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CONTENTS

PAPERS FROM CONFERENCE "FORESTRY: BRIDGE TO THE FUTURE", MAY 13–15, 2010

FORESTRY IDEAS, 2010, vol. 16, № 1 (39)

EXTENSION IN FORESTRY: LESSONS FROM A CENTURY OF EXPERIENCE

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Abstract

The current Cooperative Extension System in the United States has in roots in two historic pieces of legislation. The first, the Morrill Act of 1862, created the land grant university system, in which a network of agricultural universities was established in each state, followed by agricultural research stations. In 1914 the U.S. Congress passed the Smith-Lever Act, which created the Cooperative Extension System, a joint partnership between the U.S. Department of Agriculture, the state land grant universities, and local units of government in each state. This partnership has endured to the present day, and is often held up as a model for helping farmers, families, and individuals improve their lives and livelihoods. Today, most state Extension Services have statewide programs in the broad areas of agriculture; youth, families, and communities; and the environment and natural resources, including forestry. Hallmarks of extension education include a focus on problem solving, education based on research-based knowledge, education oriented toward client needs, an emphasis on partnerships (particularly at the local level), and an emphasis on evaluation of results. A typical extension model involves engaging stakeholders and partners to identify problems and potential solutions through education, designing educational materials and programs, conducting programs, and follow-up evaluations to determine outcomes in both the short and long terms. A typical example of such a program in Oregon is the Master Woodland Manager Program, which has been in operation for over 20 years. In 2008 this program won a national award for the best Forestry Extension program in the U.S. from the National Woodland Owners Association. Through this program forest owners receive 85 hours of training in 11 modules. They become very knowledgeable in subjects such as silviculture, reforestation, watershed management, and communications. Following completion of the program they become volunteers, assisting other forest owners and often leading them to practice much better management on their lands. Since the inception of the Master Woodland Manager Program, over 400 forest owners have completed the training, and provided over 30,000 hours of volunteer service.

Key words: Forest Extension, Cooperative Extension System, forest owners.

Introduction

Extension, both the institution (Cooperative Extension Service) and the process of extension education, has played an important role in agriculture, natural resources, and rural development in the United States. All 50 states have an Extension Service tied to the land grant university and the U.S. Department of Agriculture, and all are still functional after nearly a century of work (Seevers et al. 1997). To be sure, the nature and role of Extension have evolved over the years, and now contemporary topics such as nutrition education, youth and family development, and economic development are now as familiar to users as the more traditional agricultural extension programs.

Although the roots of extension lie within the broad field of agriculture, extension work in forestry and related natural resources management dates back to the early 1920's in the U.S. Critical issues during that time were largely related to protection from rampant wildfires, insect and disease problems (particularly from newly introduced pests from Europe and Asia such as white pine blister rust, Chestnut blight, and the European gypsy moth), and reforestation of cut over and abandoned agricultural lands. Educational programs provided by extension foresters and newly created state forestry agencies assisted farmers and forest owners in dealing with these issues using the best scientific information of the day. Over time, the "generalist" extension foresters were joined by technical specialists such as "extension silviculturists", "extension forest pathologists", "extension forest entomologists", and "extension hydrologists".

Today the Cooperative Extension model in most states employs a statewide network of extension agents working out of local, county-based or regional extension centers, augmented by statewide extension specialists who often work out of the central university campus or agricultural research stations. However, Cooperative Extension in most states is declining due to reduced funding, particularly at the federal level, where flat year to year funding results in a decrease in real terms (Morse 2009). Given this budget pressure, the need for extension work is greater than ever, with current issues such as climate change, payment for ecosystem services, bioenergy development, invasive species, and economic development requiring more scientific investigation and resultant extension services.

Historical Context

The concept of "extension" dates back to England in the mid 1800's, when British universities first instituted the concept of taking the knowledge of the university to the citizenry outside the halls of academia (Van den Ban and Hawkins 1996). In the United States there was a movement underway during this time to broaden the education of young people in "practical subjects" such as agriculture, mechanical arts, and home economics. In the U.S. universities were based on the European system that focused on classical education in liberal arts and science, primarily for wealthy students. The cry for a new system was heard and in 1862 President Abraham Lincoln signed into law the Morrill Act, which created a state by state network of "land grant" universities. Each state was granted a tract of public domain land that could be sold to fund the new universities, that would be run in partnership with the U.S. Department of Agriculture. In 1887 the Hatch Act was passed, which led to the creation of Agricultural Experiment Stations tied to the land grant universities. As new agricultural research was developed, the idea of "extension" to the people became more prevalent, and in 1914 the Smith-Lever Act was passed, which created the nationwide Cooperative Extension Service, a joint partnership between the states and the U.S. Department of Agriculture. Today the sub-agency responsible for the Extension Service is the National Institute for Food and Agriculture (NIFA).

Over the years, the extension model has been widely disseminated and adopted throughout the world. For example, the Food and Agriculture Organization of the United Nations summarized their recommendations for organizing and conducting extension programs in two publications (FAO 1986, Sim and Hilmi 1987). In 1993, the International Union of Forest Research Organizations established the Extension Working Party within the Division of Economic, Social, Policy, and Information Sciences, or Division 6 (Johnson 2006). This Working Party has been very active over the years, hosting international conferences in Germany, the U.S. (twice), Kenya, Slovenia (twice), Australia, Italy, and Canada, with resultant proceedings published in print or electronic formats.

Hallmarks of Extension Education

Over the years, certain "hallmarks" of extension education in the U.S. have emerged. They may be considered unique features of extension that distinguish it from other adult education programs. They are as follows:

– Based on local needs, following a process for engaging stakeholders in identifying issues, problems, and solutions.

– Focused on problem solving through the use of a deliberative educational process.

– Based on the best available scientific knowledge grounded in peer-reviewed research from universities, federal agency research labs, and other credible sources.

– Committed to life-long learning.

– Committed to partnerships with other stakeholder organizations from various communities, including business and industry; local, state, and federal agencies; other educational institutions; and non-governmental organizations.

– Committed to accountability and use of accepted procedures for evaluation and reporting of outcomes in both short and long terms.

To achieve its goals, extension follows a series of deliberate actions. The relationship between the research and extension functions, and the stakeholders or end users are shown in Figure 1. Of importance to note is that the arrows in the diagram flow in all directions. Thus, the researchers are influenced not only by the extensionists, but by the end users as well. For example, Creighton et al. (2009) reported that from 69 to 82 percent of extensionists engage end users in applied research, and an additional 16 to 18 percent currently do not but would like to. Furthermore, this phenomenon occurred throughout the world. Likewise, from 61 to 82 percent of extensionists facilitate peer to peer learning opportunities with the end users often or sometimes, and an additional 15 to 18 percent do not but would like to.

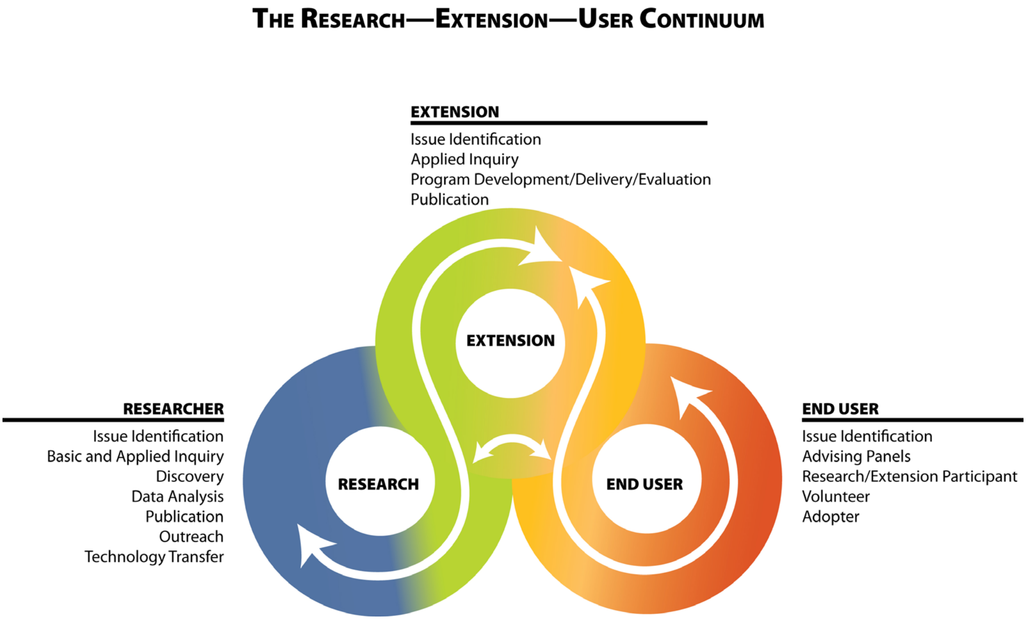

Fig. 1. The relationship between the research and extension functions, and interactions with stakeholders or end users.

A typical approach to utilizing extension would involve the following steps:

– Needs assessment.

– Issue identification.

– Scoping for research-based educational materials.

– Program development (may include development of educational materials).

– Program delivery.

– Evaluation and follow-up.

Interaction with researchers and end users would occur through the various steps, as necessary.

The Oregon Master Woodland Manager Program – a Case Study

A suitable example of a modern extension program in action is the Oregon Master Woodland Manager Program (Fletcher et al. 1985, Fletcher and Reed 1986). Oregon is the ninth largest U.S. state and is heavily forested, with about 50 percent of its land area in forests. Oregon has nearly 12 million ha of forest land. In Oregon, 60 percent of the forest land is owned by the federal government, and 35 percent is in private ownership (OFRI 2009). However, 83 percent of the timber harvested in the state is from the privately owned forests (OFRI 2009). Thus, the private forests are disproportionately important to the state's economy. Sharing the private ownership with industrial owners are about 150,000 individual or family forest owners. In order to assist these owners in better managing their lands, comply with laws and regulations of the state, and to achieve their personal management objectives, the state relies on education provided by the Oregon Extension Service, technical assistance provided by the Oregon Department of Forestry, and additional services provided by the state's forestry consultants. During the mid-1980's, in an effort to pool resources and develop volunteers, the Oregon Extension Service, Oregon Department of Forestry, and the U.S.D.A. Natural Resources Conservation Service conceived of the Master Woodland Manager Program. The intent was to develop a cadre of trained forest owners who would be empowered not only to practice better management on their own lands, but to also serve as volunteers to assist other forest owners with their educational needs. This model would greatly expand the local capacity of the sponsoring agencies.

A series of 11 training modules was developed, covering 85 hours of instruction in such areas as reforestation and silviculture, watershed management, forest management planning, forest health, forest measurements, and wildlife management. In addition, such topics as communications and leadership were also covered. In exchange for the educational program, the Master Woodland Managers would be expected to deliver back 85 hours of volunteer service. In addition, every other year the Oregon Extension Service offers a multi-day mini-college which serves the role of continuing education for the Master Woodland Managers. Both advanced and refresher topics are covered in these sessions. Since its inception, about 400 Master Woodland Managers have been trained, and nearly all complete their voluntary service. The most recent evaluation, conducted in 2003, showed that the volunteers logged 4,815 hours in that year alone, and nearly 27,000 hours total since inception of the program. The volunteer service takes many forms, including conducting educational programs for youth, providing site visits to other properties, service on various committees and task forces, conducting actual stewardship projects, building web sites, and more. The Master Woodland Manager Program received the nation's outstanding family forest owner Extension Award in 2008, provided by the National Woodland Owners Association and the National Association of University Forest Resources Programs.

Conclusion

Forestry and Natural Resources Extension remains a critical part of the Cooperative Extension Service, both at a national level and in many forested states in the U.S. The basic hallmarks of good extension work apply, regardless of the subject area. However, the issues change over time, and the Extension Services need to be adaptive as well.

Embracing new technology is a notable example. Not many years ago only a few forest owners had internet access, and now nearly all do. As a result, web-based educational programs are becoming more common.

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VALUABLE WOOD PRODUCTION – AN OPTION FOR THE FUTURE?

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Abstract

Ecological and economic considerations increased the interest in growing valuable tree species. Timber quality depends on the genetic characteristics of the individual tree, site conditions as well as on management. Applying an appropriate treatment trees can yield high quality timber within relatively short production times. Forest management has to find new ways to increase net revenue from timber sales by increasing wood quality while keeping production costs low. Through precise and aim oriented management efficiency can be improved. All activities have to be linked to the value producing trees, as those are the economically relevant trees. When dealing with fast growing broadleaves the number of final crop trees per ha is relatively small. This is due to the fact that valuable trees need to have a large diameter, and those trees can only be produced with a big crown. In order to reduce costs the number of trees to be planted can be limited to much less than was considered in the past.

Thinning is applied for controlling the quality of the wood production; in particular, it is used for favoring future crop trees, controlling their diameter growth and natural pruning. A two-phase management system is recommended: first phase emphasizing pruning, and second phase encouraging crown expansion and stimulating diameter growth. There is a close relation between crown expansion and diameter growth. An allometric model describing the relation between crown width and stem diameter is used to calculate the intensity of thinning in order to control diameter growth. The time of harvest is determined by the time of maximum average value production, the marked situation and other factors. The idea of fixed rotation may be abandoned as trees of the same age can grow in groups. Group selection cut may be preferred as larger gaps are needed to fulfil the light requirements of the new generation.

Key words: economically relevant trees, pruning, revenue, timber quality, valuable tree species.

1 Reasons for growing valuable wood

1.1 What makes trees "valuable"?

Valuable species are considered to be valuable because of their high timber prices, and aesthetics of their timber, or simply because of rareness and beauty of the tree. Which species really is valuable, is often a matter of subjective opinion. However, common ash (*Fraxinus excelsior* L.), sycamore (*Acer pseudoplatanus* L.) and wild cherry (*Prunus avium* L.) are considered to be the most important representatives of the group of valuable broadleaved species with still increasing economical importance in Europe (Thies et al. 2009). Not only these species, but also several other valuable broadleaves such as walnut (*Juglans regia* L., *J. nigra* L. and hybrids), wild service tree (*Sorbus torminalis* (L.) Crantz.), black alder (*Alnus glutinosa* (L.) Gaertn.), lime (*Tilia cordata* Mill.) and to a large extend oak sp. are cultivated for valuable wood production. Coniferous species may in exceptional cases produce valuable timber, as well. However, coniferous species will not be considered in this paper.

1.2 Ecological reasons for growing valuable wood

Valuable broadleaved forests may form important habitats for numerous plants, insects, fungi and animals and so increase habitat values, as well as contribute to biodiversity and nature conservation.Valuable broadleaves produce flowers in springtime, and their flowers and fruits enrich habitats. They enrich the understory and ground vegetation as crown competition of adult trees has to be avoided and therefore canopy closer will vary. Valuable broadleaves mixed with other species in groups or small stands reduce risks of pests and diseases. When planted in huge monocultures risks of pest and diseases may increase, on proper sites, mixed with other tree species or in hedge rows these risks are reduced.

1.3 Economic reasons

The net income of forestry depends on the difference between costs and revenues. Only some costs such as plant material, pruning, continuous release from competitors and special arrangements for marketing and selling are directly related to the quality of the timber. Other costs, such as cost of labour for planting, felling, logging, transport cost as well as cost for general administration are quality-independent. As a consequence high quality timber should be produced, especially when labour cost or transport cost are high. A simple example may show the attractiveness of valuable wood production:

(I) veneer wood of highest quality:

1.000 €.m^{-3} – 30€ (harvesting cost) = = 970 € (net income per m^3)

(II) average quality Norway spruce wood:

80 €.m^{-3} – 30€ (harvesting cost) = = 50 € (net income per m^3).

This example shows that 5 m^3 of valuable timber (I) can create the same net income as 100 m^3 of medium quality of a mass assortment (II).

1.4 Social reasons

Valuable wood is a source of income and creates jobs. Moreover, valuable broadleaves contribute with their colour and texture to the beauty of the landscape and increase the attractiveness of forests for recreational use. In natural conditions, valuable broadleaves grow scattered as single trees and in groups. Apropriate management including the formation of internal edges and gaps may change the visual impacts and create high aestethic values. However, contribution to landscape varies from place to place (Bell 2009).

The public preference as well varies locally and depends on the social background of the people. Even so there is a trend towards more "broadleaved" forest, the public does not emphasize to a high extent valuable broadleaved tree species but clearly prefers mixture of species. Size and structure of the forest is more important than species composition (Schraml and Volz 2009).

2 Growing valuable wood

2.1 What criteria determine the wood quality?

The dimension and wood properties of the clear bole determine the value of the crop. The required dimension depends on the purpose for which the timber is used. For veneer wood for example the minimum length of the trunk generally is 2.8 m or 3.0 m (length of doors or panels) and the larger the diameter the higher the value for producing veneer. The branchy core should be as small as possible and the proportion of the clear wood without branches should be large. The stem should be straight and not twisted. These parameters can be controlled by forest management such as initial spacing, thinning, pruning and the time of harvest.

For producing as much high-quality and knot-free timber as possible two important general principles are targeted in the case of all valuable broadleaved tree species:

(I) *Restrict branchiness*: less branches mean better wood quality and higher market value.

(II) *Produce large diameter* ("the larger the better") *butt logs*.

Both branchiness and dimensions (diameter and length) can be manipulated by silvicultural measures (planting distance, cleaning-respacing, and thinning) controlling the stand density and available free space around tree crowns. Artificial pruning (formative and high) can have the same effect on branchiness as natural pruning.

High quality timber can be achieved by the application of adequate measures. Economic activities must be be linked to the value-producing trees only. When dealing with valuable broadleaved tree species the number of final crop trees per ha is relatively small. This is due to the fact that valuable trees need to have large diameters and crowns. At the rotation age, only a low number (for most species 40-80 per hectare) of large diameter trees is expected. The stand management has to focus on these value-producing trees and their choice and marking facilitates efficient management. Valuable broadleaves generally grow in naturally mixed stands and *single-tree management* may facilitate growing them under such conditions.

2.2 Which site conditions are required for growing valuable wood?

Trees should be well-adapted to the site and resistant to biological and environmental threats. When aiming for high wood quality in a relatively short time, productive sites are required. The site conditions modify growth dynamics including height growth and crown architecture. On fertile sites the clear bole up to the crown base may be higher or the wanted diameter of trees with similar crown base will be reached earlier.

3. How to grow valuable wood?

3.1 General considerations

The management aims vary considerable in different regions and they change over time. Diversification and flexible management have to scope with this challenges. Natural processes help to reduce cost and precise management concentrating on the production goals increase the wood quality as well as environmental services of the forest without substantially increasing management cost.

3.2 Forest structure

Valuable trees can be grown successfully as part of an existing forest management regime, in private and public forests, and in a mixture with both broadleaved and coniferous trees. Furthermore, they can be grown as a result of afforestation of farmland, in orchards, along roads or in hedge rows combined with agricultural land use, either arable land or grazing land (Thies et al. 2009). These alternatives show that there is a huge variety of options on how to grow valuable wood: Single tree selection system, group selection or even aged forest management. The size of the land is of little relevance. It seams that growing valuable wood is especially attractive for small and medium sized forest owners, as they may like the idea of well concentrated, precise and consistent treatment of well selected trees. Valuable broadleaves mixed with other species in groups or small stands reduce risks of pests and diseases on proper sites, mixed with other tree species.

3.3 Genetic material

Timber quality depends not only on management of the trees but as well on the genetic characteristics of the individual tree. Stem form, crown architecture and growth characteristics, as well as resistance against pests and diseases are partly predetermined by genetic properties. Unregulated human interventions have changed the genetic composition of valuable broadleaved stands. Recent efforts in tree breeding and genetic conservation help to improve the situation. It is recommended to select site adapted genetic material that has proven to produce high quality timber.

3.4 Planting

When planting, only a small number of genetically well selected and site adapted trees are needed. Spacing: depends on the diameter to be achieved. The distance between trees that have reached the wanted dimension can be estimated by the rule of thump:

Equation 1:

$$d_{1.3} \times 25 = D,$$

where:

$d_{1.3}$ = *diameter at 1.3 m and*

D = *distance between the crop trees.*

In addition, the spacing design is influenced by the need of selecting best performing trees out of a larger number of trees in case the genetic material is not of excellent quality. Furthermore, the spacing is influenced by the landscape and technical aspects. Geometric forms such as rows facilitate the access to the trees and the use of machinery, on the other hand naturally shaped diffuse edges in an irregular and asymmetric way may enhance the beauty of a landscape. Valuable broadleaves as well regenerate naturally from seeds or root suckers. Young trees may need to be protected against mice as well as against browsing and bark stripping by red deer or other animals. Naturally regenerated minority tree species in mixed forests offer an often underestimated potential for growing valuable timber when properly managed.

3.5 Pruning

A two-phase management system is recommended: first phase emphasizing pruning, and second phase encouraging crown expansion and stimulating diameter growth. In this phase, the crown base should be kept at a fixed height. In the phase of pruning, artificial pruning can have the same effect on branchiness as natural pruning by competition. As competition induced natural pruning can be replaced by artificial pruning of open grown trees, alternative management options offer innovative ways for the production of valuable wood. These management options may at the same time also increase the supply of non-wood products and services. Valuable wood production has to concentrate on the individuals which are expected to produce the high quality wood in the wanted dimension. In order to improve management efficiency interventions have to be limited to actions, which support those value producing individuals (Fig. 1).

For efficient and precise quality oriented management future crop trees have to be selected. The number of future crop trees per ha depends on the target diameter and the production time: the larger the diameter and the shorter the production time the fewer trees per ha should be selected as future crop trees (see equation 1, rule of thump).

Future crop trees should be selected, when the future development can be predicted and measures for supporting the development of the future crop trees are needed. Such a measure is artificial pruning. The timing of pruning has an impact on the stem shape and development of the remaining branches. Artificial pruning has to be repeated in order to avoid pruning of large branches, to reduce the impact of pruning on the tree and to reduce the size of the knotty core inside the trunk. Two types of pruning are distinguished: (I) Proleptic pruning, where the biggest braches and the branches with steep angles including fogs are pruned first and (II) whorl-wise pruning.

The pruning systems and pruning intensities have an impact on the diameter growth as well as on secondary shoot development. Conventional whorl-wise reduction of the crown can be an appropriate method, if it is not done too intensely. While the height growth is not severely affected (Koupka 2007), a reduction of the crown to less than 5 whorls or a relative crown length under

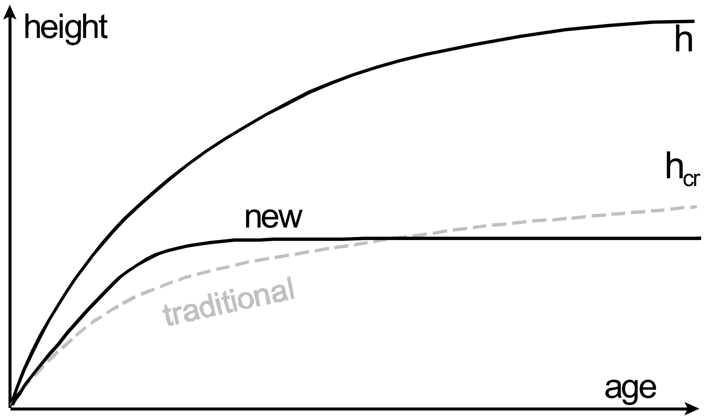

Fig. 1. Development of height (h) and crown base (h_{cr}). It is recommended to accelerating pruning in the early phase of development. Later the crown base is kept on a constant level, which means that no branch should die after the wanted crown base has been reached (Spiecker and Spiecker 1988, modified).

50% leads to a significant loss of diameter increment. In addition, it leads to vital secondary shoots, which may affect wood quality. In contrast, a moderate conventional pruning or proleptic pruning shows similar effects on diameter growth. However, proleptic pruning helps to reduce risk of fungi infections by avoiding large pruning wounds. Furthermore, it leads to a reduced vitality of the secondary shoots. Furthermore, the early removal of steep branches may improve the stem form. These advantages could legitimate the higher and more complex labour input of proleptic pruning (Springmann et al. 2011).

3.6 Thinning

One common feature of growing valuable wood is that generally regular release from competitors on most sites for survival and optimal growth are required, as many valuable broadleaves have a limited capacity to compete in forests. They require more interventions especially when mixed with fast growing and shade tolerant tree species (Fig. 2).

Moreover, thinning is applied for controlling the quality of the wood production; in particular, it is used for favoring future crop trees, controlling their diameter growth and natural pruning. In the second phase of development, crown expansion is encouraged and diameter growth stimulated. There is a close relation between crown expansion and diameter growth. An allometric model describing the relation between crown width and stem diameter is used to calculate the intensity of thinning in order to control diameter growth. The number of competitors to be cut depends on the development phase, the diameter growth wanted, and the thinning cycle. The competitors with the greatest negative impact on the valuable trees should be removed first. In the phase of crown expansion, the crown base should be kept at a fixed height. This requires regular interventions as valuable broadleaved tree species often are getting less competitive with increasing age.

3.7 Harvesting

The time of harvest is determined by the time of maximum average value production, the marked situation and other factors. High-quality timber of large dimension generally realise high prices on the market and demand exceeds supply. The wood of lower quality is of far less value. The answers to an questionnaire 1998–2000 clearly predict an increase of the relevance of veneer wood (Thies et al. 2009). The idea of fixed rotation may be abandoned as trees of the same age can be harvested individually or in groups. Group selection cut may be preferred as larger gaps are needed to fulfil the light requirements of the new generation.

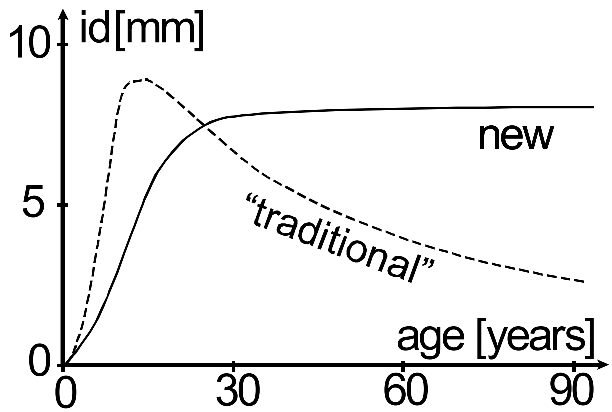

Fig. 2. Annual diameter increment (id) over time. In the phase of pruning, diameter increment is reduced. However, this phase does not last very long. Later the diameter growth is stimulated as the crown gets continuously larger.

3.8 Future perspectives

Even so the demand for valuable timber is increasing, and there is a notable interest among forest owners and farmers to grow valuable broadleaved species, on a global scale the relevance of growing valuable broadleaves is still low. However, these species offer an option to produce high value timber in a relatively short time. They may as well fulfil the needs of stakeholders such as small forest owners, farmers and the wood industry. The proposed management options at the same time also increase the supply of non-wood products and services, as well as the diversity of habitats through the varying forest structure and light regimes. Using the ideas of agroforestry in combination with the management of valuable broadleaved trees may create new and innovative management regimes. New ways of multiple land uses may arise, as better habitats offer opportunities for raising livestock, and may also generate jobs and new business ideas, ultimately offering people a possibility to make a living other than from pure farming and forestry. Valuable broadleaves at the forest edge may help to grade the edge from the full forest height to the shrubs by forming naturally shaped, diffuse edges in an irregular and asymmetric way. They can contribute to the uniqueness and beauty of the area in question, taking into consideration the aesthetic, ecological and economic values of the surroundings. As urban forests are becoming increasingly important for people living in cities, cultural values get more attention. Even so broadleaved forests become more popular, species often are not as important to people as the size or structure of the forest.

Valuable broadleaved tree species offer options for increasing ecological, economic and social values and may contribute to sustainability of forestry in Europe and other parts of the world. They may increase the production of high quality timber while maintaining and improving environmental values such as biodiversity, stability and naturalness. However, the high diversity in sites, ownership, economic and socio-cultural conditions in Europe require different strategies adapted to the local needs. There may be a wide range of management aims to be accomplished within the same forest. The aims vary considerable in different regions and they change over time. Diversification and flexible management has to scope with this challenges. Natural processes help to reduce cost and precise management concentrating on the production goals still produces high values.

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CONTRIBUTION OF LOCAL TRADE IN *ZIZIPHUS SPINA-CHRISTI* L. FRUITS TO RURAL HOUSEHOLD'S ECONOMY IN RASHAD LOCALITY, SUDAN

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Abstract

Local trade in tree fruits has offered an important source of cash income and employment to trading households for generations in the drier areas of Sudan. Yet, it is contribution to the rural households is not acknowledged. The study investigates the extent to which the local trade contributes to rural household economy with special emphasis on cash income and employment; and identifies the factors influence the level of cash income earned from the local business. Data were collected from 70 households purposely selected using interviews and direct observation in 2008/2009 season. The results indicated that fruits local trade was generated the highest annual average cash income (US$ 202.73) fallowed by agriculture (US$ 71.57), remittances (US$ 49.81), wage labor (US$ 30.10), and livestock (US$ 20.40). Also, the most of the employment (30%) was generated by local trade fallowed by agriculture (25%). There are significant variations in cash income earnings. These variations are attributed to household personal characteristics and market variables. The study concluded that tree fruits local trade is the most important source of cash income and employment. Microfinance and local sellers' organization are recommended to sustain and increase the economic returns from the local business in the fruits much beyond what currently contribute today.

Key words: cash income, employment, rural economy, Sudan, tree fruits.

Introduction

The trade in non timber forest products (NTFPs) for income generation is not new. Tree fruits are examples of some available NTFPs that may be found for sale in the vast majority of the rural markets and nearby towns and cities (Shacklenton 2006). Local markets can provide a guaranteed way of reaching some of the poorest people, and play a crucial role in improving rural economy. Despite some recent works in non timber forest products (NTFPs), numerous gaps exist in understanding the role of NTFPs local trade in rural economy, and there is a need for further empirical studies (Campbell and Byron 1996, Arnold

2002). Lawrence (2003) mentions that there is still a need for case specific, systematic analysis of the potential or actual role of trading NTFPs on development. Indeed, in many countries little national level information, based on sold empirical study, exists that quantifies the contribution of local trade in tree fruits to household income and employment, reliably assesses their role or examines their potential for rural economic development (Sunderlin and Ndoye 2004, Rose-Tonen and Wiersum 2003). Although the growing local trade in tree fruits in drier Savannah of Sudan and the increasing recognition of its importance to households, however, the contribution of the local trade to households' cash income and employment is not acknowledged. Most of the literature on NTFPs in Sudan focuses on exported products (e.g. gum Arabic). Therefore efforts are needed to develop understanding of the role of local trade in tree fruits in rural economy. With this knowledge gap, it is difficult to design development programs to build on what already exists. Accordingly, this study was initiated to investigate the contribution of local level trade to rural economy with special emphasis on household's cash income and employment in relation to other economic activities; and to identify the factors that affect the cash incomes earned from local trade in tree fruits.

Research Methodology

Study Area

The area selected for the study was Rashad locality in the north-western part

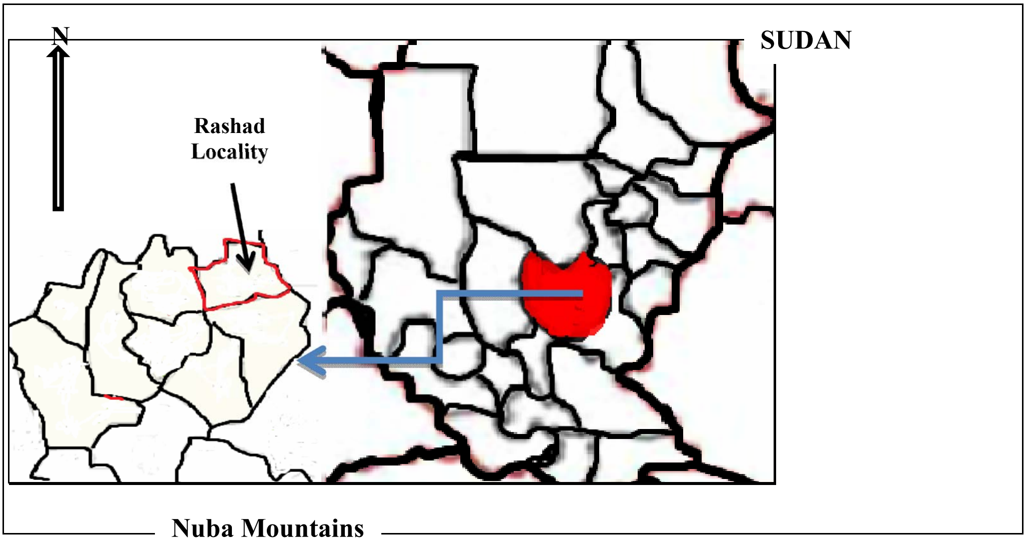

Fig 1: The study area (Rashad Locality).
Source: Rural South Kordofan Food Security Assessment, March, 2009.

of central clay plain in dry land Savanna Zone of Nuba Mountains in South Kordofan State. It lies between latitudes 10° and 13° north and longitudes 29° and 33° east (Fig. 1). The study area occupied a total area of 7872 km^2 with a population around 241,046 (UNDP 2003). There are three main livelihood groups in the study area; the agriculturists, the pastoralists; and the town/ urban groups. The key determinant of wealth and main form of income for agriculturists, pastoralists are crop production and livestock population (NMPACT 2002). Non timber forest products also contribute to rural people income (El Tahir and Gebauer 2004), and are only the source of income during the dry season for the payment for food as well as for water, education and health expenditure (UNDP 2003, Hassan 2005).

