation of the load can contribute to better utilization of the tractor's technical characteristics in uphill skidding. This information should be considered when tractors operate at their maximum capacity.

Similar results were obtained in measurements of wheel slip. Slip values increase in line with the longitudinal gradient and load size (Fig. 5), as has been found and proven by a number of prominent authors (Bekker, 1960, Jacke, Drewes, 2004, Šušnjar, 2005).

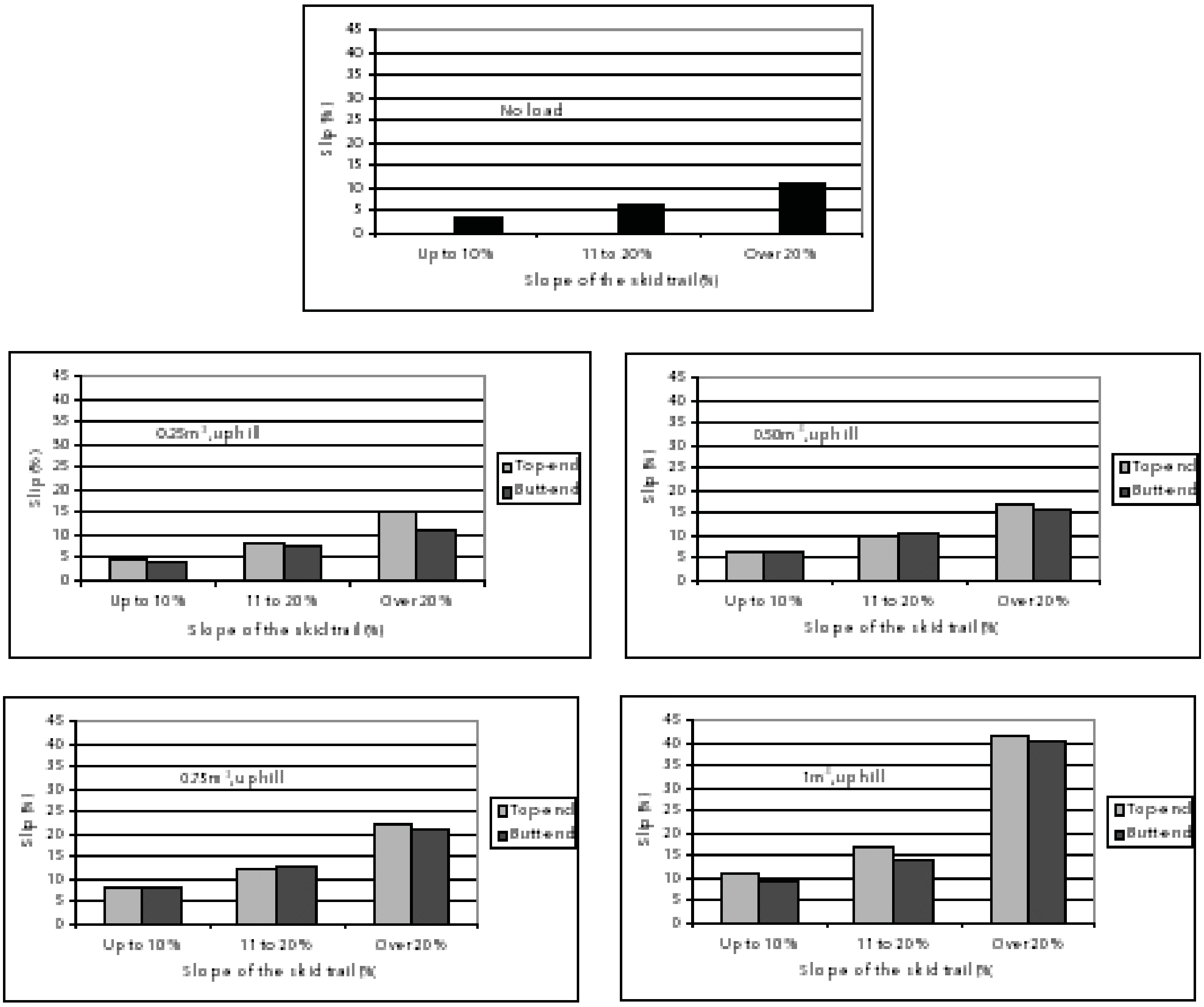

Fig. 5. Wheel slip with regard to longitudinal gradient, load size and load orientation; uphill skidding

As expected, slip was lowest when the tractor was travelling empty, and increased as the longitudinal gradient of the skid trail and the load size grew. Under more demanding conditions, right before the tractor stopped, the wheel slip value might even reach 40%.

It is worth noting, however, that the slip rate can also be affected by load orientation. As a rule, wheel slip percentage is higher when the load is carried top-end forward, as in this case a smaller part of the weight is actually on the tractor, increasing the rolling resistance. In general, high slip percentage indicates lower traction on the ground, which means lower efficiency and, consequently, the tractor stops sooner. Although the differences in such small loads may be insignificant, knowledge and consideration of these results are useful in planning and execution of timber skidding.

The 1 m^3 load was determined as the threshold value for the skid trail of the controlled maximum longitudinal gradient of +27%, as expected in view of the technical characteristic of the AGT 835 T tractor. The test has helped define the threshold of the technical ability of the selected tractor in uphill skidding, which can be reached if the machine operates in difficult working conditions. It is evident that the tractor is not intended for professional forestry operations, but rather for occasional forest work. Despite its limited technical ability in specific working conditions as defined in the presented test, the low purchase price of the tractor makes it a useful and viable choice for occasional forest work.

The abovementioned limitations are not relevant in downhill skidding, which is why timber transport instead of ground skidding should be considered. Transport of load on the semi-trailer would allow the load volume to increase, while at the same time reducing damage to the ground and the load rate of the

CONCLUSIONS

There is a market niche for small tractors also in Slovenia as small-scale forest property remains the predominant form of ownership in many parts of the country (the Littoral, parts of eastern Slovenia). Small tractors which can be used in forestry if outfitted with proper equipment include AGT wheeled tractors and small tracked tractors, Ironhorse, of different brands.

The limiting factor of these small, wheeled tractors with mechanical transmission is low weight and power, which sets their threshold value due to wheel slip in uphill skidding at a load of approximately 1 m^3 of softwood at the slope of the skid trail of 27%. Wheel slip in travelling empty does not differ significantly from the slip rates in uphill skidding of tractors carrying a load of 0.25 m^3. In uphill skidding of heavy load, however, wheel slip rate increases until it reaches the threshold value where slip is prevented by further motion of the loaded machine. Future research should be aimed at testing the efficiency of skidding with a tractor-trailer where the limitations established through the present research would be presented in a different light.

It is not simple to ensure economic efficiency of these tractors as they do not meet the efficiency standards used by professional foresters. In assessing the efficiency of small-scale forest property management, there are numerous interactions between the integral elements of property return (industrial, agricultural, crafts) and a number of possible combinations of including the workers into the production process. Experience show that family members, regardless of their age, are actively involved in agricultural and forestry production, and the transfer of the value of work done cannot be included and explained through simple and commonly used calculations of machine work. The tractors which were studied in the research belong to the group of small machines that can successfully compete with larger purpose-built forestry machines thanks to their specifics of operation.

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A LOGISTIC MODEL OF THE MOBILE REPAIR WORKSHOP OPTIMIZED RATIONS AND DISTRIBUTION.

S. Madjov, G. Tassev

The study of technical support set up on territorial principles is a topic of present interest. The information on the intensity of demand is average intensity of failures of the machinery for a period for an administrative region. We have studied the two cases. In the first region is served by one mobile repair workshop (MRW), in the second one-several mobile repair workshops serve on a large region.

We assume that the central base of the mobile spare part stocks is into the geometrical center of the serving region.

We have to make up so many serving zones, that their number for this region is minimal, but the quality of serving have to be acceptable for the requirements of the model. The serving model is based on two basic variable elements: the time for confirmation of the application and the time necessary for serving of the application. We assume that the application is received in the moment when MRW are available in the system for technical support (STS), ready to begin technical maintenance (TM), and the time for TM includes the time for traveling up to the client and the time needed for repair.

With augmentation of the radius of the zone of TM the coefficient of usage of MRW increases, but the quality of service decreases, that is to say the time for confirmation of the application and the time requisite for traveling increases.

This is the main aim of this study – to determine the optimal service zone.

We have used the average time for waiting of the confirmation of the application and the time requisite for serving of the application as an indicator of the quality of service.

When the intensity of failures of machinery is small, the size of the zone of TM is determined by the time requisite for traveling.

Small intensity of failures of the machinery means that the chance of appearance of more than one application in the same moment is almost zero.

We have explored a comment service model for a zone with one MRW and assumed that the service intensity is

$$\mu = 1/\left(t_n + t_p\right),$$

where $t_п$ and $t_р$ are time for traveling up to the client and the time used for repair.

The time for traveling is calculated by this the formula:

$$t_n = \frac{L}{V},$$

where L is the average distance between the central service base and the client's position;

V – the average speed of MRW.

The dependency between an average distances (L), depending of the service area S_o becomes by the formula:

$$L = k\varepsilon\sqrt{S},$$

where ε is the coefficient of the geometrical shape of the area and the place of the ware house in this area.(ε = 0,4,…,0,8);

κ – the coefficient of the lengthen of the road because of the relief (κ = 1,3,…,1,5).

The average time for waiting of the MRW is:

$$t_n = \frac{k\varepsilon\sqrt{S_0}}{V}. \quad (1)$$

The average time for waiting in System for common service [M/M/1] is:

$$W = \Lambda / [\mu(\mu - \Lambda)],$$

where Λ the intensity of the application in to the service zone.

The intensity of application of the machinery and the intensity of maintain μ depend on the surface of the zone (S):

$\Lambda(r) = S\lambda ng$,

where λ intensity of application, h^{-1}.;

S – the surface of the zone, κm^2.;

n – number of the same elements, nr.;

g – the average number of machinery, nr./κm^2.

The intensity of maintain μ, using the formula (1) for the average time for waiting of the MRW, become:

$$\mu(r) = \frac{1}{t_p + \frac{k\varepsilon\sqrt{S}}{V}},$$

where t_p is the average time used for the repair, h.

The final formula for the time for waiting the beginning of service is:

$$W = \frac{S\lambda ng\left(t_p + \frac{k\varepsilon\sqrt{S}}{V}\right)}{\left(t_p + \frac{k\varepsilon\sqrt{S}}{V}\right)^{-1} - S\lambda ng}.$$

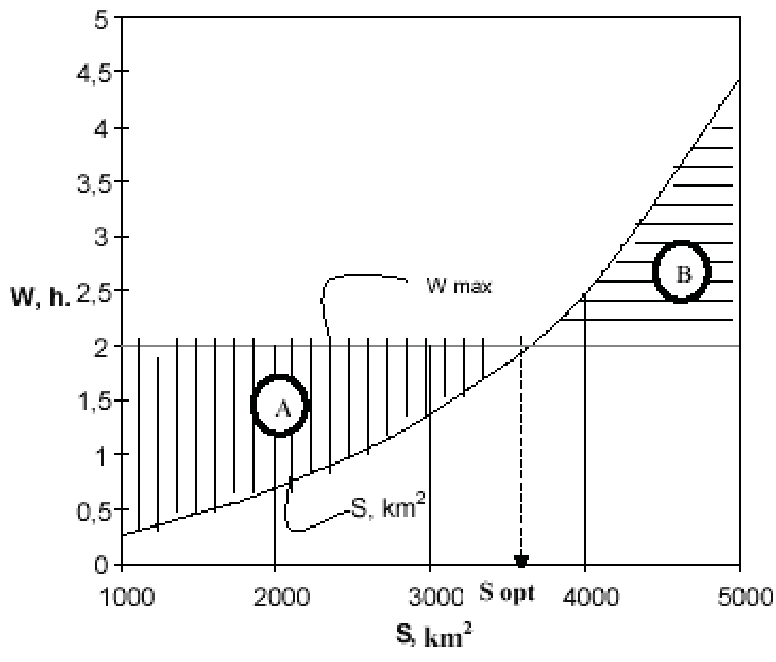

Fig. 1. Optimal value of surface of service zone (S), observing the limit: the time for waiting the beginning of service (W) have to be shorter then 2 h; A – the multitude of acceptable values of surface of service zone (S); B – the multitude of unacceptable values of surface of service zone (S).

Now we assume that the intensity of failures of the machinery is big, and the size of the zone of TM is determined by the time requisite for traveling.

We have explored a comment service model for a zone with some MRW and assumed that the service of clients in this case can be accepted as m channel SMS by the type M/M/m without priority.

For this system the coefficient of usage is $\rho = \Lambda / \mu$.

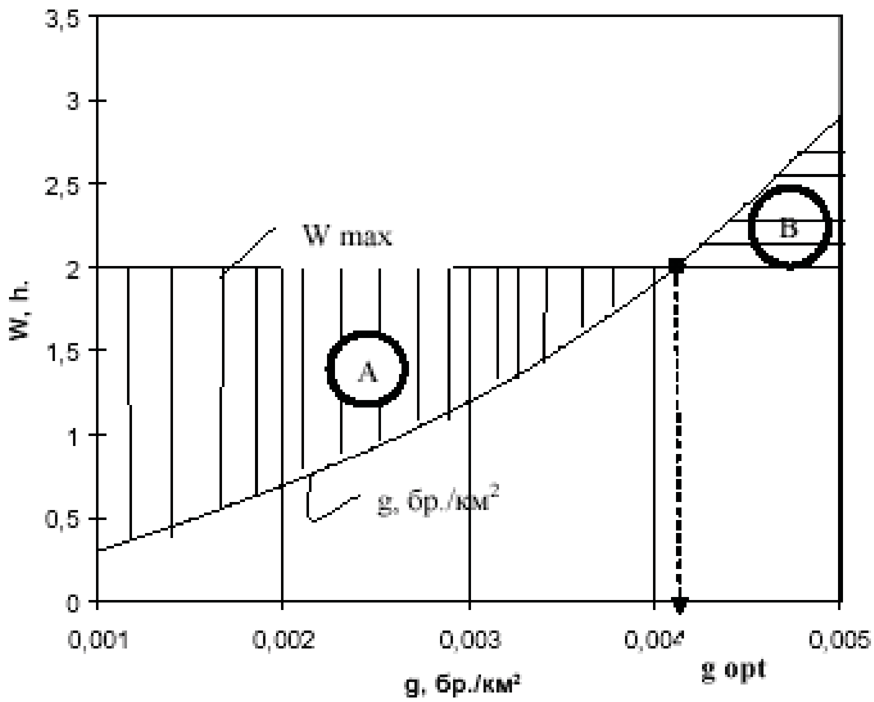

Fig. 2. Optimal number of tractors (g), observing the limit: the time requisite for serving of the applications (W) have to be shorter then 2 h; A – the multitude of acceptable values of number of tractors (g); B – the multitude of unacceptable values of number of tractors (g).

The final formula for the time of waiting the beginning of service when the system is multi-channel is:

$$W = \left[\frac{\rho^m \mu}{(m-1)!(m\mu - \lambda)^2} \right] p_0 ,$$

where m is the number of service channels in SMS;

p_0 – stationary probability, that multi-channel system is free and we have found it using the formula:

$$p_0 = \frac{1}{1 + \sum\limits_{1 \subseteq j \subseteq m-1} \frac{\rho^j}{j!} + \frac{\rho^m}{(m-1)!(m-\rho)}},$$

where j is the number of application in the system;

At the end we have explored with the model for optimal distribution of spare parts the time for waiting the beginning of service in tree forestry territory organizations in south – west region of Bulgaria. In Table 1 is done information for their surface.

Table 1. Surface of the territory organizations in south–west region of Bulgaria

Organization	surface, км².
Sofia	8409
Kyustendil	5445
Blagoevgrad	6450

The time (W) for waiting the beginning of service has to be less then 2 h (W≤2ч.). We have calculated the time (W) for different number of tractors for each of these regions.

The average intensity of applications for spare parts (λ) for one tractor is 0,0024 h^{-1}., and the average time for changing of one element from engine Д 240Л is 2 h. The average speed of MRW (V) is 40 km/h.

The research has done for one MRW for each region.

The results from the research for Sofia, for the time (W) for waiting the beginning of service are represented in Fig. 4. These results are for 20, 40, 60, 80 and 100 tractors.

The results from the research for Kyustendil and Blagoevgrad are represented in fig.5 and fig. 6.

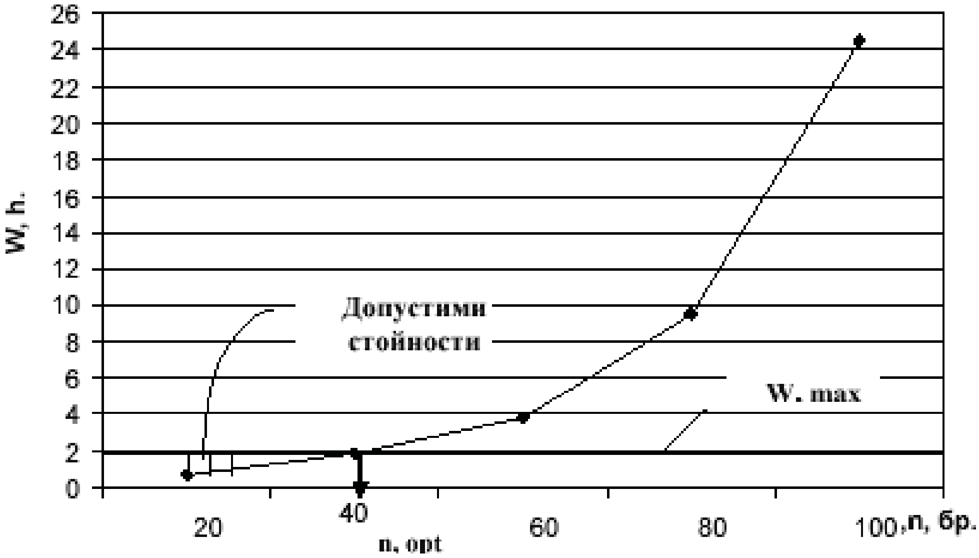

Fig. 3. Change of time for waiting the beginning of service (W) for a zone with one MRW and variable in different number of tractors for the region of Sofia.

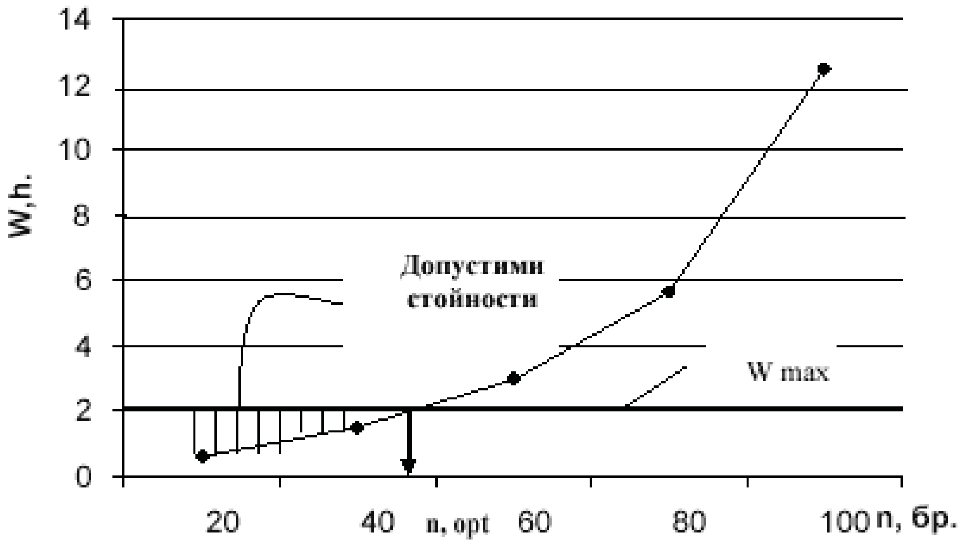

Fig. 4. Change of time for waiting the beginning of service (W) for a zone with one MRW and variable in different number of tractors for the region of Kyustendil

The research proves that the forestry organization of Sofia could be served by one MRW, if the number of tractors in the area is less then 40. If the tractors are more, the time for waiting the beginning of service (W) increases rapidly and in case of having 100 tractors the time for waiting (W) nearly 25 h. In the other explored organizations (Kyustendil and Blagoevgrad) the situation is analogical – the time of waiting the beginning of service (W) is less then 2 h if the tractors in the area are less then 40. If the number of tractors is bigger then 40 the time of waiting (W) is more than 2 h.

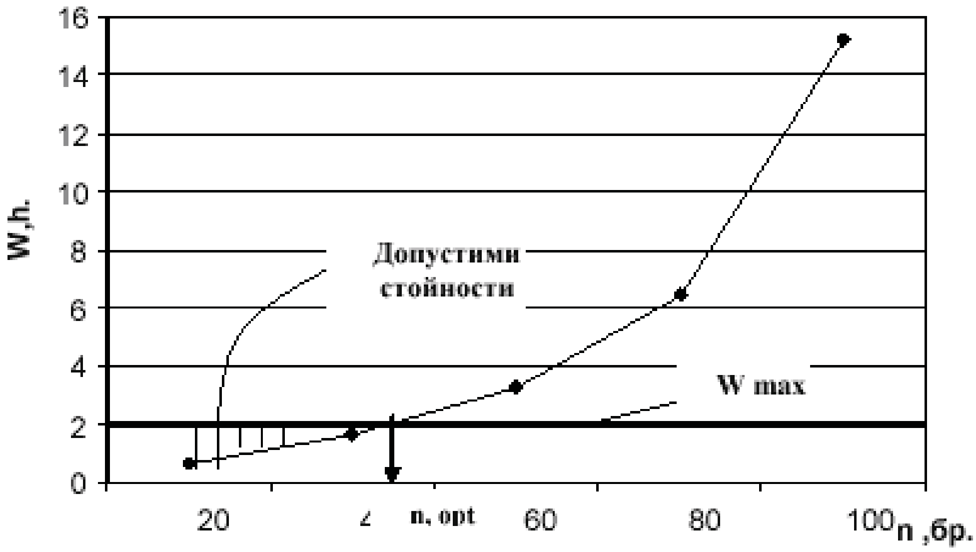

Fig. 5. Change of time for waiting the beginning of service (W) for a zone with one MRW and variable in different number of tractors for the region of Blagoevgrad.

CONCLUSIONS

We have created a logistic model of distribution of spare parts based on territorial specifics.

The model is verified for the forestry organizations in Bulgaria and shows really good results of logistic efficiency.

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ЛОГИСТИЧЕН МОДЕЛ НА ПОДДРЪЖКАТА НА ТЕХНИКАТА В ГОРСКОТО СТОПАНСТВО

Й. Йовков, Г. Тасев, България

Предлага се системно решение за обслужване на машинния парк на горското стопанство, разработено на основата на логистиката.

Също така се предлага модел за предварително определяне на необходимите резервни части в рамките на логистичната система за обезпечаване функционирането и готовността на обслужваните машини.

Направен е анализ на параметрите на математическия модел при различни фактори, използувани при вземане на решения при логистичните системи.

A LOGISTIC MODEL FOR MACHINERY MAINTENANCE IN FORESTRY

Y. Yovkov, G. Tassev, Bulgaria

A logistic based system design has been developed and proposed for the servicing of the fleet of machinery for the forestry needs.

Also suggested has been a model to predetermine the indispensable amounts of spare parts within the logistic system to provide for the functioning and operability of the serviced machinery.

An analysis of the mathematical model parameters under various factors has been conducted to be used in decision-making within logistic systems.

At the basis of every logistic model for machinery maintenance in Forestry is the issue for determining the necessary number of spare parts for maintaining the machinery operable condition [1,2].

The aims of the present research are to draw and study analytical models for defining the Failure Flow characteristics at the most frequently used strategies for machinery maintenance, by which to insure the information logistic system.

The research has been carried out under two strategies of maintenance and analytical dependencies for determining the Failure Flow characteristics H (t).

Study of failure flow characteristics under the strategy of planned repair activities

The Failure Flow characteristics H(t) $H(t)= \lambda t/(1-e^{-\lambda t})$[2] has been studied in the range of variation of the force of mortality of machinery elements $\lambda= 2.10^{-2} \div 14.10^{-2}$; $\Delta\lambda= 2.10^{-2}$h; $T= 50 \div 300$; $\Delta T= 50$h и $t= 100 \div 1000$, при Δ t= 200 h.

The obtained results are shown on Fig. 1 and by the analysis of graphic dependencies it has been determined that the surface, showing H (t) in a three-dimensional coordinate system tends to bigger values when increasing the force of mortality A and the regularity of planned repair activities T.

When changing the time t, for which H (t) is determined, the intensive change of the Failure Flow characteristics has been observed. Using the values of H (t) at T=const and λ=const, we will be able to determine the variation of H ft) as a function oft (Fig. 2).

Study of the Failure Flow characteristics under the combined strategy of maintenance

The function of the Failure Flow characteristics under combined strategy of maintenance is [1, 2]:

$$H_1(t) = H_2(t) = H(t) = \frac{\lambda_1 \lambda_2 t}{\lambda_1 + \lambda_2 - \left(\lambda_1 e^{-\lambda_2 T_2} - \lambda_2 e^{-\lambda_1 T_1}\right)}$$

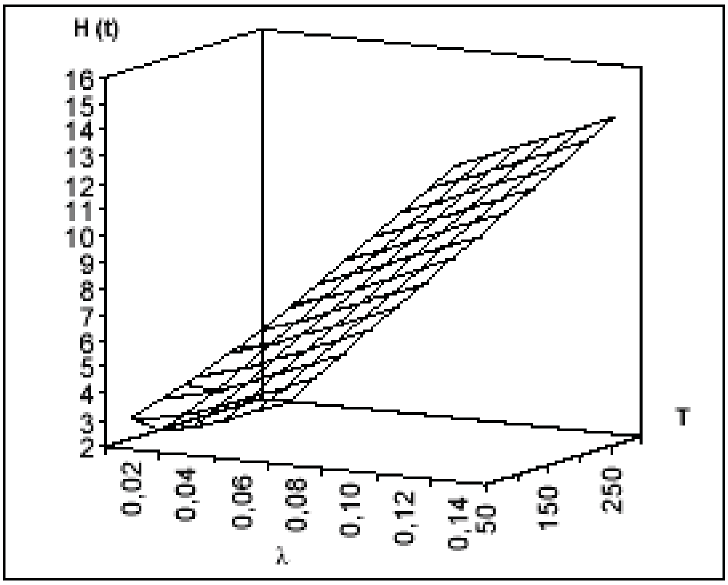

Fig. 1. Failure Flow characteristics H (t) depending on the force of mortality λ and the regularity of the maintenance activities (T) at t=100h.

where λ_1 and λ_2 are the respective force of mortality of the elements under planned strategy of maintenance and failure strategy.

T_1 and T_2 are mean values of working hour rates of planned maintenance and working hour rates up to failure.

The obtained results on Fig. 3 show that the Failure Flow characteristics H (t), expressed on a three-dimensional coordinate system is a protruding surface, i.e. with the increase of λ_2 H (t) also increases, but with intensity, much smaller than at the increase of λ_1. The graphic dependencies show that with the variation of T_1 and T_2 the characteristics of H (t) do not vary. It shows that more important is the force of mortality impact of the elements $\lambda_1$and λ_2 than the regularity of the precautionary maintenance.

The precautionary maintenance impact (and T_2) on the function H (t) at $\lambda_1=\lambda_2$=const and t=const is shown on Fig. 4-6.

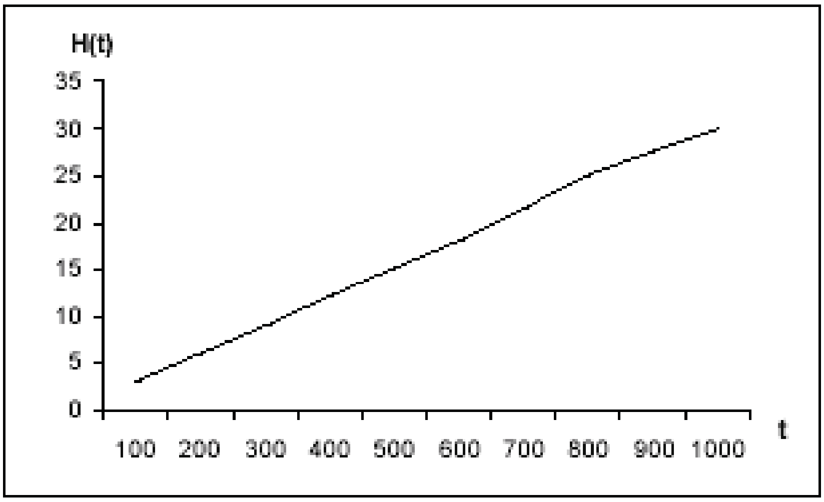

Fig. 2. Failure Flow characteristics H (t) at T=100h - const and λ=0,02 - const.

