FOREST MANAGEMENT IN TEMPERATE AND BOREAL FORESTS:

CURRENT PRACTICES AND THE SCOPE FOR IMPLEMENTING SUSTAINABLE FOREST MANAGEMENT

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FOREST MANAGEMENT IN TEMPERATE AND BOREAL FORESTS: CURRENT PRACTICES AND THE SCOPE FOR IMPLEMENTING SUSTAINABLE FOREST MANAGEMENT

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FOREWORD

The principle of sustained yield is a concept that has developed over many decades of forest management and research. Most foresters are familiar with this concept and many attempts have been made to devise systems of forest management that follow sustained yield principles. More recently however, a broader concept of sustainable forest management has been introduced into the national and international policy debate about how forests should be managed. In contrast to sustained yield, sustainable forest management considers the sustainability of production of a wider range of forest outputs, rather than concentrating on one or two products (usually timber and, occasionally, non-wood forest products). There is currently still little agreement as to what exactly constitutes sustainable forest management, or how it should be achieved, although most commentators would probably agree that only a small proportion of the world's forest estate is currently managed in a way that is broadly sustainable.

It is against this background, that this paper has been commissioned by FAO on behalf of the World Bank to review and summarise current experiences with attempts to manage forests sustainably. Due to the difficulty noted above, it concentrates largely on attempts to manage forests for sustainable wood production. The paper also only focuses on temperate and boreal forests. Another paper in this series discusses progress towards sustainable forest management in tropical countries.

The paper is in seven main sections. The first two sections describe the temperate and boreal forest and describe the forest practices that are currently employed there. The following two sections describe the challenges and opportunities to implement sustainable forest management in these forests and describe some of the experiences with different attempts that have already been made. Section five discusses the impacts on forests of events that occur outside the forestry sector and section six makes some recommendations about how sustainable forest management might develop in the future. This theme is further expanded in the final concluding section of the report.

This paper has been prepared by Stig Hagner, drawing on his experience of these issues in temperate and boreal forests and a review of published materials. An informal questionnaire was also used to solicit the views of some of the large forestry corporations in North America. FAO would like to express its gratitude to all the contributors to this study and to thank everyone that has provided comments on earlier drafts of this work. FAO will continue to explore, with member countries, the ways in which sustainable forest management can be implemented with greater success and to assist with implementation through its technical and normative work programmes. In this respect, we would welcome comments on all aspects of this study from readers.

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FOREWORD: BACKGROUND TO THIS REVIEW

This document is based on my experience of forestry operations in many countries on all continents. I have participated in and followed the development of the rational sustainable forest management concepts in use today in commercial forestry all over the world. I also have a long experience as a participant in the important and never-ending debate about environmental issues in forestry.

As part of the work, I have interviewed key people in several countries involved in the present decision-making process as regards sustainable forest management concepts and certification issues. A special questionnaire was also sent to important large forest owners or forest leaseholders in North America and elsewhere.

Due to time constraints, it has not been possible within this report to cover the whole area covered by temperate and boreal forests. This deficiency is most pronounced for parts of Asia.

Stig Hagner

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1 INTRODUCTION: A BRIEF DESCRIPTION OF TEMPERATE AND BOREAL FORESTS

This section presents a brief description of the location and main ecological characteristics of forest ecosystems found in the temperate and boreal regions.[1]

1.1 Temperate forests

Temperate forests extend from the tropics towards the poles, up until latitudes of around 50°. At lower latitudes, warm temperate forests are bounded by the continental steppes (in the Northern Hemisphere) or the subtropical forest zone. Temperate and warm temperate forests exist in both the Northern Hemisphere and the Southern Hemisphere, but there are no boreal forests in the Southern Hemisphere.

The climate of temperate forests is characterised by cold winters when it may snow (at higher latitudes) and mild and moist summers. Vegetative growth occurs for up to nine months each year in most parts of the zone.

Temperate forests often occur close to farmland and/or densely populated urban areas. Therefore, these forests are often utilised intensively as a source of recreation-related, non-forestry activities (e.g. hunting, fishing, picking mushrooms, picking fruits and berries etc.). However, temperate forests constitute an important source of industrial roundwood of the same magnitude as boreal forests. For example, the currently estimated total net increment in European temperate forests is in the order of 500 million m^3/year and the gross increment for temperate forests in North America is estimated to be in the order of 800 million m^3/year.

1.1.1 Characteristics of temperate forest ecosystems

The principal forest species groups in temperate forests include: pines; oaks; beeches; and eucalypti. In contrast to boreal forests, broadleaved trees - especially oaks - often play an important role in these forests. However, there is no general characterisation of the world's temperate forests. Indeed, the temperate forests of the world contain a great variety of ecotypes. There are humid rain forest types, e.g. along the American West Coast (where conifers dominate) and in the wet southernmost parts of South America (where these forests are characterised by the presence of broadleaved *notofagus* species). The original tree vegetation of the forests of the north-eastern United States of America, including the Appalachian Mountains, closely resemble those of central and south-eastern Europe. Here, an abundance of broadleaved species occur, including: oak; ash; beech; elm; and maple, and softwoods like: pine; spruce; fir; and larch.

Pines tend to dominate in areas where the climate is favourable for frequent forest fires, such as in the southern states of the United States of America. Here, the rejuvenation process is similar to that of the boreal forest. Without fire, oak species tend to dominate over time, being later replaced by even more shade tolerant species such as beech and maple if the absence of

[1] A forest ecosystem can be described as a biological community with interrelationships between the various trees and other organisms constituting the community and with interrelationships between these organisms and the physical environment in which they exist.

fire continues. But, even where broadleaved trees dominate the natural forest, softwoods that are more or less shade tolerant generally occur in mixtures with these. In such communities with trees of uneven ages the natural regeneration process takes place in an environment containing seedlings, younger trees as well a mature ones.

In the northern temperate forest zone, softwood and hardwood species have been successfully cultivated in pure even-aged stands as commercial tree crops over long periods of time. This type of "even age-class forestry", which has replaced both the original light demanding natural temperate forests as well as the uneven-aged mixed temperate forests, is widely practised at present all over both temperate forest zones.

1.2 Boreal forests

The boreal forest zone is the northernmost forest zone and forms a circumpolar belt of more or less closed forests growing in harsh climates between the latitudes 50° N to 70° N.

These forests play a very important role as a source of industrial roundwood to satisfy the world's demand for forest products. Widespread harvesting takes place in the Nordic countries, European parts of the Russian Federation, Siberia (including parts of China's Heilongjang Province) and Canada. The Alaskan boreal forests are only currently utilised for commercial forestry to a fairly small extent.

Some of the boreal forest may seem desolate but it is the home of many ethnic groups. Modern societies exist there, which share the environment with people for whom reindeer herding, hunting and fishing are of central importance for their livelihoods.

Under normal conditions, the total yearly harvest of industrial roundwood from boreal forests is around 500 million m^3. This corresponds to about 37 percent of global industrial roundwood production. In terms of coniferous (i.e. softwood) industrial roundwood production, 45 percent is harvested in boreal forests.

1.2.1 Characteristics of boreal forest ecosystems

Frost-hardy conifer species dominate in these forests, most typically: spruce; pine; larch; and fir. Broadleaved tree species, mainly poplars and birches, occur mixed with the conifers or occupying a few special sites. Of all the tree species, the spruces are the most widespread in distribution and the most characteristic of boreal forests.

During ice ages, boreal forests must retreat to more southerly latitudes. As a result of these disturbances, all organisms within boreal forest ecosystems are not only hardy enough to stand a harsh and cold climate, they have also developed an ability to migrate over vast distances. Another characteristic of boreal forests is the similarity between each other wherever they occur. The same types of trees, plants, mosses, lichens, mushrooms, fish and animals appear regardless of the continent on which they occur.

An adaptation to surviving catastrophic events is a typical feature of boreal forest ecosystems. Some catastrophic events are even important for the rejuvenation of most tree communities and the survival and health of many organisms. Due to frequent fires, the natural boreal forest

ecosystem usually consists of a patchwork of tree communities having been rejuvenated after forest fires or other catastrophic events on different occasions over time.

With a few exceptions, present-day boreal forests grow on land that was previously covered with ice. One characteristic of these glaciated soils is that, except in mountainous areas or along riverbeds, they are quite resistant to erosion. Therefore, they are not very sensitive to sudden changes in the forest cover; such as occurs during natural wild fires or forest harvesting.

Boreal forests have been successfully managed under sustainable yield systems for the longest time in Northern Europe.

In summary, the boreal forest is relatively tough and flexible ecosystem. Even if it is maltreated, for example during careless forest operations, in most cases it is likely that it will resume its original form and structure over time. However, the natural process of recovery may take a century or more.

2 FOREST MANAGEMENT, HARVESTING AND SILVICULTURE

This section describes the main characteristics of forest management, harvesting and silviculture in temperate and boreal forests, before describing some of the challenges they present for the implementation of sustainable forest management in temperate and boreal forests.

2.1 Current forest management practices in general

The management of temperate and boreal forests is both large-scale and small-scale. In the Northern Hemisphere there are more than 20 million small private forest owners, about equally divided between North America and Eurasia. In the temperate forest zones, large-scale private (corporate) forest operations are to be found mainly in the United States of America and in the Southern Hemisphere. The boreal forest is mostly owned by the state, except in the Nordic countries where small private and corporate forest owners dominate.

In European countries with many private forest owners, very strict forest legislation has often been established that requires management of their forests according to various sustainable yield principles. Legislation also usually demands environmental protection and nature conservation to various degrees. Most countries have government agencies with the task of advising private forest owners and ensuring that management is carried out in line with legislation. In North America private forest owners have much more freedom over how to manage their forests.

Modern management of larger forest holdings utilises forest inventories, maps, aerial photos, stand databases etc., as important tools for forest management and planning. Many managers have computerised systems that utilise very accurate satellite remote sensing systems to keep track of, for example, the geographical location of all individual forest stands, roads and ownership boundaries. In addition, detailed information about important forest characteristics such as: tree species composition; age; increment; quality and standing volume of wood, are available down to the forest stand level in may cases. At the national level, most forest-rich western countries conduct regular national forest inventories. These give information (with various degrees of accuracy) about important forest features, making it possible to follow and calculate, for example, changes in the national forest estate subdivided into regions and types of forest owners.

In Sweden, a very accurate National Forest Inventory has been carried out since the early 1920´s. It is based on a yearly field survey of sample plots spread out over a grid-system. This is probably the most accurate and detailed forest assessment in existence. It is based on statistical sampling and, thus, gives information with a known standard error. Larger forest-owning corporations also frequently use the same or similar methods. Less reliable but still useful information can be obtained from aerial photographs and satellite images. When supplemented with field surveys, the accuracy of such information can also be estimated. This type of assessment has been widely used in Canada and the former Soviet Union, where it is used to monitor vast inaccessible forest areas.

Apart from statistically based forest assessments such as these, the traditional way to assess forest resources in well organised forestry enterprises was to estimate data by utilising information from existing stand records covering the whole forest estate. This method may

work well if the information is accurate and fresh but, due to various types of bias and other problems, this method is often not very useful for the purposes of producing data covering larger forest areas.

2.2 Current harvesting and silvicultural practices in temperate forests

Most European temperate forests have been managed according to "classical" sustainable yield principles for a very long time. This is true even for countries in Eastern Europe that were formerly under the influence of the Soviet Union. In the west, especially in France, vast areas of deciduous forests have been cultivated on short rotations for the production of fuelwood under so-called "low forest" regimes. Many of these forests are now being converted back to high forest management.

