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ABSTRACT

There is strong pressure on silviculturists in British Columbia to modify the practice of large clear cuts in overmature, natural forests. The relevance of European silviculture practices (and some American precedents and practices) for British Columbia conditions is assessed, based on the voluminous literature and on several visits to Europe. Some fundamental differences in the forests, forest use, and regulating controls are identified. European practices are based on over 100 years of work and tend to be very traditional, but are also subject to contemporary environmental criticism—some guiding principles are identified. Comments are made on individual systems and on the scientific basis for silvicultural systems research. Canadian silviculture should be flexible, imaginative, innovative, and should demonstrate an understanding of forest dynamics. It is concluded that European guidelines for silviculture principles and nature conservation are relevant to British Columbia, but are not a model for Canadian silviculture prescriptions intended to meet multi-use objectives.

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APPENDICES

1 INTRODUCTION

The objective of this paper is to examine the relevance of European silvicultural systems to silviculture practice in British Columbia, based on study tours made between 1980 and 1990 to examine European silviculture, and on a review of the voluminous literature on silviculture practices and on forestry and environmental policy.

Earlier in this century, there was reluctance to apply dogmatic European views on silviculture to wild Canadian and American forests. This paper proposes that foresters in British Columbia can learn from history.

With increasing public interest in Canadian silviculture, improved silviculture budgets, demands for more natural and intensive silviculture practices, and for changes to the practice of clearcutting, in particular, Canadian environmentalists and foresters again look to traditional European silviculture practice for guidance and precedents.

Jean-Philippe Schütz (1990) has outlined the evolution of "grand ideas" in European silviculture generally, and of thinnings, selection systems, and genetic improvement specifically. He identifies the key figures: Duhamel du Monceau (1700–1782), the father of forest sciences and silviculture; Heinrich Cotta (1763–1844) and George Ludwig Hartig (1764–1837), the first masters of German silviculture; Bernard Lorentz (1775–1865) and Adolphe Parade (1802–1865), the first professors of the French school; Karl Gayer (1822–1907), the father of silviculture close to nature; Comte C. de Reventlow (1748–1827) and Walter Schädelin (1873–1953), the developers of crown and selection thinnings; and Henry Biolley (1858–1939), associated with the selection system.

In reviewing the history and philosophy of silviculture management in the United States, Mustian (1976) pointed out that

> *In trying to trace the history of silviculture, more particularly the development of forest culture systems, we can readily, if not quickly arrive at four conclusions so obvious as to be elementary:*
>
> 1. *Silviculture has been the product of situations of similar character and import in diverse (sometimes widely separated) locations;*
> 2. *The same problems and questions that forest managers have encountered and asked since the beginning and which have led to development of the various silvicultural systems and practices are still with us;*
> 3. *Either we cannot or will not learn from history, or the experience of others. (Fernow 1911, Smith 1972, Troup 1952);*
> 4. *Public opinion, political expediency, and/or individual personalities often dictate the form and substance of cultural practices irrespective of silvicultural requirements, site conditions, and often contrary, if not conflicting, objectives.*

J.V. Thirgood (1989), recently retired from the Faculty of Forestry, University of British Columbia, has reviewed man's impact on the forests of Europe, and concluded

> *The European experience provides historical evidence of the contribution of forest, even through its destruction, to human advance; and of its potential for modification as needs change. It also shows that, once embarked upon, the path of forest destruction, although it inevitably results in change, need not lead to catastrophe, and may indeed lead to higher productivity. If nothing else, it demonstrates that mankind can approach to the brink and yet draw back.*

Two good reviews in English of classical European silvicultural systems are "Silviculture Systems" (Mathews 1989), a revision of the classic text by Troup (1952), and "Silviculture systems for broadleaved woodland in Britain" (Pryor and Savill 1988).

2 THE HISTORICAL AND CONTEMPORARY SETTING FOR SILVICULTURE

Some historical events are relevant to modern public concerns about silviculture practices.

- In 1880, Gayer wrote against whole-scale planting of Norway spruce on unsuitable sites in Germany. He advocated re-establishing mixed conifer-hardwood stands in regions where they had constituted the indigenous forest before human intervention.

[AC1]• At the beginning of this century[AC2] the first Dean of the Faculty of Forestry at Toronto, B.E. Fernow, originally a Prussian forester, came to Canada after the U.S. forestry school at Cornell University had been closed over the issue of clearcutting hardwoods in the Adirondacks. (Twight 1990)[AC3].

- In the 1960's, the Bitterroot Forest controversy in Montana triggered a public outcry over inappropriate silviculture site preparation, that led to the establishment of regional Silviculture Institutes, and to certification of silviculturists by the U.S. Forest Service as a requirement for silviculture prescriptions on U.S. National Forests.

- In the 1970's, a controversy over logging in Algonquin Park in Ontario was resolved by successfully applying selection management of tolerant hardwoods.

- In 1987, the British Columbia Ministry of Forests adopted mandatory signing of preharvest silviculture prescriptions for Crown cut blocks by a registered professional forester, and established the Silviculture Institute of British Columbia to provide 10 weeks of instruction for practicing silviculturists.

- In 1989, the Ontario Ministry of the Environment launched an ongoing judicial inquiry into the timber management practices of the Ministry of Natural Resources.

- In 1990, the Ontario Advanced Forestry Program began.

- In 1990, the British Columbia Ministry of Forests developed a strategy to find alternatives to conventional clearcutting, and several experimental cutting trials were initiated throughout the province.

- In 1991, British Columbia initiated a permanent forestry commission to investigate the public's "vision" for Crown forests (Forest Resources Commission 1991).

In the 1970's, a clearcutting controversy in the U.S. led to the formation of the President's Advisory Panel on Timber and Environment in 1973. That report contains an excellent review on "maintaining timber supply in a sound environment and the question of guilt by association in clearcutting," by D.M. Smith (1973). Throughout the U.S., pressure for change in silviculture practices led to numerous studies, workshops, and reviews of silvicultural systems. Mustian (1976) reviewed the development of silviculture in the United States, and "The continuing evolution of silviculture practice," by D.M. Smith (1972), reads as well today as when it was written. The determinants, characteristics, and terminology for Canadian silviculture are outlined in Weetman (1987) and in Forestry Canada (1992). The evolution in British Columbia is outlined in Appendix 1.