The following correlation between H (t) and T_1 and T_2 - the surface, representing H (t) in the three-dimensional coordinate system, is furrow-like with an open upper part and changes its three-dimensional shape (Fig. 4-6) and becomes flat and parallel to the surface T_1- T_2 (Fig. 6) at the changing of $\lambda_1=\lambda_2$=const from value 4.10^{-2} to 14.10^{-2} h^{-1}. This shows the complex dependence of H (t) from the reliability of elements $\lambda_1$and λ_2 and the regularity of maintenance (T_1 and T_2).

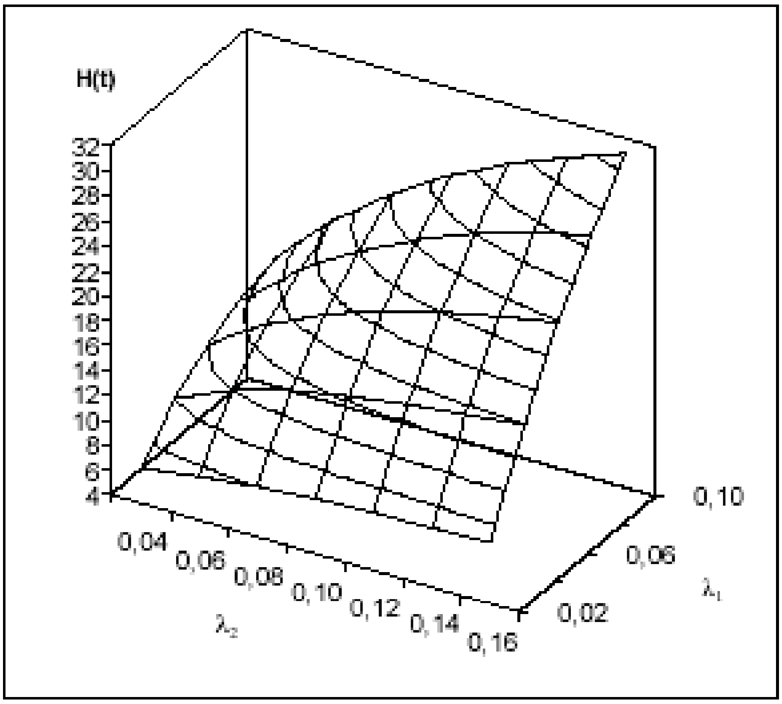

Fig. 3. Failure Flow characteristics variation H (t) under combined strategy of maintenance and at $T_1=T_2=200h$ and t=500h

The study of the Failure Flow characteristics under combined strategy of maintenance H ft) at constant values of strategy parameters (Tj; T_2) and forces of mortality (λ; λ_2) shows that H (t) in three-dimensional space is a plain, tilted to the plain ($T_1=T_2$; $\lambda_1=\lambda_2$). When increasing t H (t) is a linear increasing function (Figure 7).

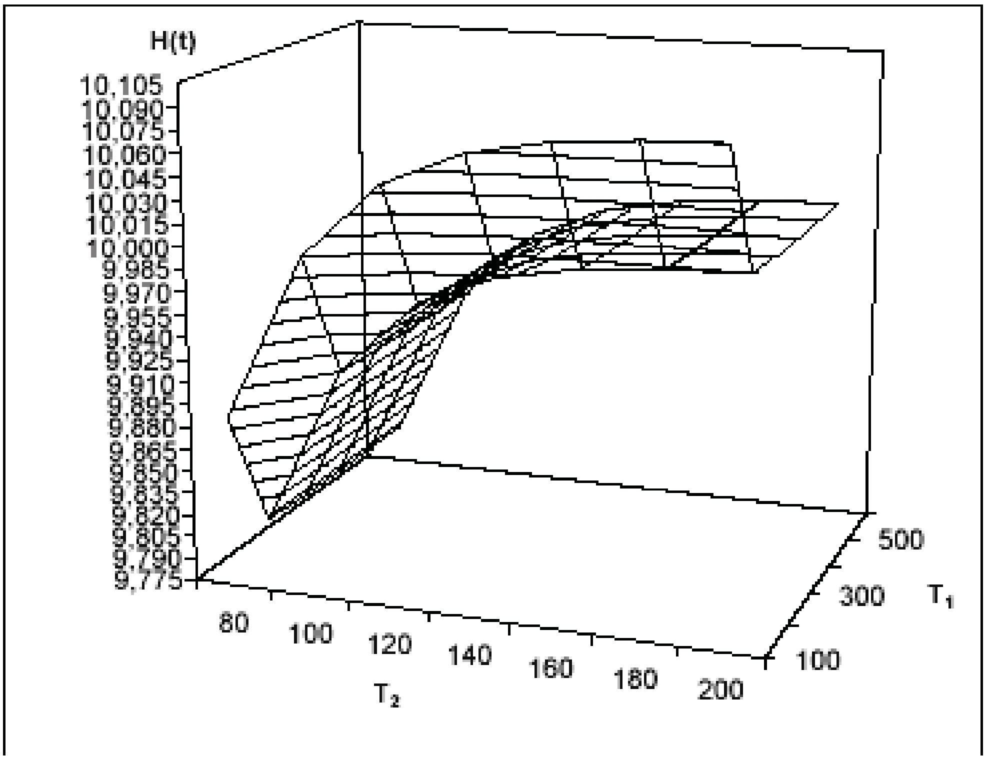

Fig. 4. Failure flow characteristics H (t) under combined strategy of maintenance depending on the regularity of repair activities T_1 and T_2, $\lambda_1=\lambda_2$=const and t=const.

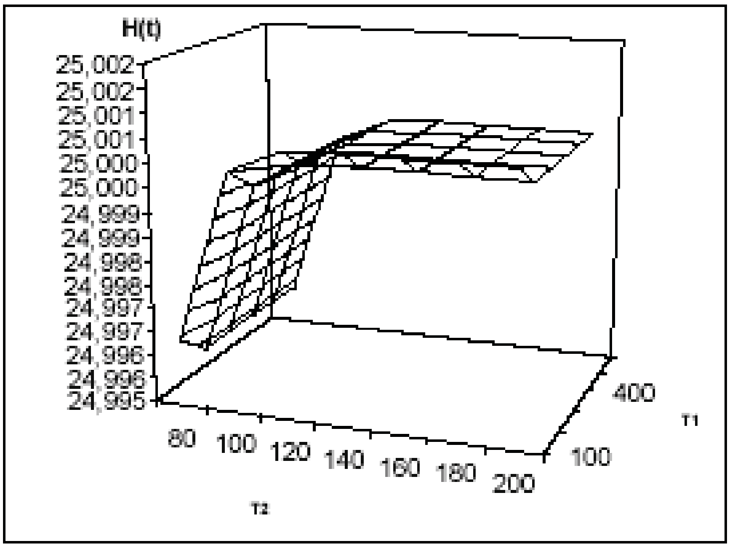

Fig. 5. Failure flow characteristics H(t) under combined strategy of maintenance depending on the regularity of repair activities T_1 and T_2, $\lambda_1=\lambda_2$=const and t=const.

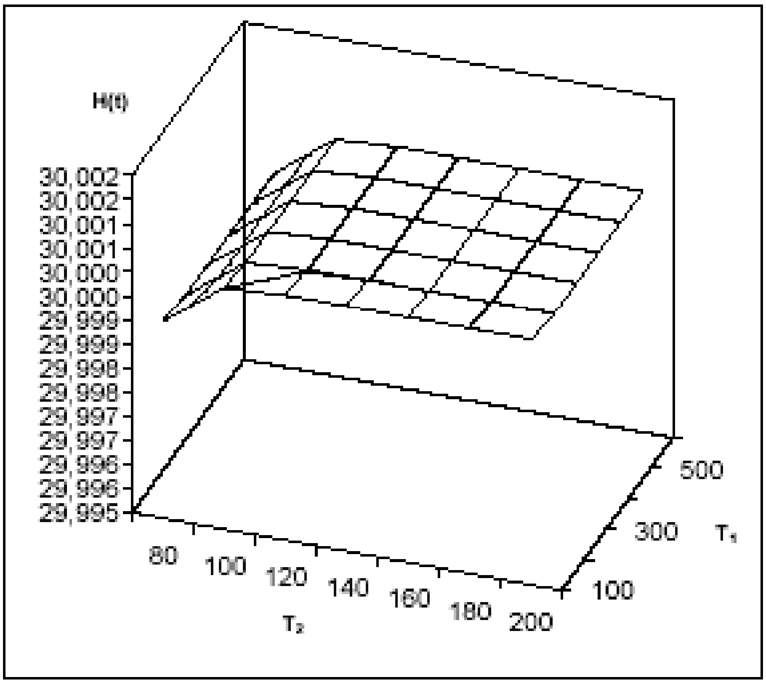

Fig. 6. Failure flow characteristics H(t) under combined strategy of maintenance depending on the regularity of repair activities T_1 and A_2, $\lambda_1=\lambda_2$=const and t=const.

CONCLUSIONS

The analytical dependencies for determining the Failure flow characteristics of machinery elements under two of the most commonly used strategies for technical maintenance and repair of machinery in Forestry have been drawn up.

The impact of the force of mortality on the Failure flow characteristics under both strategies for technical maintenance and repair of the machinery has been studied.

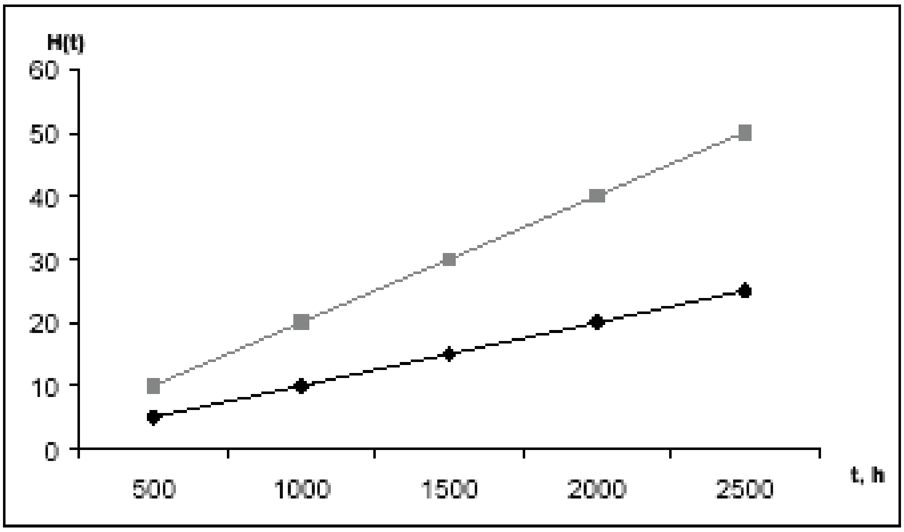

Fig. 7. Failure flow characteristics H (t) variation depending on the parameters of combined strategy of maintenance under combined strategy (T_1, T_2) and the force of mortality of the elements (λ_1;λ_2)

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КОМПЛЕКСЕН МЕТОД ЗА ИЗБОР НА ТРАКТОРИ И ТЕХНОЛОГИИ В ГОРСКОТО СТОПАНСТВО

Д. Динев, Г. Тасев, Ив. Марков, България

Предлага се комплексен критерий за вземане на решения при избор и доставка на оборудване за нуждите на горското стопанство.

Предложеният критерий отразява относителната тежест на параметрите при оформянето на технологичен комплекс от машини.

Критерият е приложим при вземане на решение въз основа на повече от два параметъра.

COMPLEX CRITERIA FOR SELECTION OF TRACTORS AND TECHNOLOGIES IN FORESTRY

D. Dinev, G. Tassev, I. Markoff, Bulgaria

Proposed henceforth is a complex criterion to be employed in decision-making for the selection and supplies of equipment or technological-machinery complexes for the needs of forestry.

The presented criterion will take into account the parameters of weight in featuring the technological complex of machinery.

The criterion is applicable to the cases of decision-making based on more than two parameters.

Very often in practice we must take a decision which of available on the market tractors (technology for mechanisation of the forestry or technologies for mechanisation of wood industry) to choose because of variety of supply and multiplicity of tractor parameters. Analogous to this is the selection of technology variant.

Further we will investigate suggested criteria in example of decision-making for selection of a forestry tractor only.

It is known that parameters of different brands and models of tractors very often are different. A problem appears how, by which parameter to choose the needed tractor. This problem gets more complicated because of that tractors are universal machines and are used as energy sources in many technological operations in agriculture, road building etc.

The purpose of suggested work is to suggest a complex criterion for selection of a tractor, which recognizes participation of single parameters in the complex evaluation.

In other words, when is necessary to make a parallel between two brands of tractors or two models of the same brand, is necessary to use a complex criterion for taking a decision which tractor to prefer.

If we must choose between two or several tractors by one parameter (power, carrying capacity, price etc.) better is the one with higher (power, carrying capacity) or lower (price) value of this parameter.

Let's have to compare two or more objects (tractors, engines). Let's mark the parameters of these objects with N, Q, and C. Let's assume that power of the engines of these tractors is equal (N_1=N_2), i.e. by this parameter both objects are equivalent. Then we must decide which tractor to select by the other two parameters (carrying capacity (Q) and price(C)).

It is known that graphic interpretation of a geometrical figure, which is received in a plane when we make multiplication of the two parameters (Q and C), is a rectangle and its area is S=Q*C. This way we assume the influence of two parameters on the complex valuation of the tractor.

Therefore, if we compare two tractors with parameters Q_1,Q_2 and C_1,C_2 , we can bring in coefficient k, which can express a relation between both areas, i.e.

$$k=\frac{Q_1.C_1}{Q_2.C_2}.$$

It is established, that when k-1.1-1.5, the evaluation about better object is very good; when k=2-2.5 it is high; when k≥2,5it is very high.

During the calculation of a coefficient k we must give an account of following:

- if we construct and develop new model of a tractor or engine, in the numerator of a formula we put parameters of a new model and we will get the value of coefficient k and we will decide if the valuation is good, very good, high or very high;

- if we are on the market and must choose better machine, but we don't know which model is newer, we replace the values of parameters of one model of machine in the numerator, and the other in the denominator and if the value of k≥1 better variant of the machine is the one, whose parameters are in the numerator;

- if we have calculated the value of the coefficient k and we have got value of k<1, then better is the model of a machine whose parameters are in the denominator of a formula of k. To give a valuation good, very good, high or very high we must calculate a reciprocal value of coefficient k, i.e. $k' = \frac{1}{k}$.

Analogically we proceed if we must choose better variant of a machine by three or more parameters. Then the value of a coefficient k is calculated using the following relations:

$$k = \frac{Q_1 N_1 C_1}{Q_2 N_2 C_2}; \qquad k = \frac{Q_1 N_1 C_1 ... L_1}{Q_2 \, N_2 C_2 ... L_2}.$$

Suggested complex criterion will be tested for some brands and models of tractors of John Deere and Massey Ferguson.

We compare three models of John Deere tractors (Table 1) by three parameters: power (N), carrying capacity (Q) and price (C).

Table 1. Parameters of John Deere tractors

Parameters	Model		
	6620 Premium Plus	6820 Premium	6820 Premium Plus
Power, h.p.	125	135	133
Carrying capacity, kg	7280	8240	8240
Price, € (Euro)	74109	69663	80045

We compare tractors John Deere model 6620 Premium Plus with model 6820 Premium.

$$k = \frac{135.8240.69663}{125.7280.74109} = 1{,}08.1{,}13.0{,}94 = 1{,}15.$$

Therefore, valuation of a John Deere tractor model 6820 Premium is good, compared with model 6620 Premium Plus tractor.

If we must compare model 6820 Premium with model 6820 Premium Plus, we get:

$$k = \frac{133.80045}{135.69663} = 0{,}985.1{,}149 = 1{,}13.$$

Therefore, model 6820 Premium Plus is better.

The same way we can compare Massey Ferguson tractors by parameters given in Table 2.

Table 2. Parameters of Massey Ferguson tractors

Parameters	Models		
	4270	6265	6260
Power, h.p.	110	114	114
Carrying capacity, kg	5500	7150	7150

We compare models 4270 and 6265. Then

$$k = \frac{114.7150}{110.5500} = 1{,}036.1{,}3 = 1{,}35.$$

Therefore, model 6265 is preferable because of its good rating.

Further we will compare two models of tractors of both brands by data, given in Table 3.

Table 3. Parameters of tractors

Parameters	Brands of tractors	
	6820 Premium Plus	Massey Ferguson 6260
Power, h.p.	133	114
Carrying capacity, kg	8240	7150

Value of coefficient is k= $\frac{133.8240}{114.7150} = 1{,}167.1{,}152 = 1{,}35.$

Therefore, 6820 Premium Plus tractor is better than Massey Ferguson 6260 and for that reason must be preferred by farmers, if it satisfies technological requirements of agricultural production.

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ПАРАМЕТРИЧНА ДИАГНОСТИКА НА НАДЕЖДНОСТТА НА МАШИННИ КОМПОНЕНТИ

К. Чуканов, Г. Тасев, България

Представен е математически модел, основаващ се на теорията на функция със случаен аргумент.

Изследването беше проведено и резултатите бяха получени поредица различни функции на диагностичните параметри и различни модели на флуктуация на стойността на параметрите при диагностичния процес.

DIAGNOSTIC PARAMETERS-BASED DETERMINATION OF MACHINERY COMPONENTS RELIABILITY

K. Choukanov, G.Tassev, Bulgaria

Developed and presented hereafter is a mathematical model set up using the theory of the random argument fraction.

The case study has been conducted and results have been obtained under a range of diverse functions of the diagnostic parameters and various patterns of parameter values fluctuations within the diagnostic process.

In sufficiently general conditions for operation of machines, the condition parameter U(t) is a monotonously increasing and (or) decreasing function of working off (t). For each fixed value of t the parameter U is a random quantity that according to our research is distributed according to Veibul`s or normal law [1; 2].

We assume that U_0 characterizes the initial velocity of the condition parameter, and U_r is the limit value of that quantity. For optimizing the regularity of the operations under TO, included in the TO system, it is necessary that the numerical characteristics of the quantity T be determined, which is viewed as a function of U, i.e. T = f(U). We designate with T_0 the value of the quantity T that corresponds to $U = M_{bi}$.

Thus,

$(M_t - U_0)/S_t = (M_{t1} - U_0)/S_{t1} = (M_{t2} - U_0)/S_{t2} = const.$

With linear correlation of U and t we get $U = U_0 + Vt$

Then $U_r - U_0 = VT$,

(1) $T = (U_r - U_0)/V = (U_r - U_0)t/(U - U_0)$,

Where $V = (U_r - U_0)T$, because $U_r - U_0$ is the constant at the moment T. The time when failure occurs under average value of the parameter U = Mt.

We expand the function (1) in Taylor`s line with close meanings of U = Mt and omit members of the line of third and higher order and after a series of transformations, using the characteristics of mathematical expectation, we obtain

The mathematical expectation

(2) $M(T)=T_o[1+St^2/(Mt-U_o)$

Or the dispersion

(3) $D(T)=T_o[St^2/(Mt-U_o)]\{1+2[St^2/(Mt-U_o)]\}$

The function of the resource distribution is obtained through integration of the expression for f(T) within the limit from 0 to T [1; 2] and reporting the function $V_r = f(V_u)$.

The important issue is how to find the distribution of U = f(T) if we know the distribution density of the random quantity (U) at the moment (tg) (Fig 1). It is proved (3) that if U = f(t) is differentiable and is a monotonously increasing or monotonously decreasing function whose reverse function is Ψ(t) = U/T, then the distribution density f(t) of the random quantity T will be found through the equation

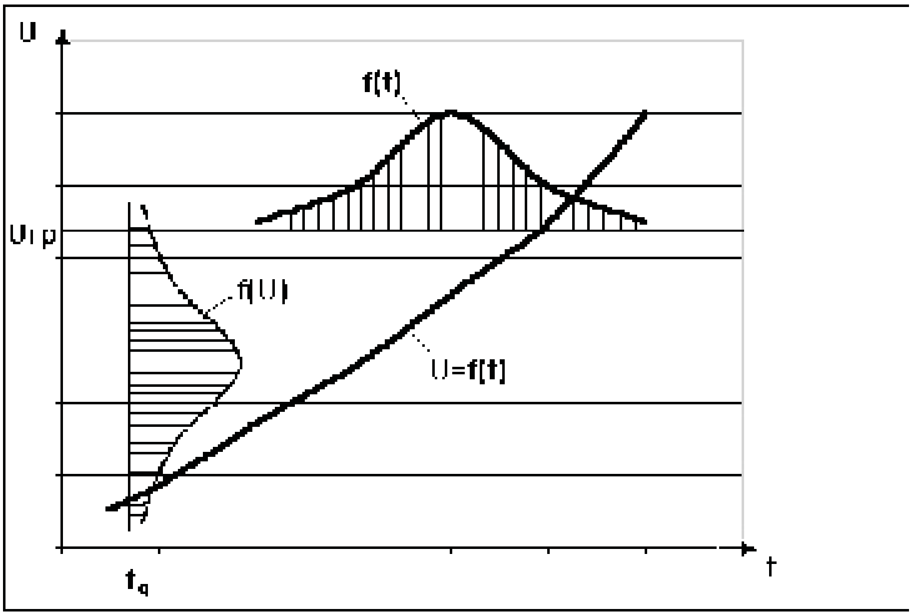

Fig 1. Distribution density of the condition parameter (U) at the moment tg

If we wish to obtain the correlations for determining the major numerical characteristics of the reliability indicators under normal law of distribution of the random coefficient, it is sufficient to put that b = 3,25 in the correlations in Table 1.

The distribution function of the reliability indicators in Veibul`s distribution is obtained after integrating of f(t) (Table 2) within the limits from 0 to t, and the correlations for determining the major numerical characteristics are displayed in Table 3.

Table 1. Distribution density of the reliability indicator f(t)

Function of the condition parameter, U(t)	Distribution density of υ according to Gauss`s law
$U(t)=V_o(t)$	$f(t)=\frac{U_{ГР}}{t^2\sigma_\nu\sqrt{2\pi}}e^{\frac{(U_{ГР}(t-m_y)^2}{2\sigma_v^2}}$
$U(t)=U_o+V.t$	$f(t)=\frac{U_{ГР}-U_o}{t^2}\cdot\frac{1}{\sigma_\nu\sqrt{2\pi}}e^{\frac{[(U_{ГР}-U_o)(t_o-m_y)^2]}{2\sigma_v^2}}$
$U(t)=V.t^\alpha$	$f(t)=\frac{\alpha U_{ГР}}{t^{\alpha+1}}\cdot\frac{1}{\sigma_\nu\sqrt{2\pi}}e^{\frac{[U_{ГР}(t^\alpha-m_y)^2]}{2\sigma_v^2}}$
$U(t)=U_o+V.t^\alpha$	$f(t)=\frac{\alpha(U_{ГР}-U_o)}{t^{\alpha+1}}\cdot\frac{1}{\sigma_\nu\sqrt{2\pi}}e^{\frac{[(U_{ГР}-U_o)(t^\alpha-m_y)]^2}{2\sigma_v^2}}$

Table 2. Distribution density of the reliability indicator f(t)

Function of the condition parameter, U(t)	Distribution density of υ according to Veibul`s law
$U(t)=V_o(t)$	f(t)= $\frac{U_{ГР}}{t_2}.\frac{bK_b^b}{m_\nu^b}.(\frac{U_{ГР}}{t})^{b-1}.e^{-\left(\frac{U_{ГР}}{t}.\frac{K_b}{m_\nu}\right)^b}$
$U(t)=U_o+V.t$	f(t)= $\frac{U_{ГР}-U_o}{t^2}.\frac{bK_b^b}{m_\nu^b}.(\frac{U_{ГР}-U_o}{t})^{b-1}.$ $.e^{-\left(\frac{(U_{ГР}-U_o)}{t}.\frac{K_b}{m_\nu}\right)^b}$
$U(t)=V.t^\alpha$	f(t)= $\frac{\alpha U_{ГР}}{t^{\alpha+1}}.\frac{bK_b^b}{m_\nu^b}.(\frac{U_{ГР}}{t^\alpha})^{b-1}.e^{-\left(\frac{U_{ГР}}{t^\alpha}.\frac{K_b}{m_\nu}\right)^b}$
$U(t)=U_o+V.t^\alpha$	f(t)= $\frac{\alpha(U_{ГР}-U_o)}{t^{\alpha+1}}.\frac{bK_b^b}{m_\nu^b}.(\frac{U_{ГР}-U_o}{t^\alpha})^{b-1}.$ $.e^{-\left(\frac{(U_{ГР}-U_o)}{t^\alpha}.\frac{K_b}{m_\nu}\right)^b}$

Table 3. Major numerical characteristics of the reliability indicators in Veibul`s law for distribution of the random coefficient V

Function of the condition parameter U(t)	Major numerical characteristics		
	$\bar{t}$	G	V
$U(t)=V.t$	$\frac{K_b.U_{гр}}{m_v}\Gamma(1-\frac{1}{b})$	$\sqrt{\left(\frac{K_b.U_{гр}}{m_v}\right)^2.\Gamma\left(1-\frac{2}{b}\right)-\bar{t}^2}$	$\sqrt{\frac{\Gamma\left(1-\frac{2}{b}\right)}{\left[\Gamma\left(1-\frac{1}{b}\right)\right]^2}}$
$U(t)=U_o+V.t$	$\frac{K_b.(U_{гр}-U_o)}{m_v}\Gamma(1-\frac{1}{b})$	$\sqrt{\left(\frac{K_b(U_{гр}-U_o)^2}{m_v}\right).\Gamma\left(1-\frac{2}{b}\right)-\bar{t}^2}$	$\sqrt{\frac{\Gamma\left(1-\frac{2}{b}\right)}{\left[\Gamma\left(1-\frac{1}{b}\right)\right]^2}}$
$U(t)=V.t^\alpha$	$(\frac{K_b.U_{гр}}{m_v})^{1/\alpha}\Gamma(1-\frac{1}{\alpha b})$	$\sqrt{\left(\frac{K_b.U_{гр}}{m_v}\right)^{2/\alpha}.\Gamma\left(1-\frac{2}{\alpha b}\right)-\bar{t}^2}$	$\sqrt{\frac{\Gamma\left(1-\frac{2}{\alpha b}\right)}{\left[\Gamma\left(1-\frac{1}{\alpha b}\right)\right]^2}-1}$
$U(t)=U_o+V.t^\alpha$	$[\frac{K_b.(U_{гр}-U_o)}{m_v}]^{1/\alpha}\Gamma.$ $(1-\frac{1}{\alpha b})$	$\sqrt{\left(\frac{K_b(U_{гр}-U_o)}{m_v}\right)^{2/\alpha}.\Gamma\left(1-\frac{2}{\alpha b}\right)-\bar{t}^2}$	$\sqrt{\frac{\Gamma\left(1-\frac{2}{\alpha b}\right)}{\left[\Gamma\left(1-\frac{1}{\alpha b}\right)\right]^2}-1}$

In the conducted study we found out that the change in the condition parameter of the elements is best approximated by the function $U(t) = U_0 + Vt$, where:

U_0 – the random quantity, characterising the harmonious co-working of the elements, numerically equal to the ordinate when t = 0, providing a good approximation of the parameter change from the end of the period of co-working until the moment of reaching the limit value of U(t);

The V-random coefficient, characterising the intensity of the parameter change.

The outcomes of the study have been shown in Table 4.

Table 4. Model of the parameters change of the technical condition of the elements of tractor TK-80 of class 14 kN

No	Parameters of the condition of the elements	Equation of the change in the parameters of the condition
1	Oil consumption	$U(t) = 2{,}10 + 11{,}05.10^{-5}t$
2	Passing of gases into the crankcase	$U(t) = 0{,}98 + 0{,}02.10^{-2}t$
3	Pressure in the system	$U(t) = 3{,}43 – 0{,}015.\ 10^{-2}t$
4	Revolutions of the centrifugal filter	$U(t) = 5780 – 1{,}528t$
5	Depositing on the walls of the centrifugal filter	$U(t) = 0{,}01 + 6{,}35.10^{-3}t$
6	Looseness of the valves	$U(t) = 0{,}27 + 1{,}25.10^{-5}t$
7	Pressure in the nozzles	$U(t) = 3{,}57 – 0{,}08.10^{-3}t$
8	Pressure before the filter for fine cleaning	$U(t) = 0{,}95 – 5{,}26.10^{-5}t$
9	Pressure after the filter for fine cleaning	$U(t) = 0{,}95 – 2{,}46.10^{-5}t$

The distribution density of the resource f(T) with a particular limit value of the condition parameter U_g can be obtained as a function of a random argument (3).