In Britain and Ireland, considerable areas of forest plantations have been established utilising exotic trees, mainly: Sitka spruce; Norway spruce; Lodgepole pine; and Douglas fir. In Spain and Portugal, the same is true with Radiata pine and Eucalypti. All of these forest plantations are now yielding increasing quantities of industrial roundwood.

In Chile and New Zealand, considerable areas of natural temperate forests have been converted into forest plantations, which nowadays yield most of the industrial roundwood produced in these countries. Radiata pine and various Eucalypti are the most common species found in these countries. The further expansion of this very successful plantation forestry model, at the expense of the natural forest, has been limited by legislation in New Zealand and is, at present, under debate in Chile.

Because temperate forests vary a lot with respect to ownership, management history and management objectives, forest harvesting practices vary a lot too. In some places in Central Europe the hand axe and horse is still the most common means of harvesting and extraction. A few hundred kilometres further west, modern sophisticated processors and forwarders are doing the same kind of job. Differences such as these can also be found in North America.

In North America, industrial forest harvesting is mostly highly mechanised. Most operations are similar to those found in the boreal forests and are driven by concerns about profitability, cost efficiency, and operational control. Clearfelling is very common in harvesting operations in mature softwood stands. In sensitive areas, various types of selective harvesting systems are practised, both in coniferous and deciduous forests (except, until recently, in harvesting operations along the Pacific Coast). Harvesting is usually carried out by companies, contractors or small-scale loggers, regardless of the type of forest or forest ownership.

In Central Europe, clearfelling is usually restricted to a few hectares for various reasons (e.g. aesthetic, biological, risks of erosion, etc.). Instead, forests are (or should be) intensively thinned. Many Central European foresters prefer to use manual harvesting methods and/or light harvesting equipment that prevent soil damage. This is a difficult proposition when it comes to the handling of tall, heavy trees, which often grow in these forests. In comparison with forestry in the boreal zone, such considerations make these operations relatively more expensive.

The silvicultural practices used in temperate forest management are numerous and cannot be dealt with here in detail. Traditional labour intensive forest management techniques are still

commonly employed in much of Central Europe. These include such practices as numerous tending operations in young oak and beech stands and the simultaneous trimming of individual stems. Therefore, generally speaking, forest management costs tend to be very high, but the results are excellent. In other areas, reforestation after clearfelling is carried out in the same way as in boreal forests, utilising both natural and artificial regeneration. This is true for large parts of North America. However, one difference in North America is the intensive forest establishment methods used in the Yellow pine areas of the Southern United States of America, which include complete soil cultivation, bedding and planting.

Later stand management operations generally include frequent or occasional thinnings. Fertiliser is also often applied nowadays, especially in company owned pine plantations in the Southern States of America and in cultivated second-generation forests on the American West Coast.

In Central Europe one traditional school of forest management utilises a particular type of selective cutting - the “Plenterwald” (selection forestry) system. The concept of the Plenterwald system is to create, conserve and utilise mixed (often hardwood dominated) forest stands of uneven age, by harvesting single trees as they reach maturity. In addition, some trees of smaller sizes are harvested during these operations, to keep the composition and structure of the forests in a particular state in perpetuity. Technically, the system works well in forests containing shade tolerant tree species. It becomes more difficult to use, or even impossible, for light demanding species such as pine or larch.

The Plenterwald system has attracted the attention of today’s environmentalists who perceive this as a very eco-friendly forest management system and, therefore, biologically superior to even-aged forest management. This is probably true for some hardwood-dominated ecosystems, which also may include shade tolerant conifers, but the opposite is true in circumstances where light demanding tree species are growing. It is also regarded as an aesthetically more acceptable forest management system.

In Central Europe, there is a trend towards the greater use of the Plenterwald system, particularly in publicly owned forests. On the American West Coast, selection forestry systems have also been recommended by some forest ecologists as biologically suitable for the coastal “rainforest”.

2.3 Current harvesting and silvicultural practices in boreal forests

In boreal forests, roughly 75 percent of total annual removals of industrial roundwood come from large-scale final felling in natural forests situated on public land in the Russian Federation (about 50 percent) and Canada (about 25 percent). Here ”large-scale” means removals during clearfelling operations over areas that often cover 25 ha to 100 ha or more and yield tens of thousands of cubic meters of wood at a time. Most of the rest of the industrial roundwood harvest in the boreal forest zone takes place in the Nordic countries. Here, the large-scale forest industry operates in a similar way, although the forests being harvested in most cases are second-generation or third-generation forests rather than primary forests.

Generally, forest harvesting in boreal forests is characterised by large-scale harvesting operations. Consequently, harvesting operations in the boreal forest tend to utilise high levels

of mechanisation and, at least in western countries, these forests are largely harvested with the aim of maximising cost efficiency, operational control and profitability. Even in forests belonging to small private forest owners, which are mainly to be found in the Nordic countries and Eastern Canada, harvesting methods do not differ much, generally speaking, from those of the larger forestry operations. One reason for this is that small private forest owners often sell their wood standing to the industry, which then use their own equipment or contractors to harvest the timber. Another reason that mechanisation is so common, is that current harvesting machines are very flexible and can perform very well (i.e. they are very cost effective) even when they are harvesting small areas.

The reforestation methods used after clearfelling in boreal forests are more or less the same throughout the zone. Natural regeneration, either spontaneous or under seed-trees or shelter-wood, is widely used. Experience shows, however, that as management becomes more intensive (e.g. with the use of selected tree species with, maybe, genetically improved properties) planting or, in some cases, direct seeding of sites, becomes a more common way of reforesting clearfelled sites. It is also more common nowadays to precede replanting (and often also natural regeneration) with some type of soil treatment (e.g. scarification or controlled burning), which makes it easier for seedlings to establish themselves. In some areas however, shade tolerant fir trees regenerate in sufficient numbers without any special measures at all.

After some time, immature boreal forest stands are ready for pre-commercial thinning (or respacing), which is used to improve the structure and condition of the future forest stand. This labour-intensive but important investment for the future is difficult to mechanise and it is, therefore, tempting to postpone this operation until it is too late.

The next stage in the development of the forest crop is commercial thinning, which starts when the trees have become large enough to be utilised and stocking has reached a level where some of the growing stock can be removed. Thinning has been a common practice for many years in the Nordic countries, but is less common elsewhere in the boreal forest zone. Outside of the Nordic countries, the second-generation boreal forests have mostly either not yet reached the thinning stage or there is no market for the small diameter wood that such thinning would produce.

The application of fertiliser in boreal forest stands is used in the Nordic countries to boost tree growth in closed forest stands or to provide the basic essential nutrients on mineral-poor peat-land. However, fertiliser application in forest stands is less common elsewhere in the boreal forest zone.

Aerial spraying against insect pests is regarded as unavoidable in many areas of the boreal forest, in spite of the clear environmental impacts of such operations. An example is the large scale spraying against the spruce budworm in Eastern Canada and adjacent parts of the United States of America, which regularly takes place. In many areas, newly planted seedlings must also be treated with insecticides to prevent planting failure. The use of herbicides in the boreal forest is prohibited in some western countries but is permitted in others (with various restrictions on the use of such chemicals).

2.4 The challenge of sustainable forest management for forest managers: is it possible to manage temperate and boreal forests and keep reasonable levels of biodiversity?

It notable that in the boreal forest (and, to a lesser extent, the temperate forest) forest management and harvesting is important for the national economy and the livelihoods of many individuals. Many countries in the temperate and boreal forest zones are also where the greatest demand for forest products exists. Consequently, apart from a few remote forest areas in the boreal forest zone, most of these forests are intensively managed and used for the production of industrial roundwood. In a world with an increasing population and, consequently, increasing consumption of wood products, the important question is therefore: "how can these forests be managed even more effectively than today, in order to produce industrial roundwood for the benefit of mankind?" The challenge that forestry is currently facing is how to combine this task with demands to preserve a reasonable portion of unaffected forest ecosystems and demands to conserve biodiversity more widely. Policy-makers in different countries with temperate and boreal forest areas have, in the past, tended to take different positions on this issue.

Intensive forest management, which may include operations such as: site preparation; tree planting (including, sometimes, the use of genetically improved trees and/or exotic tree species); tending; thinning; and fertiliser application, is often criticised as being inconsistent with the goal of achieving an acceptable level of forest biodiversity. However, forest managers argue (and many scientists agree with this argument) that a reasonable level of biodiversity can be preserved even if a major portion of the forest is managed intensively as long as these forests are managed in a way that is reasonably environmentally friendly. For example, leaving a few snag trees, hollow trees and other dispersed trees that are ecologically important, can provide refuges for species to re-colonise forest areas that have been newly established after clearfelling. Furthermore, even under intensive forest management, some forest areas can be left untouched as reserves for biodiversity conservation. These areas should be selected so that they form a continuous web in the landscape and include ecotypes that are particularly valuable for conserving biodiversity. This relatively new management concept is sometimes called "landscape ecosystem management" or "landscape planning".

The landscape planning approach to forest management has been widely practised in Nordic countries, North America and elsewhere, for more than a decade now. It leads to higher silvicultural costs, but also to a high and predictable yield of industrial roundwood. Indeed the overall development of the whole managed forest area is reasonably well predictable with this approach. This is important when choosing an approach to sustainable forest management that is both realistic and viable.

Another approach to sustainable forest management in temperate and boreal forests is to practise low intensity forestry. This has lower reforestation and silvicultural costs than the landscape planning approach. It is often based on natural regeneration or some type of selective harvesting system and results in little interference with the natural development of the forest stand. Biologically, this approach may work well in stands that are easily regenerated or stands that contain trees that regenerate well. If well planned, this approach also has good prospects to satisfy nature conservation objectives and result in minimum damage to valuable ecosystems.

However, the long-term consequences of low intensity forest management, particularly concerning future yields of industrial roundwood and wood quality, are uncertain and difficult

to predict. The validity of this approach as a viable approach to sustainable forest management is, therefore, somewhat questionable. For example, experience from the widespread practice of selection forestry in the Nordic countries in the past, have shown that there is a risk that this approach may lead to slowly deteriorating forest conditions and a gradual loss of biodiversity. These effects have also been shown to worsen over time and may be difficult, or even impossible, to rectify once they have occurred.

With few exceptions, large-scale forest operations in western countries currently seem to favour the landscape planning approach to sustainable forest management, when they are managing their own forestlands. However, this is sometimes in contrast to the situation faced by forest leaseholders operating on public land. In Canada for instance, forest operations in the boreal forest must follow environmental prescriptions formulated by the landowners (i.e. the provincial governments). These may, in some cases, require forest managers to carry out silvicultural and harvesting operations that are similar to the low intensity management approach. In countries that still have large areas of untouched commercial forests, such as in Canada, the harvesting area could in theory be extended to compensate for the lower yields per hectare. This is of little comfort though to companies that have existing wood processing mills that have been located and depend on industrial roundwood production from currently leased forest areas.

If major forest owners have to start to cut back production due to stricter nature conservation policies (e.g. as has happened in the United States of America when the US Forest Service started to reduce harvesting on the national forest estate), wood shortages may lead to negative effects elsewhere. This may lead to greater pressure on other forest areas to produce industrial roundwood and the delicate balance between sustainable wood production and the conservation of nature may be upset elsewhere.

In Central Europe, the situation is somewhat different. The sudden appearance of sick or even dying forests during the 1970´s was soon linked to the enormous increase in fossil fuel burning over the last few decades in many of these countries and their neighbours. However, what also became obvious was that part of the problem was that planted forests that were poorly adapted to their locations suffered the most damage. The substantial forest dieback started a kind of “back to nature” movement within forestry circles in Central Europe, which demanded changes to forestry practices and, in extreme cases, changes in the whole composition of the forest estate. Consequently, in Central European publicly owned and managed forests, there is currently a major transition underway from classical even age-class forest management for commercial softwood production towards uneven-aged mixed hardwood forest management. The latter type of forestry is regarded as being more resistant to potential stress ands damage from air-pollution and, at the same time, more useful for meeting non-commercial objectives, which are considered important in these densely populated areas.

