SYMPOSIUM PROCEEDINGS

YUKON FORESTS: A SUSTAINABLE RESOURCE

PART TWO OF TWO

February 2 - 4, 1995
Whitehorse, Yukon Territory

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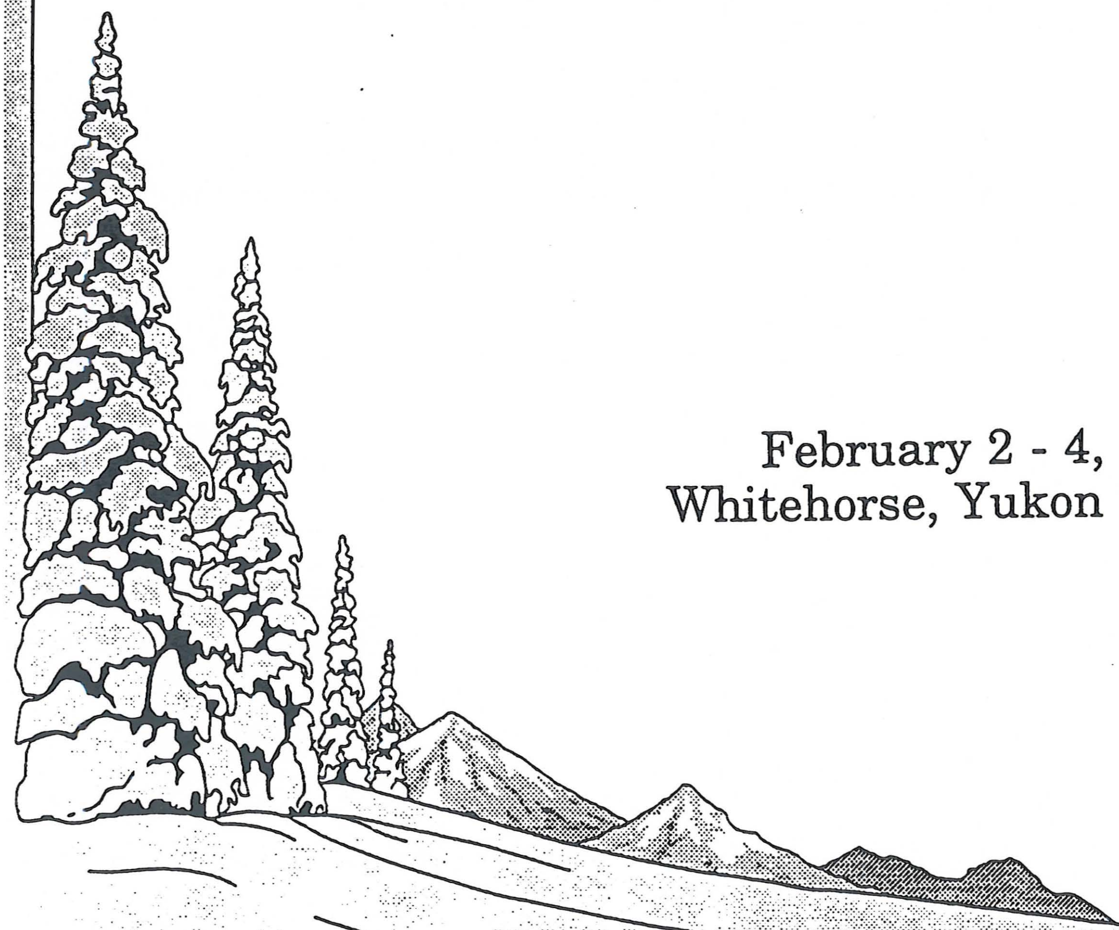

February 2 - 4, 1995
Whitehorse, Yukon Territory

FOREST RESOURCES OTHER THAN TIMBER (ROTT)

(OR, TIMBER AND ALL THAT ROTT)

by

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and

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INTRODUCTION

The Boreal forest has vast reserves of timber to feed the mills, support jobs, and to produce the materials we need for modern life. As important as these benefits are, they may be dwarfed by the ultimate worth of all that ROTT which is rarely enumerated, much less valued. ROTT? Why, Resources Other Than Timber, of course.

The ROTT of the boreal forest touches the lives of every northerner south of the tundra. It frames our viewscapes, buffers our homes from the winter wind, shelters our wildlife, and provides the wilderness environment that is the foundation for our enviable quality of life.

Some ROTT is tangible and can be easily identified, quantified and valued. Other aspects are more slippery: we sometimes are not conscious of them, yet we certainly notice their absence. A dramatic view is a good example. Put yourself at any overlook along our scenic highways and imagine the same landscape denuded of trees. How do you value a view? How do you dare ignore its value? In fact, most of the resource conflicts attached to forest harvesting proposals in the Yukon revolve around Resources Other Than Timber. We are well advised to consider it carefully.

In this presentation I will briefly examine various sorts of ROTT and its importance to northern lifestyles, economies, culture, and ecological values.

Let me say at the outset that because I will be covering a range of forest resources or benefits derived from forest resources I will not be going into a great deal of detail. My purpose is to remind us of the extent to which we use and rely on these resources. I will therefore be dealing with these resources and the issues surrounding them (to the extent that I will be dealing with issues at all) in a very general way. There are other speakers at this symposium who already have or who will be dealing with some of these forest resources and issues more specifically. I trust that they will come to my aid when we get to the question and answer session if some of you have specific questions on these issues that I am unable to answer.

Ecosystem Integrity

It seems generally commonly accepted today that it is worthwhile to pursue ecosystem integrity in our management of forests. I am assuming that by this means we will protect existing biodiversity, also generally accepted as a worthwhile goal. By preserving ecosystem integrity I expect that we also think we can protect the quality and the quantity of the water those ecosystems process. Intact Yukon boreal forest ecosystems also contribute to local and global air quality. Forest ecosystems that are functioning as we think they should will also limit soil erosion thus contributing to its conservation.

Biodiversity

Biological diversity is a subject I prefer to approach very simply. Yukon forests form only a small portion of the North American boreal forest. The Canadian boreal forest by some counts is estimated to contain the following numbers of species:

- 58 mammals
- 200 birds
- 79 reptiles and amphibians
- 22,000 insects
- 50 trees
- 1,200 - 2,000 flowering plants
- 2,000 - 3,000 fungi

As far as I was able to determine no one has done that kind of an estimate of the Yukon's portion of the boreal forest although it should not be difficult (this information will probably appear in the Yukon State of the Environment Report later this year). In the Yukon -- and the information that follows may include areas outside of the boreal forest -- there are approximately the following number of species:

- 54 mammals
- 253 birds
- 3 amphibians
- 8 trees

I do not list the number of flowering plants because I did not take the time to sort out which ones were found in the boreal forest and which ones occupied other areas such as the sub-alpine and alpine and arctic tundra -- Hulten's Flora of Alaska and Neighbouring Territories still intimidates me.

Clark Binkley, Dean of Forestry at the University of British Columbia, is quoted as saying,

> "One simple way to measure biological diversity is to list and count all the species that currently reside in British Columbia. Then 'preserving biological diversity' means 'ensuring with a high probability of success that the current list of species [in British Columbia] will be the same 100 years from now.'" (1)

Since, as I said, my approach to biological diversity is very simple, why not just substitute "the Yukon" for "British Columbia" in Dr. Binkley's quote and try to manage Yukon's forest ecosystems so as to maintain, to the extent that our management of the forest has influence over this, the same number of species as are currently found there.

Then I came across a paper written by Dr. Hamish Kimmins (2), also of the Department of Forest Sciences, UBC, in which he explored the effect that timber management may have on biodiver- sity. He introduced the topic by providing a number of measures of biodiversity:

- genetic diversity
- alpha species diversity
- beta species diversity
- alpha structural diversity
- temporal diversity
- regional or geographic diversity

I will not attempt to explain all these (the reference will be provided). I list them only to show that though I might like to simply have a list of species in the Yukon boreal forest now and have us manage the forest so that a 100 years from now there are the same number, that may not be a satisfactory measure of how well we have managed the forest ecosystem.

We may use, as I believe Parks Canada does, the grizzly bear as an indicator of the state of wellness of the environment. Because of this species' requirement for relatively large areas of intact "wilderness", if a hundred years from now there still are healthy grizzly bear populations in the Yukon along with all the other species we currently have then -- allowing for temporal and regional diversity -- we may have maintained not only biodiversity but ecosystem integrity as well. Dr. Gordon Weetman has already provided us with valuable advice on how to proceed to ensure ecosystem integrity and thereby biodiversity.

We do not often enough bring into this discussion the variety of fish species which are found in the waters within the boreal forest and this is a lamentable oversight. The way in which we manage the forest can obviously have a profound and direct effect on fish habitat as has been demonstrated in British Columbia.

One last thing to bear in mind is that, although I agree that maintaining biodiversity is important, the earth has lost species and added species for as long as earth has been in existence. I believe we should strive to maintain the present level of biodiversity all the while recognizing that ultimately there will be change.

As Forestry Canada says in one of its documents: "Because all life on earth is inter connected, the maintenance of diversity is considered a fundamental prerequisite to maintaining the health of the planet."

Water Quality and Quantity

Within the past year I was involved in a management review of the water component of the Arctic Environmental Strategy. This component was established to increase knowledge of water quality and flow regimes for sustainable development of water resources in the North. The federal government had committed itself to do this in part because it saw the need:

"To preserve and enhance the integrity, health, biodiversity and productivity of our Arctic ecosystems ..."

and

"To establish an enhanced water resource management regime."

An objective of the Yukon Waters Act in managing water is:

"to provide the optimum benefit therefrom ..."

We may assume that the optimum benefits are primarily for humans. We have stopped taking the purity of the water in Yukon lakes and rivers for granted. We now encourage people to boil their drinking water even in more remote parts of the Yukon to avoid Giardia infection. (Much as we may not like it, Giardia is part of the boreal forest ecosystem and a natural part of its biodiversity.)