Data collection, tabulation and analysis

The households were selected purposely and interviewed using a structured questionnaire. Annual quantities of collected fruits were registered. The annual cash income from local trade was obtained by multiplying the amount of the fruit sold annually by mean price obtained from the local markets and interviews. Cash income from commercial farming was computed by multiplying the crop yields with their farm gate prices. Labour earnings from local wage employment were calculated by multiplying the number of days worked by the wage rate. Information on employment was collected from individual members in terms of the number of hours worked per day and number of days worked in each operation. Employment was expressed in terms of person-days, where each person-day was equivalent to eight hours of work. The cash income from the sales of tree fruits and from other economic sources were averaged and converted to US$ using the conversion rate for Sudanese Pound at the time of the survey (2008/09).

Descriptive analysis was applied to estimate the average cash incomes and their percentages to total household cash income, whilst correlation analysis was used to identify the factors which affect the annual net cash income from the fruits local business. Net annual cash incomes from local level trade were used as the independent variable and an array of continuous as independent variables.

Results and Discussion

Table 1 reveals that 32.9% and 67.1% of fruit sellers were male and female, respectively. The same table shows also that 17.1%, 22.9%, 30%, 25.7% and 4.3% of fruit sellers have ages of <18, 18–28, 29–38, 39–48 and 49–58 years, respectively (Table 1). Table 1 depicts a great variation in education level among fruit sellers, a large percentage were illiterate (40%), only 22.9%, 32.8%, 1.4% and 2.9% have some *Khalwa*[1], primary, intermediate and secondary education, respectively. It is

[1]Religious School in which Muslim learn Holy Goran and its studies.

also found that 32.9%, 14.3%, 14.3%, 21.4% and 17.1% of fruit sellers were married, unmarried, divorced, widowed and children, respectively (Table 1). Results of the survey indicate that all collectors were women and children (Table 1).

Table 1. Sex, age, education level and marital status profiles of *Z. spina-christi* fruit sellers (% of interviewees in each class).

Variable/ attribute	Class	% of sellers (n = 70)
Sex	Male Female	32.9 67.1
Age	<18 years 18–28 years 29–38 years 39–48 years 49–58 years	17.1 22.9 30.0 25.7 4.3
Education level	Illiterate Khalwa Primary Intermediate Secondary	40.0 22.9 32.8 1.4 2.9
Marital status	Married Unmarried Divorced Widowed Children	32.9 14.3 14.3 21.4 17.1

Source: Field Survey, 2008/09.
n = number of interviewees.

Cash incomes in the study area are generated by five major activities: *Z. spina-christi* local trade (US$ 202.73), agriculture (US$ 71.57), livestock (US$ 20.40), labour wage (US$ 30.10) and remittances (US$ 49.81) (Table 2). The household total annual average cash income was US$ 374.61 (Table 2). The fruits local trade was the first most important contributor to households' annual total cash incomes when compared with agriculture and livestock as the main activities in the study area (Table 2). This is due to the fact that agriculture in the study area tends to be quite low because of the small land holding (averaging 0.55 ha), lack of rains, and poor soil quality (UNDP 2003). Livestock contribution was also small to the total household's income when compared with the contribution of the fruits local trade (Table 2). The fruits local trade share was important in providing cash income to sampled households as evidenced by higher contribution (54%) towards total household income (Table 2). These findings agree with studies conducted in, Ethiopia by Lemenih et al. (2003) and Grimes et al. (1994) in Ecuador where these independent studies reported that NTFPs sale contributing to total household income more than other alternative land uses such as agriculture and cattle ranch. Similarly, a study conducted by Ndam (2004) in middle Cameroon reported that the harvesters of *Prunus africana* bark contribution to their annual total cash income was 70%.

Table 3 reveals that the total employment days[2] per household per year was 380.68. The same table explains that local trade in the tree fruits was the major employment contributor, representing 30% (114.204) day per household per year to total household annual employment, whilst the agriculture sector share was estimated at 25% (95.170) day per household per year. Comparing employ-

[2] A day was equivalent to eight hours of work in each economic activity.

Table 2. Distribution of household's income (US$) from different economic activities in season 2008/09 (n = 70).

Activity	Annual average contribution, US$.yr^{-1}	% of Contribution to total income, US$.yr^{-1}	SE*	Minimum, US$.yr^{-1}	Maximum, US$.yr^{-1}
Fruits local trade	202.73	54	15.38	18.10	542.90
Agriculture	71.57	19	3.61	20.00	150.00
Livestock	20.40	6	2.79	0.00	80.00
Wage labour	30.10	8	3.58	0.00	98.00
Remittances	49.81	13	3.87	0.00	100.00
Total annual income	**374.61**	**100**			

n = number of respondents; * Standard error; 1US$ = 2.1SP (Sudanese Pound) at 2008/2009.

ment generation in various household sectors, the fruits local business sector generated the highest employment (Table 3). The source of employment gave by the fruits local trade to rural households has wider economic implications in the dry and semi-dry areas like Rashad locality where the opportunity to work from home is rare. In addition, the fruits sales are particularly important in lowering the unemployment rate during the dry season which extends from April to June. This risk-management role of the local trade in the fruits is crucial in rural areas of Sudan.

The correlation results show that household age is positively and significantly correlated with annual net cash income derived from local level trade in *Z. spina-christi* ($r = 0.430$; $P < 0.01$) (Table 4). This is due to the fact that elder households able to build trust and relationships with their customers as they sale the NTFPs for long time in local markets, and this, permit them to generate more than younger households. Cash income from other sources own by the households explain positive and significant correlation with the cash income earned from *Z. spina-christi* ($r = 0.595$; $P < 0.01$) (Table 4). Such observation is common in some NTFPs related studies. For instance, Cetachew et al. (2007) have reported similar results. This is mostly due to the fact that owning extra financial capital is important as this assists households to overcome numerous constraints such as cash flow problems and high transportation costs, allowing them to collect more often or reach more distance markets outside Rashad locality. In fact, there are also results demonstrating the opposite (e.g. Shackleton 2006, Inoni 2009), which indicate that poor households derive more income from collection and selling of NTFPs than the wealthy category of the households.

Table 3. Distribution of household's employment (days.hh^{-1}.yr^{-1}) in different economic sectors in season 2008/09 (n = 70).

Activity	Employment generated, days*.hh^{-1}.yr^{-1} (%)
Fruits local trade	114.204 (30%)
Agriculture	95.170 (25%)
Livestock rearing	76.136 (20%)
Wage labour	76.136 (20%)
Others	19.034 (5%)
Total annual employment	380.68 (100%)

Figures in parenthesis indicate percentage to total. n = number of respondents; *A day was equivalent to eight hours of work; hh = household; yr = year.

Labour input in the collection and selling of the fruits is positively and significantly correlated with the cash income earned from local level trade in *Z. spina-christi* ($r = 0.870$; $P < 0.01$) (Table 4). This is due to the fact that some people are hard workers- work for long time- and often also involve in other profit activities. In the same table, number of persons per household showed positive and significant correlation with the cash income derived from *Z. spina-christi* fruits local trade ($r = 0.764$; $P < 0.01$) (Table 4). Families with large labour force on account of their size can mobilize household labour in collecting more products from the forest, than households with a smaller labour force to meet their needs for cash income. This finding agrees with study conducted in south India by (Hegde and Enters 2000) where this study reported that large households tended to derive more income from NTFPs activities.

Household education level is another variable which shows a negative and significant correlation with earnings from *Z. spina-christi* fruits ($r = 0.0273$;

Table 4. Correlation between household characteristics and annual cash income derived from fruits local trade (n = 70).

Household characteristics	Annual cash income (US$) from fruits trade
Household age, years	0.430** (0.000)
Number of person/household	0.764** (0.000)
Household education level, years of education attendance	-0.0273* (0.000)
Household labour input, hrs.yr^{-1}	0.870** (0.000)
Households income from other sources, US$.yr^{-1}	0.595** (0.000)

** Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed); n = number of respondents.

$P<0.05$) (Table 4). Higher levels of education attainment makes NTFPs collection unattractive to local people. Since education improves the wealth status of literate rural families, they tend to concentrate on permanent profitable activities, in the face of the seasonality of the fruits. In addition high level of education provides a wider range of employment opportunities and reduces the economic returns from forest products. This finding is similar to Gunatilake (1998) and Adhikari et al. (2004) who concluded that education level of the family members negatively correlated to the returns from forest products.

Beside the household characteristics, it was found that other than measured variables also are important in shaping the cash income generation from local trade in the fruits. Qualitative and general observations revealed that some people were 'born entrepreneurs'. They are innovative, often also involved in other economic activities. Returns from local trade are thus often related to the degree of effort expended, as well as the ability of households. Poor infrastructure, access to market and low product price also limit the potential benefit of local people from the fruits local business. Such constraints seem universal as most NTFPs case studies reveal more or less similar conditions. For example, Pierce et al. (2002) reported almost similar constraints that limit the benefit from NTFPs activities, and so do (e.g. Marshal et al. 2003, 2006; te Velde et al. 2006). Therefore, improving market infrastructure will enhance proportionally the economic returns from the local trade and ultimately to rural household economy.

Another important constraint is lack of organization and cooperation for the fruit sellers, which influence the cash income generations due to its contribution to high transaction costs that prevent some households to transport their products to distant markets. In addition trading products individually represents weak competition of the seller, and this, limits the bargaining power in local markets due to inadequate information on the fruits market conditions and prices.

Conclusions

Local trade in the fruits is the most important source of cash income (54%) and employment (30%) for the rural household. However, there are variations in level of cash incomes generation from the local business by the rural households. These variations are due to the household's characteristics (age, level of education, other income sources, number of persons per household, household labour input and entrepreneurs) and market factors (access to markets, low price for the fruits and level of coordination and organization for the sellers).

Recommendations

Rural households with multiple sources of cash incomes earned higher returns from the local trade as this allows greater cash investment in the local business. Some extra cash incomes thus greatly ease the local business for the sellers, assisting them to overcome numerous constraints such as the high costs of transport. Sellers themselves often mentioned transportation cost as a major constraint and feel access to micro-credit would be extremely beneficial.

Building organizational and institutional capacity by assisting sellers to organize themselves better so that they have an identity, and can negotiate with different stakeholders regarding their needs, undertake group activities such as sharing transport to distant markets, and cooperate in terms of, for example, price fixing, etc. is a critical area of intervention.

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SOCIAL NETWORK ANALYSIS TO SUPPORT THE FOREST LANDSCAPE PLANNING: AN APPLICATION IN ARCI-GRIGHINE, SARDINIA (ITALY)

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Abstract

Social capital is defined as what is existing in the structures of interactions between individuals and groups (collective and individual social actors) which are said to develop trust and social rules and to strengthen cooperation and reciprocity. On the other hand social capital depends on the quality and quantity of interactions and it can facilitate coordination and cooperation in decision making process. Considering that networks are a crucial part of the social capital, the present paper analyses the potentiality of Social Network Analysis (SNA) to support the forest landscape management planning. The authors have applied, in Arci-Grighine forestry district (Sardinia – Italy), the assessment of institutional social capital. The method used to evaluate institutional social capital considers three phases: i) the mapping of stakeholders, ii) the analysis of voluntary associations with particular reference to the environmental and forestry sector, iii) the analysis of social network considering type and force of ties (weak and strong ties). The authors present and discuss the utility of these tools to support collaborative forest planning, in particular to take into account the needs of stakeholders and the necessity of limiting the conflicts.

Key words: social capital, decision making, social network analysis, forest planning.

Introduction

Social capital is a certain set of informal values or norms shared among members of a group that permit cooperation among them (Fukuyama 1997). On another side, social capital is the actual or potential resources that inhered in interpersonal group relations and is accessible to members of a group (Coleman 1988). Social capital is the norms, common rules, networks and social trust that facilitate coordination and cooperation (Putnam 1995). According to Pretty and Ward (2001) social capital is characterized by some features: relations of trust, reciprocity and exchanges, common rules, norms and sanctions, connectedness in networks and groups. The relations of trust facilitate cooperation and reduce the transaction costs between people and groups (Pretty 2003), reciprocity and exchanges contribute to the development of long-term obligations between individuals, rules and sanctions give individuals the confidence to invest in the collective goods (Pretty and Smith 2004) and social networks facilitate the information flow and the decision making process.

The social capital concept elaborated by social sciences has been extended to the natural resources management with particular emphasis to various types of management described by the terms collective-, community-, joint-, participatory- and co-management (Pretty 2003). Co-management is one of the main features of forest landscape planning. Forest landscape planning address long-term forest management issues, with special attention to social and environmental functions, that cannot be properly considered by referring to a single forest property. In consideration of this scale of analysis, forest landscape planning must take into account all society instances.

Normally, a high and well structured social capital is associated with a social substrate more suitable to introduce an incremental approach[1] (Buttoud 2000) in forest management. This is related to the fact that social capital promote healthier communities through partnerships with a shared sense of the common good (Crawford et al. 2008). To quantify the social capital in natural sciences is necessary to analyse some key-features as the memberships in voluntary associations and the connectedness in networks and groups (Liu and Besser 2003). These key-features are important elements to support forest landscape planning in evaluating whether there are the conditions to develop an incremental approach in the definition of management guidelines.

In consideration of the social capital role in forest management, the paper presents a method to quantify the key-features of social capital (associationism and social networks) at the beginning of a forest landscape plan development. The theoretical method is applied to a study case in a forest district localized in the Sardinia island (Italy).

Materials and Methods

The area of study is the Arci-Grighine district (39° 42′ 7′′ North; 8° 42′ 4′′ East) localized in the Centre-East area of the Sardinia island. The Arci-Grighine district has a total surface of 55,183 ha, corrisponding to the 2.3% of the Sardinia surface. The population is 26,207 (2001 Census) for a density of about 0.47 persons per ha. The district comprises 21 municipalities; the most populous is Marrubiu with 4,671 inhabitants (density 0.76 persons per

[1] Incremental approach considers that decisions are the result of all the needs and interests express by stakeholders, this approach is opposite to the rationalist approach that is based on a deductive chain of decisions taken by the public authority (Buttoud 2000).

ha) and the less populous is Siris with 249 inhabitants (density 0.42 persons per ha). The forest surface is 18,349 ha divided in 43.2% ha of broadleaf forests, 16.6% of evergreen forests, 39.6% of Mediterranean forests and 0.6% of mixed forests. Considering that the forests are 33.3% of land use of Arci-Grighine district, the other land uses are agricultural land (36.1%), grassland (10.7%), shrub land (12.7%), and agro-pastoral land (5.2%).

The purpose of the paper is to analyse the potentiality of social capital to support a forest landscape management plan (FLMP). Social capital is also a tool to understand the possibility of success of a collaborative approach in the forest planning decision making process.

To estimate social capital and the correlated social network 124 questionnaires have been submitted to the main stakeholders of Arci-Grighine district by interviewer. Stakeholders is "any group of people, organised or unorganised, who share a common interest or stake in a particular issue or system" (Grimble and Wellard 1997). In the present case the issue is the forest management of Arci-Grighine district. After a preliminary stakeholders analysis (Mitchell et al. 1997) the stakeholders have been divided in two groups: individual (forest and wood enterprises, forest owners, farmers) and collective stakeholders. The second group has been divided in two sub-groups: institutional organizations (such as municipalities, and other local administrations) and civil associations (environmental, game and sportive, tourist and cultural associations). Considering this framework, 46 individual stakeholders and 78 collective stakeholders (43 institutional organizations and 35 associations) have been interviewed.

According with the study's objective the social capital is analysed considering two features:

– level of associationism with particular reference to the environmental and forestry sector;

– social network among associations and institutional organizations (collective stakeholders).

According to Woolcock (1998) social capital has a role in contributing to the production of desired socio-economic outcomes. In particular, the *level of associationism* is the participation in non-profit organisations and it is a key indicator of the economic growth of an area. The associationism rate captures the cultural and civic attitudes of a society and consequently it influences the economic performance and the effect of economic policy (Clemente et al. 2008). This aspect of social capital has been measured using three indicators: (1) number of associations with reference to the population, (2) average of associates per association, (3) average of active volunteer per association with reference to the associates.

Social network is a key information to investigate the social capital because it focuses on how social structure facilitates and constrains opportunities, behaviours and cognitions (Tindall and Wellman 2002). To analyse the social network of a community it is foundamental to find out the social ties existing between collective actors. Moreover it is important to describe the strength of relationship that it is defined as "combination of the amount of time, the emotional intensity, intimacy (mutual confiding), and the reciprocal services which characterize the tie" (Granovetter 1973, 1361 p.) According to Harshaw and Tindall (2005) the weak ties are the ties with a low combination of time, emotional intensity, intimacy and reciprocal services, while the strong ties have a high combination of time, emotional intensity, intimacy and reciprocal services.

The strength of relationship has a different role to support the beginning of the development collaborative forest plan. Weak ties are more suitable to provide novel informations (Granovetter 1973) and this can make a network more resilient and adaptive to environmental changes (Prell et al. 2009). Strong ties are more influential in terms of attitude and opinion formation and these have the advantages to create a favourable environment for the mutual learning and the sharing of resources and advice (Prell et al. 2009). In this study the authors have considered three levels of strength of ties: strong ties, moderately weak ties and very weak ties.

Beyond, the type of connectedness is an important feature to characterize the network. In this paper only one type of connectedness is analysed: technical and projectual aspects of forest management.

The strength of relationship and the type of connectedness have concurred in elaborating the network structure. The statistics and the graphical representation of network (structure) are elaborated by SocNetV 0.81. Finally, the results of structure have been analysed using two parameters of network: centralization index and position of key-actors in the network (centrality).

Centralization index measures the variability or heterogeneity of node centralities and it measures the degree of dispersion of all node centrality scores in a network from the maximum centrality score obtained in the network (Sinclair 2009).

The position of single actors in the network has been analysed through three measures of centrality (degree, closeness, betweenness). In particular it has been explored to which type of stakeholder (association or institutional organization) – with its respective role in forest management – is associated the maximum value of centralities.

Degree centrality (DC) is defined as the number of nodes (actors) in direct contact with a particular node (Freeman 1979). DC includes InDegree centrality (IDC) and OutDegree centrality (ODC): IDC is linked to the concept of prestigious and it depends on the number of incoming links, while ODC sets the actors in hierarchical centrality and this concept is associate to the power.

Closeness centrality (CC) is defined as the inverse of farness and it is the sum of distances of a particular node from all other nodes. CC measures how quickly an actor can access more actors in a network and it evidences which actors are able to contact and transmit informations to a high number of other actors.

Betweenness centrality (BC) is calculated as the fraction of shortest paths between node pairs that pass through the node of interest (Newman 2005). BC measures the influence that a node has over the spread of informations through the network. Therefore, it evidences the actors that have the role of intermediators in the decision making process. These actors have a real power in the control of informations.

Table 1. Average value of associates and active volunteers for type of association.

Type of association	Associates	Active volunteers
Environmental	105	60
Hunting	95	87
Cultural and sportive	14	9

Considering centralization and centrality, it is possible to characterize

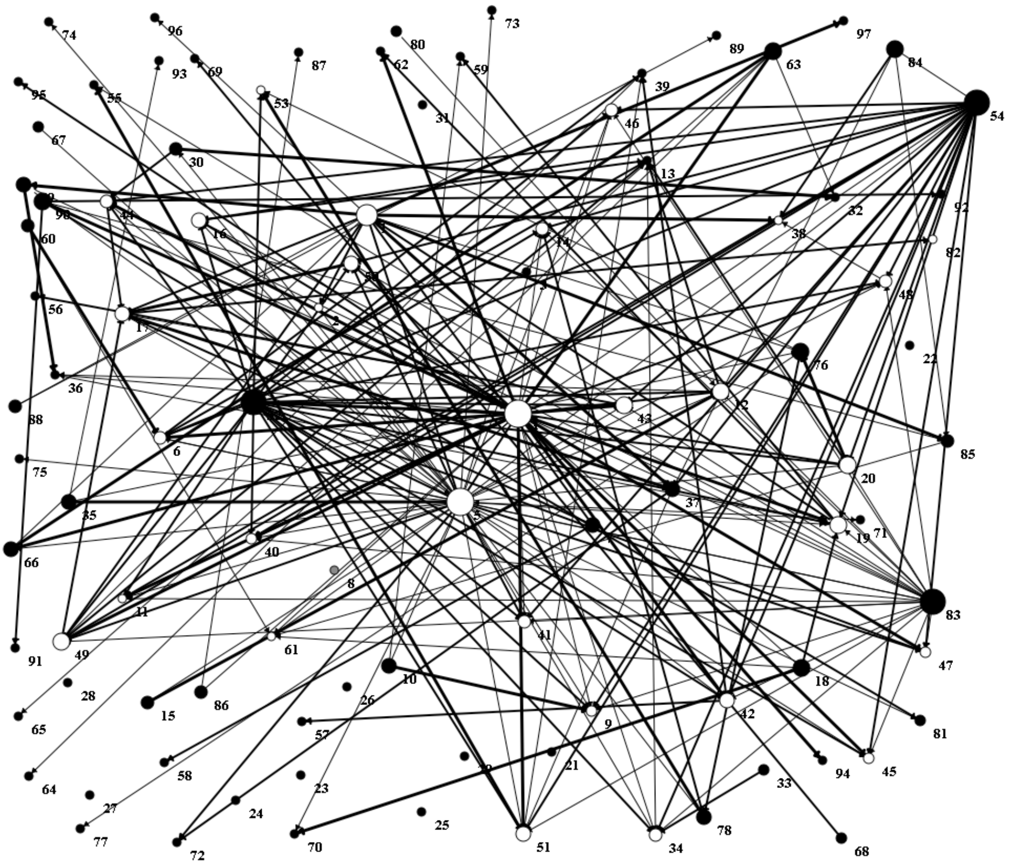

Fig. 1. Social Network Analysis (indegree and outdegree nodes) of the forest management sector in Arci-Grighine district (in white institutional organization, in black associations).

three theoretical types of network structure in decision making process in forest management:

– Centralized network: one or two actors are in dominant position and all the others are at the same level. Centralized network is helpful in the initial phase of forming groups and building support for collective action.

– Scattered network: no actors are in dominant position.

– Regionalized network: no actors are in dominant position but there are two or more groups of stakeholders in sub-dominat position. The sub-dominant groups can derive from different interest-groups or from a geographical fragmentation (two or more areas with a distinct policy and/or administrative centre).

Results

In consideration of the *level of associationism* linked to the forestry sector, in the Arci-Grighine district there are 8 environmental associations including the environmental education centres, 13 hunting associations and 14 cultural and sportive associations. Therefore, there is 1 association per 749 persons and considering only the environmental associations there is 1 association per 3,276 persons.

Eight environmental associations (100%), 7 hunting associations (53.8%) and 4 cultural and sportive associations (28.6%) have been interviewed. The average of associates per association is 79, but this value changes deeply in relationship to the type of association (Tab. 1). The environmental associations have the maximum average of associates (105), while the average for the hunting associations is 95 members and for the cultural and sportive associations 14 members. This high difference is linked to the territorial context of reference. Normally the cultural and sportive associations are local, while the hunting and environmental associations have a wider area of influence (Arci or Grighine sub-district or province).

Analysing the active volunteers per association the framework changes: the average of active volunteers per association is 59 (75% of associates). For the hunting associations 92% of associates are also active volunteers, while in environmental associations only 57% of members are active and in the cultural associations 63% of members are active.

The *social network analysis* related to the technical and projectual aspects of forest planning and management is reported in Fig. 1. The network has 97 nodes (actors), 254 links and a density of 0.027. The mean nodal in- and outdegree is 4.67. Maximum value indegree and outdegree are registered by an institution (CFVA[2]). The maximum value of closeness centrality is for a multi-purposes association active in the pasture and in the horse tourism, while the maximum value of betweeness centrality is for Ente Foreste[3]. The structure of network is centralized in

[2] CFVA (Corpo Forestale e di Vigilanza Ambientale): is the organization devoted to the forest monitoring towards natural hazards (forest fires, landslides, etc.) and to the protection of the environment (biotopes, natural areas, etc.).

[3] Ente Foreste: is the organization devoted to the forest planning and management of municipalities territory.

reason of the presence of two actors with high power in the decision making process and some actors in sub-dominant position. The actual structure is a more favorable structure for a top-down decision making process (rationalist approach) respect to a incremental approach.

Discussion and Conclusion

In conclusion, proposed method allows through two indicators (level of associationism and social network) to analyse and to evaluate the possibility of success of an incremental approach in forest planning and management. The ideal condition takes place when there are a high level of local associationism (1 association per maximum 1000 persons) and a network dense but not centralized in few powerful actors.

The associationism results of Arci-Grighine district confirm the discrete presence of social capital in Sardinia (Sabattini 2006). Also if the reserve of social capital in the forestry sector is relevant, differences among the three type of associations are registered. The difference is linked to the divergent objectives. Hunting associations have the purpose to assure hunting wildlife and to satisfy the demands for their associates. In consideration of these purposes the hunting associations are well organized and with a high contractual power. On the contrary the environmental associations pursue an ideological aim for the good of the collectivity. Consequently, these associations are large enough, but with few active volunteers and a low power in a forest management decision making process. Cultural and sportive associations have intermediate characteristics but a deep rootedness in the local context. In consideration of social network related to the technical aspect of forest planning and management, we can evidence a complex and well structurate network. The main limit of this structure is the power centralization in two actors that have at the same time the power in the decision making process and the control of information.

Finally, the strength point of the proposed method is the opportunity to analyse, with few and simple questions, the social capital and the correlated network before starting a participatory forest planning process. This opportunity is functional to the success of the incremental approach application.

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APPLICATION OF AN OPPORTUNITY COST APPROACH TO SUPPORT POLICY DECISIONS ON THE USE OF FORESTS IN GERMANY

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Abstract

Forests are experiencing a new situation in many highly industrialized countries: their goods and services are much more in demand than they were a couple of decades ago. The development of forest-based industry; the use of wood for energy production as a contribution to climate protection and to the security of energy supplies; and initiatives to tackle the loss of biodiversity, are doubtless some of the most prominent sources of growing demand for forest goods and services. This new situation increases the competition between consumers of the respective private and public goods and services, and hence, necessitates a revision of forest allocation decisions. Using the example of Germany, a simple forecast of supply and demand to the year 2020 shows that supply and demand will probably not match. To close this gap, demand must either be adjusted, e.g., through the improvement of material and energy efficiency, and/or supply must be enhanced through, e.g., reduction of high accumulated forest stock, use of small wood and short rotation coppices or imports. Since valuation results for non-market forest services are still limited to some rather general examples, opportunity costs are calculated to support policy decisions with regard to forest allocation. For this purpose, a partly closed input-output model was used to calculate added value in the use of wood. The results were applied to a current proposal to protect biodiversity. A decision to refrain from harvesting timber on 460,000 ha old beech stands yields an overall of added value loss of 2.3 billion €, which is equivalent to 41,600 full-time employees in Germany., About 880 million € taxes are included within the loss of added value. However, in order to find “optimal” solutions for forest allocation, opportunity costs only mark a minimum threshold, which benefits must exceed.

Key words: added value, forest demand forecast, future wood balance, tax revenues, wood production.

Description of the Problem

Forests in Germany, as in Europe as a whole, serve the demand for a variety of goods: wood for traditional material use; wood for “green” technology; wood for energy use; nature protection and the conservation of biodiversity; carbon sequestration; ground water recharge, recreation, etc. Many of these goods are public goods and therefore their “production” is a part of political goals and initiatives. Demand for all of these goods has increased significantly. However, forest area is rather limited, despite afforestations, which in most countries are only of minor dimensions. For Germany, net annual forest area growth averaged 0.2% of the existing forest area in the period from 2002-2008. Consequently forest goods are becoming more and more scarce. Competition between forest users increases, and political goals can conflict with the required forestry measures to achieve the goals. This means that trade-offs are needed between the goals concerned. With the following paper, the past and present situation in Germany is described and an outlook is given for the year 2020. Departing from this outlook, political implications are deduced and a method to calculate opportunity costs is presented. Finally the results are applied to a concrete proposal to maintain and enhance bio-diversity in German forests.

Past and Present Situation

At present about 70% of the German forest areas are covered under nature and landscape conservation categories. They comprise small scale (nature conservation and landscape protection areas) and large scale (national parks, biosphere reserves and nature parks) categories according to the Federal Nature Protection Law as well as Natura-2000-sites according to the EU-Habitat-Directive. A further, rather strict, category is projected: according to the National Strategy for Biodiversity, 5% of the forest area shall be left to its own natural development. We will refer to the implications of this strategy later on.

On the other hand, demand for wood has increased significantly. From 1991, the year after German reunification, to 2007, the year before the world economic crisis, round wood demand grew by 75%. In particular, saw mills and private households raised their wood consumption remarkably (Mantau 2009, p. 30 f). Additionally, large capacity extensions are projected in particular in the south of Germany (Ochs et al. 2007, p. 15 ff). Among wood users, competition between material and energy uses becomes harder. Fossil fuel prices rose, as did prices for fuel wood as a substitute. Moreover several national energy acts affect the wood markets. The Renewable Energy Sources Act rules different feed-in compensations for electricity from renewable energy sources. The compensation must be paid by the electricity network operators, but is in fact transferred at least partly to the power end-user. The Biofuel Quota Act regulates biodiesel and bioethanol proportions in fossil fuel; and a third rather recent act applies to newly erected buildings. The Renewable Energies Heat Act obligates the use of renewable energies (certain % for different energy sources), the use of heat from combined heat and power generation or the improvement of heat insulation. Financial support shall be given by strengthening the existing market incentive programme.

Economic and political support for bio-energy has influenced the development of wood prices, as can be shown for the good example waste wood (Weimar 2008). Four different waste wood category prices are available for: (i) untreated recovered wood (chipped), (ii) untreated recovered wood (crushed), (iii) treated recovered wood (crushed), and (iv) contaminated recovered wood (crushed). In 1997 only (i) yielded a positive revenue of 5 €.t^{-1} air-dry. For all other waste wood categories a disposal fee had to be paid. For (iv) it amounted to 90 €.t^{-1} air-dry. In 2008, the price for category (i) reached 25 €.t^{-1} air-dry and only prices for category (iv) were still negative. But the disposal fee for this category dropped down to 7 €.t^{-1} air-dry.

Future Outlook

There are a couple of scenarios for future wood demand in Germany. They comprise either material or energy use, or both. The oldest scenario we consulted is the EFSOS study (UNECE/FAO) from 2005. Wood demand for material use in 2020 is projected with 80 to 83 million m³ depending on the scenario. National projections (Dispan et al. 2008) range between 64 and 80 million m³. Dispan et al. (2008) also projected wood demand for energy use. Their results can be supplemented by UNECE studies together with the University of Hamburg (Prins et al. 2008) and the guidance study for implementation of EU 2020 renewable energy goals in Germany (Nitsch 2007, 2008; Schweinle 2008). According to these sources, wood demand for energy use in 2020 is projected to be between 43 and 85 million m³. In the "Future Wood Supply and Demand Balance 2020" drawn below, we refer to the 83 million m³ value of EFSOS for material use and the 72 million m³ value of the recent Nitsch study (2008, amended by the Federal Ministry of Food, Agriculture and Consumer Protection, BMELV) for energy use.

The projected demand of 155 million m³ in total is contrasted with projected supply. Since demand figures represent gross demand, including double counting (wood residue recycling, in particular saw mill by-products as raw material for panel, pulp and energy production) supply has to be estimated as a gross figure as well. Basic supply source is the forest. By means of the Forest Development and Timber Supply Model WEHAM (Schmitz et al. 2005) future round wood supply (up to a minimum end diameter of 7 cm o. b. – coarse wood) is projected. WEHAM assumes a continuation of the prevailing forest management standards in Germany. Supply of saw mill by-products is deduced from the projected sawn wood production. Wood sources outside the forest are waste wood, short rotation coppice and wood from landscape and park work. The projected overall wood supply in 2020 sums up to about 120 million m³.

According to the underlying assumptions, the Future Wood Supply and Demand Balance 2020 does not balance. Supply falls short of demand by about 35 million m³; the respective political goals are jeopardized.

Currently a "National Forest Strategy 2020" is being elaborated under the leadership of BMELV to coordinate the emerged demand. Several options are feasible to close the supply gap.

On the demand side, the enhancement of material and energy efficiency is crucial. The aim here is to get more wood products or energy power from the same volume of round wood. Another option is quite theoretical. The demand for wood for the manufacture of wood products can be curtailed and political goals affecting forests can be revised downward.