Many private forest owners’ organisations take a very critical attitude towards this change. They consider that it is unrealistic to expect that the transition can be implemented on a large-scale and are concerned about the economic effects such a change would have on their members if it were to be forced on them. They also claim that forest managers currently maintain a reasonable level of biodiversity with their present forestry practices. Even the forest products industry is concerned and fears that they will face a future drastic decline in wood supply and increased roundwood costs in the future if such practices become more common.

3 SOME TECHNICAL AND SILVICULTURAL CONSTRAINTS AND OPPORTUNITIES FOR SUSTAINABLE FOREST MANAGEMENT

This chapter deals with the technical, silvicultural and environmental issues that may constrain or otherwise affect the application of sustainable forest management principles in temperate and boreal forests. It is of course impossible to deal with all factors that affect the feasibility of implementing sustainable forest management. Included here are only some of the issues, particularly those that are considered to affect these forests universally.

3.1 Cold climates

The portion of forests that, due to cold climates, are growing close to the limit for their ability to survive, is greatest in the boreal forest zone. However, cold conditions also exist in all temperate and boreal forest areas at high altitudes and trees in such areas are also at the climatic limits beyond which they cannot survive.

It is tempting to harvest valuable timber in forests even where they are at their climatic limits. In Nordic countries, for example, harvesting frequently took place in such areas in the past. In such cases, the problem of managing forests in very cold climates, with a very short growing season, soon became apparent when forest managers tried to re-establish forests on these areas. In such areas, the trees natural ability to regenerate by self-seeding is very reduced, in fact close to zero. Natural processes had probably taken centuries to establish forest in these areas through natural regeneration. Under such conditions, these processes are difficult or even impossible to replace with artificial reforestation. In other words, planting is hazardous and unlikely to succeed. Therefore, timber harvesting in these areas should either be avoided altogether or should be carried out very carefully using a selective harvesting system.

3.2 Ground frost

The soils in the boreal and colder parts of the temperate forest zones are generally subject to ground frost during winters. In the far north the ground may be frozen permanently, allowing the trees to utilise only a shallow layer of soil which thaws during the summer.

Temporary ground frost conditions are ideal for harvesting during the cold part of the year as it increases the carrying capacity of the soils and results in little soil disturbance from harvesting operations as long as the ground is frozen. This is particularly important for harvesting operations in areas with clay or silty soils (these soil types are widespread in flat terrain in, for example, northern Russia and eastern and interior parts of Canada). On the other hand, when these soils thaw, they are easily damaged by forest harvesting equipment. The construction of permanent roads can also be problematic in these areas. Sustainable forest management in these areas therefore, requires that low intensity harvesting operations be used.

If soils with fine texture are exposed to frost after site preparation, they are easily subject to so-called “needle ice” formation during autumn and spring, when they contain a lot of moisture. Planted and even naturally established tree seedlings tend to be lifted out of the ground by the ice needles and killed when such conditions occur. Sites with these types of soil

conditions are often spread among more easily cultivated upland soils. They are often also sites of great value for biodiversity and are ideal for setting aside for nature conservation. If such sites are more widespread, a sustainable forest management approach would be to try to save the naturally established lower tree vegetation during harvesting operations, to form the next forest rotation.

3.3 Snow and wind

In areas with frequent occurrence of wet snowfall and/or high winds, the use of seed trees and shelterwoods to encourage natural regeneration may be limited, due to the risk of snow-break and windthrow of dispersed trees. On the other hand, using modern harvesting machinery, snow is seldom any hindrance in harvesting operations, except in very mountainous areas or under other extreme conditions. In areas with very steep terrain, as in the European Alps, clearcutting is prohibited or restricted to very small areas (one hectare or less), in zones where a closed forest cover is required as protection against snow avalanches.

High winds have been observed to cause more windthrow damage in recent years in Central Europe than in earlier years. This has been attributed to a higher frequency of severe storms. Another factor, which has often been overlooked, is that the affected forests have often been managed with the aim of producing old and more valuable trees. Consequently, the forests have grown increasingly taller and hence also increasingly more sensitive to windthrow.

3.4 Wet forest sites

Widespread occurrence of wetlands, in the form of treeless peat bogs and forests growing on wet and moist soils, is a typical feature of the boreal forest zone. Such areas are often also covered with a large number of streams and lakes. Even in the temperate zone, forests are frequently found on wet sites.

Wetlands and the areas adjoining wetlands are often areas of tremendous biodiversity. Sustainable forest management therefore requires careful consideration of the potentially negative environmental effects of timber harvesting on such sites. A widespread awareness of these concerns currently seems to exist within the forestry profession all over the world.

Where fragile wetlands occupy only a small or separate portion of the total forest area, it is advisable to leave such areas for nature conservation and concentrate commercial forestry activities on the more easily cultivated soils. This is reflected in most modern silvicultural prescriptions all over the world as well as in the main requirements for forest certification.

Traditionally in the past, wet forest areas have been drained to increase the growth potential of forest sites or to allow new forests to be planted. This was in the past important in the Nordic countries and the former Soviet Union. It has though, currently been more or less brought to a halt for the sake of nature conservation. For the same reason, the conversion to forest plantations of flatlands with high groundwater levels, has been restricted in the Southern United States of America.

In Finland, forest drains are however, still maintained over large areas of earlier drained forest sites, in order to take advantage of these investments. In Ireland and Scotland, vast areas of

peat covered land and even deep peat bogs have also been converted to forest plantations after draining them. Growing trees in such areas requires the repeated application of fertilisers in most cases. The growth results can be startling, but this kind of plantation forestry is meeting increasing criticism from environmentalists.

3.5 Harvesting practices

Currently, most forest harvesting is highly mechanised in temperate and boreal forests. The development of ground based machines (as opposed to cable extraction systems) is targeted at building lighter, more flexible machines, which have improved economic performance and cause as little damage to remaining trees and the forest floor as possible. Great improvements have already been made in this area. This is particularly important because the trend in most forest harvesting operations is towards continuous harvesting all year round.

For sustainable forest management, soil compaction and damage to tree roots and tree stems should be avoided as much as possible. Modern machines operating on unfrozen ground should have a low specific ground pressure, by using sufficiently wide rubber-tires or tracks that do not penetrate deep into the ground. On sensitive sites (e.g. silty, moist or wet sites) the machines movements should preferably be located parallel to skid-trails and roads and skid-trails should be reinforced with a layer of debris from harvested trees.

3.6 Site preparation on upland sites

Existing forest cover is often a hindrance to the establishment of tree seedlings. This is particularly the case in boreal forests, where a thick humus layer develops during the lifetime of the forest. On top of this layer germinating seedlings frequently die during drought spells. Seeds and small seedlings also fall victim to the many animals that dwell on the forest floor. Site preparation, using different types of cultivators or ploughs, has proved to be an important silvicultural measure in intensive forest management. This encourages a successful start to the regeneration process, regardless of whether planting, direct seeding or natural regeneration is used to establish the next crop.

Many cultivators only create parallel furrows or rows of patches in the otherwise unaffected forest floor. In cold climates so called “tilt-ploughing” and “mounding”, producing elevated planting spots, have proved to be very efficient measures that encourage good seedling survival and early growth. A special type of deep ploughing is sometimes carried out on sandy soils where a layer of so called “hardpan” has developed. Hardpan has to be broken up because it is a major hindrance for tree roots that prevents them from reaching deeper down in the ground to secure the water and nutrients that they need. In forest plantations it is often necessary to use a number of major site preparation operations in order to plant bare land.

Site preparation methods have been criticised as being too destructive and as causing unnecessary soil disturbance, erosion and even damaging archaeological monuments. The accusations are justified to some extent, at least in boreal forests, even though serious erosion has seldom been observed. In Sweden, for example, deep tilt ploughing has been banned, partly because of the effects it has on reindeer breeding. Forest managers worldwide should nowadays be quite cautious and selective in the choice of methods for site preparation and their application. On the other hand, it would be difficult for any intensive sustainable forest

management system to totally refrain from using at least some basic forest cultivation measures.

3.7 Forest fires

Under natural conditions, forest fires constitute the most important rejuvenating factor in boreal forest ecosystems and in many temperate forest ecosystems as well. Millions of hectares of forests still currently burn every year, mostly in the remote far North of the boreal forest zone. When forests are managed for wood production wildfires are of course seen as a great danger and an undesirable and expensive disturbance factor. Therefore, forest fire fighting has been an important forest management activity for decades. Today, most attention to forest fires is given in forest areas with pronounced spells of drought in the summer and in areas with old unmanaged forests that contain a lot of dry and inflammable wood. On the other hand, controlled burning is a tool that has long been used as part of some sustainable forest management systems, to promote forest rejuvenation and control unwanted ground and brush vegetation.

Sustainable forest management generally reduces fire events because it results in healthy green forests and reduces the presence of old stands with dying trees. Consequently, the absence of forest fires in some forest ecosystems has threatened the survival of some forest plant and animal species. In recent years however, as aspects of nature conservation have gained greater influence over commercial forest management, the appreciation of fire as a natural component of many forest ecosystems has started to attract due attention. In Nordic countries for instance, silvicultural prescriptions for large scale forestry operations nowadays require that a certain portion of the annual restocking area should be burnt, even if the controlled burning is not necessary (or is even inconvenient) from the operational point of view. In addition, but on a much more limited scale, fire may be used as a management tool in some stands with live trees.

3.8 Pest control

Outbreaks of insect attacks or fungus infections are a common problem in forestry worldwide. Typically, some of these outbreaks occur if and when trees are subject to stress for some reason (e.g. drought; frost damage; overstocking; lack of nutrients; etc.). There are also pests that start to become more of a problem as trees become very old. These act as a natural rejuvenating factor by killing or weakening trees and making them more susceptible to wildfires or to attack by other organisms.

Large areas of even-aged monocultures are particularly sensitive to such damages and experience shows that continuous pest control may be necessary in order to maintain forest health and vitality in forest plantations. For example, Radiata pine plantations in New Zealand and Chile are sensitive to Dothistroma needle blight during one stage of their development, but aerial spraying of a copper agent has proved effective at keeping this pest under control.

All over the temperate and boreal forest zone, the rule-of-thumb is that a green forest (i.e. one with relatively few dead and dying trees) is a healthy forest and will be most resistant to pests and diseases. Even so, pest outbreaks can not be avoided entirely, especially if the forest is under some type of stress. The general solution to this problem is therefore, to reduce

susceptibility by utilising a mixture of tree species that are appropriate for the site, to regularly tend the stands and thus avoid overstocking and, finally, to harvest the trees at an appropriate time (i.e. before they become susceptible to age related diseases).

Nowadays, the forest manager can also rely on some rather effective biological means of pest control, such as parasitic micro-organisms and pheromone traps, instead of using chemicals. However, in many cases, the application of chemicals to control pests can not be avoided. There is a noticeable trend though, towards the development of more biological means of control as an alternative to the greater use of chemicals.

3.9 Genetic improvement

Trees currently planted in forests, largely originate from seeds produced in seed orchards. Such new forests consequently consist of trees with properties that are genetically improved in terms of their yield and overall performance.

There is currently a major debate about this subject and it is sometimes claimed that the use of improved planting stock is irresponsible, because it changes the natural and/or original gene pool in managed forest areas and doesn't preserve natural variety. The alternative argument is that forestry serves two purposes: nature conservation and the production of wood raw material supplies for expanding forest products market and, consequently, the benefit of mankind. Another argument in favour of the use of genetically improved planting stock is that this has been done for centuries in agriculture without, until recently, questions about the appropriateness of crop breeding and improvement.