These events demonstrate the timelessness of debates over silviculture practices. The usual rough-and-readiness and huge-scale messiness of Canadian harvesting practices in overmature stands generally conflict with European ideas of orderly and rational forest management and silviculture. This perception by Europeans of an apparently unregulated, exploitive, and primitive Canadian silviculture fuels environmental controversies, and leads to questions about the environmental acceptability[AC4] of selling high-quality coniferous forest products, produced without silviculture costs from natural overmature stands, in the European market. Currently, the European Community (EC) imports 90 million m^3 of its annual consumption of 190 million m^3 (Lanier 1990). However, in the European Community, only about 140 million m^3 is harvested out of an annual growth of about 215 m^3

European foresters usually work in traditional land-use patterns, where many environmental and multiple land-use issues, though under their specific control or jurisdiction, are difficult to change. In contrast, Canadian and American foresters working in public forests are required to prepare silviculture prescriptions that tend to set multi-resource issues that are under their control. For example, Marquis (1990) has outlined a silvicultural decision model for multi-resource management for U.S. National Forests in the northeastern United States. This model incorporates four timber management goals, six wildlife management goals, and four aesthetic goals, for a total of 96 combinations of any forest type. In British Columbia, the preharvest silviculture prescription required for each cut block is similar in complexity; multiple land use planning goals must be considered.

European silvicultural systems, as outlined in Mathews (1989) (Appendix 2) did not evolve to handle this complexity. They are classified systems, unrelated to specific stand management objectives and are not prescriptions for stand intervention. Occasionally there is a reasonable fit between classic European silvicultural systems and multi-resource management, but it is more often by good luck than by design.

Some public protesters in Europe object to human intervention in forests, especially to cutting. An example is the 1989 decision in Zurich to stop cutting mature trees in the famous city forest of Sihlwald, and only permit thinning. This beech forest has been classically managed under a group shelterwood system for over 400 years—to a traditional forester's eye it is a magnificent and beautiful example of the practice of intensive silviculture, and was a source of inspiration for Gifford Pinchot (Walsh 1989). It represents a relatively natural forest in a Swiss landscape that has been greatly changed by man, and current management is designed to make it more natural. Furthermore, it conforms to the Swiss Federal Office of Forestry policy banning clearcutting, and to the policy directive to maintain the forests as naturally as possible. Nevertheless, the people of Zurich do not want the forest cut. This parallels public objections to silviculture prescriptions to prevent further deterioration of the old-growth conifer forest in Stanley Park in Vancouver, and to maintain its original character (Beese and Paris 1989).

Today, nearly all 25 million ha of "commercial" forests in British Columbia are publicly owned. Most Tree Farm Licenses and Timber Supply Areas are composed of predominantly mature and overmature forests, and logging occurs mainly in very old virgin forest stands. In most Timber Supply Areas, appreciable areas of second-growth plantations or tended stands will not be logged for several decades.

3 THE NATURE OF EUROPEAN SILVICULTURE

European silviculture tends to be very regional, i.e., associated with certain schools of thought, and dealing with the national forest types. Practice today draws heavily on a century of experience of silviculture in these forests. The regeneration and tending components[AC5] of silvicultural systems have been worked out and refined, named and system-atized, and become long-established practices. The older textbooks often present these practices in a "how it is done" manner (Köstler 1956). Explanations for their success are provided, together with historical overviews, reviews of the silvics of the main species (oak, beech, spruce and pine), and reviews of ecological and physiological relationships.

Much European silviculture literature has been published in German, which very few Canadian foresters can read. There is a long German tradition of silviculture practice, and some notable new texts (Röhrig 1980, Mayer 1984), but the relevance of traditional silvicultural systems to most wild Canadian forests is questionable. However, the broad principles of silviculture currently being recommended in Germany show a similar ecological concern to that expressed in British Columbia (Appendix 4). Schütz (1990), from Switzerland, has published a new book in French that reviews the use of the classical selection system.

Most Scandinavian forest literature is now published in English. Although Swedish and Canadian boreal forests are ecologically similar, the silvics of the tree species, forest history, access, and markets do not make these systems models for Canadian boreal forests. Most recent texts stress ecological issues, landscape problems, and the need for "designed" silviculture (Lanier 1986, Savill and Evans 1986, Schütz 1990).

To help understand European approaches to silviculture the following should be noted:

1) European silviculture practices were developed in forests that were overcut, overgrazed, and high-graded for the best trees until the 1800's. This process of degradation has been outlined by Ellenberg (1988). The challenge to early foresters was to make degraded and disturbed forests productive, and to protect forests from further abuse (James 1981). Rebuilding devastated forests through silviculture was in the national interest of each country. Thus, foresters enjoyed strong central government support, as they still do today. The result is a largely man-made forest, a domesticated and artificial creation. Many early mistakes were made in planting trees on unsuitable sites, using incorrect seed sources, and by inappropriate site prep-aration. Calamitous large-scale die-back of forests and serious decrease of growth occurred (van Goor 1985).

2) Rigorous forest laws have effectively placed control of silviculture practices on all European forest lands into the hands of government foresters (Reade 1960). The government rules, regulations, and attitudes have been quite rigid, are seen to be successful, and are difficult to change. There are major tax incentives and subsidies in place to favour silviculture practices in some countries (e.g., the United Kingdom [Forestry Commission 1992]); but not all (e.g., Switzerland [Swiss Federal office of Forestry 1987]).

3) Most European forests are private; thus, planning and control are on a very small scale by Canadian standards. Management and working plans are drawn up specifying the silviculture treatments for all stands (usually 0.1–3 ha) in forests (10–500 ha) on a compartmental basis. The silviculture at the stand level is an assigned and long-established series of treatments. Nearly all stands have been treated before, and the traditional approaches and continuity of work are maintained, sometimes with the

force of law (e.g., cuts required every 10 years).