On the supply side, a fast-working measure would be to reduce high accumulated forest stocks. Obviously this is not a long term option. Under the provisions for maintenance of nutrient balance, use of wood residues, small wood and roots is an auxiliary supply option. Under a long term perspective, regeneration with higher-yield tree species like Douglas Fir (*Pseudotsuga menziesii*) or Grand Fir (*Abies grandis*) is a promising option to sustainably enhance wood supply. Options outside German forests comprise, e. g., extension of short rotation coppice cultivation on agricultural land. Import of round wood and wood residues is also an option, but restricted to cases where the costs for transport can be kept low.

Political Implications

As already mentioned above, forests produce private as well as public goods. The most important private good is wood, in particular for material use. With regard to private goods, the political implications of the supply gap are rather low. Under the assumption of perfect markets, market prices will ensure that an optimal production volume is realized and the scarce factor wood is used for those products where factor income is highest. Under the traditional economic assumptions (people and enterprises as utility, respectively, profit maximizers, perfect markets, no external effects, etc.) this would be efficient from a welfare perspective. However, reality does not meet these assumptions. Forests also produce public goods (e. g., nature conservation) or private goods which are associated with public goods (e. g., wood for energy use serving the public good, climate protection). In those cases policy influences production volume either through administrative law or market interventions (e. g., Renewable Energy Sources Act, see above).

To find “optimal” solutions from a welfare perspective (in contrast to a power preservation perspective as argued by new political economy, see Weimann 1995, p. 175), policy makers need information based on the utility- and cost-curves of production volume of all forest goods. Even though a respectively highly sophisticated welfare economic theory has developed for practical application, some severe constraints exist: (i) Utility estimates of public goods are largely not available. Estimates are available only for single, rather general, examples of public goods or changes in the supply of those goods. Since many public goods are concerned and many interactions exist between them, the required information would have to cover a multitude of possible changes.

If information were to be gathered by a survey, only a slight chance would exist that respondents fully understand the problematic, and hence the answers on willingness to pay would be not too reliable. (ii) Interpersonal comparison of individual utility is not possible; there is still a theoretical deficit. (iii) Even if individual utility were to be ascertained, the precondition to match demand for public and private goods would not be given. Models to estimate price changes of all affected private goods are lacking.

Against this background an alternative approach is followed: opportunity costs of the production of public goods are calculated. They mark a minimum threshold benefits must exceed, if production of public goods is favourable from a welfare perspective.

Method

Opportunity costs are calculated as change of added value due to a change in round wood supply. This means that added value as defined in the European System of Accounts (Eurostat 1996) is the economic unit. A rather sophisticated model would be required to cope with this task. It should be comprehensive and cover all production processes and final consumption of wood products and substitutes of wood. Likewise, it should be differentiated and include cross price elasticity between wood products and substitutes. Such a model is not available for Germany. As an alternative solution, an input-output-analysis is chosen. Data source is the Input-Output-Table 2004 of the Federal Statistical Office, broken down in its deepest subdivision into 71 branches of production. A fundamental constraint of the input-output-analysis is the assumption of strict linearity of factor input to achieve one unit of good irrespective of the production volume, of possible price changes and resulting substitution. This is why input-output-analysis can be applied for the present purpose only with three significant preconditions (for more details see Dieter 2008):

1) To avoid substitution effects on the domestic markets, the surplus in wood product output induced by a change in round wood supply must be sold on foreign markets. To ensure this, regarded branches of production must have performed as significant exporters in the past (high export share).

2) The input factors wood and wood products must be relevant as compared to the other complementary production factors. This is to prevent the absolute increase in these complementary input factors from being so high that a relevant rise in prices can be expected.

3) The regarded branches must be dependent on domestic wood supply. This is assured through the third precondition: import share of wood input factors must be low.

Among all branches of production, these three preconditions are given only for manufacturers of wood. A partly closed input-output-model is used where foreign demand is exogenous according to precondition 1). With this model the relationship between one unit supply of round wood and the corresponding value of (exported) wood products is detected. The results are presented for two different assumptions: (i) soft proportionality assumption – direct, indirect and feedback effects are regarded only for the manufacturers of wood and (ii) rigid proportionality assumption – direct, indirect and feedback effects are regarded for the economy as a whole. The second assumption implies that additional income of all branches contributing to the manufacture of wood induces economic growth in all branches of production. For the sake of keeping the estimate conservative, assumption (i) stands in the focus of the following analysis. Model formulation is given by the following equations.

$$\mathbf{A\ x} + \mathbf{c\ Y} + \mathbf{g} = \mathbf{x}$$

since $\mathbf{Y} = \mathbf{v}^{T}\,\mathbf{x}$

$$=> \quad \mathbf{A\ x} + \mathbf{c\ v}^{T}\,\mathbf{x} + \mathbf{g} = \mathbf{x}$$

$$<=> \mathbf{x} - \mathbf{A\ x} - \mathbf{c\ v}^{T}\,\mathbf{x} = \mathbf{g}$$

$$<=> (\mathbf{I} - \mathbf{A} - \mathbf{c\ v}^{T})\ \mathbf{x} = \mathbf{g}$$

$$<=> \mathbf{x} = (\mathbf{I} - \mathbf{A} - \mathbf{c\ v}^{T})^{-1}\ \mathbf{g}$$

with

A = quadratic non-negative matrix of input-coefficients;

x = n-element column vector of production;

c = n-element column vector of the share of income-related final consumption (domestic demand);

Y = scalar of total final consumption;

g = n-element column vector of autonomous final consumption (export);

$\mathbf{v}^{T}$ = n-element row vector of primary input coefficients.

Opportunity Costs

Under the preferred soft proportionality assumption (i), one unit round wood in monetary terms induces added value through the manufacture of wood amounting to 10.4-times the value of round wood (Dieter 2008, p. 205). Accepting the rigid proportionality assumption (ii), one unit results in an added value factor of 30.6. The added value factor of 10.4 shall be applied to an example in the field of nature conservation.

In 2007 the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) published the National Strategy for Biodiversity. Among others, it comprises the target to leave 5% of forest areas to their own natural development. This was concretized by the Federal Agency for Nature Conservation (BfN) in a proposal to abandon old state-owned beech forests. Based on data of the second National Forest Inventory and the model WEHAM, this proposal will be valuated by its opportunity costs.

120,000 ha forest area are already strictly protected and not available for wood supply. The difference to the 5%-goal amounts to 460,000 ha. To meet the proposal, all beech forests older than 60 years, owned by the Federal Republic of Germany and the Laender, must be set aside (see Dieter 2009, p. 43). Potential timber (coarse wood) use in these forests sums up to 4.4 million m³ u. b. or 6.6 million m³ biomass per year. At a timber price of 50 €.m^{-3}, the very loss of timber value sums up to 220 million € a year, with further losses when other woody biomass is accounted for as well. Taking into account the omission of added value through wood manufacture, the loss of value results in 2.3 billion € a year. Taxes and duties amounting to 880 million € a year are included therein, affecting public budgets on Federal, Laender and communal level (see Dieter and Bormann 2009, p. 171). In Germany, the average (gross) value added per employee amounts to 55,000 € a year. Transferred to the calculated added value, loss employment effect of the proposed implementation of the National Strategy for Biodiversity corresponds to a loss of 41,600 employees in full time equivalent.

Conclusion

Competition between forest users in Germany is fact. Higher future round wood demand can be expected on the basis of the projected development of the forest based sector, energy security and climate protection initiatives, etc. On the other hand, demand for conservation purposes also increases, e. g., due to implementation of FFH-directive, National Biodiversity Strategy, etc. Thus both an intensification of forestry and a reduction of forestry intensity are needed. Without change in forest management, future demand to reach all economic, ecological and social targets related to forests can not be met. Opportunity costs of refraining from timber use and the related negative employment effects are considerable, in particular when including manufacture of wood. However, costs must be opposed to benefits, which are only known for some rather general examples. The opportunity costs presented here represent the minimum threshold level that benefits must exceed to be of value. Thus the opportunity costs should serve as a very helpful decision support for policymakers.

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FOREST FUNCTIONS EVALUATION TO SUPPORT FOREST LANDSCAPE MANAGEMENT PLANNING

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Abstract

A preliminary evaluation of forest functions is fundamental in the forest landscape management planning. The evaluation addresses long-term management issues, with special attention to social and environmental functions, normally not meticulously considered when working on a single forest property level. This paper presents a method to evaluate forest multifunctionality, in order to define management guidelines and support forest planning. A case study based in the Basilicata region, Southern Italy, was conducted. A total of 92 study areas comprising the main forest types – i) Turkey Oak, Hungarian Oak, and Sessile Oak Forests, ii) Downy Oak Forests, and iii) Mediterranean Evergreen Oak Forests, were considered. According to each forest type, an Index of Importance of Function (I) and three different indicators of multifunctionality were calculated.

Key words: forest functions, land classification, Forest Landscape Management Plan (FLMP), Basilicata region (Italy).

Introduction

Ecosystem functions refer to either habitat, biological or system properties, or ecosystem processes that provide, either directly or indirectly, benefits for human populations (Costanza et al. 1997). The functions of the ecosystem are diverse. Taking into account the economic aspect, for instance, this multifunctionality is expressed by the fact that an economic activity may have multiple outputs and as a consequence, may simultaneously contribute to the many requirements made by society. A conceptual-theoretical definition of multifunctional forestry dates back to the explanation of the “theory of forest functions” by Dieterich (1953) expounded in the text *Forstwirtschaftspolitik* (Hytönen 1995). In this theory, three main groups of functions were descibed (utility, protection and recreation), and these functions were then integrated, refined and perfected by many authors over the following decades. The modifications implemented included: production, option, regulation and information functions (Vos 1996), or utility, realization, perception and protection functions (Fernand 1995). As a result of the spread of the concept of multifunctional forestry and the changed environmental awareness after the Rio de Janeiro Conference (1992), forest planning in Europe has shifted from a model based mainly on wood and timber production (Farcy 2004) to multipurpose planning.

Within this frame, the Forest Landscape Management Plan (FLMP) is a useful and integrated instrument to address long-term forest management issues, with special attention to those forest features that cannot be systematically considered when working on a forest management unit level (i.e. single forest ownership). Using a hierarchical approach between the different levels of planning (operational, tactical and strategic), the FLMP -tactical level- (Baskent and Keles 2005) provides forest management guidelines on a broad scale, only providing details when considered either useful or necessary (Bettinger et al. 2005). Based on these premises, the authors provide a technical-managerial evaluation methodology of forest multifunctionality. The research was carried out within a forest management plan in a Comunità Montana[1] of Southern Italy.

[1] The Comunità Montana is the Italian administrative body that coordinates the municipalities located in the mountainous areas and is responsible for administration and economic development.

Materials and Methods

The Comunità Montana Collina Materana (the Materana Hills), located in the central-western part of the Matera Province in the Basiliata region, Southern Italy, was chosen as the study area (Fig. 1). The territory of the Comunità Montana occupies about 60,784 hectares, which are divided into seven municipalities (Accettura, Aliano, Cirigliano, Craco, Gorgoglione, San Mauro Forte and Stigliano).

The forests areas cover a surface area of 12,304 hectares, comprising 19.8% of the territory. The large diversity of forest formations are attributable to the great variability in morphology, altimetry and lithology of the area. In the eastern part of the territory, the forests are more sparse, providing space for agricultural lands, shrub lands and bad lands.

The agricultural landscape of the Mountain Community is mainly characterized by wheat fields alternating with pasture lands, with a predominant presence of either bush or degraded Mediterranean high shrub formations.

An original methodology, aimed at drawing up the FLMP, was conducted in the Comunità Montana territory. In this approach, the preliminary evaluation of forest multifunctionality is of key importance in organizing future management scenarios (Agnoloni et al. 2009).

The FLMP was assembled using the existing regional forest map, which is based on forest type and silvicultural management. The informative content of the map was reclassified following a specific and original classification, which was based on the use of a homogeneous cultivation

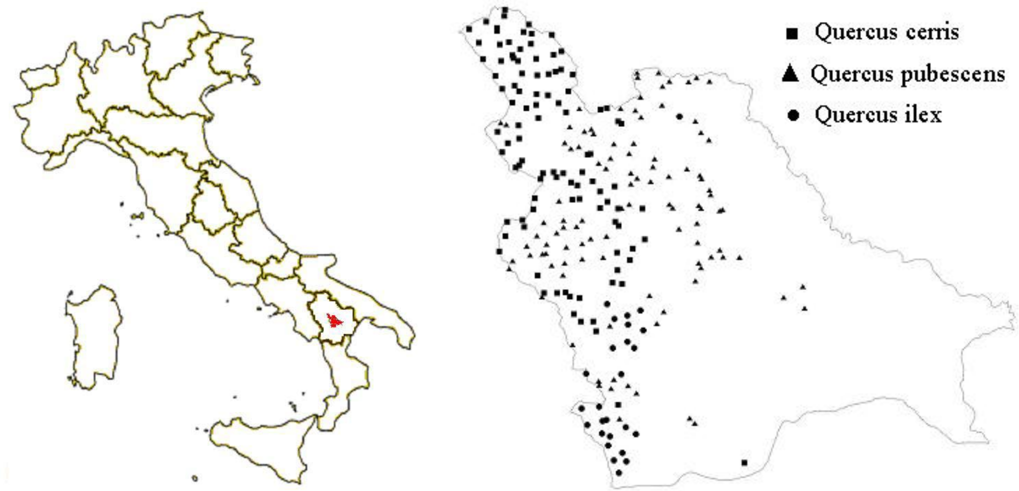

Fig. 1. Basilicata Region (left) and the Comunità Montana Collina Materana with the forest inventory sampling points divided by forest types (right).

subcategory. This feature was ranked as an intermediate between the forest category and the forest type, and took into account both the silvicultural system and possible treatments of the wood. This classification was obtained according to the existing regional forest types and was coherent with superior reference systems (INFC, EUNIS, CORINE).

The qualitative and quantitative description of forests and shrub lands were obtained through stratified descriptive sampling, based on the homogeneous cultivation subcategory, while pasture lands and uncultivated lands were described with extensive surveys.

A circular sampling area of 0.5 hectares was chosen for forests and shrub lands. The features sampled were harmonized, where possible, to both the National Forest Inventory Standards and the Sustainable Forest Management (SFM) Indicators.

A total of 349 descriptive areas were classified, 122 assigned to shrub formations, and 227 to forest formations. The information, retrieved from the forest inventory sampling, was then entered in a Geographical Information System (GIS) built on the regional forest map. In fig.1, the sampling point locations of the main forest types is reported. The distribution analysis showed the differences between the north-western and the south-eastern sector of the Comunità Montana. These differences were a direct consequence of the diverse geo-pedological conditions.

The most widespread forest types in the Collina Materana territory were considered in order to carry out the multifunctionality analysis (EEA 2006):

– Turkey Oak, Hungarian Oak, and Sessile Oak Forests (*Quercus cerris* dominant);

– Downy Oak Forests (*Quercus pubescens* dominant);

– Mediterranean Evergreen Oak Forests (*Quercus ilex* dominant).

The multifunctionality of each sampling point was evaluated by estimating, in the context of an Index of Importance of Function (I), the capacity of each forest to fulfill different functions. This index was calculated by providing a score for each function. A scale ranging from 0 to 10 was utilized. A value of 10 was assigned to the most prevalent function, with each decreasing value (9, 8, 7 etc), respectively, signifying those functions with an increasingly minor importance. Functions that were not applicable in the context, were given a score of 0. This method of evaluation of multifunctionality needs operators with high experience, able to objectively assess the various forest functions in each specific inventory point.

The functions, reported in the literature, had to be adapted to the Collina Materana context because of the characteristics specific to that territory. A number of 8 functions was eventually considered.

The functions were defined and codified before the survey phase since these were based on the result of the synthesis of the data gathered from both the first phase of the participation process and information already owned by the technicians (including: cartography, previous management plans, etc). The following functions were taken into account:

– Fuelwood production: wood and wood products, possibly including coppices, scrubs, branches, that were bought or gathered, and then burnt primarily for heating or cooking.

– Timber production: production of timber attributable to environmental factors, condition of the stand, and labour and capital.

– Biomass energy production: forest biomass including, trees that are of harvestable age (but not suitable for lumber), pulp, thinning, residual material from harvesting and trees killed by either fire, diseases or insects.

– Hydro-geological protection: the wood cover plays an important role in flood avalanche proofing, due to the action of water and snow retention, and soil erosion by water and wind, as well as contamination of ground and spring water, desertification, etc. (Führer 2000).

– Tourism and recreation: “forests hold a wide range of recreational opportunities. Forests are the backdrop for non-consumptive recreational activities such as hiking, birdwatching, wildlife, viewing and other such pursuits. Moreover, wilderness areas attract substantial recreational activities (game, fishing)” (Krieger 2001).

– Habitat conservation: the role of the forest in preserving flora and fauna and ecological processes as a result of the protection of the space that they occupy (Hierl et al. 2008).

– Landscape conservation: given that the landscape is the result of the interactions of human activity and natural environment (Brady 2003).

– Environmental protection: this function includes the positive effects of forests on air and water quality, and the key-role of forests in the global carbon cycle.

The sampling points were aggregated according to forest type and compared with indicators measuring the level of multifunctionality. The indicators were:

a) the average number of functions fulfilled by each forest type $\overline{\mathrm{N}}_{\mathrm{fft}}$ calculated as the mean of the functions of all sampling points related to the forest type.

$$\overline{\mathrm{N}}_{\mathrm{fft}} = \frac{\sum_{i=1}^{i=n} f_i}{n}$$, where:

n = total of sampling points per forest type;

f_i = number of functions fulfilled in a sampling point *i*.

b) the average value of each function associated to a forest type $\overline{v}_{\mathrm{fft}}$.

$$\overline{v}_{\mathrm{fft}} = \frac{\sum_{i=1}^{i=n} I_i}{n}$$, where:

n = total of sampling points per forest type;

I_i = index of importance of function in a sampling point *i*.

c) the mean total value of all functions $\overline{\mathrm{V}}_{\mathrm{FFT}}$ referred to each forest type.

$$\overline{\mathrm{V}}_{\mathrm{FFT}} = \frac{\sum_{j=1}^{j=m} \overline{v}_{\mathrm{fft}\,j}}{m}$$,where:

m = total of functions;

$\overline{v}_{\mathrm{fft}\,j}$ = average value of a forest type for the function *j*.

Results and Discussion

The evaluation of multifunctionality in the three forest types showed the highest value of $\overline{\mathrm{N}}_{\mathrm{fft}}$ (3.52) and $\overline{\mathrm{V}}_{\mathrm{FFT}}$ (4.00) in the Turkey Oak Forests (Table 1). The Mediterranean Evergreen Oak Forests scored a $\overline{\mathrm{N}}_{\mathrm{fft}}$ equal to 3.40 and a $\overline{\mathrm{V}}_{\mathrm{FFT}}$ equal to 3.88, whilst the Downy Oak Forests yielded the lowest scores of $\overline{\mathrm{N}}_{\mathrm{fft}}$ and $\overline{\mathrm{V}}_{\mathrm{FFT}}$, with values of 2.66 and 3.08, respectively. These results were verified with the non-parametric test of Kruskal-Wallis, where the null hypothesis (H0) is that samples are derived from identical populations. This test was chosen since the different number of observations among forest types and the low number of observations that made difficult to assess the reliability of the distribution. The test was applied to the total number of observations subdivided in forest types (264 in Turkey Oak Forests, 40 in Mediterranean Evergreen Oak Forests and 232 in Downy Oak Forets). Trasformation of data was not necessary in reason of the fact that Kruskal-Wallis test is appropriate for non-normal distribution of data. The test did not highlight any significant difference between the three forest types (K observed = 5.22, K critical = 5.99, α = 0.05), consequently the H0 was rejected.

Taking into account the $\overline{v}_{\mathrm{fft}}$, Turkey Oak Forests are important for landscape conservation, and, secondarily, for firewood production and hydro-geological protection. Downy Oak Forests had the highest average value for firstly hydrogeological protection and then for firewood production. High values for hydrogeological protection and landscape conservation were also found for the Mediterranean Evergreen Oak Forests.

The data of $\overline{v}_{\mathrm{fft}}$ were successively grouped into three macro-groups of functions (social, economic and environmental) according to Ritter and Dauksta (2006), in order to analyse the multifunctionality on a less detailed scale and, as a consequence, to retrieve useful information for wide-scale management guidelines. The biomass energy, fuelwood and roundwood functions were included in the economic group, whereas tourism and landscape conservation, intended as landscape contemplation, were included in the social group. Habitat conservation, environmental and hydrogeological protection were all included in the environmental function category. Table 2 shows that, the data aggregation into macro groups produced the highest values for the environmental functions, followed by the social functions. The reason is attributable to the fact that the Collina Materana forests are without timber production and as a result, have a low economic importance. The non-parametric test of Kruskal-Wallis shows significant differences between the three

Table 1. Average value of each function associated to a forest type ($\overline{v}_{fft}$).

Functions/Forest type	Turkey Oak Forests	Mediterranean Evergreen Oak Forests	Downy Oak Forests
Biomass energy	0.85	0.00	0.34
Habitat conservation	1.52	0.00	0.34
Fuelwood	7.94	4.00	7.45
Roundwood	0.00	1.40	0.00
Tourism	0.55	0.00	0.34
Environmental protection	5.91	7.00	1.79
Landscape conservation	8.18	9.00	5.59
Hydrogeological protection	7.06	9.60	8.79
Mean	**4.00**	**3.88**	**3.08**
St. dev.	**4.60**	**4.61**	**4.41**

Table 2. Average values of macro-group of functions per forest type ($\overline{v}_{fft}$).

Macro-group of functions/Forest type	Turkey Oak Forests	Mediterranean Evergreen Oak Forests	Downy oak forests	Mean	St. dev.
Environmental	4.83	5.53	3.64	**4.37**	**4.66**
Economic	2.93	1.80	2.60	**2.70**	**4.22**
Social	4.36	4.50	2.97	**3.77**	**4.58**

macro-groups of functions (K observed = 23.76, K critical = 5.99, $\alpha = 0.05$, p-value < 0.0001). The non-parametric test of Mann-Whitney was applied to compare mean values of pairs of macro-groups. The test did not highlights any significant differences only between social and environmental functions, while the differences are significant between economic and environmental function (U = 66950.0, Expected value = 80802.0, $\alpha = 0.05$, p-value < 0.0001) and between economic and social function (U = 48106.0, Expected value = 53868.0, $\alpha = 0.05$, p-value = 0.005).

Conclusion

This method provides an evaluation of the multifunctionality of an area. In absolute terms, the method indicates the number of functions and provides a global value, whereas, in comparative terms, a rank among functions or group of functions is provided.

Hence, the preliminary evaluation is a valuable instrument in supporting the design of a FLMP, addressed to long-term forest management issues, and which is also required to consider the environmental, social and economic aspects of a forest. The knowledge of the relative importance of any single function in a certain area permits the selection of a particular silvicultural option, best able to optimize multiple functions and, concomitantly, to achieve both mid and long-term planning goals. The advantages of the method reside in its speediness and easy applicability. This is of relevance when planning large territories, which require a strategy providing a good compromise between limited financial resources and the reliability and quality of the data obtained. On the contrary, the main constraint regards the operative application of the method, since experienced operators are needed to assess, within each context, both the productive and recreational aspects of the forest. Additionally, the operators who perform the evaluation must be both objective and precise and must also avoid simply embracing any specific management paradigm.

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The authors have contributed to this study and paper in equal parts.

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PRODUCTIVITY OF NEW HOLLAND FARM TRACTOR AT BEECH STANDS ON MOUNTAINOUS AREAS IN BLACK SEA REGION

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Abstract

In the Black Sea region located in north of Turkey, timber extraction with skidding vehicle is the most common system and also the one that tends to cause erosion problems. The combination of the timber type and topography limit harvesting mechanization to perform transport operations. Rubber tires tractors are used on the more gentle slopes and on skid roads on steeper terrain. In this study, productivity of New Holland farm tractor in beech stands was tested in the area of Gurgentepe Local Forest Enterprise within the Ordu Forest Administration in Turkey. Timber was skidded uphill by New Holland farm tractor in felling area. Time study of a cycle was carried out by using collected data and by statistical analysis. In this study, skidding distance ranges between 140 and 320 m. Hourly productivity are 11.350 $m^3.hour^{-1}$ for skidding distance of 140 m, 7.700 $m^3.hour^{-1}$ for skidding distance of 320 m. The cost of cubic meter of skidding are 4.5 \$ and 8.6 \$ as different distance. The average fuel consumption are 6.0 $l.hour^{-1}$.

Key words: New Holland tractor, skidding, productivity, cost, time study.

Introduction

The combination of the timber type and topography limit harvesting mechanization to perform transport operations. Rubber tired skidders are used on the more gentle slopes and on skid roads on steeper terrain (Gholami and Majnounian 2008). In many regions of the world, farm tractors have been used in forestry where the terrain conditions and the size of the forest operation are not limiting (Akay 2005). A farm tractor was modified to become a single grip harvester. Farm tractors are often used in forest operations, particularly in small scale forestry (Johansson 1997). Mechanization started with the introduction of farm tractors modified by installation of additional equipment, which enabled easier and safer work in the forest. Modified farm tractors play an important role in forest exploitation, even after the development of specialized forest articulated tractors (Zecic et al. 2006). In Turkish forestry a lot of farm tractors modified for forest operations are used. These tractor are various type and dimension.

Forest machinery production are of various types and dimensions in the

Turkey and forest machines by Turkey forestry are purchased on the foreign market. Forest machines and equipment are usually designed to suit the working conditions of the procuder's home country. Therefore, when purchasing these machines and equipment, it is not sufficient to make decision on the basis of factory data and on their productivity referred to in foreign literature (Sabo and Porsinsky 2005).

This paper deals with the research of primary transport of beech timber by farm tractor. The purpose of this research is to give contribution to gaining knowledge of the productivity of a farm tractor in extracting timber from mountainous area in Black Sea region in Turkey.

Technical Characteristics of New Holland TD85D Farm Tractor

The farm tractor New Holland is a two-wheel drive vehicle. It is modified for skidding timber on strip roads and skid trails, which implies that one end of the dragged timber is in touch with the ground. This

Fig. 1. New Holland TD85D tractor.

tractor is used to slope untill average 30%. Tractor New Holland TD85D is modified for work in skidding operations. It is equipped with single drum winch. The cab is well laid out, noise level is minimal, and seats are ergonometrically designed (Figure 1). The main technical characteristics of the tractor are shown in Table 1.

Table 1. Main technical characteristics of the tractor New Holland TD85D.

Characteristics	New Hollad TD85D
Machine power	85 HP
Tractor weight	3700 kg
Number of cylinder	4
Volume of cylinder	3.9 l
Cooling system	Water cooling
Speed – front	35–40 $km.hr^{-1}$
– back	35–40 $km.hr^{-1}$
Type of vinch	Special
Diameter of cable	14 mm
Length of cable	100 m
Speed of cable	40–70 $m.min^{-1}$
Depot capasity	120 l
Average productivity	2.5–5.0 $m^3.hr^{-1}$

Research Area

The present research area was located in northern Turkey. The study area is managed by Gurgentepe Forest Office within Ordu Forest Administration (Figure 2). The total area of Gurgentepe Forest Office is 20,031 ha. The information as growing stock and road density are not calculated, yet because this forest office is a new establishment as forest office. The most important commercial tree species in this region are *Picea orientalis* (L.) Link., *Abies nordmanniana* (Stev.) Spach., *Fagus orientalis* Lipsky and *Pinus sylvestris* L. The average slope in research area is between 25 and 45%. This tractor was skidding along skid roads in research area. The length and width of skid road are 350 m and 2.5 m, respectively. The type of soil is clay loam.

Data Collection

Performance and productivity of New Holland tractor was investigated by time and work study method. The productivity works of forestry machines are used time measurements and time study techniques (Klepac and Rummer 2000). Time consumptions of the duration of working components were studied by repetition method and records were taken throughout the whole working day (Ozturk 2010). The distance of skidding was measured by use of a measuring type, the slope gradient of the terrain and strip roads was measured by clinometer and the load data were collected by measuring the diameter and length of each piece of timber under bark was measured by caliper.

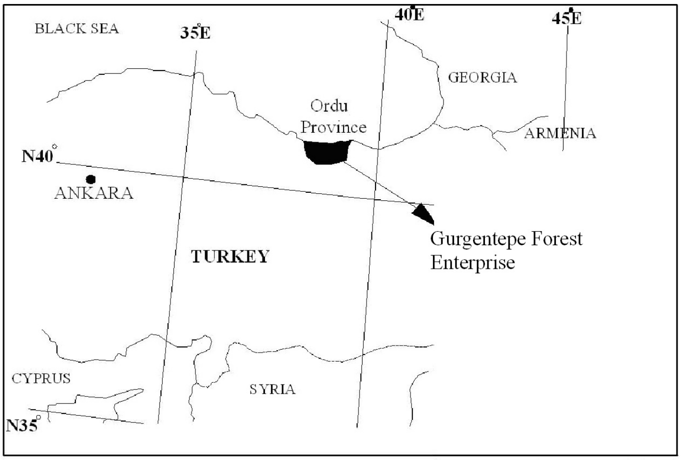

Fig. 2. Ordu province in Turkey.

The measurement data were entered into computer files from the record sheets so as to make them available for data processing. Data processing covered the control and selection of data, classification of recorded times and calculation of the achieved work productivity. Statistical data processing was carried out by use of a computer with the application of the software package Microsoft Excel 2003 and SPSS 11.00.

In this study, the impact of the following independent variables to "total cycle time" (total time) were measured. Here the total time is chosen as a dependent variable whereas; "skidding distance", "load volume" and "load number" have been selected as independent variables.

The definitions of both dependent and independent variables and how to measure them are summarized below:

Dependent variable:

t = total time, which is measured as time at scale level variable and the measurement unit is minute.

Independent variables:

Sd = skidding distance which is described as distance between loading point and destination. The distance is measured by meter and marked at regular intervals and recorded.

Lv = load volume is a variable that represents the volume of all transported logs at the destination. This variable is measured as cubic meters.

Ln = load number is a variable that represents the number of all transported logs at the destination. This variable is measured as cubic meters.

All the variables given above are considered as scale variable.

Then, theoretically the mathematical equation like below is obtained:

$\mathbf{t} = a + b + c + d + e + f + Dt + Sd + Lv + Ln.$

A skidding cycle of tractor is arisen from five phases. These phases are:

a = unloaded tractor travel, this phase starts when the tractor is ready to move the loading area. Then, ends of this phase when tractor arrive the loading area.

b = hookup of load, it begins at the end of lateral out and ends when the choke setter has completed hooking.

c = winching, begins at the end of hookup period and it ends when the operator is skidding timber through tractor side.

d = loaded tractor travel, begins at the end of lateral in and ends when the tractor has reached to the ramp.

e = unhook of load, begins at the end of in haul when the tractor passes over to the trip block and ends when the hook is pulled back to the loading point.

Results

SPSS Statistical Software and Excel 2003 were used for skidding the analyses of data. A regression model was developed for the statistical analyses. Initially a 95% significance level was set to test the null and alternative hypotheses presented above. F-Test and statistically based on a 0.05 significance level statistics were based. The data were consistent with the alternative hypotheses that the proportion of variance in total time, explained by the set of independent variables included in the regression model, was greater than 0.0 in the population from which this sample was selected. It also implied that at least one of these independent variables had a statistically significant effect on total cycle time and tat this relationship was linear. The regression model was calculated as follows:

$\mathbf{t} = 9.686 + 0.07.Sd + 0.893.Lv - 0.601.Ln$ ($R^2 = 0.276$).

In preparing the model for research area, when the other variables were hold constant above, the dependent variables, and the coefficient of Durbin-Watson was 2.502. Since the coefficient was approximately 2 or below, this means that there was no correlation between the independent variables that form the model, and that they were completely separated independent from each other.

The tractor performance was observed at the feeling area for 15 working days. During that time 400 m^3 of timber was extracted in 30 recorded cycles. Timber extraction was carried out at two different distances. The total cycle times of tractor at the distances of 140 and 320 meters are 11.20 and 12.35 minutes, respectively. Average results of measurements are shown Table 2.

The average load volume for 140 and 320 meters skidding distance is 2.150 $m^3.cycle^{-1}$ and 1.620 $m^3.cycle^{-1}$, respectively. The volumes of an average piece of tim-

Table 2. Average results of measurements.

