ARTICLES

Ecological silviculture: The application of age-old methods

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ABSTRACT

Historical background, current trends, and forest management systems are presented that utilise the natural features of forests for sustainable wood production. Recent NZ legislation challenges the forestry profession to diversify management systems that can fulfil ecological, economic and social criteria for forests. The case is argued for ecological silviculture with examples of selection systems that maintain continuous forest cover while producing substantial harvestable increment with a high proportion of good-quality sawlogs. The key lies in skilful low-impact harvesting, working with natural regeneration, targeting increment to the best dominant trees, and using the stand canopy for silvicultural self-tending. Research provides forest process information for impacts of indigenous forest management to be kept within limits similar to those found in the natural patterns of forest growth. Much of New Zealand's existing native forest possesses the main structural attributes to practise selection systems for productive, near-natural forestry. New Zealand has great opportunity for natural forest management, especially in its beech forests, to fulfil society's expectations for ecological sustainability. Ecologically-based systems for natural forest will complement plantation forestry.

INTRODUCTION

The World Scene

Forests are centre stage in global environmental planning with special focus on their significance for climate change, biodiversity and sustainable management (Schmidtbauer *et al.* 1990). The recent World Forest Research Congress (Korpilahti *et al.* (eds.) 1995) theme was "caring for the forest in a changing world" and emphasised environmental and ecological sustainability. Forest management must widen far beyond management of timber alone if forest sustainability is to be in accordance with international criteria (e.g., Montreal Process) and NZ legislation (the Forests Amendment Act (FAA) 1993). Forest industries now recognise that, *"Our biggest challenge today is preserving biodiversity in our forests"* through forest management that is *"in harmony with nature"* (Härmälä 1995). Such protected biodiversity encompasses stand composition, structure and succession, i.e., much more than species abundance (Spellerberg 1996, Rosoman 1996).

The majority of countries, unlike New Zealand, manage predominantly natural or modified forests of indigenous species. Many developed countries have multiple-use forest policies based on protection, production and recreation functions enshrined in laws that commit the land owners to sustainable forest management. However, these have generally not provided adequate guidance for ecological sustainability. Thus European States advocate sustainability of forest functions through near-natural mixed forest (that can include exotics), and that *"unnatural uniform stands on large areas are to be avoided"* (Bavarian State For. Admin. 1982). Further, *"....commercial forests should retain features of wild forests. Therefore, forest management should be patterned on the natural cycle of forest growth"* (Salminen 1995). A similar trend is seen in North America as "... an alternative to the stark choice between tree farms and total preservation" (Franklin 1989).

New Zealand

NZ society's expectations (as expressed in the Resource Management Act 1991 and the FAA 1993) challenge the forestry profession to diversify its advocacy of management systems for all forests, both native and exotic. It is, however, not so much 'alternative' approaches we need to find but to practise management systems 'additional' to our already successful clearfelling regime for plantations.

In spite of the good intent of the FAA 1993, indigenous forest management remains sidelined to minor status. Indicative is the substantial Forestry Handbook (Hammond ed. 1995) which devotes little space to description of New Zealand's extensive indigenous forests and gives scant coverage of their management, with a focus on their short-rotation cropping. Support for the ecological science needed to underpin natural forest management has also remained consistently elusive.

The fact that almost all of New Zealand's 6 million ha of indigenous forests remain unmanaged silviculturally is often cause for comment by visiting foresters. Although some 80% is on conservation estate, at stake is a substantial timber resource, primarily beech (*Nothofagus*) species with a much reduced role for the native conifers. A serious challenge for New Zealand forestry is clearly how to bring a significant proportion of the indigenous forest estate under sustainable management through practising ecological silviculture. A central issue for indigenous forestry is that the legal requirement of "sustainability" now extends beyond constraints on logging and timber yield. If natural values are to be sustained, as the FAA 1993 requires, then the structure and diversity of existing native forest need to be retained. Mixed species, uneven-aged silviculture needs to be practised if indigenous forestry is to be 'near-natural'. Until now, New Zealand's traditional clearfelling systems for indigenous forest management encouraged the conversion of natural diversity to even-aged uniformity akin to plantations.