4) Silviculture practices tend to be national in character, i.e., individual countries have built up traditional practices and approaches (e.g.; Office National des Forêts (1989) (ONF) use of uniform shelterwood in oak and beech in France, Swiss selection management, Slovenian selection management, the use of shelterwood and clear cut systems in German speaking countries, and Swedish clearcut and plant-and-seed tree systems.

Since Swiss mountain forestry is sometimes used as a paradigm for mountain forestry in British Columbia, it is interesting to note that only 9.4% (98 000 ha) is regenerated under selection management (régénération dans la futaie d' aspect jardiné) while 33% (348 000 ha) is regenerated under formal shelterwood management (régénération sous abri); of the balance of the 1 043 900 ha of accessible forest inventory in regeneration condition, only 8% is in plantations and open natural regeneration (recrus/fourrés). Under either selection or shelterwood management, average regeneration densities are between 4000 and 60 000 stems per hectare (Swiss Forest Research Institute 1990).

With increasing environmental and "green" pressures to reduce and modify conventional harvesting, to pay more attention to nature conservation, and even to stop cutting altogether, European foresters, like North American foresters, have found their traditional silvicultural practices under attack. When practices are so established and traditional, change becomes difficult. Biological diversity and more naturalness are issues where European foresters find themselves on the defensive. Most European silviculture has been oriented towards sustained yield, quality timber production, often with an early strategic national aim of improving the national economy and reducing reliance on imported timber (FAO 1986). Increasing affluence in western Europe is changing the older mandates for silviculture practice.

High labour costs, declining demands for some species (notably beech), European Economic Community revisions in agriculture and silviculture subsidies, severe regional pollution and acid rain problems, more investment in growing timber outside central Europe, and demands for more nature preservation and wildlife habitat location are all factors causing revision in the established approaches to European silviculture. The nitrogen pollution problem, in particular, may be causing some very serious long-term changes in the forests (Nihlgard 1990). Change is also difficult because there is a reluctance to modify silviculture regulations and practices unless the new ways can be shown to be operationally feasible, but the required large-scale and long-term testing of new techniques may be illegal, or very difficult to establish on the ground—a "catch-22" situation.

4 CONFLICT OVER IDEAS ON FERTILITY AND THE ECOLOGICAL BASIS OF SILVICULTURE

The first European foresters contended with degraded forests where fertility had been reduced, apparently by nutrient exports due to litter-raking, grazing or erosion, or direct conversion to heath or fields. In some cases, forests on poorer fertility soils had degenerated into heaths dominated by heather (*Calluna*), as can be seen today in Britain. Originally, forests were considered to have a great ability to rebuild soil fertility. It was even thought that Scots pine planted on sandy heaths would improve the fertility enough that Douglas-fir could be planted in the next rotation. Hardwoods were seen as "better" at building fertility than conifers, whose "bad" effects were associated with lower nutrient availability from raw humus. Such simplistic notions favoured the silvicultural systems for oak, beech and birch, and mixed forests. There was also a strong reaction against planting fast-growing Norway spruce and Scots pine crops, because of a wish to return to more "natural" indigenous vegetation, and because these species were assumed to cause decreased soil productivity. Today, such notions have little scientific support (Fried *et al*. 1990). Van Goor (1985) has pointed out that terrain and soil preparation largely control the trees' effect on the soil. The presence of raw humus is not evidence for soil deterioration (Stone 1956). A critical analysis of the related European studies (up to the mid-1950's) by an IUFRO working party could not establish any evidence for tree species having an adverse effect on soil (IUFRO 1956).

Fertility issues are still very important in North America (Perry *et al*. 1989). In Canada, with largely virgin forests and intact fertility, clearcutting is seen as a threat to the maintenance of long-term fertility, again, with little scientific support (van Goor 1985).

In Europe, [AC6]infusions of nitrogen due to pollution are accelerating stand growth rates, but are leading to concern and discussion over silviculture techniques to build up organic matter as a sink for the added nitrogen, and to fear of nitrate losses, nitrogen saturation, nutrient imbalances in trees, and windthrow instability (Hofman *et al*. 1990). The fertilization effects of pollutants override the adverse effects, and Austria, Finland, France, Germany, Sweden, and Switzerland show a general increase in resources (Kauppi *et al*. 1992). These issues favour silvicultural systems that use natural regeneration. Even death and deterioration of European forests associated with "acid rain" and cation leaching favour silviculture that is natural and that produces more stable ecosystems. The issues have triggered a vast research effort to rediscover or evaluate the original forest cover in Europe as a basis for revising silvicultural systems along historically natural and, hopefully, more stable lines. High-priority ratings are given to natural stand characteristics when setting aside natural areas (e.g., Netherlands, Appendix 5). Naturalistic schools of thought exist that tend to idealize virgin forests (Mlinsek 1990). Today, hardwood forests in Europe are popular because of their perceived benefits to the environment, wildlife, and recreation (Davis 1990).

In Canada, we are fortunate to have vast areas of natural hardwood and conifer forests to provide precedents and understanding for silviculture practice. The increasing use of regional ecological classification guidebooks that identify the natural forest ecosystems, their structure, fertility, and relation to soil moisture and nutrient regime gradients is envied by European foresters, who must work in very unnatural and artificial forest conditions. The British Forestry Commission is trying to develop the a system for the British Isles similar to the British Columbia biogeoclimatic zone system.

Contentions by some environmentalists (Maser 1988) that there are no examples of European forests managed for three or more rotations without loss of fertility are not valid. Most European forest management started with degraded composition and (possibly) soil fertility; to the extent that it is possible, forest cover has retained or rebuilt fertility, although the base line reference for site fertility is not known. The well-known decline in productivity of Saxony spruce plantations is associated with winter water-logging after replacing oak on sites of loess sand over heavy clay soils, thereby closing the deep oak root canals. This is really a problem of poor matching of species to site[AC7], and is an exception rather than a rule (Holmsgaard *et al*. 1961, Rehfuess 1986).