Skidding distance	Load volume	Load number	Unloaded tractor travel	Hookup of load	Winch-ing	Loaded tractor travel	Unhook of load	Total time
sd	*lv*	*ln*	*a*	*b*	*c*	*d*	*e*	*t*
m	m³	number	min / cycle					
140	2.150	2	2.10	2.20	2.30	3.40	0.30	11.20
320	1.620	2	2.50	1.55	3.00	4.10	0.40	12.35

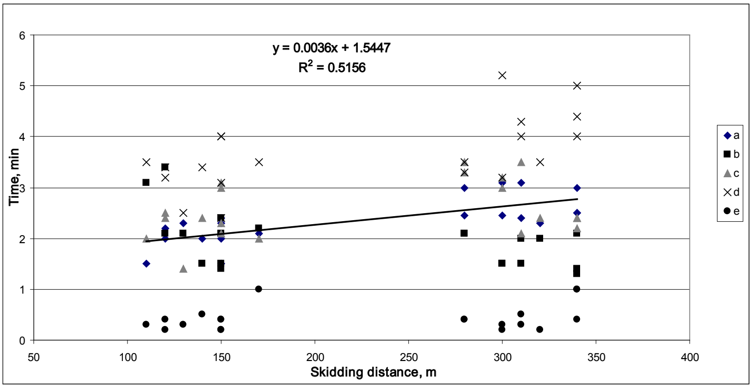

Fig. 3. Relationship of skidding distance vs. total time.

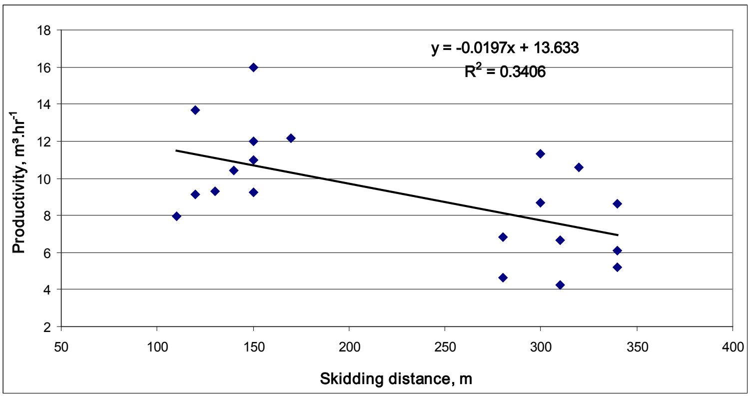

Fig. 4. Relationship of skidding distance vs. productivity.

ber are 1.125 m³ and 0.810 m³. The skidding timber is beech and length of timber is 5 m. The average productivities for different skidding distance at the felling area were 11.350 m³.hr^{-1} (for 140 m) and 7.700 m³.hr^{-1} (for 320 m). The average fuel consumption per operating hour was 4.5 l.hr^{-1}. The cost of cubic meter of skidding for this felling area are 4.5 $ and 8.6 $ for different distances.

The relationship between total time and skidding distance is shown in Figure 3 and the relationship between total time and productivity is shown in Figure 4.

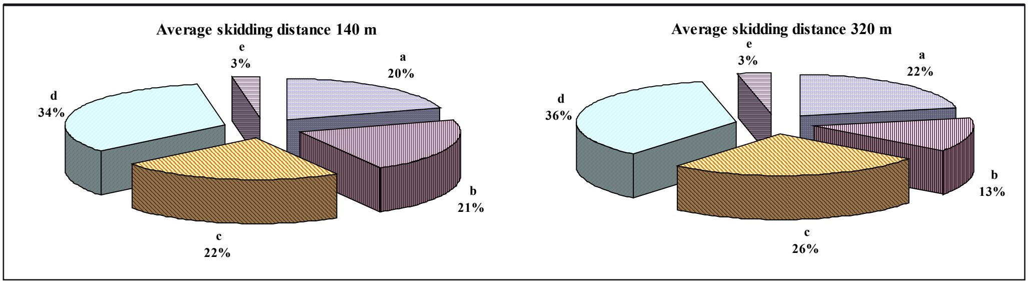

Fig. 5. Percent of work phases.

As shown in Figure 3 and 4, when the skidding distance increases, the total time of a cycle is increasing. In addition, when the skidding distance increases, the productivity of tractor is decreasing. The distribution of time consumption is shown in Figure 5.

This paper shows the results from skidding beech timber by the New Holland tractor. Four forestry workers with an experienced tractor operator were engaged in the skidding operation. The timber skidding was carried out uphill for one skid roads with the slopes of 2% to 12%.

Increasing the average skidding distance during the forest operations decreases the efficiency of machines. At the same time, the cost of skidding increases in felling area. Therefore, in the felling areas forest engineers should use shorter skidding distances. Besides, the skid roads should be coated in the form of a network in production areas.

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FOREST DECLINE IN THE SLEZSKE BESKYDY MTS.

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Abstract

The total forest area in the Czech part of the Slezske Beskydy Mts. is 196,894 ha. Forest decline appeared on ca 32 thousand ha of forest land. Climatic studies confirmed the changes of precipitation amounts and its pattern as well as the change of temperature and sunshine in the period 1961–2006 in comparison with long-term average values in 1901–1950 and with calculated standard of 1961–1990. It is apparent that cultivation of Norway spruce in this region in previous extent will be impossible in future. The study brings more detailed information about this ecological catastrophe and the main principles of the new forestry concept in the Slezske Beskydy Mts. which consists in the differentiated change of species composition, adequate thinning regime, more natural continuous cover forestry supporting water management in the forest stands and fertility of forest soils.

Key words: forest decline, Norway spruce, climate change, forest soils, silviculture.

Introduction

The Slezske Beskydy Mts. is the region which lies across the border between Slovakia, Poland and The Czech Republic (Fig. 1). The total forest area in this region is 196,894 ha and there are 76% of coniferous and 24% of broadleaved trees in the frame of the Czech part. Norway spruce stands, which were established in the last century, grew relatively well in the last decades. But forest decline (drying, yellowing) has been observing here several last years on 24% of forest land, i.e. on ca 32 thousand ha. Massive dying is observed now in spruce stands cultivated in oak-beech and beech vegetation zones (elevation 400–600 m, mean temperature 6.0–7.5°C, precipitation 650–800 mm), i.e. in the zones where spruce is not the original species, at least not in monocultures.

The main causation of the Norway spruce decline in the Beskydy Mts. is the fact that spruce was cultivated in Beech and Beech with Fir forest vegetation zones, i.e. on localities naturally dominated by broadleaves.

Spruce stands disintegration is caused by a combination of three main influences: (1) serious nutrient disturbances consisting in nutrient exhaustion of upper soil horizons and minimal base saturation, (2) gradual change of climatic conditions and (3) massive occurrence of fungi (*Armillaria ostoyae*) and bark beetles (*Ips typographus, Ips duplicatus*). It was observed that affected trees change the colour of needles (from yellow to even brown). Only one or two needle year-classes instead of four or five remain. Trees gradually decline and consequently die.

Climatic studies (Bagár 2007) reported the change of precipitation amounts and its pattern as well as the change of temperature and sunshine in the period 1961–2006 in comparison with long-term average values in 1901–1950 and with calculated standard of 1961–1990.

The presented paper summarizes the results of investigation of health conditions and nutrition of forest stands, air pollution in the region and analyzes the biotic harmful factors. On the basis of presented analyses the main silvicultural measures are elaborated as the change of species composition, techniques of stand conversion and thinning.

Health condition, nutrition and air pollution

Health condition of spruce stands continually decreased in the observed period. Rapid change in health condition (up to dying) was found for the stands and individuals with mean defoliation, mainly due to attack by biotic agents (honey fungus and bark beetle). Effect of elevation and forest type on health condition of spruce stands was not observed. On the other hand, younger stands (up to age of 30 years) showed lower defoliation compared to older stands (Fig. 2). But yellowing was detected in the young stands as well.

Despite of the fact that major part of the stands is located on nutrient rich soil category, serious nutrient disturbances were found in some localities. Historical air pollution load is probably main reason of this status. In the spruce and beech stands with mean damage, typical stage of basic nutrients was observed, i.e. higher nutrient exhaustion in

Fig. 1. Location of the Slezske Beskydy Mts.

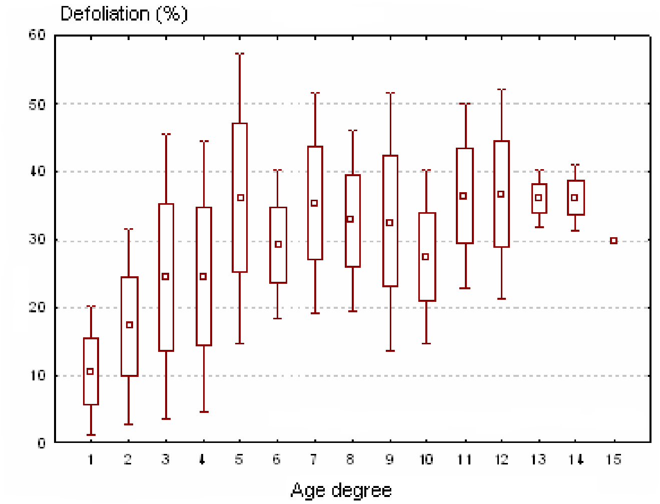

Fig. 2. Defoliation (box plots – mean with standard deviations) by age degrees in the spruce stands (according to Šrámek et al. 2007)

upper soil horizons under spruce stands and in lower soil horizons under beech stands. But in the heavily damaged localities, minimal base saturation was determined in the whole soil profile under both, spruce and beech stands. Principal amount of nutrients remains only in the humus horizons.

Current concentration of SO_2 and NO_x are under limits and these immissions are not risk to health condition of stands. On the other hand, higher concentrations of ozone were detected in the last years, mainly during the summer. But observed values corresponded with results from the other localities in the Czech Republic.

Level of current acid deposition is not critical in the observed area, but this amount is not negligible compared to other localities in the Czech Republic. Additionally, this deposition together with observed status of forest soils can be limiting for spruce stands in the future.

Biotic factors

Main biotic harmful factors (honey fungus and bark beetle) are crucial for current status of spruce stands in the observed area. Chronic course of attack of *Armillaria ostoyae* massively converts into acute phase. It means dying of cambial tissues and quick drying of invaded trees. This trend is supported by repeated dry periods in the last years (see above). Constant increase and spread of bark beetle was observed in spruce stands. Species composition is wider, but main damage is caused by *Ips typographus* and *Ips duplicatus*, partly by *Pityogenes chalcographus* and *Ips amitinus*.

Forestry concept

The main principles of the new forestry concept in the region consist in:

– Differentiated change of species composition.

– More natural continuous cover forestry.

– Adequate thinning regime supporting water management in the forest stands and fertility of forest soils.

The system of silvicultural treatments proposed below is based on information collected in the region by previous studies. Conclusions can be summarized as follows:

– Mosaic and discontinuous forest decline with relatively low effect of site condition;

– Imbalanced and disrupted nutrition of forest stands (especially low content of Ca and Mg and increased content of Pb and S in humus) and very low values of base saturation;

– Interrelation between health condition and climate, especially adverse effect of drought;

– Low difference in soil conditions in spruce and beech stands;

– Better health status of younger stands.

Species composition

Target tree species composition (TTSC) is composition at the end of rotation optimized from the viewpoint of economy, biology and ability to fulfill all requested forest functions and services with respect of particular natural conditions. For the process of forest conversion, TTSC was proposed in two variants: Basic TTSC and Transient (Ameliorative) TTSC. Basic TTSC proceeds from the present information on spruce decline and increased drought stress on the sites unsuitable for spruce. It can be reached in longer time horizon (1 or 2 rotations). Transient Ameliorative TTSC is based on ability of some mostly broadleaved species to ameliorate the site, to draw the nutrients from deeper horizons and to decrease the acid deposition in throughfall. The main aim of this composition is to ameliorate the site and to prepare it to gradual introduction of Basic TTSC.

In studied area, four unites of forest types prevail. First it is fertile and exposed localities of Beech with Fir forest vegetation zone (FVZ) – *Abieto-Fagetum* with approximately 47 thousand hectares and second it is fertile and exposed localities of Beech FVZ – *Fagetum* together 7.5 thousand hectares. Natural species composition of forest stands on these sites consists of beech, fir, sycamore, elm and in higher elevation with admixture of Norway spruce. The present mostly declining spruce stands must be consequently converted into more stable structured mixed stands (Tab. 1).

The basic strategy for forest conversion is based on following principles:

– To save an admixture of Norway spruce for future natural regeneration in Beech with Fir FVZ.

– To omit Norway spruce in lower Beech FVZ (no chance for its natural regeneration).

– Proportion of beech would not be increased in species composition (it is not the best species from the viewpoint of amelioration and production).

– Proposed species composition should be widened by species as Fir, Wild cherry, Elm, Aspen and Birch and enriched by introduced Douglas fir. These species are efficient from the viewpoint of both amelioration and production.

Techniques of conversion

During the conversion of forest stands it is recommended to utilize the posi-

Table 1. An example of proposed target tree species composition (TTSC) for fertile and exposed sites of Beech with Fir forest vegetation zone (Abieto-Fagetum) in North-Western part of the Beskydy Mts. (digits show the decimal proportion of particular tree species).

Fertile sites of ***Abieto-Fagetum***	**Forest tree species composition**													
40,257 ha	NS	EB	SF	La	Li	Ma	O	HB	A	Dg	WCH	Asp	E	BR
Forest plan for spruce dominated sites	6-7	2-1	1-2			0-1				+				
Forest plan for beech dominated sites	0-2	7-5	2-1	+		0-1				+	+	+		+
Natural composition	+	5-7	3-5			+								
Basic TTSC	**1-3**	**2**	**2**	**1-2**	**0-+**	**+-2**			**0-1**	**0-1**	+	+	**0-+**	
Ameliorative TTSC	**0-1**	**1-2**	**2-3**	**0-+**		**1-3**				+	**0-1**	**1**	**0-+**	**0-2**

NS – Norway spruce, EB – European beech, SF – Silver fir, La – Larch, Li – Linden, Ma – Sycamore maple, O – Oak, HB – Hornbeam, A – Ash, Dg – Douglas fir, WCH – Wild cherry, Asp – Aspen, E – Elm, BR – Birch.

tive effect of the present stands, especially ability to soften the climate extremes, to protect the forest soil from erosion, drying out or from increased water table. For this reason, the most common techniques recommended for conversion are interplanting and underplanting.

Interplantig is made in young stands (to the top height ca 4 m) where it is possible to integrate the present stand into the newly created structures. Regeneration elements can have a character of strips or round openings both with shelter or clear cut.

Underplanting is used in older stands and present stand is generally not included into new forest structure. This technique is recommended in open canopy stands. If not, the canopy should be decreased to 40–60%. The optimal area of the regeneration element is c.a. 300–800 m^2 (area not shadowed by crowns). Very important is the planting position. Drip zones of the shelter trees should be avoided.

Thinning

The previous study of the health condition of forest stands in the Beskydy Mts. showed that younger stands (up to age of 40 years) are less defoliated compared to older stands (see Fig. 2). Therefore, the stabilization of these stands by proper treatment is urgent. The main objectives of thinning of young spruce stands in the Beskydy Mts. are following:

Maintaining vitality and stability of dominant trees, i.e. to increase vitality of whole stands before conversion into the stands with more natural species composition.

– Reduction of stand interception for better water management of stands.

– Creation of microclimate favourable to continual decomposition of litter (improvement of soil conditions, prevention of raw humus accumulation).

Thinning models for stands with prevailing Norway spruce are based on one very heavy thinning at the thicket stage; at the top height h_o 5 m. First, heavily damaged trees are to be removed by negative selection both from below and from above. Thereafter, trees with medium damage are removed from below and above, respectively. This first thinning is finished by traditional negative selection from below resulting in recommended density (Fig. 3). During the thinning, support of admixture of shade-tolerant broadleaved species (especially beech) is recommended as well.

First heavy thinning stimulates diameter increment of trees left after thinning as individuals with higher relative stress resistance. Consequently, the resistance of spruce stands to snow and rime damage is increased. Open canopy improves stand microclimate (higher air and soil temperature, higher soil moisture) resulting in continuous litter-fall decomposition (Novák and Slodičák 2004). Annual litter-fall in the spruce thicket exceeds 5 tons of dry-mass per hectare and litter decomposition is important process of nutrient balance maintenance in the spruce stands. From the second thinning (especially for relatively healthy stands), combination of low and high thinning is recommended in case of improvement of health condition.

Recommendations for thinning were prepared as thinning models where number of trees per hectare is proposed across to top height (the mean height of 100 thickest trees per hectare). Models are differentiated according to health condition of the stands (to 25% of

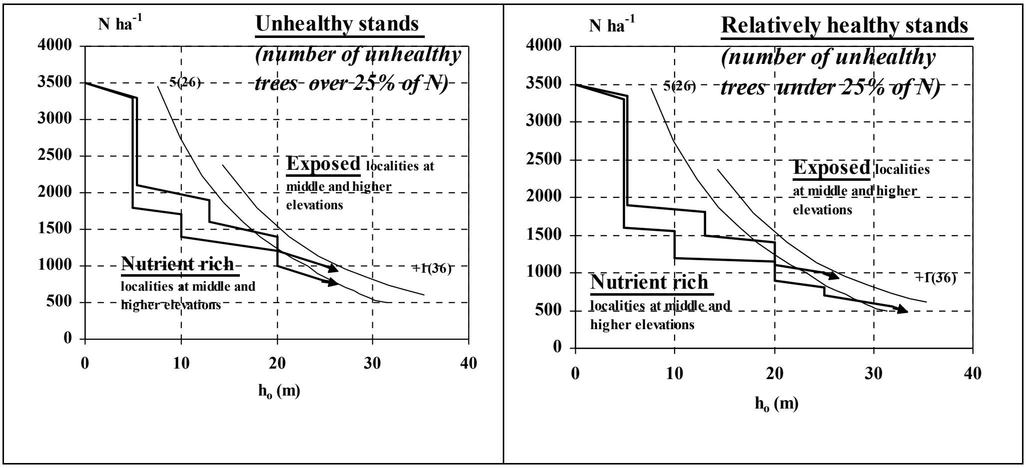

Fig. 3. Thinning programs for spruce stands differentiated according to health condition of the stands and site type compared with growth tables Černý et al. (1996) for site indexes +1 (36) a 5 (26).

damaged trees and over 25% of damaged trees) and according to site type (exposed sites 41 and 51 and fertile sites 45 and 55). Proposed densities are compared with growth tables Černý et al. (1996).

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COPPICE-WITH-STANDARDS: MANAGEMENT OPTIONS FOR AN ANCIENT FOREST SYSTEM

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Abstract

Coppice-with-standards (CWS) is an ancient forest system in Europe which served for centuries to provide timber and a number of other goods, like firewood, poles and fodder to the society while maintaining a continuous forest cover. Since the dawn of modern forestry the area of coppice and CWS forest in Germany has constantly decreased. With the recent rise of energy prices and of wood as a renewable source interest in this system aroused again. Also it was found that CWS forests because of their diversity in structure are a precious habitat for rare and endangered animal and plant species in comparison with high forests. We present two management options in one of the biggest remaining forests of this type in Germany, in Lower Frankonia, Bavaria. The first management option is directed to increase the value of the remaining trees (standards) in the coppice stands in order to cope with timber trees from high forests. The second management option includes an agro-silvopastoral component: in a pilot project we use coppice-with-standards forests as a pasture for Swabian-Hall swines, which are famous for their superior meat quality. The integrative character of this project may support the conservation of the Swabian-Hall swine, which remains an endangered race on the red list of the Society for the Conservation of Old and Endangered Livestock Breeds.

Key words: forest reared Swabian-Hall swine, oaks, silvopastoral system, uneven coppice.

Introduction

Coppice-with-standard (CWS) forests are two-storey forests, where simple coppice is forming the underwood and scattered trees (standards) are building the upper-storey component (Buckley 1992). Indeed CWS forests are a combination of simple coppice and high forest on the same area (Vlad 1940). While in the simple coppice compartment firewood is the main product, in the high forest compartment timber production is in the focus. Until the 18th century many regions in Germany were characterised by this type of forest management. In the course of switching from firewood to fossil fuels, e.g. petroleum and natural gas, the production of firewood increasingly lost its importance.

At the same time the demands on quality of big timber arose, an assortment, which can be produced only in a limited amount in CWS forests (Hochbichler 2005). As a consequence CWS ceased in many regions and those forests subsequently have been converted into high forests. Nowadays the area of CWS forests in Germany is only 0.7% of the total forest area, more than half of these forests is located in Bavaria and Rhineland-Palatinate (BMVEL 2002).

Within Bavaria this type of forestry nowadays is still practised in parts of Franconia. One of the prominent examples is the community forest of Iphofen in Lower Franconia. To keep those remnant forests alive they often have received state subsidies in the past. After a reform of the funding criteria in 2004 by the Bavarian government, a drastic cutting of funding took place. As a consequence many communities planned to convert the remnant CWS forests into high forests.

A conservation of this ancient type of forestry seems possible only, if the financial returns from CWS can compete with the expected financial return from high forests. Interestingly a renaissance of firewood use – especially in rural areas – in combination with a significant increase in market prices for firewood has taken place recently and give reason for hope.

So as not to become dependent on the firewood market a crucial factor will be whether it is possible to produce also highly valued oak timber under a CWS management system, too. Within the framework of a project the TUM Institute of Silviculture (Summa 2007) tried to evaluate what potential oaks from CWS forests have and whether this potential can be improved[1].

An alternative management option for former CWS forests includes an agrosilvopastoral component. In 2005 a pilot project[2] was initiated with the aim to conserve the CWS forest in its structure and use it as a pasture for Swabian-Hall swines, an endangered breed, which hopefully may support the efforts on the conservation of the Swabian-Hall swine. In that project we focus on the quantity and quality of acorn production, which is one of the major components of fodder of swine, but also on the impacts of pig herding on the composition of ground vegetation, tree regeneration, and soil fauna. The study took place in an ancient CWS forest, which is quite similar to the forests where we tested silvicultural optimization.

Increasing the value of standards

Object of our research were typical CWS stands in Lower and Middle Franconia, where we established a set of experimental plots to study the following objectives:

1. Evaluation of current quality potential of valuable timber candidate trees (standards) in CWS

[1] This project was funded by the Bavarian Ministry of Food, Agriculture and Forestry.
[2] This project was funded by the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) via the Federal Agency for Agriculture and Food (BLE).

2. Improvement of quality potential by silvicultural means

3. Comparison of the potential with corresponding results from high forests

We established permanent sample plots in two CWS forests, one in Iphofen (county of Kitzingen) second in Weigenheim (County Neustadt an der Aisch). The CWS forest of Iphofen is a mixed Oak-Hardwood forest on moderately dry sand beds, whose upper canopy layer is dominated by Sessile Oak (*Quercus petraea*), associated with Pedunculate Oak (*Quercus robur*) and some single specimens of Common Beech (*Fagus sylvatica*), Lime tree (*Tilia cordata*), and Wild Service Tree (*Sorbus torminalis/ domestica*). The sparsly existent understory is made up mainly of regeneration of the two Oak species as well as coppice of Lime Tree and Common Beech. The Weigenheim forest is a mixed Oak-Hardwood forest, too, which grows on moderately dry loam beds. The upper canopy layer is also dominated by Sessile Oak and Pedunculate Oak, accompanied by some single specimens of Silver Birch (*Betula pendula*), Aspen (*Populus tremula*), Hornbeam (*Carpinus betulus*) and Lime Tree (*Tilia cordata*). The understory is composed of saplings of Oak and coppice of Silver Birch, Lime Tree and Field Maple (*Acer campestre*). We subjected the sample plots to three different silvicultural treatments:

Treatment A: Control plots without any quality improving silvicultural management prescription. Stand should be converted passively in high forests, a usual practice applied in many locations in Germany.

Treatment B: On these plots the traditional way of management of CWS has been continued.

Treatment C: On these plots we tried to improve the quality of timber by various silvicultural means. For this reason a number of 60 candidate trees was selected and subsequently pruned.

In total we established in the two forests of Iphofen and Weigenheim 12 experimental plots with an area of 0.25 ha each. On each of the two locations we performed two replications of the three treatments (2 locations x 3 treatments x 2 replications = 12 plots). Apart from an inventory of the remaining stand, an evaluation of the thinning and an inventory of the advanced regeneration a quality monitoring of the standards on each plot took place. These data provided insight in the age structure, stand structure and quality structure of the stands and gave chance for comparison with data from high forests.

All experimental plots should carry at least 15 standards each (i.e. 60 standards per ha) and should be comparable with each other. The modified type of CWS silvicultural system (treatment C) aimed to build up an uneven-aged stand structure in the standards of the remaining stand, as it was suggested already by Cotta (1835, cited in Hamm 1896). Following Cotta the optimum stocking of the plots with standards should be 30 (or 120 standards per ha) exhibiting a specific distribution in various age classes (Table 1).

Thinning treatments in each of the age classes reduce the number of trees to half of the number, i.e. that the density will be reduced on a plot with each

Table 1. Optimum density of maiden trees on Treatment C experimental plots.

Age class	Labelling	Age	N per plot	N per ha
1	Maiden (Lassreitel)	< 30	15	60
2	Oberständer	30 – 60	8	32
3	Angehende Bäume	60 – 90	4	16
4	Bäume	90 – 120	2	8
5	Hauptbaum	> 120	1	4
∑ 1–5	Standards (Kernwüchse)	< 30 ≥ 120	30	120

thinning by 15 trees (60 per ha). Because 15 new maidens will be selected in each thinning the total number of standards will remain constant and supports the sustainability of this type of forest management.

Quality parameters

Standards tree quality parameters were monitored according to the methodology of Sliwa (1988):

– DBH.

– Tree height.

– Position where crown of tree commences (i.e. position of large vital branches; no epicormics or water sprouts).

– Position and diameter of the largest living branch of the crown.

– Position and diameter of the largest dead branch beneath the living crown.

– Position and width of stem crookedness (highest deviation of the stem from plumb line and its distance to the midpoint of stem at root collar).

– Position of forks.

– Number of epicormic sprouts (up to a height of 10 m; in three classes: single < five per trunk; several = 5 to 20 per trunk; many > 20 per trunk);

– Number of wounds (distinguishing between the following wound types: mechanical wounds, cancer, fungal disease).

In addition another quality criterion, the length of clear bole was determined, which has not been monitored and analysed in the studies of Sliwa (1988) and Mosandl and Kleinert (1998). It is defined as the length of bole from the lower end to the position of the lowest vital branch with a minimum diameter of 1 cm. At least a pruning of standards was applied on all C plots, where branches and epicormics have been removed up to a height of 7 m.

Comparison with oaks from high forests

Data for comparison originated from studies of Sliwa (1988) on the quality of young sessile oaks from mixed Oak-Beech-Hardwood forests on red sandstone soils from Lower Franconia

Table 2. Comparison of maiden trees from CWS forests with oaks from high forests of Rohrbrunn and Weisswasser.

Parameters	Weigenheim		Iphofen		Rohr-brunn[1)]	Weiss-wasser[2)]
	A+B	C	A+B	C		
Age, years	30	30	30	30	49	50
Height h_g, m	14.5	12.9	13.3	14.1	16.0	14.5
DBH d_g, cm	15.4	10.5	13.5	15.1	15.6	14.2
Position where crown commences, m	7.8	6.3	6.6	7.7	9.7	6.2
Length of crown, m	7.3	5.3	6.0	7.3	6.3	8.4
Position of the largest living branch, m	9.0	7.2	7.7	8.9	10.5	7.8
Position of the largest dead branch, m	6.2	5.6	6.7	8.0	7.6	5.1
Diameter of the largest living branch, cm	5.7	4.1	4.5	4.5	5.0	5.2
Diameter of the largest dead branch, cm	2.4	2.0	2.2	3.3	3.8	3.6
Percentage of trees with stem crookedness, %	28	27	27	23	72	61
Mean width of stem crookedness, cm	22	38	21	17	52	33
Percentage of trees with forks, %	18	27	21	39	22	39
Percentage of trees with epicormic sprouts, %	69	0	66	0	32	39
Percentage of trees with wounds at bole, %	13	23	25	35	0	6

[1)] from Sliwa (1988) [2)] from Mosandl and Kleinert (1998)

as well as from studies of Mosandl and Kleinert (1998) on the quality of oaks resulting from dispersal by jays in mixed Oak-Pine forests on sandy brown soils and podsols in Weisswasser/Saxonia.

For the comparison between trees from CWS forests and high forests oaks have been selected from high forests which have had an individual age of about 20 years older. The reason was that oaks from high forests ranked significantly in height and diameter behind those from CWS forests. For a qualitative comparison it seems reasonable to compare individuals with a similar developmental stage, although of uneven age. Hence the data from a 49 year old stand from the Rohrbrunn forest district (Sliwa 1988) and those from a 50 year old stand from Weisswasser (Mosandl and Kleinert 1998) have been selected. In the following Table 2 the quality characteristics of the maiden trees from the CWS forests are shown in comparison with the oak trees from the two high forests. In addition the Weigenheim and Iphofen data have been subdivided according to treatments 'A+B' (= unpruned) and 'C' (= pruned).

Regarding height of maiden trees in comparison with oaks from high forests we observed, that the height of CWS trees, although distinctively younger in age, was nearly similar to that of the high forest oaks. The height of oaks from Rohrbrunn (16.0 m) was slightly higher than that from CWS (heights between 12.9 and 14.5 m). Oaks dispersed by jays from Weisswasser exhibited a height of 14.5 m – the same height as maiden oaks from CWS.

DBH from maiden oaks and jays' oaks showed values between 10.5 und 15.4 cm. Oaks from Rohrbrunn (Spessart) were slightly wider (DBH 15.6 cm). One of the main reasons for this result could be an enhanced diameter growth rate of CWS trees as a result of the periodical removal of the underwood.

The position, where crown commences, was 9.7 m in oaks from Rohrbrunn, and hence considerably higher than that from CWS (6.3 and 7.8 m, respectively). Jays' oaks from Weisswasser showed the lowest mean value (6.2 m). Mean crown length in CWS was between 5.3 and 7.3 m; this is very similar to oaks from Rohrbrunn (6.3 m). Jays' oaks from Weisswasser had considerably longer crowns (8.4 m).

An important quality criterion is the branchlessness of the bole. The smaller the branches and the higher their insertion on the bole, the higher is the value of the bole. The mean position of the largest living branch in CWS oaks was up to 3.5 m lower than that from oaks from Rohrbrunn. Jays' oaks from Weisswasser showed similar positions as those from CWS.

Concerning the mean position of the largest dead branch we found comparable results. CWS oaks exhibited values of 5.6 m and 8.0, respectively, which is up to 2 m less than oak forests from Rohrbrunn (7.6 m). Jays' oaks from Weisswasser showed the lowest insertion height with 5.1 m.

Oaks from the high forests of Rohrrunn and Weisswasser revealed a stem crookedness of 72% and 61% of the trees, respectively, whereas CWS oaks revealed only a maximum of 38% in Iphofen. Sliwa (1988) supposed that the high percentage of crooked oaks in high forests may be a result of the high stem density, which leads to enhanced phototropic reactions.

In many cases forking is matter of genetic disposition, and seldom a result of management. Between 18 and 39% of oaks exhibited forking.

Epicormic shoots were detected in a considerable amount in maiden trees from CWS. In the sub-category of unpruned CWS stands 69% and 66%, respectively, of the monitored maiden trees have some to many epicormic shoots at the bole and result in a decrease of wood quality. On the other hand oaks from high forests also display epicormic shoots, with about 32% in Rohrbrunn and 39% in Weisswasser. In treatment C all the epicormic shoots have been removed.

The percentage of trees with wounds on the bole was relatively high in CWS trees between 13% and 35%. In comparison oaks from high forests perform much better with a very little amount of wounds, e.g. in Weisswasser only 6% of the trees monitored. Reason for the high number of wounds in CWS are mechanical injuries as a result of logging and extraction due to improper handling by private persons.

Definition of quality categories

The solely description of quality criteria in the previous chapter give no information about the percentage of "very good", "good" or "worse" maiden trees. Only the correct classification of individual trees into categories helps to quantify the latter (Table 3).

Figure 1 give an overview of the quality performance of maiden trees from CWS versus oaks from high forests in Rohrbrunn and Weisswasser. As expected plus trees from oak high forests of Rohrbrunn performed best in the high quality categories. In the maiden trees from CWS the percentage of worse qualities was relatively high (in Weigenheim > 40%, in Iphofen > 60%), but in comparison with jays' oaks from Weisswasser the maidens exhibited a high share of very good individual specimens. In addition there is higher share of very good maidens in pruned plots (treatment C), which is nearly double in percentage to that in the unpruned stands.

Conclusions from the experiments on increasing the value of standards

While comparing DBH and height data of maiden trees from CWS with data of oaks from high forests there is a great evidence of better growth performance of oaks in the CWS stands in the juvenile age phase. This observation can encourage forest managers to produce highly valuable timber in CWS stands in a shorter rotation period than in high forests.

On the other hand quality of oaks from CWS is poorer than from high forests. So some efforts should be undertaken to improve quality of standards in CWS stands. Quality improvement of standards is feasible by three measurements:

– New standards must be carefully selected with regard to timber quality within the coppice system.

– Harvests in CWS stands should be carried out in a way to avoid wounds at the bole of the standards.