Usually when we think of the positive effects an intact ecosystem has on the quality and quantity of water, we think in terms of water purity and influence over flow regimes. The Yukon has wonderfully pure water. I recall twenty years ago doing some work on the Sixty Mile River before it was as heavily mined for placer gold as it now is. A fisheries biologist also working there at the time showed me a water sample he had drawn from Matson Creek at its confluence with the Sixty Mile. That sample was clearer than the vial of pure clear water in his comparison kit which he had brought with him from Vancouver. I am sure we all have an appreciation for the filtering effect of undisturbed forest ecosystems on the quality of our water.

The news media these days are carrying the distressing accounts of flooding in Germany, the Netherlands and England. While unusually heavy rains are the main cause of this, one reporter quoted a German scientist as attributing part of the cause to rapid runoff due to removal of forests and hedges in the Rhine watershed.

In the Yukon the forest legislation requires that a strip of forest be left along the margins of streams and lakes, presumably to continue to provide stability to these margins as well as to attempt to maintain the forest's function in water flow regulation. As I'll mention later, these strips are also important to wildlife and to people using these waterways for recreation purposes.

Air Quality

We are probably most aware of the effects a forest can have on air quality when there is a forest burning. Aircraft are grounded because of poor visibility. People with respiratory ailments experience even greater difficulty breathing. Also as a result of the smoke, we have some spectacular red sunsets.

We are probably less conscious most of the time of the importance of the boreal forest in the carbon cycle. Some writers in popular publications suggest that the world's boreal forests are as important in this regard as the world's rain forest. They refer to them as "the world's lungs" -- a reversed analogy. Some argue that a mature forest provides greater benefit in this regard than a young forest. I don't know who is right in that debate or even if we know enough about the subject for anyone to decide who is right. I do know that this is something which must be taken into account in managing the boreal forest ecosystem but that it will probably be taken care of by default if the other values of these ecosystems are maintained.

Soil Conservation

When I hear the term soil conservation I usually think of it in the context of agriculture. Even in the Yukon we have soil conservation programs aimed at Yukon farmers. It is well that we do. We should recognize however that some of the best soils in the Yukon are those found under the forest.

Dave Murray and Scott Smith have improved our understanding of Yukon soils with their presentation this morning. I want only to emphasize that we need to protect the soils of Yukon forests while we make use of the forest resources. In saying this I am thinking not only of forestry activities but also of access roads created for other purposes such as mining exploration. I have also seen instances where horse trail stream crossings have provided an opportunity for the stream to flow into the trail, cut a new channel and erode the soil. I have seen camping areas overused to the point where soil compaction has resulted in the death of the adjacent trees. I recognize that these may seem like relatively minor examples of soil loss but ecosystems are usually lost by immeasurable increments.

In talking briefly about soils I want as well to return to Dr. Kimmins' paper which I mentioned earlier. He suggested that while some tropical forests have very high above-ground species diversity some northern forests have very high below-ground animal and microbial diversity. In order to protect the overall diversity of boreal forests we need to protect the soil base.

I introduced the subject of ROTT, resources other than timber, with this brief ecosystem integrity discussion to set the stage for the remainder of this paper. I am convinced that unless we protect the integrity of boreal forest ecosystems through our management of them, human life will be poorer for it.

ROTT of Current and Future Significance

Country Food

Prior to the arrival of non-native people in the Yukon, the forest ecosystem had provided the food requirements of the aboriginal people. Some may point out that this food source was not always reliable and that starvation sometimes resulted. This is certainly true but it is still true in much of the world in spite of our capacity to produce, on this continent at least, food surpluses.

Studies have been carried out on the importance of the country foods to the physical and cultural well-being of First Nations people. The value of meat from such species as ground squirrels, waterfowl, upland game birds, and caribou, moose, and mountain sheep is significant in the economy of almost all Yukon First Nation communities. So is the food provided by freshwater and anadromous fish. It is significant because of its nutritional value. Country food just tastes better to most First Nations people than does store-bought food. It is also significant because of the economic saving that results for the individual from not having to pay money for this amount of food. This translates into a further benefit to the Yukon's economy in that presumably some of the money saved may be spent on items in the Yukon that do not result in the bulk of the funds immediately leaving the Territory.

Of perhaps equal significance to the First Nations is the importance of country food in retaining that important link to the land. Obtaining, preserving, sharing and preparing country food is important to maintaining many cultural traditions. There are others participating in this symposium who are better qualified than I am to speak to this aspect so I raise it only to draw your attention to it as a caution. Aboriginal culture has been substantially impoverished in other ecosystems in North America where dominant species which were relied on for food have disap- peared. We should be careful not to let it happen in the Yukon.

Country food is also important to non-native people. The annual hunting trip, whether for moose, caribou, sheep, upland game birds or waterfowl, is something that many Yukoners look forward to and enjoy. The meat produced by the hunt is counted on by many non-native Yukon families to supplement their diets which otherwise may consist mainly of imported foods.

The food provided by fish and wildlife is what comes to my mind most readily when I think about country foods but others think immediately of flowers, berries, herbs, and mushrooms. There are many traditional uses of these forest resources as food for First Nation families. The same is true of many non-native families. Berry picking is an enjoyable past-time in its own right as well as providing the raw ingredients for condiments, jellies and preserves.

The use of boreal forest plants for medicinal purposes continues to be practiced by First Nations people in traditional healing. The Yukon's Workers' Compensation Act provides for traditional healing to be accepted as a recognized form of treatment. While the policy governing this section of the Act has yet to be prepared, it is an indication that the value of these medicinal treatments is also being taken seriously outside First Nations society. Non-native people have also relied on herbal home remedies for years in the Yukon.

Besides personal home use of boreal forest plants for food and medicine there is potential, as yet largely unrealized, for commercial use of these resources. At present commercial harvest of wildlife for food is not permitted in the Yukon although traditional barter practices are written into the Porcupine Caribou Herd Management Agreement. Such traditional practices are also provided for in the Yukon Indian Land Claims Umbrella Final Agreement.

A feasibility study and a pilot project have been carried out on wild berry harvesting and processing in the Yukon. The results were not encouraging enough to prompt anyone to enter this field as yet. One can however cite examples of successful wild berry processing businesses in Scandinavian countries so it may simply be a matter of time before such businesses are established here. In Newfoundland the cloud berry, also called bake-apple, is harvested in large quantities. These berries are then shipped to Finland where they are made into an exquisite liqueur which is then imported only into Newfoundland. These berries grow well in the wild in the Yukon (as well as in Scandinavia) but thus far no one has been able to grow them in a cultivated situation. This may be an interesting research project for someone.

There appears to be increasing interest in herbal remedies and a variety of these can be purchased at health food stores even here in Whitehorse. This may be another opportunity for commercial use of boreal forest plants which have medicinal properties. A member of the Champagne-Aishihik First Nation has conducted field seminars on identifying plants with medicinal qualities and preparing traditional herbal medicines from them; there is likely unfulfilled demand for this need (market).

Wildflower honey finds a ready market and fireweed honey is usually available for sale in the Yukon every summer. Production varies with the weather and none of the Yukon's honey producers are able to derive their income solely from this business.

One boreal forest resource which has been receiving a lot of commercial harvesting interest in the last few years is wild mushroom picking. Mushrooms do well in areas which have recently been burned by forest fires. Mushroom pickers and mushroom buyers, most of them from British Columbia, have been coming into the Yukon as well as Alaska to take advantage of this phenomenon. I understand that numerous requests have been received from such companies for satellite imagery maps and the coordinates of the most recent forest fire areas. The dollar figures that are being mentioned are significant; one British Columbia company is rumoured to have bought one and a half million dollars worth of mushrooms picked in the recent Tok "burn" north of Beaver Creek on the Yukon-Alaska border.

This brings to mind the possibility that slash-burning in the Yukon following logging, were that to be shown to be an effective site preparation technique for reforestation here, might have the additional effect of releasing the nutrients that appear to prompt the mushroom growth. Management of cutover areas for mushroom production in the first few years following timber harvest may provide another forest resource use.

MATERIALS

The Boreal forest offers many materials from trees and woody plants that are processed into final form having by-passed the large industrial mills. Some of these are fashioned from the raw state by hand, in other cases, they may be processed by small capacity bandsaws or circular saws as a "cottage industry".

We consider these uses to be ROTT in that they are not "timber" in the conventional commercial sense. These activities are significant at the "grass-roots" level of the economy and society, being intimately connected to the independent life-styles and the sense of place enjoyed by those who live in the Boreal forest.

Building Materials

Dimensional kiln-dried lumber, plywood, and building panels are not the only way that northern woods are used in building. Many northerners live in homes that are built of round logs or rough-sawn cants. Many of homes are built by the owner with timber that is selectively cut from a dispersed area around the homesite. The home builder often gathers logs piecemeal from land clearings, right-of-way clearings and random forays into the forest. The satisfaction of personally crafting one's own home is a vital ingredient to many northern lifestyles.

Similarly, fence rails, posts, and poles are used by locals in many ways, especially in rural settings. These are often cut from forests nearby.

Fuelwood is vital to many northerners. It is near at hand, and it is the cheapest heat energy available for people who have more time than they have cash. Most rural homes are heated with wood usually cut by the homeowner. In some regions, even entire villages rely on fuelwood. Managed as a renewable resource, the use of fuelwood is a small example of regional self-sufficiency and can be an element of sustainable development.

Boats, Sleds, Snowshoes

For thousands of years, northern traveling technologies were based on materials from the forest. Cottonwood and spruce logs were burnt and adzed into dugout canoes. Spruce bark, birch bark, or moosehides were bent over frames and ribs of spruce, willow, or birch. The same woods were used for winter travel by snowshoe, dogsled and tobbagon.

Not everyone relys on these implements today. However, in some remote sites there are people who prefer to build the traditional "Yukon-style" poling boat or river scow over the commercial craft available. Some of these boats are built from store-bought lumber, but others are from local rough-sawn wood. They are cheap, durable, easily fixed, and handle currents, shallows and muddy landings in ways unknown to conventional boats.

Although some trappers and bush people make their own snow shoes and sleds, there is a growing market that values these as crafts and even folk art. Teslin snowshoes, for instance grace the walls of homes from Anchorage to Ontario and beyond into Europe.