5 COMPARISON OF EUROPEAN AND CANADIAN CONDITIONS

Appendix 6 compares 21 differences between European and Canadian silviculture planning situations. In contrast to the regulated, intensive, and traditional practice of silviculture in Europe, Canada is still in a pioneering era. There are challenging opportunities to find treatments for individual stands of greatly varying species composition, on a vast scale and without historical precedent. In Canada, the emphasis is on preparing customized, individual stand prescriptions to meet many difficult management objectives, and the level of risk is often very high (Weetman 1991, Brumelle *et al*. 1990). The supporting evidence for these prescriptions must come from observing the dynamics of natural forest stands, and from a good understanding (in several disciplines) of forestry theory. It is doubtful that "silvicultural systems," as they are understood in Europe, are the appropriate basis for Canadian practice. The possible variations in general seed tree, shelterwood, selection clearcutting, and coppice systems are endless, and blindly applying "tests" of classic European systems makes little sense. The silvics of the tree species, ecological factors, and management objectives that have made a system or prescription successful should be considered very carefully. It is up to the individual silviculturist to show a high degree of professionalism and understanding of the forest.

Even some of the excellent American species silviculture guides should be used with caution. For example, R. Alexander (1986), who has prepared guides for the Engelmann spruce type in Colorado has advised caution when applying such guides to the Engelmann spruce/sub-alpine forests in Western Canada, where ecological conditions differ.

6 FEATURES OF THE DIFFERENT SILVICULTURE SYSTEMS

6.1 Selection System

Controversy over clearcutting old-growth forests (e.g., in the Carmanah Valley on Vancouver Island) has produced demands to practice "selective cutting," and wide-scale use of selection management in conditions as diverse in Sweden, France, Switzerland, and Germany has been claimed as a precedent. In fact, classical selection management is only practiced on limited areas of Slovenia, Switzerland, France, and Germany—mainly mountain forests composed of silver fir, Norway spruce, and beech, where quality advance growth is readily obtainable. Such a system can only be applied under very special combinations of stand structure, markets, ease of obtaining advanced regeneration, and road access. As D. Handley (1989) has pointed out, the requirement for massive road construction renders selective cutting unfeasible in the unlogged, overmature Sitka spruce/western hemlock forests of the Carmanah Valley. The vitally important distinction between selective cutting (associated with high-grading) and selection cutting (associated with maintaining reverse J-shaped diameter distributions and uneven-aged management) is lost in the heat of debate. Smith (1973) has made the distinction clear:

> *The term "selection cutting" and the seemingly similar one, "selective cutting,"*

are also subject to loose and confusing usage. Any partial cutting, regardless of intent, which does not lead to the uneven-aged condition by successful establishment of new, free-growing age-classes is simply not selection cutting. Partial cutting which does not lead to regeneration is usually thinning; that which creates even-aged stands is shelterwood cutting. The terms "selective cutting" has become so thoroughly corrupted that it is now only a popularized term covering a wide variety of kinds of partial cutting.

Smith (1971) has also pointed out that

*The forests of the Coast Douglas-fir region provide examples of what both theoretical ecologists and foresters can learn from the results of silvicultural treatments. It is a region where one of the most honored hypotheses of theoretical ecology, that of the balanced, all-aged "ecosystem" or selection forest, has been tested and found wanting.....The selective cutting episode of **1930–50** has been too easily forgotten by foresters and overlooked by ecologists. The harvests then conducted in the pursuit of single-tree selection cutting, development of all-aged stands, gentle treatment of nature and sustained yield proved to be such a fiasco in the ancient stands to which they were applied that our profession has been all too reticent to discuss them.*

There is an interesting parallel to the current "selective cutting" debate. A century ago, when Biolley and Gurnaud were struggling to establish selection systems in the Swiss Jura, pejorative terms like "jardinage" (gardening) and "furetage" (from stealing) were applied to the system (Schütz 1990).

It is interesting that runs of the Forestry Abstracts TREE CD-ROM 1939–91 produced 325 references for the key words "selection system." A selection of the more interesting abstracts from the 325 is available on request. The pressure for more naturalistic forestry (a German usage) has caused a re-appraisal of long-term studies; some of the Swiss records date back to 1888, with almost 100% forest inventory.

Silviculturists in British Columbia who attempt to use the selection system in prescriptions should go through the following steps:

1. Read "The Practice of Silviculture on the selection system" (Smith 1986), "Silviculture Systems" (Mathews 1989), and "Correlated guidelines for management of uneven-aged Drybelt Douglas-fir stands in B.C." (B.C. Ministry of Forests 1992).

2. Obtain a copy of "Uneven Management," the U.S. Forest Service Symposium in 1976 and examine the article by Marquis (1978) on q values.

3. Look at the guides for using Engelmann spruce (ESSF) in Colorado (Alexander 1974, Alexander 1986, and Alexander and Edminster 1977).

4. Examine stand structure, advanced regeneration possibilities, road access and markets, and stand growth rate in basal areas very carefully.

5. Remember that the selection system has been demonstrated in Interior Douglas fir (IDF) and Ponderosa pine (PP), and is used in Sub-boreal spruce old growth at the Aleza Lake Experimental Forest, Prince George, and in the United States.

6. Remember that slavish reliance on q-values and basal area growth controls of periodic harvests is not required, but these calculations do provide guidance for first entry harvests in old growth, or in re-entries in stands previously subject to diameter limit/high-grading cuts. UNEVEN, a program that helps calculate the choice of basal area, q-value, and stand structure goals, is available on diskette from the Silviculture Institute of B.C.

7. Establish the goals of *forest* management as clearly as possible to ensure that the stand level strategy of the selection systems is appropriate. Rigorous use of the selection system is complex and costly, and is not

necessarily a fix for all multiple resource use objectives. Forest-level planning is required.

6.2 Shelterwood System

This attempts to provide some characteristics of old-growth stand structures by leaving standing dead trees, holding some trees over a rotation, leaving groups of trees, and using limited basal area removals. This so-called New Perspectives Forestry (Franklin and Forman 1987, Hopwood 1991), has no historical parallel in Europe. Those in favour of naturalistic silviculture, or even romantic silviculture based on long-gone natural stands, usually favour a type of selection system as the closest approximation. Old virgin forests as precedents for more "natural" silviculture are extremely rare in Europe.