ECOLOGICAL SILVICULTURE – THE PARADIGM

Historical Perspective

It is useful to look back at the silvicultural concepts that evolved over the centuries in Central Europe (e.g., Troupe 1955, Köstler 1957, Burschel & Huss 1987). The once desperate state of Central Europe's largely ill-managed forests , ranging from selectively-depleted cutover high forest to degenerated hardwood coppice, led to the timely development early in the 19th century of conifer plantation forestry for sound reasons of productivity and economics. Spruce monocultures managed by area and age-

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class under clearfelling regimes became the profitable norm and visibly out-performed existing, poorly managed, uneven-aged mixed-hardwood and conifer-hardwood stands. However, in the mid 19th century, positive silvicultural concepts began to evolve for selection systems as an alternative to the fashionable even-aged coniferous monocultures.

A good review of the evolution and justification for near-natural continuous-cover forestry is given by Lang (1994). The much-lauded European selection system or *"Plenterwald"* with its uneven structure (age) and mixed species, has its origins in a form of plunder-forestry or *"Plünderwald"* where farmers selectively creamed out the best single stems (Hartig 1791). It was Gayer (1886) who provided the basis for its recognition as a silvicultural system and he was a great advocate of the uneven-aged near-natural forest of mixed species. He wanted forests that not only looked more natural but also reduced the impact of natural risks (e.g., storms and insects) to wood production that played havoc in European plantation forests late last century.

About the same time, the French forester Gurnaud published in 1879 a practical inventory method for selection silviculture. This allowed the Swiss silviculturist Henry Biolley to switch to the selection system in 1889 at Couvet in the Swiss Jura after heavy windthrow had severely damaged forest under a clearfelling regime. The selection system has continued to be practised there, and in the rest of the province (Canton Neuchatel) without interruption to this day.

Early this century, Möller (1923) took up Gayer's ideas and developed them into modern continuous-cover forestry. In this system, the poorest stem is taken first and the best is left standing to grow large, high-value clearwood. He described the forest as an organism in the way we now understand a forest ecosystem, not as a wood factory but as an interrelated living community of soil, plants and animals, in which cautious management takes heed of the natural successional processes.

Natural gap of 0.02 ha in mixed beech forest (*Nothofagus* sp.), as practised in group selection silviculture, Glenhope, Nelson. Photo: U. Benecke

Since forestry worldwide came under public scrutiny in the 1970s because it no longer met the expectations and needs of society, near-natural (selection) forestry has steadily gained influence in Europe, so that its concepts are now advocated in many State forest policies. Today there is a substantial transition in progress in Europe, from the primacy of clearfelling age-class

Continuous-cover forestry by selection system silviculture practised with flexibility in fir-beech-spruce forest (*Abieto-Fagetum*) yielding high-grade veneer – and sawlogs on a 6-8 year felling cycle, Couvet Forest, Switzerland. Photo: H. Soyer.

forestry (i.e., 'normal' plantation forestry) to selection forestry of continuous-cover, uneven-aged and multi-species forests that vary according to local site and climate (Fig. 1). In spite of policy directives, this movement is not progressing at similar speed everywhere. However, the trend was again strongly reinforced after the 1990 storms which flattened much forest in Central Europe. In Germany, 75 million m^3 were windthrown with a disproportionately high percentage in even-aged spruce. Timber markets still have not recovered.

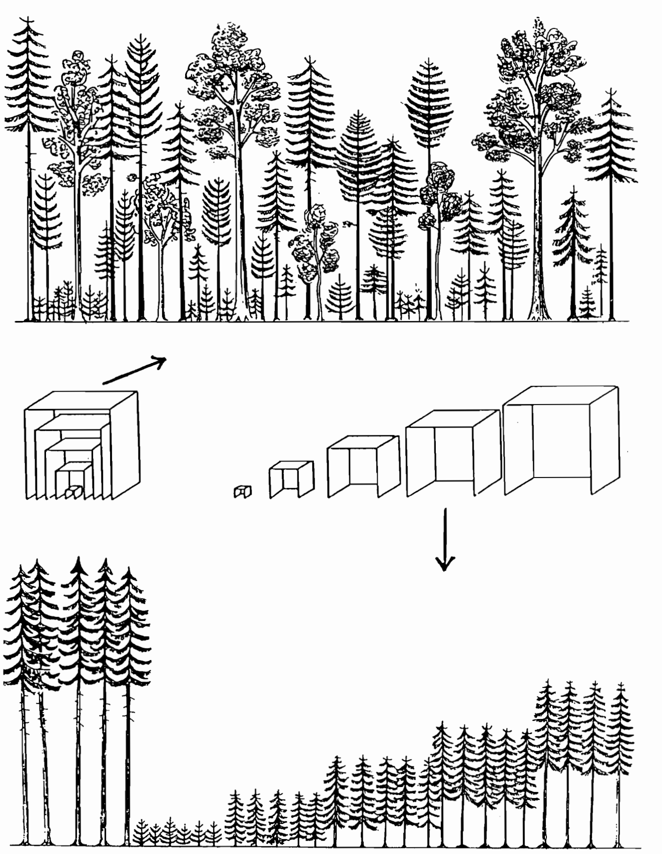

Fig. 1 Uneven-structured selection forest of spatially integrated species and size classes, versus uniform high forest monoculture of spatially separated age classes (*after Favre*, 1994).