Furniture

Furniture made from Boreal forests ranges from the highly processed commercial products of Ikea (definitely not ROTT) to curious contraptions found in trappers cabins. Yukon and National Park campgrounds feature picnic tables made from split solid logs. Bent willow chairs and couches are found in homes, cottages, and are sold in northern craft stores. Fire killed poplar and pine are sawed and planed and crafted into cabinets, desks, beds, tables, chairs, and panelling. Spruce is also used. Properly dried, the close grain of boreal woods are known to be structurally stable as well as pleasing to the eye. Lodgepole Pine is a bright and serviceable flooring if given a hard finish. Most of these woods are the result of selective cutting, often by the very people who craft them into fine products. Most of these products are custom-made, but some are marketed through specialty stores in northern communities.

Arts and Crafts

Northern homes and gift shops are full of arts and crafts that come from the forest. Raw materials vary, including such diverse items as driftwood, burls, bark, twigs, curiously shaped branches, and stumps. The objects produced are as varied as the materials: bowls, plates, cups, ladles, lamps, carvings, candleholders, bird decoys, picture frames, fine wood sculpture.

Arts and crafts are produced by a cross-section of northerners. Hobbyists make things for themselves and for others. Many dedi- cated craftspeople work out of their homes or backyard shops to supply gift stores or private commissions. Although most arts and crafts originating from the boreal forest are for personal or local use, some are exported.

Trapping

Trapping is an important forest-based activity in the Yukon. There are 371 Registered Trapping Concessions in the Yukon and 5 large group trapping areas which are held by Yukon First Nations. By virtue of these concessions or group areas trappers hold the right to harvest furbearers on them. There are approximately 460 licensed trappers in the Yukon who rely on trapping to a greater or lesser extent to earn a living or to supplement summer time wage employment. The value of the Yukon fur harvest has ranged from a high of 1.3 million dollars to a low of $ 250,000.

Essentially all trapping concessions in the Yukon include a portion of the boreal forest. Harvest of timber resources in those forested areas must respect the needs of the trapper and the habitat requirements of furbearers. This does not mean that there should be no logging on traplines. It does mean that the form of logging and the access constructed to support it should meet criteria suitable for the local conditions. Indications are that some furbearer species such as marten do not require continuous mature forest but can accommodate small clearcuts. The trapper can adapt his trapping practices to catch dispersing juvenile animals rather than the adults with established territories in the unharvested forests.

Leave strips along the margins of streams are important not just to prevent accelerated erosion of the banks. These strips also provide feeding habitat for aquatic furbearers such as beaver and travel corridors for other furbearers.

The fur market fluctuates and this in turn has an effect on trapping effort. The fur market price invariably returns to a level that provides sufficient inducement to the trapper to practice his craft. A trapper and his or her family can in most years realize a return on their investment of effort and equipment. This income can be earned year after year if the forest ecosystem is managed so that the habitat of the furbearers the trapper relies on is not disturbed to the point where there are not enough animals to make it worthwhile for the trapper.

In considering the total value of the fur harvest factors other than just the dollar value have to be taken into account. Trapping is a way of life and it is impossible to quantify the sense of well-being and self-worth that an individual trapper derives from pursuing a vocation that gives identity and purpose to life. In the absence of trapping some individuals are forced to rely on social assistance to maintain themselves. Lack of meaningful activity in the communities can contribute to social problems such as alcohol abuse. To counter these problems some jurisdic- tions such as the Northwest Territories have initiated a guaranteed fur price system to encourage trappers to make use of their trapping areas, even though the price paid for the fur by the government may be higher than the market price. Such a system in the long run is more economical than having idle people collecting social assistance in town.

Big Game Outfitting

Big game outfitting is another economic or commercial activity based on forest resources other than timber. There are 20 Registered Outfitting Concessions in the Yukon; these concessions give the outfitter the exclusive right to outfit and guide hunters within that concession. Non-resident hunters who are guided by the big game outfitters contribute approximately five million dollars per year to the Yukon economy.

Portions of all the outfitting concessions contain boreal forest which, at least for some part of the year if not for all of it, provide habitat for moose, caribou, and grizzly and black bears. Even sheep and goats in some areas can be found well below tree line at certain times of the year or when moving from one portion of their range to another. The habitat requirements of these large species have to be considered in managing the boreal forest ecosystem. They have to be considered in their own right obviously but also because a significant sector of the Yukon economy depends on their well-being and continued availability in huntable numbers.

I will mention here that hides that result from hunting activity by both resident and non-resident hunters may be processed at a local tannery. They may then be fashioned into products such as moccasins or slippers, mukluks, mitts, gloves, and jackets to be sold locally. I should also mention that not all the fur trapped in the territory is shipped out to the fur auctions. Some of it too is tanned locally and used in making mitts, trimming parkas and so on.

Grazing

The boreal forest under more open canopies and on grassy south facing slopes and meadows and wetlands produces forage which is sought by stock owners for their animals. From 1988 to 1990 a forage productivity study based on vegetation type and carrying capacity was carried out in the Yukon. This formed the basis for the Yukon government's grazing policy. Most outfitters have grazing leases as do a number of farmers. Generally no improvements other than fencing are permitted on these leases which convey to the lessee only the right to graze stock on the lease. The public is permitted access to other resources on the lease, such as fuelwood harvesting, which sometimes has lead to conflicts as a result of fences being damaged and stock getting out. Grazing is one of those other resources that needs to be accommodated in forest management.

Outdoor Recreation by Yukon Residents

I've already referred to hunting by Yukon residents. Other outdoor pursuits are also popular with Yukon residents and most of them take place against the backdrop of the boreal forest or else well within it. Yukoners watch birds, photograph wildlife, go for hikes, go for picnics, get out on dirt bikes and mountain bikes, go trail riding and the list goes on.

A few years ago when the Yukon 2000 economic planning exercise was underway Yukoners said that one of the things they valued about living here was the quality of the natural environment. The boreal forest is a major aspect of this and the attention focussed on managing it in the news media is a good indication of the care and concern people feel for this part of their environment -- they want to be able to continue to enjoy it as it is.

Tourism

After government, tourism jostles with mining as the second most important industry in the North. Unlike mining, it can be indefinitely maintained - it is an essential component of sustainable development here, and it is a major employer. It is not often recognized that tourism depends on the forest just as much as the forest products industry does.

It may be embarassing, but it is true that tourists do not come North for our fine theaters, haut cuisine and classic architecture. In one form or another, they are lured by our environment and by the human history and culture supported by it. Our environment is dominated by forests and our tourists experience the forest as either a scenic backdrop or as the actual setting for their vacation. In short, this multi million dollar industry depends upon ROTT.

The conventional road-bound bus tourist expects to enjoy dramatic views of pristine country on his or her route. The satisfaction of this need depends on the scenic integrity of the forest. Read ROTT. The Yukon and Alaska are developing a reputation as destinations where motorists can enjoy such views, since so much of the mountain West elsewhere has visible clear cuts.

Ecotourism and Adventure Travel are the fastest-growing segments of the tourism industry and are particularly well-suited to the North. Canoeing, rafting, backpacking, horse trips, dogsledding, wildlife watching, are examples of commercial tourism in the backcountry. As a destination experience, this field provides the maximum in employment and in retained dollars in the economy. It depends entirely on an intact forest ecosystem as the very setting for its product. An even-aged plantation will not provide this setting, nor will a well-managed industrial forest: the values, or ROTT inherent in a wild forest ecosystem is essential.

Closely associated with Ecotourism and Adventure travel is the emerging field of Native Cultural Tourism. One of the economic hopes for First Nations, this field meets a demand based on the yearning of customers to experience authentic land-based aboriginal culture in an authentic environment. In addition to providing the setting, ROTT provides country foods, craft materials and other ingredients for the the cultural encounter.

Intangible Benefits of Intact Forest Ecosystems

Lastly, I'd like just to mention a few of the intangible benefits of intact forest ecosystems. For many people forests are a place of solitude to which they can retreat to recover from the ravages of simple day-to-day life. This goes beyond recreation to what might be called "re-creation". Garry Merkel has reminded us that to some cultures the boreal forest contains "places of worship".

Other people find inspiration in the forest. Members of the Group of Seven painters certainly did. Their paintings of the boreal forest struck a responsive chord in many people and prints of these paintings still find a market. The Yukon has its own share of artists whose theme is the boreal forest.

Conclusion

This brief overview of ROTT, resources other than timber, has not been exhaustive nor has it done justice to the true value of these resources to society. These resources do not necessarily stand in the way of the use of the boreal forest's timber resources. They do require, however, careful management of the forest ecosystem to ensure that these resources are not diminished over time.

References

(1) Binkley, Dr. Clark. 1993? in Forestry on the Hill - Special Issue Biodiversity and Monocultures, pp. 54. Canadian Forestry Association, Ottawa, Ont.

(2) Kimmins, Dr. J.P. (Hamish). 1993? Biodiversity: An Environmental Imperative in Forestry on the Hill - Special Issue Biodiversity and Monocultures, pp. 3 - 12. Canadian Forestry Association, Ottawa, Ont.

QUESTION PERIOD

Topic: **Forest Resources Other Than Timber (ROTT)**
Speaker: **Bill Klassen**

Q: Mr. Klassen, you made the suggestion that many of these things are items that we can't put a value, or a price, on. I recognize that disposition. The aesthetic often touches us that way. Some years ago, I was working on a project in Glacier Bay. The number of whales that use Glacier Bay is limited -- 30 animals, 20 of which we would consider to be resident animals. When certain problems arose, we had to address an issue: what is a whale worth? At first, of course, it is not an answerable question -- because one locks into that aesthetic sense -- but we had to come up with an answer. I am suggesting to you that you have an opportunity to articulate that.

In our case -- if I just give you some simple figures. If tourism in Alaska is a $300 million experience, and 90 percent of the people -- according to surveys -- who come to Alaska come to interact with whales. If 90 percent of those people come to interact with whales and go into Glacier Bay because that's where it can be done, you end up recognizing -- when you look at tour vessel traffic and the cost that people pay for the ticket -- and coming up with a picture of what it would be worth if you wiped out that population. So, there is a mechanism. Again, I applaud the feeling that you ask us to address -- and Gary did the same -- and that's important. But I also recognize that, almost any academian in here will tremble at the idea, "Oh, my gosh, we might have to put a dollar value." But we have a certain number of kilometres, we have a certain number of viewpoints, we know tourism traffic, etc. So, I would encourage you to turn the screws down and get some numbers.