Uniform shelterwood systems are still used with very long rotations in hardwood silviculture to produce regular growth on quality stems, notably oak and beech in France (Lanier 1990). These systems, which are based on training and forming stems over very long rotations, remain unchanged. They are magnificent and beautiful to observe, but are maintained for reasons of policy, not economics. European foresters, like foresters in North America, are trying to extend the use of modified clearcut and partial cut systems on older, sensitive forests in response to [AC8] criticism on environmental grounds of clearcutting (Burschel, Mosandl and Katels 1990).

The application of the shelterwood system is very difficult in many parts of Europe because of browsing by deer. Deer populations commonly exceed carrying capacity due to the absence of predators and the need for cash revenue from leased hunting rights. This heavy browsing also greatly reduces species diversity and results in very "clean" forests, relatively free of underbrush and advanced growth.

Most of the 1 million ha of Swiss forest estate are under some form of shelterwood management, with clearcutting forbidden, and there is only a small amount of planting. However, it should be noted that stumpage values are high, the forests are mainly roaded, have high protection value, are under tight cantonal control, and have been cut many times. The elements of Swiss forest policy that relate to silviculture are given in Appendix 7.

British foresters have reviewed the applicability of silvicultural systems to the very limited remaining area of broad-leaved forests in the U.K. (Pyror and Savill 1986, Evans 1989). Shelterwood systems are of little use in Scandinavian boreal forests of Scots pine, but the uniform shelterwood system has been widely used in Norway spruce stands in Finland. Trials of shelterwood overstories are currently under way in Sweden to improve boreal forest plantation survival and cold soils with strong vegetative competition (Skolefald 1989).

The European experience with oak and beech and the American experience with tolerant hardwoods is interesting, but not very relevant to silviculturists in British Columbia. The work from the western United States and the limited use of shelterwood in European conifers and in Russian conifers east of the Urals is more relevant.

There are few European precedents outside Russia for shelterwood prescription for an old-growth conifer forest. The Russian boreal forest has old stands with advance growth and, in some instances of logging, vigorous attempts are made to protect it. In practice, much so-called clearcutting in old conifer forests across Canada has really been a rough-and-ready sort of one-stage, shelterwood overstory removal, with much of the next crop coming from advanced growth. This type of "natural shelterwood," associated with the break-up of the overstory in old forest, may in some cases have resembled the planned thinnings, seed cuts, and one- and two-stage overstory removals in classic shelterwood systems.

A good understanding of stand dynamics of old forests is required for shelterwood prescriptions in overmature forests. "Forest Stand Dynamics" (Oliver and Larson 1990) is strongly recommended as a text. Little study has been made of old-growth forest dynamics in British Columbia.

6.3 Coppice System

The very ancient European use of coppice, still common in France, the Netherlands, and parts of Britain, is of interest to British Columbia, very large-scale aspen coppice management has begun on the northeast, and limited use for red alder on the west coast. As energy prices rise, the use of coppice for house fuelwood and community heating units is again being discussed and researched in Europe. The use of coppice in Europe dates back to the time of the Romans. While there are modern concerns about nutrient exports from short (< 20 yrs) rotations, the sustained productivity over centuries of some European coppiced stands indicates a long-term positive nutrient balance.

The historical and biological diversity values of ancient coppice are being reappraised, while conversion to conifer plantations is slowing.

6.4 Seed Tree System

Mathews (1989) considers European use of the seed tree system to be a variant of the uniform system, but it is not very widely used. Of interest to silviculturists in British Columbia is its widespread use in Scots pine forests in Scandinavia with seedbed preparation. Scots pine is not serotinous like jack or lodgepole pine. Dense, natural regeneration of pine is considered desirable, since small juvenile cores are produced, with the first pre-commercial thinnings delayed to produce quality 'northern pine' sawtimber, which commands a premium price. Planting Scots pine at high densities (3000 to 5000 sph) is costly, so natural regeneration from seed trees tends to be used. British Columbia lodgepole pine has a natural advantage, since it often produces high-density natural regeneration without seed trees, due to cone serotiny. Lodgepole pine prescriptions crop-planned to produce small juvenile cores and small branches, can be done at less cost and trouble in British Columbia with natural regeneration than can be done with Scots pine in Scandinavia.

Large-scale corporate lodgepole pine plantations (400 000 ha) in Sweden are at lower densities, and are crop-planned for some sacrifice in wood quality due to large juvenile cores and knotty boles. In contrast, British Columbia can place very high-quality lodgepole pine sawtimber from fine origin stands of high natural regeneration density on the world market for many more decades.

6.5 Clearcutting

A notable feature of European clearcutting is the very small size of the cutblocks. Forests in central Europe are restricted to patches or very narrow strips because of the small scale of the forests, and because of environmental concerns. The word "coupes" is used to designate the annual or periodic cuts. This term is appropriate for describing one-, two- or three-stage strip cut systems, as have been tried in black spruce stands in Ontario, but hardly fits the 50% leave block system that has been used in Alberta.

Clearcutting is the usual method of cutting in Scandinavian boreal Norway spruce forests. Selection cutting was banned in Sweden in the 1950's because of regeneration failures, and because of the slow growth of residual stands (Hassenkamp 1955). Lately[AC9], cutblock sizes have been greatly reduced. It should be noted that there are few extensive forests of one age class in Europe. Nearly all forests have already been cut and are roaded. The problem of pushing expensive long-distance roads into remote virgin old forests, all of one age class, just does not exist in Europe.

While there are objections to clearcutting, the system, as practiced, enjoys more public acceptance in the domesticated forests of Europe than in the entirely natural landscapes of British Columbia. Landscape design criteria are applied in plantation establishment and removal, particularly in the United Kingdom, where Sitka spruce plantations exist on moorlands. The U.S. Forest Service Landscape manual is the most relevant reference of its type for British Columbia, since it illustrates how the principles can be applied to key British

Columbia forest types (U.S. Forest Service 1976).