Evolution of old silvicultural concepts to near-natural forestry is not just a European fad. Thus under the American "New Forestry", the forest comes before the trees so that the trees are selected for retention contrary to previous practice of selecting trees for removal. The end result is that " ... *the forests after cutting resemble natural forests ...*" (Franklin, 1989).

The Concept Today

Ecological silviculture aims to be sustainable and takes guidance from natural succession to achieve "near-natural" forest composition and structure while maintaining optimum harvestable increment from continuous-cover stands. Such forest means management without a rigid rotation. Forest is never clearfelled to then start again, waiting a rotation for a return on investment in growing stock. Instead, increment is harvested from continuous standing volume by felling trees selected on the basis of size and quality, but not age. In Central Europe and Scandinavia, the basis of silviculture is the forest ecosystem (e.g., MAF 1994, BML 1994). There is a gradual implementation of silvicultural methods aiming to mimic natural stand dynamics. Thus, forest practices become inevitably small-scale and are adaptive to concur with natural site variability and natural regeneration.

Near-natural forestry aims for continuous forest cover of species mixtures in uneven-stand structure, both vertically and horizontally, that falls within the range of ecological forest types that can be expected to occur locally. This form of forestry is practised by a flexible range of single-tree and group-selection systems that depend on the ecological characteristics of the tree species and their position in the vertically structured canopy. As an approximation, harvest coupes significantly larger in diameter than stand top-height would tend towards clearfelling.

In the New Zealand context, Wardle (1984) has noted that silvicultural practice should reflect the ecology of the forests and in reviewing silviculture of beech forests advocated a group selection system concluding that *"....the group selection system ...leads to improved forest stability, provides ideal conditions for regenerating the beeches, and encourages good growth rates.....".* Above all the flexibility of the system is recognised with variable size of cutting coupes but ideally not more than 20-30 m across, equating to maximum felling of 10-20 mature trees.

It is misleading to think the ecological leanings of such silviculture will result in managed natural forest indistinguishable from virgin stands. Hence one needs to think of "near-natural" forest as forest where ecological factors are maintained to the highest degree that is compatible with low-impact wood production. Though the managed forest of the future will not be a totally natural one, it will come much closer to it than many of today's managed forests (Plochmann 1989).

ECOLOGICAL SILVICULTURE IN PRACTICE

There are good examples of near-natural forest management in Central Europe, though true selection systems probably exist in no more than 5% of all forest. Of the 95% stands having age-class structure, up to three-quarters have mixed-species stands and only one-quarter are in even-aged coniferous monocultures (e.g., BML 1994). Examples of ecological silviculture from a recent European study tour are chosen because the long continuity of well-documented practice allows a realistic appraisal of their silvicultural system in terms of ecological and productive sustainability.

Examples of Near-natural Forestry

1. Selection Forest of Couvet - Switzerland (Plenterwald System)

Forester Biolley's selection system has been followed in Couvet Forest since last century to maintain steady production from within a continuous forest structure of multi-tiered stands with a natural species mixture (Favre 1994). All size classes continue to be represented over the compartment area, and production over the whole area is continuous, i.e., in short (six-eight years) felling cycles with allowable cut determined from a full inventory.

The classical selection forest of Couvet has magnificent fir-beech-spruce (*Abieto-Fagetum*) stands of good productive capacity with stand structure that meets many of the criteria for ecological sustainability. It has healthy conifer canopy emergents of 50 m height and large diameter that show no decline in wood increment. Detailed records between 1890 and 1992 from 16 complete inventories of all trees over 17.5 cm DBH provide a remarkable picture of the benefits of transition from clearfelling to the selection system. For stands on a north slope overall current annual increment has increased from 6 m^3/ha to 9 m^3/ha over the hundred-year period (Fig. 2). Most significant is the steady shift of this increment to large-dimension stems of high sawlog quality, so that the proportion in standing volume of diameters above 52.5 cm DBH is 55% in 1992 as against only 27% in 1890. This has been achieved under the selection regime during a consistent and sustained harvested cut of around 10 m^3/ha/yr (i.e., ca 60 m³/ha per six-year felling cycle) when the permanent standing volume has been deliberately reduced from 392 m³/ha in 1890 to the current 365 m³/ha.