A: I appreciate the comment. Perhaps I am just reflecting my own ignorance of economics I remember my economics professor at the University of Alaska telling me, when I said I didn't know how I was going to try it, he was talking about much the same as you are -- putting a price on a sunset. I wouldn't suggest we burn a forest just to produce a nice sunset. You'd be able to figure out what that was worth, I guess. But, he said I wasn't an economist, and he was right. I wasn't even a good biologist. Numbers are not what I'm good at, but there are people in the Yukon who have gone through the kind of exercise you recommend, about determining what the value of wilderness is as a component of tourism. In another responsibility I've had, where you have to assess what the worst case scenario is on the environmental impact of a proposed project. We had to come up -- in order to be able to tell the developer what the bond would be with: what's a polar bear worth? Well, you may say, that's easy. It's just worth whatever the market will bear. If you sell a polar bear hunt for $18,000, then a polar bear is worth $18,000. But that's only part of what a polar bear is worth. So, I agree with you that we can put dollar values on it, as much as some of us may not even like to think about doing that. But we have to recognize that, even as we're putting that dollar value on whatever it is in the ecosystem -- at least, by my likes -- we're under-valuing them.

Q: I have really more of a follow-up comment. When you consider that tourism is -- depending on how you measure it and what the boundaries of it are -- somewhere in the neighbourhood of an $80 million dollar industry in the Yukon. If I recall the last figures from Harry right, forestry is approximately a $26 million industry. Follow that with the observation that the forest is the backdrop and the essential component for this $80 million industry, then it follows also that tourism is a major player in forest management. Really, what we're talking about is increasing our value system, and restructuring power, and how our different social values are arranged.

EVOLVING AND INCREASING DEMAND FOR FOREST DEVELOPMENT OPPORTUNITIES AND CONSERVATION VALUES: THE ALBERTA EXPERIENCE

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Abstract

Timing is everything. The past decade has given rise to boom times in the forest industry in Alberta. The government's decision to promote deciduous timber (a former weed species) for development and improved access and more infrastructure within the province linked with strong markets producing expansion opportunities provided the elements for successful economic development.

The identification of possible development areas and the associated promotion of these areas is not a random action. It results after addressing existing industry requirements as well as evaluating spatial distribution and type of timber resource to promote new development.

Expansion brings with it learning. Situations arose that showed that economic development cannot take place in isolation. Social considerations play a critical role. The general public as well as special interest groups clearly identified that they wanted to be involved in the future development of their provincial resources.

The lessons learned and the outcomes of those lessons have created a stronger understanding and respect for the values Albertans place on forest resources.

Introduction

Increasing, and competing, demands for forest development and forest conservation have become a fact of life in many parts of the globe. The Alberta experience records how these demands can evolve, and how they can be brought to satisfactory resolution.

The Alberta experience falls into a fairly concise 10-year timeframe. It was not much more than a decade ago that the province threw open its doors to some very intensive forest development - and to the social reactions that inevitably accompany such activity. Today we can look back on 10 years of rapid industrial development, and can make a fairly accurate assessment of what we did right, and what we might have done differently.

The Alberta boom

In many ways, the 1970s saw the end of forest industry as it had existed for a century in Alberta. That industry was stable, relatively invisible to the majority of the population, and reliant mostly on the coniferous sawlog. Our provincial forest inventory of the time reflected this focus on coniferous sawlogs, though there was some recognition of the deciduous forest covertypes. The first shift in utilization demands came as our two kraft pulp mills turned to smaller pulplogs.

At a global level, the industry was already expanding to meet market demand, but Alberta was slower to follow suit. The province had long been subject to perceptions that it suffered certain barriers to development. We are not located close to major markets and rely on rail transportation;

we do not have tidewater ports. Much of our uncommitted timber resource was in remote areas of the province, and access and infrastructure amenities were still not in place. Finally, much of that uncommitted resource was deciduous timber, long dismissed as weed species.

The decade of the 1980s brought unprecedented market strength, particularly in pulp, and this energized companies throughout the world to look for expansion opportunities. All of a sudden, Alberta became a very attractive place to investigate new business opportunities.

The province boasted a substantial volume of unallocated timber - 7.1 million cubic metres of deciduous and 6.8 million cubic metres of coniferous in 1986. At that time 54.7 per cent of our coniferous annual allowable cut was committed, and only 34 per cent of the deciduous AAC was committed.

However, the fact that much of this unallocated timber was deciduous was now something of a bonus, because more companies were starting to see the future for a hardwood diet in pulp mills and composite panelboard plants. Alberta offered a strong tenure system that provided security of fibre supply. Add in the province's low energy costs, abundant water supplies, competitive labor pool, low taxes and the government's willingness to expand the essential infrastructure, and it can be seen why the world was knocking on Alberta's door.

The government was not slow to recognize this opportunity for economic development. In 1986 it created a special branch, staffed by business economists and foresters, to assist industry in putting forward development proposals. Since then, this branch has overseen the investment of more than $3.5 billion in new pulp mills, panelboard mills, sawmills and remanufacturing plants. And there's another $3 billion in the wings.

In 1995, 99.6 per cent of our coniferous annual allowable cut is allocated. For deciduous, 88.6 per cent is allocated.

Summary of Provincial AAC Allocation

	1986	1995*
Conifer AAC	15.1 million m^3	12.8 million m^3
Committed AAC	8.3 million m^3 = 54.7%	12.7 million m^3 = 99.6%
Deciduous AAC	10.7 million m^3	9.3 million m^3
Committed AAC	3.6 million m^3 = 34%	8.2 million m^3 = 88.6%

* - committed AAC includes pending FMA reserves and quota sales
- AAC reflects supply analysis conducted and underway since September 1994

Handling the boom

Government staff were able to draw on some substantial science and information assets when faced with managing the public's interest in Alberta's ever-busier forest.

We were helped by the fact that 1986 marked the first renewal of long term (20 year) volume tenures, commonly known as quotas, in the province. This allowed us to draw up new agreements built on the best and latest resource information available. Some essential elements were -

- Annual Allowable Cuts were recalculated individually for each administrative, or forest management, unit.

● We used our most recent Phase 3 forest inventory data and new yield curves.

● We incorporated the government's evolving requirements regarding utilization and merchantability - companies were expected to make use of the smaller logs.

● We incorporated rotation ages that addressed the nature of the timber in each administrative unit.

● We incorporated more recognition of the environmental and other resource values as they affect the productive forest land base. These considerations were incorporated into computer models that offered a high degree of flexibility, compared to the formulas often used previously.

● We encouraged operational planning that recognized existing infrastructure, mill diet needs and community needs on a broad scale.

Still the focus was generally on coniferous timber, with only a few administrative areas in the province using deciduous timber on a commercial scale.

Planning for further development

Management plans for each administrative unit contained not only the long term harvest projections, but also the 20-year spatial distribution of operations within the unit.

This helped us see what timber, from which area, would be used. In turn this revealed areas not being fully utilized, and hence open for promotion as sites for future development.

The results

Within a very short time period four new major pulp and paper projects were announced. While the technical questions of fibre supply and infrastructure had, to a large extent, been well resolved, our staff were suddenly confronted by a storm of new, and perhaps unexpected, questions.

● The public wanted to know if potential environmental implications had been ignored for the sake of economic development. We soon discovered that we had not done a good job of telling the public what we were already doing, such as:

- adhering to existing legislation and policies;
- following certain processes in identifying timber development areas;
- following processes that ensured existing operations were carefully planned;
- following a coherent process of management planning, which included features such as integrated resource planning.

In the absence of this information, the public assumed the arrival of development was sinister, haphazard and not subject to controls.

● The public wanted to know why it didn't have a role to play in the process leading up to the allocation of timber development areas.

● The public wanted to know who would prevent the province from being shorn of all its forests in one fell swoop.

● The public wanted to know what level of information the government had when making decisions that would affect not just the resource, but also the broader economy and the social context of the province.

Misgivings quickly coalesced into quite intense opposition as fear filled the information vacuum. Opposition to forestry development became the mainstay of the headlines, and action groups sprang into existence.

The province's largest pulp mill project experienced lengthy delays as government and the proponents initiated a public review, information sessions and hearings. An Expert Panel on Forest Management was appointed to advise the Minister on public concerns about forest industry and its expansion. The Alberta-Pacific Environmental Assessment Review Board considered public concerns about the impact of pulp mills on the environment.

A short time later, the Alberta government was taken to court by individuals concerned with levels and standards of forest management in the province.

It could be said that ultimately the government won in both these situations, but when any issue reaches this level of confrontation, no one wins. No government or industry can afford to force the public into the loser's corner.

Alberta has moved beyond the confrontations of the 1980s, and we can list some of the efforts that have helped us achieve this:

- The government gave priority to several initiatives proposed by the Expert Panel, and has made commitments under several international frameworks such as the Brundtland Report. It has completed the Alberta Conservation Strategy, and is pressing hard for completion of the Alberta Forest Conservation Strategy and Special Places 2000 (a protected areas network), which will ensure preservation of representative natural areas.

- It has developed a public involvement component in forest management planning activities, and expects industry to use it.

- We have initiated a new forest inventory that incorporates more than fibre information.

- We are currently conducting research and publishing reports in topics that reflect an ecosystem-based forest management strategy.

- Ecosystem management principles, which consider the vitality of all components and values of an ecosystem, are under development and implementation. Industry is using public input to develop and monitor its standards of forest practice, under the Forest Care Code initiated by the Alberta Forest Products Association.

- The government has made strong commitments to national developments such as the National Forest Strategy and the National Biodiversity Strategy.

Ten years after

Alberta today counts forestry as its fourth largest industry. We have 200 sawmills, three oriented strandboard mills, one medium density fibreboard plant and one plywood mill. There are six pulp mills, four producing kraft pulp and two CTMP. We also have one newsprint mill and two paperboard and felt producers. Two new OSB plants are now under construction. Total direct and indirect employment is about 50,000, and total shipments are valued at about $2.5 billion a year. The industry has become a pillar of the capital city's economy, and of the career pages of the local newspapers. It also brings stability, security and diversification to many of the province's more remote and isolated communities.