– Pruning of epicormic shoots seems to be an appropriate means to produce valuable timber (the long term effect has still to be investigated).

Pig Herding in the CWS Forest

Pig herding took place in an ancient CWS forest near Possenheim (Huss

Table 3. Categories of quality for the evaluation of maiden trees (Sliwa 1988).

Quality of maidens	Factor	Thresholds
Worse	Wounds on the bole	all
	Width of crookedness over	80 cm
	At a height lower than	7 m
	Height of forking lower than	10 m
	Epicormic shoots	many
Satisfactory – good	Width of crookedness over	80 cm
	At a height more than	7 m
	Otherwise below	40–80 cm
	Height of forking higher than	10 m
	Epicormic shoots	some
	Diameter of biggest living branch higher than	5 cm
	At a height of lower than	10 m
	Diameter of biggest dead branch higher than	4 cm
	At a height lower than	8 m
Very good	Without defects or max. width of crookedness lower	40 cm
	Epicormic shoots	single
	Diameter of biggest living branch lower than	5 cm
	Diameter of biggest dead branch higher than	4 cm
	At a height higher than	8 m
	Otherwise below	4 cm

2006), which is quite close and very similar to the forest of Iphofen, where we tested silvicultural optimization. The Possenheim forest is a mixed Oak-Hardwood forest, which was actively managed as a CWS until the late eighties of the last century. The upper canopy layer is dominated by Sessile Oak (*Quercus petraea*) accompanied by Pedunculate Oak (*Quercus robur*) and also harbours single specimens of *Acer pseudoplantanus* and *A. platanoides*, *Populus tremula, Betula pendula, Fraxinus excelsior, Sorbus domestica* and *S. aria, Malus sylvestris*, and *Pyrus pyraster*. The mid- and understorey is characterized by numerous young hornbeam (*Carpinus betulus*) trees, mostly from resprouts, together with an extensive regeneration consisting of a fine grained mixture of saplings of the already mentioned canopy species.

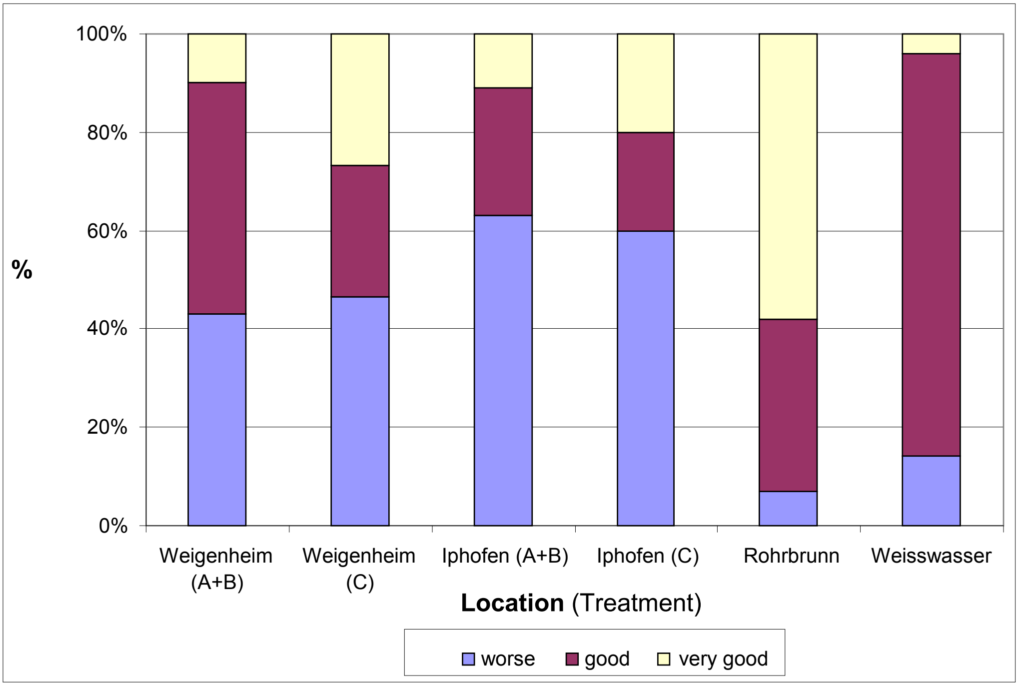

Fig. 1. Quality performance of maiden trees from CWS in comparison with oaks from high forests.

Acorn production was monitored quantitatively and qualitatively for a period of four years with a variety of methods, including Unmanned Aerial Vehicle (UAV) which carried a camera (Hofmann et al. 2009). In addition the impacts of swine on the composition of ground vegetation, tree regeneration, and soil fauna were examined.

Substantial fluctuations in acorn production occur from year to year. We observed a good mast in 2006 with an acorn production of 1154 $kg.ha^{-1}$ that allowed for herding of up to 171 pigs on an area of 20 ha for a fattening period of 90 days or allowed for herding 150 pigs for a fattening period of 103 days, respectively (Table 4). In the two following years 2007 and 2008 acorn production was only a fraction of the 2006 production (~ 28%), and in 2009 was nearly zero. Although acorns are an important staple pigs obviously find suitable substitute feed (e.g. roots, bulbs, herbs, mushrooms, insects, beetles, caterpillars, earthworms and mice). This has been demonstrated in studies with domestic and feral pigs (Genov 1981, Matthes et al. 1997, Schley and Roper 2003). Severe feed shortage can be alleviated by complementary feeding of acorns (collected in other stands and/or purchased), alternatively herd size can be adapted to the mast conditions.

Table 4. Evaluation of acorn production, herd size and fattening period.

Year	Acorn production, kg.ha^{-1}	Carrying capacity (on 20 ha for 90 days)	Calculated fattening period (on 20 ha for 150 pigs)
2006	1154	171 pigs	103 days
2007	315	47 pigs	28 days
2008	321	48 pigs	29 days
2009	26	4 pigs	2 days

Conclusions from pig herding

Yearly acorn production in oaks stands is highly variable. Unfortunately there are only few data series on the periodicity of mast. Local and regional data series are needed as a basis for evaluation, planning and model building for an alternative use like pig herding in CWS. Basic methodology of forecasting is already available but relatively imprecisely and hence has to be improved considerably. Pig herding in CWS with Swabian-Hall swine supports the conservation of the endangered race and also supports the conservation of CWS forests, because the potential use of underwood and/or standards is not affected by herding. First investigations demonstrate that in mast years (e.g. 2006) pigs leave over a considerable number of acorns, which may give raise to a sufficient amount of oak regeneration.

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ANALYSIS OF SHADE CONDITIONS OF *PINUS NIGRA* ARNOLD STANDS IN THE ISLAND OF THASOS IN GREECE

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Abstract

The aim of the present study was to analyze the shade conditions of *Pinus nigra* Arn. stands in the island of Thasos, which is situated in the northern part of Aegean Sea. Thirty six plots of various dimensions were established in *P. nigra* stands, varying in age and structure. For every plot, the diameter at breast height (DBH) for all trees was recorded and the dominant height in each story was estimated. Moreover in each plot, increment cores were taken, at a height of 1.3 m, in the main diameter classes. Three to fifteen hemispherical photographs were taken in each plot resulting in a total of 240 photographs. The amount of sky visible (V.s. = Visible sky) as a proportion of the whole hemisphere when viewed from a point was used as a measure of shade. For each photograph the V.s. value was calculated. Visible sky is related to the potential of the canopy to transmit incident light and allows comparisons between sites in different locations. The V.s. values in *P. nigra* stands ranged from 0.036 to 0.281. The young stands in stem exclusion stage exhibited the lowest mean V.s. value, while the greatest range of V.s. values (0.042 to 0.281) was observed in stands having old growth structure. The *P. nigra* stands in Thasos exhibit a wide range of shade – light environments as a result of their different and heterogeneous structures in combination with the morphological characteristics and ecology of the species.

Key words: light, stand structure, stand age, old growth, stem exclusion, biodiversity.

Introduction

Pinus nigra Arnold expands from west Asia to south Europe (Athanasiadis 1986). It is an important timber tree that forms forests in the mountains throughout most mainland Greece, as well as in some mountainous island areas (Christensen 1997). *Pinus nigra* is a semi-shade tolerant tree which has the ability to grow in pure stands (Athanasiadis 1986).

Stand structure and stand development in combination with the morphological characteristics and ecology of the component species determine the shade conditions in forests (Dafis 1986, Oliver and Larson 1996). Shade – light conditions in forest stands constitute one of the dominant ecological factors determining the growing space availability and growth rates of plants (Dafis 1986, Oliver and Larson 1996, Milios et al. 2008). Moreover shade – light conditions and their alterations strongly influence the biodiversity in forests (Lindenmayer and Franklin 2002). As a result, the determination of shade conditions created under the canopy of different species in different stand structures and stand development stages contributes to ecological knowledge and superior forest management.

The aim of the present study was to analyze the shade conditions of *P. nigra* stands in the Greek island of Thasos.

Study Area

The study was carried out in the pure *P. nigra* stands in the island of Thasos, which is situated in the northern part of Aegean Sea in Greece. The *P. nigra* stands cover an area of approximately 3617 ha (41^{0}09′ N, 26^{0}03′ E). They are located at elevations from 560 to 1200 m (Eleftheriadis et al. 1982). In the closest meteorological station which lies at an elevation of 3 m, the annual sum of precipitation averages 777.3 mm, and the mean annual air temperature is 15.3^{o}C.

The main parent material is gneiss – schist and crystalline limestone and the forest soils are sandy – clay to clay – sandy (Hlikas and Kontos 1997, Eleftheriadis et al. 1982). The *P. nigra* stands are found in medium productivity sites (Hlikas and Kontos 1997, Eleftheriadis et al. 1982).

In 1985 and in 1989 two severe forest fires took place in the area. The first burned about 900 ha and the second about 800 ha of *P. nigra* forest. As a result of the 1985 *P. nigra* forest fire, no silvicultural treatment took place after 1988. Until then, thinnings and regeneration fellings were applied in the area (data from the Forest Service). The regeneration procedure in most cases was based in the creation of gaps as a result of the felling of one or two adjacent trees having large dimensions.

Research Method

In order to analyze the shade conditions in pure *P. nigra* stands the forest was divided into structural types according to the physiognomy of stands and groups having same density. Two main criteria were used for the separation of structural types; the first was the competition regime among trees and the existence of regeneration or available growing space for regeneration, while the second, which is related to the first criterion, was the dimensions of trees. In order to give names to the structural types, the terms of the development stages proposed by Oliver and Larson (1996) were used.

Oliver and Larson (1996) recognize four stand development stages after a major disturbance if no other disturbance occurs: stand initiation, stem exclusion, understory reinitiation and old growth stage. The same terminology has also been used to classify structures, since each structure is in many cases, though not always, the result of processes occurring in each development stage (Oliver and Larson 1996).

In this study four structural types were determined: Stem exclusion A, Stem exclusion B, Understory reinitiation and Old growth. In the 'Stem exclusion A' structural type, the dimensions of trees are small and there is not any regeneration or herbs in the forest floor, since there is no available growing space. Moreover the trees exhibit differences in height and diameter. The 'Stem exclusion B' structural type has the same characteristics with 'Stem exclusion A' structural type but the trees have larger dimensions and their density is lower. In the 'Understory reinitiation' structural type, an understory of *P. nigra* regeneration plants appears. Moreover herbs and shrubs survive in the forest floor. The understory of *P. nigra* seedlings and small saplings is quite small and thus is visibly distinct from other trees in upper strata. In the 'Old growth' structural type, there are large dimension trees, large, dead standing trees, relative open canopies with foliage in many layers and understory.

During the spring and summer of 2006, 36 plots of various sizes were established in areas having slopes from 0 to 20%. In particular: 10 plots of 25 m^2 (5 m x 5 m) were established in 'Stem exclusion A' structural type stands and groups, 10 plots of 100 m^2 (10 m x 10 m) in 'Stem exclusion B' structural type, 10 plots of 500 m^2 (20 m x 25 m) in 'Understory reinitiation' structural type and 6 plots of 0.1 ha (40 m x 25 m) were established in 'Old growth' structural type. The plots were established using the stratified random sampling method. For every sample plot the diameter at breast height (1.3 m) (DBH) in cm, for trees over 2 cm in DBH, was recorded. In each plot, increment cores were taken (at breast height), in trees of the main diameter classes. In the same trees the height, in m, was recorded for the estimation of the dominant height in each story.

In order to determine the shade conditions hemispherical photography was used. More specifically, the amount of sky visible as a proportion of the whole hemisphere when viewed from a point (=Visible sky), taking values from 0 to1, was used as a measure of shade. A value of 0 means that the sky is completely blocked; while a value of 1 means that the sky is completely visible. 'Visible sky' or 'gap fraction' is related to the light that reaches a point, since it gives a measure of the potential of the canopy to transmit incident light and allows comparisons to be drawn between sites in different locations (Hale 2001).

Two hundred forty points were selected in all plots using the stratified random sampling method. In the 'Stem exclusion A' plots 30 points were selected (3 in each plot), 30 points were selected in the 'Stem exclusion B' plots (3 in each plot), while 90 points were selected in each of the 'Understory reinitiation'(9 in each plot) and 'Old growth' structural types (15 in each plot).

In each point a hemispherical photograph was taken at a height of 1.5 m. The photographs were taken with a Nicon Coolpix 900 digital camera with fisheye lens and a self – leveling mount. All photographs were taken during August 2006 under a clear sky, before sunrise or after sunset. Photos were processed with the Hemiview software (Delta–T Devices 1999, Cambridge, UK). For each photograph the Visible sky (V.s.) value was calculated.

The effect of structural type on V.s. was tested using the Dunnett T3 test, since there was heterogeneity of variances (Toothaker 1993).

Results

In the 'Stem exclusion A' structural type the breast height tree age ranges from 9 to 17 years old, while in the 'Stem exclusion B' structural type there are two major groups of ages. In the first group the trees have an age of between 19 and 25 years and in the second group the age ranges from 53 to 64 years. The 'Understory reinitiation' and 'Old growth' are uneven aged structural types since the breast height ages of trees are distributed more or less uniformly between the ages of 29–92 and 22–88 years respectively.

With the exception of 'Stem exclusion A' structural type, where the height of trees ranges from 4 to 7 m, the other structural types have at least two (and more) strata. In the 'Stem exclusion B', 'Understory reinitiation' and 'Old growth' structural types the height of trees ranges from 6 to 12, 7 to 20 and 7 to 22 m respectively.

The lowest range of diameters is observed in the 'Stem exclusion A' structural type while the highest range is observed in the 'Old growth' structural type (Fig. 1). Moreover the 'Stem exclusion A' structural type exhibits the highest tree density (6080 ha^{-1}) and the 'Old growth' the lowest (622 ha^{-1}). The tree densities in the 'Stem exclusion B' and 'Understory reinitiation' structural types are 2740 ha^{-1} and 790 ha^{-1} respectively. The basal area in the 'Stem exclusion A' structural

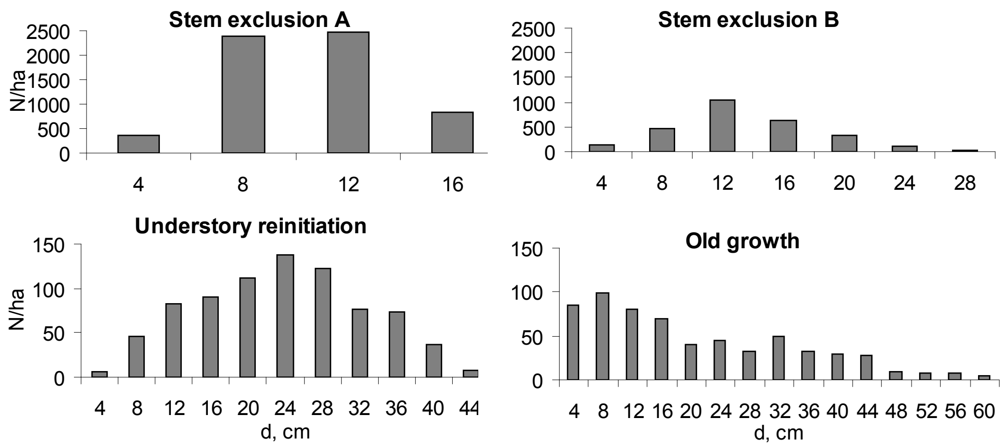

Fig. 1. Diameter distribution of trees in the four structural types.

Table 1. Visible sky values in the four structural types.

Structural types	Visible sky				
	mean	S. D.	min	max	N
Stem exclusion A	0.089[a]	0.034	0.036	0.172	30
Stem exclusion B	0.134[b]	0.010	0.117	0.149	30
Understory reinitiation	0.134[b]	0.017	0.099	0.172	90
Old growth	0.148[c]	0.043	0.042	0.281	90

The mean V.s. values are statistically significant different at $P<0.05$ when they share no common letter.

type is 52.66 $m^2.ha^{-1}$ and in the 'Stem exclusion B', 'Understory reinitiation' and 'Old growth' structural types are 40.58, 38.10 and 28.61 $m^2.ha^{-1}$ respectively.

The 'Stem exclusion A' structural type exhibits the lowest V.s. values with a statistically significant difference on average (Table 1), while the 'Old growth' structural type exhibits the highest V.s. values with a statistically significant difference. On the other hand there is no statistically significant difference, on average, between the V.s. values in the 'Stem exclusion B' and the 'Understory reinitiation' structural types.

The lowest V.s. value of *P. nigra* stands, was found in the 'Stem exclusion A' structural type (0.036) and the highest in the 'Old growth' structural type (0.281). The class of 0.060 dominates in the distribution of V.s. values (Fig. 2) of 'Stem exclusion A' structural type, and follows that of 0.100, while in the 'Stem exclusion B' structural type almost all V.s. values appear in the class of 0.140. In the 'Understory reinitiation' structural type the most V.s. values appear in the class of 0.140, but in this case the range of V.s. values is higher than that of 'Stem exclusion B' struc-

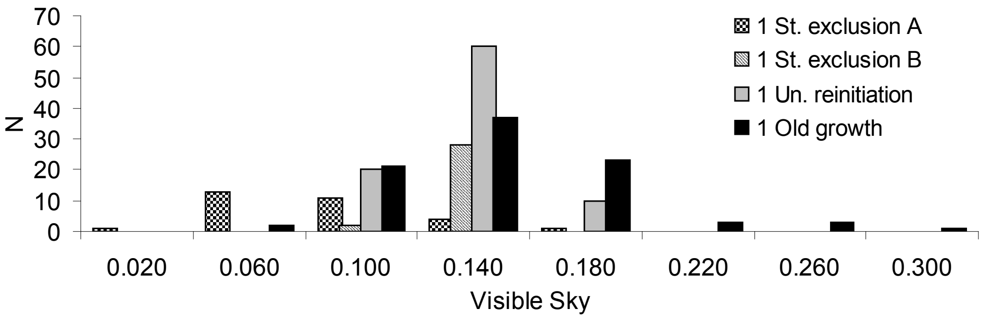

Fig. 2. Visible sky distribution in the four structural types.

tural type. In the 'Old growth' structural type, even though the V.s. values are distributed between the classes of 0.060 to 0.300, most of them are found in the classes from 0.100 to 0.180.

Discussion

The four structural types represent the full array of structures of *P. nigra* stands in Thasos. Only the 'Stem exclusion A' structural type corresponds to the stem exclusion development stage. All the trees were established after the forest fire of 1985 and no other disturbance which led to establishment of trees occurred. In this structural type the V.s. values are the lowest due to the dense canopy of young trees. All the growing space is occupied and there are not any seedlings or saplings in the forest floor.

The other structural types are the result of more than one disturbances. In the 'Stem exclusion B' structural type there are two age groups of trees. The youngest group was established in the growing space that was created as a result of an intense thinning in 1975 (see Eleftheriadis et al. 1982). The V.s. values are higher than those of 'Stem exclusion A' structural type but the growing space probably is also fully occupied, resulting thus in the absence of seedlings and saplings in the forest floor. The 'Understory reinitiation' and 'Old growth' structural types are uneven aged formations that were created by the gradual cutting of trees having large or medium dimensions since the remains of old stumps are still visible. In the case of 'Understory reinitiation' structural type, the cuttings were fewer and after some time the growing space was reoccupied, allowing only the establishment of seedlings that exhibit little growth. Thus, this understory is visibly distinct from other trees in upper strata. In this case, even though the V.s. values are more or less the same with those of 'Stem exclusion B' structural type, seedlings and saplings appear in the forest floor creating an understory. The mechanisms of this phenomenon are not clear. Possibly a higher carbon dioxide concentration near the forest floor in combination to pedogenic processes may create more growing space near the forest floor of the 'Understory reinitiation' structural type stands (see Oliver and Larson 1996). On the other hand, in the 'Old growth' structural type the cuttings led to relatively open canopies with foliage in many layers and understory, resulting in a broad range of V.s. values.

The foliage of *P. nigra* contains shade needles and thus is relatively dense as in other semi – shade and shade tolerant species (see Dafis 1986). The V.s. values found in the four structural types are close to V.s. values of shade tolerant species stands. In a plot of 100 m x 100 m that was established in a low elevation *Fagus sylvatica* stand in northeastern Greece, Papalexandris and Milios (2009) found that the V.s. values ranged from 0.038 to 0.161 (mean 0.089). In Croatia, in the Dinaric *Abies alba* – *Fagus sylvatica* forests, Jelaska (2004) found that the V.s. values ranged from 0.027 to 0.137 (mean 0.061). In Czech Republic in a *Fagus* *sylvatica* stand, in which the first regeneration felling has taken place, Modrý et al. (2004) found that V.s. values ranged from 0.056 to 0.241 (mean 0.154).

The seedlings in the stands of the semi-shade tolerant species of *P. nigra* in Thasos are found to be established in V.s. values of over 0.099, which are higher than the V.s. values needed for *F. sylvatica* regeneration. Milios and Papalexandris (2008) point out that *Fagus sylvatica* regeneration in low elevation *Fagus sylvatica* stands in northeastern Greece appears even at V.s. values of between 0.033 and 0.076.

More research is needed in many ecosystems under various ecological conditions in order to achieve a better knowledge of the shade conditions in *P. nigra* forests.

Acknowledgments

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ASSESSMENT OF VULNERABILITY TO CAVITATION IN SMALL WOOD SAMPLES OF *PICEA ABIES* (L. KARST.)

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Abstract

The hydraulic effectiveness of the xylem affects tree growth and the ability to survive drought conditions. Under drought stress the water transport system can fail. Trees differ in their capacity to maintain a functional xylem at low water potential, which is described by xylem vulnerability. In this study we present a method for measuring xylem vulnerability curves in small samples. Using tangential sections of Norway spruce (*Picea abies* (L.) Karst.) wood, we quantify the loss in hydraulic conductivity by measuring the number of ultrasound acoustic emissions, which result when water-containing tracheids cavitate. At the same time the water potential of the sample was measured with a thermocouple psychrometer. To test the method we measured vulnerability to cavitation in samples of different wood types. The comparison between juvenile wood and mature earlywood spruce samples indicates that juvenile wood is more resistant to cavitation than mature wood. The anatomy of studied wood samples was also analyzed and was related to xylem functionality.

Key words: hydraulic diameter, juvenile wood, mature wood, *Picea abies*, tracheid thickness to span ratio, xylem vulnerability.

Introduction

Water is lifted from the roots to the leaves of the tree crown under negative pressure (or tension) that is created in the leaf xylem through transpiration. When the tension rises through increasing transpiration demand or reduced supply from the soil, the water columns inside the tracheids may break. The mechanism of dehydration-induced sudden breakage of water columns (cavitation) caused by rapidly expanding air bubbles at the pores of pit membranes between embolized (conduits full with air) and water-filled conduits was demonstrated by Sperry and Tyree (1988). Many embolized conduits severely limit the potential to transport water, the consequence of which can be reduced tree growth and dieback. Xylem dysfunction is generally analyzed by “vulnerability curves”, which represent the increase in the amount of embolism or the consequent reduction in hydraulic conductivity with decreasing water potential in the xylem. Vulnerability curves were used for the estimation of theoretical limits of the water transport in the xylem of several conifers (Tyree and Sperry 1989a). Also, they provide information about the ecophysiological behaviour of the plant (Cochard 1991). Different methods were developed for measuring the embolism rate in xylem samples. The degree of embolism in a stem segment can be estimated by its initial conductivity as a percentage of a maximum obtained after removing the emboli by repeated high pressure flushing (Sperry et al. 1988, Tyree and Sperry 1989b, Vogt 2001, Mayr et al. 2002, Mayr and Cochard 2003), or by using centrifugal force to measure the occurrence of cavitation as a function of negative pressures in xylem (Alder et al. 1997). Xylem conductivity in stem cross sections has been determined by using a dye staining method (Mayr and Cochard 2003, Mayr et al. 2007, Hietz et al. 2008). Only recently, various hydraulic methods for measuring vulnerability were compared and their advantages and potential problems discussed (Hietz et al. 2008). Beside hydraulic methods, xylem embolization has also been studied based on the number of ultrasound acoustic emissions during cavitation. In 1966, Milburn and Johnson found that cavitation events in plants cause a rapid relaxation of tension that produces ultrasound acoustic emission (UAE). First, UAEs were detected using audio (i.e., low-frequency range, <15 kHz) acoustic transducers and amplifiers (earphones), while in the 1980s and later techniques for automatic monitoring of ultrasound acoustic emissions were developed (Tyree and Dixon 1983, Tyree and Sperry 1989b, Beall 2002).

It is well-known that wood properties vary with distance from the pith, e.g., structure and function of the xylem differs between juvenile and mature wood (Domec and Gartner 2003, Rosner et al. 2007, Rosner et al. 2008). Juvenile wood is characterized by tracheids with a smaller diameter and higher wood density compared to mature wood, leading to a lower hydraulic conductivity and vulnerability to cavitation (Domec and Gartner 2001, Rosner et al .2006).

The main objective of the current study is to develop a method for analyzing xylem vulnerability in small stem samples (*Picea abies* (L.) Karst.) using an approach based on ultrasound acoustic emissions, and to validate the method as we relate the hydraulic vulnerability to the anatomical properties of the wood.

Material and Methods

Sample preparation

Juvenile and mature wood samples were taken from 25-year-old Norway spruce (*Picea abies*) growing in southern Sweden (latitude 56°67′, longitude 13°07′, 60 m above sea level). The sample material was harvested during a wet period in the middle of June, 2008, when trees did not suffer from drought stress. Trunk wood samples were taken immediately after felling, juvenile wood from the top of the tree (third internode) from the beginning of the crown and mature wood at a height of 1 m above the ground. Wood boles were debarked, split along the grain, and the outer 2 cm of the split sapwood part were transported to BOKU, Vienna (Austria) in plastic bags with fresh water containing 0.01% Micropur (Katadyn Producte AG, Walliseellen, Switzerland), preventing microbial growth. Samples were thereafter stored at -18°C. From the sapwood pieces, tangential rectangle samples (1.1 cm x 0.7 cm x and from 0.33 to 0.4 mm thick) were isolated under a binocular. From the mature sapwood samples, earlywood with homogenous lumen diameters, which can be found between springwood (first formed earlywood cell rows) and latewood, was isolated. Young juvenile wood (age < 3 years) shows density variations and a less distinct latewood zone. Specimens were split from juvenile wood regions with quite uniform wood structure avoiding compression wood. Afterwards specimens were soaked in distilled water containing 0.01% Micropur, and kept under vacuum for several hours until air bubbles stopped coming out from the sample, which indicates full saturation.

Measurements of wood split samples from spruce trees were made based on the modified method employed by Kikuta et al. (2003). For this purpose a new chamber for measuring the small wood samples was designed. The chamber has a cylindrical shape where in the middle a removable metal grid is situated onto which the wood section was placed. The sample was on one side directly attached to an R15C transducer connected to a μDiSP™ Digital acoustic emission system from the Physical Acoustic Corporation (Princeton Junction, NJ, USA), which recorded the UAEs over a standard frequency range of 50–200 kHz. A thermocouple psychrometer was positioned on the opposite wood surface in order to measure the water potential. The psychrometer was placed inside the chamber where vapor pressure equilibrium between water potential in the wood sample and vapor pressure in the air are in dynamic equilibrium. At the beginning of our experiments, when the samples were saturated with water, the relative humidity of the vapor phase was close to 100% and the samples had a water potential slightly below 0 MPa. As the wood dried the water potential decreased and cavitations were recorded in parallel. The acoustic emissions recorded during drying the samples were calculated in percent of the total number of emissions ($\%UAE = 100\ UAE^{drying\ sample}/UAE^{total}$).

Anatomical investigations

Transverse sections were made from each of the wood samples that had been used to produce vulnerability curves. Three 30 μm thick sections were made with a sliding microtome, stained in methylene blue and mounted in Entellan (Merck, Darmstadt, Germany). Of each slice three pictures were made randomly over the whole radial length of the sample with a Leica DM4000M microscope interfaced with a digital camera (Leica Microsystems Wetzlar GmbH, Germany). The tracheid lumina and cell wall thickness were measured with SigmaScan Pro 5 (Systat Software Inc., Chicago, USA). First, the mean hydraulic diameter $D = \Sigma d^5.(\Sigma d^4)^{-1}$ was calculated, where d is the individual conduit diameter. For each sample separately, six rows of tracheids were randomly selected and the diameter of all the tracheids was measured in radial direction. To characterise the conduit wall reinforcement against collapse from bending we measured the "double wall thickness to span ratio" $(t.b^{-1})^2$. The $(t.b^{-1})^2$ ratio was calculated for each sample, where only the cells with a diameter of within 10% of D were considered (Domec et al. 2009). The double cell wall thickness of adjacent conduits (t) and the conduit lumen (span, b) were measured on 26–40 tracheid pairs.

Results and Discussion

The main result we can draw from our experiments is that juvenile wood was more resistant to cavitation than mature early wood. The water potential required to achieve a 50% loss of conductivity was -2.82 MPa for juvenile wood and -1.47 MPa for mature wood (Fig. 1).

The study of wood anatomy showed that juvenile wood has a smaller mean hydraulic diameter and a higher tracheid wall to span ratio $(t.b^{-1})^2$ than mature earlywood (Tab. 1, Fig. 2).

The trade-off between vulnerability to cavitation and hydraulic conductivity observed in our study for mature and juvenile wood (Fig. 1, Tab. 1) confirmed the results obtained by other authors (Domec and Gartner 2001, Rosner et al. 2006). Vulnerability to embolism is

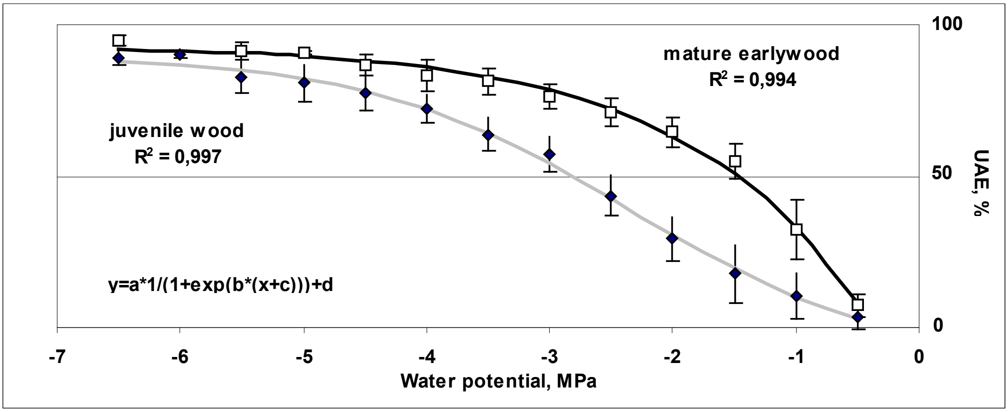

Fig. 1. Vulnerability curves for small stem segments (1 cm x 0.7 cm) of mature earlywood and juvenile wood taken from *Picea abies*. Percent ultrasound acoustic emissions (UAE) are plotted versus water potential. Each plot is the mean of the percent UAE measured in intervals of 0.5 MPa of water potential on 5 (juvenile) and 4 (mature earlywood) stem segments. Error bars show standard errors. The solid lines resulted from sigmoidal regression and are described by the given equation. The same function was used to interpolate the water potential at 50% UAE.

known to be influenced by the structure of the xylem (Hacke et al. 2001, Domec and Gartner 2002) and pit pore characteristics (Domec et al. 2006). Larger conduits are often more susceptible to cavitation (Hargratte et al. 1994). According to the air-seeding hypothesis (Zimmermann 1983) air enters the lumen of water-filled vessels through pores in the pit membrane of the walls of embolized conduits. Consequences thereof are cavitation and the following embolism. Wider conduits such as the tracheids in mature earlywood have larger pores in their pit membranes, allowing easier air penetration (Tyree and Sperry 1989a). These elements therefore are more conductive than juvenile wood. Additionally, thicker cell walls in juvenile wood are associated with a thicker pit

Table 1. Mean hydraulic diameter (D) and tracheid thickness to span ratio $(t.b^{-1})^2$ in Picea abies juvenile wood and mature earlywood stem sections used above for producing vulnerability curves. Means (±SE) are shown.