Table 5. Resource of the elements as per the parameters of the technical condition, liters of fuel

No	Parameters of the condition of the elements	V_t	$\overline{T} = \eta.T$	$T = \frac{U_g - U_o}{V}$	η	V_u
1	Oil consumption	0,45	1,36	22490	30586	0,90
2	Passing of gases into the crankcase	0,28	1,12	256000	286720	0,37
3	Pressure in the system	0,10	1,06	26000	27560	0,22
4	Frequency of revolution of the centrifugal filter	0,35	1,21	1200	1452	0,58
5	Depositing on the walls of the centrifugal filter	0,72	2,62	1280	3353	1,02
6	Agreement between the front wheels	0,36	1,24	16429	20371	0,54
7	Idle motion of the clutch	0,29	1,11	9117	10119	0,41
8	Idle motion of the steering mechanism	0,34	1,13	4083	4613	0,54
9	Looseness of the valves	0,48	1,46	4615	6737	0,92
10	Pressure in the nozzles	0,15	1,12	14700	16464	0,13
11	Full motion of the brake pedal	0,22	1,08	2371	2560	0,27
12	Loosening of the belt	0,32	1,14	9057	10324	0,49
13	Pressure before the filter	0,20	1,06	6993	7412	0,24
14	Pressure after the filter	0,34	1,22	18532	22609	0,54

In Table 5 the resource of the elements of tractors TK-80 as per the respective condition parameters has been shown, and in table 6 – the major numerical characteristics of the diagnostic parameters.

Table 6. Major numerical characteristics of distribution of the values of the diagnostic parameters in a particular section of the working off of elements of condition

No	Parameters of the condition of the elements	Section I fuel, (t_i)	Major $\bar{X}$	numerical S	character-istics V
1	Oil consumption, %	21220	3,6	0,55	0,44
2	Frequency of revolution of the centrifugal filter, min^{-1}	960	4,45	660	0,33
3	Depositing on the walls of the centrifugal filter, mm	960	8,68	6,04	0,70
4	Passing of gasses in the crankcase, m^3/h	4800	1,27	0,32	0,26
5	Pressure in the system, MPa	5760	2,97	0,52	0,18
6	Idle motion of the steering mechanism, ^{0}	4800	28,54	9,04	0,32
7	Looseness of the valves, mm	3840	0,254	0,12	0,48
8	Pressure before the filter for fine fuel cleaning, MPa	960	1,27	1,29	0,18
9	Idle motion of the clutch, mm	5760	50,0	13,5	0,27
10	Pressure at the beginning of sprinkling of the nozzles, MPa	5760	110,5	13,3	0,12
11	Full motion of the brake pedal, mm	1920	119,9	24,7	0,21
12	Pressure after the filter for fine cleaning, MPa	4800	0,77	0,81	0,31

CONCLUSIONS

Analytical correlations have been worked out for determining the reliability characteristics of the machine elements as a function of a random argument under Veibul`s law for distribution of the values of the diagnostic parameters.

The reliability of the elements of tractors TK-80 has been studied as per the major diagnostic parameters and the major numerical characteristics of their resource have been determined.

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ВЛИЯНИЕ НА ДИНАМИКАТА НА ЦЕНИТЕ ВЪРХУ ОБНОВЯВАНЕ НА МАШИННИЯ ПАРК

Г. Тасев, С. Глушков, Ив. Марков, България

Въз основа на уравнението на Волтер е развит математически модел, който описва параметрите и характеристиките на потока от неизправности на машини.

В настоящата работа са представени зависимости, които задават живота на машините (срока на служба) в зависимост от цените и влиянието на растежа на цените върху политиката на закупуване на машини и обновяване на машинния парк.

A STUDY OF THE PRICE DYNAMICS INFLUENCE ON THE POLICY OF MACHINERY FLEET'S RENOVATION

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A mathematical model based on Voltaire's equation has been developed to describe the parameter and characteristic of the flow of machinery decommission.

Provided in this paper have been relations indicating machine life-times (service terms) depending on the prices and prices growth influence on the policy of machinery fleet's purchases and renovation.

One of the important elements of technical policy in forestry is development of well founded strategy for replenishing, renovation, modelling and repair of machinery fleet, especially in conditions of lack of circulation assets in business organizations.

In works [1,2] are made attempts for solution of the problem and are given algorithms for working out, but with other parameters of economical environment where machines work.

Dependence of the production capacity of machinery fleet in function of the time and the dirigible factors can be presented in following description:

$$(1) \quad U(t) = N_1 Q_c(t) y(t) + \int_1^t u(t-\tau) Q_c(\tau) y(\tau) d\tau \,,$$

Where N_1 is an available machinery park in moment t_1;

$Q_c(t) = 1 - F_c(t) = 1 - \int_0^t f_c(\tau) d\tau$ - function of machines' durability.

Dirigible factors in (1) are the function of buying a stock of new machines u(t) and distribution of their lifetime $F_c(t)$. So the intensity of rejection of the machines depends on distribution of , in similar sums for unknown variable quantity can be taken a mathematical expectation of lifetime T_c. Type of this distribution function and numerical characteristics are considered as known because they can be determined in implementing of the experimental investigation of machines' lifetime. Distribution function of lifetime depends on machines' load, conditions of exploitation and legislative documents, which regulate a process of using of the machines.

In equation (1) there are more of one unknown quantities, i.e. machinery fleet can be formed in different variants of technical policy of the business organization. The fleet can be replenished intensively or by different methodology, using potential reserve of the machines. In every variant can be one or another positive or negative aspect because they are connected with different expenditures for their realization.

Let's examine some economical aspects in choosing of optimal lifetime of the machines as management parameter, determining to considerable degree the policy of using and renovation of the machinery fleet.

Expenses connected with buying a machines and their exploitation

$$(2) \qquad C_\Sigma(t) = S_{mo} \exp[\alpha(t) - \delta(t)] + \int_0^t S_T(\tau) \exp[\alpha(t) - \delta(\tau)]\tau d\tau \,,$$

where S_{mo} is a value of a replacing of the machines with new ones in moment t_o in BGN;
α (t) - factor, displaying a change of fabrication costs of the new machines.
δ (t) - discount factor;

$S_T(\tau) = k.S_{mo}.t^{\beta}$ - intensity of the expenditures of the machines' use in dependence of their age;

exp*t* - factor, displaying a maturing of the machines ;
k relation between the cost of the machines' use for an interval $\Delta t = 1$ and the price of the new machines in moment t_o

Gross income, which is realized by the business organizations, using the machines for time t can be expressed like:

$$W(t) = y\int_0^t S_{go}.\exp[\psi(\tau) - \delta(\tau)]\tau d\tau\ , \qquad (3)$$

where y is productivity of the machines, m^2/*year* ,
$S_{go}\exp\psi(\tau)\tau$ - price of 1 m^2 of wood in the function of time;
S_{go} - price of 1 m^2 of wood in the moment t_o;
$\exp\psi(\tau)\tau$ - index of change of the price of wood.

It is necessary to find such $t = T^*$, that adjusted to the initial moment summary relative expenditures for using of the machines and their replacement in moment $0 + T_c$ for the lifetime for unit adjusted production expenditures to be minimal.

We divide expression (1) into (2) and after some transformations formulate criterion for optimality in such mode:

$$Z = \frac{S_{mo}^0}{y}\left\{ \exp\left[\alpha(t) - \delta(t)\right]t + k\int_0^t \left[\tau^{\beta}\exp(\alpha(\tau) - \delta(\tau))\tau\right]d\tau \Big/ \int_0^t \exp\left[\psi(\tau) - \delta(\tau)\right]\tau d\tau \right\} \Rightarrow \min, \qquad (4)$$

Where $S_{mo}^0 = S_{mo}/S_{go}$ is equivalent value of the machine, m^2, wood in moment t_o.

Root of this normalized equation T_0^* is such optimum exploitation period, where minimum part of time, used for production is equivalent by value to expenditures for technical use of the machines for year.

CONCLUSIONS

A mathematical model for optimizing of a lifetime of the machines is elaborated. Suggested model is used for development and optimizing of the parameters of strategy for renovation of the machinery fleet, conformed to machines' prices dynamics.

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ЗАВИСИМОСТ НА ТРУДОЕМНОСТТА И РАЗХОДИТЕ НА ТЕХНИЧЕСКОТО И БИОЛОГИЧНОТО ПРОИЗВОДСТВО ОТ СТРУКТУРАТА НА ГОРАТА ПРИ ЕСТЕСТВЕНИТЕ СМЪРЧОВО-БУКОВИ ГОРИ В БАВАРИЯ

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Резюме

Отдавна се дискутира дали горскостопанските машини трябва да се съобразяват с изискванията на лесовъдството („лесовъдството е над техниката“), или обратно, лесовъдските концепции трябва да се съобразяват с възможностите на техниката („механизирана гора“)? Дали новите технологии на дърводобива не поставят отново под въпрос концепцията за природосъобразното горско стопанство? Дали са съвместими техническият прогрес и биологическият автоматизъм?

Данните, въз основа на които се отговаря на тези въпроси, трябва да са колкото може по-близко до практиката на горското стопанство. Затова в настоящата работа се анализират главно отчетните данни на горските стопанства, данни от инвентаризацията на горите и дългосрочни наблюдения върху горскостопанската техника. Резултатите са дадени в едри щрихи, за подробности препращаме към публикацията Pausch (2005).

Задачата на настоящата работа е от параметрите на гората да се изведат статистически модели за определяне на трудоемността и разходите за възобновяване и отглеждане на насажденията („биологично производство“) и на дърводобива („техническо производство“). За целта по данните на няколко близки до естественото си състояние и съответно стопанисвани смърчово-букови ревира на баварските държавни гори бяха потърсени връзките между параметрите на гората, лесовъдската концепция и технологията на дърводобива.

Статистическите резултати бяха свързани в система, която позволява да се проучи реакцията на различни рамкови условия, задания и параметри.

Резултатите говорят, че има два минимума на добивните разходи, които отговарят на силно различни, дори диаметрално противоположни, лесовъдски опции:

1. Едновъзрастна голосечно стопанисвана гора с висок дял на младите насаждения. Почти пълна механизация на дърводобива.
2. Изборно стопанисвана и подчертано дългосрочно възобновявана разновъзрастна гора с много големи размери на дърветата и значителен дял на машинно-ръчния дърводобив.

Резултатът от балансирането на трудоемността и разходите за възобновяване, отглеждане и добиване важи за горски стопанства със стопанска цел природосъобразно горско стопанство: В съответствие с тази цел трябва да се предпочита много дълъг възобновителен период в многоетажни насаждения, така че оскъпяването на дърводобива, което се получава при сегашното състояние на техниката, да се компенсира от поевтиняване на възобновяването и отглеждането („биологичния автоматизъм“). При това продължава да съществува голямото предизвикателство и при природосъобразното горско стопанство да се реализира наличният потенциал за технически рационализации и да се работи за тяхното развитие.

Най-новите харвестери и комбинираните технологии на дърводобив може би ще бъдат в състояние да намалят планината от разходи, която се издига между горните две алтернативи.

INTERRELATIONSHIPS BETWEEN FOREST STRUCTURE, WORK VOLUME AND COST OF STAND ESTABLISHMENT, STAND TENDING AND HARVESTING OPERATIONS IN FOREST DISTRICTS OF BAVARIA

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Abstract

The harvester technology again stimulates the old discussion whether forest machines should primarily adapt to silvicultural demands or, the other way around, silvicultural regimes should follow technical requirements. Are we now forced to leave the concept of nature oriented forestry? To what extent are technical rationalisation and „biological automation" compatible?

The data necessary to answer these questions should be as close to forest practice as possible. Therefore the analysis primarily bases on operational statistics of forest districts, forest inventory and long term studies of harvesting technology.

A central issue of this study was to derive statistical models of work volume and costs for stand establishment, stand tending („biological production") and logging („technical production") in Bavarian forest districts sustainable managed according to the principles of nature oriented forestry. The dominating tree species of these districts are spruce and beech. Interrelationships between the structure of forests, the concept of stand treatment and logging techniques are shown. For this purpose a system was built up which consists of the derived statistical relations and that allows to calculate the consequences of varying preconditions. A sketch of results is presented here. Details are documented in Pausch (2005).

The results prove that there exist two very different and opposed silvicultural options which lead to relatively low harvesting costs:

1. „High cutting intensity in fast cleaned even aged stands of medium sized tree volumes and a high portion of young stands. Harvesting is nearly exclusively mechanised."
2. „Selective cutting combined with particularly long-termed regeneration in unevenaged stands with very high tree volumes and a major percentage of chainsaw operations."

The resulting work volume and costs for measures in stand establishment, stand tending and technical production refer to forest districts managed according to nature oriented forestry in Bavaria. From this point of view very long-term regeneration in multi-layered stands should be preferred because actual possible disadvantages in logging costs are expected to be at least equalised by lower costs for stand establishment and stand tending („biological automation"). Herewith it is seen as a demanding task to materialize the given potentials of technical rationalization in nature oriented forestry.

The newest harvester generation together with combined harvesting methods may succeed in equalising the wall of higher harvesting costs between the opposed silvicultural options mentioned above.

ZUSAMMENHÄNGE ZWISCHEN WALDSTRUKTUR, ARBEITSVOLUMEN UND KOSTEN DER TECHNISCHEN UND BIOLOGISCHEN PRODUKTION IN NATURNAHEN FICHTEN-BUCHEN-WÄLDERN BAYERNS

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Kurzfassung

Es ist eine Diskussion mit langjähriger Tradition, ob Forstmaschinen sich in erster Linie an waldbaulichen Forderungen ausrichten sollten („Waldbau vor Technik") oder umgekehrt waldbauliche Konzepte der Technik zu folgen hätten („maschinengerechter Wald"). Ist das Konzept naturnaher Waldwirtschaft durch die aktuelle Holzerntetechnologie nun erneut in Frage gestellt? In welchem Umfang sind technische Rationalisierung und „biologische Automation" kompatibel?

Die zur Beantwortung dieser Fragen herangezogenen Daten sollten möglichst nahe an der forstlichen

Praxis liegen. Deshalb werden hier in erster Linie forstbetriebliche Statistiken, Daten der Forstinventur und aus langfristiger Beobachtung von Forsttechnik analysiert. Ergebnisse werden hier skizziert, zu Details wird auf Pausch (2005) verwiesen.

Im Zentrum steht die Aufgabe, statistische Modelle für die Abschätzung des Arbeitsvolumens und der Kosten in Bestandsgründung und Pflege („biologische Produktion“) sowie in der Holzernte („technische Produktion“) aus Parametern der Waldstruktur abzuleiten. Für naturnah bewirtschaftete Fichten- Buchen-Reviere der Bayerischen Staatsforstverwaltung werden Beziehungen zwischen der Waldstruktur, dem Konzept der Waldbehandlung und der Holzerntetechnik aufgezeigt.

Die statistischen Zusammenhänge wurden zu einem System zusammengefügt, dessen Reaktion auf die Veränderung verschiedener Rahmenbedingungen, Vorgaben und Parameter studiert werden kann.

Die Ergebnisse belegen die Existenz zweier Holzerntekosten-Minima, welche sehr verschiedenen bis entgegengesetzten waldbaulichen Optionen zugeordnet sind:

1. Altersklassenwald mit rascher Räumung in der Endnutzung und hohem Anteil junger Bestände. Die Holzernte ist nahezu vollständig mechanisiert.
2. Selektiv genutzte und ausgesprochen langfristig verjüngte, ungleichaltrige Wälder mit sehr hohen Baumdimensionen und einem bedeutenden Anteil an motormanueller Holzernte.

Das Resultat der Bilanzierung von Arbeitsvolumen und Kosten in Bestandsgründung, -pflege und Holzernte gilt für Forstbetriebe mit der Zielsetzung naturnaher Forstwirtschaft: Aus dieser Sicht sollte sehr langfristige Verjüngung in mehrschichtigen Beständen bevorzugt werden, da zur Zeit zu erwartende Nachteile in den Holzerntekosten durch Vorteile in Bestandsgründung und Pflege zumindest ausgeglichen werden können („biologische Automation“). Hierbei besteht jedoch die große Herausforderung, auch bei naturnaher Forstwirtschaft gegebene technische Rationalisierungspotentiale umzusetzen und an deren Weiterentwicklung zu arbeiten.

Die neuesten Harvester sind zusammen mit kombinierten Holzernteverfahren voraussichtlich in der Lage, den Holzerntekostenberg zwischen den beiden genannten Alternativen abzubauen.

BIOLOGISCHE AUTOMATION

Das Thema der waldbaulichen Rationalisierung wird seit langem diskutiert und mit unterschiedlichen Schwerpunkten bearbeitet (z.B. Pockberger, 1952; Leibundgut, 1973). Bereits Steinlin (1967) diskutiert die „[...] Automation der biologischen Produktion [...]“ mittels derer „[...] große Mengen und hohe Werte bei geringer Störungsanfälligkeit und geringer Notwendigkeit von Steuerungseingriffen durch den Menschen erzeugt werden“ und stellt die zwei Richtungen der „man-made-forests“ bzw. naturnah bewirtschafteter Wälder gegenüber. Er sieht die Automation vor allem für die organische Produktion als erfolgversprechend an, während die Mechanisierung der nicht automatisierbaren Tätigkeiten sowohl in der organischen als auch in der technischen Produktion möglichst weit getrieben werden sollte.

Definition biologischer Automation

Biologische Automation kann man als einen waldbaulichen Idealfall definieren, bei welchem allein durch die Entnahme hiebsreifer Bäume mit einem maximalen Anteil der Zielsortimente die für angestrebte Holzerzeugung notwendigen Wachstumsabläufe erhalten und gesteuert werden können. Es wird erwartet, dass es sich in der Praxis um einen möglichst eingriffsextensiven, auf Selbstregulation bedachten Weg zum angestrebten, theoretischen Idealzustand handelt. Dabei nutzt biologische Automation die lebenden Teile des bestehenden Waldökosystems.

Schütz (1996) unterscheidet bei der biologischen Rationalisierung die Prinzipien der Naturautomation und der Konzentration. Naturautomation kann demnach durch Ausnützung der natürlichen Selbststeuerungsmechanismen wie der natürlichen Selbsterneuerung und der Selbstdifferenzierung erzielt werden. Konzentration lenkt die Produktion oder die notwendigen Maßnahmen auf möglichst wenige Bäume zum Beispiel durch weite Pflanzverbände oder positive Auslese Durchforstung.

Naturautomation ist demnach ein Unterbegriff zur biologischen Rationalisierung. Im Idealfall der hier definierten biologischen Automation werden lediglich steuernde Holzerntemaßnahmen angewandt, nicht nur, um Selbststeuerungsmechanismen in Gang zu halten, sondern auch, um eine Konzentration des Wachstums und der Holzerntemaßnahme auf wenige Bäume zu erreichen. Die Naturautomation nach Schütz ist damit ein Teilbereich der Mittel der biologischen Automation, wohingegen bei biologischer Automation obiger Definition nicht alle gegebenen Möglichkeiten der Anwendung des Konzentrationsprinzips zum tragen kommen.

Biologische Automation ist also nicht deckungsgleich zum Konzentrationsprinzip oder der Naturautomation nach Schütz (1996) und ein Unterbegriff, kein Synonym der „biologischen Rationalisierung".

Die verbreitete Bezeichnung „biologische Automation" kann man aus der Definition heraus begründen. Die günstige Gestaltung des „Produktionsapparates" durch die Art der Entnahme der Produkte soll biologische und insofern natürliche Regulationsmechanismen in Gang setzen, die weitere steuernde Eingriffe unnötig machen oder großteils ersetzen, das heißt gleichsam automatisieren. Waldstruktur und Nutzung werden gemäß den Anforderungen dieser Regulationsmechanismen eingestellt, weshalb das Adjektiv „naturgemäß" hinsichtlich dieses Aspekts durchaus begründet ist.

FOLGEN FÜR DIE WALDSTRUKTUR UND DIE ART DER EINGRIFFE

Bei biologischer Automation ist die Stellgröße im forstbetrieblichen Regelkreis die Holzentnahme. Weil möglichst nur hiebsreife Bäume entnommen werden sollen, sind die Variationsmöglichkeiten der Stellgröße beschränkt. Es verbleiben als Variationsbereich der Holzentnahme:

- zeitliche Abfolge,
- Baumartenzusammensetzung,
- Eingriffsstärke und räumliche Verteilung.

Da auch in Zukunft wieder soweit möglich Zielsortimente geerntet werden sollen, ist die bevorzugte und laufende Entnahme der besseren Stämme dann nicht zulässig, wenn sich die Qualität des zu erntenden Holzes dadurch längerfristig verschlechtert. Vor allem muss die Holzernte ausreichend pfleglich von statten gehen. Je umfangreicher die verfahrenstechnischen Alternativen sind, desto besser kann der mögliche Rahmen der Stellgröße technisch ausgenutzt werden.

Der Spielraum für die Steuerung ist umso breiter, das System also umso stabiler, je eher es die gegebene Waldstruktur erlaubt, zwischen Alternativen nach Zeit, Baumarten und räumlicher Verteilung auszuwählen. Daraus folgt, dass in zeitlicher und räumlicher Verteilung sowie in der Baumartenzusammensetzung ausreichend Holzvorrat vorhanden sein sollte. Mit geplanten Holzerntemaßnahmen wird deshalb in der Regel deutlich weniger als der vorhandene Vorrat genutzt werden.

Um zeitliche Alternativen zu erhalten, muss auch für die Zukunft ein ausreichender Wahlbereich für die Stellgröße der Holzentnahme bestehen bleiben, damit nicht für lange Zeiträume auf die Möglichkeit der Steuerung im Sinne der biologischen Automation verzichtet wird. Aus den vorgenannten Punkten folgt, dass eine Optimierung der Variationsbreite in der zeitlichen Abfolge und der Eingriffsart stattfinden muss.

Die möglichen Alternativen der räumlichen Verteilung der Entnahme sind an die gegebene Strukturvariation eines Waldbestandes gebunden. Der Wald sollte demnach bevorzugt gemischt und strukturreich sein, einen Mindestvorrat aufweisen und selektiv mit nicht zu großer Eingriffsstärke genutzt werden. Dies kann an der Baumart, -zahl, -dimension und der Verteilung des verbleibenden und des ausscheidenden Bestandes festgemacht werden. Die Schwankungen der Waldstruktur dürfen deshalb in der Regel einen bestimmten Rahmen nicht verlassen. Die Variationsbreite der Eingriffsstärke wird weiterhin umso größer, je schneller die über Holzeinschlag als Stellgröße eingesetzten Produkte wieder nachwachsen können.

Das forstliche Handeln wird von selektiver, zielstärkenorientierter Nutzung, mittel- bis langfristiger Naturverjüngung mit kleinräumiger Differenzierung und Überlappung der Nutzungs- und der Jungwuchsphase gekennzeichnet sein. Der Anteil an reinen Vornutzungsbeständen soll hierbei möglichst niedrig gehalten werden.

EIN MODELL DER FLÄCHENZUSAMMENSETZUNG FÜR FICHTEN-BUCHEN - REVIERE NORDOSTBAYERNS

In der früheren Bayerischen Staatsforstverwaltung wurde über Jahrzehnte ein einheitliches Konzept der Forsteinrichtung angewandt, Details sind den Richtlinien für die Forstbetriebsplanung zu entnehmen (Bayerische Staatsforstverwaltung, 1982). Die Waldbestände werden Nutzungsarten zugeordnet:

Jugendpflege (JP), Jungdurchforstung (JD), Altdurchforstung (AD) und Verjüngungsnutzung (VJ). Des Weiteren gibt es die langfristige Behandlung (LB), eine Sonderform in Verjüngung stehender Altbestände, die in den untersuchten Revieren nur mit etwa 4 % Flächenanteil vertreten ist.

Bei vollständiger biologischer Automation ist eine kleinräumig variierende Überlappung zwischen Altholz und Verjüngung auf ganzer Betriebsfläche zu erwarten. Das Verhältnis reiner Jungwuchsflächen (Jugendpflege, abgekürzt „JP“) zur Fläche in Verjüngung stehender Altbestände (Verjüngungsnutzung, abgekürzt „VJ“) ist dann sehr gering. Hingegen sind nachhaltige Betriebe, die das Konzept rascher Abnutzung anwenden, durch einen relativ hohen Anteil an Jungwuchsflächen gegenüber flächenmäßig begrenzten Endnutzungsbeständen gekennzeichnet.

Wenn sich die Waldzusammensetzung eines Revieres im Gleichgewicht befindet, dann stellt sich abhängig vom waldbaulichen Konzept ein bestimmtes Verhältnis der VJ zur JP ein, da der JP-Anteil als langfristiges Produkt der Verjüngungsnutzung gesehen werden kann. In realen Revieren ist selbstverständlich durch Schwankungen in der Geschichte der Nutzung eine Streubreite zu erwarten. Bei langfristigem Vorgehen sinkt die Dauer der JP - Phase, da zur Zeit der „Abnutzung“ der Folgebestand bereits weiter entwickelt ist. Der Übergang von der VJ zur JP kann fließend gestaltet werden.

Der Anteil der VJ - Flächen an der Summe der VJ- und JP- Flächen ist somit ein Weiser für die Geschwindigkeit des Verjüngungsganges. Diese Relation wird im folgenden VJ-Quotient genannt:

VJ-Quotient := VJ / (VJ + JP) * 100 [%]

Auf der Basis von 76 Fichten-Buchen-Revieren Nord- und Ostbayerns wurde ein Modell hergeleitet, welches abhängig vom VJ – Quotienten die Flächenzusammensetzung eines Forstrevieres nach Nutzungsarten schätzt. Die Forsteinrichtungsdaten entstammen dem Zeitraum 1983 bis 1989, welcher durch geringe organisatorische Veränderung und relativ ungestörte betriebliche Abläufe gekennzeichnet war.

Abbildung 1 zeigt für ein kalkuliertes Szenario mit ¾ Nadelholzanteil, wie mit zunehmendem VJ – Quotienten der Flächenanteil der VJ an der Revierfläche überproportional ansteigt. Flächen mit Vornutzungsbeständen nehmen entsprechend ab. Bei einem VJ – Quotienten von 85% beträgt der Anteil der VJ einschließlich LB über 50% der Holzbodenfläche eines Reviers. Der Anteil der JP sinkt deutlich unter 10% der Holzbodenfläche ab. Zudem nimmt mit dem Umfang an VJ - Flächen auf diesen die Vorausverjüngung nicht nur überproportional zu, sondern wird auch strukturreicher.

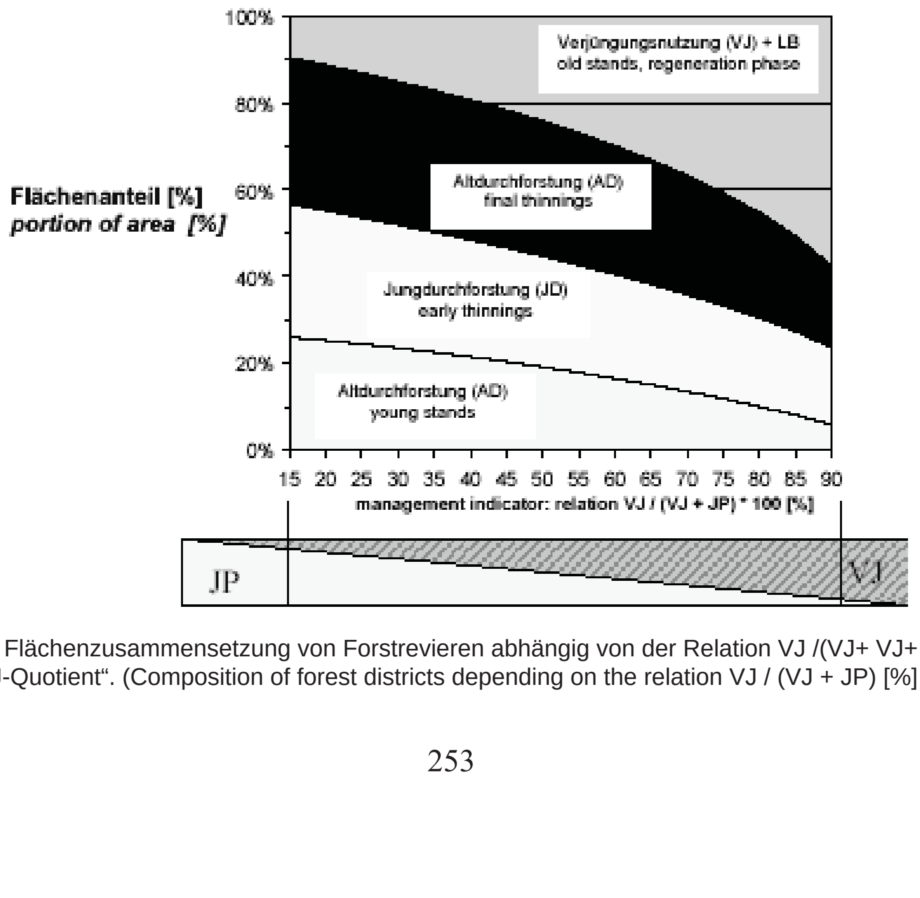

Abbildung 1. Flächenzusammensetzung von Forstrevieren abhängig von der Relation VJ /(VJ+ VJ+ JP) in % =: „VJ-Quotient“. (Composition of forest districts depending on the relation VJ / (VJ + JP) [%]).