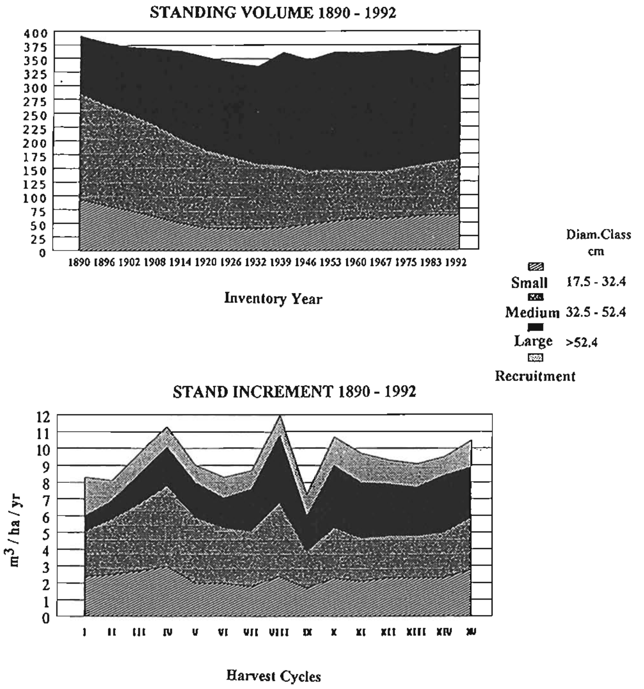

Fig. 2 From clearfelling to selection forest during 102 years in fir-beech-spruce stands, showing increase of large sawlog volume from 27 to 55% and of increment from 6-9 m³/ha, Couvet, Switzerland (*after Favre*, 1994).

The economic target is to maintain only as much standing volume as gives the maximum sustainable increment to produce the highest quantity of top-quality sawlog. Modest standing volumes keep the main crop trees growing steadily and leads to very even growth rings. Too much large standing volume results in a two-tiered tendency instead of the multi-tiered structure of selection forest. This is a common failing in practising selection silviculture.

The key to successful stand management at Couvet is (L.-A. Favre *pers. comm.*):-

- Good road and extraction-track network
- Skilled bushmen who take pride in their work. Last century Biolley introduced a three-year training programme for forest workers.
- Tree health, growth vigour, and status in stand structure are the prime criteria for selection; no strict adherence to "target" diameter.

Favre teaches appraisal of each tree individually to determine its role in present and future stand structure. Tree marking is done by a forester plus a student scribe and takes one day for six to eight hectares. Periodic inventory of all trees > 17.5 cm DBH results in measuring 311 trees per ha in ca three hours, i.e., 40 seconds per tree. Such inventory accounts for 1.7% of stand management expenses.

2. Group Selection Forest - Bavaria (Femelschlag System)

The strong shift back to a more natural forest of uneven structure and mixed species can be seen at Teisenberg (Inzell, Upper Bavaria) where stands are under a group selection system. Trees of 40 m top height and long clean boles of up to 75 cm DBH for both spruce (*Picea excelsa*) and silver fir (*Abies alba*) are interspersed with mostly subcanopy beech (*Fagus sylvatica*). Here beech is climatically outside its optimum range for high-quality timber but it is recognised as an important natural component enhancing stand stability and the ecological sustainability of the forest. Felling of small groups (< 0.1 ha) is on a 10-year cutting cycle under the classical "*Dauerwald*" (continuous-cover forestry) regime of tending for "quality and dimension" by removing the poorest competing stems and leaving the best to grow on, but taking enough large high-quality stems for economic viability.

In developing such group-selection stands in nearby even-aged compartments of tall spruce, the past strip clearfelling of two to three ha blocks has been phased out and stands are progressively thinned under a 100-year transition to near-natural, uneven-structured stands of mixed species. 20 ha clear-cuts were stopped more than 100 years ago because of serious windthrow and slope erosion. The aim now is to manage for maximum stability. However, there is a windthrow risk when late-thinning even-aged stands where tree H/D factor (height/diameter ratio) can often exceed 80. Emergent trees in selection or group selection stands commonly have H/D factors around 60 with long healthy crowns of up to 60% of tree height. These emergents are more stable than trees with higher factors (p. 60, Burschel & Huss, 1987).