The negative headlines today are few, though we have learned to never take that for granted. The number of private Albertans involved in round tables, strategy development, planning committees and policy initiatives is enormous.

It has been a learning experience for everyone, and a journey that has brought us to the point where there is a lot of confidence and stability in Alberta's forest sector. Just as important, it has taught us how to build partnerships which allow all sides to really articulate why they hold certain forest values dear to their hearts, and how they want to protect these values in a spirit of mutual concern.

The lessons

- Take heed, and develop a broad focus from as early a stage as possible. The more parties you can involve from the beginning, the smoother the road will be. There is a learning process that all parties must undertake, so start early to save time later. Make sure you are able to collect and analyze all the information you need. Inventory processes must match the sophistication of the decisions to be made and the pressures you will face.

- Timber planning in isolation is land use planning by default. Do your planning in the broad context of the overall direction you wish to take. Never assume timber is the only resource in an area.

- Keep sustainability in a broad context. Be aware of all resource uses and demands. Identify your long term objectives before proceeding with development. Ensure the appropriate legislation and tenures are in place to facilitate your approach.

- Development forces consideration of expansionary issues, such as regional infrastructure, social impacts and environmental impacts.

- Development forces consideration of industrial change and rationalization. Certain operations will face closure, or a change of focus.

- Development forces consideration of wood supply issues, including sustainable forest management, environmental challenges and internal administrative resources, such as staff, budgets, policing and expertise.

Conclusion

There are two sides to the forest management story. On one side is industrial development, with its issues of utilization, expansion, secondary processing and social impacts. On the other is conservation, with its equally pressing issues of old growth management, esthetic appeal of the forest, aboriginal values and the need for protected areas.

A first step for any jurisdiction facing accelerated forest development is to choose an overall management direction for the long term. Immediately after this the various management and tenure issues can be addressed in a coherent and rational fashion. Involve the public from the start, and the forests, the industry and the economy will flourish.

QUESTION PERIOD

Topic: **Evolving and Increasing Demand for Forest Development Opportunities and Conservation Values -- The Alberta Experience**
Speaker: **Dr. Kenneth Higginbotham**

Q: Can you indicate a concern around private land, and logging on private land. What percentage can you estimate for us, in Alberta, of merchantable timber is on private land versus provincially-owned land?

A: I don't know the exact figure, but it is very small -- not more than 10 percent, I would think, and much of it is hardwood. I think that's one of the things that has raised the concern that exists now, because so much of the private land harvesting is focused on the softwood, and there's an awful lot of that on the private land, which, of course, is largely in the southern part of the province.

Q: You made a very brief comment about pegging stumpage rates and that that might lead to mill closures. Can you talk a little bit about Alberta's stumpage system and why you make that comment?

A: Well, it's easier to talk about it now than it was a year ago. A year ago, we had a stumpage rate that had been set at a given level and had been in place since 1976. It was set at that level with all good intention because the industry was in the tank -- the sawmill and the industry at the time that the dues rate was set at that level. But what we did a year ago, or something more than a year ago, was went to the industry association and indicated to them that the revenue that was coming to the Crown -- regardless of all the jobs, and so forth, that were being produced -- was not sufficient.

We suggested to them some sort of a market-based system. We have an excellent relationship, generally speaking, with our industry, and they sat down and negotiated a new system with us. It is based on the establishment of a base rate of stumpage that is in place until such time as the price for lumber, or whatever the commodity is, exceeds the cost of producing it. After that, the stumpage rate goes up fairly dramatically, and it is based very much like our natural gas royalty system is, where the government then takes a percentage of "profits". It starts out at 15 percent and goes up to 50 percent, at its highest level.

So, the day that our new system went in to place, the rate for saw logs went from 70 cents per cubic metre to $25.00 per cubic metre. It has followed, though, the market during the year, and currently the rate is about $8.00 per cubic metre. The industry seems to like it, particulary as we dealt with some issues around the costs that we would charge for salvage wood -- so-called black wood -- or bug-killed wood and poor quality wood. We have recently concluded discussions with the hardwood producers in the province on a system that would be very much the same.

The key thing for us was to gain a fair return for the people of the province for its resources, even though the companies hire people, pay them, they pay taxes, they spend money. But the resource needs to have a fair return. But it was our view that it needed to follow the conditions out there, given the fact that all the sectors of the forest industry are cyclic.

Q: I have two questions. The first one -- you mentioned the Lubicon Cree. I wish there was somebody here from the Lubicon Cree to maybe respond. But I was just wondering what are the actual steps that the Alberta government has done concerning some of the concerns of the Lubicon Cree, especially around forest management issues that do affect traditional uses of the land?

My second question has to do --I'm from British Columbia, and we have a little bit longer history, in terms of providing economic development opportunities for incorporations, than maybe Alberta has with regards to the forest sector, at least. I was just wondering if there has been any assessment, in terms of the actual resource wealth, that will be, basically, exported out of the province of Alberta because of the level of foreign corporate control that has been granted over the last few years?

A: Maybe I could try the second question first. There have been some assessments that, I guess, would probably be viewed as an academic approach to trying to view these things after the fact. The assessments vary substantially, depending on the assumptions that the various analysts put in to it. They range from the book that recently came out, *The Last Great Forest*, which is highly critical of the Alberta Pacific and Diashowa forest management agreement allocations and mill constructions, to others, which suggest that these are very good things, not only for the communities in which they're located, but for the province generally. In the case of the Lubicon situation, the issue, as you well know, is complex. The Lubicon's biggest problem is that they do not have a settled land claim with the federal government. They are interested in doing so, and the federal government appears to be interested sometimes and not, at other times.

Some would suggest that the natives are asking too much. There are arguments over how many members of the band there are. In the recent history, there have been two bands recognized that are, in essence, or could be said to be, split-offs from the Lubicon Cree -- the Woodland Cree and the Loon River Cree. The Woodland Cree have had a settled land claim, and it sits right next door to where the Lubicons are. Some would suggest that those other two bands have just as much right, in terms of trapping, and so forth, as do the Lubicons. So, it's very complex in that regard.

The provincial government, several years ago, negotiated with the chief a land claim agreement, and that area was withdrawn from any of the forest industry development activity. At the present time, no harvesting is occurring in that traditional use area, largely as a result of the fact that the Diashowa has determined not to do it. But the time is going to come when, for forest management purposes, they're not going to have any other choices, and I'm not sure what will happen. Historically, however, for other activities, such as reforestation projects that we've carried out from former harvesting by quota operators, pipeline access across that general area, oil and gas developments within the area, and so forth, have been able to be worked out quite effectively by sitting down and talking about things, such as economic opportunity for the band, location of the pipeline, or location of the pump station, or whatever it might be. I think it comes down to the specifics of given situations. Both the various types of industry and the band have worked fairly well together. The bigger issue, which gets tied up in the politics of the final settling of this thing, though, is what really makes it difficult.

Q: Just to follow up a bit on the first question you answered. Government hasn't done any assessments, in terms of the actual amount of resource value or the level of support that has been provided by the people of Alberta. I recently read some interesting figures that for every Albertan, the actual -- just the one mill, ALPAC mill -- will cost them up to $2,600 each, for every Albertan, to have that facility in place and operating over the term of its license. I was just wondering whether or not the Government of Alberta has done any kind of assessment, in terms of how much it has cost to make these opportunities available for foreign corporations.

A: If the government has done that type of analysis, I am not aware of it. I am sure that the people in Treasury in the province, who are responsible for the concerns you are raising around loan guarantees, and what not, are probably tracking that kind of thing pretty closely. The fact, of course, is that what the government has committed to is loan guarantees and debentures, which are to be paid back. Now, if the project was to fail, of course, then it might cost that $2,600 per person. The mill is built, however. It came on line faster than any other pulp mill that I am aware of, to its rate of capacity. It's operating now above its rated capacity on some days. Now, of course, with the markets the way they are, it's making money. The government is not out-of-pocket at this point, other than some infrastructure help that they provided, in terms of roads and the rail. In both cases, except where the rail goes from the spur line, which was built over to the mill, the rail line is being used for other things besides that company.

Q: Could you just go over the CTP system in Alberta -- how you distribute the timber to the small operators, and stuff like that?

A: Yeah, I could do it very simply and say we are changing the system. The CTP system -- for those of you who may not be aware -- is commercial timber permits. They can be coniferous or deciduous. The system was put in place to provide, in essence, own use wood supplies to farmers, and others, who live in rural areas. Over time, of course, the wood from those permits is being used for mills, and that kind of thing.

Typically, what we have done is developed -- what we call -- miscellaneous timber use programs within ranger districts within our administrative structure within the forest service. What we have normally done, is invited a group of people, who are the loggers and/or sawmillers -- who would be using the permit wood -- to come together and decide how they want the permits allocated. Do they want five big ones, or 15 small ones? -- that kind of input. There have been lots of problems with it. Primarily, they have become a major concern over the past two or three years, since while we allocate them according to what those committees may want, we do normally put them up for bid. The commercial timber permits have been selling at sky-high prices -- prices that, really, many of those farmers, and so forth, can't afford to pay, even though the price of lumber is as high as it has been over the past few months. So, it's been suggested that we need to come up with a different system -- or, at least, a revised system.

Recently, the Northern Alberta Development Council, with our assistance, has done a study and has made some recommendations that would lead, in essence, to those local committees deciding who it is that should get wood in an area, i.e. who the eligible receivers of permits would be. Then, the volumes would be determined

through that consultative process, up to whatever the level of allowable cut is in the miscellaneous timber use program. Then, the stumpage that would be paid would be the regulation rate, ie. the same a quota holder would pay, or something like that. The system is due to go before the Standing Policy Committee of the Legislature on Natural Resources, and we'll see if they are in agreement with what the development council has come up with.

ECOLOGY OF THE NORTHERN FORESTS

by

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Ecology of the Northern Forests. Edmond C. Packee, Ph.D., School of Agriculture and Land Resources Management, University of Alaska Fairbanks, Fairbanks, Alaska.