SZENARIO ZU KOSTEN DER HOLZERNTE

Im Folgenden wird abgeschätzt, welche Holzerntekosten sich für bayerische Forstreviere bei unterschiedlichem VJ - Quotienten ergeben. Für die Modellkalkulation wird hier angenommen, dass alternativ entweder klassisch mit der Motorsäge gefällt und aufgearbeitet oder ein Langkran-Harvester für die Fällung und Aufarbeitung eingesetzt wird. Die Holzbringung erfolgt mit Forwarder, bei motormanueller Fällung und Aufarbeitung auch mit Forstschlepper und Seilwinde. Ausgewählt wird das jeweils kostengünstigste Verfahren.

Den unterschiedlichen Nutzungsarten werden für die Modellkalkulation bestimmte Entnahmemengen pro Hektar und Jahrzehnt zugeordnet. Sie orientieren sich an Zielgrößen der für die Forsteinrichtung zuständigen Forstdirektionen. In der Vornutzung (JP, JD und AD) erfolgen rein selektive Eingriffe. In der End- oder Verjüngungsnutzung hängt die Selektivität der Eingriffe vom VJ –Quotienten ab. Die Eingriffe werden umso selektiver, je höher der VJ – Quotient ist, je langfristiger also verjüngt wird. Der Anteil sogenannter Zielstärkennutzung nimmt entsprechend zu. Bei niedrigem VJ-Quotienten wird hingegen pro Eingriff ein hohes Volumen pro Hektar entnommen (rascher Verjüngungsgang).

Mit dem VJ-Quotienten ändert sich des Weiteren die Zusammensetzung eines Reviers nach dem mittleren Baumvolumen der Bestände. Hiervon hängt schließlich das mittlere Baumvolumen der Holzentnahme ab. Harvester sind bis zu bestimmten maximalen Baumvolumina einsetzbar. Die Selektivität der Eingriffe beeinflusst über die Fahrstrecke pro Baum die Produktivität, auch höhere Vorausverjüngung wirkt sich aus. Bis vor wenigen Jahren hatten auch die starken Harvester der zweiten Generation nur mäßige Netto-Hubkraft und mussten Bäume mit der Krone durch die Verjüngung ziehen, was hohe Schäden hervorruft. Die bis vor kurzem überwiegenden Harvestertypen konnten demnach in starken Beständen mit hoher Vorausverjüngung schlecht eingesetzt werden.

Die Reaktion des Systems auf unterschiedliche Vorgaben zum Beispiel hinsichtlich technischer Grenzen, Produktivitäten und Kosten kann studiert werden. Abbildung 2 zeigt beispielhaft ein Szenario der Holzerntekosten für Fichten-Buchen-Reviere in befahrbarem Gelände mit Einstellungen der Parameter, wie sie bei der bisherigen Harvestertechnologie der zweiten Generation galten. Einige Parameter der Modellkalkulation sind in Tabelle 1 genannt.

Tabelle 1 . Parameter des vorgestellten, beispielhaften Szenarios. (Parameters of the presented example of a scenario). (Efm = harvested timber, m³ solid under bark)

Merkmal	Ausprägung
jährlicher Einschlag gesamt	16,5 Efm/ha Nadelholz, 10,5 Efm/ha Laubholz
Einschlag Vornutzung	Nadelholz: 100 Efm/ha in JD; 75 Efm /ha in AD Laubholz: 50 Efm / ha in JD; 75 Efm / ha in AD
Zahl der Eingriffe	1 Eingriff pro Jahrzehnt
Durchschnittlicher Holzanfall pro Hieb	1000 Efm
Harvester in der Verjüngungsnutzung	kein Einsatz in Vorausverjüngung > 1,3 m Höhe
Obergrenze des mittleres Baumvolumens, Harvester	Nadelholz 1,6 fm, Laubholz 1,2 fm ohne Rinde
Baumartenanteile	75 % Nadelholz (Fichte); 25 % Laubholz (Buche)

Die Abbildung veranschaulicht, wie die mittleren Holzerntekosten pro Erntefestmeter ohne Rinde (Efm) frei Waldstraße eines gesamten Forstrevieres von zwei Größen abhängen. Eine der Einflussgrößen ist der bereits oben beschriebene VJ – Quotient (angetragen als Rechtswert).

Die andere Einflussgröße ist das „Niveau des Baumvolumens“ (angetragen als Hochwert). Letzteres beschreibt, um wieviel die Bäume über alle Bestände eines Revieres gegenüber dem Durchschnitt stärker oder schwächer sind. Der Durchschnitt gilt für die Häufigkeitsverteilung der mittleren Baumvolumina gemäß Inventurergebnissen.

Auf davon abweichende Niveaus des Baumvolumens wird extrapoliert, um das Systemverhalten zu studieren. Bei einem Niveau des Baumvolumens von 150% wird beispielsweise kalkuliert, dass die mittleren Baumvolumina über alle Bestände eines Revieres 50% über dem Durchschnitt nach Inventur liegen.

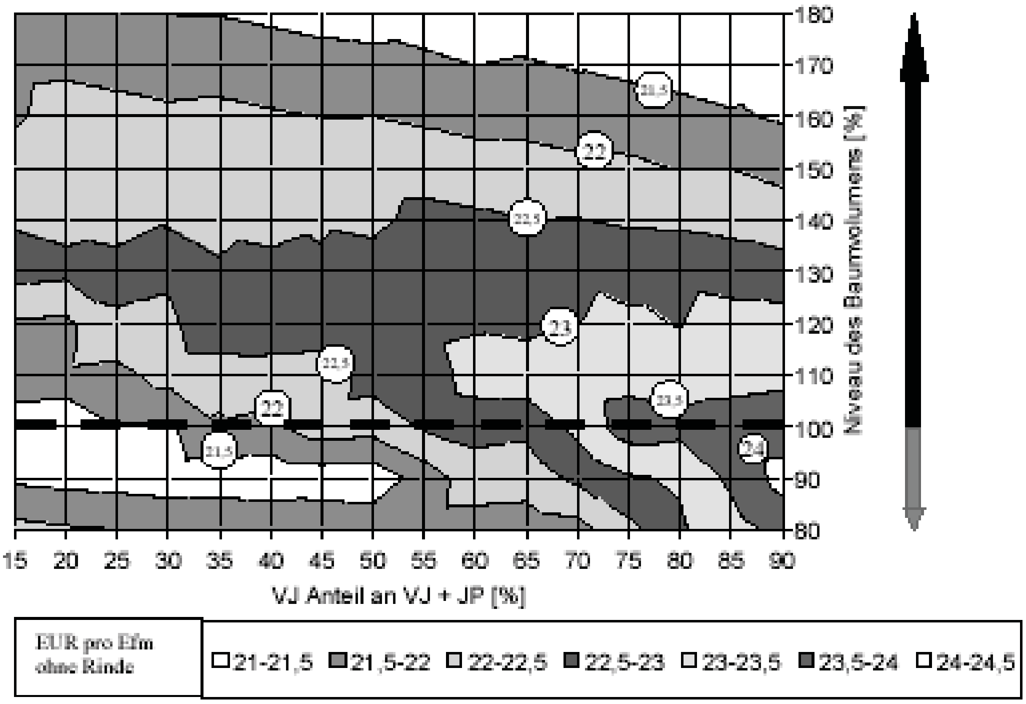

Abbildung 2. Beispielsszenario zu fichtenreichen Forstrevieren; Holzerntekosten frei Waldsstraße pro Efm, VJ-Quotient und Niveau des Baumvolumens; Einstellungen nach Tabelle 1.
(Example of a spruce dominated scenario; logging costs free forest roadside of forest districts depending on the relation VJ / (VJ + JP) [%] and the level of tree volumes. Parameters of Table 1).

Es ergeben sich Zonen unterschiedlicher Holzerntekosten je nach VJ-Quotient und Niveau des Baumvolumens. Zum Beispiel werden für ein Revier mit einem VJ – Quotient von 70% und einem Niveau des Baumvolumens von 120% Holzerntekosten von 23 Euro pro Erntefestmeter ohne Rinde frei Waldstraße kalkuliert. In der Realität dürfte die Marktkonkurrenz und das zeitliche Verschieben teurer Durchforstungen zu niedrigeren Kostenwerten führen. Hier geht es um den prinzipiellen Verlauf.

Ausgerechnet bei einer Häufigkeitsverteilung der Baumvolumina, wie sie nach Inventur vorgefunden wurde (Niveau 100%), nehmen die durchschnittlichen Holzerntekosten eines Forstrevieres zu, je längerfristig verjüngt wird (zunehmender VJ – Quotient). Zwar steigt die Stückmasse, jedoch müssen anteilig mehr Hiebe motormanuell durchgeführt werden. Trotz geringen Vornutzungsanteils steigen deshalb die Holzerntekosten unter Annahme der im bayerischen Staatswald anzusetzenden Löhne für Arbeit in Eigenregie.

Würde in Forstrevieren sehr langfristig verjüngt (hoher VJ – Quotient), dann können bei sehr hohem Niveau des Baumvolumens (sehr starke Bestände) auch mit höherem Anteil motormanueller Holzernte relativ günstige Holzerntekosten erreicht werden. In Abbildung 2 rechts oben führt die hohe Stückmasse wieder zu konkurrenzfähiger Produktivität motormanueller Holzernte.

Insgesamt werden zwei Minima der Holzerntekosten sichtbar, die sich diametral gegenüberliegen und dementsprechend die Diskussion prägten. Sie sind sehr verschiedenen, geradezu gegensätzlichen waldbaulichen Optionen zugeordnet:

A Altersklassenwald mit rascher Räumung in der Endnutzung und hohem Anteil junger Bestände. Die Holzernte ist nahezu vollständig mechanisiert (in Abb. 2 „links unten“).

B Selektiv genutzte und ausgesprochen langfristig verjüngte, ungleichaltrige Wälder mit sehr hohen Baumdimensionen und einem bedeutenden Anteil an motormanueller Holzernte (in Abb. 2 “rechts oben“).

Unter den vorgegebenen Rahmenbedingungen ist die Lage dieser Minima ist im Wesentlichen durch folgende Effekte begründet:

1. Bisherige Harvester der zweiten Generation können nun einen Teil der in den Endnutzungsbeständen vorkommenden Baumdimensionen aufarbeiten.

2. Je höher der VJ – Quotient, desto höher wird der Anteil der Zielstärkennutzung. Die geernteten Stämme sind also deutlich stärker als der Durchschnitt in den Endnutzungsbeständen. Damit wird mit dem VJ - Quotienten auch der Anteil der Stämme höher, welcher die bisherigen technischen Grenzen der Harvester überschreitet.
3. Mit zunehmendem VJ – Quotienten steigt auch der Anteil hoher Vorausverjüngung, in welcher bisherige Harvester schlechter einsetzbar sind.
4. Motormanuelle Holzernte wird erst bei sehr hohen Baumvolumina weit über dem in den Revieren gefundenen Niveau produktiv genug, um das Minimum B zu ermöglichen.

KOSTEN FÜR HOLZERNTE, BESTANDSGRÜNDUNG UND BESTANDSPFLEGE

Der Umfang der Aufwendungen für Bestandsgründung und Pflege hängt natürlich stark von der waldbaulichen Zielsetzung ab. In den untersuchten Revieren wurde gemäß den Vorgaben naturnaher Waldbewirtschaftung im bayerischen Staatswald ein Fichten - Buchen - Betriebsziel verfolgt.

Nach der Theorie der biologischen Automation nehmen die Kosten für Bestandsgründung und Pflege mit zunehmendem VJ - Quotienten ab. Das wurde durch die Analyse der Revierdaten statistisch bestätigt, war in den untersuchten Revieren jedoch nicht a priori zu erwarten. Denn es wäre auch denkbar gewesen, dass durch die hohe Zahl an Verjüngungsbeständen bei hohem VJ – Quotienten der Umfang künstlicher Vorausverjüngungsmaßnahmen, wie zum Beispiel gruppenweises Pflanzen von Laubholz, und damit der Aufwand für Bestandsgründung sogar zunähme. Auch das Volumen an Pflegeaufwendungen hätte mit den wachsenden Vorausverjüngungsflächen steigen können. Beides war in den untersuchten Revieren nicht der Fall.

Insgesamt folgt aus den Auswertungsergebnissen, dass die Kosten für Bestandsgründung und Pflege mit wachsendem VJ – Quotienten stärker abnehmen, als die kalkulierten Holzerntekosten ansteigen (Vergleiche 100 % Linie in dem Szenario nach Abbildung 2). Das heißt, dass bei langfristiger Verjüngung die Einsparungen bei Bestandsgründung und Pflege Mehrausgaben bei der Holzernte überwiegen.

Addiert man demgemäß die Kosten der Holzernte, Bestandsgründung und Pflege je genutztem Erntefestmeter, so folgt ein Kostenminimum für Reviere mit sehr langfristiger Vorausverjüngung (VJ - Quotient sehr hoch) und sehr hohen Baumdimensionen, das heißt mit weit mehr Starkholz, als in den untersuchten Revieren beobachtet wurde.

FOLGERUNGEN

Erst die verbesserten, aber hinsichtlich der Baumdimension noch deutlich begrenzten technischen Möglichkeiten der Harvester der zweiten Generation führen angesichts der Situation der Holzerntekosten im bayerischen Staatswald zur Aufspaltung in zwei Minima (Abbildung 2).

Die Harvester der ersten, in Mitteleuropa eingesetzten Generation waren hingegen noch zu schwach für die vorgefundenen Altbestände. Zudem ist hochmechanisierte Holzernte mit Harvestern in der Erst- und Zweitdurchforstung nicht kostengünstiger als motormanuelle Holzernte im Starkholz der Endnutzung, sodass Minimum A noch nicht deutlich wurde.

Die neueste, dritte Harvestergeneration mit sehr hohem Kranhubmoment und starken Aggregaten stellt gegenüber bisherigen Harvestern eine enorme technische Verbesserung dar. Besonders in Verbindung mit kombinierten Holzernteverfahren (z.B. Heindl, 2007) wird sich die Holzerntekostenlandschaft aus Abbildung 2 bei nadelholzreichen Beständen wiederum stark verändern.

Weitere Veränderungen sind zum Beispiel durch Mehrfach-Fällköpfe, Ernteverfahren für Biomasse, teilautomatisierte Bewegungsabläufe zu erwarten.

Szenarien der beschriebenen Art zu Holzerntekosten geben allmählich sich wandelnde Momentbilder mit einigen Jahren Gültigkeit bei einem bestimmten Entwicklungsstand der Forsttechnik wieder. Sie hängen stark von den betrieblichen Rahmenbedingungen ab. In der Zeit ihrer Gültigkeit dürften sie das forstliche Handeln und somit die Waldstruktur stark prägen.

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ОЦЕНКА НА ВЛИЯНИЕТО НА ИНСТИТУЦИИТЕ ВЪРХУ УПРАВЛЕНИЕТО НА ЧАСТНИТЕ ГОРИ В СЛОВЕНИЯ

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В настоящата работа е представена началната фаза на изследване, целта на което е определи влиянията върху управлението на частните гори и да оцени обективно мерките за институционална организация на управлението им.

След независимостта на Словения институционалното устройство на горскостопанския сектор се промени. Преди независимостта управлението на горите беше организирано така, че повечето решения се вземаха „отгоре". След независимостта частните горовладелци станаха самостоятелни и получиха своята отговорност за управлението на горите. Държавната служба по горите, която се финансира от правителството, не може да защитава достатъчно интереса на частните горовладелци. Според закона за горите е длъжна при управление и ползване на горите да осигури обществения интерес, независимо от собствеността. Следователно, една и съща институция представлява противоречиви интереси.

При все това лесовъдите от Държавната служба по горите изиграха важна роля за създаване на нова форма на асоцииране на частните горовладелци в Словенския частен горски сектор. Тези сдружения се организират „отдолу". При този подход немонополността/конкурентноспособността на управлението на частните гори ще расте. На сегашния етап възниква въпрос за ролята на ведомството при асоциирането на частните горовладелци и за това как то и другите субекти, свързани с управлението на частните гори, ще приспособят дейността и организацията си към обстоятелствата и промените.

Промените в социалната, естествената и икономическата среда ще доведат частните горовладелци и институции до етап, който определено е по-оптимален и при който те ще трябва да работят и да си сътрудничат. Всички фактори и институции, които имат влияние върху конкурентноспособността на управлението на частните гори ще бъдат изследвани. Трябва да се установи доколко те са успешни и да се покаже какви предимства и възможности ще имат частните горовладелци, ако промените настъпят.

EVALUATION OF THE INFLUENCE OF INSTITUTIONAL SUBJECTS ON PRIVATE FOREST MANAGEMENT IN SLOVENIA

Špela Malovrh, Janez Krč, Slovenia

Abstract: With the independence of Slovenia the institutional organisation in the field of forestry has changed. Before Slovenian independence, the management of forests had been organised so that the majority of decisions were made from top down. After independence private forest owners become independent and thus responsible for forest management. The Public forestry service which is financed by the Government can not protect the interest of private forest owners as well as it should, particularly as the Public forestry service is by the Forest Act obligated to assure public interest over management and use of forests regardless of the ownership. As a consequence, one institution represents conflicting interests. Nevertheless, foresters from the Public forestry service have played an important role in establishing a new form of associating the private forest owners in the Slovenian private forest sector. These societies are organised from the bottom up. With this approach the competitiveness of management of private forest property will increase. At this level, there is a question about the role of the individual institution in associating the private forest owners, Furthermore, how will individual institutions and other subjects that are connected with the management of private forests adapt their work and organisation to circumstances and changes? Changes in the social, natural and economical environment will lead private forest owners and institutions to a level which is definitely more optimal and where they will have to take part and work together. All the factors and institutions that have influence on the competitiveness of

management of private forest will be examined. We need to find out how successful they are and foresee what kind of advantages and opportunities private forest owners will have if changes occur.
In this paper, an initial phase of the research is presented in which are estimated the impacts on the management of private forest property that will objectively evaluate measures on a field of institutional organisation of private forest management.

INTRODUCTION

Since Slovenia gained its independence (1991), the institutional organisation of forestry has undergone a lot of changes. With separation of public from business activities (after 1993), Slovenian forestry experienced organisational changes. During the process of changes to the social regime and legislations, diverse institutions and forms of associations of forest owners emerged, however management of forest was organised from the top down, so the primary focus was the public interest rather than the interest of forest owners. Disadvantages in realization of organisational changes are seen today in weak organisation of forest owners, technological setback, non-optimal organisation of institutions, expensive institution activity etc.

Slovenian forestry will have to deal with the task of how to optimally use all production possibilities, how to organise forest owners so that they will manage their forest efficiently and how to optimally organise institutions in the field of forestry. The task is difficult and responsible if we know that private sector is predominant in Slovenian forestry.

PRIVATE FOREST IN SLOVENIA

In 1990 (i.e. before Slovenian independence), 38 % of the forests were state-owned and the rest was privately owned by approximately 250,000 owners. In 1991, the process of returning privately owned forests, seized by the government in the agricultural reform after WWII began denationalisation. A lot of forests have been returned thus causing a drop in the percentage of state owned forests down to 30 % of the total forest area (Bončina, Winkler 1999).

Private forests in Slovenia cover 70 % of forest area. In Slovenia forests take up 1,169,196 ha, out of which 0.8 million ha are privately owned. They are split into more than 300,000 properties and even more owners and co-owners. Average forest property size is reducing progressively. In comparison with the beginning of the previous century when the average property size was 5.6 ha, average property size has reduced by a half. So the average property size today is less than 3 ha. The reasons that have triggered these changes include: selling of part of forest, redirection of farms into non-farm property, division of forest because of payment of inheritance, denationalization etc. Private property is very fragmented. From the forest management point of view it is important that we know how many spatially separated plots a forest owner has as this indicates a real fragmentation of property. From results of a different survey it is possible to gather that a forest owner has on average three spatially separated forest plots. Fragmentation of private property is not only displayed in small size of individual property and in large number of spatially separated plots but also in most different shapes of these plots.

All of the above-mentioned factors led to the point when number of forest owners because of division of property on inheritance is constantly increasing, when average property size is smaller, when attachment of private forest owners on forest and dependence on wood is low. For these reasons, the realization of possible removal is in average lower than the actual capacity of forests.

OWNERSHIP STRUCTURE OF SLOVENE FORESTS

As can be seen in Fig. 1, 27 % of Slovenian forests are owned by the state, 33 % are owned by family farms, 37 % are owned by non-farm owners and 3 % are owned by others, like cooperatives, church etc.

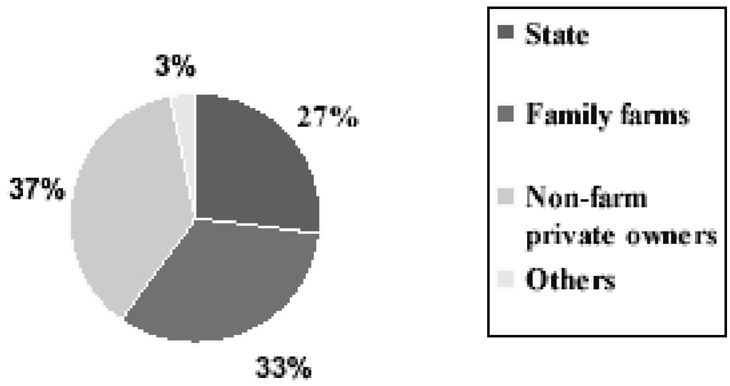

Fig. 1. Ownership structure of Slovenian forests

HISTORY OF ORGANISATION MANAGEMENT WITH PRIVATE FORESTS IN SLOVENIA

For over 150 years, the majority of Slovenian forests were owned by small holders. After the Land Absolution Decree of 1848, the majority of Slovene forests were brought into family ownership. Initially, forest owners had to pay substantial compensations, and many took out large loans to cope with increasing liabilities. As a result of high interests charged by lenders, forest owners were forced to start organising into credit cooperatives (Medved, Malovrh 2006). Cooperatives experienced a boom at the beginning of the 20th century, but their growth was stopped by WW I and the Great Depression that followed.

In the first post-war period of WW II (1945-1951), the main aim in the field of forestry was to ensure the foreseen extent of felling. The state-owned forests were managed by state forestry organisations, but there was no particular organisation for the management of private forests. Only after the demand for extensive production had fallen, it was possible to consider a complex management in private sector and consequently an appropriate organisation to perform it. This assignment was primarily confided to co-operatives (Winkler, 1983). Cooperatives prospered once more. By including the management of private forests into agricultural cooperatives in 1960, a strong grouping of cooperatives was carried out. Forest management within the cooperatives was intended to be organised as an independent facility; however, this principle was never put into effect. Despite some success with combining private forests and private forest production, the cooperatives had not given the expected results.

The beginnings of the joint management of state-owned and private forests can be traced into the early 60s, when under the Forest Act from 1961 a process of nationalization of private forest production had started. Institutions responsible for the nationalization were agricultural cooperatives as well as forestry enterprises. The Forest Act from 1965 determined that all private forests in the region should be managed by regional forest enterprise. Thus a process of joint management of state-owned and private forests within the forest enterprise had begun. The position of farmer - forest owner in the joint management was further defined by the constitutional amendments in 1971 and later confirmed in the new constitution in 1974.

For associated farmers - forest owners were by common management assured cooperation in administration (management) of Forest enterprise organisations, independent decision making concerning management of their forests and about created profit. Forest owners were able to organise themselves within Forest enterprises into Organisations of Cooperants. Only one in ten private forest owners was actually a member of such an organisation (Winkler, Gašperšič 1987). The share of members was higher in areas where the average size of forest holdings was larger. Forest owners had the possibility to fully or partly participate in forest production with their work or equipment. Additionally, forest owners were able to entrust the management of their forests to Organisations of Cooperants. The membership in this organisation was voluntary, but the members were obliged to sell their wood through the Basic Organisation of Cooperants (Šumarska enciklopedija, 1987). All this caused the owners to feel that their ownership was only theoretical, as their ability to make decisions in forest management was limited.

On the basis of a new Forest Act (OG RS, 30-1299/93), the separation of activity was done with which separated public interest from business. Private forest owners that were members of the former organisation, because of legal regulation of common management strongly dependent on Forest enterprises became in the new circumstances independent and thus responsible for the management of their properties, but in matters of public interest for all forest they became dependent on the help and counsel of Slovenian Forestry Service (Winkler, 1997).

ORGANISATION OF PRIVATE FOREST MANAGEMENT NOWADAYS

Within the Government of Republic Slovenia works the Ministry of agriculture, forestry and food, whose tasks primarily include: preparation of legislation and regulations, accompanying of forest management, control, confirmation of forest management plans and representation of interests of forestry in relation to other branches of economy and other social activities, such as ensuring integrated development of forestry (Košir, 1996).A body comprising the Ministry is Inspectorate for Agriculture, Forestry and Food. The inspectorate is organised into six inspection services. One of them is the Forestry Inspection Service. The activities of Forestry Inspection Service are to supervise all work in the forest and inspect the documentation for this work, monitor the implementation of the general subsides of forest management and forest cultivation plans, supervise the work of the persons working in the forest, forest owners and other users of the forest and the forest area, stop work which contravenes the law and break its regulations and review and monitor the implementation of forest protection measures (www.mkgp.gov.si).

The task of the Forestry section at the Ministry of Agriculture, Forestry and Food is also to monitor the Slovenian Forest Service and professionally co-operate with it in relation to the preparation of programmes at state level.

Slovenian Forest Service, which is professionally responsible for activities of public forestry service, directs the development of all forests in Slovenia The tasks of Slovenian Forest Service are: directing forest management, monitoring the forest and their development, constructing the forest protection plan, financing and co-financing of some investments to forests from the state budget of the Republic Slovenia, execution of administrative procedure, protection of forests, selection of trees for removal in cooperation with forest owners, consultancy to owners of forests, maintenance of forest roads, planning of development of populations of wild animals and measures in wild animals environment, execution of training activity for forest owners, public and edition of agreements for interventions to forest space (www.sigov.si/zgs).

As a nongovernmental organisation the Chamber of Agriculture and Forestry was established based on the Chamber of Agriculture and Forestry Act (OG RS, Nr. 41-2025/99). The act requires compulsory membership for all forest owners and agricultural land owners whose cadastral income exceeds a prescribed limit (approximately 85 EUR/ha in 2005). Forestry advisory service that works in the frame of Chamber whose services are accessible to all members is not sufficiently covered as 13 regional units only have 3 advisors (as of March 2006). Another problem is also that forest owners with a small forest holding have a low cadastral income and are consequently not members of the Chamber. However, it is known that most forest management problems occur with owners of small forest holdings (Jeromel, 2004).

At the national level, forest owners are combined into the Cooperative Association and Association of Forest Owners. The Cooperative Association of Slovenia was established in 1972. In accordance with the Cooperatives Act (OG RS, Nr. 13-1/92) and following the principle of voluntary membership, the members of the Association became cooperatives who performed agricultural and forestry activities, and other legal persons, managed mostly by those cooperatives or those whose membership was in the interest of the Slovene cooperative system. The Cooperative Association primarily performs activities for the improvement of the economic situation of its members, participates in the regulation of social issues in rural areas and represents the interests of farmers and their organisations in the Republic Slovenia

(Jeromel, 2004).