Low-impact logging on steep mountain slopes in Upper Bavaria is commonly done with small cable systems that ensure full suspension of short logs, causing no soil disturbance and minimal damage to standing trees. Settings are spaced some 40 metres apart with the width of extraction lines down to two metres through standing forest.

In the "Steigerwald" area of Northern Bavaria near-natural forestry is being practised in beech-dominant forest on easy slopes through careful harvesting that avoids excessive soil compaction. A well-planned fine network of skidder tracks is important, and is spaced at 40-metre intervals indicated by permanent tree markings. Wide-tyred tractors are the norm for skidding. There is strict control on who is allowed to operate in the forest stands and how they must move about (e.g., confinement of skidding to marked fine-extraction lanes). Harvesting is mostly contracted out to local farmers who use farm tractors with suitable winches but a few use two-horse teams. The standard of work is rated to be excellent with very little damage to soil or residual growing stock.

Key silvicultural guidelines set for the mixed hardwood forests of this region are summarised as:

- Work with natural regeneration without protective fencing.
- Use the overstorey canopy to do the silvicultural tending.
- Target growth into quality, large boles.

3. Near-natural Forestry in New Zealand

If we look back in time, it is sobering to discover the advanced deliberations on forest management in New Zealand of more than 100 years ago. Papers relating to State forests, their conservation, planting, management etc., were presented to both Houses of the General Assembly in Wellington (Hansard 1874).

These document debates date back to 1868 on the needless destruction of our natural forests and the need for conservation. Also included is a review (loc. cit., part III) presented to Parliament on silvicultural practice in Europe by Campbell Walker. He reported from the State of Hanover (p. 5) a growing tendency to do away with clearfellings *"..... and remove the old trees so gradually that there can scarcely be said to be any clearing at all....."* and when visiting the Black Forest *"....it is difficult .... to say when the (forest) block passes from one point (the oldest) to another (the youngest) so gradually is the old crop thinned out and removed"*.

He also commented: *"It need scarcely be pointed out that it requires ....intelligent treatment to ensure success of such a system; ..... much greater care is necessary in felling and removal of the old crop when the trees are already surrounded with* *saplings .... and in this the axemen and foresters of the Black Forest are adepts; hence the damage done is really wonderfully slight, ...".*

We have here an early description in New Zealand of *"continuous-cover forestry"* resulting from *"Femelschlag"* silviculture or a form of group-selection system. Some 122 years later we are not much further forward with such forestry, though this age-old silviculture still has relevance to New Zealand, especially if the FAA 1993 is to be successfully implemented.

Well-established examples of sustainable management practice that approach near-natural forestry through selection silviculture are still rare in New Zealand. Small but important areas of beech forest are being managed by two notable farm foresters. Timberlands West Coast also practises sustainable harvest by single-tree selection on some 8000 ha of terrace rimu forest in Westland (Richards 1994). Large-scale beech management is under consideration, but a recent report highlights gaps in our knowledge to guarantee ecological sustainability, especially if harvesting is to simulate natural processes (Hughes *et al.* 1995). While uneven-aged silviculture offers management prospects for New Zealand's indigenous forests to fulfil ecological, productive and social criteria, there is a lack of knowledge about practising such near-natural forestry and its impacts (Halkett 1984). We have yet to do much silvicultural research. In using harvesting as the tool for implementing silviculture, for example, coupe size is a most contentious issue. Therefore, good ecological work into natural gap processes is important.

In NZ beech forests recent studies (Harcombe *et al.* in press) using long-term records of mountain beech plots reveal a pattern of natural catastrophic disturbance causing stand turnover times of hundreds of years (350 to 4000 years). A second extensive, low-intensity, high-frequency disturbance leads to regular stand turnover in decades (66 to 83 years). Therefore, natural events generally lead to frequent small gaps and much less frequent large gaps (several hectares).