John Zasada and my desire today is to present ideas and realities about the ecology and silviculture of the Northern Forests of the Yukon. These ideas, we hope, will benefit the people of the northwesternmost portion of Canada. The decision of how to manage the Northern Forests of the Yukon, a truly sustainable resource, is left to the people of the Yukon. You determine and set your own forest policies to ensure a sustainable resource for future generations. You set the policy on how these forests are to be managed and for what.

INTRODUCTION

Northern Canada, Canada north of latitude 60° N, is vastly different from the more settled portions of the country. In summer it is the land of the midnight sun and in winter a land of long, frigid nights and shimmering northern lights. The Yukon Territory, the Canadian "Jewel of the North" is immortalized in "The Spell of the Yukon" and the "Cremation of Sam McGee" by Robert Service.

Depending upon the way it is measured, the Yukon Territory has a gross area, land and water, of 482,681 to 536,325 square kilometres (Oswald and Senyk 1977). The MILEPOST (Graef 1994) suggests even fewer—482,573. The Yukon Bureau of Statistics (1994) states that there are 483,540 square kilometres of which 4,480 are water. Elevations range from sea level in the north to 5,951 metres (Mt. Logan) in the St. Elias Mountains in the southwest. Vegetation ranges from "dense" closed forests to grasslands and alpine and Arctic tundra. The Fact Sheet (Yukon Bureau of Statistics 1994) states that there 281,030 square kilometres of forest and 197,940 square kilometres of non-forest. Emphasis in this paper is on the forested area.

To address the ecology of the forests as a prelude to the discussion of the management of the forest requires an understanding of basic concepts, a brief review of the environmental setting, and a discussion of the silvics of the species, community ecology, and ecosystem processes.

BASIC CONCEPTS

FORESTRY

Forestry is "...the science, business, and art of creating, conserving, and managing forests and forest lands for the continuing use of their resources" (Society of American Foresters 1991). It is "the management of forest lands for the many products and services the forest can permanently supply, and the sustained use of these products and services for the benefit of mankind" (Shirley 1952). It is the willful manipulation of forest stands to provide goods and services. Such manipulation is referred to as silviculture. Silviculture is "the art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands" (Silviculture Instructors'

Subgroup 1993). Clearly, forestry is far more than just cutting timber.

To be a good silviculturist, an individual must be a good ecologist; but a good ecologist does not necessarily make a good silviculturist or resource manager!

ECOLOGY

The term "ecology" once had a fairly precise meaning. However, since becoming part of the average citizen's vocabulary, the term means different things to different people. To avoid confusion, a strong definition and understanding of the term are essential. Ecology, comes from the Greek and literally means the study of organisms at home. Webster's Unabridged dictionary defines ecology as the "totality or pattern of relations between organisms and their environment." Odum (1971) defines ecology as the study of the structure and function of nature, it being understood that mankind is a part of nature." Ecology deals with species and communities. Community suggests relationships or interactions. And humans are a part of communities, interact with the communities, and function as part of the communities.

ECOSYSTEM

An ecosystem is "Any unit including all of the of the organisms (i.e., the 'community') in a given area interacting with the physical environment so that a flow of energy leads to a clearly defined trophic [food chain] structure, biotic diversity, and material cycles (i.e., exchange of materials between living and non-living parts) within the system" (Odum 1971). The size of an ecosystem can range from smaller than the hollow inside of one's eyelash to global. It can be an individual tree branch, an individual tree, a forest stand, a watershed, a portion of a stream, or a lake. The size and "what" an ecosystem encompasses often is determined by the manager's or researcher's objectives or interests.

In addition to species, an ecosystem has structures, processes, and functions. It is critical to use the structures, processes, and functions, to achieve society's goals. Heady and Child (1994) state: "The manager's approach should be one of guiding, not replacing, the natural processes of ecosystem succession toward societal goals as rapidly as possible." To cost effectively apply such an approach requires the recognition of ecosystem units. Fortunately, several basic ecosystem classification building blocks, specific to the Yukon, already exist:

Ecoregions of Yukon Territory by Oswald and Senyk (1977); and

Forest Communities in Lake Laberge Ecoregion, Yukon Territory by Oswald and Brown (1986).

Some Silvicultural Ecosystems in the Yukon by Stanek and Orloci (1987).

From neighboring British Columbia and Alaska, you have two complementary building blocks:

Ecosystems of British Columbia prepared by Meidinger and Pojar (1991); and

The Alaska Vegetation Classification by Viereck and colleagues (1992).

Understanding the implications and information provided by these building blocks is essential to being a good ecologist and hence a good resource manager in the Yukon.

SUCCESSION AND CLIMAX

We often hear reference made to an ecosystem having reached a steady state or comments that nature is in a delicate balance and that humans upset that balance. In the Northern Forest, especially that of the Yukon and Alaska, three closely associated concepts must be addressed: 1) climax, 2) succession, and 3) disturbance. The latter two certainly challenge the idea of a steady state or a balance. Today, the term "climax" is out of vogue (politically incorrect?); the substitute term appears to be "old-growth"; but old-growth can refer to any forest of any species that has reached a specific age. That specific age has been determined, arbitrarily, by humans; on a given site, it often ignores stand characteristics, ecosystem processes, and ecosystem functions.

The concept of climax continues to evolve. I present three definitions of climax for consideration:

- "The final or stable biotic community in a developmental series (sere); it is self-perpetuating and in equilibrium with the physical habitat" attributed to Odum (1971) by Schwarz et al. (1976).
- "A more or less stable biotic community which is in equilibrium with existing environmental conditions and which represents the terminal stage of an ecological succession"—Lincoln et al. (1982).
- "A species or community that is self-regenerating, with no evidence of replacement and in which all species appear to be maintaining their population densities"—Lee and Pfister (1978).

Note that the definition of Lee and Pfister (1978) is the least restrictive. Unquestionably, there is a tendency for communities to evolve toward a climax condition. This condition is fixed by environmental limitations regional climate, elevation, topographic position (aspect, slope, position on slope, slope configuration), parent material, soil moisture, and soil temperature. Within any particular regional unit, a polyclimax, many site specific climaxes, is the rule. More importantly, biotic or abiotic disturbances often thwart achievement of climax. The question begs, do forests of the Yukon routinely reach a climax stage? Climax forest stands that I am sure of are black spruce dominated stands on permafrost soils, especially on north slopes; open black spruce forest stands where permafrost is dominant; and the open white spruce forests near Arctic tree line. Pure alpine fir forests in the subalpine zone are also likely to be climax.

Definitions of succession also occur throughout the literature.

- "...an orderly process of biotic community development that involves species, structure and community processes with time; it is reasonably directional and, therefore, predictable"—Schwarz et al. (1976).
- The gradual and predictable process of progressive community change and replacement, leading towards a stable climax community; the process of continuous colonization and extinction of species populations at a particular site;..."—Lincoln et al. (1982).
- "The progressive changes in plant communities toward climax"—Lee and Pfister (1978).

Note the simplicity in the definition of Lee and Pfister (1978); there is no mention of orderly process or predictability! I suggest, that looking for predictability or orderly development often leads one down a hypothetical but non-realistic path; chaos theory is totally ignored. Development of an ecosystem does not have to follow the same pathway every time and spatial patterns of the species vary considerably. This is not to say that there are not some general directional pathways.

Connell and Slayter (1977) define succession as "the changes observed in an ecological community following a perturbation [disturbance] that opens up a relatively large space." There are four pathways and all can be working at a particular time in the Northern Forest.

FACILITATION: One dominant species or group of species modifies the environment in ways that make possible the entry of a second species or group of species. The second species or group becomes dominant and modifies the environment in ways that suppresses the first species or group and makes possible the entry of a third dominant. The third, in turn, alters its environment for the fourth, and so forth, progressing toward the climax (Connell and Slayter 1977). Plant colonization of a flood plain, a sand dune, or gravel pit are excellent examples.

TOLERANCE: Modifications wrought on the environment by early colonists neither increase nor reduce rates of recruitment or growth of later colonists. The species that gain dominance later are simply those that arrive either at the beginning of colonization or later and then grew slowly ultimately outlasting the earlier, less tolerant individuals (Connell and Slayter 1977). For example, white spruce can tolerate the shade of paper birch or quaking aspen, but not vice-versa.

INHIBITION: Once earlier colonists secure the space or other resources, they inhibit the invasion of subsequent colonists or suppress the growth of those already present. By interfering with further invasion they may prevent succession from progressing (Connell and Slayter 1977). Examples include quaking aspen leaf fall/litter inhibiting later colonization by white spruce or sod formation by bluejoint (*Calamagrostis canadensis*) blocking seedling establishment of conifers and hardwoods.

PARALLEL: Early and late colonists grow together, sharing the same crown position for extended periods, without either physically dominating or interfering substantially with each other. Replacement occurs simply because the late arriving species continue to grow in size, whereas the early species decline in growth rate at a certain stage of community development (Osawa 1992). Examples include white spruce and black spruce sharing the same permafrost-free, westerly aspects and tamarack and black spruce occurring on permafrost-rich muskeg. The pairs of species seem to regenerate together and compete without excluding each other.

Depending on the site, stage of community development, vegetation layer being considered, and the species present, all of the pathways can operate at the same time! The process of succession is not straight forward! However, where ecosystems can support closed canopy forests, a simple pattern of stages develops. Oliver and Larson (1990) list four stages of development following disturbance that are typical of most temperate and boreal forest stands or communities:

STAND INITIATION STAGE: After disturbance, new individuals and species continue to invade/appear and colonize the site for several years.

STEM EXCLUSION STAGE: After several years, new individuals do not invade and some already present die; survivors grow larger and express differences in height and diameter; one species may appear to replace another.

UNDERSTORY REINITIATION STAGE: The dominant overstory begins to die and the stand begins to open up; forest floor herbs, shrubs, and advanced regeneration again invade/appear and survive in the understory; however, vigor and growth may be low.

OLD GROWTH STAGE: Dominant overstory trees die in an irregular fashion and some of the understory trees begin to grow into the overstory.

These stages seem to parallel the stand cycle suggested by Watt in 1947:

- pioneer,
- building,
- mature, and
- degeneration (senescence).