The Association of Forest Owners was established in 2006 and combines 11 local societies (forest owner societies and machinery hire syndicates). The Association of Forest Owners is the first organisational form at the national level where the initiative came from the bottom up, namely from the owners themselves. The Association was established with the principal aim of ensuring more effective management of private forests, that is to say that the forest, in respect of all criteria of sustainable and close-to-nature forestry, gives the owner a certain income (Founding General Meeting of the Association 2006).

On a local level, the owners are combined into machinery hire syndicates, study circles, forest owner societies, cooperatives and machinery communities.

Cooperative system has a long and strong tradition. The cooperatives in the forestry field join forest owner mostly in the marketing of wood, but partly also in forestry production itself (Jeromel, 2005).

Machinery community as a form of interconnection and cooperation reached its peak in 1976 with cheap loans. The main feature of machinery community was the combined purchase of machinery and equipment. The investment is distributed among several farms, which are community members. The machinery is used by community members when they need it (Plej, 2001).

Study circle is a form of pleasant, voluntary non-verbal learning primarily for adults with the expert assistance of a mentor. A group consists of five to twelve members who can be very different, but are connected by a common wish or interest to achieve something or carry it into effect. The topics of these groups can be most diverse (Study groups, expanding the circle of development, 2005).

Within machinery hire syndicates private forest owners with their work carry out services for other members through their work and use of own machinery within the framework of an activity defined by regulations on neighbour assistance (Dolenšek, 2006; Klun, 2002). Machinery hire syndicates are voluntary associations of farmers operating on a group basis. These associations do not require a lot of administration. The main purpose of their operation is rational usage of expensive machinery and work capacity rather than profit (Medved, Malovrh, 2006).

Forest owner societies started to appear after 2001. Forest owners organised themselves in forest owner societies because of a series of local initiatives aimed at establishing special forest owner societies. The Societies Act (OG RS, Nr. 60-2789/95) forms the legal basis for such organisations. In their efforts, forest owners are helped by field foresters employed by the Slovenian Forest Service. The society aims to increase the effects of sustainable and close-to-nature forest management of private forests. It places particular emphasis on the following activities: informing its members, education, organised sale of timber and work projects in forests, promoting the completion of necessary work, assisting its members in obtaining appropriate education for forest work etc. (Mori, 2005).

Educational programs for private forest owners are carried out by Secondary School for Forestry and Wood Processing in Postojna. They organise a special training for forest owners in co-operation with Slovenian Forest Service.

Organisation of private forest management is schematically shown in Fig.2.

AIM OF RESEARCH

The aim of the research is to study the influence of institutions on forest owners with regard to property size, socio-economic status, forest owner dependence on forest and to examine the roles and tasks of individual institutions in organising private forest owners. On a base of condition analysis we will examine what are the possibilities of adapting their activities (of taking steps) of individual institutions in changed technological and social circumstances and to assess the suitability of inter-institutional links. We want to pass directives for optimal organisation and develop a decision support system in the process of assessing factors that affect private forest management. A decision support system will have for the utility function more alternatives that will be related to a rise of private forest management level – from point of forest production as from effect of forest for needs of social and ecological functions of forests. The suggested decision support system must be flexible in terms of including different institutional subjects (addition of new and elimination and transmission of tasks and duties on existing subjects) as well as optimization of their momentary tasks.

DECISION SUPPORT SYSTEM

We will make a decision support system (picture 2), which will help us evaluate factors that have influence on private forest management. That decision support system will help us in planning private forest management. A model will be a conglomeration of modules with a specific entrance. By varying them, we will generate output data for an assessment of private forest management. Basic entry data are natural potential, social environment, conditions in private sector and institutional influences. Decision support system will be introducing a projection of present conditions into future. The analysis of possible scripts considering changing of factors that have influence on management system will be carried out. As a result we want to achieve a social and economic balance, bigger economic efficiency and optimal institutional organisation.

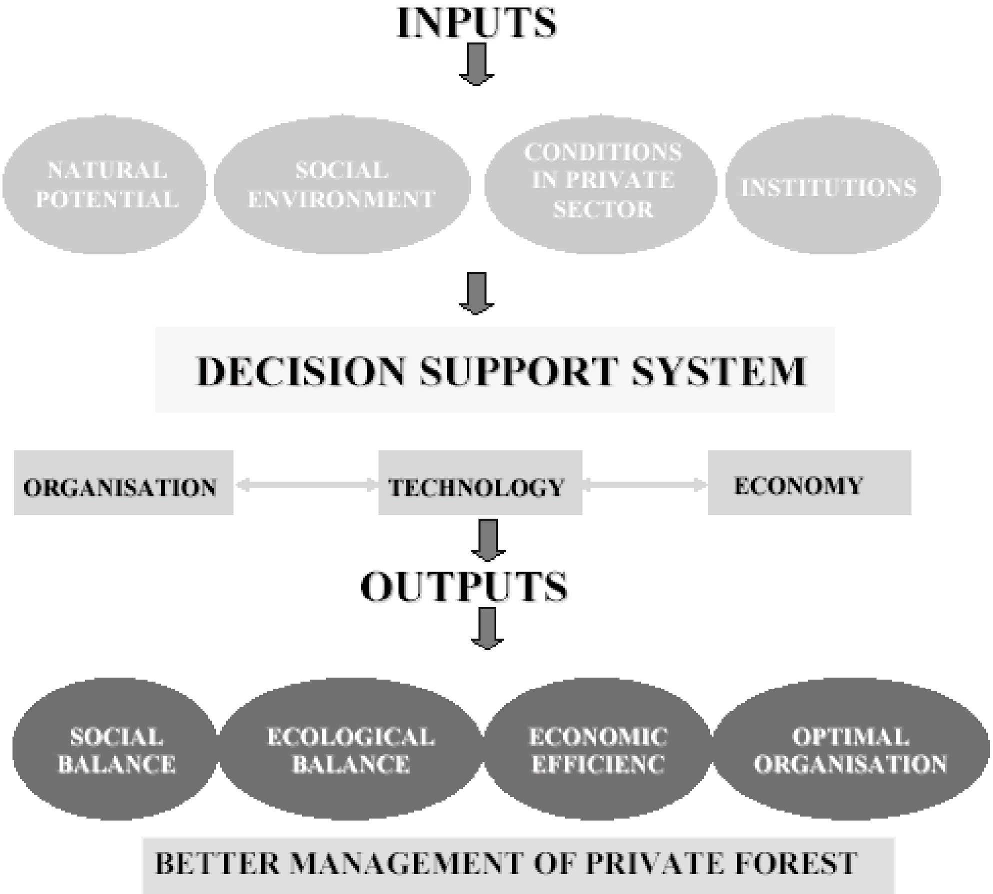

Fig. 2. Decision support system

DISCUSSION

Large plots, a high percentage of private forest and low intensity level of forest management and consequently low exploitation of natural potentials (production, social and environmental) of Slovenian private forests dictate organisational changes in forestry. Private forests need firm and stable organisations of forest management that will be adapted to the role of forests and goals of those who manage them. The organisation of private forest management must allow reconciliation of private interests and public interests for forests.

Organisational solutions must give every private forest owner an opportunity to assert their interests concerning the management of forest regarding all forest functions. All organisations that act in the field of private forestry must be optimally and rationally organised. The tasks covered by different organisations should not double. Organisations must stimulate private forest owners to associating, which contributes to more rational, more efficient and economically more successful management of forests. Different forms and manners of associating of private forest owners and properties must be suggested, voluntary or with legal regulative. The best solution is forms of associating that are voluntary and sufficiently flexible in their operation.

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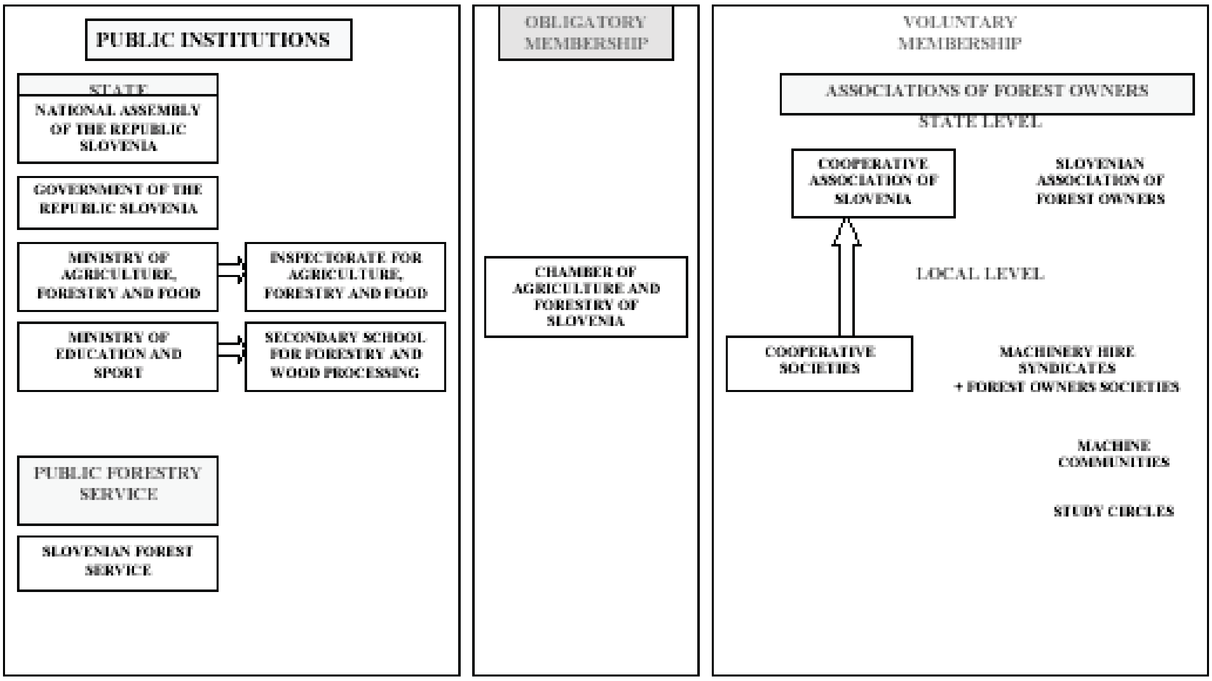

Picture 1: Organisation of private forest management

OPTIMIZATION OF TECHNOLOGICAL STRUCTURES SAWING OF WOOD IN VIEW OF REQUIREMENTS OF THE MARKET

Chernykh A.S., Russia

In modern conditions the attitude of the world public and state structures to forestry, forestry storing up and wood processing qualitatively changes. Solving the problems of forestry complex the main demand is providing a careful attitude to a forest as a source of clean air, water and trade ecologically pure competitive production, is producing on the basis of effective resource saving technologies of wood processing. Besides, under conditions of a rigid competition it is necessary to provide for a rapid change of nomenclature of produced goods of raw wood material.

The existing equipment of many wood-processing enterprises, as a rule, is not adapted to readjustment according to a market demand for the producing production. The cardinal solution of wood-processing enterprises work problem under the condition of rapidly changing market demands for saw production is possible by using new approaches to a doing work technology.

One of such new approaches is an introduction of flexible economical techniques to a saw production manufacture which allow to easily adapt to different parameters of raw material processing by producing goods of the required look and quantity. In forestry sawing first of all we mean a possibility of raw material cut out scheme changes and resizing which go to a log sawing.

Nowadays three principally new approaches to creating flexible technologies of saw production manufacture are known. The first one is based on using a band-sawing equipment. It is a regulation of saws' turning by changing schemes of log cut out in every sawing circle. The second approach provides for using of forestry sawing frames working with the fixed saw turning for cutting raw material out. The principle of the third approach provides for using flexible transport system in forestry sawing workshops, based on using cranes-girders and different pine lines.

Concerning three basic flexible technologies of saw production and their combinations we on the basis of a multicriteria optimization of technological structure of a complex system which ensures realization of a number of conditions of wood have offered a new approach to the development of the appropriate variants of technologies. The specific of solving problems of saw production manufacture optimization defines the methods of the used mathematic description. The existing regular methods of optimization in Russia and abroad, linear and nonlinear programming do not give a quite objective solution. On the one hand, the mathematic system of these methods intends for the restricted number of variants and varying parameters and their increasing demands significant assumptions and simplifications stipulated by complexity of computational procedures. On the other hand, the area of admissible solutions is non-convex and incoherent, i.e. the problem discrete. Unlike integer problems (problems about assignments, planning, control, etc.) the area of admissible change of any variable here is not the series of the whole non-negative numbers and the given final sets which are discrete and closed. It is a subject domain of discrete mathematic programming, the tasks of which are treated as irregular. That is why the solution of saw production manufacture optimization with the account of all the range size-quality raw material parameters, ready-made production and technical equipment parameters, indexes of effectiveness, etc. is necessary to find in the field of discrete programming by taking it to the of an integer task. Thus, the mathematic relations as a component of the theory of sets and in particular the theory of binary relations is applied.

The language of binary relations allows to compare any objects according to qualitative indication. According to a type of qualitative information there is a definite class of relations. And with their help we can describe different types of cohesion element set and sets. With the help of binary relation and introduction of mathematical programming schemes it is possible to describe any mechanism of choice, however, thus an examined object should be presented as a system.

The system is defined by a family of sets and determined as a proper subset of the cartesian product where V-family of sets. For transformation from common complex system to technological model of a complex process two possible relations are selected. In the first case the system is understood as a ratio $S \subset X \times Y,\ X \subseteq A^T,\ Y \subseteq B^T,\ S \subseteq A^T \times B^T$, where X, Y-input and output objects of the system S; T-the linearly ordered set of instants; A, B-functions defined by sets of instants T. In the second case it is possible to present a ratio as a ratio of sets in an algebraic system. The algebraic system, such as t, is an object $V = \left(A, O_F, O_P\right)$ consisting of three sets: nonempty subjects A, sets of operations $O_F = \left(F_0, ..., F_n, ...\right)$ and sets of predicates $O_P = \left(P_0, ..., P_n, ...\right)$ given on the set A as that pair of the examined operations and predicates should satisfy to the conditions: for all $i\left(F_n\right) = j_n$ $n<a$ and for all $i\left(P_b\right) = i_b$ $b<\beta$. The type of t level (a, b) there is a pair of maps W(a)→N, W(b) →N of sets W(a), W(b) in the set N = [0,1,2...] The type t is written as t=(jo,...ja...,io,...ib...) $n<a$, $b<\beta$. Here a, b, n, β are serial numbers. According to the algebraic system definition we can conclude that the subject area of the theory of algebraic system is sets the definite sequences of operations and ratios.

The combination of ratios can be presented by a matrix which is an analytical map of the graph. The link of the graph of matrix as binary ratios allows transferring the features of the structure of a technological process to the language of numbers. The graph keeping his obviousness and content of the object reflected by it allows to build formal algorithms of transformations using its own matrix equivalents is easily treated by the computer.

During multivariable projection of the flexible economical technologies of saw production manufacture the problem of searching an optimal coverage of the one set by another according to the chosen criteria is solved, i.e., a minimum coverage of the graph is calculated. The technological structure of the manufacture is optimized step by step with the introduction of the needed criteria and binary relations between sets on every step.

The task of the first stage is the choice of variants of the least power-intensive technological equipment on set of indexes of efficiency, parameters of preforms and workpieces, values of parameters of this equipment and on set of technological operations with the quantitative estimation of redundancy and chosen variants complexity. For this purpose the ordered train of preform and workpieces surfaces is shaped, i.e. the geometrical model is made. On the basis of binary ratios between the range of parameters of the technological equipment both ranges of parameters of raw material and production introduced as Boolean matrixes, the estimation of redundancy of the technological equipment is made.

The index of complexity is evaluated at the coverage of technological operation set by the technological equipment set. At the second stage the technological structure admissible variants of manufacture satisfying the system of efficiency indexes are selected. Thus the number of indexes and variants is not restricted. The purpose of the first stage is a technological structure multicriteria optimization of wood processing on the basis of unconditional criteria reference system with the help of information searching method. The unconditional criteria of reference (criteria of Pareto) have inpertant features from the point of view of choice multicriteria task solving elimination at an early stage of set of the worse variant set.

The input data for each of variants is represented as matrixes on the basis that variant comparability conditions can be formulated with the help of binary ratios of not strict order and tolerance. During the third stage of optimization three types of restrictions are taken into account: technological – the sequences of process equipment applications should not disturb technological order ratios; constructive – the arrangement of technological equipment should not contradict its constructive compatibility; and technical and economic ones.

At the final stage the operation condition of optimal technological structure are analyzed and specified.

At each design stage a lot of problems are solved the most significant of which is the choice of the optimal scheme cut out on size-qualitative parameter set of raw material and ready-made production.

One of the most characteristics of forestry material cut-out way is an orientation of saw production to a year's layer. Saw production of tangential arrangement better comes in zones of log quality and their exit is more than of radial arrangement. It is possible to explain according to the analysis of qualitative zones of the appropriate breed.

Saw logs in different parts have a different amount of wood defects which define the quality of the appropriate log parts. The series of the main defects is rather regularly arranged according to the length direction and a cross section of the saw logs. By this way, usually knots, core week wood are arranged. If the regularities of defect distribution is known, the saw cut material for getting a high quality production can be lead with the optimal direction of kerfs. The solution of this problem becomes more difficult when in the orders of the consumers requirements are put to give saw production of a special quality or sort. For example, saw production which has the greatest cost and demand. However, it is produced by using a sector way which is the worth as for qualitative zones of logs that leads to a lot of wastes.

The qualitative use of log zones depending on the application of this or that scheme of cut out will decrease in the following order-circular, paving, segment, sector. The given conclusion can be used in the cut out scheme choice and is formalized according to the following: circular- OK – an estimation of a zone quality use (01), paving – OK (02); segment – OK (03), sector – OK (04) and so on:

$$S_{xi} = \begin{cases} 1,\ \text{если} \left[\left(\hat{\Pi}_{\beta\delta}^{\varepsilon\delta} \in \hat{\Pi}_{\beta\delta}^{\varepsilon\delta}\, рек \right) \cup \left(\hat{\Pi}_{jt}^{lt}\, спец \right) \right] \& \left(OK \rightarrow \min \right) \& \left(Q_{пил} \rightarrow \max \right) \\ 0,\ \text{в противном случае} \end{cases}$$

i.e. the cut – out scheme choice is determined as the following: i.e. the first cut-out scheme is selected in condition of that the parameter values of log surfaces come in a recommended range (chosen on shaping of ordered train condition at the given scheme in view of execution of the given saw production specification at the best use of raw material (OK); qualitative zones and at providing of the greatest velumetric exit production.

The advantage of the suggested approach is a full formalization of a computing process that allows atomizing easily; the accelerated searching of any quantity and combination of natural-producing factors. The offered of flexible technology projection and the algorithms developed on its basis comprise a complex of geometrical technological and technical-economic models, and the developed methods multi criteria optimization allows transforming geometrical models into technological ones at estimation according to technical-economic models. Thus, the designed system of criteria of criteria of reference conditional and unconditional which have high sensitivity and opportunity to estimate any of variants of technological process according to any number amount and combination of indexes of efficiency, including the minimum amount of waste at the best quality with the minimum adequacy. This informational-methodical approach to the designing of flexible economical technologies of wood-processing was tested in a number of forest farms of Voronezh region and showed, that its introduction will provide a well-founded selection of models of least energy-consuming equipment which strictly corresponds to the nomenclature of saw production and at the same time doesn't exclude a quick readjustment of production process (a flexible technology). The result is a significant improvement of production quality, of its output and a reduction of prime cost of production process due to the more sound selection of parameters, work conditions and types of the technological equipment.

From the point of view of ecological factors, the results are following: the reduction of the amount of waste and the dust level in the saw shops that improves the working conditions and reduces the level of energy expenses as a result of which the environmental damage is reduced.

ОПТИМИЗАЦИЯ ТЕХНОЛОГИЧЕСКИХ СТРУКТУР ЛЕСОПИЛЕНИЯ С УЧЕТОМ ТРЕБОВАНИЯ РЫНКА

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В современных условиях качественно меняется отношение мировой общественности и государственных структур к ведению лесного хозяйства, лесозаготовок и переработке древесины. При решении проблем лесного комплекса важнейшим требованием является обеспечение бережливого отношения к лесу, как источнику чистого воздуха, воды и товарной экологически чистой, конкурентоспособной продукции, получаемой на основе эффективных, ресурсосберегающих технологий переработки древесины. Кроме того, в условиях жесткой конкуренции необходимо предусматривать быструю смену номенклатуры выпускаемых изделий из древесного сырья. Существующее оборудование многих предприятий деревообработки, как правило, не приспособлено к быстрой переналадке в соответствии с рыночным спросом на выпускаемую продукцию. Кардинальное решение проблемы работы деревообрабатывающих предприятий в условиях быстро меняющихся потребностей рынка в пилопродукции возможно при использовании новых подходов к технологии выполнения работ.

Одним из новых таких подходов является внедрение в производство пилопродукции гибких экономичных технологий, которые позволяют легко приспосабливаться к различным параметрам обрабатываемого сырья и полуфабрикатов при производстве потребного вида и количества изделий. В лесопилении при этом имеется в виду, прежде всего обеспечение возможности изменения схем раскроя сырья при изменении размеров поступающих в распиловку бревен.

В настоящее время известно три принципиально разных подхода к созданию гибких технологий производства пилопродукции. Первый подход, известный давно, основан на применении главным образом ленточнопильного оборудования. Его принцип состоит в регулировании настройки пил при изменении схем раскроя бревен в каждом цикле распиловки. При втором подходе предусматривается использование лесопильных рам, работающих по совмещенным поставам с фиксированной настройкой пил для раскроя сырья. Принцип третьего подхода подразумевает применение в лесопильных цехах гибкой транспортной системы, основанной на использовании тельферов, кран-балок и различных конвейеров.

Относительно трех базовых гибких технологий производства пилопродукции и их комбинаций нами, на основе многокритериальной оптимизации технологической структуры, как сложной системы, обеспечивающей реализацию целого ряда состояний древесины, предложен новый подход по разработки соответствующих вариантов технологий. Специфика решаемых вопросов оптимизации производства пилопродукции определяет круг методов используемого математического описания. Существующие регулярные методы оптимизации в России и за рубежом, в частности, линейное и нелинейное программирование, не дают достаточно объективного решения. С одной стороны, математический аппарат этих методов рассчитан на ограниченное число вариантов и варьируемых параметров, а при их увеличении требует значительных допущений и упрощений, обусловленных сложностью вычислительных процедур. С другой стороны, область допустимых решений является невыпуклой и несвязной, т.е., задача является дискретной. В отличие от целочисленных задач (задачи о назначениях, планировании, управлении и т.д.), областью допустимого изменения каждой переменной здесь является не ряд целых неотрицательных чисел, а заданные конечные множества, которые являются дискретными и замкнутыми. Это является предметной областью дискретного математического программирования, задачи которого относятся к нерегулярным. Поэтому, решение задачи оптимизации производства пилопродукции, с учетом всего диапазона размерно-качественных параметров сырья, готовой продукции, параметров технологического оборудования, показателей эффективности и т.д. необходимо искать в области дискретного программирования, путем сведения ее в область целочисленной задачи. При этом применяется математическая теория отношений как составная часть теории множеств, и в частности бинарные отношения.

Язык бинарных отношений позволяет сравнить по качественным признакам любые объекты. Каждому типу качественной информации соответствует определенный класс отношений. С их помощью можно описать разнообразные типы соответствия между элементами множества и множествами. С помощью бинарных отношений и с введением схем математического программирования возможно описать любой механизм выбора, однако при этом исследуемый объект необходимо представить в виде системы.

Система задается семейством множеств и определяется как собственное подмножество декартова произведения. $S \subset X\left[V_i, i \in I\right]$, где V_i – семейство множеств. Для перехода от общей сложной системы к технологической модели комплексного процесса выделяются два возможных отношения. В первом случае под системой понимается отношение

$S \subset X \times Y,\ X \subseteq A^T,\ Y \subseteq B^T,\ S \subseteq A^T \times B^T$, где X, Y – входные и выходные объекты системы S; T – линейно упорядоченное множество моментов времени; A, B – функции определенные на множестве моментов времени T. Во втором случае отношение можно представить, как отношение множеств в алгебраической системе. Алгебраической системой типа τ является объект $V = \left(A, O_F, O_P\right)$ состоящий из трех множеств: непустого множества A, множества операций

$o_F = (F_0, ..., F_n, ...)$ и множества предикатов $o_P = (P_0, ..., P_n, ...)$, заданных на множестве A, причем парности рассматриваемых операций и предикатов должны удовлетворять условиям: $i(F_n) = j_n$ для всех n<a и $i(P_b) = i_b$ для всех b<β. Типом τ порядка (a,β) есть пара отображений W(a)→N, W(β)→N множеств W(a), W(β) в множество N=[0,1,2…]. Тип τ записывается в виде τ=(j_0,… ,j_a,…,i_0,…,i_b,…) n<a, b<β. Здесь a,β,n,b – порядковые числа. Из определения алгебраической системы следует, что предметная область теории алгебраических систем есть множества с определенными на них последовательностями операций и отношений.

Совокупность отношений можно представить матрицей, которая является аналитическим отображением графа. Связь графа и матрицы в виде бинарных отношений позволяет перевести особенности структуры технологического процесса на язык чисел. Граф, сохраняя всю наглядность и содержательность отображаемого им объекта, позволяет строить формальные алгоритмы преобразований и при использовании своих матричных эквивалентов легко обрабатывается на ЭВМ.

В процессе многовариантного проектирования гибких, экономичных технологий производства пилопродукции решается задача поиска оптимального покрытия одного множества другим относительно выбранных критериев, т.е. находятся минимальное покрытие графа. Технологическая структура производства оптимизируется последовательно, в несколько этапов, с введением на каждом этапе соответствующих критериев и бинарных отношений между множествами.

Задачей первого этапа является выбор вариантов наименее энергоемкого технологического оборудования на множестве показателей эффективности, параметров заготовок и изделий, значений параметров этого оборудования, и на множестве технологических операций с количественной оценкой избыточности и сложности выделенных вариантов. Для этого формируется упорядоченный кортеж состояний поверхностей заготовок и изделий, т.е. составляется геометрическая модель. На основе бинарных отношений между множеством значений параметров технологического оборудования и множеством значений параметров сырья и продукции, представленных в виде булевых матриц, производится оценка избыточности технологического оборудования. Показатель сложности оценивается при покрытии множества технологических операций множеством технологического оборудования.

На втором этапе выбираются допустимые варианты технологической структуры производства, удовлетворяющие системе показателей эффективности. При этом число показателей и вариантов не ограничивается.

Целью третьего этапа является многокритериальная оптимизация технологической структуры переработки древесины на основе системы безусловного и условных критериев предпочтения с помощью метода информационного поиска. Безусловный критерий предпочтения (критерий Парето) обладает свойствами, важными с точки зрения решения многокритериальной задачи выбора, отсева на ранней стадии множества худших вариантов и выделения множества перспективных вариантов. Исходные данные для каждого из вариантов представляются в виде матриц на основании того, что условия сравнимости вариантов можно сформулировать с помощью бинарных отношений нестрогого порядка и толерантности. В ходе третьего этапа оптимизации учитываются три вида ограничений: технологические — последовательность применения технологического оборудования не должна нарушать отношения технологической упорядоченности; конструктивные — компоновка технологического оборудования не должна противоречить его конструктивной совместимости и технико-экономические. На заключительном этапе анализируются и уточняются режимы функционирования оптимальной технологической структуры.

На каждом этапе проектирования решается целый ряд подзадач, наиболее значимой из которых является выбор оптимальной схемы раскроя на множестве размерно-качественных параметров сырья и готовой продукции.

Одной из основных характеристик способов раскроя лесометериалов является ориентация пластей пилопродукции относительно годичных слоев. Пилопродукция при тангенциальном расположении пластей лучше вписываются в зоны качества бревна, и их выход больше, чем при радиальном расположении. Это можно объяснить, исходя из анализа качественных зон бревна соответствующей породы.