To compensate for intensive forest management, most countries are also currently actively trying to preserve biodiversity in a number of other ways, such as: utilising landscape planning techniques; encouraging the use of selective harvesting systems; protecting sensitive sites; and setting aside some forest areas as forest reservations.

3.10 Site impoverishment

Within the forest sector, there has been a long debate over many centuries about whether forest sites in temperate climates, with a long history of intensive cultivation (especially where monocultures are being grown), slowly loose their fertility. In particular, certain tree species, such as: spruces; pines; and eucalypti, have been accused as causing losses of site fertility over the long-term.

However, scientific studies, as well as practical experience, do not lend much support to this hypothesis. In Europe, for example, Norway spruce has been cultivated with startling results for two hundred years on sites that originally contained mixed deciduous forests. Some Radiata pine plantations in New Zealand are also now into their third rotation, without any measurable loss in site fertility.

Where site impoverishment is observed, it can usually be explained by other factors. A classic example in Europe, was the situation whereby farmers, in the past, tended to repeatedly collect the decomposing forest ground cover (i.e. the humus layer) in pine plantations. Because this ground cover provides the trees with many of their nutrients, this resulted in

slower tree growth over time. It seems highly likely that, at least in terms of sustained wood yield, there is little evidence that intensive sustainable forest management in temperate and boreal forests will not be sustainable in the long term due to a gradual loss of soil fertility.

3.11 Forest decline

The significant decline in forest health that became apparent during the 1970´s in Central Europe was identified as being related to the burning of fossil fuels in these and neighbouring countries. Further studies showed that the large areas of dying spruce forests in Central Europe were just the tip of an iceberg. Similar situations were discovered all over the world in densely populated and industrialised regions, wherever pollution from industry, cars and homes was significant and widespread. As a result, policies started to be introduced in many countries, to halt and decrease the amount of dangerous pollutants emitted into the atmosphere each year.

The concerns expressed at this time, that even larger forest areas were going to collapse and die in Europe, have not been fulfilled so far. In central and eastern Europe, parts of North America and elsewhere, trees in exposed areas and positions show clear signs of stress but, apart from this, most forests do not show any evidence of forest decline, even in areas that suffer from high levels of air pollution. However, the problem of forest decline is still present in many places even if trees are not dying in large numbers.

Eliminating the major causes of forest decline will take time, or may never be accomplished. In recognition of this, forest managers in the regions most affected have been forced to deal with both known and hypothetical effects of air pollution. A major problem however, is that there is very little knowledge or experience about how to best handle such situations. Some experts believe that conifers grown in even age class stands are especially sensitive to damage and decline from air pollution. They suggest that, at least in Central Europe, the forest should be gradually converted back to its original composition (i.e. mixtures, often dominated by broadleaved trees). However, even forests with their original composition are currently suffering from decline due to air pollution and stress, in particular, some of the most valuable climax trees (i.e. the oaks and beeches). Opposed to this view, is the view that such a change would have very little impact on forest decline. This view is supported very strongly by private forest owners that want to continue their commercial forestry operations. They reject any suggestion of drastic changes in overall forest species composition and highlight the enormous costs[2] and poor profitability that such a move would bring about, with little guarantee of the certainty of success from such a change.

A somewhat surprising fact is that, overall, the forests in Central Europe are now growing faster than ever before, despite the present problems with air pollution in some areas. The explanation for this is complex, but one reason is that air pollutants typically contain nitrogen that can act as a fertiliser. The soil conditions in many forests have also simultaneously deteriorated due to air pollution and have shown sharp decreases in pH-levels and losses of mineral nutrients. It is suggested that, to help maintain the long-term fertility of the soil in such areas, fertiliser should be applied to compensate for the loss of mineral nutrients through leaching and lime should be applied to improve soil pH.

[2] For example, it is estimated that it would cost about US$ 15,000/ha to create one hectare of oak plantation in place of a pine or spruce stand in Germany.

4 CURRENT EXPERIENCES WITH ATTEMPTS TO IMPLEMENT SUSTAINABLE FOREST MANAGEMENT

4.1 The Nordic countries

The Nordic countries generally have a longer history of boreal forest utilisation for industrial purposes than elsewhere. In these countries, the earlier old-growth forests have long since been replaced with managed forests that are now being harvested for the second or third time. These forests are managed according to the principle of sustainable yield; a principle that has been accepted in these countries for a long time. As a result of intensive forest management, the growing stock volume contained in these forests has increased by 23% during the past 40 years and increment has increased by as much as 36%. Consequently, sustainable harvesting levels have increased considerably in all the Nordic countries. These increases in forest stocking and growth are due to targeted improvement policies that have been worked out and guided by repeated forest assessments and long-term management programs both at the national and local level in private and public forests. Indeed, current long-term predictions for Sweden's boreal forest show that it may be possible to increase sustainable harvesting levels in the future by 55% over current levels.

Scientific studies of natural processes in boreal forests in the Nordic countries were started during the 1970´s and were partly financed by the forest industry. These resulted in a better understanding of the natural processes in the ecosystems. As a result, during the 1980´s, forest owners started to work out guidelines for combining nature conservation objectives in commercial forest management. For example, one large Swedish forest owning corporation - SCA - published a "Declaration on Nature Conservation" for their forest operations in 1987 (see Box 1). Other Swedish forest companies have started similar forest environmental protection programs.

Box 1: One example of a sustainable forest management initiative currently being promoted by private industry in Sweden

In 1987, a large Swedish forest owning corporation (SCA) published a "Declaration on Nature Conservation" for its forest operations. This was one of the first commitments made by a large forest owner to introduce a modern environmental vision as part of its commercial forestry strategy. The SCA document states that its forestry operations should be conducted in such a way as to:

- avoid permanent adverse effects on soil, surface water and ground water;
- preserve a rich variety of plant and animal life;
- protect all plant and animal species occurring in the part of the country where we operate (although we are aware that this objective cannot always be achieved, this is not an acceptable excuse for failing to pay attention to or take action that has a reasonable chance of succeeding);
- preserve the plants and animals now living in the area in the first instance, with reintroduction of vanished species to take second place; and
- give first priority to species that are unique, with second priority to other species that are locally rare but plentiful elsewhere.

The operational consequences of this commitment, including the reservation of production forest areas, leaving trees that could have been harvested and other measures, resulted in a 10 percent reduction in timber harvest at a cost of about US$ 10 million per year.

4.1.1 Forest Certification in the Nordic countries

During the 1990´s the question of forest certification became increasingly topical. Work on developing certification systems has been conducted separately in Finland and Sweden and has lead to different systems for forest certification in each of these countries. The main approaches to forest certification in each of these countries are briefly described below.

Finland. In Finland, forestry is to a large extent a small-scale or family-owned and managed activity. Small private forest owners, numbering around 440,000 in total, produce about 80% of total industrial roundwood used in Finland. In terms of forest ownership structure, 63% of forest properties are smaller than 20 ha.

In April 1997, a working group on certification standards, with a broad base of members representing many different stakeholders,[3] produced the National Criteria for Forest Certification in Finland. The main aim underlying a lot of this effort was the desire to improve the marketing of forest products from Finland, by identifying forests that are managed in an economically, ecologically, socially and culturally sound way.

The system, which is just starting operation in Finland, will be improved as new research results point to new ways in which the management and use of forest resources can be improved. The criteria used as part of the certification system will also be reappraised after five years and any necessary adjustments will be made if they meet with the consensus of all stakeholders.

Certification under this system in Finland is voluntary and forest owners can apply to be certified either individually or as part of a group of forest owners. A random selection of forest holdings will be inspected each year and the inspection process and inspection results will be available for verification by an independent third party. Thirty-seven criteria are listed under the process for group certification, which is the most comprehensive part of the system that has been developed.

Sweden. The Forest Stewardship Council (FSC) established an FSC certification working group in Sweden in 1996, with the purpose of producing a proposal for a Swedish FSC standard to be submitted to the FSC for approval. The participants in the working group represented commercial forestry interests, government forest authorities, research institutions and non-governmental organisations (NGOs). In 1988, consensus was reached on most issues and the working group presented the standard. This has since been adopted by most large Swedish forest landowners,[4] although smaller forest landowners have chosen not to participate in the system, for a variety of reasons (see below).

The Swedish FSC standard is, perhaps, the most restrictive of all of the certification systems in existence today. Fundamentally, it builds upon the prescriptions for nature conservation in commercial forestry that the large Swedish forest landowners and government forest agencies started to include in their operational manuals during the 1980´s. In the Swedish FSC standard, these prescriptions have been made a compulsory condition for certification. As a

[3] Representatives of 29 organizations representing different stakeholder interests collaborated in the working group and specialists in ecology and forest management from 8 universities and research institutes were consulted during the process.

[4] Large landowners covering about 50% of Sweden’s total forest area have adopted the standard.

result, the scope for implementing measures to increase forest yields and the options for forest utilisation are considerably reduced for any forest operator wishing to be certified.

It is also interesting to note that the aim of achieving high and sustainable levels of roundwood production is only cited in the last paragraph of these Standards (and is also played down in Swedish Forest Policy and its associated legislation). This contrasts markedly with the situation in Finland, where this is stated as a primary goal of sustainable forest management and the certification process.

The Swedish Federation of Forest Owners (*Skogsagarnas Riksförbund*) originally participated in negotiations about the Swedish FSC standard. However, they could not accept several aspects of the proposed certification system and have become one of the systems strongest critics. Some of their arguments against the current Swedish FSC standard are presented below.

- The Swedish FSC standard is not appropriate for all types of forest ownership, particularly small-scale and family run forestry operations, which are common throughout Europe and especially in the Nordic countries. The Federation argued that the certification of groups of small forest should be allowed, but this was not accepted during the negotiations.

- They argued that it is impossible, when dealing with thousands of small forest owners and the widespread trading of forest products, to demand that it must be possible to trace back to source of origin, the wood raw material used in a certain forest product.

- The forest owners were insistent that the certifying system should be internationally harmonised and that the rules must be more or less identical to the rules applied in other countries. They failed to reach agreement on this with the environmental groups.

- Generally speaking, the Swedish FSC standard demands enormous economic sacrifices for the private forest owner. According to calculations by the Federation, they estimated that about 14% of the productive forest area would have to be withdrawn from production to meet the requirements of nature conservation. In the south of Sweden the estimated figure is even higher (15-20%). They argued that there is no scientific proof that it is reasonable to reduce the potential production from the forest by this amount.

- The Federation also felt that the NGOs were only interested in trying to limit forest production.

The Federation also argued that, in reality, there should be greater utilisation of forest products in order to substitute for the use of other non-renewable materials like steel, aluminium, concrete and fossil fuels. They argued that a major environmental achievement would be to sustain high levels of biomass production from forests and that this would be a much more responsible way to utilise the nation's forest resources.

4.2 Central Europe

Forest inventories throughout Central Europe have shown that the forests there are steadily increasing both in terms of total growing stock volume and volume increment. In many countries, potential industrial roundwood supply (i.e. sustainable yield) is greater than current

demand from the forest products industry, partly due to limited demand for some sizes and species of trees.

The structure of forest ownership in Central Europe is similar to Finland, with many small or very small forest owners. It is estimated that there are about 12 million forest owners in Europe who own, on average, only 8.5 ha of forest each. In some countries, ownership is even more fragmented. In Germany, for example, the average size of privately owned forestland is estimated to be only 3.5 ha.