6.6 Geriatric Silviculture

This tries to provide least-cost, simultaneous production of several interdependent and useful goods and services, while trying to modify large-scale clearcutting in very old virgin conifer stands, where the risk of loss from insects, disease, and blowdown is high. Most silviculturists in British Columbia are faced with the problem of multi-resource forest management (Behan 1990) and geriatric silviculture. There are virtually no European precedents for this situation, since European silviculturists did not face it a century ago. Their challenge was with overcut, grazed, and high-graded forests, most often with crops of oak and beech. Even Swiss mountain forests were in such a bad state, and exposed to so many dangers, that a police law was needed to protect and rebuild them (Swiss Federal Office of Forestry 1987). Extensive areas of high-graded tolerant hardwoods and some spruce fir forests in Eastern Canada are our closest modern parallel. Here, where selection cutting has already been tried, foresters again face the challenge of restoring quality forests.

7 CHANGES IN SWEDISH SILVICULTURE PRACTICES DUE TO ENVIRONMENTAL PRESSURE

Sweden has long been compared with, and served as a model for, boreal forest silviculture practice in Canada. The Norway spruce and Scots pine forests are ecologically very similar to black spruce/jack pine and interior spruce/lodgepole forests. Swedish silviculture is particularly relevant to the ESSF, MS, and SBS biogeoclimatic zones of British Columbia. Swedish scarification, site preparation, and container stock production systems have been widely used in Canada. Lodgepole pine plantations from British Columbia and Yukon seed sources now cover 400 000 ha[2] of Sweden.

Under the force of Swedish forest law, all forest stands have been subject to uniform silviculture methods; notably the seed tree system in Scots pine with scarification, compulsory removal of advance growth and pre-commercial thinning, and clearcutting of most Norway spruce forests. So-called selective logging was phased out in the 1950's and replaced by clearcutting. Swedish silviculture laws were enforced throughout Sweden, including vast areas of composed of small private woodlots, and even extended to compulsory removals of mature growing stock. This national silviculture program was prompted by a need to cover age class gaps caused by predicted shortages in national wood supply. The results have been a domestication of most of the Swedish landscape by silviculture, and uniformity of forest stand structure.

The combined environmental concerns over biological diversity and a surplus of allowable cut, due to the success of the silviculture program and to a higher than predicted growth rate of treated stands, have resulted in a dramatic shift in Swedish silviculture. The Swedish Forest Act is being revised to remove the compulsory thinning and harvest treatments, and much emphasis is being placed on biological diversity concerns and feasibility, rather than on conformity. Swedish ecologists and silviculturists are now trying to design stand structures that provide for high stand-level diversity and the New Perspectives forestry ideas of J.F. Franklin are being considered. In addition, the National Board of Forestry requires that private forest owners only meet minimum regeneration standards, and serious consideration is being given for the first time to landscape-level planning of biological diversity, timber, and other multiple-use objects. Considerable effort is being put into new interdisciplinary forest research to meet these new objectives.

Sweden, like Canada, is very sensitive to international criticisms and perceptions about the environmental quality of forest management.

This fundamental shift in thinking about the goals and practices of silviculture is one of the greatest changes to take place in Swedish forestry for many decades. The selection system, in particular, and its place in the Swedish landscape is being reassessed. Only a handful of stands have been treated this way. With most of the stands long committed to even-aged management, Lundqvist (1989) has estimated that only about 2.5% of the forest area of Sweden is suitable for the selection system. Natural regeneration is also being re-assessed, and some ecologists are calling for a return to prescribed burning, since most boreal forest stands have a long history of fire origin. Standing dead trees and rotten wood, notably absent from the thinned even-aged stands that dominate the landscape, are also being favoured in revised silviculture planning because they are associated with many of the plant and animals species in Sweden that are considered to be rare or endangered.

8 GENERAL COMMENTARY ON BRITISH COLUMBIA AND EUROPEAN SILVICULTURE

The difference between European and Canadian silviculture is that, in Europe, a genuine attempt at sustainability has been made over the last 150–200 years. The principle of sustainability has inspired all silvicultural systems; therefore, all sites must be regenerated. In mountainous areas, for example, this has led to "puttering" with gaps of only a few trees[1].

[AC10]British Columbia silviculturists need an innovative and creative spirit. Formalized, textbook approaches, based on European or U.S. precedents, are not appropriate.

In comparison to Europe, British Columbia is ideally suited to innovative and creative silviculture practice. The rest of the world envies the state of British Columbia's forests and expects British Columbia foresters to manage well, but suspects they do not.

Since 1800, European silvicultural systems and techniques[AC11] have evolved in response to the silvics of local tree species, the stand conditions, and social and economic pressures. European silviculture has a long tradition, of bureaucratic precedent, and methods, prescribed by law and custom, are applied to broad species groups. Silviculture prescriptions, in the North American sense, are really not developed, or if they are, the emphasis has been on quality timber production. The North American "multiple-use values" (i.e., game, landscape, recreation, watershed, etc.) were decided in Europe decades ago. Hence, change in European silviculture will be slow and difficult.

[AC12]

The attitudes of Europeans towards forests and environmentalism are powerfully influenced by history. Pincett (1993), in reviewing the origins of French environmentalism for example, has pointed out that

> *France has a rich history of debate over questions of nature, including philosophical debates that lie at the heart of environmental politics. Rousseau and Descartes represent the two archetypical* [sic] *and opposed philosophical positions. Rousseau, a forefather of the Romantic movement, saw the savage life as virtuous and wild nature as an oasis free of the ills of civilization. To Rousseau, the human animal was naturally good and civilization a distorting element. He used*

[1] P. Puttonen. Personal communication.

Native Americans as the inspiration for his Noble Savage: not tempted by wealth, free of priests, kings, and laws, they alone lived in liberty with compassion and kindness. Descartes, a founding father of modern science, introduced the concept that mind and matter were distinct and that the natural world, far from being an oasis, was a machine to be dissected, discovered, and dominated by humans who were separated from insensate nature. Contemporary French environmentalism has evolved from these opposing views, influenced by the historic evolution of a powerful central state.

[AC13]The great economic changes and prosperity of western Europe, with new European Community rules on removal of subsidies and supports for marginal agriculture due to great food surpluses, have for the first time, created a situation when the economic rationale for massive and mandatory application of silvi-culture to marginal forests is now being questioned. This new economic situation comes later in Europe than in North America, where economic prosperity and surpluses made silviculture and agriculture uneconomic over large areas. Vast areas of agricultural land in the U.S. and Canada have reverted to forest.