Пиловочные бревна в различных частях имеют разное количество тех или иных пороков древесины, определяющих качество соответствующих частей бревен. Ряд основных пороков сравнительно закономерно распределяется по направлению длины и поперечного сечения пиловочных бревен. Таким путем обычно распределяются сучки, сердцевинная ослабленная древесина, гнили и др. Если закономерности распределения пороков известны, то раскрой лесоматериалов для получения пилопродукции высшего качества можно вести с наивыгоднейшим направлением пропилов. Решение этой задачи усложняется тем, что в заказах потребителей ставятся требования дать пилопродукцию только определенного качества или сорта. Например, пилопродукцию радиальной распиловки, которая имеет наибольшую стоимость и спрос. Однако она производится при использовании секторного или развального способа, которые хуже всего вписываются в качественные зоны бревна, что ведет к большему количеству отходов.

Качественное использование зон бревна в зависимости от применения той или иной схемы раскроя будет уменьшаться в следующем порядке – круговой, брусовочный, сегментный, секторный, развальный.

Данный вывод, чтобы воспользоваться им при выборе схемы раскроя формализован исходя из следующего: круговой – ОК "оценка использования зон качества"(01); брусовочный – ОК(02); сегментный – ОК(03); секторный – ОК(04); развальный – ОК(05).

Тогда выбор схемы раскроя определяется как

$$S_{xi} = \begin{cases} \boldsymbol{1,\ если} \left[\left(\hat{\Pi}^{\varepsilon\delta}_{\beta\delta} \in \hat{\Pi}^{\varepsilon\delta}_{\beta\delta}\ \boldsymbol{рек}\right) \cup \left(\hat{\Pi}^{lt}_{jt}\boldsymbol{спец}\right) \right] \& \left(\boldsymbol{ОК} \to \min\right) \& \left(\boldsymbol{Q_{пил}} \to \max\right) \\ \boldsymbol{0,\ в\ противном\ случае} \end{cases}$$

т.е. -ая схема раскроя выбирается при условии, что значения параметров поверхностей бревна $\left(\hat{Í}^{\varepsilon\delta}_{\beta\delta}\right)$входят в рекомендуемый диапазон $\left(\hat{Í}^{\varepsilon\delta}_{\beta\delta}\ ðåê\right)$(выделенный еще на стадии формирования упорядоченного кортежа состояний) при данной схеме, с учетом выполнения заданной спецификации $\left(\hat{Í}^{lt}_{jt}ñïåö\right)$ пилопродукции, при наилучшем использовании качественных зон сырья ($ОК_i$) и при обеспечении наибольшего объемного выхода продукции ($Q_{пил}$).

Достоинством предлагаемого подхода являются: полная формализация вычислительного процесса, что позволяет его легко автоматизировать; ускоренный поиск по любому количеству и сочетанию природно-производственных факторов. Предлагаемый метод проектирования гибких технологий и разработанные на его основе алгоритмы содержат комплекс частных моделей геометрических, технологических и технико-экономических, а разработанная методика многокритериальной оптимизации позволяет трансформировать геометрические модели в технологические при оценке по технико-экономическим моделям. При этом разработанная система критериев предпочтения условного и безусловного, обладающих высокой чувствительностью и возможностью оценить любое количество вариантов технологических процессу по любому количеству и сочетанию показателей эффективности, в том числе, минимум отходов при наилучшем качестве с наибольшей адекватностью.

Данный информационно-методический подход к проектированию гибких, экономичных технологий переработки древесины, при его апробации в ряде лесхозов Воронежской области показал, что его внедрение позволит обоснованно выбрать типажи наименее энергоемкого оборудования, строго соответствующего номенклатуре пилопродукции и в тоже время не исключающий быстрой переналадки производства (гибкая технология). В итоге существенно повышается качество продукции, ее объемный выход и снижается себестоимость производства, так как более обоснованно выбираются параметры, режимы работы и типы технологического оборудования. Относительно экологических факторов – снижается количество отходов, а вместе с тем уровень запыленности лесопильных цехов, что улучшает условия труда рабочих, а также снижается уровень энергозатрат в результате чего уменьшается ущерб окружающей среде.

ТЕХНОЛОГИЧЕСКИЙ КОМПЛЕКС МАШИН ДЛЯ ОБРАБОТКИ СЕМЯН ХВОЙНЫХ ПОРОД

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Лес – единственный возобновляемый природный ресурс Земли, депонирующий углекислый газ и вырабатывающий кислород. Площадь лесов в мире ежегодно сокращается более чем на 20 млн га. В настоящее время лесистость планеты составляет 27 %. При лесистости в 20 % и ниже могут возникнуть необратимые биосферные процессы. В России ежегодно происходит сокращение лесов от рубок и пожаров. Согласно стратегии лесовосстановления, к 2010 году посадка и посев леса, формирующие породный состав, должны составлять половину всех лесовосстановительных мероприятий.

Для проведения лесовосстановления и лесоразведения ежегодно требуется около 500-700 тонн семян хвойных пород. В естественном состоянии семена сосны, ели и лиственницы непригодны для посева на лесокультурных площадях и выращивания лесопосадочного материала в питомниках. Поэтому необходима их обработка в семяочистительных машинах. Известные конструкции этих машин травмируют 5-7 % (при норме 1 %) полноценных семян и отправляют 8-15 % необескрыленных семян в отходы.

Исследования показали, что семена хвойных пород, предназначенные для высева в питомниках, целесообразно разделять на четыре размерные фракции При этом во фракциях образуется выровненный посевной материал, в котором масса 1000 шт. семян соседних фракций отличается в среднем на 15 %.

В Воронежской государственной лесотехнической академии (ВГЛТА) разработан перспективный технологический комплекс для обработки (обескрыливания, первичной, вторичной очистки и сортирования) семян хвойных пород. В его состав входят: универсальная малогабаритная семяочистительная машина, пневмосепаратор лесных семян, решетная установка, сепараторы вальцового и дискового типов.

Универсальная малогабаритная семяочистительная машина непрерывного действия предназначена для первичной обработки исходного семенного материала. Она включает загрузочно-обескрыливающее устройство непрерывного действия (ЗОУ НД), системы воздушной очистки и решетного сортирования, раму и клиноременный привод с электродвигателем.

В машине использован новый перспективный принцип двухстадийной технологии обескрыливания семян, осуществляемый по непрерывной схеме. Здесь семена обескрыливаются на 50-55 % в загрузочном бункере при их подаче шнеково-щеточным питателем (первая стадия), и непосредственно в обескрыливателе щеточными рабочими органами (вторая стадия). В машине реализован ряд новых технических решений, связанных с конструкциями рабочих органов (щеточных элементов) обескрыливателей и их расположением на валу (а.с. СССР 1144655, 1528358), корпуса и вала обескрыливателя (а.с. СССР 1628958), а также загрузочного бункера (пат. РФ 2089055, 2235450).

Машина обеспечивает повышение производительности в 1,5-1,7 раза, по сравнению с существующими аналогами, полноту отделения крылаток от семян 97,8-98,5 % за один пропуск через машину и снижение их травмирования на 3-5 %.

Пневмосепаратор лесных семян ПЛС-5М, разработанный ВГЛТА совместно с ЦОКБЛесхозмаш (г. Пушкино МО), предназначен для первичной очистки и сортирования предварительно обескрыленных лесных семян по удельной массе (плотности). Отличительной особенностью сепаратора является конструкция дозатора 11, герметично совмещенного с воздуховодом 14 (пат. РФ № 2150338), что позволяет по сравнению с известными аналогами упростить конструкцию, удешевить его производство, повысить производительность и качество разделения семян на фракции.

Решетная установка предназначена для вторичной обработки лесосеменного материала по геометрическим параметрам (ширине, толщине семян).

Отличительной особенностью решетной установки является установка в зоне выпускной щели бункера гребенчатой регулировочной заслонки и отсечение питателя от семенной массы специальной наклонной перегородкой, что позволяет добиться равномерной строго дозированной подачи семян на решетный стан (пат. РФ 2167725). Решетный стан закреплен на раме с помощью двух пар подвесок, расположенных на противоположных концах решет с возможностью изменения длины подвесок и амплитуды колебаний (пат. РФ на полез. модель № 46685). Указанные особенности позволяют повысить качество очистки на 6-8 % и производительность – на 8-13 %.

В ВГЛТА разработана группа безрешетных сепараторов вальцового (пат. РФ №2111068, №2170147) и дискового (пат. РФ №2179079) типов, обеспечивающих вторичную очистку от мелких примесей и сортирование семян.

В основу конструкции сепараторов вальцового типа положен технологический принцип перемещения сортируемых по толщине семян в узком пространстве между двумя наклонными вальцами с величиной щели от минимального размера в зоне подачи (начало разделения) к увеличивающемуся размеру в зоне их окончательного разделения.

В основу конструкции сепаратора дискового типа положен технологический принцип перемещения сортируемых по длине семян в пространстве между скатной доской (или гладким вальцем) и вращающимся цилиндром, составленным из дисков различного диаметра, которые образуют между собой кольцевые щели прямоугольного сечения с величиной щели от минимального в зоне подачи (начало разделения) к увеличивающемуся размеру в зоне их окончательного разделения.

В базовом варианте сепаратора в качестве рабочих органов используется пара гладких вальцев, вращающихся с большой частотой в противоположные стороны и обеспечивающих сортирование семян на достаточно большое число фракций. Выполнение вальцев ступенчатыми (пат. РФ №2111068) с технологически обоснованными соотношениями длин и диаметров ступеней позволило сортировать семена на четко определенное исследованиями [4] количество фракций (как правило, четыре).

Сочетание новых технологических решений привело к созданию многоступенчатого вальцового сепаратора, конструкция которого содержит ориентирующе-сортирующее приспособление, выполненное в виде нескольких пар ступенчатых вальцев, установленных с возможностью вращения в противоположные стороны и изменения зазора между осями в опорах, и механизм равномерной подачи семян, выполненный в виде пары наклонных, вращающихся в противоположные стороны гладких вальцов, установленных вдоль загрузочного бункера (пат. РФ №2170147).

Использование предложенного устройства позволяет за два цикла обработки лесных семян хвойных пород достичь показателя чистоты семенной массы 96 %, повысить производительность на 2-3 %.

Сепаратор дискового типа предназначен для вторичного сортирования семян и элиминирования трудноотделимых примесей (хвои).

Новизна конструкции сепаратора дискового типа заключается в выполнении рабочего органа четырехсекционным с кольцевыми канавками различной ширины на поверхности, при этом в направлении от загрузочного к разгрузочному концу ширина канавок в смежных секциях увеличивается и соответствует максимальной длине семян в каждой из выделяемых фракций, а длина секций уменьшается (пат. РФ №2179079), что обеспечивает эффективное выделение из лесосеменного материала трудноотделимых примесей в виде хвои и ее фрагментов (до 99,6 %) и разделение семян на четыре размерные фракции: мелкую, среднюю, среднекрупную и крупную.

Таким образом, применение нового технологического комплекса для обработки семян хвойных пород позволяет повысить производительность в 2-2,5 раза; снизить травмирование семян на 5-7 %; уменьшить потери семян в отходы на 8-13 %, а также дает возможность реализовать технологию выращивания укрупненного посадочного материала без перешколивания.

TECHNOLOGICAL COMPLEX OF MACHINES FOR PROCESSING SEEDS OF THE WOOD

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Forest - the unique renewable natural resource of the Earth collecting carbonic gas and forming oxygen. The area of forests in the world is annually reduced more than 20 million ha. Now the percentage of forest land of the planet makes 27 %. At a percentage of forest land about 20 % and below there could be observed irreversible biosphere process. In Russia annually there is reduction of forests from cuttings and fires. According to strategy of a reforestation, by 2010 planting and seedling of trees should make half of all reforestation measures.

For carrying out of a reforestation and an afforestation annually it is required about 500-700 tons of seeds of conifers. In natural condition seeds of a pine, a fir-trees and larch are unsuitable for planting forest culture areas and cultures of tree-planting material in nurseries. Therefore their processing in seed dressing machines is necessary. Known designs of these machines injure 5-7 % (at rate of 1 %) high-grade seeds and send 8-15 % seeds in waste products.

Researches have shown that the seeds of conifers intended for dropping in nurseries, it is expedient to divide on four dimensional fractions thus in fractions the leveled seed in which the pulp 1000 piece of seeds of the next fractions differs on the average on 15 % is formed.

In Voronezh Goverment Forest Academy (VSAFE) the perspective technological complex for processing (dewinging, independent, lateral clearing and a sorting) seeds of conifers is developed. Into its stock enter: a universal small-sized seed dressing machine, a pneumoseparator of sylvan seeds, screen grader, separators of roller and disk types.

The universal small-sized seed dressing machine of continuous action is intended for a primary conversion of an initial seed material. It includes feed-dewinging device of continuous action, systems of aircraft clearing and screen sortings, a frame and wedge-belt drive with the electric motor.

In the machine the new perspective principle of two-phase technology of a dewinging of the seeds, conducted on the continuous scheme is used. Here seeds are dewinged on 50-55 % in the loading bunker at their feeding by the brush feeding mechanism (the first stage), and is direct in the dewinger brush attachments (the second stage). In the machine a line of new technical decisions, attached attachments with designs (brush elements) dewingers and their arrangement on the shaft ampere-second is realized (author's certificate USSR 1144655, 1528358,1628958), and also the loading bunker (patent RU 2089055, 2235450).

The machine provides increasing productivity in 1,5-1,7 times, in comparison with existing analogues, completeness of branch of key fruits from seeds of 97,8-98,5 % for one gap through the machine and their reduction injure on 3-5 %.

The pneumoseparator of silvan seeds developed VSAFE is intended for independent clearing and a sorting preliminary dewinging silvan seeds on specific density. Distinctive feature of a separator is the design of the batcher tightly combined with an air conduit (patent RU 2150338) that allows simplifying in comparison with known analogues a design to reduce the price of its production, to increase productivity and quality of segregation of seeds on a fraction.

Screen grader is intended for lateral processing a forest seed material on geometric parameters (to width, thickness of seeds). Distinctive feature Screen grader is installation in a zone of a damboard of the bunker of a pectinate adjusting door and cutting off of the feeding mechanism from seedling pulp a special inclined dam board that allows to achieve uniform strictly dosed feeding of seeds on sieve boot (patent RU 2167725). Sieve boot it is fixed on a frame with the help of two pairs the suspensions located on the opposite ends screen with an opportunity of change of length of suspensions and range of fluctuations/ specified features allow to raise (increase) quality of clearing on 6-8 % and productivity - on 8-13 %.

In VSAFE the group of without screen separators roller (Patent RU 2111068, 2170147) and disk (Patent RU 2179079) types, providing lateral clearing of second-growth impurity and a sorting of seeds.

The technological principle of movement of seeds assorted on thickness is put in a basis of a design of separators of roller type in dray space between two inclined rollers with rate of a cleft from the minimum size in a zone of feeding (the beginning of segregation) to the increasing size in a zone of their definitive segregation.

The technological principle of movement of seeds assorted endways is put in a basis of a design of a separator of disk-type type in space between ramp board (or glazed roller) and the rotating cylinder made of disks of a various diameter which form among themselves ring clefts of rectangular section with rate of a cleft from minimum in a zone of feeding (the beginning of segregation) to the increasing size in a zone of their definitive segregation.

In base variant of a separator as attachments the pair glazed rollers, rotating with the large frequency in the opposite parties and seeds providing a sorting on large enough number of fractions is used. Execution rollers stuggered (with technologically proved ratio of lengths and diameters of steps has allowed to assort seeds on quantity of fractions precisely determined by researches (as a rule, four).

The combination of new technological decisions has resulted in creation of a multi-stepwise roller separator which design contains the orientation assorting adaptation executed as several pairs staggered rollers, content with an opportunity of rotation in the opposite parties and changes of a fit-up gap between axes in foots, and the mechanism of uniform feeding of the seeds, executed as pair inclined, rotating in the opposite parties glazed is roller, content along the loading bunker.

Utilization of the suggested device allows reaching a data of cleanliness of seedling pulp of 96 % for two operation cycles of sylvan seeds of a conifer, to raise (increase) productivity on 2-3 %.

The separator of disk type is intended for a lateral sorting of seeds and elimination of difficult separable needles.

Novelty of a design of a separator of disk type consists in execution of an attachment four-split with ring flutes of various width on a surface, thus in a direction from loading by the unloading end the width of flutes in abutting sections increases and meets to maximum length of seeds in each of allocated fractions, and the length of sections decreases, that provides effective escape from a forest seed material difficult separable impurity as needles and its fragments (up to 99,6 %) and segregation of seeds into four dimensional fractions: second-growth, average, average-large and large.

Thus, application of a new technological complex for processing seeds of a conifer allows to increase productivity in 2-2,5 times; to lower injure seeds on 5-7 %; to reduce losses of seeds in waste products by 8-13 %, and also enables to realize technology of culture of the integrated planting material without transplanting.

МЕХАНИЗАЦИЯ НА СРЕДНОПЛАНИНСКИЯ ДЪРВОДОБИВ В ТЮРИНГИЯ

Ерик Финдайзен, Германия

(Резюме)

Тюрингия е една от „новите“ германски провинции. Обединението с ФРГ доведе до значителни икономически промени, в т. ч. се увеличи себестойността на дърводобива с моторен трион. За икономически ефективно стопанисване на горите стана необходимо още по-интензивно механизиране на горските дейности. В условията на Тюрингия тази тенденция е от особено значение, защото само 65% от горите са достъпни за обикновените горскостопански машини (т.е. имат наклон на терена до 35%). При наклони над 50%, които са характерни за 15% от площта на горите, се използват въжени линии. В терените с междинен наклон се прилагат множество комбинирани методи.

Механизацията на държавните гори в Тюрингия (200 000 ha), се извършва главно от държавните „машинни опорни пунктове“, които работят със собствени персонал и техника. Тази система обаче може да има успех, само ако се оптимизират планирането, организацията на труда, реализацията на продукцията и квалификацията на персонала. Други условия са развитието на пътната мрежа и създаването на местна дървопреработваща промишленост.

MECHANIZATION OF HILL FORESTRY IN THÜRINGEN

Erik Findeisen, Germany

Abstract

Thüringen is one of the young „Bundesländer” of Germany. The change of the political system includes change of costs for manual workers in forestry. That’s why the mechanisation of forest procedures is necessary for a successful enterprise. Another reason is found in the natural conditions of Thüringen. Only 65% of forest area is accessible for normal forest machines (inclination up to 35%). Area with an inclination over 50% takes place on 15% - logging procedures use cable crane. Between both are used many combinations of different techniques. In state forest of Thüringen (200 000 ha) the mechanisation is developed by state machine stations with own staff and machines. This way is successful, when planning, organisation, realisation and staff training are optimised. Other prerequisites for effective forest management are the well-developed forest infrastructure and good possibilities for sell timber.

DIE MECHANISIERUNG DER WALDARBEIT IM MITTELGEBIRGE AM BEISPIEL DER FORSTWIRTSCHAFT IN THÜRINGEN

Erik Findeisen, Deutschland

Thüringen ist eines der neuen Bundesländer in Deutschland. Mit der politischen Wende waren wirtschaftliche Veränderungen verbunden, speziell auch bezüglich der Kosten für die (motor-) manuelle Waldarbeit. Im Sinne der effektiven Bewirtschaftung des Waldes wurde eine intensivere Mechanisierung der Arbeiten notwendig. Unter den Bedingungen in Thüringen kam diesem Bestreben eine besondere Bedeutung zu, da nur 65% der gesamten Waldfläche als befahrbar für normale Forstmaschinen gilt (Hangneigungen bis zu 35%). Über 50% werden Seilkräne eingesetzt, dieses Gelände umfasst 15% der Waldfläche. Im dazwischen liegenden Übergangsgelände werden eine Vielzahl von kombinierten Verfahren angewendet. Die Mechanisierung im Staatswald Thüringens, der ca. 200.000 ha einnimmt, wird vor allem durch die staatlichen Maschinenstützpunkte unter Nutzung eigenen Personals und eigener Technik betrieben. Diesem System ist jedoch nur Erfolg beschieden, wenn die Planung, die Arbeitsorganisation und –realisierung sowie die Ausbildung des Personals optimiert werden. Weitere Voraussetzungen sind eine geeignete Walderschließung sowie die Ansiedlung einer holzverarbeitenden Industrie.

1. Einleitung

Der Freistaat Thüringen ist bekannt für seinen Waldreichtum, wegen seiner zentralen geographischen Lage wird er auch das „Grüne Herz Deutschlands" genannt. Tatsächlich sind rund 34 % und damit 547.678 ha der Fläche des Freistaates bewaldet. Rund 39 % der Waldfläche sind privates Eigentum, wobei in großen Teilen kleinparzellierte Strukturen die Bewirtschaftung des Waldes erschweren. Der Körperschaftswald (z.B. Kommunen und Kirche) nimmt einen Anteil von 16 % der Waldfläche ein. Gegenstand der Betrachtungen in diesem Artikel soll der Staatswald des Freistaates Thüringen sein. Er umfasst mit knapp 200.000 ha immerhin 36 % der Gesamtwaldfläche. Entsprechend der Ergebnisse der zweiten Bundeswaldinventur (BWI II) beträgt der mittlere Holzvorrat 301 Vorratsfestmeter je Hektar, der jährliche durchschnittliche Holzzuwachs liegt bei rund 10 Volumenfestmeter pro Hektar (entspricht 8,3 Erntefestmetern), die Nutzung lag 2004 bei 7,6 Erntefestmeter je Hektar. Die räumliche und prozentuale Verteilung der Hauptbaumarten Fichte, Kiefer, Buche und Eiche sind aus der Abbildung 1 zu ersehen. Bezüglich der stockenden Vorräte ist bedeutsam, dass die der wirtschaftlich wichtigsten Baumarten unterschiedlich verteilt sind. Während bei der Fichte (Picea abies) vor allem in den Altersklassen III bis V große Vorräte stocken, finden diese sich bei der Buche (Fagus sylvatica) in den Altersklassen VI bis VIII. Das hat Auswirkungen auf die Struktur der Holzabnehmer und die anzuwendenden Arbeitsverfahren.

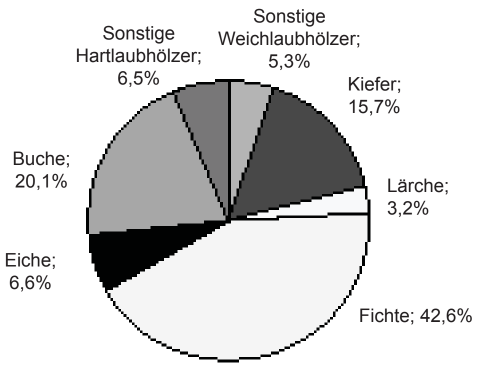

Abbildung 1 – Prozentuale Baumartenverteilung in Thüringen

Der Staatswald des Freistaates wird durch die Thüringer Landesforstverwaltung bewirtschaftet, die als zweistufige Verwaltung auf dem Prinzip des Gemeinschaftsforstamtes aufgebaut ist. Ziel dieses Gemeinschaftsforstamtes ist es, die Hoheits- und Betriebsaufgaben effizient unter Nutzung von Synergieeffekten wahrzunehmen sowie insbesondere den Eigentümern der kleinen Waldparzellen bei der Bewirtschaftung ihres Eigentums zu helfen. Gerade die letztgenannte Aufgabe hat unter dem gegenwärtigen Aspekt der Rohholzmobilisierung an Bedeutung gewonnen. Die durchschnittliche Fläche eines der insgesamt 28 Gemeinschaftsforstämter liegt bei rund 19.500 ha, wobei die Flächengröße in Abhängigkeit von den Aufgaben stark variiert. Die Thüringer Forstämter unterstehen direkt der für Forsten zuständigen Abteilung im Thüringer Ministerium für Landwirtschaft, Umwelt und Naturschutz.

Nach der Wiedervereinigung der beiden deutschen Staaten wurden im Jahre 1991 aus 17 Staatlichen Forstwirtschaftsbetrieben, die auf einer durchschnittlichen Fläche von je rund 32.000 ha alle Eigentumsformen bewirtschafteten, 60 Forstämter gebildet. Mit einer Kreisreform wurde diese Zahl im Jahr 1994 bereits auf 53 und bis 2005 auf 28 reduziert. Dabei wurden Forstämter mit Spezialaufgaben – sogenannte Stützpunktforstämter – gebildet. Für die hier betrachtete Waldarbeit sind vor allem die jetzigen 2 Maschinenstützpunkte relevant.

2. BEDINGUNGEN DER WALDARBEIT IM THÜRINGER STAATSWALD

Ein Großteil der staatlichen Wälder und ein erheblicher Teil des nutzbaren Vorrates befindet sich in den Mittelgebirgslagen Thüringens, die sich auf den Thüringer Wald, das Thüringer Schiefergebirge und den Südharz konzentrieren. Da die Bewirtschaftung der Hanglagen besondere Ansprüche an die Arbeitsverfahren stellt, ist die Erprobung und Umsetzung rationeller Technik und Technologien eine wesentliche Aufgabe der staatlichen Maschinenstützpunkte. Zur Beurteilung der systematischen Bewirtschaftung der Mittelgebirgslagen ist es notwendig, komplexe Zusammenhänge darzustellen.

2.1 Holzabsatz

Entsprechend der Analyse des mittel- und langfristigen Holzaufkommens wurden in den 90er Jahren in Thüringen mehrere große Werke der holzverarbeitenden Industrie angesiedelt. Zu nennen wären Profilzerspanerwerke zur Verarbeitung von Nadelholz (Klausner Holz Thüringen mit einer Jahreskapazität von 2.100.000 fm, Rettenmeier mit 750.000 fm einschließlich der Weiterverarbeitung), auf die Baumart Buche spezialisierte Säge- (Pollmeier mit 400.000 fm Jahreskapazität) oder Furnierwerke (Werzalit mit 50.000 fm) sowie Industrieholzverarbeitende Werke (Plattenwerk Kunz mit 150.000 fm und Zellstoffwerk Blankenstein mit 600.000 fm). Auch die Energieholzabnahme steigt stetig an, neben industriellen Anlagen (Biomasseheizkraftwerk der Stadtwerke Leipzig mit jährlich 140.000 fm) entwickelt sich vor allem der Markt der privaten Haushalte.

Die Holzvermarktung wird für die Großkunden und Rahmenverträge zentral durchgeführt, dadurch kann Holz kontinuierlich und zu guten Konditionen aus den Wäldern des Staates sowie der kooperierenden Waldbesitzer an die Holzindustrie geliefert werden. Neben den Rahmenverträgen wird Holz auch an spezielle Vertragspartner – meistens kleinere Sägewerke und spezialisierte Holzverarbeiter – verkauft, 1% des gesamten Einschlages wird auf Submissionen meistbietend verkauft. Auf dem Stock werden keine nennenswerten Mengen veräußert.

2.2 Erschließung der Wälder

Zunächst ist es notwendig, eine angepasste Walderschließung mit einem konstanten Netz an LKW-tauglichen Abfuhrwegen und einem eher variablen Netz an Maschinenwegen und Rückegassen zu realisieren. Im Jahr 1991 verfügten die Staatswaldreviere über ein den kleineren LKW mit ca.7 t Achslast entsprechendes Wegenetz. Die mittlere Wegedichte von rund 17 Laufmetern je Hektar (lfm/ha) widerspiegelte den allgemeinen Stand, nicht jedoch die Erschließungswirkung und die Unterschiede zwischen den diversen Revieren. Folglich war es eine erste Voraussetzung, mit einer zielgerichteten Erschließung das Wegenetz für effektive Arbeitsverfahren auszubauen. Mit der Planung und der Durchführung der Wegebauten wurden im Staatswald funktional tätige Diplomforstingenieure in den Maschinenstützpunkten beauftragt. Entsprechend der modernen Anforderungen an die Holzernte und –rückung, den Holztransport durch LKW´s mit 11 t Achslast und den umweltrelevanten Forderungen der Gesellschaft wurde eine Walderschließungskonzeption erarbeitet, durch die Vorgehensweise und Ausbaustandards festgelegt wurden. Bezüglich der Wegedichte konnte die anfängliche Zieldichte, die in Anlehnung an westliche Bundesländer mit ca. 35 lfm/ha veranschlagt worden war, auf 22-24 lfm/ha reduziert werden. Grund dafür ist einerseits die Optimierung der Erschließung zur Schaffung der Voraussetzungen für die Anwendung der Arbeitsbestverfahren sowie die Vermeidung von Mehrfacherschließungen, andererseits die konsequente Kosten-Nutzen-Analyse unter Berücksichtigung der Multifunktionalität des Waldes. Auf die maschinelle und daher kostengünstige Pflegbarkeit der Wegenetze wurde insbesondere geachtet. Bezüglich der Bewirtschaftung der Hanglagen wurde jeder Abfuhrweg hinsichtlich seiner Eignung für die jeweilige Erntetechnik überprüft – z.B. Forwarderabfahrten über steile Böschungen, Einbindung von hangdiagonalen Maschinenwegen mit Streifen für die Holzpolterung und –manipulation sowie Eignung als Seilkranstandplatz. Die allgemeine Abfuhrwegezieldichte ist bis auf die Erschließung in speziellen Einzelfällen erreicht, Grundlage der Begutachtung der optimalen Wegedichte je Erschließungseinheit ist die Minimierung der Transportkosten, die sich aus Wege- und Rückekosten zusammensetzen.