Stand renewal in beech forests is primarily by gap-phase replacement, and infilling from advance growth seedlings. The result is a mosaic of very small, even-sized groups akin to a natural group-selection system. Stewart and Hewett (*pers. comm.*) studied natural gaps of red/silver beech forest in the Maruia Valley silvicultural research area and found gaps to be most commonly 0.02 to 0.03 ha created by one to four gapmakers (large trees). Gaps of around 0.05 ha were created by six to eight gapmakers and the largest natural gap was 0.10 ha in size. This is in line with previous published studies (Stewart & Rose 1990). It suggests for these forests that harvest coupes should not be larger than 0.1 ha if we are to mimic the common natural-forest replacement process, i.e., by coupes with diameters equivalent to about canopy height. In Switzerland by comparison, 0.2 ha (50 m across) is the upper limit for felling coupes in group selection systems.

Findings about natural successional processes have influenced current operational research into group-selection silviculture in beech forest (Benecke & Baker 1994). The prime aim is to determine if impacts of small 0.1 ha regeneration fellings can be contained within limits similar to those of natural-forest processes. At the same time, it is hoped an ecologically effective approach to minimising damage by pinhole beetles (*Platypus* spp) to forest health and wood degrade will be found.

Signature of selection forest systems is their reverse-J stem diameter class distribution with trees of all sizes mixed singly or in groups (Burschel & Huss 1987, Halkett 1984). In natural beech forest such "ideal" distribution was found to exist at a sub-compartmental scale of less than 0.5 ha (Fig. 3), and is a common feature in much of New Zealand's natural forest.

Trials are under way (Benecke, Baker & Wiser 1995) in different types of mixed beech-podocarp forest (PB 5) dominated

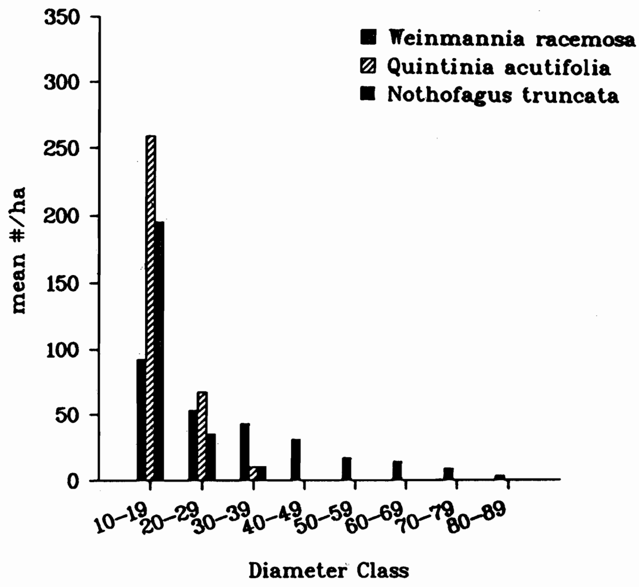

Fig. 3 Natural forest stem diameter-class distribution from 0.1 ha research coupes in group-selection trials, Granville Forest, Westland, showing the reverse-J curve signature of selection forest.

by hard beech (Granville, Westland), red beech (Maruia Valley, Westland), and mixed red/silver/mountain/hard beech forest (Glenhope, Nelson), which should be followed by similar research in silver beech (Western Southland). This is providing an opportunity for testing different low-impact harvesting, i.e., by aerial, ground and cable extraction systems, as well as demonstrating the high standards of bushwork needed in felling and extraction for practising group selection silviculture in natural beech forest.

Economic Considerations

Comparisons from a business management perspective of well-advanced near-natural forestry enterprises with clearfelling forestry (i.e., age-class or plantation stands) have been published (Brabänder 1983). However, many selection forests in Europe are still at early stages of conversion from species-poor plantations. The process of transition to near-natural forest, given the regional climate and indigenous species, takes 20 years to begin to see results and 100 years or more for completion. Production is, of course, not precluded during the transition.

Leibundgut (1983) reviewed for Switzerland the question of near-natural forestry leading to improved economic returns. Because of the high costs of artificial regeneration and early tending, re-establishment of spruce plantations has declined to less than 25% of all forest regeneration. The widely-held notion of planting burdening the balance sheet less than natural regeneration is incorrect. Comparative annual per hectare costs for regeneration and tending are quoted as $NZ21 for continuous-cover selection forest and $152 for clear-felling plantation forest. Harvest cost comparisons can also favour selection forestry. The cost of extra care in felling and extraction is compensated by more favourable log grades (i.e., fewer and larger piece sizes) so that the per m^3 harvest costs average 10% less than for age-class forest. In 1980 the overall average forest enterprise expenditure as a percentage of harvest income amounted to 55-60% for clear-felled forests and 45-50% for selection forests.