Large parts of central and eastern Europe are badly polluted, and in some areas forests are dying. The stability and diversity of these largely domesticated forests appear to be threatened, and is a cause for scientific concern. The spread of radioactive cesium into ecosystems from the Chernobyl nuclear disaster has also heightened public and scientific awareness.

The environmental (or green) movement is growing in Europe, particularly among the young, and large-scale tourism is accelerating with increasing economic prosperity. Demands for more natural, stable, and undisturbed forest ecosystems, with high recreation and wilderness values, are the result. Mountain and rural farms and villages are dying: when the young leave, tourism and recreation often take over as the primary economic activity. High labour rates make traditional intensive silviculture and logging practices less economic, while mechanization reduces the need for local untrained labour.

The established forestry profession, which has *de facto* control of forests, has responded slowly and guardedly. European foresters may lose some of their control of forest land practices unless they adapt quickly. Foresters in Europe and in British Columbia face the same challenge. However, divisions between foresters, the public, and environmentalists over these issues are deeper in British Columbia. If British Columbia foresters can display some initiative and spirit in developing new land-use and silviculture practices, they may retain control of the forests.

Foresters in Europe and in British Columbia have pointed out that silviculture is always dependent on forest policy, which often has short-term objectives compared to the long-term needs of silviculture programs. If natural, permanent forests are to be produced and maintained, silviculture must be given a dominant position in the administration of forests, and in policy formation (Scheeder 1991).

[AC14]

The idea of carefully prepared silviculture prescriptions, custom-designed to meet the wishes of the owner, and taking into account multiple-use issues and benefits, is fundamentally very sound.

The future of forestry in British Columbia, and of the forestry profession, will depend on the ability of foresters to develop sound silviculture prescriptions. These prescriptions should be designed to meet the stand management objectives set by higher-level forest planning.

The Silviculture Institute of B.C. has the vitally important task of stimulating new, knowledge-based silviculture (Weetman, Carvill, and Laird 1992).

9 THE SEARCH FOR A SCIENTIFIC BASIS FOR SILVICULTURE SYSTEMS IN OLD-GROWTH FORESTS OF WESTERN CANADA

The present situation:

- We are still cutting old growth on a vast scale (at least 100 000 ha per year).
- Many old-growth ecosystems have little or no precedents for a large-scale clearcut disturbance—especially in wet coastal systems with no history of fire.
- Some ecosystems are being cut on poor sites and at high elevations, where periods of recovery are long and slow (i.e., they are resilient but not elastic).
- While clearcutting disturbances at lower elevations go back 50 years, at higher elevations and in some forest types, the large-scale clearcuts are recent (i.e., 20–30 years).
- While the silvics of the species are generally well known, there is almost no history of research on silvicultural systems for many forest types, nor is there a well-documented set of observations on the resilience and recovery patterns for large areas of British Columbia.
- There is a growing sense of public concern over the necessity and desirability of clearcutting in many forest ecosystems.
- Many media statements about forest ecosystem developments and management in British Columbia are based on misconceptions and on false comparisons with other regions.
- There is no support structure for studying the scientific basis for silvicultural systems in British Columbia and Alberta, although a strategy has been developed in British Columbia (B.C. Ministry of Forests 1993).

What is the scientific basis?

- The essence of science is relating what is known to what is not known: Silvicultural systems are based on 1) a body of theory; 2) a body of research; and 3) sets of long-term observations on stand development made in the field. Systems are designed to meet the wishes of the forest owner. In setting specific objectives, there are many choices, and some are mutually exclusive. In the case of public forests, the resolution of conflicting objectives has no ready solution, since no one silvicultural system can meet all public demands. Even the complete absence of human intervention (i.e., presiding passively over the majestic forces of nature) can cause problems when natural catastrophic disturbances such as wildfire and insect attack occur, or when the absence of fire leads to unwanted species invasion on successional trends. System understanding is required for scientific management. It is axiomatic that such understanding will yield to reliable reduction of change in space and in time.
- When stand development time scales are long (up to 500 years for some ecosystems) and system recovery time scales are also long (up to 50 years), the discovery and understanding of ecosystems must substitute space for time; i.e., retrospective or chronosequence study techniques are needed.

If ecosystems at differing stages of development are examined, it is essential that the ecosystems be recognizable as the same, i.e., the site classification must be known and the site correctly identified.

We do have the advantage of well established ecological classifications as a framework for chronosequence studies. We also have the disadvantage of the small number of such studies, and of the lack of age classes for ecosystems of differing ages.

Obviously, experiments that deliberately manipulate stands in different ways (e.g., clearcut, selection, seed tree, and shelterwood cuts) need to be carefully calibrated and conducted, and the responses must be documented over many decades. There are almost no such studies in western Canada. Experimental manipulations of stands with slow regeneration dynamics require 30–50 years of documented study.

Retrospective studies of older, non-controlled partial cuts and clearcuts are very difficult to conduct and interpret. Causal relations in controlling mechanisms for stand recovery are almost impossible to identify, long after they have ceased to operate.

Over the last 150 years, generations of foresters have developed silvicultural systems empirically, largely based upon systematic observation of forest ecosystem, subject to change. This systematic collection and organization of long-term system response in regeneration and stand development has to be organized within a site classification because it is so site specific.

The extreme site specificity of ecosystem development means that

a) general statements about the appropriateness of a silvicultural system for a general timber type are not valid, even though they are widely made by the media and environmentalists;

b) tests, demonstrations, and experiments conducted on one stand condition do not produce information that is readily portable to other stands, unless the stand structure, age, and site are similar;

c) success or failure with one system in a general forest type cannot be imputed, or taken elsewhere, except with much caution. Local development and usage are features of successful silvicultural systems. The only portable features are the silvics of the species; how they work is a local phenomenon;

d) the "solution" to finding a scientific basis for workable silvicultural systems comes from observation of, and feedback from, local forest changes conducted over may years; European and U.S. experience bears this out. Blind, empirical, one-off, short-term tests of different systems are not a sound basis for new systems[AC15].