Eine bedeutende Rolle spielt dabei das sogenannte „Übergangsgelände“. Laut der Richtlinie im Thüringer Kompendium Waldarbeit werden die Arbeitsbestverfahren wie in Abbildung 2 zu sehen eingeteilt. Zwischen einer Hangneigung von 35 und 50 % sind je nach Hanglänge seilgestützte Arbeitsverfahren mit einem Seilschlepper oder dem Kettenbagger mit Seilwinde vorgesehen. Dazu bedarf es jedoch der Maschinenwege. Diese erdfesten Wege werden durch landeseigene Kettenbagger mit Spezialausrüstung für 3-5 €/lfm gebaut – seit 1991 insgesamt 450 km. Dadurch konnten im Übergangsgelände die Holzerntekosten je Festmeter um durchschnittlich 5 – 10 € gesenkt werden.

Wie bereits angesprochen, ist beim Ausbau des Abfuhrwegenetzes zu berücksichtigen, dass das Wegenetz kontinuierlich unterhalten werden muss. In die Gesamttransportkosten fließen bekanntlich neben den Rückekosten die Wegekosten ein, die ihrerseits die Wegeinstandhaltungskosten beinhalten. Über das gesamte Wegenetz kann je Jahr und Laufmeter mit 0,50 Cent gerechnet werden. Die Wegeunterhaltung im Staatswald wird durch die Maschinenstützpunkte mit ihren aus Grader und Doppelbandagenwalzen bestehenden Zügen gewährleistet, ergänzt durch eigene Mobilbagger und Fräsen.

2.3 Mechanisierung der Waldarbeit

Schon bald nach der politischen Wende erfolgte die Einführung der D-Mark und damit die tendenzielle Angleichung der Löhne. Es wurde schnell deutlich, dass nur ein hoher Mechanisierungsgrad eine effektive Waldbewirtschaftung möglich machen kann. Somit wurde angestrebt, möglichst viele der staatlichen Waldarbeiter für die Arbeit auf forstlicher und Wegebau-Spezialtechnik zu qualifizieren. Positive Auswirkung hatte dabei die hohe Qualität der forstlichen Berufsausbildung der ehemaligen DDR. Viele Forstfacharbeiter hatten in ihrer Lehre oder berufsbegleitend technische Qualifikationen erlangt und konnten sich schnell auf die moderne Technik einstellen. Parallel dazu wurden auch junge Forstwirte in der Thüringer Landesforstverwaltung ausgebildet und bei Eignung im Maschinenstützpunkt für forsttechnische Aufgaben qualifiziert. Das Modell des Stützpunktforstamtes Gehren mit Gemeinschaftsforstamt, Landeswaldarbeitsschule und Maschinenstützpunkt unter einem Dach erwies sich hier als überaus praktikabel !

Die Mechanisierung der Waldarbeit spielte sich vor allem in der Holzernte ab. Dabei gab es wichtige Tendenzen, die zu berücksichtigen waren:

□ Der Holzverkauf erfolgt tendenziell in Form kurzer Sortimente (2-6m lang), was eine Folge der Sägewerks- und Transporttechnik ist. Im Vergleich der Jahre 1995 und 2004 kann man folgenden Technologieentwicklung beobachten (Anteil an gesamt gerückter Holzmenge):

Rückemittel	1995	2004
Seilschlepper / skidder	48 %	19 %
Tragschlepper / Forwarder	22 %	68 %
Seilkran / cable crane	3 %	7 %

□ Die Holzernte im Nadelholz in befahrbaren Lagen (bis 35% Hangneigung) kann bis zum Brusthöhendurchmesser von 25 cm mit motormanueller Holzernte nicht mehr kostendeckend ausgeführt werden – der Einsatz von Harvester und Forwarder ist unumgänglich. Die Maschinenstützpunkte entwickelten demzufolge ihre Personal- und Technikausstattung.

Harvester ThüringenForst	1995	2004
Jahresleistung gesamt	4.500 fm	135.600 fm

□ Die Holzernte in den Hanglagen unterliegt in besonderem Maße einem hohen Kostendruck. Es werden spezielle Verfahren notwendig – wegen der hohen Pfleglichkeit werden trotz hoher Kosten über 50% Hangneigung und Hanglängen über 150m mittelstarke Kurzstreckenseilkräne und ganz speziell der Gebirgsharvester eingesetzt. Harvester mit Kettenlaufwerken finden hier keine Anwendung, sie sind bis maximal 50% Hangneigung zugelassen. Für die Rückung kurzer Sortimente eignen sich die Forwarder mit Traktionshilfswinde.

Als sehr günstig hat sich bei ThüringenForst die Abfassung eines Waldarbeitskompendiums für die Forstämter erwiesen. Auch im Sinne der PEFC-Zertifizierung konnte ein einheitliches System von Anforderungen an die Holzernteverfahren durchgesetzt werden. Gleichzeitig wurden Kalkulationspreise erarbeitet, die im Sinne der qualitativen Anforderungen ein nachhaltiges Wirken gewährleisten.

Das Waldarbeitskompendium eignet sich für die Auswahl des jeweiligen Arbeitsbestverfahrens, was bei der Realisierung der Maßnahmen vorrangig anzuwenden ist. Dabei wird zunächst in drei Geländetypen nach der mittleren Hangneigung unterschieden. In Abbildung 2 ist diese Einteilung zu sehen – befahrbare Lagen bis 35% Hangneigung, mittelsteile Lagen zwischen 35 und 50% sowie Steilhänge über 50% Hangneigung. Je nach Hanglänge und Sortimentsaushaltung kommen unterschiedliche Technologien zur Anwendung. Auch spielt die Bodentragfähigkeit eine große Rolle. Bei Kurzholzverfahren werden Arbeitsfeldbreiten von 20m angestrebt, die aber um ein Vielfaches erweitert werden können, wenn Schädigungen des Bodens zu erwarten sind. Natürlich gibt es zahlreiche Kombinationsmöglichkeiten, wobei auch die Pferderückung bis zu Vorlieferentfernungen von 50m möglich ist. In den Abbildungen 4 – 7 sind die wesentlichen Arbeitsverfahren für die nicht mit normaler Forstspezialtechnik befahrbaren Waldflächen dargestellt. Durch die Anwendung dieser Technologien konnten die Deckungsbeiträge (Differenz zwischen Holzerlösen und Holzerntekosten) der Holzerntemaßnahmen maßgeblich verbessert werden. Zu jedem Arbeitsverfahren gibt es spezielle Kalkulationstabellen, die eine einheitliche Planung im Staatswald möglich macht.

2.4 Arbeitsorganisation

Das Waldarbeitskompendium von ThüringenForst gibt auch prinzipielle Hinweise zur Arbeitsorganisation. So wurde zur Effektivierung der Waldarbeit die Blockarbeitsweise intensiver genutzt. Es werden zu bearbeitende Waldflächen zu möglichst großen Komplexen zusammengefasst. Damit sind folgende Vorteile verbunden:

- Optimierung des organisatorischer Aufwandes
- Minimierung von Umsetzungskosten
- Optimierung der Wegeinstandhaltung
- Optimierung der Holzabfuhr
- Beschränkung der mit Forstarbeiten verbundenen Beunruhigung von Waldgebieten.

Voraussetzung für ein sinnvolles Abarbeiten der Blöcke ist eine intensive Planung. Darüber hinaus wird mit teilautonomer Gruppenarbeit versucht, selbstständigere Waldarbeiterteams zu entwickeln und motivierenden Spielraum für verantwortungsbewusstes und den Betriebserfolg positiv beeinflussendes Handeln zu schaffen.

Abbildung 3 – Holzrückung mit Seilwinden-Kettenbagger

Geländetyp	Fein-erschließung	Sortiment bzw. Sortenlänge	Einschlags-verfahren	Vorrückung	Rücke-verfahren	Bemerkung
Eben bis schwach geneigt (Hangneigung bis 35 %)	Arbeitsgassen Arbeitsfeldbreite 20m	≤ 6m	Harvester		Forwarder	
			motor- manuell		Forwarder	
		>6m	Harvester		Seilschlepper	
			motor- manuell		Seilschlepper	
Mittelsteile Lagen (Hangneigung 36- 50% sowie Hangneigung >50% bei Hanglänge < 150m)	Maschinenwege 70- 100m Abstand, Seillinien nach bedarf, Arbeitsgassen für Kurzholzverfahren mit Rückung durch Forwarder mit Traktionshilfs-winde	entastet, ohne Ausformung	motor- manuell seilgestützt		Seilschlepper	motor- manuelle Ausformung mit anschließendem Poltern/Aufsetzen
		entastet, ausgeformt	motor- manuell seilgestützt		Seilschlepper	
			Kettenharvester oder motor-manuell (eventuell seilgestütztes Fällen)		Forwarder (mit Traktions-hilfswinde)	
		unentastet	motor- manuell; seilgestütztes Fällen; u.U. gezopft		Forwarder	Prozessorausformung am Maschinenweg
			motor- manuell, seilgestützt; u. U. gezopft		Seilschlepper	Prozessorausformung an Waldstraße, Poltern/ Aufsetzen durch Prozessor
Steilhang-gelände (Hangneigung > 50%; Hanglänge > 150m)	Seiltrassen 30m Abstand	entastet, ohne Ausformung	motor- manuell	Seilkran	Seilschlepper	motor- manuelle Ausformung an Waldstrasse; Poltern/ Aufsetzen
		entastet, ausgeformt	motor- manuell	Seilkran	Seilschlepper	
		unentastet	motor- manuell; u. U. gezopft	Seilkran		Prozessorausformung an Waldstraße; Poltern/ Aufsetzen durch Prozessor
				Gebirgshar-vester	Gebirgshar-vester	Prozessorausformung an Waldstraße; Poltern/ Aufsetzen durch Prozessor

Abbildung 2 – Arbeitsbestverfahren aus dem Kompendium Waldarbeit ThüringenForst

Abbildung 4 – Hochmechanisierte Holzernte in mittelsteilen Lagen

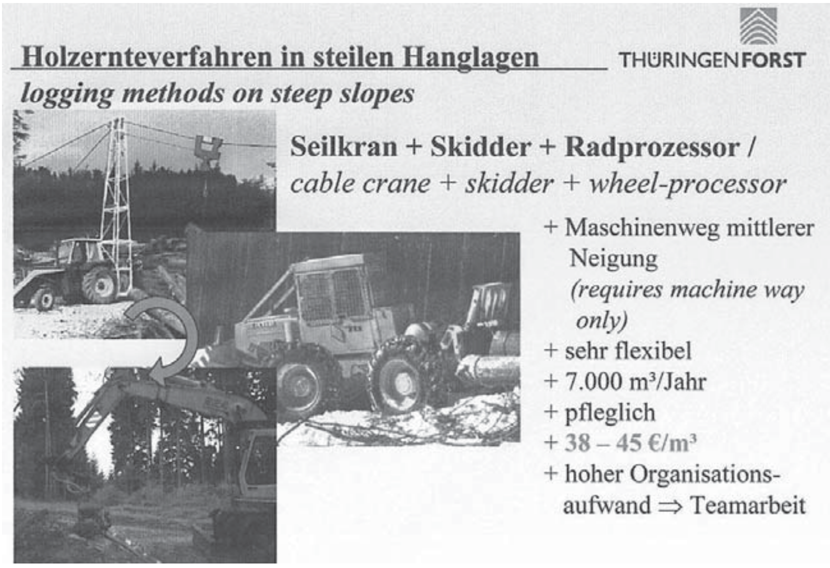

Abbildung 5 – Holzernte mit dem Seilkran

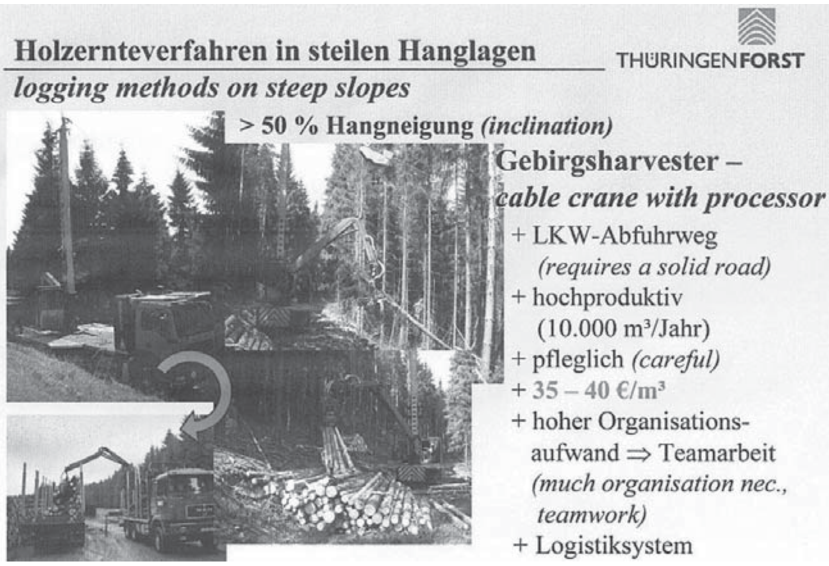

Abbildung 6 – Holzernte mit dem Gebirgsharvester

3. ZUSAMMENFASSUNG

Da sich ein erheblicher Teil des nutzbaren Holzvorrates in den Mittelgebirgslagen Thüringens befindet, stellt die Entwicklung kostengünstiger und ergonomisch verträglicher Arbeitsverfahren eine große Herausforderung dar. Im Staatswald des Freistaates Thüringen wird diese Entwicklung wesentlich durch die staatlichen Maschinenstützpunkte getragen. Die in herkömmlichen Arbeitsverfahren zu teuren Arbeitskräfte wurden als Maschinenführer für forstliche Spezialtechnik sowie die Wegebaumaschinen qualifiziert, womit sich das Betriebsergebnis positiv beeinflussen ließ. Der Einsatz von Regietechnik ist aus betriebswirtschaftlicher Sicht nur dann sinnvoll, wenn die Arbeitsplanung, die Arbeitsorganisation und –realisierung optimiert werden und die Qualifikation des Personals aktiv betrieben wird.

Vorteile des Regiebetriebes sind:

► gut ausgebildetes Personal
► moderne Formen der Arbeitsorganisation (teilautonome Gruppenarbeit)
► Gewährleistung eigenen Technik- und Technologie-Know hows
► eigene Technologieentwicklung (Holzbereitstellungsketten)
► relative Marktunabhängigkeit
► schnelle Reaktion bei Kalamitäten
► moderne forstliche Aus- und Weiterbildung.

Die jeweiligen Arbeitsbestverfahren sind Grundlage eines speziellen Waldarbeitskompendiums. Nach einem Schema können insbesondere für die Mittelgebirgslagen geprüfte, rationelle und pflegliche Verfahren ausgewählt und kostenseitig kalkuliert werden. In den mittelsteilen Hanglagen sind hochmechanisierte Erntesysteme (Kettenharvester und Forwarder mit Traktionshilfe) oder Seilrückung durch Skidder oder Seilwindenkettenbagger vom Maschinenweg aus kostengünstige Verfahren. Über 50% Hangneigung kommen Seilkräne zum Einsatz, wobei sich der Gebirgsharvester als optimales Verfahren in Bezug auf Ergonomie, Produktivität und schneller Bereitstellung des Holzes frei Werk erwiesen hat. Eine effektive Waldbewirtschaftung ist im Mittelgebirge jedoch nur bei sinnvoll erfolgter Erschließung mit LKW-Abfuhrstrassen und Maschinenwegen möglich – die Zielwegedichte für das LKW-Wegenetz liegt in Thüringen bei 22-24 lfm/ha. Grundlage der Bestimmung der optimalen Wegedichte muss die Minimierung der Gesamttransportkosten, die sich aus Wege- und Rückekosten zusammensetzen, sein. Die Multifunktionalität des Waldes ist dabei angemessen zu berücksichtigen.

Eine weitere Voraussetzung für die effektive Bewirtschaftung der Mittelgebirgslagen sind umfangreiche Holzabsatzmöglichkeiten. In Thüringen wurden diese durch die Ansiedlung moderner holzverarbeitender Industrien geschaffen.

4. QUELLEN

Die im vorstehenden Artikel veröffentlichten Daten stammen aus den Jahresberichten der Thüringer Landesforstverwaltung und dem Kompendium Waldarbeit von ThüringenForst. Interessenten können sich bezüglich detaillierterer Angaben gerne an den Verfasser wenden.

ГОРСКИ ПЪТИЩА И ИЗВОЗНА ТЕХНИКА В БЪЛГАРИЯ – СЪСТОЯНИЕ И НЕОБХОДИМИ МЕРОПРИЯТИЯ

Волф Гугелхьор, Германия

Българското горско стопанство засега очевидно не успява да реализира значителния си икономически потенциал. Проблемните места са в пътната мрежа и механизацията на извоза.

Голяма част от камионните пътища са в толкова лошо състояние, че първо е необходимо препроектиране на пътната мрежа за да се намали съществено гъстотата й в съответствие с модерната техника за извоз. Освен това се предлага нов инженеринг на пътното строителство, като се извади с багер използваемият инертен материал, едрите камъни се доведат до необходимия размер с дробилна машина и пътната постилка се профилира и уплътни.

Преоборудването изисква капитал, който трябва да се набере като възвращаем капитал по примера на средствата по ERP.

Модерните машини на първо време ще се използват успоредно с наличната животинска тяга и остарели трактори и постепенно ще се заменят. Успоредно с тракторите и въжените линии в България значителен потенциал имат форвардерите. Ще се внасят предимно употребявани машини, които са рентабилни поради по-ниските разходи за работна ръка. Машиностроителната промишленост съответно трябва да предложи подходящи машини с гаранция за резервните части и да подпомогне България при подготовката на механик-водачите.

FOREST ROADS AND HAULING MACHINERY IN BULGARIA – STATUS QUO AND NECESSARY CHANGE

Wolf Guglhör, Germany

ABSTRACT

It is obvious that Bulgarian forestry does not realise its significant economic potential. The problematic areas are the forest roads net and the mechanization of timber hauling.

Most of the truck roads are in such a bad condition that makes a re-design of road net necessary in order to reduce significantly its density in accordance with modern hauling machinery. Moreover, a re-engineering of the roads reconstruction is proposed, digging up by bagger the employed constructive material, the large stones to make much smaller in necessary size with a machine and the road cover to profile and dense.

Pre-equipment needs capital which should be collected as a reimbursable capital following the manner of ERP funds.

Modern machinery will at first be used along with the existing animal force and old tractors and gradually will replace them. Together with the skidders and the lifts in Bulgaria significant potential have the modern forwarders mostly used machines will be imported, which are profitable because of lower expenses for the workers. The machinary industry should offer suitable machines guaranteeing the removable details for them and to help Bulgaria to training and educate the drivers.

WALDERSCHLIESSUNG UND RÜCKETECHNIK IN BULGARIEN – STATUS QUO UND ERFORDERLICHE MASSNAHMEN

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AUSGANGSSITUATION

Stark vereinfacht kann die Situation der Walderschließung in Bulgarien so geschildert werden: Bis in die 70er Jahre des vorigen Jahrhunderts gehörte Bulgarien zu den in Forsttechnik und Holzernte führenden Ländern. Das betraf nicht nur die Forschung, wo uns im Westen z.B. die mathematische Analyse von Horizontalkurven bei Seilbahnen und ähnlichen Spezialproblemen Respekt, aber auch Erstaunen abnötigte. Es betraf auch die praktische Umsetzung, z.B. bei der erfolgreichen Erschließung der Wälder durch Waldstraßen und Seilanlagen, die Nutzung bis hin zur Verarbeitung in mehr oder weniger großen Werken und Kombinaten.

Leider hat diese Phase vielfach auch zu Übernutzungen geführt, z.B. in den Buchenwäldern des Balkans. Schon unter kommunistischer Herrschaft kam es dann zu einem Paradigmenwechsel: Nationalparke und Naturschutz wurden wichtiger, die großen Holzkombinate gerieten wie die Planwirtschaft insgesamt in eine Krise, die Forstwirtschaft wurde über Jahrzehnte unterfinanziert. Neuinvestitionen in Forsttechnik oder Wege waren undenkbar, selbst Ersatzbeschaffungen und Wegeunterhalt waren nicht mehr finanzierbar.

Die Wende ab 1989 mit Transformation des Wirtschaftssystems und Restitution des Waldeigentums hat leider nach meinem Eindruck bislang zu keiner Besserung geführt. Die Chancen der Forstwirtschaft sind glänzend, mit Holzpreisen fast wie in den alten EU-Ländern, Exportmöglichkeiten in die umliegenden prosperierenden Holzmangelländer Türkei und Griechenland, künftig vielleicht auch Serbien. Gleichzeitig betragen die Lohnkosten, die deutlich mehr als die Hälfte der forstwirtschaftlichen Gesamtkosten ausmachen, nur einen Bruchteil der in den alten EU-Ländern üblichen ca. 25 € pro produktive Stunde. Gleichzeitig sind Ausbildung und Motivation der meisten Waldarbeiter und Maschinenführer auf hohem Niveau, wie wir u.a. von vielen Bulgarischen Gastarbeitern wissen.

Aus eigener Kraft konnte die bulgarische Forstwirtschaft die Chancen offenbar nicht nutzen, aus Kapitalmangel, aber auch wegen organisatorischer Hemmnisse. Die Internationale Zusammenarbeit schickt viele Experten mit ganz unterschiedlichen Vorschlägen, aber wenig Investionskapital. Politisch ist es in den alten EU-Ländern korrekt und sogar schick, Programme zur Entwicklung von Nationalparken, zur Erhaltung der Urwälder und der Biodiversität zu unterstützen, was unstreitig vorrangig ist aber wozu Bulgarien keine Hilfe von außen benötigt. Hocheffiziente Potentiale wie z.B. die Energieerzeugung aus auf derzeitigem Brachland erzeugter Biomasse oder eben die Walderschließung und Erneuerung der Rückemaschinen stoßen auf wenig Akzeptanz.

Dabei ist allen Forstleuten klar, dass die Zugänglichkeit der Wälder und ein effizienter Holztransport Vorraussetzung und Motor jeder Waldwirtschaft sind.

Nicht nur ökonomisch kann nicht darauf verzichtet werden, durch pflegliche Holzernte leisten sie auch einen bedeutenden Beitrag zu Natur- und Umweltschutz – solange man nicht gänzlich auf Holznutzung verzichten will.

Besonders hervorzuheben sind in diesem Zusammenhang die etwa 1 Million ha neue Wälder, überwiegend Nadelwälder, die seit Ende des Zweiten Weltkriegs gepflanzt wurden und inzwischen dringend durchforstet werden müssen. Meist sind sie völlig unerschlossen, voller Dürrholz und außerordentlich gefährdet durch Waldbrände. Die Trockenzeiten werden auch in Bulgarien durch den prognostizierten Klimawandel künftig länger.

VORSCHLÄGE ZUR WALDERSCHLIESSUNG

Die Wegedichte war bisher meist relativ hoch, bei 30 lfm (laufende Meter) pro ha und mehr. Wegen fehlenden Unterhalts über viele Jahrzehnte sind sie heute vielfach nur mit Schleppern oder leichten Allradfahrzeugen befahrbar, oft auch nur durch Mulis oder Ochsen. Alle früher LKW-fahrbaren Wege wieder LKW-fahrbar zu machen, ist weder finanzierbar noch notwendig. Durch die moderne Rücketechnik, wie unten beschrieben, spielt die Rückedistanz ohnehin nicht mehr die ausschlaggebende Rolle wie früher. 15 lfm pro ha wie z.B. im Durchschnitt des Bayerischen Staatswaldes reichen völlig aus, wenn im Seilkrangelände mit Kippmastkranen und im Schleppergelände mit Tragschleppern oder Forwardern gearbeitet wird. Aber auch mit einer Grunderschließung von nur 8 – 12 lfm können mindestens 80 % der Waldfläche abgedeckt werden. Damit gelangt man betriebswirtschaftlich in Bereiche, die durch ein 10-Jahresprogramm umsetzbar und in 2 – 4 Jahren refinanzierbar sind – natürlich die ungünstigsten Fälle auf etwa 20 % der Waldfläche ausgenommen.

In Abb. 1 werden die theoretischen Auswirkungen des geringen Rückekostenanstiegs mit der Rückeentfernung bei einem Forwarder illustriert.

Derzeit ist leider vielfach zu beobachten, dass bringungsgünstige ortsnahe Waldlagen mit Hilfe von Zugtieren und alten rumänischen Traktoren gerückt werden, zu hohen Kosten. Früher oder später werden auf diesen Wegen moderne LKW fahren, aber die Rückekosten sind dann bereits ausgegeben und stehen nicht mehr als Deckungsbeitrag für den Wegeunterhalt zur Verfügung. Ökonomisch wäre es ungleich sinnvoller, über einen Kredit erst die Wege LKW-fahrbar zu machen und den Kredit aus den eingesparten Rückekosten rasch zurück zu zahlen. In Bulgarien scheitert dies am Mangel an Krediten bzw. astronomisch hohen Zinsen. Ein relativ bescheidener Kapitalstock, aus dem der Wegeunterhalt finanziert und dann rasch zurückgezahlt wird, wäre die Abhilfe. Auch in Deutschland oder Österreich wäre die moderne Walderschließung undenkbar gewesen ohne die ERP-Mittel aus dem sog. Marshallplan.

Doch zurück zu den technischen Aspekten: Als erstes ist ein Re-Design des Wegenetzes erforderlich, in dem nur ein Teil des ursprünglichen Netzes zum Ausbau vorgesehen wird, nämlich derjenige, der auch beim Einsatz moderner

Technik benötigt wird. Dieses neue Wegenetz ist in Prioritätsklassen gegliedert, abhängig von der ökonomischen Effizienz, d.h. der Rückzahlung des Wegeunterhaltskredits z.B. in 2 Jahren, 4 Jahren und 6 Jahren.

Der zweite Schritt soll als Re-Engineering des Wegeaufbaus bezeichnet werden. In den meisten Fällen ist die Deckschicht vollständig und die Tragschicht weitgehend in den Untergrund gedrückt oder erodiert worden. Die Anfuhr neuen Trag- und Deckschichtmaterials wäre viel zu aufwendig. Ein Kettenbagger mit etwa 20 to Gewicht und 8 m Reichweite ist meist in der Lage, einen Teil des Materials zurückzugewinnen und neu einzubauen. Gleichzeitig kann er Steine sammeln und zur Sicherung der Bankette bzw. als Trockenmauer einbauen. Vorzuziehen ist ein 2-Schalen-Greifer gegenüber dem weiter verbreiteten Tieflöffel, wie er auch in Bulgarien verfügbar ist.

Der Bagger bringt unvermeidlich grobes Material auf den Weg, das dann durch einen Steinzerkleinerer deckschicht-tauglich auf eine Korngröße maximal 0 – 40 mm gebracht werden kann. Gegebenenfalls müssen Durchlässe wieder ausgerichtet oder sogar neu angelegt werden. Auch dazu ist der Bagger bestens geeignet. Die Decke muss profiliert werden, wozu ein Gräder gut geeignet ist aber auch ein verstellbares Anbauschild ausreicht. Wünschenswert ist sodann eine Verdichtung durch Gummiradwalze, Vibrationswalze oder Vibrationsplatte. Wenn sich der LKW-Verkehr durch den Forstbetrieb je nach Witterung entsprechend steuern lässt, kann eine zufriedenstellende Verdichtung auch durch die Holzabfuhr mit gelegentlicher Nachprofilierung erreicht werden.