Does this suggest that the old-growth stage for some stands is really one of a community falling apart? Or one in which losses are balanced by new recruits? The new recruits are able to enter the forest due to minor disturbances that create holes in the overstory canopy.

DISTURBANCE

Until I read the book, *The New Catastrophism: The importance of the rare event in geological history* by Derek Ager (1993), I was rather complacent about disturbance—disturbances were just happenings. But Ager talked about violence and rare event—catastrophes. The Northern Forest landscape became excitingly alive with catastrophic disturbances thwarting development of the climax community! Fire, insects, flood, avalanches, permafrost (accretion and ablation), glaciers (advance, retreat, and surge), eolian deposits, and volcanoes were catastrophes. At the other end of the spectrum are minor disturbances ranging from a single tree dying to a small open patch created by windthrow or beaver cutting individual trees along a river bank. All are impacting the Yukon today.

How rare is rare in the development of the ecosystem? I think of rarity as a combination of frequency and intensity (violence). However, a single event can be sufficiently violent to destroy an individual, a living community, a forest stand, or a complex of communities or stands. This violent event is the rare event in the life of that individual or community, but it is significant.

Fire is today, a common natural occurrence in the Yukon. Upland soil profiles typically contain charcoal. We are well aware of the Eg Fire Complex just south of the Yukon border in British Columbia, the more recent Hyland River fires south and east of Watson Lake, The Tok fires in the Eastern Interior Forest Zone of Alaska (Zasada and Packee 1994) where hundreds of lightning strikes can occur in a single day! Natural fire frequency is high in the Northern Forest (Tables 1a and 1b). Fire return averages 100 to 175 years on non-flood plain sites. Intensity of fire and area burned determine how far succession is set back. Intensity and frequency depend on biomass production and the parallel build-up of fuel (the fuel loading).

There are many single cohort stands of lodgepole pine in the southern Yukon that cover several thousand hectares. Fires in the Northern Forest can exceed a million hectares. The mid-1980's Great Black Dragon Fire in northern China was more than a million hectares; and the fire complex to the north in Siberia was around six million hectares. The 1982 Eg Fire complex in northeastern British Columbia covers a mere 300,000 or so hectares. Such fires were catastrophic. Excluding reburns within the first 20 to 40 years after the major disturbance, it is unlikely that these areas will experience another catastrophic fire for 100 to 200 years—the fuel structure and loading simply are not there.

One must recognize that on a landscape basis, these large fires did not burn everything. Typically, there are pockets of forest that did not burn. These pockets can range from a few to several hundred hectares. The unburned area may have been protected by a body of water, may have been a different forest type (species or age), be unburned just by chance. These patches are important as refugia. They contribute to the landscape mosaic and thus to biodiversity. Note that the patchwork of stands in a large burn is just the opposite of that created by man's good intentions of limiting the size of clear-cut harvest units to a few to one hundred hectares. To be sure, there are many small burns; the point is that small harvest units in a large burn do not mimic the types of habitats created naturally. Large burns create new stands with much "interior" stand structure and little edge effect.

Insects are another element of change. The current outbreak of spruce beetle (*Dendroctonus rufipennis*) now exceeds 1.2 million acres in Alaska and continues to spread. White spruce down to eight centimetres in diameter, much smaller than the 20-centimetre limit anticipated, is attacked and killed. This species of bark beetle is even attacking black spruce. In the upper Alsek drainage west of Haines Junction, this beetle reached outbreak proportions in 1994. It apparently has done so in the past. Engraver beetles, species of *Ips*, are also active killers of spruce. In British Columbia, the mountain pine beetle *(Dendroctonus ponderosae)* attacks and kills lodgepole pine. Bark beetles and engraver beetles set ecosystem development back successionally and increase the risk of fire that will further set back succession. On the other hand, the mountain pine beetle may speed succession along by releasing the more shade tolerant spruce in the understory. Most important is to recognize that these beetles are endemic to the Northern Forests and wait their time until the stand is stressed to explode into a major outbreak. They survive near the base of the trees below the snow under bark or in the litter, sheltered from temperatures -40°C or colder!

Catastrophic glacial events of the Holocene (the last 10,000) are common in the Northern Forest of the Yukon and Alaska (Table 2). A series of glacial cycles began about 4,000 years ago. The white spruce forest surrounding Haines Junction is less than 150 years old; the "Another Lost Whole Moose Catalogue" (Lost Moose Publishing 1991) suggests that Lake Alsek was present in the mid-1880's. Lowell Glacier, a surge glacier, dammed the Alsek River forming a large glacial lake. Visualize the icebergs floating on Lake Alsek! It took only a few days to drain the majority of this lake; the flow, allegedly, equaled that of the Amazon!

In Alaska the Black Rapids Glacier south of Delta Junction advanced at rates of up to 200 feet per day during 1937. It was feared that the glacier would cut the Richardson Highway and destroy the Black Rapids Roadhouse so spectacular was the event that a radio announcer was stationed at the roadhouse to broadcast the details of the glacier's advance and the destruction of the highway and roadhouse; the glacier did not quite make it to the highway or roadhouse. Some suggest that Black Rapids Glacier is on a 60-year cycle. The oldest Holocene moraine of the Black Rapids Glacier adjoins forest stands of white spruce that are older than the trees on the moraine (Péwé and Reger 1983). Many southwest Yukon glaciers like the Lowell, the Donjek, Klutlan are surge glaciers similar to the Black Rapids Glacier.

Normal melt of glaciers presents another kind of catastrophic event—retreating glaciers expose glacial till and outwash for plant colonization. Till and outwash commonly are moved downstream creating braided river channels and fresh alluvial materials for retransportation or plant colonization. All one has to do is look at the White River, the Donjek River, the Duke River, to see the braided stream character. Flooding erodes and redeposits; destroys and recreates. Transportation of sediments and flooding impacts the forest strongly. Balsam poplar is adapted to sediment deposition; conifers, birch, and aspen are not. White spruce cannot handle extended periods of flooding when the soil is not frozen.

Now a quick look at permafrost. There are essentially three zones of permafrost: Continuous, Discontinuous, and Sporadic. Most mapping lumps Discontinuous and Sporadic together. Disturbance that impacts the forest canopy can also affect permafrost. Ice-rich permafrost can develop thaw ponds following disturbance. Where ice is lacking, the permafrost table recedes. At the University of Alaska Experimental Farm in Fairbanks, the permafrost is 8 metres or more below the surface and under the adjacent black spruce forest, the surface it is within 30 centimetres of the mineral soil horizon.

Volcanic activity has not spared the Yukon. The White River Ash covers much of the southern Yukon. The whitish-gray ash spewed forth from Mt. Bono just inside Alaska in the St. Elias Range. The volcano did more than just dust the Territory. The two eruptions, one a little more than 1900 years ago and the other about 1275 years ago left deposits in some places in excess of 50 centimetres deep. Today the thick ash deposits are frozen; permafrost invaded the ash. One can see these deep, frozen ash deposits just west of the Donjek River bridge.

Wind does more than merely blow trees over. The shifting and blowing sands of the Carcross area are and example of a process that once was more widespread and could again become more widespread if climatic changes sufficiently. Where the dunes are stabilized, forests grow.

Finally, humans (aboriginal and modern) have had an impact on the forest. Humans are part of nature. Canada's First Nation People in the north used fire in spring, summer, and fall to create habitats essential to their well-being. More recently, travel on the river systems required steam to power the river boats and gold dredges and for thawing frozen ground; and the fuel was wood from the riparian zone and lower slopes adjacent to the rivers. Logs were floated down river as large rafts to mill sites for conversion into construction lumber, planking, mine timbers and lagging. Bisset et al. (1993) provide a detailed summary of reported harvesting for the 75-year period, 1896-1970. Without a doubt, Bisset and colleagues (1993) indicate a substantial, but temporary, impact on stand species composition and structure; what is unknown is the impact on the genetic base.

BIODIVERSITY

Biodiversity, short for biological diversity, as defined by the Society of American Foresters (1991), is "The variety and abundance of species, their genetic composition, and the communities, ecosystems, and landscapes in which they occur. It also refers to ecological structures, functions, and processes at all these levels. Biological diversity occurs at spatial scales that range from local through regional to global." Diversity of plant communities creates a vegetation mosaic across the landscape. Species are distributed along environmental gradients. Adding to the mosaic are patterns resulting from disturbance and recovery (Romme and Knight 1982). The mosaic idea is very important in the Northern Forest. This is so obvious after the discussion of disturbance. Keep in mind, topography, soils, and climate also contribute to the biodiversity of the Northern Forest.

Biodiversity is more than species richness. Oftentimes, species richness gets more attention than the other components of biodiversity. This is particularly true when it comes to managing the resources.

Briefly, we often talk about a species. However, when it comes to resource management we are not just managing a species but a population of the species which is relatively distinct. White spruce in Newfoundland most likely has a genetic structure vastly different from that found in the Yukon. On a smaller scale, white spruce in the Firth River is probably quite different than that found near Watson Lake. A breeding population of a species is called a deme. Regeneration methods should be directed toward managing for the particular deme. Natural regeneration, as long as the stand has not been high-graded, provides the greatest opportunity to utilize the full extent of the local breeding population. Other demes should only be introduced after careful testing. This really raises questions about planting programs. There is a need for seed zones and seed transfer rules to ensure a successful and healthy artificial regeneration program.

Ecosystem structure, processes, and functions are often ignored. In many cases, they are not known or, if known, not understood. Both the scientist and manager are at fault. There is a communication gap. I wish to illustrate with one example. Clearcuts are often kept small to ensure maintaining adequate habitat for this or that species. Yet, there are numerous areas of fire originated stands that cover hundreds to thousands of hectares. If society really wishes to address biodiversity, should not the forest manager be harvesting such stands on the scale of the disturbance? There are big fires and little fires and the proper mix may be essential for the maintenance of processes and structures.

SUSTAINABILITY

The concept of sustainability is now a key consideration with respect to resource development in modern society. It is used in reference to ecosystem integrity and health; it is also used in reference to cultural communities (Rolston 1994).