Köpsell (1983) compared expenditure over 10 years for forest enterprises under uneven-aged, near-natural management with statistics for predominantly clearfelled, age-class plantation management in two German provinces. The trends are in general agreement with Leibundgut's findings (loc. cit.) (Fig. 4).

The fashionable but divisive dichotomy between plantation and natural-forest management heralding green management of plantations at the expense of the other is not in the best interests of sustainable forestry. We can renew enthusiasm for active indigenous forest management through ecologically orientated silviculture. Further, it is quite plausible that such "alternative" approaches to management should find a parallel place in exotic forestry. Douglas-fir is an obvious candidate for uneven-aged silviculture, alone or in mixture with other species, especially where landscape, amenity and recreational values are important.

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School of Forestry News

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exchange of materials, staff and students between institutions, as well as the joint organisation of courses and international meetings. Dean O'Reilly also visited the Forestry Research Institute, Malaysia, the Ministry of Forestry in Jakarta and the School of Forestry at Bogor.

Staff Activities

Staff at the School have been funded by FORST to study the sustainable management of indigenous forests on Maori land. This research integrates the ecological, economic and socio-cultural dimensions of sustainability. Dr Nora Devoe, who specialises in the silviculture of indigenous forests, heads the research, while other members involved are Drs Norton, Bilek and Boston and Dean O'Reilly. Ms Lisa Langer, a social forester with NZFRI, Mr Gerard Fitzgerald, a sociologist in private practice, and Mr Kel Sanderson, a business development specialist with the Federation of Maori authorities, complete the team.

Dr David Norton has also received funding, this time from DOC, for projects on "Restoration of Riparian Habitats" and "Restoration of Threatened Plant Habitats". Dr Norton recently gave seminars to both Auckland and Christchurch Botanical Societies on the Management of Threatened Plants.

Forestry Society News

The Forestry Society of Canterbury University (FORSOC) was established primarily for students studying forestry. Our aim is to provide a medium within which members can mix with fellow students in an academic and social environment. Members are entitled to attend FORSOC barbecues held twice each term.

As a part of the University of Canterbury Students' Association, FORSOC is required to submit a constitution outlining the Society's aims and objectives for the year. This year's committee decided the constitution should be based around:

- encouraging membership by way of social activities
- promotion of forestry as a career within the University
- establishment of contact with the forestry industry.

It has been a successful year to date, having achieved the majority of our aims and objectives. We now feel it is necessary to establish closer contact with the New Zealand forestry industry. This would facilitate not only a smoother transition from student to professional, but also provide those in the industry with an opportunity to communicate their expectations for future professional foresters. Any correspondence regarding this issue would be greatly appreciated and can be sent to Tim Myers, President, care of the School of Forestry, University of Canterbury.

Ron O'Reilly

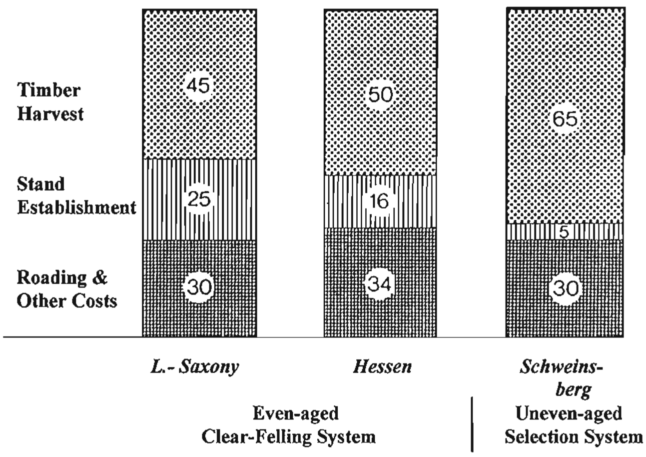

Fig. 4 Relative management and production costs in even-aged "plantation forest" and uneven-aged "near-natural" forest, in two German provinces (*after Köpsell*, 1983).

Pre-1981, the economic return from Couvet Forest timber sales was high when production costs remained steady at ca $NZ 75/m³ and sawlog income ranged between $150-225/m³. Since then sawlog prices have stagnated at around $NZ150/m³ while costs have steadily risen in line with the rising Swiss cost of living, and so the average net profit from log sales over the 1984-1991 period dropped to $38/m³. This modest positive return has to be seen in the light of losses for many forest enterprises in adjoining regions (Cantons) with coniferous stands under age-class clearfelling regimes producing proportionately more industrial wood and sawlogs of lower grade than under the selection regime at Couvet Forest.