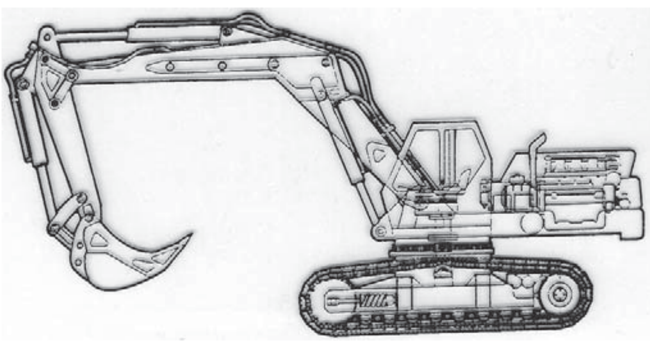

Abb.2: Kettenbagger mit 2-Schalen-Greifer

Abb.3: Steinzerkleinerer (Steinfräse)

Abb. 4: Wego-Anbauprofiliergerät

Die Kosten einer solchen Generalsanierung hängen weitgehend davon ab, wie der Maschineneinsatz organisiert werden kann und wie viel Material zugeführt werden muss. Ein entsprechender Maschinenzug mit Bagger, Steinzerkleinerer und Profilierschild kann pro Tag 0,5 bis 2 km bewältigen, zu Kosten von etwa 1500 € im Tag. Somit entstehen pro lfm nur Kosten von 1 – 3 €, bei Materialzufuhr und anderen Extras entsprechend mehr. Auf ganz Bulgarien gerechnet geht es dann allerdings um ein Programm von 50 bis 100 Millionen €.

Ohne diesen Kapitaleinsatz ist jedoch schwer vorstellbar, wie die Forstwirtschaft ihr Potential an Holzaufkommen, Arbeitsplätzen, Be- und Verarbeitung, letztlich neuen Häusern, Möbeln und Export-Einnahmen realisieren könnte.

VORSCHLÄGE ZUR RÜCKETECHNIK

Gemessen am geringen Holzeinschlag – zumindest was die offizielle legale Nutzung betrifft – ist Bulgarien reichlich mit Forstschleppern versorgt. Allerdings sind die meisten über 20 Jahre alt, soweit sie mit Kran ausgestattet sind, hält die Hydraulik einem Dauereinsatz nicht mehr statt. Ferner gibt es eine große Zahl von Mulis, Mauleseln, Pferden und Ochsen, die überwiegend als Zugtiere, teils auch als Tragtiere eingesetzt werden.

Unter moderner Rücketechnik werden hier Seilskidder verstanden, also Allradschlepper, in der Regel Knickschlepper, mit einer Seilwinde, die Langholz über Distanzen von 20 bis etwa 80 m beiseilen, bündeln und dann rücken können. Vor allem zählen dazu Kran-Forwarder, also Tragschlepper für Kurzholz bis etwa 6 m Länge, die das Holz mit Kran aufladen und dann transportieren. Dies ist vor allem über Distanzen von mehr als 200 m deutlich preisgünstiger und pfleglicher als der Seil-Skidder.

Bei den Kosten haben die traditionellen Rückemittel den Vorteil, dass sie zunächst keine Neuinvestition erfordern, im Falle des tierischen Zuges nur Futter, das auf dem Feld wächst, Pferde vermehren sich sogar ohne Kosten für eine Neubeschaffung. Was Produktivität und letztlich Stückkosten betrifft, sind sie jedoch nicht konkurrenzfähig, auch in Bulgarien nicht mehr. Die Personal- und Instandsetzungskosten sind nämlich hoch.

Das bedeutet aber keinesfalls, dass die traditionellen Rückemittel ausgemustert und durch modernere ersetzt werden sollten. Vielmehr sollten die unschätzbaren Vorzüge tierischen Zuges zum Sammeln (Vorrücken) der einzelnen Stücke, zum Rücken auf kurze Distanzen bis etwa 150 m, für schwaches Holz und auf schlecht befahrbaren Böden genutzt werden. Ältere Schlepper mit Anhänger können sehr effizient im Verbund mit leistungsfähigen Kranfahrzeugen eingesetzt werden, indem sie nur fahren und nicht laden.

Der Schlüssel zur Modernisierung der Rücketechnik wird aber in der Einführung moderner Forwarder gesehen. Sie können vorübergehend nicht mehr LKW-fahrbare Wege benutzen, bis das oben beschriebene Ausbauprogramm greift. Vor allem können sie mit hoher Produktivität auch größere Rückedistanzen bis zu 800 m, in Sonderfällen auch mehrere Kilometer, bewältigen. Durch Mehrschichtbetrieb lassen sich die Fixkosten in Grenzen halten.

Abb. 5: Kranforwarder

Die Fixkosten sind nämlich das Problem, bei der Investition von 200 000 € und mehr für einen neuen Forwarder. Ein neuer Forwarder ist allerdings auch nicht unbedingt erforderlich. Ähnlich wie die Motorisierung der Transformationsländer Osteuropas hauptsächlich über den Import von Gebrauchtwägen erfolgt, sollte auch die Forstwirtschaft auf die Gebrauchtmaschinen des Westens zurückgreifen. Das hat nichts mit Rückständigkeit zu tun, die Stärke Bulgariens liegt eben in den vergleichsweise niedrigen Lohnkosten eines Mechanikers oder Maschinenführers. Dadurch ist die Reparatur eines älteren Forwarders ökonomisch sinnvoll, wenn sie bei uns längst zur Ersatzbeschaffung führen müsste.

Gefragt sind dabei die Hersteller in den alten EU-Ländern, die diesen Markt entsprechend entwickeln und pflegen sollten: durch das Angebot von preisgünstigen, aber dennoch sicheren und zuverlässigen Maschinen, durch Garantie auf zentrale Komponenten auch bei Gebrauchtmaschinen, durch Unterstützung bei der Ausbildung von Maschinenführern.

Nicht vergessen werden sollte beim Gebirgsland Bulgarien, dass man auch Forwarder nicht in Gelände schicken darf, für das sie nicht geeignet sind. Zur modernen Rücketechnik rechnen unbedingt die Kippmastkrane unterschiedlicher Reichweite und Tragkraft. Darauf kann hier nicht mehr näher eingegangen werden. Auch die traditionellen Schlittenwinden, bei denen Bulgarien eine lange Tradition hat, sollten nicht vergessen werden. Auch hier bieten die geringen Lohnkosten Chancen, längere Aufbauzeiten durch die geringeren Investitionskosten zu kompensieren.

ZUSAMMENFASSUNG

Der bulgarischen Forstwirtschaft ist es bislang offenbar kaum gelungen, ihre bedeutenden ökonomischen Potentiale umzusetzen. Die entscheidenden Defizite liegen in der Walderschließung und der Rücketechnik.

Die LKW-fahrbaren Wege sind vielfach so degradiert, dass zunächst ein Re-Design des Wegenetzes erforderlich ist, mit dem Ziel die Wegedichte deutlich zu reduzieren und auf moderne Rücketechnik abzustellen. Ferner wird ein Re-Engineering des Wegeaufbaus vorgeschlagen, um mit Hilfe eines Baggers noch vorhandenes Baumaterial wiederzugewinnen, grobe Steine mit Steinzerkleinerer auf die erforderliche Korngröße zu bringen, die Decke zu profilieren und zu verdichten.

Die Umsetzung erfordert Kapital, das als refinanzierbarer Kapitalstock (revolving fund) nach dem Vorbild der ERP-Mittel organisiert werden sollte.

Moderne Rücketechnik sollte die vorhandenen Zug- und Tragtiere und alten Schlepper zunächst ergänzen und allmählich weitgehend ersetzen. Neben Seilskidder und Kippmastkran liegen vor allem in den modernen Kranforwardern bedeutende Potentiale für Bulgarien. Vorwiegend sollten Gebrauchtmaschinen importiert werden, wegen der geringeren Lohnkosten können sie wirtschaftlich genutzt werden. Die Maschinenindustrie sollte entsprechend geeignete Maschinen mit Garantie für Komponenten bereitstellen und Bulgarien bei der Ausbildung von Maschinenführern unterstützen.

ТРУДОВИ ЗЛОПОЛУКИ В ДЪРЖАВНИТЕ ГОРИ НА ГЕРМАНИЯ

Йоахим Морат, Германия

До 1999 г. нямаше общогерманска статистика на трудовите злополуки в държавните гори. Статистиката се правеше от провинциите /lender/, които ползуваха различни определения на понятията, така че получените резултати бяха несъпоставими. През 1999 г колектив от експерти на провинциите и KWF изработи единна федерална статистика. Тук даваме анализ на тази статистика за периода 1999 – 2004.

- Наблюдава се подобряване на всички показатели. Например показателят "брой на злополуките" е намалял от 2114 през 1999 г. до 1520 през 2004. Това означава намаление от 28%, което е по-голямо от намалението на броя на горските работници за същото време (20%). Подобряването на показателите говори, че взетите мерки са били ефикасни.
- В провинциите на Източна Германия показателите са по-добри. С течение на времето се наблюдава изравняване на показателите между източната и западната част на страната.
- Механизацията на дърводобива и екстензификацията на залесяването /planting/ и отглеждането доведоха до изместване на профила на дейността по посока на дърводобива /logging/. Следствие от това е повишеният дял на злополуките при дърводобива.

Като главни причини за намаляване на злополуките се очертават:

- механизацията на дърводобива
- екстензификацията на залесяването и отглеждането
- подобряването на обучението, техниката и личните предпазни средства.

UNFALLSITUATION IM STAATSWALD IN DEUTSCHLAND

Joachim Morat, Deutschland

Bis 1999 gab es auf Bundesebene keine Übersicht über das Unfallgeschehen im deutschen Staatswald. In den Unfallstatistiken der Länder wurde eine Vielzahl unterschiedlicher Begriffe benutzt, die eine Zusammenfassung unmöglich machten (Unfallbegriff, Bezugsdaten für Kennziffern etc).

Die von den Unfallexperten der Länder gemeinsam mit dem KWF erarbeitete Unfallstatistik hat zum Ziel bundesweit relevante Unfallkennziffern der Länder zu erheben aufzubereiten und zusammenzufassen. Die Kennzahlen sollen das Unfallgeschehen im Staatswald dokumentieren und eine bundesweite Analyse ermöglichen. Die Bundesstatistik soll ein entfeinertes Instrument zum Beobachten, Steuern und Bewerten des Unfallschutzes sein. Die Feinanalyse soll wie bisher durch die Unfallstatistiken der Länder gewährleistet werden.

Die im folgenden vorgelegten Ergebnisse von 1999 – 2004 sind als Zeitreihe verhältnismäßig kurz, statistisch abgesicherte Trends sind deshalb nicht zu ermitteln. Mit Hilfe der Zahlen lassen sich aber nichtsdestotrotz Entwicklungen erkennen.

- Absolute Unfallzahlen: Rückgang von 2114 Unfällen im Jahr 1999 auf 1520 Unfälle im Jahr 2004. Dies entspricht einem Rückgang von 28% und einem jährlichen Rückgang um 4,7 %. Gleichzeitig ging im Zeitraum die Zahl der Waldarbeiter von 14874 auf 11972 zurück. (= 20%).Länderweise bestehen erhebliche Unterschiede.
- Arbeitsunfälle pro 1000 Waldarbeiter: Rückgang von 147 auf 123 Arbeitsunfälle pro 1000 Waldarbeiter. Dies entspricht 17% und einem jährlichen Rückgang um 2,8 %. Hier ist vor allem die regionale Dynamik der Entwicklung interessant. 1999 betrug diese Quote im Mittel der ostdeutschen Länder 109 Arbeitsunfälle pro 1000 Waldarbeiter, im Mittel der westdeutschen Länder 172 Unfälle/1000 Waldarbeiter. Im Jahr 2004 waren es 131 Unfälle/1000 Waldarbeiter in den westdeutschen Ländern und 107 in den ostdeutschen Ländern.
- Arbeitsunfälle pro 1 Mio. Produktivstunden: 1999 waren es 106 Arbeitsunfälle/ 1 Mio. Produktivstunden; 2004 betrug diese Quote 89 Unfälle. Dies entspricht einem Rückgang von 16% über die gesamte Periode und einem jährlichen Rückgang um 2,6 %. Auch hier bemerkenswerte regionale

Unterschiede. 1999 waren in den ostdeutschen Ländern pro 1 Mio. Produktivstunden 76 Unfälle zu verzeichnen, in den westdeutschen Ländern 135 Unfälle pro 1 Mio. Prod. Stunden. 2004 waren es in den ostdeutschen Ländern 74 Unfälle pro 1 Mio. Produktivstunden, in den westdeutschen Ländern 97 Arbeitsunfälle pro 1 Mio. Produktivstunden.

- Arbeitsunfälle in den Arbeitsbereichen: Hier zeichnet sich eine Verschiebung des Unfallgeschehens in Richtung motormanuelle Holzernte ab. Im Jahr 1999 waren 62% der Unfälle im Bereich Holzernte; 2004 waren es 71% der Unfälle. Unfälle in der Bestandesbegründung gingen von 9 auf 3%, in der Bestandespflege von 7 auf 4 % zurück.
- Arbeitsunfälle pro 1 Mio. Produktivstunden in der Holzernte: Hier stagnieren die Zahlen bundesweit auf hohem Niveau, zwischen 156 und 189 Unfällen pro 1 Mio Produktivstunden. Es gibt allerdings regional erhebliche Unterschiede. Während diese Quote in den meisten Bundesländern (darunter auch die großen Waldflächenländer Brandenburg, Bayern, Baden Württemberg) sinkt, steigt sie in Hessen, Mecklenburg -Vorpommern und Thüringen teilweise Besorgnis erregend an. Einen Versuch zur Interpretation dieser Quoten werde ich am Ende des Vortrags machen.
- Arbeitsunfälle bei den Ablaufabschnitten der motormanuellen Holzernte: Hier ist bei den wichtigeren Gefährungsabschnitten nur eine geringe Veränderung festzustellen. 25% der Unfälle ereignen beim Entasten, 15-20% beim Fällen, ca. 10% beim Zufallbringen.
- Verletzungsursachen und deren prozentualer Anteil: Hier ist nur eine geringe Dynamik festzustellen. Bäume und Baumteile sind mit Werten zwischen 35 und 45 % die bedeutendste Unfallursache, gefolgt von Stolper- und Sturzunfällen, die zwischen 25 und 30% der Verletzungen verursachen.
- Verletzte Köperteile und prozentualer Anteil: Auch hier ist keine gravierende Veränderungen festzustellen. Die Fuß-Bein-Verletzungen nehmen Werte um die 35% der Gesamtverletzungen ein,, der Rumpf wird bei 17% der Unfälle verletzt, der Arm-Hand-Bereich bei 25% der Unfälle.
- Unfallschwere Leichte Unfälle 4-20 Ausfalltage, mittlere Unfälle 21-45 Tage; schwere 46-90 sehr schwere Unfälle mehr als 90 tödliche Unfälle zwischen 2 bis fünf. Die Quote pro 10000 Waldarbeitern zeigt uneinheitliches Bild.
- Das Unfallgeschehen zusammengefasst:

o Der Rückgang aller relevanten Kennziffern zeigt, dass die Präventionsanstrengungen der Länder insgesamt, besonders in den ost- und westdeutschen Waldflächenländern, erfolgreich sind. Es bestehen allerdings regionale Unterschiede, besonders bei der motormanuellen Holzernte.
o Grundsätzlich ist zu beobachten, dass sich die Unfallquoten der östlichen und westlichen Länder angleichen.
o Der verstärkte Einsatz mechanisierter Holzerntesysteme und die Extensivierung der Bestandesbegründung und der Bestandespflege hat zu einer Verschiebung des Tätigkeitsprofils der Forstwirte in Richtung Holzernte geführt. Dies zeigt sich auch in der prozentualen Verteilung der Arbeitsunfälle in der Arbeitsbereichen.

- Die Ursachen des Rückgangs sind vielfältig, verschiedene Faktoren beeinflussen sich gegenseitig. Der Rückgang kann nicht linear auf die Wirkung einer Intervention zurück geführt werden. Hier die wesentlichen Einflussfaktoren:

o Der verstärkte Einsatz mechanisierter Holzerntesysteme
o Die Extensivierung von Bestandesbegründung und Pflege
o Arbeitsschutz als Betriebsziel, nicht nur Lippenbekenntnis
o Arbeitsschutzmanagementsysteme
o Systematische Gefährdungsanalyse
o verbesserte Schulung und Sensibilisierung aller Akteure
o verbesserter technischer Arbeitsschutz
o verbesserte persönliche Schutzausrüstung.

ЗЕМЕДЕЛСКА И ГОРСКА ТЕХНИКА – ПРАВОСПОСОБНОСТ ЗА РАБОТА

Михо Михов, Д. Маринова, България

Направен е анализ на законодателната уредба, регламентираща пряко или косвено въпроси, свързани с придобиването на правоспособност за работа със земеделска и горска техника. Подробно са разгледани категориите правоспособност, изискванията за извършване на обучение, провеждането на изпити и документите за правоспособност. Посочени са съществуващите пропуски и проблеми и са направени предложения за подобряване и разширяване на обхвата на системата за обучение.

AGRICULTURAL AND FOREST EQUIPMENT – A WORKING CAPACITY

Miho Mihov, D. Marinova, Bulgaria

Abstract

A legislation analyse has been made related to legislation regulating directly and indirectly some questions about agricultural and forest equipment workers capacity. In details had been studied categories of working capacity, training requirements, examinations procedure and worker's certificates. Some existing gaps and problems had been mentioned and constructive proposals to improve and to expand the scope of training system had been also made.

In Bulgaria the training to adopt a capacity to work with agricultural and forest equipment began in the early 60s of twentieth century. The Ministry of Agriculture (MA) had approved first training plans, procedure to hold exams and types of working capacity documents. The capacity licenses were divided into four groups: assistant-tractor driver, tractor-driver, assistant combine-operator, combine-operator. A separate document had to be issued for each of those groups. This document was termless and without control check. In 70s the total invasion of mechanisation equipment in agriculture and forestry and the need of annual education of few thousand people leaded the Ministry of agriculture to approve a new procedure of training and adoption of working capacity, exams methods as well as new types of documents. New kinds of working capacity in the agriculture area were divided of three groups: a tractor-operator IIIrd class; a tractor-operator IInd class; tractor-operator Ist class, and in the forest industry – by types of equipment. The level was also mandatory, as well as in 60s requirements, e.g. The exam for tractor-operator – IIIrd class. The training to adopt a working capacity documents was arranged in the professional and training centers organized to the Agricultural and Industry complexes. The exam commissions were organised by municipalities. Analogical working capacity documents were issued to the scholars by the technical schools at the Ministry of agriculture and the Committee of forests. They were issued on the grounds of qualification exams by approved training plans related to different special fields. That was the situation until 1987-1988.

After the liquidation of Agricultural and Industrial complexes the professional training centers organized in few regions of country continued to provide some training courses until 1990, but without any legal grounds. In practice, since 1988, we have not been applied any legal act in virtue of which to regulate the training for a working capacity, the issue of documents for capacity to work with agricultural and forest equipment and the control of working staff. This situation leaded to big ten years-prolonged legislation gap in this area. Because of that legislative gap the work with tractors and combines have continued on the grounds of capacity documents issued by virtue of Roads Traffic Act - “Tractor”(Tct) and “Combine” (C).

Since the adoption of Registration and control of agricultural and forest equipment act (RCAFEA), (Off. J., № 79/1998) and some regulation acts by virtue of this law, a new process have began – the process of harmonisation of our legislation with the European legislation in this field. The amendments adopted by virtue of that legal regulation consist of few points, as follows:

Registration of tractors, agricultural and forest equipment – to allow and to put only registered equipment to work. The procedure of registration is determined in the Regulation №26 /19.11.1998 (Off. J., №140/27.11.1998). Owners have been obliged to register automotive equipment with a motor power up to 18 KW and farm equipment attached. The equipment registered by virtue of Roads Traffic Act (wheel carrier tractors and tractors trailers) has also to be registered in the municipalities where is the owners' living place.

Exams of agricultural and forest equipment – there are three types of exams provided: seasonal, annual and thematic. These are control-diagnostic exams of machines working order and safety. The seasonal and annual exams are executed by regional services of Control – Technical Inspectorate (CTI) in schedule approved by the Minister of agriculture and forests or by authorized person and they have to be paid by tariffs approved by Council of Ministers.

The machine is in good working order if it is completed and in a technical level according to production regulations and to legal instructions and requirements.

Capacity to work with tractors, agricultural and forest equipment – the procedure of adoption and withdrawal of working capacity is determined by Regulation №5 (Off. J., № 18/7.03.2000). Since I st of September 2000, new categories of working capacity entered into force, as well as the type and the methods to issue documents of working capacity.

The so existing three classes of capacity "tractor-operator" (III, II and I) were substituted by new four categories divided in two groups: for work with tractors and for work with specialized and special automotive equipment:

- Category "Tvk" – which give a capacity to work independently with wheel carrier tractors and chain-tractors and working machines units to them;
- Category "Tvk - Z" - which give a capacity to work independently with specialized and special automotive agricultural equipment;
- Category "Tvk – M" - which give a capacity to work independently with automotive meliorative equipment;
- Category "Tvk – G" - which give a capacity to work independently with automotive forest equipment.

The basic category "Tvk" is included in the first group. This basic category is necessary to adopt a category of second group – "Tvk-Z", "Tvk-M" and "Tvk-G". A driving license by virtue of Roads traffic act is also necessary if the automotive agricultural and forest equipment have to use the public roads.

A special capacity document is also introduced in case of work with several types of portable and static equipment. These are as follows: motor saws, log band saws, milking machines and shearing machines (clippers). There is no any limitation of capacity types. Persons who have adopted some type of capacity could adopt each other type of capacity.

The education to adopt a capacity to work with tractors, agricultural and forest equipment is provided in the professional high schools, universities, schools, firms, etc. having license by the Minister of agriculture and forests. The duration of courses related to different categories of capacity is different. In the training programs approved by the Ministry of agriculture and forests a mandatory minimum of hours is provided. It is necessary to allow an exam and is proved by education booklet, arranged by teachers in theory and practice and signed by each of trainees.

The capacity adoption exams aim to verify knowledge and skills of candidates to work independently with agricultural and forest equipment according to their qualification characteristics. They are divided in two parts: theory and practice. The theory consists of test. Those of candidates who had received poor marks on the theory test are not allowed to the practice part of exam. The practice part is divided in two separated parts – equipment preparation to work (aggregation, regulations, service and remove of defects) and equipment work.

The necessary equipment to hold the exam (offices, basic and reserve machines, ranges and platforms) has to be assured by the training form where the exam will be hold. Those of candidates who take the exam have to apply for a capacity license issued by the regional offices of Control-technical inspectorate to the Ministry of Agriculture and forests.

To work with static and portable agricultural and forest equipment a capacity license is issued, and to work with tractors and automotive agricultural and forest equipment - a capacity license and control check attached are issued.

The application of law presented substantial gaps and non-solved problems even in the narrow area of registration and control. This situation was based on the little experience in preparation of legal acts by specialists working in this field. In this law were not introduced so needed legal acts as Regulation of safety work with agricultural and forest equipment; Regulation of technical exams; some administrative measures related to those persons (natural persons and legal entities) who had violated some provisions; procedures provided to issue certificates and registration were so clumsy, etc… They were particularly removed by the Amendment of agricultural and forest equipment act (Off. J., № 22/11/03.2003). This situation leaded to preparation and issue of new Regulation № 8/2004 related to adoption and withdraw of working capacity licence. This Regulation continues the provisions of Regulation № 5 and some of requirements are saved and another new requirements are introduced, as follows:

- training documentation (plans, programs, training booklets, registration books, etc…) to adopt a capacity license;
- necessary equipment to the education (offices, illustrations of training material, sections, miniature models, stands and machines for basic types of works related to the category or type of capacity);
- theory and practice teachers;
- procedure to apply for adoption of license to training and license-forms;
- method of preparation and hold of exams and exam documentation.

At the same time the number of licenses had increased by introducing of new machine groups used in the agriculture and forestry – chain lines, hydraulic engines on tractors and automotive agricultural and forest equipment, electric truck and motor truck.

These legal amendments aim to increase the quality of training according to the qualitative renovation of machine and tractors park with new high –productive, powerful, at a high price equipment, and on the other side – the prestige of work with agricultural and forest equipment.

There are also some serious problems existing. An agricultural and forest equipment act is not yet adopted and this is an obstacle to the legislation development in the field of training. In the frame of Registration and control of agricultural and forest equipment act the legislation can not be developed because of specifics of this law and it's application by the Executive Agency "Control-technical inspectorate", which is not specialized on training development. By opposite of another EU countries our legislation does not provide any preferences for professional training in this area. Because of that reason it is extremely difficult to renovate the necessary equipment to education and to avoid the inconformity of preparation level with the contemporary technical requirements.

CONCLUSIONS

- Irrespective of amendments adopted, the registration and control of agricultural and forest equipment act can not cover all live circle of machines from their sale till their transformation to scrap. An elaboration and adoption of new law on agricultural and forest equipment is necessary and this legal act must include: test of agricultural and forest equipment and it's put on the market; equipment safety and registration; training to work with agricultural and forest equipment; equipment service and repair; control and registration.
- At this time the equipment needed a capacity license to work is not so numerous. There are no included even all basic machines used in agriculture and forestry – more than 60 % of equipment used. There are no elaborated any legal acts related to safety work with this type of equipment and training to work with.

СРАВНИТЕЛНО ИЗСЛЕДВАНЕ НА ВЛИЯНИЕТО НА КОЛЕСНИТЕ И ВЕРИЖНИТЕ ТРАКТОРИ ВЪРХУ ГОРСКИТЕ ЕКОСИСТЕМИ

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Резюме

Използването на тежка техника в планински условия предизвиква разрушаване на приземната растителност, уплътняване на почвата, почвена ерозия, разкъсване на почвената постилка и покривка, свличане на земни маси, промяна на нивото на подпочвените води и замърсяване на водните течения. Целта на настоящата работа е да се проучат екологичните последици от дърводобива с наземни извозни средства (колесни и верижни трактори) върху горските екосистеми в украинските Карпати с оглед минимизирането на тези последици.

COMPARATIVE EVALUATION OF WHEELED AND TRACKED SKIDDERS IMPACT TO FORESTRY ECOSYSTEM

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SUMMARY

The use of heavy harvesting equipment in mountain conditions results in the destruction of underwood, intensification of soil compaction, erosion and rutting, surface damage, debris slide, change of underground waters level and pollution of flows. The work aims to study the ecological consequences of harvesting to substantiate proposals on the minimization of impacts caused by ground-based skidding machines (wheeled and tracked tractors) to the Ukrainian Carpathians forestry ecosystems.

Keywords: soil erosion, soil rutting, damage to underwood, wheeled and tracked skidders

Damage to ground surface

Ground surface is damaged mainly as a result of wood skidding by tractors during clear cutting at the External Carpathians (Gorgany) slopes. The slope steepness growing from 15º-20º to 21º-30º, the loss of soil increases approximately by a factor of 1.5; for the steepness up to 31º-40º, the loss of soil increases more than twice. The cutting area length growing from 100-200 m to 201-400 m, the loss of soil increases almost by a factor of 2.5; for the length over 400 m, the loss increases by a factor of 3-3.5. The volume of soil moved averages 3-4.5 m^3/running meters for the main skidding ways and 1.5-3 m^3/running meters for the strip skidding ways. About 80% of cutting area remains intact during tractor skidding.

Soil rutting

The intensity of soil rutting depends considerably on the level of ground bearing capacity which, in its turn, very largely depends on the Carpathians geomorphologic structure. In the turn with a minimum radius, the rut depth increases by a factor of 1.5-2 for a wheeled tractor and by a factor of 2-3 for a tracked one as compared to straight traffic. The presence of a brash mat decreases the rut depth by a factor of 1.5-2 for a wheeled skidder and by a factor of 2-4 for a tracked one.

Damage to underwood

In the course of skidding, up to 17% of underwood is destroyed: 46.2 – 53.8% by means of trunks barking and 27.0 – 30.8% by means of damaging rootage. Nevertheless, as a whole, a sufficient number of sprouts are left after wood skidding at the areas examined (about 15.7-19.6 thousand per hectare), which is enough for the complete natural regeneration.

CONCLUSIONS

The forestry ecosystem is damaged mainly by the ground-based skidding of wood. There is no significant difference between the use of wheeled or tracked tractors with respect to the intensity of damage done to the forestry ecosystem in mountain conditions. Thus, it is expedient to base the steep terrain logging on the optimal combination of special harvesting equipment with various kinds of carrier platforms, depending on specific natural and industrial conditions, with the indispensable preliminary construction of the extensive network of forest roads to provide optimal distances for the skidding of wood.

Among the most effective ways to decrease the negative impact of wood skidding to the forestry ecosystem is to use cable yarding systems at steep slopes.

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