	D, μm	$(t.b^{-1})^2$
Juvenile wood	25.63 ± 1.40	0.046 ± 0.012
Mature early wood	31.30 ± 2.05	0.037 ± 0.010

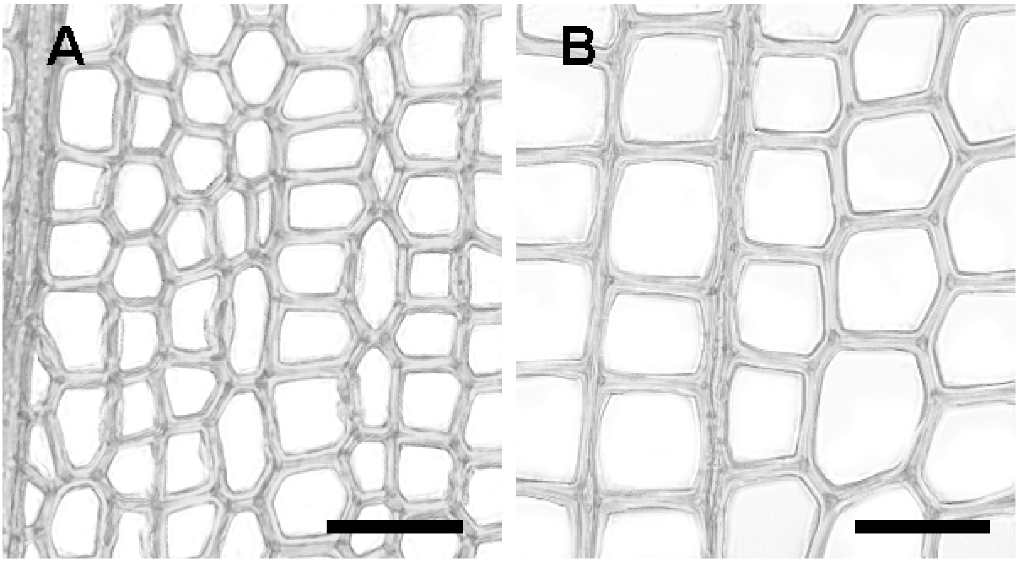

Fig. 2. Transmission light microscope pictures made on transverse juvenile (A) and mature (B) stem *Picea abies* sections showing tracheid lumen and cell wall thickness. The reference bar is 30 μm.

chamber depth, making this wood more resistant to air seeding (Domec and Gartner 2001). On the other hand, the measured increase in cell lumen diameter relative to cell wall thickness in mature early wood is consistent with the higher hydraulic vulnerability of mature early wood (Tab. 1).

Conduits carrying water over long distances under negative pressure need reinforced and lignified cell walls to prevent implosion (Hacke and Sperry 2001). The safety factor against implosion caused by negative pressure, given by tracheid thickness to span $(t.b^{-1})^2$ ratio, was seen to be proportional to resistance to cavitation in the studied wood samples. The decrease of the $(t.b^{-1})^2$ ratio from juvenile to mature wood as vulnerability to cavitation increases has also been described for other conifers species (Domec and Gartner 2001).

Our study has shown that the developed method can be used for simultaneous measurements of the percent loss of conductivity and the corresponding water potential in small wood samples. We confirmed a relation between cell anatomy and cavitation resistance: juvenile wood had a higher $(t.b^{-1})^2$ ratio compared to mature earlywood and correspondingly a higher resistance to cavitation. Furthermore, our results support the conclusion made in previous studies that juvenile wood is more resistant to cavitation than mature early wood.

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FOREST CHANGE DETECTION BY MEANS OF REMOTE SENSING TECHNIQUES FROM THE EU PROJECT CORINE LAND COVER

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Abstract

The main aims of the Pan-European project CORINE Land Cover (38 countries participating, including Bulgaria) are to identify and map the changes in land cover/land use for the period 2000–2006 using multispectral satellite imagery and producing a 1:100 000 digital map of Europe for the year 2006 (creating a geospatial database). The change detection is a process of a comparison and analysis of vector and raster data from the two time horizons. The adopted unified nomenclature for the 44 interpreted and mapped land cover classes includes 6 classes directly and closely connected with the thematic mapping of timber productive areas of the forest fund. Three of the most frequent changes in the Bulgarian forests are analysed by means of the CORINE Land Cover database – clear cuts, burnt areas and spots of sport and leisure facilities construction. A large scaled research has been also carried out for assessing the locations, the areas of the Mountain pine (*Pinus mugo* Turra) associations in Bulgaria and their long period changes.

Key words: satellite images, computer assisted image interpretation, land cover classes, clear cuts, burnt areas, Mountain pine (*Pinus mugo* Turra) associations.

Introduction

Forests are a huge resource to our economics and one of the most important parts of our environment. Remote sensing techniques allow us to gather information about our forests from a distance through the use of sensors mounted on satellites or airplanes that collect digital images of the Earth.

The project "Mapping the territory of the country by land cover/land use classes by means of satellite images interpretation – CORINE Land cover methodology" for Bulgaria is a part of the EU project "CORINE Land Cover 2006" (CLC 2006). The main aims of the this Pan-European project are to identify and map the changes of land cover/land use for the period 2000–2006 using multispectral satellite imagery and to produce a 1:100 000 land cover/land use map of Europe for the year 2006 (creating a geospatial database) (Bossard et al. 2000, Büttner et al. 2002, Feranec et al. 2006). The project (38 countries participating) is a direct continuation of the previous CORINE Land Cover mapping campaigns (1990, 2000) and it has been finished in 2008.

Methodology

The CORINE 2006 project is implemented in all participating countries strictly following a standard methodology described in details in CLC2006 technical guidelines (CLC2006 technical guidelines 2007). The methodology includes choice of satellite images, choice of software and ancillary data and detection and mapping of land cover changes.

Satellite images

For the project, the following satellite images have been used:

– Satellite images for the year 2000 from the American satellite Landsat 7 ETM+ (database IMAGE2000) – 11 scenes.

– Satellite images for the year 2006 ± 1 year – database IMAGE2006 (see Table 1).

Table 1. Number of images by year of acquisition and satellites.

Satellite:	2005	2006	2007	Total
IRS P6	5	17	2	24
SPOT 4	0	32	3	35
SPOT 5	1	16	2	19
Total	4	65	7	78

As a total 24 images are provided from the Indian satellite IRS P6 and from the French satellites SPOT 4 and SPOT 5 – respectively 35 and 19 images. Their distribution by year of acquisition is presented in Table 1.

Raw satellite images first have been pre-processed and enhanced to yield a geometrically correct document in a certain map projection.

Choice of software and ancillary data

Methodology of the project requires creation of an optimal software environment: software for satellite image processing PCI Geomatics, version 10.2. – modules Orthoengine and FOCUS, specialized software for the preparation of data and throughout the interpretation of the satellite images, ESRI software ArcInfo for the creation of the CLC2006 database, the transformation and the integration of the data.

For the implementation of CLC 2006 project for Bulgaria a number of additional products have been used: digital topographic maps at 1:100 000; 1:50 000 and 1:25 000 scales, thematic maps: vegetation, soil, climatic etc., digital georeferenced aerial orthophotographs, high and very high spatial resolution satellite images: all accessible images from Google Earth; the available in our archive images from the American satellites QuickBird and IKONOS, the Israeli satellite EROS-B, the French satellites SPOT 4 and SPOT 5 and Russian images from the KWR-1000 and statistical data.

Detection and mapping of land cover changes

The location of land cover/land use changes for the period 2000–2006 or the creation of CLC Change 2000–2006 database is an essential step in the process of mapping, which defines the accuracy of the new CLC2006 database too (Feranec et al. 2007). According to the CORINE methodology, a change in a given land cover/ land use class is registered when the following geometric requirements are met:

– The obligatory minimum area of a change is 5 ha.

– A special type of "elementary" changes can be smaller than 5 ha, but the total group area of these neighboring polygons should be greater than 5 ha;

– The minimum width of a polygon is 100 m.

Change detection is a process of comparing and analysing vector and raster data from the two time horizons. It totally depends on the expertise and the skill of the interpreter. The correctness of the decisions is also determined by the good knowledge of the territory of research as a natural geographic region, the social and economic conditions, the seasonal changes in the reflectance of land cover, the knowledge and the experience in computer assisted interpretation of satellite images.

Technically changes are located by means of an analysis of all available data. Change polygons are delineated in the images from 2006. During the process of change detection the following rules are followed:

– only real land cover changes that reflect certain natural, social and economical processes and trends are mapped;

– the development of landscape as a natural and anthropogenic system are taken into account;

– for each change the likelihood and the chance of occurrence within the 6 years period are considered;

– short term and periodic changes (daily or seasonal), are not marked.

Land Cover Classes of Interest to Forestry

The adopted unified nomenclature for the 44 interpreted and mapped land cover classes (Feranec et al. 2006) includes 6 classes directly and closely connected with the thematic mapping of the timber productive areas of the forest fund, with the inventory of the forest stands and their monitoring referring to forest fires. The multitemporal analysis of satellite images, being in the basis of the project methodology, provides a study of the development of these land cover classes and facilitates for forest changes detection. The CLC classes of interest to this study are shown in Table 2, where those directly related to forestry are bold.

The multitemporal analysis of satellite images provides a study of the territorial distribution of these land cover classes and detection of the most important changes in Bulgarian forests.

Territorial distribution of land cover classes of interest to forestry

In the CLC2006 Bulgaria database 36 land cover classes by the CORINE nomenclature are presented by 52,478 polygons covering a total area of 11,242,620.6 ha

(112,242.6 km^2) (Stoimenov 2008). The mapped territory exceeds the country territory (110,993.6 km^2). The reason is the project methodology – mainly the 2 km buffer zone mapped along the terrestrial country borders and national borders.

More than half of the territory of the country belongs to two classes:

– "Nonirrigated arable land" – 3,899,946.4 ha (34.69%).

– "Broadleaved forests" – 2,360,819.0 ha (21.00%).

The Land Cover nomenclature classes of interest to forestry distribution for the CLC 2006 database statistics – number of polygons, class area and class percent of the all territory mapped are summarized in Table 3.

Level 1 class distribution is presented in Table 4. Almost 99% of the territory is occupied by 3 Level 1 land cover classes:

- "Arable lands" – 5 760,750 ha (51.24%);
- "Forest and seminatural areas" – 4,795,873 ha (42.66%);
- "Artificial surfaces" – 558,410 ha (4.97%).

Table 2. Land cover classes of interest to forestry.

Level 1	Level 2	Level 3
3. Forest and semi natural areas	3.1. Forests	**3.1.1. Broad leaved forest**
		3.1.2. Coniferous forest
		3.1.3. Mixed forest
	3.2. Scrub and/ or herbaceous vegetation associations	3.2.1. Natural grassland
		3.2.2. Moors and heath lands
		3.2.4. Transitional woodland scrub
	3.3. Open spaces with little or no vegetation	3.3.2. Bare rocks
		3.3.3. Sparsely vegetated areas
		3.3.4. Burnt areas

Table 3. Class of interest to forestry distribution for CLC 2006 Bulgaria database statistics.

№	Code	Level 3	Polygons	Area, ha	%
1	3.1.1.	Broad leaved forest	5,429	2,360,819.0	21.00
2	3.1.2.	Coniferous forests	1,988	543,044.3	4.83
3	3.1.3.	Mixed forest	4,008	645,219.5	5.74
4	3.2.1.	Natural grassland	2,886	406,735.8	3.62
5	3.2.2.	Moors and heath lands	90	31,753.1	0.28
6	3.2.4.	Transitional woodland-scrub	7,765	751,310.9	6.68
7	3.3.2.	Bare rocks	148	12,558.4	0.11
8	3.3.3.	Sparsely vegetated areas	382	41,420.3	0.37
9	3.3.4.	Burnt areas	1	368,8	0.00
		Total	**22,697**	**4,793,230.1**	**4,263**

Table 4. Level 1 class distribution for CLC 2006 Bulgaria data base statistics.

Level 1	CLC class	Polygons	Area, ha	%
1	Artificial surfaces	5,734	558,410	4.97
2	Arable land	23,024	5,760,750	51.24
3	Forest and semi-natural areas	22,276	4,795,873	42.66
4	Wetlands	82	11,399	0.10
5	Water bodies	425	116,189	1.03
	Total	**51,541**	**11,242,652**	**100.00**

Table 5. CLC 2006–2000 changes (level 1).

Level 1	CLC 2006-2000 changes	Area, ha	%
1	Artificial surfaces	4,594.73	7.86
2	Arable land	4,893.29	8.37
3	Forest and semi-natural areas	48,810.57	83.49
4	Wetlands	165.97	0.28
5	Water bodies	0.00	0.00
	Total	**58,464.57**	**100.00**

Change detection in the land cover classes of interest to forestry

During the investigated period of 6 years the identified changes are presented in 2,706 polygons with total area of 528,272 ha, which cover 0.53% of the country territory.

The biggest changes are in class "Forest and seminatural areas", followed by "Arable lands" and "Artificial surfaces". The Level 1 changes are presented in Table 5.

Table 6 shows the changes in land cover classes of interest to forestry in Bulgaria arranged in descending order. The greatest changes detected for the period 2000–2006 refer to two classes – "Transitional woodland-scrub" – 3.2.4. (59.5%) – deforestation and "Broad leaved forest" – 3.1.1. (20.1%) – aforestation.

Most Important Changes in the Land Cover Classes of Interest to Forestry

Three of the most frequent changes in the Bulgarian forest over a 6 years period can be analysed through data collected from the CORINE Land Cover database:

3.1. "Clear cuts" – class 3.2.4.

Land cover class 3.2.4. is derivative of the sub-class 3.2. – "Scrub and/or herbaceous vegetation associations" included in the major class 3 –

"Forest and semi natural areas" (CLC2006 technical guidelines, 2007).

Class 3.2.4. "Transitional woodland/shrub" includes before all bushy or herbaceous vegetation with scattered trees. It can represent either woodland degradation or forest regeneration/decolonization. Young plantations, forest nurseries and clear cuts in forest areas are also included here. Since the Bulgarian regulations no matter the case do not allow clear cuts larger than 5 ha (and this is the lower area limit for a CLC Change polygon) this class gives a brilliant possibility for identifying and quan-

Table 6. CLC 2000–2006 changes in the land cover classes of interest to forestry.

CLC code	Area, ha	%
3.2.4. Transitional woodland-scrub	34,810.2	59.54
3.1.1. Broad leaved forest	11,777.1	20.14
3.1.3. Mixed forest	1,176.5	2.01
3.1.2. Coniferous forests	609.9	1.04
3.3.4. Burnt areas	382.6	0.65
3.3.3. Sparsely vegetated areas	33.0	0.06
3.2.2. Moors and heath lands	21.3	0.04
Total	**48,810.6**	**83.48**

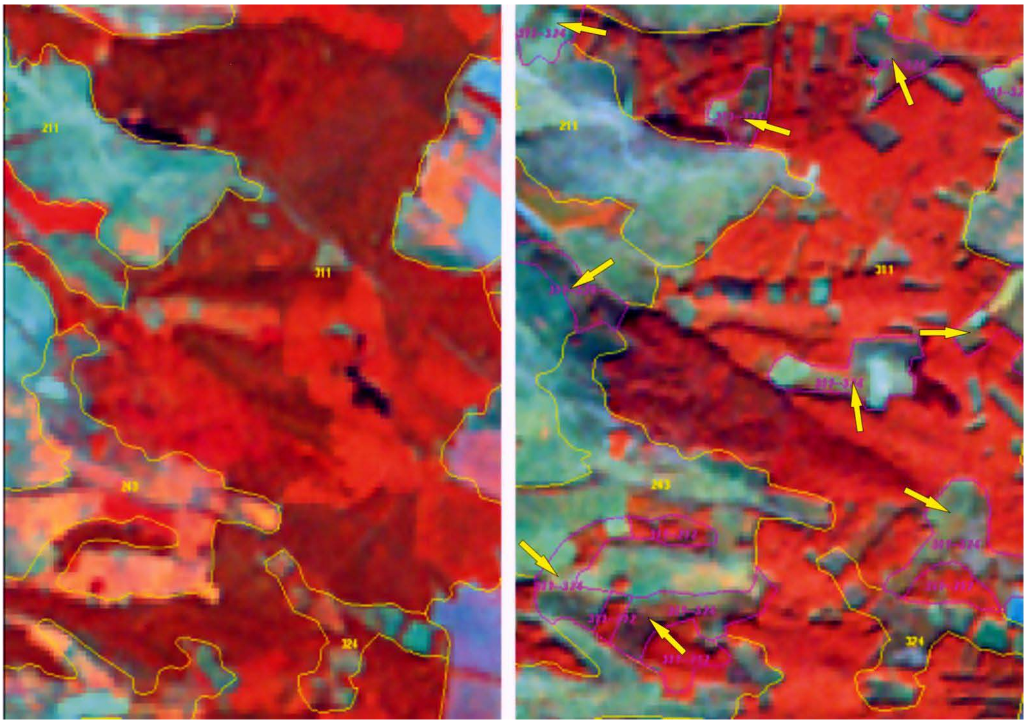

Fig. 1. Multiple clear cuts larger than 5 ha, found eastwards from Lukovit – the total area of such clear cuts for the working unit (one 1:100 000 map sheet) amounts to 1752 ha.

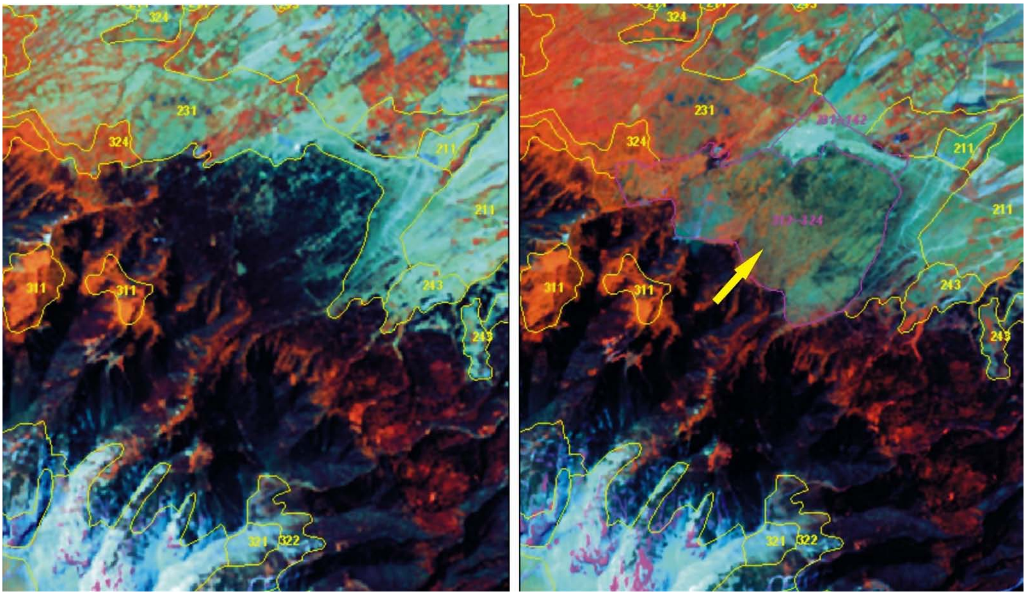

Fig. 2. Changes due to a forest fire and consequent cuts of coniferous forests in the region of Bansko.

tification of illegal cuts. Such an example of multiple clear cuts larger than 5 ha, found eastwards from Lukovit, are shown in Fig. 1 (dark green coverage with brownish spots in the right window).

Changes of this type amount to 59.5% of all changes in land cover classes in Bulgaria.

“Burnt areas” – class 3.3.4.

Land cover class 3.3.4. “Burnt areas” is a derivative of the sub-class 3.3. – “Open spaces with little or no vegetation” included in the major class 3 – “Forest and semi natural areas” and includes areas (mainly forest and heathlands and moorlands) after recent fires.

An example can be given from the region of Bansko (Fig. 2) – burnt and consequently cut of forest stands of Austrian pine (*Pinus nigra* Arn.) with a total area of 642 ha.

Spots of “sport and leisure facilities” construction – class 1.4.2.

Land cover class 1.4.2. “Sport And Leisure Facilities” is a derivative of the sub-class 1.4. “Artificial, non-agricultural vegetated areas”, included in the major class 1 “Artificial surfaces”. This class contains camping ground, sport ground, leasure parks, golf courses, race courses, etc. There are included also formal parks not surrounded by urban areas.

Spots of “Sport and leisure facilities” construction are connected with clear-

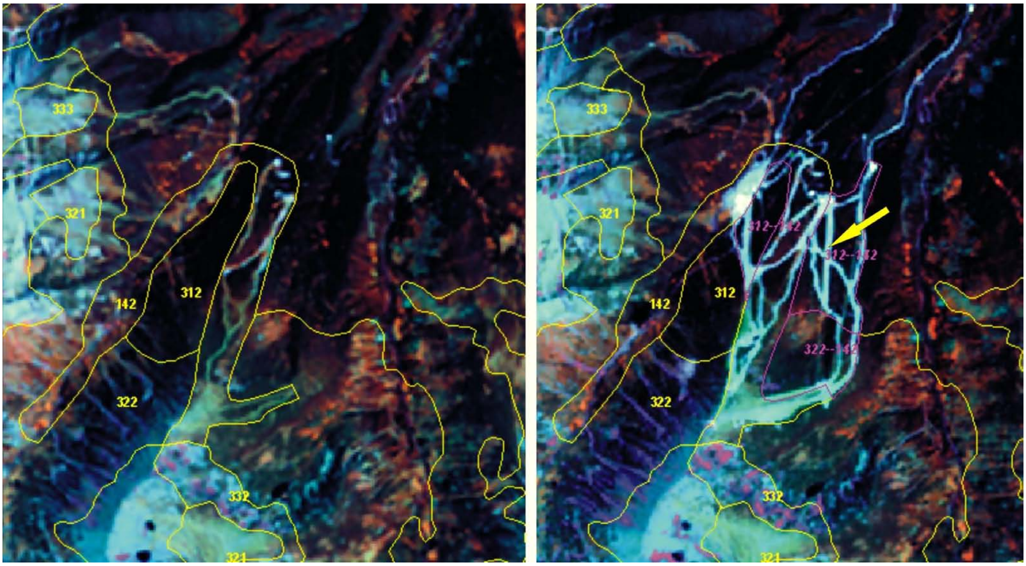

Fig. 3. Cuts of coniferous forests for new skiing tracks in the region of Bansko.

ance of large territories, often clear cuts. Such an example is presented in Fig. 3, but the total area of similar changes on the whole Bulgarian territory amounts to 586 ha.

Assessment of the Locations and the Area of Mountain Pine Assosiations in Bulgaria

On the basis of data, satellite imagery and technology of the project CORINE Land cover – Bulgaria, a large scaled research has been carried out for assessing the locations and the area of the Mountain pine (*Pinus mugo*) associations in Bulgaria. The results of the research are compared to the official data of the national Executive Forest Agency.

In Bulgaria the only large enough areas that should be assigned the 3.2.2. code are those covered with dwarf pine (*Pinus mugo*). Such associations proved out to be wide spread in the high mountain belt (altitude between 1400–2500 m) of the Rila and Pirin mountains and some separate stands could be found in the high parts of the Vitosha mountain and the Western Balkan mountain. High in the mountains the vast *Pinus mugo* associations prove to be usually pure. Their spectral reflectance makes them easy to identify by color in the satellite images, separate them from the other coniferous stands and delineate the 3.2.2. CLC polygons. They are also characteristic with their smooth texture (see the left window in Fig. 4).

The total area of the CLC 3.2.2. polygons for the country is 24,753 ha. It is compared with the available ground truth data of the 4 Regional forest de-

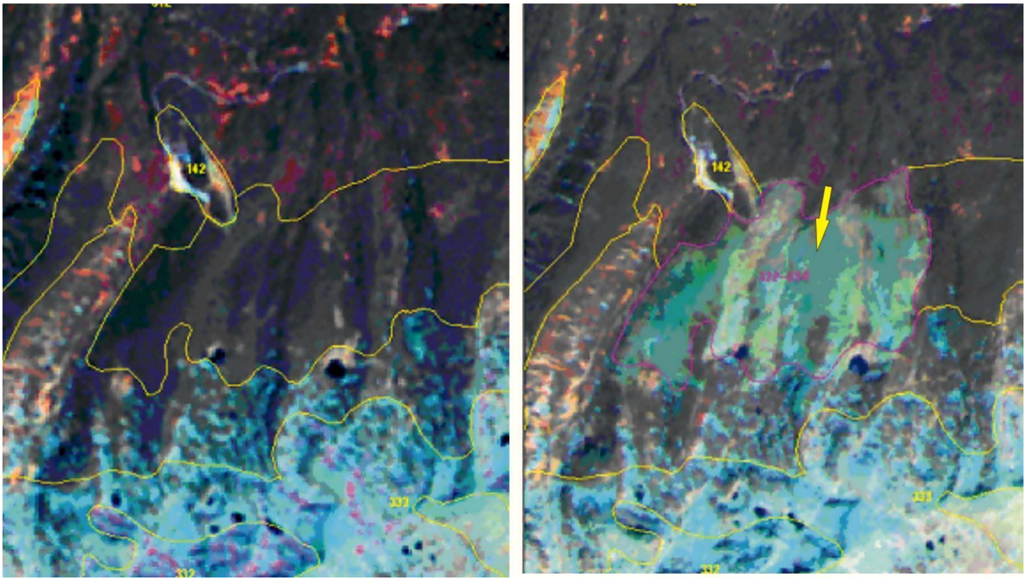

Fig. 4. A burnt and consequently submitted to clear cut 369 ha areas of *Pinus mugo* near the Malyovitsa peak.

partments which territories take in the *Pinus mugo* associations – Blagoevgrad, Kyustendil, Pazardjik and Sofia. According to these data the total area of interest is 23,073 ha. The difference is due to the availability of some rare stands on rocky grounds that have been delineated as CLC polygons, but are not accounted as a part of the forest fund.

All the work has been done within several days, whereas having in mind the hard terrain access to the spots, the precise solving of the task by terrain methods is very time-taking, expensive and for some places impossible.

Changes in the *Pinus mugo* associations are very slow. Cuts in them are not allowed in Bulgaria as it is everywhere in Europe. Nevertheless, some large changes in this CLC class have been found due to forest fires and consequent cuts. Such an example for the region of the Malyovitsa peak is shown in Fig.4. In the left image from Landsat-7 ETM+ (2000) the dark patch with smooth texture in the middle represents the high mountain *Pinus mugo* stands, touching a skiing track in the north direction. The burnt and cleared area can be seen as a large dark green patch in the right image from SPOT 4 (2006). The southern boundary is tong-like – typical of burnt areas because of the specific way in which fires spread due to the relief.

Conclusion

The more than 15 years history of the CLC Project data applications shows that this huge database is the only periodically updated pan-European spatial database. It strongly impacts the policy and the applications in the regional development and spatial planning; coastal zone management; implementation of the biodiversity conventions, habitats and protected sites; integrated watershed analysis; assessment of air emission and air quality measures; impacts of agriculture policies on the environment etc. The CLC project methodology, based on multitemporal analysis of satellite images, provides data which can be used in enormous number of scientific and application projects.

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FORESTRY LEGISLATION – STIMULATING OR DISCOURAGING FOREST OWNERS?

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Abstract

All legislation implies compromises between conflicting interests. In forestry, the stakeholder groups can be defined as forest owners, timber users, general public and ideological interests groups such as conservationists. Furthermore, a single actor may have ties to more than one group. Forestry legislation in its narrow sense usually has the owners as their primary target group, by issuing prohibitions, restrictions and mandatory actions, as well as in some cases incentives such as subsidy and advisory services. In many countries, forest owners are poorly organized, or there may be a strong polarity between the interests of family, corporate and public owners. Legislators tend to take law compliance for granted, but the process of making laws and regulations operative involves many steps, including communicative and value-based process. These aspects are frequently dealt with in forest policy research. Yet, forest owners can also be seen as economically rational actors. Much well intended legislation may never be effective, as the cost of law compliance is high to the owners. We examine three cases: Sweden in the 17th century, and in the first half of the 20th century, and Argentina today, and discuss the current situation in (mainly) Europe, where broadened societal targets such as sustainability and multifunctionality have to match the interests of family foresters.

Key words: goal conflicts, law compliance, rational choice.

Introduction

The elaboration of National Forestry Plans (NFP) or other corresponding instruments has been an important component in European forest policy, both under the MCPFE and EU umbrellas. A key for making this planning socially legitimate and not only ecologically sustainable, public participation has been emphasized as an indispensable component of the planning process (eg. Appelstrand 2002). Yet, regardless whether a set of normative regulation (laws, administrative regulation, market driven rules such as certification) is imposed from above or created in a truly discursive process (cf. Schanz 2002), is has to be implemented by those who control the forestry operations, normally the forest owners. Our principal message in this paper is that these owners' own preferential behaviour follows a normal rational-choice logic, and that the regulation has the best chances of being successful if the owners self-interests can be made to coincide with the objectives of that regulation. The alternative is coercion, which is resource-intensive, creates a spirit of resistance, may lead to outright sabotage, and in all cases foster corruption. In our paper, we discuss four cases out of a simple model found useful in environmental policy analysis (Gunningham et al. 1998).

Laws and regulations as steering instruments

Legislators and policy makers normally assume that their prescripts will be implemented and that concerned citizens will obey existing regulations. Active law enforcement is seen as a special measure to use against particularly recalcitrant individuals. This applies above all to criminal law, the purpose of which is to *conserve* social order. But with modern times, legislation has come to be seen as a toll to *change* peoples' behaviour. This applies particularly to forestry and environmental legislation, a discussion opened by Per Stjernquist (1973), writing about introducing modern or 'scientific' forestry, and more recently by one of his disciples, Marie Appelstrand (2002, 2007), writing about introducing enhanced environmental ambitions in private forestry in Sweden. Changing behaviour requires more active efforts, a reason for advisory and educational services being part of forest governance systems in many countries; in Sweden from the very beginning in 1903. Yet, as briefly argued above, if the forest owners see the totality of policies as directly negative to their interests, they may seek ways to evade the unwelcome regulation, or search for even more radical options.

Gunningham et al. (1998), discussing "smart regulation" for implementing environmental policies, identify three criteria of functional regulation.

– Effectiveness: the policy contributes to reaching the politically defined objectives

– Efficiency: the effect is brought about at lowest possible cost, (including administration overheads and transaction costs.

– Equity: the burdens and gains are equitably distributed among stakeholders.

Appelstrand (2007) comments, that effectiveness and efficiency are the two most basic characteristics policies leading to desired performance. But she adds that equity probably would be ranked highest by, in her case, environmentalists, who claim that no conservation policies will be sustainable without environmental justice. It is easy to extrapolate that argument to our field of study:

The four cases

Case 1: 17th century Sweden (cf. Nylund, 2009)

In 1647, Sweden was a leading power in northern Europe, and its navy dominated the Baltic. Navies are built from oak. Its armies controlled the main ports of the Northern rivers mouths. Arms are made from iron. The country had recently introduced a modern style central administration that tried to stimulate economic development. This year Sweden got its first set of forestry legislation, properly prepared by a parliamentary committee. It was in many respects a very enlightened piece of legislation, calling for regeneration measures when 'carrying' trees and valuable hardwoods were felled. It reserved oak and coniferous mast trees for the Crown, even when growing in private land, to serve the Navy's needs. It forbade the wide-scale shifting cultivation in the forest, threatening the supply of charcoal to the mining industry. To enforce the law, forest guards were required to approve all felling on private land and village commons.

However, the results were disastrous. Villagers started uprooting oak saplings, as the Crown rights blocked rational land use and the timber oak extraction involved compulsory assistance in the transport of the heavy logs to the shipyards and castles. Settlers in the forested areas with little tillable soil had no way of feeding themselves or of producing for the markets if excluded from burn beating. The forest guards became rapidly corrupt, the forest continued to be "wasted", and the popular loathing of any regulation of forest use was so strong, that the whole system had to be abandoned during a constitutional crisis in the late 1700s to ensure political support for the Crown. New legislation was delayed until 1903 in spite of half a century's lobbying by forestry professionals, and a complete set of laws was accepted only in 1923.

Case 2: Present-day Sweden

Before final cutting, called regeneration cutting by the law, a forest owner must notify the local Forest Agency office. The Agency has a possibility to inspect the intended logging site and to issue compelling instructions. Under the present green policy, in theory applauded by all, it is likely that the Agency will take an extra look in areas rich in "key biotopes" with high conservation values. The authorities may in that case mark out areas for protection, reducing or forbidding logging, or even expropriate them for conservation, alternatives not to be discussed further here. In any case, in some regions the key biotope areas may cover a sizeable part of a property, reducing income substantially or at least making management more difficult. Until 1993, there was an obligation to log "over-age" forest, but presently, old growth is to be conserved. So, an owner seeing large environmental values on his land does not go for regeneration, but makes instead repeated thinnings, which require no notification to the Forest Agency. In the end, the stand cannot be thinned more without another clause coming into force, 'too low stocking', but during a prolonged transition time, possible many decades, the owner can keep out the intrusive Agency forester.