4.2.1 Sustainable forest management and forest certification in Central Europe

The basic principles underlying sustainable forest management in Europe, were set-out and agreed during the Helsinki Process (now also called the Pan-European Process) to establish criteria and indicators for sustainable forest management in Europe. According to the Helsinki Process, operational level guidelines for sustainable forest management should be looked upon as being in a state of continuous improvement. Nature conservation groups are encouraged to participate in this process of improvement and, hence, to influence the development of European criteria and indicators.

As noted above, there are a huge number of small private forest owners in Central Europe. This implies that any attempt to introduce a certification system in Central Europe should therefore, if it is to be realistic, consider certifying groups of owners at a regional level. Germany provides a good example of the development of certification in Central Europe.

In Germany, the German Forestry Council (*Deutsche Forstwirtschaftsrat*) has been involved in a dialog with partners from both industry and the NGOs at national and international levels. They hope to reach consensus about a workable certification mechanism around the end of 1998. They have stated that certification in Germany should be based along the following lines:

- the process should follow the Pan-European Criteria, Indicators and Operational Level Guidelines for sustainable forestry, formulated in Lisbon in June 1998 by the European forest ministers;

- in order to be credible, the certification system must cover broad regions, for example in Germany, they should cover a whole Bundesland;

- the system must be voluntary, with forest management units agreeing to participate in the system by making a commitment to follow the agreed rules; and

- independent auditors should be used to regularly check adherence to the rules of the system.

The German Forestry Council states that the overall principles guiding the sustainable management of forests in Germany must be based on German forest and environmental legislation. They consider this a fundamental aspect of the system that will eventually be developed. They also note that sustainable forest management means more than sustainable wood raw material supply and should also consider the importance of forests for soil, groundwater, climate, biodiversity and recreation services. However, the Council considers

the responsibility for the management of forests to meet economic objectives, to be completely in the hands of the forest owners.

The Council also stresses some other very important points, which they consider must be included in a certification system:

- the certification system must be voluntary for all participants and in no way interfere with ownership rights;
- the system must be transparent (i.e. easy to observe) and have credibility;
- all parties involved in the process, including the environmental groups, must accept the agreed standards;
- the certificate of sustainability must not be a certificate of origin and should be documented separately so that it does not restrict competition and the free transfer of goods and services;
- control within the system must be carried out by an independent third party;
- the process of developing a European certificate of sustainability has to be adapted to the specific conditions that are found in European forests while, at the same time, also be accepted in international markets; and
- the system should not involve any complicated red tape (e.g. associated with chain of custody monitoring), but rather the process should aim to offer the wood consumer a sustainably produced forest product rather than attempt to distinguish between every single product.

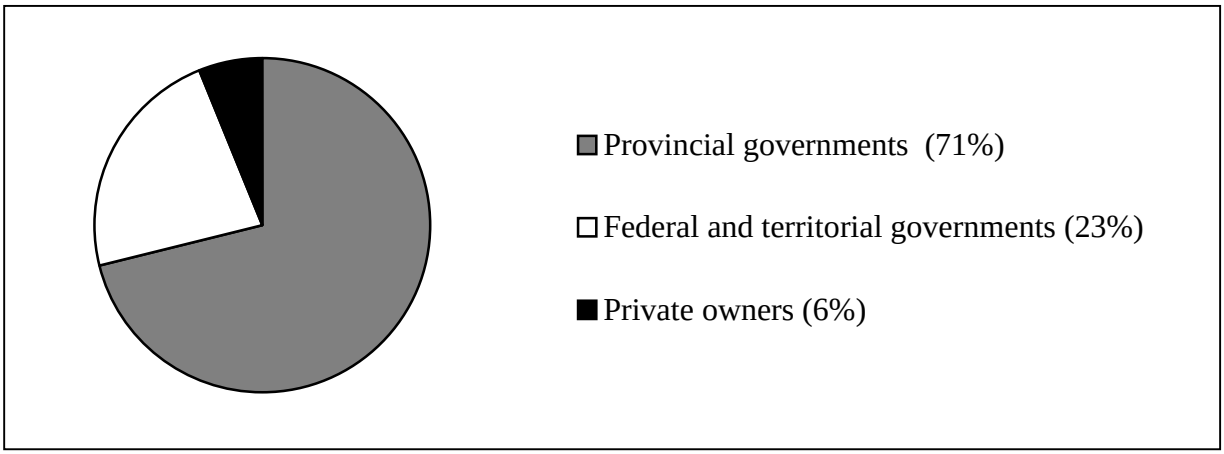
4.3 Canada

Canada has 417 million ha of forest, of which 220 million ha or more can be considered as commercially viable. About 117 million hectares of this commercial forest is in the boreal forest zone and the remainder is in the temperate forest zone. About 118 million ha, or just over half of the commercial area, is currently managed for timber production. Most forests in Canada are publicly owned (see Figure 1). Some 225,500 private forest owners own the relatively small proportion of the forest estate that is in private hands.

Until a few decades ago, forest harvesting in Canada was carried out with little regard to the concepts of long-term planning and future wood supply. Vast areas accumulated that had been previously harvested and were now in very poor condition.[5] Their poor condition was attributed to a lack of silviculture in the past or the use of ineffective silvicultural measures. More effective silviculture programs, aimed at securing forest regeneration and regrowth, now seem to be implemented almost everywhere. In 1996 for example, about 700 million tree seedlings were planted throughout Canada.

[5] Different estimates of this backlog have been made, suggesting that the area might have been around 15-20 million ha.

Figure 1: The current distribution of forest ownership in Canada



These reforestation programmes have yet to make an impact though and, because of the earlier lack of attention given to reforestation after harvesting, the Canadian forest industry (which largely operates in the boreal forest) must still mostly rely on wood from untouched natural forests to meet demands. In many regions this is likely to be the situation for a very long period of time but, in most provinces, there are still large new areas that can be utilised for industrial roundwood supply (as noted above). However, these areas are becoming increasingly remote. Furthermore, in some eastern provinces, the past lack of attention given to reforestation continued for so long that, given current levels of industrial roundwood demand, future wood supply problems are already foreseen. This situation will last until the recent improvements in reforestation have an impact on final felling volumes at the end of the next harvesting cycle.

4.3.1 Forest certification and sustainable forest management in Canada

In Canada, a group comprising many different stakeholders developed national standards for sustainable forest management during the 1990´s. The result of this was the Canadian Standards Association sustainable forest management system (CSA 808 and CSA 809). Any organisation seeking to register a defined forest area under this system must be periodically audited by certified third party auditors, who will assess whether:

- the sustainable forest management system in place in the forest has been established with public participation;
- the sustainable forest management system is being implemented according to the plan and the sustainable forest management objectives agreed for area;
- progress towards achieving the sustainable forest management objectives is being monitored and new knowledge is being used to continually improve the sustainable forest management system; and
- the sustainable forest management system is achieving any performance indicators that have been set for the defined area.

An example of one forest management system following this approach is given in Box 2.

Box 2: Extract from a "Forestry Green Balance Sheet" produced by STORA, Port Hawkesbury, Nova Scotia, Canada

This environmental policy states that, in maintaining an environmental management system, the company through its employees shall:

1. commit itself to a continuos improvement in forestry methods;
2. sustain the long-term production of valuable wood;
3. commit itself to pollution prevention, soil conservation and waste reduction;
4. utilise long-term landscape ecosystem planning, appropriate silviculture systems and operating practices that conserve biodiversity;
5. provide appropriate training to company employees and contractors in relevant environmental aspects of their work;
6. encourage private wood suppliers to comply with forest stewardship and the company's environmental standards;
7. develop and use emergency response plans for environmental emergencies;
8. meet or surpass the requirements of applicable regulations and legal obligations; and
9. regularly report on environmental performance and status to the public.

Management activities are based on the principle of landscape ecosystem management, appropriate silvicultural treatments and special conservation measures to protect wildlife habitat, social culture and scenic values. Depending on the different ecosystems present in the managed forest, the wood harvest is carried out in the form of:

1. partial cutting in birch and balsam fir forest;
2. clear cutting in fire adapted forests; and
3. thinning and partial cutting to regenerate red spruce ecosystems.

The management practices also consider nature conservation including forest stand level attributes, such as riparian buffers, wildlife corridors, residual tree clumps, coarse woody debris retention, correct forest road construction and careful stream crossing techniques. The nature conservation goal is to preserve the natural occurring plant and animal species in the forest landscapes. The approach is:

1. to maintain connectivity of ecosystems with a system of interconnecting corridors and regionally protected areas, at a landscape or eco-district level;
2. to provide a variety of habitats, forest age class, forest stand shapes and size classes;
3. to employ silviculture management systems that are appropriate considering the natural ecological development sequence of each site; and
4. to employ day to day management practices that protect ecosystem functions at the forest stand level.

Ecological landscape planning is carried out to maintain connectivity of ecosystems and provide a variety of landscape elements through:

1. assessing how the landscape currently functions with regard to matrix patches, corridors and pathways, unique habitats, protected areas and genetic flow;
2. describing the natural history of the landscape (natural disturbance, human agents, succession);
3. determining integrated management objectives based on landscape parameters, industrial interests, public interest and other demands from the forest and legislation; and
4. using discretion in the use of non-native tree species.

Every year a "Green Audit" is completed, which comprises a 5% random inventory of the current year's harvest areas. Department of Natural Resources employees (two forestry personnel and two biologists) conduct this audit.

To better judge the industry's views about the current state of sustainable forest management in Canada, a questionnaire was sent to several large Canadian forest product corporations and

forest leaseholders. Their opinions about the present sustainable forest management process in Canada are summarised below:

Opinions about the current policy:

- Legislation and government policy towards sustainable forest management tends only to be focused on forest management for timber production.

- It is important to consider the demands of First Nations tribes and local communities, but their demands often lie outside the boundaries of forest operations.

- It is very difficult to obtain public participation because of the wide range of levels of understanding of the concept of sustainable forest management amongst the different stakeholders.

Impact on operations:

- Reductions in the area of production forest expected to occur as a result of the impact of sustainable forest management varies between 5 and 16%.

- A big problem is the demand for extensive documentation, public participation and extensive requirements to measure biodiversity under sustainable forest management systems.

- Respondents were cautious about the effect of the implementation of sustainable forest management on wood harvest. They suggested that, generally, cutting levels may be reduced by 15% and production costs will be higher but, hopefully, there will then be fewer critics of forest operations.

- Clearfelling is generally practised, but is sometimes modified to protect the soil and regeneration and more closely emulate natural disturbance patterns.

- There is however, more and more use of partial cutting systems (e.g. shelterwood, thinning and irregular shelterwood systems) in order to simulate natural forest development processes.

- The use of reforestation methods needed to maintain stand productivity has been reduced.

- Managers now tend to leave more structural features in the forest such as: snags; patches of trees burned by wildfire; and woody debris.

- Topics considered when implementing sustainable forest management systems include: biodiversity, fish and wildlife resources, recreation values, forest health, and landscape ecosystem management.

Challenges for the future:

- There is an inadequate understanding about the concept of sustainable forest management amongst private woodland owners.

- There is still a need for a broader discussion about sustainable forest management involving the government, local stakeholders and the general public.

- There is still a general lack of understanding about forestry amongst the general public, particularly in urban areas (that tend to have the most political influence).

Another source of information about the current implementation of sustainable forest management in Canada is the study on private woodland owners in the Maritime Provinces,[6] recently published by the National Round Table of Environment and Economy (NRTEE). The conclusions of the report can be summarised as follows:

- the main forest management problems in forests that are privately owned, concern the overharvesting of what is becoming a declining resource and a lack of interest in long-term forest stewardship practices;

- these problems arise partly due to a lack of understanding about the principles of sustainable forest management and the desire to make “fast money”; and

- there is a lack of silvicultural programs and government planning to address these problems.