Meanwhile, what should be done?

Without proven and demonstrable success with silvicultural systems other than clearcut-plus-plant (and even that is questionable for some types), how should modification of cutting practice be conducted? Foresters are apprehensive about conducting large-scale clearcuts in ecosystems of low or slow resilience. For this situation, a moratorium on harvesting until silviculture prescriptions can be supported with local evidence of success would be reasonable. In some cases this is possible; in others, due to the lack of information, it is very difficult to gather such evidence. In most situations it is possible to examine old cutblocks, disturbed and undisturbed road cuts, old fires, and old partial cuts. Systematic examination of regeneration occurrence and stand development, within the framework of the site classification, yields information on the resilience, elasticity, and development patterns of the major ecosystems.

Some of this information is already incorporated in the ecosystem field guide manuals. More information is contained in the heads of the regional ecologists, silviculturists, and industrial foresters. This successional information is essential for developing defensible silviculture prescriptions. For some forest types, notably the boreal forests in other parts of Canada, the successional trends are already documented, i.e., the pathways following fire, logging, and blowdown are documented for each major site type. The problem in the western mountains lies in the complexity and variety of the forest ecosystems in different ecological regions, and in the lack of ystematic study of succession. The issues and the challenges are given from a United States perspective in Appendix 8. A list of knowledge requirements is given in Appendix 9.

10 A REVIEW OF STUDY STRATEGIES

There have been various options, and much debate and discussion for the last 50 years in Canada. Some of the early silviculture research (since 1930) focused on a search for cut modification procedures (at no extra harvesting cost!) to produce regeneration that would meet provincial minimum stocking standards. The rationale was simple; there are vast forests of natural origin in Canada, mainly of fire and insect disturbance origin, and it should not be difficult to discover the mechanisms that control their establishment.

Such naiveté resulted in many unsuccessful empirical attempts at cut modification. The unreliability and uncertainty of the results led to a demand for more critical and focused studies, while developing and confirming the differing characteristics of the tree species failed to produce portable information critical to the development of silvicultural systems.

Tightly focused, cooperative, and intensive studies of individual forest ecosystems that attempted to control as many variables as possible through scientific reductionist thinking did not produce the longed-for "key" to successful natural regeneration either. What did develop was a good understanding of the seed bed and seed supply requirements that favour each species, but do not guarantee success. However, extending these requirements to specific and successful prescriptions for each major site proved difficult. The result was an increased reliance on planting, except for a few types that naturally regenerated—almost in spite of variation in cutting and logging practice.

The mixed success of regeneration research has been further complicated by four recent events: a) public demands to use cutting systems other the clearcutting to meet multiple-use objectives, b) the discovery of poor plantation performance on high-elevation and rich sites without herbicide use, c) dropping all government subsidies to licensees for regeneration costs, and d) tightening of minimum performance standards for licensees, including free-growing, required on 180 000 ha of provincial cutover each year.

These events put emphasize the urgency for silvicultural system research in old-growth stands, since only 10–100 years of predicted cut in old growth remain, depending on the regeneration. Public demands for partial-cutting silvicultural systems in very old forests call for a type of "geriatric" silviculture that has never been practiced before, not even in Europe.

These demands for cut modification in 150- and 500-year-old western mountain ecosystems focus close attention on stand structure and stand development. In particular, there is a demand for stand management objectives such as maintenance of old-growth structure, biological diversity, and vertical stand structure on cutover conditions. The feasibility of such objectives for many forest types and sites is questionable, given the great age, blow-down hazard, degree of rot, and poor live crown ratio in old-growth forests. These feasibility problems are compounded by very high logging costs and by increased roading.

A reasonable research strategy to meet the new demands for silvicultural systems in the western Canadian mountains requires the following:

1) a program of documentation and study of forest succession to complement the field ecological classification manuals;

2) an analysis of stand structure and stand development in old-growth and second-growth forests;

3) a program of adaptive management, i.e., a system of good feedback from operational successes and failures on each major site and forest site combination, no matter which system is used;

4) a cooperative program between industry and government to develop and test a range of feasible silviculture prescriptions that are carefully documented and measured.

The important knowledge requirements are given in Appendix 8.

CONCLUSIONS

Of all the classical silvicultural systems, some forms of the group system and the irregular shelterwood system (Souleres 1990) have the best potential for geriatric silviculture prescriptions in over-mature Canadian conifer ecosystems. As D.M. Smith (1986) has pointed out in setting out seven objectives for choosing a system, resolving conflicting management objectives is extremely difficult, and leaves the silviculturist to spread unhappiness about when preparing his stand-level prescriptions. Deliberate variation in silviculture treatment is needed to avoid excessive stereotyping.

There is a much closer parallel between U.S. and Canadian forest conditions, than between European and Canadian forest conditions. The following statements by D.M. Smith (1973) refer to U.S. National Forests, but are also valid for Canada:

> *The pattern of natural variability is intricate enough that it takes essentially intuitive judgment to decide which variations are important enough that practice should be adjusted to fit them.*
>
> *American silvicultural practice in general and that on Federal lands in particular is too stereotyped. Some of this has arisen because of insufficiency of creative imagination and analytical though on the part of the forestry professional. Too many ideas and practices have been carried from places where they fitted to one where they did not; others tend to linger beyond their time.*
>
> *The variability is great enough that decisions about silvicultural treatment are best made by competent practitioners on the ground. Generalized guidelines and policies can be established from a distance but they lead to mistakes if they are too specific.*

The recent flurry of European texts and articles on silviculture provide helpful examples of how forests are treated, but they should not be used as models for the silviculture of Canadian forests. There many fundamental differences between European and Canadian foresters, which this paper has tried to document. Canadian silviculture must find its own methods and precedents, particularly in geriatric problems of overmature virgin forests. Customized silviculture prescriptions, to meet varying Canadian multiple-use objectives may conform to generally defined seed tree, shelterwood, clearcut, and coppice silvicultural systems, but need not, and should not, rely on European systems and precedents, even when the tree genera are the same. There is a unique Canadian application of the broad silviculture principles on which both European and the American systems are based.