Case 3: Early 20th century Finland (cf. Siiskonen 2007)

Finland accepted a corresponding legislation on private forestry in 1917 (updated in 1928), but where Sweden chose a (too?) soft way of implementing the ambitions of 'scientific forestry', Finland chose to challenge the prevailing perceptions of the predominant owner group, family farmers with associated forest. Several cases were taken to court. These owners saw the forest as a bank account to be used only for investments or as a safeguard against failing crops. The inherited wisdom told them that hard times could return any time; the stocking of the forestland should be as high as possible, implying a high portion of old age classes. This contrasted sharply with the 'new' concepts of sustainable timber supply and the associated ideal of an even age class distribution. As a result, numerous cases of recalcitrant farmers were brought to court for refusing to accept the legal vision of proper management.

Case 4: Present day Argentina (cf. Nylund and Gowda 2009)

Argentina has currently revised its legislation regarding the natural forest (Law 26.331, 2007). The guiding principle is the preservation of remaining forest, including biomes of very high conservation value, such as the Andine cloud forest (*yunga*) and the mixed *Austrocedrus-Nothofagus* forest along the Patagonian Cordillera. The forest (not the forest land!) is divided into three categories:

1. Full protection, no human activity permitted. The owner is invited to apply for compensation, but over two years since passing the law, the administration and the funding are still not set up. From the owner's point of view, the forest has no economic value whatsoever.

2. Sustainably managed forest. The owner should prepare a detailed management plan and apply for compensation for losses caused by restriction on his free use, but no framework for plans exists yet, nor even documented knowledge how to use these forests sustainably. Future land value can presently not be determined.

3. Forest of low value possible to convert to more profitable uses (farming, animal husbandry). The owner should present a conversion plan comparing the economic return of the alternative uses, and show how the timber would be disposed of. Deforestation is thus encouraged.

The law is a clear improvement of traditional legislation in large parts of South America, where land titles could be won through deforestation of 'public' natural forest. Yet, even now, and assuming that yet to be implemented arrangements will become functional, the law reduces the value of owning forest compared to other uses. Wildfires, natural or not, can easily destroy *Austrocedrus* forest classified for protection, after which cattle ranching would be permitted.

Analysis: Lessons learned?

We will examine the four cases using the criteria of Gunningham et al. (1998), and other the above stated assumption of users making rational choices – based on their own rationality.

Case 1 can serve as a model for much well-meant green policy making today. The goals – if we look away from the historical setting – protection of common good, sustainable use of valuable trees, protection of threatened species. Yet, from the view of the rural population, the logic is perverse. They have no incentive at all to comply with the law. Not only that, they see the law as a step towards further encroachment on their age-old land use rights: next time, the mines and iron works may forbid them all access to the forest to safeguard the supply of charcoal and firewood. The equity criterion is clearly not served: the villagers pay the bill, the Crown and the ironworks reap the benefit. The policy was only partly effective: the Crown got its ship timber, but forest devastation went on unchecked. Efficiency was definitely bad: for 150 years, a totally corrupt forest authority was maintained to no real benefit for anybody. Only total deregulation in 1783 brought an end to a situation which could not deteriorate further. As for stakeholder participation, the Crown and mining industry had had their voice heard; there is no research showing how the Estate of Peasants in the Parliament had argued during the preparation of the 1647 bill (The peasants never lost their political freedom in Sweden-Finland, Norway and Iceland). There is no way proposing a policy which would have worked better, given the times, but parallels to modern well meant legislation with little chance to succeed are obvious.

Case 2 provides a less clear lesson. From the forest owners' view, the main issue at stake is fairness in the application of the law. Even if the national policy has been elaborated in relative political unanimity, there are special cases where large parts of small private properties would be put under compulsory protection. A farmer whose family has been using the forest for generations suddenly finds its property rights set aside. Furthermore, there have been a number of cases where the owner for a long time has promoted environmental values, for example actively creating old stands dominated by oak and other hardwoods, only to see them expropriated for total protection. Again, the equity perspective dominates: the policies should not hurt some much harder than others. From an effect point of view, on the other hand, the evasion by the owners is not very negative: Old forest generally is in short supply in the southern part of the country, and the key biotopes are not clear cut, which would be the normal procedure on such fertile sites. The only damage is a deviation from standard management prescriptions. However, this type of conservation conflicts are quite common and may foster a negative attitude which in the long time will be negative, as owners will avoid creating or even erode possible key biotopes and other desirable features. The example calls for policies where the land owner's role in the management is more active but also the need for flexibility in relation to the owners needs is recognised. Current schemes for voluntary conservation in both Sweden and Finland seem to be encouraging.

Case 3 is dealing with conflicts between management objectives, and in a way the reverse of Case 2: the farmers want to be conservative in their management, the professionals to change the whole way of looking at the forest as an asset to be actively managed. Seen from the professional's point of view, the deal offered the farmer-landowner was certainly fair: continuous and even growing income from the forest. The long term development proved the policy to be effective and efficient; Finland and Sweden have been very successful introducing the principles of 'scientific forest management' and will continue to increase both potential cut and stand stock from today's already high level. But why then a conflict? The farmers behaved in an economically rational way, but out of their own rationality, not that of the professionals or greater society. With centuries of war, crop failures and starvation in memory, the farmer's rationale was security, not income maximization. To that came a 'social rationality'. In local society, logging, except for household or investment needs, was seen as a sign of insolvency. A farmer converting his forest into clearcuts was suspected of profligacy. It took two generations of patient extension work, and a societal change from subsistence to cash economy, for farmer-owners to accept the 'new rationality'.

In **case 4**, we in a way return to the situation in case1, but even more perverse. Firstly, the forest owner has the option of alternative land uses with better rewards under alternative 3, encouraging deforestation of all land not earmarked for conservation or sustainable management. By linking the protection to the forest, not to the land, 'calamities' destroying the conservation value of the stands to be protected offer an escape route to conversion into other land uses. But furthermore, by not having the administrative and financial arrangements in place when the law comes into force, the owner of land classified for protection or sustainable management finds a dead hand over his land, providing further incentives for destroying the values the law was meant to protect.

Conclusions

In line with our argumentation in Nylund and Gowda (2009), the lawmaker is frequently blinded by his own objectives or tied up by political compromises necessary to get the particular legislation approved, and tends to ignore the reality and concrete interests of those stakeholders on whom the success of the reform depends, in our case small family forest owners, which in Sweden and Finland account for over half of the land area and even more of the logging volume. The voice of these people may not be strong enough to make other participants in the policy making process attend to them, or the consequences may not be obvious before the regulation is in place. However, without ensuring fairness as seen from their horizon, their active support of the actual policy will not be obtained, and the intended target group behaviour, the goal of most forestry and environmental legislation (Stjernquist 1973), will not be reached. This obliges the principal institutional actors – politicians, professionals, pressure groups) to out of their way and even compromise high principles, to ensure that the policy in its totality offers advantages to the forest owners.

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A SIMPLE METHOD TO FORECAST THE TIMBER FOREST PRODUCTS IN THE MEDITERRANEAN EUROPEAN COUNTRIES USING SOCIOECONOMIC FACTORS

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Abstract

Main objective of this research is the study of the wood market and the wood products for the four Mediterranean member states of the European Union (Greece, Italy, France and Spain) and how the multiple regression could estimate the relationship between production, imports, exports and consumption for each wood product for every country, with explanatory demographical and economical variables and the time periods. The econometric research became using linear regression. The use of these simple models could be a useful tool in the hands of policy makers to take critical decisions about the future of the Mediterranean European timber market and how this market could strengthen the domestic economies generally.

Key words: wood products, European Mediterranean wood market, forest sector, timber production, forecasts.

Introduction

The forecasts contribute in the recognition of problems that examine the timber as natural resource and in the adoption of suitable policy and more specifically the suitable programs of development that will contribute in the concretization of desirable objectives. (Adams et al. 1978) The models of forecast in the forest sector are many and they can be separated in various types with various criteria (Narbuurs and Paivinen 1996). Wide (2005) used a simple model of simulation for the forest sector. He claimed that the main advantages of use of this model are the usage of fundamental economic theory but also that this model is ready to be used simulating various scripts. It is so adaptable that could give simple and possible answers in what will happen in the production, consumption and trade if we have changes in offer and demand. The imported data that author used is 1) the observed quantities of production and consumption in each region. 2) the observed prices of products in each region 3) the observed elasticities of offer and demand in each region. Many others models were used in time for predictions in forest sector us G.T.M. (Global Trade Model) (Kallio et al. 1987), T.S.M. (Timber Supply Model) (Sedjo and Lyon 1996), C.G.T.M. (Cintrafor Global Trade Model) (Cardellichio et al. 1990), A.T.L.A.S. (Aggregated Timber Supply System) (Mills and Kincaid 1992), H.O.P.S.Y. (Hinssen 1994), N.A.P.A.P. (North American Pulp and Paper model) (Zhang et al. 1993). The aim of this study was to investigate how the multiple regression could estimate the relationship between production, imports, exports and consumption for each wood product for every European Mediterranean country, with explanatory demographical and economical variables such as population, GDP, Consumer's Price Index, Industrial Production Index and also the time periods. As results we get the simple / multiple linear regression analysis, and the respective predictive ability tests. The major product categories, witch have been examined, are roundwood for coniferous and non coniferous trees, sawwood for coniferous and non coniferous trees, wood panels, wood pulp and paper – paper board.

Material and Methods

As region of research in the present paper were received the four European countries of Mediterranean basin, Greece, France, Italy and Spain. The data sets, that were used, are derived from Food and Agriculture Organization's announcements and the analysis was based on annual values from F.A.O. for the period 1972–2002 (FAO 1986, FAO 1993, FAO 1994, FAO 1998). The data for the independent variables (Population, Gross Domestic Product and Industrial Production Index were received from UNECE (Eurostat 2005), (UNECE 2005) and Eurostat databases and the Consumer Price Index from the International Labor Organization database (ILO 2005).

All the above mentioned products are converted to round wood equivalent units with the usage of coefficients that were taken from FAO, in order to compare with each other. In particular, the research focused on the investigation of the supply, the demand and trade for wood and wood products for each member state. The individual categories as mechanical, semi-chemical and chemical woodpulp after they were first converted in cubic meters (cum), are summed and gave the total of equivalent round timber for the woodpulp. The same procedure followed for the all categories that they had subcategories. At analysis were used linear models applying simple and multiple linear regression. The models that were used have the general form $Y = b_0 + b_1 x_1 + b_2 x_2 + + b_3 x_3 + \ldots\ldots + b_n x_n$. (1)

The method of simple and multiple linear regression used with scope to calculated the value of a variable (dependent) from two or more independent (explanatory) variables via the data with linear relation from each other. The main reason for which was used the linear regression method is because it is the simplest and the most practical. The models that have been used occasionally and are reported extensively above (T.A.A.M., C.G.T.M, G.F.S.M., G.F.P.M. and other) are very specialized and they require a big number of data. The advantages of these models are certain that they give detail reports for the market and also for the exterior factors that influence the market. Although they need a lot of information and data to import. At the same time it is obvious the need of existence of more practical alternative solution (Wide 2005). The multiple regression is a general and flexible method of analysis of data that can be used when the made dependent variable is studied as operation of independent variables but also when is studied the relation from each other (Cohen and Cohen 1983). The method of multiple linear regression contributes biggest in the manufacture of predictable models (Draper and Smith 1981). Existed also cases of products in which the linear regression did not give reliable results. After the calculation of the equation, became the following tests which certify the correctness of process. Thus in the tables following are given the basic statistical tests of regression. Adjusted R^2 (R^2_{adj}), SEE (Standard Error of Estimate), P Value ($P>0.05$) is the probability of being wrong in concluding that there is a true association between the variables and V.I.F. (Variance inflation factor). One simple and important diagnostic of multicollinearity is the Variance inflation factor (Matis 2004). When the value of V.I.F is bigger than 10 there are redundant variables in the regression model and the parameter estimates may not be reliable.

Results and Discussion

The econometric models that were calculated for the production, consumption and trade for the Mediterranean European countries for the products that are examined are given above and is observed good adaptation of models in the data.

For Greece (Table 1) the R^2_{adj} oscillates from 0.66 to 0.86 statistically important with P Value smaller the 0.05 ($P<0.05$) for all variables, while the

Table 1. Econometric models for coniferous and non coniferous wood and wood products for Greece.

GREECE	R^2adj	SEE	P Constant	P Year	P GDP	VIF
Conifers Roundwood Production = -657,815.7 + (340.9 * year)	0.74	1,911.33	<0.001	<0.001		
Wood Panels Imports = -42,879.2 + (21.6 * year) + (43.2 * GDP)	0.66	135.431	<0.001	<0.001	<0.001	$V.I.F._1 = V.I.F._2 = 1.23$
Wood Panels Consumption = -61,078.7 + (33.371 * GDP) + (31.09 * year)	0.86	112.279	<0.001	<0.001	0.029	$V.I.F._1 = V.I.F._2 = 1.23$
Paper-Paperboard Imports = -102,775.7 + (52.09 * year) + (76.6 * GDP)	0.76	258.335	<0.001	<0.001	<0.001	$V.I.F._1 = V.I.F._2 = 1.23$
Paper-Paperboard Consumption = -147,764.211 + (75.335 * year)	0.82	336.198	<0.001	<0.001		

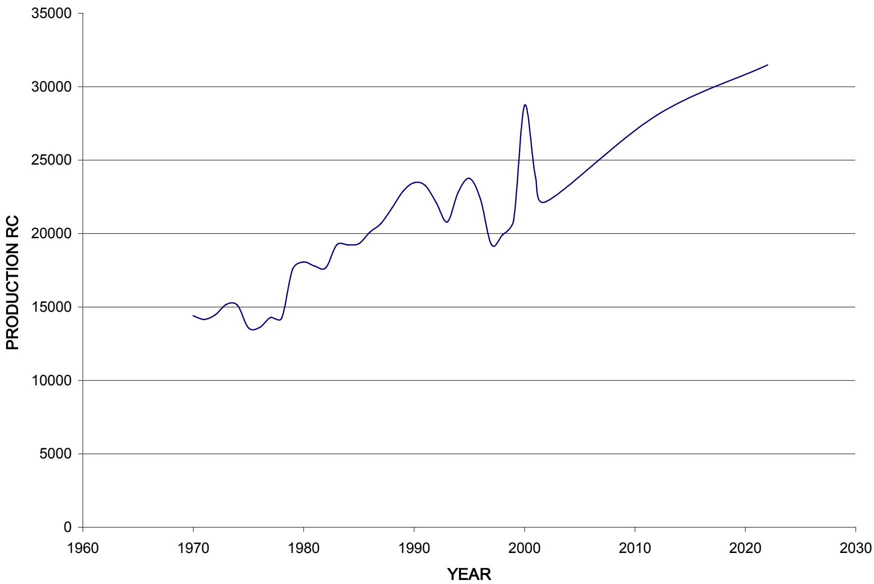

Fig. 1. Conifers roundwood production trend for Greece.

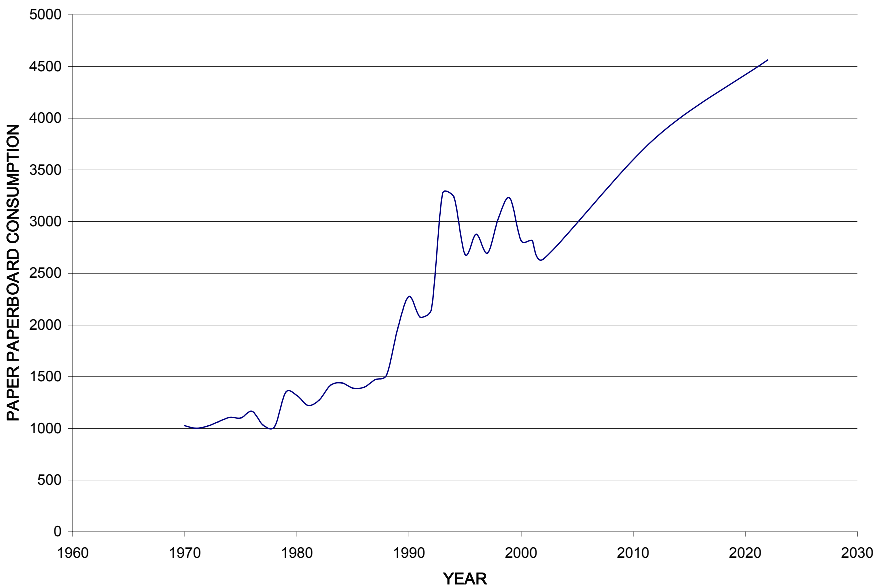

Fig. 2. Paper-paperboard consumption trend for Greece.

standard error of estimate for each equation is considered acceptable. By the five (5) equations that are presented in this paper two (2) of them were calculated with the method of simple linear regression and three (3) with multiple linear regression. The indicator V.I.F. is acceptable. So the prediction for these products remain easy and not complex as if we predict the GDP for the next years we ll be able to predict the conifers roundwood production, the imports of panels and the imports and consumption of the paper. The usage of forecasting model in a productively pure county like Greece, accommodate the work of recipients of decisions to specify the imports policy in the sector of timber, procedure very

Table 2. Econometric models for coniferous and non coniferous wood and wood products for Italy.

ITALY	R^2adj	SEE	P Constant	P Year	P GDP	P IndP	P Pop	P ConPI	VIF
Conifers Sawnwood Exports = -4,935.2 + (2.5 * year)	0.52	22.897	<0.001	<0.001					
Non Conifers Sawnwood Production = 18,688.9 - (0.2* population)	0.53	286.936	<0.001				<0.001		
Non Conifers Sawnwood Imports = -118,794.9 + (60.9 * year)	0.72	364.175	<0.001	<0.001					
Wood Panels Production = -326,372.1 + (167.1* year)	0.72	1002.622	<0.001	<0.001					
Wood Panels Exports = -86,461.570 + (43.9 * year)	0.7	272.353	<0.001	<0.001					
Wood Panels Consumption = -412,367.9+ (210.8* year)	0.79	1,039.515	<0.001	<0.001					
Wood Pulp Production = 86,612.2 - (42.7 * year) + (23.8 * ind production)	0.83	1,89.697	<0.001	<0.001		0.006			V.I.F.1 = V.I.F.2 = = 1.01
Paper-Paperboard Imports = -865.3 + (88.8 * consumer price)	0.92	1212.556	<0.001	0.039				<0.001	
Paper-Paperboard Exports = -32,3504.102 + (164.435 * year)	0.84	735.773	<0.001	<0.001					

Table 3. Econometric models for coniferous and non coniferous wood and wood products for France.

FRANCE	R^2adj	SEE	P Constant	P Year	P InP	P Pop	P ConPI	P GDP	VIF
Conifers Sawnwood Consumption = -53,672.16 + (11.114 * Population)	0.61	958.107	<0.001			<0.001			
Non Conifers Sawnwood Production = 58,310.2 – (28.9 * year) – (25.1 * GDP)	0.72	127.309	<0.001	<0.001				0.020	V.I.F.1 = V.I.F.2 = = 3.16
Wood Panels Imports = -6,935.569 + (0.140 * Population)	0.81	279.444	<0.001			<0.001			
Wood Panels Consumption = -6,035.026 + (0.131 * Population)	0.70	353.230	<0.001			<0.001			
Paper-Paperboard Imports = -23,990.478 + (0.472 * Population)	0.68	953.630	<0.001			<0.001			
Paper-Paperboard Consumption = -21,999.684 + (0.444 * Population)	0.62	920.790	<0.001			<0.001			

needful for the country. Some possible forecasts display in Figures 1, 2. The results for Italy, France and Spain presented in the tables 2, 3, 4 and could be analyzed with the same procedure.

The number of equations that is given per country varies because all examined depended variables did not give acceptable results. From all examined variables that are not presented they are those in which the models were not adapted as should in the data. (Not acceptable $R_{adjusted}$).

Table 4. Econometric models for coniferous and non coniferous wood and wood products for Spain.

SPAIN	R^2adj	SEE	P Constant	P GDP	P Year	P ConPI	P Inp	VIF
Conifers Sawnwood Consumption = 3,068.19 + (25.57 * consumer price)	0.46	1306.932	<0.001		<0.001			
Wood Panels Production = -31,7517.330 + (161.667 * year) + (59.703 * ind production)	0.80	739.434	<0.001		<0.001		0.049	$V.I.F._1$ = V.I.F.2 = = 1.06
Wood Panels Exports = -104,727.614 + (53.092 * year)	0.63	393.517	<0.001		<0.001			
Wood pulp Production = -323,036.669 + (165.608 * year)	0.92	515.477	<0.001		<0.001			
Paper Paperboard Production = -495,453.45 + (253.90 * year)	0.91	759.743	<0.001		<0.001			

Conclusions

Forecasts in the forest sector remain significant tools for the sustainable management of domestic forest ecosystems but also for the configuration of national forest policy and economy generally. In the Mediterranean countries the usage of socioeconomics factors and the regression method attributed and the equations that were constructed can be used widely for forecasting process. Also it's important to say that the explanatory variables that were used in the above forecasting method are not unique. It's obvious, that with the usage of more explanatory socioeconomic variables or with the usage of non linear simple or multiple models the predictions could be more. (for more wood product categories). More generally we can conclude that because of that weak economic growth is still hurting European economies and the forest sector demand and forecasts for the current and next years entail many uncertainties, the use of socioeconomic explanatory variables for the construction of simple or multiple linear regression forecasting models with the cautious examination of the trends for each product over the years, remains efficient in the forest sector of Mediterranean countries, strengthening the economic growth with right decisions and choices.

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MODELLING OF THE VARIABLE LOADS OF THE WORK OF THE CLASS WIND TURBINES

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Abstract

This paper investigates some possibilities for suitable modeling of variable external loads in a regime of exploitation of a kind of wind turbines. On the base of the developed original model of wind turbines it is possible to study dynamical processes in different specific work regimes of this kind of wind turbines. This model allows to examine the behavior of the system in extraordinary situations and different work regimes and to define some recommendations for more effective work of that kind of wind turbines.

Key words: effectiveness, multibody dynamics, wind turbines.

Introduction

One of the important problems in development of wind turbines is provision of high effectiveness in different work regimes. The necessary safety and ecology in work must be provided. The analysis of modern technical decisions concerning these problems points the main tendencies in development of these machines. Higher towers which provide the necessary height of the rotor for better speed of the wind are used in current constructions. It is necessary to use rotors with blades that have bigger dimensions. Except these advantages, the wind turbines have also some disadvantages. For example, there are problems with appearance of extra loads in the construction. These loads require extra limits in their designing, manufacturing, installation and exploitation. To satisfy the requirements, modern options for modeling of dynamic processes in the machines.

The increase in the rotor size and hence the turbine size leads to a complicated design of a drive train in the wind turbine besides higher requirements of turbine reliability. Design calculations for wind turbine base on simulation of mechanical loads on the turbine components caused by external forces. The external forces are the wind, the electricity grid and sea waves for offshore applications (Hansen 2001). The various simulation techniques are used to analyze the loads on internal components of drive trains. The first approach is the multibody system formulation and it is typically used for the simulation of wind turbine dy-

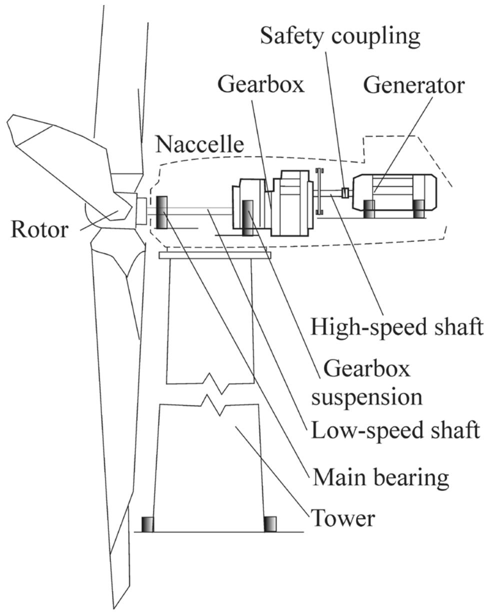

Fig. 1. Schematic sketch of wind turbine.

namics. All drive train components are treated as rigid bodies with maximally 6 DOF's corresponding to 3 translational and 3 rotational motions. Each body has mass and inertia properties, but cannot deform. The joints between the bodies represent the flexibility in the system. This approach yields a set of ordinary differential equations. The second approach is the finite element modeling techniques. Finite element models are used for internal analysis of the individual components. These models add a possibility of calculating stress and deformation in the drive train components continuously during the time. This approach yields a set of partial differential equations. Each addition to the model leads to additional information about dynamics of the drive train but makes the modeling and the simulation more complicated.

Dynamical Model

An original dynamical model of a wind turbine drive train is developed (Vukov 2009, Todorov and Vukov 2007, 2009a). It includes all parameters of a wind turbine drive train – the designer's, the inertia's, the mass`s. It includes also the contact forces between gear pairs, bearing and shaft stiffness, gearbox suspension flexibility and flexibility of safety coupling between the gearbox and the generator. The most wind turbine components are considered with 6 degrees of freedom.

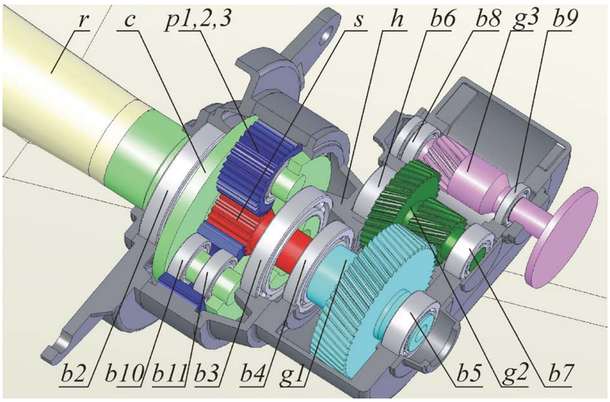

Fig. 2. Sketch of gearbox.

r – rotor, *c* – carrier, *p1÷3* – planets, *s* – sun, *g1÷3* – gears, *b2÷11* – bearings, *h* – hull

The schematic sketch of a wind turbine is shown in Fig. 1. The wind turbine consists of

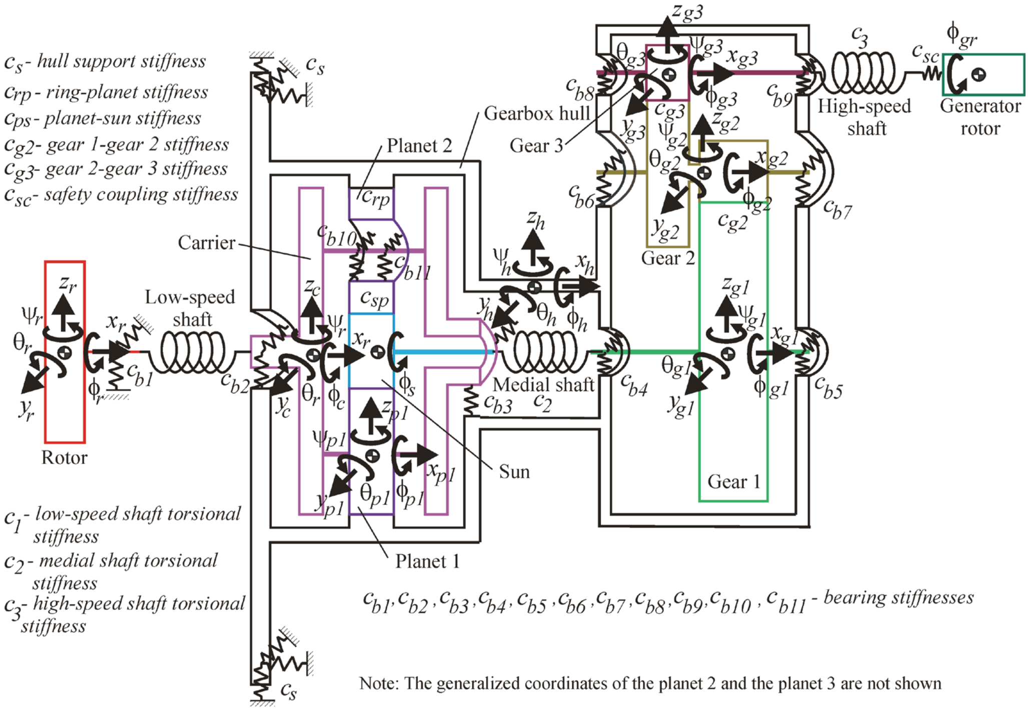

Fig. 3. Wind turbine dynamic model.

a rotor with three blades, a low-speed shaft, a gearbox, a high-speed shaft, a safety coupling and a generator.

The gearbox`s sketch is shown in Fig. 2. The gearbox has three stages. It consists of a low-speed planetary gear stage (three identical planets with spur teeth, a sun and a fixed ring wheel) and two high-speed stages (helical gear pairs).

The dynamical model of the wind turbine is shown in Fig. 3. The model has 11 bodies and 53 DOF's.

The gear contact forces between wheels are modeled by linear spring acting in the plane of action along the contact line (normal to the tooth surface) (Brandlein 1999, Shabana 2005). The stiffness gear is defined as the normal distributed tooth force in the normal plane causing the deformation of one or more engaging tooth pairs, over a distance of 1 μm, normal to the envolvent profile in the normal plane. This deformation results from the bending of the teeth in contact between the two gear wheels, of which one is fixed and the other is loaded. Damping and friction forces are not included. These assumptions are valid for heavily to moderately loaded gears (Thomsen et al. 2003).

The bearings are modeled as springs. The bearing stiffness depends on the number of rollers in contact, which can vary according to the applied load. The relation between bearing deflection and the applied load is nonlinear. Burton et al. (2001) describes the bearings properties in more details.

The stiffness of the low-speed, the medial and the high-speed shafts and the safety coupling are presented as torsional springs.

Results and Discussions

Lagrange's equations are used to describe the movement of the obtained complicated dynamical system. In this case Lagrange's equations of motion are written as

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}}\right)-\frac{\partial T}{\partial q}=-\frac{\partial L}{\partial q}-\frac{\partial F}{\partial \dot{q}}+Q\,,$$

where: q is the generalized coordinates, T and L are respectively the kinetic and the potential energy of the multibody systems, Q is the vector of the generalized external forces, F is the vector of the dissipative functions.

The expressions of the kinetic and the potential energy, of the generalized external forces and the dissipative functions are composed and determined in (Vukov and Bonova 2009, Todorov and Vukov 2009b, Todorov et al. 2007). Using these methods, the system of parametric differential equations describing the vibrations of the wind turbine can be obtained.

The linear parametric differential equations which are used to describe the behavior of the investigated system are

$$A(\omega t)\ddot{q}+\omega B(\omega t)\dot{q}+\left[C_m(\omega t)+C_\omega(\omega t)\right]q=Q(\omega t)$$

where: A is the inertia matrix, C_m is the mesh stiffness matrix, B is the gyroscopic matrix, C_ω is centripetal stiffness matrix, ω is the rotational speed of the rotor. The matrices A, C_m and C_ω are symmetric and B is skew-symmetric. Q is the vector of external loads.

This model allows creating of some variable loads on the system with the vector of the external loads Q depending from the work regimes.

The developed model of this kind of wind turbines can be used to study some dynamical processes in different specific work regimes of the same kind of wind turbines. Different extreme situations and unusual work regimes are modeled by using suitable formation of the vector of external loads. The vector of external loads allows investigating the influence of some typical groups of unchangeable loads.

I. Variable loads on the rotor caused by wind. Some regimes in variable windy conditions and high turbulence are modeled. The most favourable impact of the wind is accounted by 3D analysis of the wind for a definite zone. It is composed the function Q, which describes its characteristics. Thus in this dynamical model and composed equations is included the impact of the unchangeable loads from the wind on the rotor. Consequently it is possible to investigate the dynamical processes and the behavior of the wind turbine during such unfavorable conditions.

II. Variable loads caused by starting and stopping of the rotor. In fact starting and stopping of the rotor are unestablished regimes. These regimes, especially accidental stopping, cause extra dynamical loads in the whole construction. They can be accounted by introduction of the function Q, which depends on the mass, inertia and elastic characteristics of the construction.

III. Variable loads caused by passing through resonance regimes and working nearby these regimes. The passing through resonance regimes cannot be avoided during the exploitation of the wind turbine. Except starting and stopping of the rotor, the sudden change of the strength and direction of the wind can be a typical example for that. The offered model can help to definite and investigate the resonance regimes in advance. Then it can be possible to model the behavior of the system in different speed of passing through these regimes. The function Q which gives extra dynamical loads in these regimes is introduced.