To overcome these problems, the report proposes a number of steps towards achieving sustainability including: increasing co-operation; better education and training for forest contractors and owners; and incentives for sustainable management. In summary, it suggests that tax reform, research and development, greater co-operative efforts, better training, a forest certification system and codes of forest practice, are needed.

4.4 United States of America

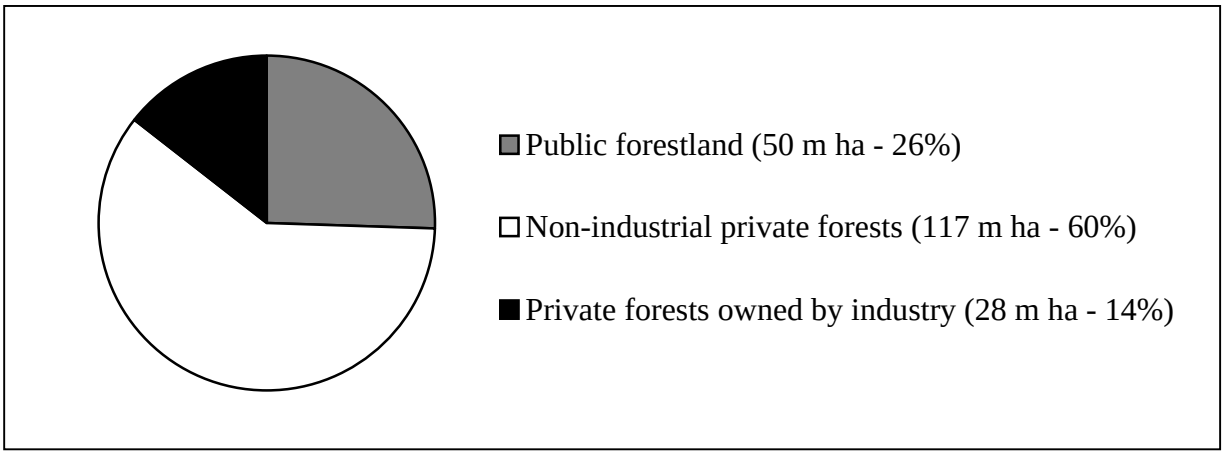
The total productive forest area in the United States of America is about 195 million ha and is largely privately owned (see Figure 2). Federal timber supply has gradually been reduced throughout the United States of America as federal agencies have worked to meet environmental objectives that entered into legislation in the 1970´s. This has increased the reliance of the forest products industry on wood production from the country's estimated 9 million non-industrial private forest owners, who currently produce more than half of the industrial roundwood in the United States of America.

Forestland owned by the wood processing industry is often intensively managed, particularly the forest plantations in the Southern States. Consequently, the timber harvest is, on average, about three times as higher (per ha) than in private forests. However, this is nowhere near enough to secure adequate future wood supplies for the forest processing industry. As a result

[6] Around 82,000 small private forest owners, comprising over 30% of Canada’s total number of woodland owners, are located in the Maritime Provinces (Nova Scotia, New Brunswick, Newfoundland and Prince Edward Island). These small woodland owners manage over 4 million ha of land.

of this situation, the forest industry in the United States of America has realised that it is important to help non-industrial private forests owners to both intensify their forest management while, at the same time, meet sustainable forest management standards. This task is a key element in the "Sustainable Forestry Initiative", developed by the American Forest and Paper Association (AFPA) and launched in 1995.

Figure 2: The current distribution of forest ownership in the United States of America



4.4.1 Forest certification and sustainable forest management in the United States of America

The main focus of activity on the development of sustainable forest management in the United States of America, is the AFPA's Sustainable Forestry Initiative. This program comprises a comprehensive system of principles, guidelines and performance measures that integrate the sustainable growing and harvesting of trees with the protection of wildlife, plants, soil and water quality.

AFPA members have agreed to practise sustainable forest management at all levels of their operations by carrying out a number of activities including the following:

- following the locally determined Best Management Practices;[7]
- protecting stream sites;
- protecting aesthetic and other special places;
- educate forest loggers, contractors and suppliers;
- assisting private land owners; and
- monitoring and reporting on performance in order to aim for continuous improvement.

[7] Best Management Practices are measures to prevent or reduce water pollution caused by runoff as the result of forestry activities. The appropriate measures are determined according to the particular circumstances in each state.

As part of the Sustainable Forestry Initiative, a number of guidelines have also been formulated for the implementation of sustainable forest management:

For forest operations in an AFPA member's own forest, the member shall:

- employ an array of sound practices in the growth, harvest and use of forest;
- promptly reforest harvested areas;
- protect water quality in streams, lakes and other waterbeds;
- promote habitat diversity and the conservation of plant and animal populations;
- design felling coupes to blend into the terrain and restrict the size of felling coupes;
- manage lands of ecological, geological or historical significance for their special qualities;
- contribute to biodiversity, enhance landscape diversity and provide an array of habitats;
- improve the efficiency of forest resource utilisation; and
- continue with the prudent use of chemicals in the forest.

When procuring wood and fibre from loggers and other landowners, the member shall:

Broaden the practice of sustainable forest management by involving: non-industrial landowners; loggers; consulting foresters; and company employees who are active in wood procurement, in extension and assistance programs. This includes promoting the training and education of loggers and informing landowners about sustainable forest management practices.

In reporting to the public and involving them in the practice of sustainable forestry, the member shall:

- report annually on progress to the AFPA, who will issue an annual report to the public;
- a group of independent experts will validate and draw conclusions from the reported progress; and
- the public and the forestry community will have opportunities to participate in this process.

In addition to integrating sustainable forest management practices into the culture of the forest products industry, a key element of the Sustainable Forestry Initiative is to contact private woodland owners, loggers and foresters (who produce more than half of the industrial roundwood supply in the United States of America). Since 1995, more than 20,000 loggers and foresters have completed comprehensive training programs that include elements of sustainable forest management practices and, in 1997, more than 86,000 landowners across the country received information about the Sustainable Forestry Initiative.

In order to reach out to private landowners, loggers and foresters, the Sustainable Forestry Initiative has involved the creation of a network of alliances with other agencies, including: state forest associations; logging associations; government agencies; and universities. AFPA members also co-operate with conservation groups and others to develop and deploy sustainable forest management strategies that promote forest growth and are considered to be consistent with the promotion of biodiversity. They also provide funding for forest research.

In 1997, AFPA members reforested 1.3 million acres by planting, seeding and natural regeneration. This area represents about 2% of their total forest holdings, corresponding to a rotation period of about 50 years.

An example of one company's interpretation of sustainable forest management in the United States of America is given in Box 3. Felling coupes in Weyerhaeuser's forests vary from a few acres to a hundred acres and more and, in some states, the state set limits on the maximum felling coupe area. The size of felling coupes are determined by considering the landscape and surrounding forest and by following the locally determined Best Management Practices. In the mountainous Pacific Northwest, analyses of watersheds are regularly worked out with government agencies, environmental groups, native tribes and other landowners. The results from these analyses are used to prescribe preventive measures, correct past damage and monitor improvements. Wildlife conservation planning in these forests mostly concerns management for mammals, birds, reptiles and amphibians, but very little is said about the conservation of plant life.

Box 3: An extract from Weyerhaeuser's strategy for intensive forest management

Weyerhaeuser's intensive forest management includes:

- preparing soil before planting;
- hand planting genetically improved seedlings;
- controlling competing vegetation;
- protecting the forest from fire, insects and disease;
- applying fertiliser to supplement natural nutrients;
- thinning stands when appropriate; and
- pruning trees for higher quality wood.

Weyerhaeuser prefers clearcutting because:

- most tree species grow better when exposed to full sunlight;
- other harvesting methods make regeneration more difficult;
- clearcutting requires fewer roads and thus reduces damage to soil; and
- clearcutting is the most cost-effective harvesting method.

Weyerhaeuser's goal is to plant one year after harvest.

A questionnaire about sustainable forest management was also sent to a number of industrial forest owners in the United States of America. A summary of the answers received from various companies are given below:

Opinions about the current initiative:

- Sustainable forest management and responsible stewardship of forestland are important issues.

- A major priority should be to consider what is scientifically important, then to take into account other issues such as public opinion.

- In general, state forest practice laws cover some aspects of sustainable forest management, particularly issues concerning water quality, but there are often few legal requirements to address other sustainable forest management issues.

- The concept of sustainable forest management within the Sustainable Forestry Initiative goes beyond what is legally required in most states. Even the measures to protect water quality, set under the Best Management Practices, often go beyond what is legally required. The Sustainable Forestry Initiative is comprehensive, in that it covers a wide range of concerns, including: water; wildlife; aesthetics; and protection of special places.

Impact on operations:

- Many companies reported that it was difficult to establish formal public participation in the process of developing their sustainable forest management policies.

- All companies reported that they followed Best Management Practices, whether they were legally required or voluntary. Most companies assessed sustainable forest management at the landscape level and used statistically based field inventory surveys as part of their management planning.

- Sustainable forest management programmes included measures to conserve or improve: reforestation; wildlife habitat; water quality; special areas; recreation areas; and soils, and to examine the cumulative or long-term effects of management.

- Forest zonation is a widely used tool. For example, one company reported that they divided their forestlands into: intensive management areas; general management areas; restricted areas; and special places. Special places are either completely protected or are managed using special management practices.

- When attempting to put sustainable forest management into practice, many companies reported that they had to rule out options such as banning clearcutting and the use of herbicides, because they would be too costly and unrealistic. However, some companies reported using selective harvesting systems for up to 50% of production.

- As a result of implementing sustainable forest management, all companies reported lower harvesting volumes and higher operating costs, but most were not certain of the exact magnitude of these effects. A few suggested that operational costs had risen by 10-15%. Many suggested that it would be nice if these efforts were recognised and would result in fewer conflicts, but they were not sure that this would occur.

Challenges for the future:

- The biggest problem at the moment is getting people outside the sector to believe that the companies are making real changes without regulation.

- When they explained their policies to their critics, it was reported that many of their critics believed that only certification by the Forest Stewardship Council or government regulation would be good enough.

- The Sustainable Forestry Initiative should be viewed as a living program that will always be modified as new information becomes available. The industry is still at a very early stage in the development of sustainable forest management and the aims and objectives of the initiative will always be changing. As noted above, in terms of redirecting the initiative, the highest priority should be given to new scientific information, followed by changes in public expectations.

- Many non-industrial private forest owners harvest their forests without any plans for reforestation. They generally don't want to make the long-term investment that this requires.

- Many of the US Forest Service forests are not currently being managed for timber production, due to a variety of constraints and restrictions. Many of these forests, particularly those at low elevations, are burning regularly and in a way that is not part of the historical disturbance regime.

4.5 Russian Federation

The Russian Federation contains 23% of the world's forest area and about 55% of the world's growing stock of coniferous species. Although forest management in the Russian Federation was built on classical European forestry traditions and many of the forests there have been managed for more than 200 years, overharvesting in the European part of the Russian Federation has taken place over recent decades. This has led to the depletion of vast forest areas, has damaged the ecology in many places and has led to the loss of many highly productive sites. As a result, secondary birch and aspen forests have replaced over 30 million ha of natural spruce and pine forests and this conversion is projected to increase to between 60 million ha and 70 million ha during the next 15-20 years.

In the Far East of the Russian Federation, the forests have been high-graded for a long time.[8] Of the many millions of hectares of the most productive forest that have been clear-cut during the last few decades, one-third is now classified as not regenerating. The general degradation of the forest resource towards low-value secondary forest after harvesting is typical across many of the regions of the Russian Federation.