By further example for beech forest, recent harvest and stand records (*K.Behr, pers. comm.*) in a compartment under group selection thinning in Northern Bavaria (Dammersgrund, Eltmann) serve to illustrate the potential economics of the "new" forestry. From a stand carrying 377/m³/ha, 50 m³ was harvested under a 10-year cutting cycle. Average log prices ranged from $543/m³ for veneer grades to only $37/m³ for industrial wood. With yields under the group-selection system now progressively shifting into veneer log grades, the overall economic return after harvest costs averaged $127/m³.

Table 1
Benefits of uneven-aged near-natural forestry, e.g., group selection system, relative to clearfelling systems.

Advantages:

1. Natural species composition and tiered stand structure
2. Natural regeneration reduces establishment costs
3. Reduced tending costs through "self-tending" of stands
4. Good stand increment directed to high-value trees
5. High-quality saw and veneer logs and less industrial wood
6. Enhanced stand stability, less prone to windthrow
7. Greater disease resistance of stands
8. Good soil protection especially on steep slopes
9. Less susceptible to weed invasion than clearfelling forestry
10. Natural biodiversity retention to a high degree at all levels
11. Enhanced recreational value of near-natural forest
12. Good prospects for long-term sustainability of all values

Advantages at the cost of:

1. Detailed planning and regular inventory
2. Complex harvesting with fine extraction tracks
3. High skill levels especially for felling and extraction
4. Intensive management decision-making in the forest
5. Animal control is difficult in forest with tiered understorey.

CONCLUSION

Economic considerations are no longer the sole driving topic of discussion for determining forest management systems. Foresters in Europe, and now in North America, must put multiple-use and sustainability of natural values first, and learn to work with natural processes to practise "ecological silviculture".

To many mainstream forestry people in New Zealand it still appears to be unclear that the FAA 1993 is not about sustainable logging (i.e., wood harvest), but concerns sustainable forest management (i.e., intrinsic forest values and wood harvest). NZ history has shown 'selective logging' of natural forest leads to creaming and degraded forest 'cutover'. By contrast, 'selection silviculture' demands pro-active stand management based on an ecological understanding to produce wood by near-natural forestry through low-impact harvesting.

Continuous-cover forestry as practised by a range of flexible silvicultural selection systems through small-coupe harvesting offers an opportunity to harvest high-quality indigenous timber while retaining ecological and social values of the natural forest. The theory of "near-natural" forestry is old but its practice, with all too rare exceptions, is new to New Zealand.

A great advantage of near-natural forestry overseas, with its aim of providing continuous forest cover, is in its public acceptance. Near-natural forestry, to a high degree, meets sustainability values of protection and recreation while producing wood. It is unfortunate that assigning monetary value to multi-use functions other than timber remains unfashionable and forest enterprises continue to provide environmental and recreational benefits gratis.

Legislation has now placed New Zealand in a similar situation to Central Europe. Maintaining mixed stands of uneven-age structure by using small-scale, low-impact harvesting techniques will enhance our chances of achieving ecologically credible indigenous forest management, important both nationally and internationally if we are to fulfil public expectations of clean and green sustainability. With more than one million hectares of indigenous forest in private ownership plus some 100,000 ha of State forest designated as sustainable indigenous production forest, a great opportunity has presented itself for developing forest management systems that are economically and ecologically viable. In New Zealand, and unlike Central Europe, much of this natural forest already possesses the key structural attributes for selection forestry.

A way forward is through cooperative efforts between private and public stakeholders that promote appropriate management expertise and low-impact harvesting methods to implement near-natural forestry. To achieve this will require substantial operational and research resources to:

- develop systems for practising ecological silviculture in natural forest;
- establish indigenous research forests for demonstration and long-term monitoring of forest management impacts;
- promote ecological process studies that can underpin prediction of forest sustainability at different levels of biodiversity;
- provide indigenous forest owners ready access to planning expertise for sustainable management of natural forest.

An appropriate level of resources to meet such objectives, especially research funding, has been notably absent since introduction of the well-intentioned FAA 1993. It is, however, encouraging to see that small private forest-owners, mostly farmers, have taken the initiative by forming an Indigenous Forest Section of the Farm Forestry Association. This Association strives *"to promote ecologically sustainable management of natural forest for production of wood ..."* by systems that reduce impacts and *"....mimic natural processes ...within the limits imposed by practical and economic realities"* (NZFFA, 1996).