IV. Variable loads from the generator. It is necessary to investigate the dynamical characteristic of the generator to obtain these loads. The influence of this dynamical characteristic on the behavior of the wind turbine is accounted by introducing of the relevant function Q.

Conclusion

The developed model of wind turbines can help to investigate dynamical processes in different specific work regimes of this kind of wind turbines. Suitable modeling of variable external loads gives some possibilities to investigate the behavior of the system in extraordinary situations and different work regimes. In this way it is possible to define some recommendations for more effective work of that kind of wind turbines.

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THE INFLUENCE OF THE HEAVY METALS ON THE GROWTH OF PATHOGENIC FUNGI

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Abstract

The reaction of the isolates of the pathogenic species *Fusarium oxysporum* Schlecht. and *Pythium debaryanum* (R. Hesse) Nieuwl. to the presence of zinc, copper, lead and cadmium, which were added to the nutritive medium for the determination of their *in vitro* tolerance, measured by the inhibition of the growth of mycelium were studied. The experiments were performed in the laboratory conditions by adding the suspension of the zinc, copper, lead, and cadmium in three different concentrations on the nutritive medium. The influence of the heavy metals on the growth rate of the pathogenic fungi depended on the type of metal and their concentration. The lowest degree of influence was exhibited by the presence of zinc, whereas the highest concentration of cadmium exhibited the highest degree of influence. *Fusarium oxysporum*, the mycelium of which grew considerably slowly in the presence of all metals, exhibited the lowest degree of tolerance to heavy metals, whereas even the lowest concentrations of *Pythium debaryanum* are tolerant to the presence of all metals, even in case of the highest concentrations.

Key words: pathogenic fungi, nutritiv medium, tolerance to heavy metals, the growth of mycelium.

Introduction

The different metals are essentials to the biological activity. Nevertheless, in spite of being toxic or not, all metals can exibit toxicity at different levels. Heavy metals are toxic to all organisms when higher concentrations of them is present in the soil (Arnebrant 1987). The influence of them is unfavourable also to the microorganizms and microbial processes. The influence on the microbial processes in the soil is reflected by the influences on the discomposition of litter, enzyme activity and growth of plants (Whipps 2000), whereas it influences the fungal population by changing the number, composition and diversity of microorganisms (Rudawska 2000). The soil influences the presence of the fungi by its physical and chemical charcteristics (Carter 1987) and, mainly by the increased concentrations of heavy metals which can be present separately (Puhe 2003) or in a combination of several of them (Kieliszewska-Rokicka et al. 2000).

However, the interaction between the heavy metals and pathogenic fun-gi is conditioned by many factors, the most significant one being the degree of tolerance of the fungi and their possibility of absorption of the metal suspensions. Nevertheless, under the influence of the adverse environmental effects the different types of the fungi became able to survive in the unfavourable conditions in the forms of scleroses, chlamydospores, or other (Agrios 1997).

The tolerance of some species of fungi to the presence of heavy metals is conditioned by the peculiarities of some species (Van West et al. 2003). It is necessary to be familiar with these peculiarities so that some species can be recommended as very favourable fungus for the future use of these fungi as the bioremediator in the polluted soils, or as the bioindicator (Khan et al. 2000).

Material and Method

The conditions for the growth of pure cultures – Laboratory studies were conducted in the laboratory of Institute of Forestry in Belgrade. The pure cultures of isolates were preserved on the nutritive medium at 23 ± 1 °C in the dark.

The preparation of the media with the heavy metals – lead, copper, zinc or cadmium in the concentrations 0, 3, 33 and 100 ppm were prepared of the zinc, copper and cadmium added as sulphates ($ZnSO_4 \cdot 7H_2O$, $CuSO_4 \cdot 5H_2O$, $CdSO_4 \cdot 8H_2O$) and lead in the form of $Pb(NO_3)_2$, since the sulphate of lead is heavily soluble compound (Dunabeitia et al. 2004). The suspensions of these heavy metals were autoclaved separately in the glass dishes and upon autoclaving, when the temperature decreased at 50 °C, they were combined with MEA medium (malt-extract agar, nutritive media which contained 20 g of malt (Sigma-Aldrich, USA) and 20 g of agar (Torlak, Belgrade, Serbia) in Petri dishes. Each Petri dishes contained the nutritive medium and suspensions of heavy metals in the concentrations 3, 33 and 100 ppm.

Inoculation of the prepared medium – When all media were poured, the fragments of fungi were sowed. The fragments (~1 cm) are extracted from the rubs of the colonies of fungus cultures with the sterile knife and used as inoculums in the experimental conditions. All concentrations were set in five repetitions. Petri dishes with the sowed fragments were put in the thermostat at the optimal temperature in the dark.

Measuring of the growth of mycelium – The radial growth of mycelium was monitored by the measurement of two cross-sectional diameters, and the obtained values were compared with the growth on the standard MEA medium. The initial diameter (~1 cm) was subtracted from the subsequent measurements.

Statistical analysis – All the experiments are set in five repetitions (4 colony radius values in each one). The average values and average errors were determined, whereas the statistically significant differences among the variances were determined by the analysis of variance (ANOVA) using SAS v.9.1.3., and averages were compared using Tukey test ($P<0.05$).

Results

The average daily growth of the fungi on the control medium ranged from 4.67 mm.day^{-1} (*P. debaryanum*) to 10.5 mm/day (*F. oxysporum*). The presence of heavy metals influenced the change growth rate of both fungi, depending on the type of metals and their concentration. The effects of heavy metals on the growth of the fungus species in the pure cultures are presented in the fig. 1–4.

Tolerance to the presence of zinc

Both of fungi that were studied exhibited significant tolerance to the presence of zinc in all concentrations (Fig. 1). The rate of growth of *P. debaryanum* in all concentrations is balanced with the growth on the control medium. This metal influenced the growth of *F. oxysporum* by decelerating the rate of growth in comparison with the control medium, but it depends on the concentration of it.

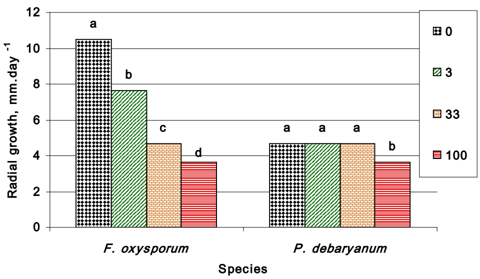

Fig. 1. The rate of growth of mycelium of the pathogenic fungi on MEA medium with the different concentration of zinc in the medium.
For each fungus values fallowed by the same letter are not significantly different ($P<0.05$).

Tolerance to the presence of copper

The copper influenced the studied species of fungi in a different way (Fig. 2). The lowest concentrations stimulated the growth of the species *F. oxysporum* and *P. debaryanum*, whereas the highest concentrations caused the significantly slower growth ($P<0.05$).

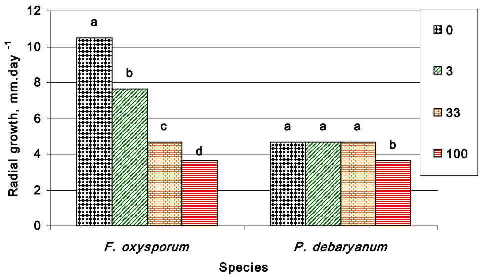

Fig. 2. The rate of growth of mycelium of pathogenic fungi on MEA with different concentrations of copper in the medium.
For each fungus values fallowed by the same letter are not significantly different ($P<0.05$).

Tolerance to the presence of lead

The lead influenced the growth of *F. oxysporum* by decelerating the rate of growth in comparison with the control medium, but it depends on the concentration of it. The rate of growth of *P. debaryanum* in highest concentrations is balanced with the growth on the control medium, and the smallest concentration of this metal stimulated the growth (Fig. 3).

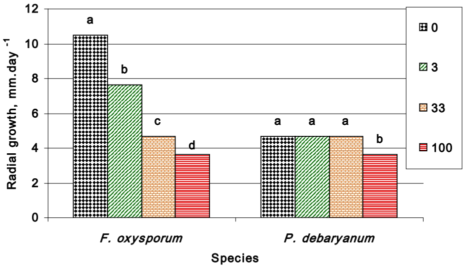

Fig. 3. The growth rate of mycelium of pathogenic fungi on MEA medium with the different concentrations of lead in the medium.
For each fungus values fallowed by the same letter are not significantly different (P<0.05).

Tolerance to the presence of cadmium

The fungi exhbited the lowest degree of tolerance to cadmium, since the presence of it caused the total inhibition of growth of *F. oxysporum* in the highest concetration. The lowest concentrations stimulated the growth of the species *P. debaryanum*, whereas the highest concentrations caused the significantly slower growth (Fig. 4).

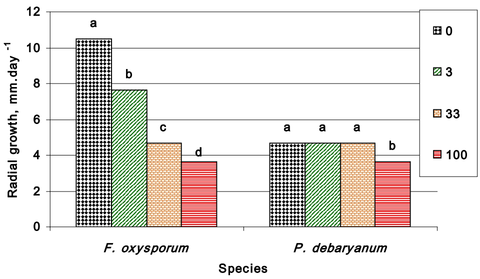

Fig. 4. The rate of growth of mycelium of mycorrhizal fungi on MEA medium with the different concentrations of cadmium in the medium.
For each fungus values fallowed by the same letter are not significantly different (P<0.05).

Discussion

In our experiment the average daily growth of both fungi with the presence of the heavy metals altered, which depended upon the type of metal and concentration of it. The most adverse effect was exhibited by cadmium in the concentration 100 ppm.

On the media with the other metals the growth of mycelium of both species of fungi was reported in the lowest concentration, and even the stimulating influence on some species of fungi was observed. The stimulating influence of lead on the growth of *P. debaryanum*, was reported. The presence of all metals in the concentration 33 ppm enabled the growth of fungi. The fungi exhibited the least tolerance to the presence of metals in the highest concentration 100 ppm. The most adverse effect was exhibited by cadmium in this concentration, since the growth of mycelia of fungi *F. oxysporum* is inhibited. Similar results were obtained in the researches conducted by Mittra et al. (2004) and Rai et al. (1995). These scientists studied the influence of lead, copper, zinc and cadmium in the media on the growth of *F. oxysporum*, and the greatest influence on the inhibition of growth was exhibited by cadmium, whereas the least influence was exhibited by zinc. In contrast to these results, Babich and Stotzky (1977) showed in their study of the influence of cadmium on the mycelium *F. oxysporum* that it was tolerant to the presence of cadmium, stating that the positive molecular cell reaction in the exposure to the heavy metals was influenced by the presence of enzymes (Antal et al. 2000, Edel et al. 2000).

Based on the results of our researches, *P. debaryanum* exhibited the highest degree of tolerance to the presence of the heavy metals, since this was the only species which grew on all metals and in all concentrations.

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LONG-TERM FORECASTING OF FOREST POLICY ALTERNATIVES

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Abstract

Forest policy making is a process, making compromises of conflicting interests and political ambitions. However, the outcome in terms of i.e. timber production tends to be a guesswork. In Sweden, forecasting tools based on national inventory data and detailed simulations make hundred-year forecasts of policy alternatives possible. A case is presented where the government's ambitious policy of fomenting wood production for sawmilling, pulpwood and biofuel is contrasted with an equally ambitious action proposal to reach general environmental objectives formulated by parliament. A realistic scenario to implement both policies proved to differ very little from the, by itself quite ambitious, business-as-usual scenario, but would have a notable impact on the forest landscape. Yet, the past 50 years' management sets a general trend of increasing potential cut and standing stock, regardless of policy alternative examined. The analysis underlines that policy needs a hard factual base but cannot be separated from political values. The role of changed perceptions of forestry in society is also discussed.

Key words: policy evaluation, harvesting opportunity forecast, national forestry plan.

Introduction

Policy decisions are a result of political processes, where both value-based arguments and material interests are taken into account. In forestry, a policy decision will have a material outcome in the form of timber production. Regional and national modelling can illustrate the consequences of policy alternatives – and may show ways how to balance seemingly opposed interests.

Sweden got its first modern forestry act and a forest agency structure to enforce the forest policy in 1903. Based on the gloomy picture of state of the nation's forest presented by the 2nd national inventory after 1950, the restoration of the forests started only after World War II, culminating in stringent demands on owners in legislation of 1979 and 1983. The policy was successful in terms of timber production. In 1950, the total felling was about 50 mi m^3; in 2007, 94 mi m^3 (Nylund 2009).

In 1993, a new act put environment and production on an equal footing, yet without defining environmental goals for forestry. Such goals were later formulated by the Forest Agency based on general environmental objectives formulated by Parliament, and much of the counselling of it's agents had greener management as a goal. The new policies are analysed in detail in Nylund (2010). For the next ten years, the Forest Agency made a determined effort to teach forest owners 'green management', and to expand the area of forest under various categories of protection, but a few years ago, it realised that more forceful policies were required if biodiversity and other targets were to be reached. The 1993 relaxation of coercive management policies had a base in the high level of allowable cutting, but ten years later, the rapidly growing use of biofuel and good prospects of the forest industry caused the government to present a new policy emphasising production, yet with good environmental standards and without reintroducing detailed management regulation.

The National Forest Inventory, operated by the Swedish University of Agricultural Sciences (SLU) in close cooperation with the Forest Agency, makes possible a continuous monitoring of the development of the forest resources, and provides a basis for long-term forecasting. The present report comments the results of the 2008 policy consequence analysis made by Swedish Forest Agency and the National Forest Inventory (Skogsstyrelsen 2008) and presents some questions on the further development, as several assumptions of the 20th century's policy seems to become outdated.

Methods

In a regular update of the 100-year timber production forecast, the Forest Agency and SLU's forecasting team modelled the consequences of four alternative policies (Skogsstyrelsen 2008):

Reference: Extrapolating today's actual management, assuming no dramatic change in forest owner or market behaviour. The policy implies a relatively high standard of "general environmental consideration" in management of production forest.

Environment: The Forest Agency's own estimate of the means necessary to reach the Parliament's general environmental objectives regarding forestlands. Most notably, the scenario sets aside 2 mi ha for strict protection and management primarily for environmental purposes. In the simulation, specific 'stands' were identified for protection on a national basis in line with general criteria.

Production: The 2008 policy decision to intensify timber production without compromising present environmental standards was translated into a number of simulated practices, such as fertilisation, genetic improvement, intensively managed plantations on abandoned farmland, etc.

A compromise, where 2 mi ha were brought under protection, but with intensified management was applied to the remaining production land necessary cutting in protected areas was taken into account.

The modelling was performed using the *"Hugin"* package, which treats every test plot in the national inventory as a stand, simulating its proper management in ten-year-iterations.

Results of the Consequence Analysis

Regardless of policy, both potential cut (Fig. 1) and standing stock (Fig. 2) will continue to increase, due to 60 years of improved silviculture. With 'business as usual', over the next 20 years potential cut will be marginally (3 mi m^3) higher than today. Under the 'Environment' scenario it will be reduced by 5 mi m^3.year^{-1} due to the transfer of old forest to reservations, while intensified management adds 2 mi m^3. After that, differences accelerate. In 100 years, potential cut will be over 50% higher under the reference scenario. Under the 'Environment' scenario, potential cut would be 10 mi m^3 less after 50 years and 15 mi m^3 after 100 years. Under the 'Production' scenario, it would increase by 15 and 20 mi m^3 after 50 and 100 years, respectively. In relation to today's level, 90 mi m^3, the gap between the minimum and maximum scenarios is striking; 35 mi m^3, after 100 years.

The potential cut under the 'compromise' alternative differs little from the 'Reference' or business as usual, but requires larger investments.

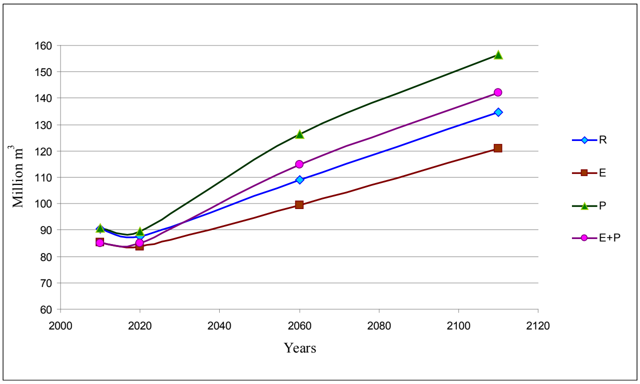

Fig. 1. Potential cut under four scenarios; million m^3, over 100 years.

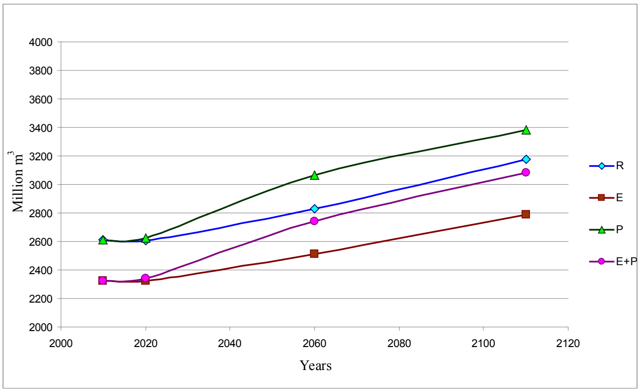

Fig. 2. Standing stock under four scenarios; million m^3, over 100 years.

R – Reference; E – Environment; P – Production; E+P – Environment and Production.

Discussion

Basic values, compromises and results

The environment scenario expresses values questioning the idea of maximising timber production in the country, and would result in some

10% of the area (including previously protected land) taken out of production-oriented management. Whether even this degree of protection would be enough to ensure the parliament's biodiversity goal cannot be said, but at least a price tag can be set in terms of 'lost' cubic meters of timber. Choosing this policy is clearly a matter of values, questioning the maximum-production philosophy.

The production scenario assumes, besides market opportunities and acceptable prices for a long time to come, that a reasonable level of environmental consideration can be maintained even under an intensified management regime. The promoters of such a policy are satisfied with today's environmental ambitions (which are quite ambitious when it comes to production forest), but also put a high value on increased raw material availability for forest and energy industries. They are also willing to pay a price right now in the form of making management more capital intensive.

While compromise has been a characteristic of Swedish forest policy in the past, the present compromise scenario brings up some consequences not enough discussed in the national discourse. It satisfies the conservationists' primary target of protected forest, but the intensified management of the remaining 90% of the land may lead to unacceptable sacrifices for biodiversity, recreation, visual landscape and reindeer herding. On the other hand, industrial and private owners have to work harder and spend more money, if they wish to keep production on more or less the same level as the business-as-usual scenario. How to strike a correct balance? Is the loss under the reference scenario larger than the combined gain through conservation and loss due to intensification? The compromise scenario seems to invite value conflicts both within and between stakeholder camps.

Assumptions and preconditions for future policy making

The recent state of the forests in the country, and thereby the reference scenario, reflects a relative political unity in forest policy over the last century, as well as some basic assumptions regarding markets and prices. Interestingly, that policy represent the visions of professional foresters all around Europe during the 19th century, which became viable due to the technical and economic development during the 20th. High, sustainable timber production for the forest industry has been the leading theme. Economic gain and other owner objectives have been secondary. The restoration of the nation's forest to full production capacity has been seen as a civic obligation. Setting aside forest for conservation purposes has been seen as a loss of potential income for the country. In contrast with densely populated Central Europe, there has been enough semi-natural forest for recreation purposes, and conflicts over forest land use have been few, and mostly limited to reindeer herding in the North. Yet, looking into the future, two changes in Nordic society challenge these assumptions.

Firstly, the Nordic forest industry is becoming transnational, and is rationalising its domestic production without regard to the interests of the home region or country. As a consequence, it can no longer be expected that forest owners or policy makers in general to will be willing to give top priority to raw material production for the industry, at the expense of other interests. The owners increasingly wish to act according to their own priorities, even if this does not mean maximum timber production, and a growing number do so; anyhow, for the majority of small-scale owners (50% of the forest area) forest income represents a minor part of the family budget (Ingemarson 2004).

Secondly, as management is intensified, the forest landscape is successively changing away from the semi-natural condition favoured for recreation, hunting, mushroom and berry collection, etc. The political support from a predominantly urban population for using most of the forestland primarily for timber production can be expected to wither.

Thus, it may prove that even the reference scenario builds on unrealistic assumptions regarding the management of 50% of the forestland. But, at least for the present rotation, the forecast shows that yield and stock will increase or at least not decline. If anything, the forecasts underline the long time perspective in cold and temperate region forestry. Hardly any news for the forestry professionals, but possibly more so for politicians with mandate periods of four-five years.

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INVESTMENT IN FORESTRY AND THE ROLE OF BANKS IN ITS ASSURANCE IN LATVIA

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Abstract

The role of investing for each country's welfare is obvious. The international capital may come into a country's economics through international investments, different funds, and also through banks. To enable forestry to progress successfully and be competitive, some regular and stable investments are needed for its development. For the banks in Latvia, forestry has not been the priority sector in recent years. Understanding the special role of bank loans in forestry, in November 2009, a social research was carried out on the basis of a questionnaire in order to understand the attitude of the Latvian banks towards the forest land as a loan. The research revealed the strong and the weak sides of forestry, as well as some possible opportunities and threats in Latvia from the point of view of the banks. The results of the survey showed that banks consider forestry to be a very risky sector and they do not plan to deal with it in the near future.

Key words: banks, investments, forest value, forestry.

Introduction

After the Latvian banking crisis in 1995, a stable and competitive financial market has developed in Latvia. According to the annual report of the Bank of Latvia (2009), until the end of 2008, 21 banks and six branches of foreign banks were registered in the Republic of Latvia.

In 2008, the global financial crisis led to a significant deterioration of the financing opportunities and conditions including for the Latvian banks, prompting them to tighten their lending standards. The decrease in the banks' solvency negatively influenced the entrepreneurs, limiting the external financial resources for them. The liquidity squeeze on the global financial markets, economic imbalances and economic downturn had a detrimental effect on the investors' confidence, which reduced loan refinancing opportunities for the Latvian banks and induced deposit outflows from those banks (Annual report of the Bank of Latvia 2009). As a consequence, the banks faced a significantly higher liquidity and financing risks. In 2009, no improvements could be observed in the banking sector because the banks "fixed" the losses by making reserves for doubtful projects and had strict credit terms and high interest rates. Currently, the banks are providing the loans for companies with a high export potential or with an effective internal market.

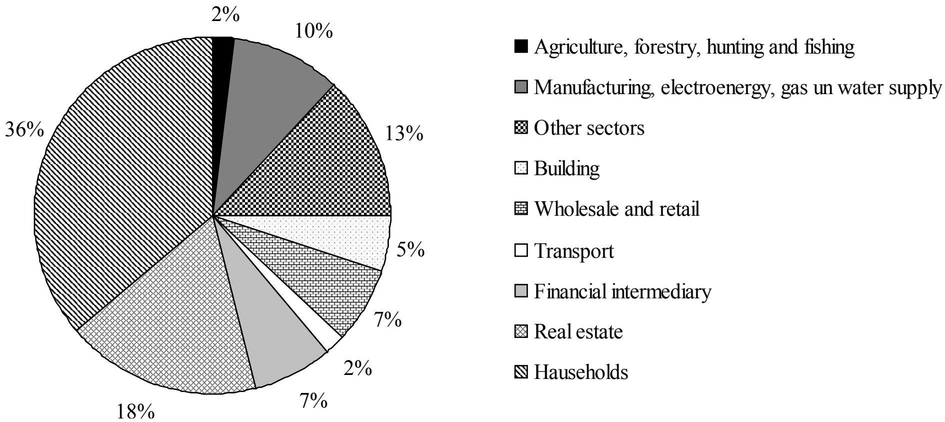

Fig. 1. Distribution of loans balance granted to residents of the Latvian commercial banks by economic sectors at the end of 2007 (Dubra 2009).

A very niggardly data is available about the amount and number of granted loans. Figure 1 shows that at the end of the year 2007, agriculture, forestry, hunting and fishing had made 2% of the total amount of granted loans. This suggests that crediting of these sectors is poorly developed and so far has not been a top priority for the Latvian banks.

In order to understand the attitude of banks towards forestry in general and forest land as a pledge, there was a need to conduct a survey of the Latvian banks.

Materials and Methods

For situation analysis, a social research methodology based on a thirteen-question survey was applied. Primary data was collected in November, 2009. The main objectives of the survey were: to clarify whether a forest is a sufficient loan for a bank; to determine why banks reluctantly take a growing forest as a pledge and to obtain information what conditions should be met in order to take a forest as a pledge.

Although the questionnaire was sent to 21 banks, in this research participated 15 banks. The answers of the banking survey reflect the assessment of the banks' leading specialists. Many banks which are niche banks with a specific activity, for example, a bank which has never issued credits in Latvia and is working with non-residents, mostly with corporate clients in Russia, refused to participate in the survey as they do not deal with forest crediting.

The collected data was counted and summarized in an EXCEL table. The scientific methods of induction and deduction were used.

Results and Discussion

To the first question whether a forest is sufficient as a pledge for the bank, the majority of the respondents answered – partly or only together with additional guarantees, 2 respondents considered a forest to be a sufficient pledge, but 2 respondents answered negatively. From the responses of the thirteen credit specialists a conclusion can be drawn that banks do not consider a growing forest to be a sufficient pledge. Such standpoint substantially hinders the Latvian forest owners from developing their own farms and entrepreneurships. In order to understand why banks are reluctant to take a growing forest as a pledge, several options were offered in the questionnaire. One third of the respondents checked off a number of variants. Overall, the impossibility of controlling the economic processes in the forest was mentioned as the main factor, risks associated with forestry – the second most important factor, whereas one third of the respondents considered that banking professionals are not enough qualified in forestry, but 3 respondents indicated that there are no professional forest appraisers. Banks consider a forest to be an asset which is difficult to realize and which requires specific knowledge.

According to the Daily Business newspaper, banks' position has not changed since the year 2006, forest is not sufficient as a pledge for a bank because the Latvian forest owners are working with mature stands (Ķirsons and Mārtiņa 2006). As to the financing coppices, the assessment of a forest creates a problem – many forest plots are being owned with different age structure, which, if selected for pledge, all should be appraised, but assessment costs are relatively high. At the same time, there are relatively few appraisers who would undertake to evaluate a forest stand, but the banks, for their part, lack expertise in checking the assessment. For the forest owners the incoming cash flow is often formed only from the sale of trees, and during the time the trees are growing there is practically no income, therefore it is impossible to pay even the interest payments.

The third question in the questionnaire was an open-search question (with no options for the answers) where respondents were asked to define the conditions which should be met so that a forest could be taken as a pledge. On the whole, five main requirements necessary for the banks could be distinguished: 1) experts are needed who can adequately evaluate a forest; 2) credit specialists should have an understanding and experience in forestry; 3) banks should understand the forest industry and its markets; 4) a control is necessary over the conservation of the forest stand value, 5) banks should comprehend risks and risk mitigation techniques. From the banks' point of view, the main problem is that a bank can not control the harvesting of a forest. Accordingly, there is a possibility that timber is harvested and sold, but the earned means are not shifted for repayment of the credit under the previously signed agreement.

The results of the responses to the fourth question demonstrate that the forestry industry is connected with a high risk: 10 banks indicated the risk was high, but 5 banks – the risk was average.

The task of the fifth question was to rank risks by their importance: mark the most significant risk as 1, and the least important – as 6. Disasters (forest fires, wind falls, etc.) were assessed as the most significant risk, fluctuations in timber price – the second most important risk, and inflation was considered as the least important risk. The following risks were ranged practically at the same level, with a two-vote difference: government decisions (prohibitions, tax increases, etc.), poor forest management, and insect and disease damage. The fact that disasters were placed first points out the banks' poor awareness of the forest risks in Latvia.

Seven banks out of 15 answered the question about forest appraisers in Latvia, saying that appraisers are "a small number and with doubtful evaluation methods", 4 banks answered that "there is no information that forests are being evaluated", one bank considered that "there is a sufficient number of appraisers and they are professional", but three banks marked off "other". On the whole, the survey suggests that banks have limited information about forest appraisers in Latvia; moreover, they are not regarded as competent in this field.

To the question how large amount of credit could be assigned against the forest assessment, one bank answered – not more than 10–20%, seven banks said – 50%, two banks – 60%, one bank – 70%, and also one bank – from 50 to 70%. The rest three banks did not give concrete answers. The responses show that 11 banks believe that the optimal forest estate crediting amount is 50–70%, but 47% of respondents estimate it at only 50%.

In assessing how large the discount rate should be in forest evaluation, 7 respondents considered that 10%, but 12% and more would be suitable for forest assets, which probably might be related to perceptions of high risks. Only 5 respondents would apply a 5–6% discount rate. Such a distribution of the respondents' replies is connected with the fact that, on one hand, the forest is considered to be a stable long-term investment, but, on the other hand, fluctuations in prices and unstable profit figures in forestry during the previous periods in Latvia make banks increase the discount rate.

Regarding the question about forest insurance, 8 banks or 53% of the total number of respondents were convinced they could do it, 4 banks answered it was not possible to do, but 3 respondents either lacked information on forest insurance or they were not informed about the terms of insurance. A conclusion can be drawn that the banking sector is not yet fully aware of such a service, which is logical if banks have not had some previous experience of forest crediting.

The next question was whether the banks have had granted money against a forest estate as a pledge. Nine banks said they have had done it, 4 banks have had not done it, 1 bank has had issued money only against the land, but 1 bank did not wish to disclose the information. Only 9 banks stated the amount of credit for forestry out of the total number of loans, which ranged within 1–3%. This confirms the credit amounts issued in the year 2007 (as illustrated in Figure 1), as well as the fact that banks are not yet ready to grant credits against forest estates in Latvia although more than half of the country's territory is covered with forests.

To the question whether the banks were planning to improve forest crediting, the majority of banks (12) or 80% answered with certainty that they did not intend to develop forest crediting in the near future. Only three banks were planning to develop it and deal with it; they confirmed they were currently improving competence in this sector.

In response to the twelfth question, what type of business is forestry in the bank's opinion, only 1 bank considered it to be an unprofitable business,

Table 1. Forestry SWOT from the point of view of the Latvian banks in 2009.

Strengths: - there will always be a demand for wood; prices might rise in the coming decades; - many educated professionals; - large areas of forests – Latvia's national treasure; - a developed industry; - a liquid asset; - a well-developed export of wood and its products; the industry plays an important role in balancing the country's trade balance and in developing the production; - favourable climate and geographical position (close to the realization markets); - a renewable resource; - the forest – a source of income, possesses a cyclical nature (sell, replant).	Weaknesses: - easily destroyable, subject to disasters; - poor forest management; - a lot of risks that cannot be operatively controlled; - changes in government decisions; - reduction of the valuable timber; - seasonality; - a relatively small part of the value added of the end-product is created in Latvia; - high dependence on the unfixed exchange rates in many export markets; - fluctuations in prices; - undeveloped long-term forest management culture; - fragmentation of forestries; - absence of strong forest co-operations; - slow turnover of money, which may take tens of years.
Opportunities: - the forest is "green gold" – the resource should be developed; - invest in forest areas in order to have a better assortment; - increase in timber prices in the market; - extensive use of wood; - biological growth of timber; - define a clear national policy for the forest sector and set it as a priority acquiring and producing industry; recovery of export markets; - positive decisions of the government, grants; - increase the value added acquired from forest products; - consolidation of the managed areas; - plenty of unused, cheap land and old traditions.	Threats: - harvested more than re-established; - global shocks and disasters; - increase of the performance of Russia's protectionist policy, which would increase foreign investing in industrial objects in Russia and would reduce the demand for/prices of Latvian timber; - weakness of the export market; - further adverse fluctuations in currency exchange rates in the export markets; - public policy and tax system – unfavourable for the sector; - fluctuating prices of logs (in comparison with Scandinavia); - growth of grey economy.

2 banks – a perspective business, but 1 bank said that forestry as a business should be further developed.

The banking specialists were also asked to point out weaknesses and strengths, as well as opportunities and threats in forestry; their answers are reflected in Table 1.

Most of the banks are looking favourably on the forest sector because it is export capable, has a significant base of local raw materials, and generally is put in order, but the sensitivity to economic cycles and the uncertainty of the state policy regarding the forestry sector are considered to be the main disadvantages.

The banks' monetary support is very important for the successful future development of a company. Therefore forestry associations, the Latvian government and the Ministry of Agriculture of Latvia should provide some greater support to forestry in order to make it more attractive for the Latvian banks.

Conclusion

Crediting the forest owners is poorly developed and so far has not been a priority for the Latvian banks. The banks' granted credit amount to forestry does not exceed 3% of the total amount of issued credits. Banks have an uncertain attitude towards a forest as a good pledge since they have not enough practice and there is a fear of risks. Banks consider forestry to be a very risky sector and they do not plan to deal with it in the near future. Reconciliation between the requirements of the banks and those of the forest owners should be continued thus stimulating the crediting of the forest owners.

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