In spite of the fact that the Russian Federation has made a number of international environmental commitments with respect to forestry, in reality the country has not taken any major steps to conserve biodiversity through improving forest management. The Russian Federation has subscribed to both the Montreal and Helsinki processes and has developed tentative criteria and indicators for sustainable forest management, which have been approved by the Russian Federal Forest Service. However, implementation of sustainable forest management is lacking due to administrative problems and a lack of financial resources. In summary, forest management in the Russian Federation does not yet adhere to even the most basic requirements of sustainable forest management, let alone some of the more advanced requirements.

[8] High-grading refers to the process whereby the most valuable trees from the forest are repeatedly removed, gradually diminishing the quality of the forest that remains.

4.6 Forest plantations

The interest in establishing forest plantations (often with exotic or non-native tree species that would result in higher yields than natural forests) emerged in Europe during the last century. This interest was followed in a few other areas with, for example, New Zealand establishing Radiata pine plantations during the 1920´s and 1930´s. However, the establishment of large-scale forest plantations did not really take off until after 1945 and the main expansion of the temperate forest plantation area took place in various parts of the world from 1950 to 1980.

The main purpose of most forest plantations is usually to produce industrial roundwood (i.e. sawlogs, veneer logs, pulpwood and pitprops).[9] Intensive management of these plantations represents a major investment and, consequently, forest processing companies are, in many countries, the main owners of forest plantations. Industrial plantation forestry is targeted towards producing large quantities of industrial roundwood at a competitive price. In areas where the climate favours rapid tree growth, such as in: Chile; New Zealand; South Africa; the Southern United States of America; and South-western Europe, plantation silviculture resemble the techniques used in agriculture. It includes the use of: genetically improved planting stock; intensive tending and pest control techniques; and fertiliser application (if necessary). The financial profitability of such silvicultural measures is assessed in terms of the impacts that they will have on sustainable crop yields and, eventually, projected timber revenues.

Forest plantations of Radiata pine and Eucalypti, established in the warm temperate climates of New Zealand, Southern Australia and Chile, have been particularly successful. In Europe, major areas of forest plantations have been found in countries with temperate climate on the Iberian Peninsula, in Central Europe and the British Isles. Depending on the location, different tree species are used in European forest plantations: Eucalypti and Pinus radiata in Spain and Portugal; Douglas fir in Central Europe; and spruces and pines in the British Isles. In the Nordic countries, as the result of intensive forest management aimed at increasing the yield of industrial wood, over half a million hectares have been cultivated with Lodgepole pine, which comes from North America but grows much faster than indigenous tree species.

The extensive industrial Yellow pine plantations of the Southern United States of America are notable by the fact that the Yellow pine is native to the area. However, in terms of the objectives of management and the way that these areas are managed, they resemble the exotic fast-growing forest plantations of New Zealand and Chile.

Probably the oldest forest plantations are the Douglas fir plantations that can be found in France and Central Europe. Douglas fir has proved to be a very successful species in this region and grows in stands on rotations of 100 years or more. It is likely that some exotic conifer species, including: Douglas fir; Sitka spruce; and Lodgepole pine, will continue to be cultivated on a large scale in European forest plantations, despite current public demands that there should be a greater use of native species.

[9] There are non-industrial plantations that are intended for other purposes, such as the production of wood for local construction activities, fuelwood and charcoal. However, these are mostly found outside the temperate and boreal forest zone and are, therefore, outside the scope of this report.

4.6.1 Sustainable forest management in forest plantations

By their very nature, forest plantations can have a greater impact on the environment than other types of forests and, consequently, the concept of sustainable forest management in forest plantations is more concerned with this particular issue than in other types of forests.

New Zealand provides one good example of a recent initiative to improve forest management in forest plantations. New Zealand has 1.5 million hectares of forest plantations (mainly Radiata pine). In 1995, the forest owners associations and the country's major environmental groups agreed upon a set of "Principles for Commercial Plantation Forest Management". They state that, in order for forest plantations to be managed sustainably, forest managers must:

- safeguard stream margins and water bodies;
- protect indigenous biodiversity in natural areas;
- recognise and provide for indigenous biodiversity (where appropriate) in forest plantations;
- conserve threatened species if they are found in the forest plantation;
- not replace natural forests and other natural areas with forest plantations;
- protect indigenous vegetation along the margins of water bodies; and
- facilitate the restoration of depleted indigenous habitat in critical areas.

Ireland presents another example of recent developments in plantation forestry. In Ireland, forest plantations are mainly planted with Sitka spruce and Lodgepole pine. Current Forestry Acts deal with the sustainability of timber production but not with the sustainable production of other forest values. The state forest management company - Coillte - is the major forest plantation owner in Ireland (owning around 433,000 ha). It is at present actively involving stakeholders in the process of agreeing on criteria and indicators, which will enable forest management practices to be monitored and evaluated over time.

The process of establishing Standard Operating Procedures will involve several workshops and these procedures will aim to fulfil the six criteria for sustainable forest management agreed as part of the Helsinki Process. The aim is also that, in addition to the basic sustainable forest management requirements, these procedures will: "allow greater recognition of forest values other than timber production, which are often under-valued or taken for granted". The expected changes in operating procedures include the following:

- greater diversity in plantations, with 20% of newly planted areas being planted with a different species (preferably broadleaves);
- greater care with forest operations, particularly: ground preparation; drainage; and fertiliser application;
- the use of improved harvesting practices that will minimise negative impacts on watercourses; and

- the introduction of measures to avoid negative impacts on archaeological heritage and landscape.

Similar major initiatives are also under way in other countries with significant forest plantation estates, such as South Africa and the United Kingdom.

5 OTHER MAJOR OBSTACLES TO THE IMPLEMENTATION OF SUSTAINABLE FOREST MANAGEMENT THAT ORIGINATE OUTSIDE THE FORESTRY SECTOR

Generally speaking, with the exception of the Russian Federation, there are few impediments to the implementation of sustainable forest management in temperate and boreal forests, which originate outside the forestry sector. In the Russian Federation, of course, the present social and economic state of the country results in sustainable forest management being given a lower priority than some of the other more pressing issues that have to be addressed. Hence, it is likely that current forest practices will continue in this country for some time to come.

In densely populated areas, such as Central Europe, expanding urban areas and infrastructure development often require the conversion of forestland to these other uses. On the other hand, agricultural land is also gradually being converted to forestland and these two processes largely cancel each other out. In some countries, the forest area is even expanding, as the conversion of agricultural land into forestland is greater than the conversion of forestland into other land-uses. In general, a similar situation to this also currently exists in North America.

According to the forest products industry in the United States of America, current laws, regulations, tax structures and other policies, compromise the ability of private landowners to implement sustainable forest management rather than promote its implementation. This is a concern because the industry is very dependent on private landowners for their long-term wood supply.

All over the world, the activities of NGOs and other advocates within the conservation movement have raised public awareness and shaped public opinion. In many countries, this has resulted in political action that has changed the policy framework in which forests are managed. However, in general, forest legislation is lagging behind developments in the sustainable forest management debate in many countries. In some countries, the forest products industry has negotiated management standards with NGOs, which commit them to implement measures, for nature conservation for example, that go far beyond what is currently required by law. This is somewhat confusing though, for the many millions of non-industrial private forest owners, when they are asked to meet the same standards. The opinion of many small forest owners is that they are doing all that they have to as long as their forest management and harvesting activities conform to all existing legal requirements.

6 TECHNICAL CONDITIONS AND REQUIREMENTS FOR ACHIEVING SUSTAINABLE FOREST MANAGEMENT

Any investment in sustainable forest management in temperate and boreal forests requires a few solid foundations, including the following:

- sufficient funding;
- continuous education and training of the workforce;
- access to the forest (even after harvest), requiring a network of permanent roads and other infrastructure;
- accurate and detailed field instructions for all of the various silviculture measures that will be employed, including nature conservation measures (this is particularly the case in large-scale forest operations);
- maps and compartment records that are both accurate and readily available; and
- appropriate systems for planning and control of all forest activities.

The list could be made much longer.

Sustainable forest management in temperate and boreal forests is also often based on the practice of clearfelling, which usually involves the following sequence of events:

- harvesting (i.e. clearfelling);
- site preparation;
- planting, direct seeding or natural regeneration;
- tending the young stand (e.g. weeding, respacing, pruning, etc.);
- fertiliser application (in some cases);
- commercial thinning or thinnings; and
- fertiliser application (in some cases).

Generally speaking enough theoretical knowledge and practical experience currently exists to successfully implement this type of forest management system (where applicable) in temperate and boreal forests. Depending on the intensity of management and the type of forest ecosystem, some of the above elements above can be excluded or exchanged. In many cases, for example, a new stand can be established by utilising already existing seedlings or the lower tree vegetation left after harvest.

Seed trees are often also frequently left to regenerate the stand, or the original stand can be gradually opened up by repeated thinnings to allow natural regeneration to establish under the shelter of the big trees. Taking this to its limit, the Plenterwald (selection forestry) system

utilises perpetual selective harvesting only and results in forest stands with a constantly similar mixture of trees of different ages and different species. At present, the Plenterwald system is used only in rather limited areas in parts of Central Europe. Selective harvesting systems that are similar to the Plenterwald system also seem biologically ideal for some forest ecosystems in wet temperate zones (e.g. on the west coast of North America). However, there are a few problems with implementing such systems under the conditions typically found on the West Coast of North America:

- it is costly to remove giant trees in difficult terrain without seriously damaging the rest of the forest stand; and

- there is an enormous hazard to workers using such a system in this particular forest environment, where the trees that will be cut are surrounded by many large unstable trees (e.g. snags) that might also fall over.

In light of the present critical attitude and actions against clearfelling in this region though, it is necessary to use aesthetically less controversial and more environmentally friendly harvesting methods. This has forced forestry companies to try new harvesting practices, which can be described as a compromise between selective cutting and clearfelling. The new felling methods that are currently being tried are by no means certain to persist in the future though and should be regarded as an experiment in new logging techniques.

In terms of profitability and simplifying forest operations, clearfelling and the subsequent cultivation of even-aged planted forest stands in the next generation, will always generally be the best forest management option. Consequently, until recently, this system has tended to the most common forest management system found across the temperate and boreal forest zone. When this system is used in gentle terrain, the results are often startling. But, on steep slopes, this practice has led to serious problems (such as landslides and erosion) and has been criticised.

In addition to the never-ending efforts to keep costs under control and improve forest yield, the present trend in the development of silvicultural practices in the temperate and boreal forest zone is to develop realistic, effective and operationally feasible measures to conserve nature and meet demands for other non wood forest products and services. This is probably the biggest challenge for today's foresters, because scientific research continues to present new information on environmental issues. Clearfelled areas should nowadays be designed to fit into the landscape and special areas and an appropriate number of old trees should be left during clearfelling operations. Protection of watercourses is also given a high priority in most areas. In order to plan such operations effectively, it may be necessary to survey the clearfelling area, the whole forest estate or even adjoining areas as well in order to implement sustainable forest management. This requires better education and retraining of forest machinery operators and other forest workers, so that they understand what they should be trying to achieve and can act accordingly as part of their jobs.

Current evidence suggests that the major large-scale forest operators in most western countries in the temperate and boreal forest zone, are acting seriously to meet these new and constantly changing demands. There is a problem though, with getting the message of sustainable forest management across to the vast number of small private forest owners. In a number of countries, government forest administrations, forest owners organisations and even wood buyers, are working hard on the task of educating and encouraging small forest owners

to pay attention to the importance of nature conservation and the other demands now being placed upon the sector.

6.1 Forest harvesting

Harvesting in large-scale forestry operations in western countries is currently nearly always highly mechanised, using a number of different machines (including: harvesters; processors; forwarders; and skidders). There are also other ground-based harvesting systems and cable systems that are used to extract timber from the forest. These are mostly used in steep terrain, particularly for the handling of very heavy logs or whole tree stems. In terms of ground-based machinery, the general trend is towards lighter, more mobile and computerised machines that can automatically optimise the value of harvested trees when cutting them into product assortments and cause little damage to forest soils and remaining trees.

Power-saws and small tractors (occasionally even horses and oxen) are still used extensively in Eastern and Central Europe (and in some other areas) and in small-scale forestry operations. But, it is generally accepted that, in many countries, more has to be done to develop appropriate machinery for the millions of small private woodland owners who want to manage their own forests, but cannot afford the significant investment in sophisticated machinery such as that used in large-scale operations.

6.2 Site preparation

Various types of cultivators or ploughs are used for preparing forest sites for planting or direct seeding or, where necessary, to improve the seedbed for natural regeneration. The trend is to minimise the soil disturbance as much as possible if this is possible, within the overall aim of the creating a favourable environment for the next crop of trees.

6.3 Planting and seeding

Nowadays, the seeds used to produce seedlings for planting are often grown in seed orchards; otherwise they are collected in the forest. Large forest owners often have their own tree nurseries and seed orchards. Containerised seedlings are mostly used in large-scale forest operations in the boreal forest zone. In temperate forests, the use of bare-root seedlings is more common.

6.4 Tending

The tending of young forest stands includes a number of possible treatments depending on the site conditions, type of forest and tree species. Respacing or cleaning operations, which determine which trees will eventually form the future stand, are very important. A current trend is to avoid, as much as possible, the creation of monocultures, but rather to create a mixture of species (e.g. by encouraging some hardwoods in a softwood stand) if this is possible. Circular saws, ordinary power-saws, or hand tools are used for these operations.

Pruning individual tree-stems is still a common practice in European beech and oak forests and is sometimes employed in commercial conifer plantations all over the world. With increasing labour-costs and the difficulty of further mechanising operation such as pruning and other forest tending measures, a real challenge for forest managers is to find cheaper ways of carrying out these important measures. This will become an even greater challenge in the future, considering the present trend towards the use of more broadleaves in managed forests.

Pesticides and herbicides are used throughout the temperate and boreal forest zone on a limited scale. Pesticides are regarded as unavoidable to prevent or defend the forest from outbreaks of insect pests. However, there is a trend towards the greater utilisation of biological means of control.

6.5 Fertiliser application

Fertiliser application is used to improve the mineral content of the soil or to more directly boost tree growth. Forests planted on organic soils (i.e. peats) often need repeated fertiliser applications in order to become properly established. This is done on a large scale in several countries (e.g. Finland, Ireland and the United Kingdom). Nitrogen fertilisers are applied to middle-aged and mature forests growing on mineral soils, to improve forest growth and result in an increase in the sustainable harvest level. This technique is utilised by large-scale forest owners in, for example, the Nordic countries and the Southern United States of America. Forest owners in most countries now avoid using fertilisers near watercourses or other protected areas.

6.6 Thinning

All over the world, increasingly larger areas of managed forest are reaching the commercial thinning stage in the temperate and boreal forest zone. In eastern and central Europe, vast areas of forests were almost totally destroyed during World War II, which was followed by huge forest replanting programs. Most of these forests have now reached the thinning stage.

However, there is not enough industry capacity to consume the forecast increase in the potential production of small roundwood from thinnings, particularly in Eastern Europe. If these forests are not thinned, this may lead to sanitary problems in the forest, as they become overstocked, increasingly difficult to mange and susceptible to pests and fire. There is, therefore, a need to encourage the forest products industry to consume more small sized wood from these areas.

7 CONCLUSIONS

7.1 Management of the temperate forest

In temperate forest areas in Europe, the Plenterwald system has its supporters in certain regions, but the traditional approach of even age class forestry is still dominant. Experienced foresters and forest owners have practised this system for generations. Forests managed under these types of systems are aesthetically attractive and valuable, but have lost many of their natural characteristics. It is not surprising that foresters and private forest owners feel confused and are reluctant to start transforming their forest estate from easily managed pine or spruce monocultures to a complicated mixture of hardwoods. Criticism of the current systems in place is strong, but the costs of such a transformation would also be very high.

The United States of America lacks much of the European-style legislation governing the management and utilisation of forest resources. Consequently, many non-industrial private forest owners in the United States of America are reported to harvest the forests without any plans for reforestation. They are believed to not want to invest in reforestation because of the long time involved in such an investment. Small woodland owners in Canada have been similarly criticised for not acting sustainably. This is a serious problem in the United States of America, where non-industrial private forest owners own a significant share of the resource.

A further complication in the United States of America is that loggers often buy wood standing from private landowners and pay little attention to the silvicultural consequences of their harvesting activities. Laws, regulations, tax structures and policies in the United States of America have also been cited as compromising the ability of private landowners to implement sustainable forest management, rather than encouraging it.

The Sustainable Forestry Initiative, developed by the AFPA, includes promising measures to promote the training and education of loggers and to inform landowners about appropriate forestry practices. It is an interesting to observe however, that private organisations have taken on this responsibility in the United States of America where it would typically be taken on by state agencies in European countries.

Temperate forestry in countries such as Chile and New Zealand is strongly focused towards large-scale plantation forestry, mostly carried-out by large corporations. The main aim is to cultivate fast growing trees on short rotations to produce high levels of wood raw materials for mills situated nearby. Sustainable yield is an important consideration in these operations, but broader issues, such as environmental impacts, should also be considered. In New Zealand the forest industry is committed to protecting indigenous biodiversity, conserving threatened species and to avoiding replacing natural forests with plantations. But in Chile the latter issue is still under debate.

7.2 Management of the boreal forest

In terms of their biology, the silvicultural systems currently used in managed boreal forests generally work well if they are properly selected and implemented. However, there are many examples of past unsatisfactory management. This is partly because the tradition of sustainable forest management in boreal forests has not been practised for very long, except in some parts of the Nordic countries.

However, even in some parts of the Nordic countries, intensive forest management, in the modern sense, did not start until some 50-60 years ago. In these areas, forest management was developed gradually, based on research and experience by trial-and-error. Forest companies and the state took a lead in this process; an approach which was also followed later in Canada and the Soviet Union. As a result of all this experience and all these efforts, boreal forest silviculture, aiming at cultivating high yielding forests, is now very successful and can be carried out in most areas. Any failures that arise now will largely be as a result of poor management (e.g. due to a lack of knowledge, experience, interest and/or resources). The economics of forest management may be partly to blame for this.

In general, the broader concept of sustainable forest management now seems to be accepted and accomplished in most boreal forest operations in western countries. Many forest owners and organisations have committed themselves to far-reaching measures for nature conservation and most large forest owners try to conduct their nature conservation efforts at the scale of the forest landscape. Furthermore, work is constantly underway in western countries to develop better standards for forest nature conservation. In the Russian Federation, the current magnitude of problems outside the forestry make it unlikely that this country will be implementing sustainable forest management in its broadest sense in the near future.

7.3 Where are we going?

The present objectives of forest management have become more complex and the question of what constitutes good silviculture is constantly debated and becoming more vague. There are two fundamentally different views about how forest management systems should be adapted to meet nature conservation objectives. Some believe that improvements in forest management should aim to increase sustainable yields of timber and nature conservation values, i.e. that the two developments should proceed in parallel. An opposite view is that improving nature conservation ultimately involves doing less after harvesting, saving in silvicultural and other costs in the short-term but, ultimately, leading to lower production volumes in the long-term. Currently, the latter approach seems to be gaining ground with both small and large forest owners leaving areas alone after harvesting. This may result in an increase in forest areas that are in an unsatisfactory condition.

Modern, far-reaching nature conservation policies also have their price, which many forest owners currently seem ready to pay. Large forest owning companies in Sweden estimate that adapting to the current requirements for sustainable forest management has lead to a decrease in their annual allowable cuts of some 10% (compared to an intensive forest management option without any restrictions). Large forest owning companies in North America seem to arrive at similar figures. In addition to lost revenues, there are also increases in operational costs associated with the implementation of sustainable forest management.

7.3.1 The clearfelling versus shelterwood debate

A question often raised is whether clearfelling large tracts should be avoided because of negative environmental consequences such as the elimination of biodiversity. It is true that the result of poorly planned and carelessly accomplished clearfelling can be criticised from various angles and that there are many examples of bad practices in all countries. However, there are also some good environmental reasons to favour clearfelling in many managed forests, not only because the method is operationally simple and cost effective. Some forest ecosystems are adapted to and even need catastrophic disturbances to retain their natural vitality. Under natural circumstances, the most important rejuvenating factor in nearly all forest ecosystems is the wildfire (often at a large-scale). Conditions favourable for wildfires dominate in many boreal forests, but fire hazards also occur frequently in many temperate zone forests.

Clearfelling imitates, to some degree, the effect of fire with one difference: that the trees are harvested before nature consumes them. However, simply clearfelling a site will not simulate the effect of natural fire. But, studies are showing how this practice can be adapted to meet environmental demands. For example, a naturally burnt area will contain lying or standing dead trees and some surviving trees and tree clumps. Current clearfelling practices should emulate this by similarly leaving live and dead, standing and fallen trees. Shelters along streams, lakes and sometimes roads, should also be left during harvesting operations. Controlled burning of clearfelled areas after harvesting is sometimes carried out as a reforestation measure, but nowadays it is increasingly used to enhance biodiversity by encouraging the survival of organisms that depend on this type of event.

Another reason in favour of the clearfelling practice is that experience has shown (not least in the Nordic countries) that, where selective harvesting systems have been practiced over long periods of time, the result has been detrimental and even catastrophic for the condition of the forest.

Forest managers and policymakers around the world are actively trying to reshape and broaden the management options available. Selection forestry has become a topical issue as it represents the main alternative to clearfelling. There is no doubt that the method is clearly useful in some forest environments and under special conditions. For example, it is successfully used in hardwood or mixed forest stands where the aim is to produce old and very large, valuable trees. It is also a method to use when, for environmental reasons, it is important to maintain a closed forest cover after harvesting. However, selective harvesting has some weaknesses compared to clearfelling. It generally results in lower yields (except possibly in terms of the yield of large sized trees), harvesting is usually more labour intensive (and, consequently, expensive) and the trees that will be cut are spread over larger areas. This increases transportation costs and the requirement for forest roads. Because the work is more difficult, there is also a greater risk of failure.

The most important objection against a more widespread use of selection harvesting though is that this type of forestry is biologically inappropriate on forest sites where the natural ecosystem is fire related and/or where light demanding tree species are being cultivated. This makes it inappropriate for nearly all of the boreal forest and a fair portion of the temperate forest as well.

7.3.1 Is intensification the way forward?

The general development in western countries is towards the increased use of mechanised and labour saving production techniques. This is as true for the forestry sector as for any other. This trend favours the continued use of clearfelling. Selection forestry has an important role to play, but even age class forest management systems (that will most likely be developed further to meet environmental concerns) are likely to continue to dominate in the future.

Most of the industrial roundwood consumed worldwide is produced in the temperate and boreal forest zones. They will therefore, continue to be utilised for timber production for a long time to come. It would neither be possible or desirable to try to substitute a significant portion of this harvest with wood from other sources. Such an attempt would most likely lead to overharvesting elsewhere and just move environmental problems to the tropical countries.

Where new forests are actively created after harvesting natural forests, this can be considered as a sustainable development as long as this is carried out in a responsible way. This is currently continuously occurring all over the world and a major debate at the moment is to what extent and under what conditions should this continue. Society is still a long way from answering this question, but it should be noted that there is an enormous area of natural boreal forest that is still untouched and is not likely to come under management in the foreseeable future.

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