The United Nations (1987) defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Because "sustainable" is usually coupled with "development" or "growth," it suggests that as a conservation philosophy, it means continued growth (Rolston 1994). It also suggests maintaining the productivity of the land for the uses policy has determined desirable.

The Canadian Council of Forest Ministers (1992) states, "Sustainable development in forestry expands the principle of sustained timber yield, to which the Canadian community has traditionally been committed, by including wildlife and fish habitats, watersheds and hydrological cycles, as well as gene pools and species diversity, to ensure that the use of forest today does not damage prospects for its use by future generations." This principle guides human activities so that they remain with the tolerance limits of the environment.

Most professional forest resource managers believe that their efforts protect and ensure the long-term health of the resource. I emphasize the words, "most" and "resource managers." This does not mean maximize one resource at the total expense or demise of another. In the case of the forest, this means maintaining the productivity of the land and the biological diversity. Biological diversity is essential to long term productivity. A policy decision must be made by the people of the Yukon as to what level and kind of productivity they wish to sustain for their generation and the generations of the future. There are three components to this decision, they can be viewed as an equilateral triangle:

- Biological (Ecological) Constraints: all-limiting; this is the limit of what can be done. All organisms live and die; trying to preserve an old-growth forest stand forever, doesn't work; replacement stands must be created and are essential for ensuring exist for the use of future generations.

- Economic Constraints: what is society or a segment of society prepared to pay for maintaining a certain level of productivity or stand structure? Are 1,002 pairs of marten worth 90 percent more investment than 1,000 pairs?

- Social Constraints: within the biological or ecological realities, what will society accept? Is timber harvest without regeneration acceptable to society?

Developing the forest resource on a sustainable basis requires much thought. It cannot be done without having an adequate reforestation plan (target) attached to the timber harvest plan. It can't be done without knowing something about the production of fruits (cones and catkins) and the yield of seed (Tables 6 through 9). Hence, the tables that address these characteristics are introduced early in the discussion of the species.

The resource cannot be sustained if the ecosystem processes are ignored; and regeneration is just one of those processes. Can sustained production of timber and associated habitat be maintained in a spruce forest if the role of the spruce beetle is ignored until it is too late? Are the forests of south central Alaska sustainable, when approximately 500,000 hectares are dead and dying due to the spruce beetle? In Alaska, this is selective harvest by the beetle; humans follow behind as the salvage crew. Should we practice "geriatric forestry"—wait until the stand is decline before trying to do something with it? If humans are part of nature, part of the ecosystem, as suggested by the eminent ecologist Eugene P. Odum (1971), then humans must wisely use or harvest the bounty of the ecosystem. Sustainable development suggests something very different than the boom and bust approach of the spruce beetle.

Sustainability means productive forests and production means all of the resource, not just trees. It means sustainable in terms of the long hall. It means using ecosystem processes to manage the forest. It suggests active management over a passive, accept whatever the whims of nature provides.

ENVIRONMENTAL SETTING

The Yukon Territory is within the Canadian Cordillera Physiographic Province (Bostock 1965), the Cordilleran Orogen (Fremlin 1974). Bostock (1965) divided the Canadian Cordillera Physiographic Province into three Systems, all of which are represented in the Yukon: Eastern System, Interior System, and Western System. The eastern system includes the Arctic Coastal Plain and the north slope of the British Mountains, Arctic Plateau, Richardson Mountains, the Peel Plateau, Mackenzie Mountains, and the Liard Plateau. The interior system extends westward to the Kluane Range and Coast Mountains and includes most of the Territory. The western system includes the Kluane Range, the Duke Depression, the extreme southern tip of the Shakwak Valley, the Coast Mountains, and the St. Elias Mountains. Except for the Liard Plateau of the eastern system and locally at lower elevations of the western system, all of the commercial forest lies within the interior system. Additionally, most of the commercial timber lies south of the Ogilvie, Wernecke, and Selwyn Mountains (Figure 1). This division of the Territory into a commercial forest region does not imply there are no trees suitable for harvest to the north. Trees to the north occur in limited areas and are an important source of construction material and firewood for local use.

GEOLOGY

Bedrock groups within the Yukon include sedimentary, volcanic, intrusive, and metamorphic. All are present within the commercial forest zone; to the north, bedrock is dominated by sedimentary rocks with metamorphic rocks and to a lesser extent intrusives accounting for less than 15 percent of the area. The type of bedrock that forms the soil parent material greatly impacts particle size and mineralogy. This has impacts on species' presence, soil moisture, soil nutrient status, and soil erosion. Complicating this simplistic picture is the transportation of bedrock material by the glaciers that once scoured most of the Yukon and now by the rivers cutting through the glacial debris.

Glaciers have been present in the Yukon for the last two million years or so. The Quaternary Period of geologic time began more-or-less two million years ago with the beginning of the Pleistocene Epoch. The Pleistocene Epoch in North America is characterized by at least four major glaciations and three interglacials:

- NEBRASKAN GLACIAL
  Aftonian Interglacial

- KANSAN GLACIAL
  Yarmouth Interglacial

- ILLINOIAN GLACIAL
  Sangamon Interglacial

- WISCONSIN GLACIAL

In the Yukon, local names have been given to the Cordilleran glacial advances. The Pre-Reid Glacial may represent two glacials, the Kansan and possibly the earlier Nebraskan Glacial. The Pre-Reid Interglacial appears to be equivalent of the Yarmouth Interglacial. The Reid Glacial most likely is of the same period as the Illinoian Glacial and the McConnell-Reid Interglacial represents the Sangamon Interglacial. The McConnell Glacial is the Wisconsin. Much uncertainty still remains as to the when and where of the various Cordillera glacials in the Yukon (Hughes 1987). The Laurentide Glaciation extended from the east into the northern Yukon to Herschel Island; a tongue also extended across the Bonnet Plume Basin (Hughes 1987). The retreat of the Laurentide tongue from the Bonnet Plume Basin provided an early access route for tree species to colonize the northern Yukon.

The beginning of the current interglacial is also the beginning of the Holocene Epoch; the Holocene was referred to as the Recent in the earlier literature. The Holocene Epoch began 8,000 to 10,000 years ago. What went on during each of the glaciations or more importantly the interglacials is not clear. What is known is that the Glaciations were dominated by ice and the interglacials were not. The Holocene has had a series of climatic periods, some warm and some cool. Glaciers waxed and waned; they continue to do so today.

Why are events of the Quaternary important to Yukon forestry? Ritchie (1987) states, "Evidence from the *Old Crow*, Yukon region...and from Hungry Creek area..., reported by Lichti-Federovich (1974) and Hughes et al. (1981), respectively, indicates that a spruce forest or woodland probably occurred regionally at approximately 37,000 yr BP, but so far no reliable data have been reported that would indicate that spruce and associated boreal elements survived the full-glacial period from 25,000 to 15,000 yr BP." The pollen record from the lowlands near Fairbanks, Alaska, provides no evidence of trees for the Wisconsin Glaciation (Matthews 1974). Cwynar (1982) found no evidence of trees in his Hanging Lake, Yukon Territory site until the early Holocene. North of the Kluane Range, on a moraine, is a shallow pond, Antifreeze Pond, from which one of the longest continuous pollen records for Canada was obtained. The record spans about 30,000 years and indicates that birch pollen, not just paper birch, increased dramatically about 10,000 years ago and spruce pollen increased dramatically about 1,300 years later (Rampton 1971).

For starters, during the last, the Wisconsin glaciation there were few trees, if any, in the Yukon. Where there was no ice, there was a very cold, dry, treeless plain. It is hypothesized that locally, there may have been some groves of trees in the most favorable settings. Where were the trees during the Wisconsin Glaciation? White spruce was down in Pennsylvania, southern Illinois, Missouri, the Black Hills of South Dakota. Where was lodgepole pine? This question can be asked about all the native species, animal and plant, fungus and alga, of the Yukon. Of equal or possibly greater significance, is how did the species arrive in the Yukon? Such questions or concerns have important forest management implications.

Table 3 provide ages of tree macrofossils found in and adjacent to the Yukon Territory. I corrected the ages of materials to within five years of 1995. I must warn that these dates are only for "found" macrofossils which happened to end up wherever they were found by chance. Are there other materials of earlier dates that have not been found as yet? Were the species there earlier, but so rare, that materials (needles, cones, wood) were unlikely to be preserved or found? Despite these concerns, there are some things which the macrofossil record suggests. The forest vegetation of the Yukon and Alaska is comparatively young when compared with most of North America; only Labrador and portions of Quebec seem to have a younger flora. There appear to be to major avenues of colonization of the Yukon: one from the east to the north of the Ogilvie, Wernecke and Selwyn Mountains and one from the southeast and from British Columbia, Alberta, southwestern Northwest Territories. The presence of two routes of colonization have major genetic implications. Material entering in the north had different selective pressures than material entering from the southeast.

Spruce and cottonwood/aspen are thought to be the early arrivals. Tamarack arrived sometime later. Lodgepole pine arrived much later. I have found no data on alpine fir; undoubtedly it exists.

Radiocarbon dated tamarack wood found in deposits of the Mackenzie Delta, NWT is 7,520 ±140 years old.

Spruce wood found in deposits at on the south bank of Count Creek, YT is 6,240 ±70 years old. White spruce cones and seeds found at Twin Lakes near Inuvik, NWT were found to represent two age groups, 7,710 ±140 11,500 ±160 years old. Spruce needles found near Old Crow were dated as being 8,110 ±160 years old; those found in a road cut near Kluane Lake, 8,400 ±135, those found at Whitefish Lake, YT, 9,540 170, in the Bell Basin of the upper Porcupine River, YT 13,510 ±310 and 15,910 ±160.

Wood of cottonwood or aspen found on Old Crow Flats, YT is dated as 8,280 ±140 years old, that from a tributary of the Bluefish River, YT 8,880 ±90, that from the east bank of the White River opposite O'Brien Creek.

Most interesting is the late arrival of lodgepole pine pollen (Table 4). One of the earliest dates of a major increase in the pollen in bogs that indicates a major increase in the pine population is at Kettlehole Pond near the British Columbia border south of Johnson's Crossing and east of Teslin where the dramatic increase was noted about 4,360 yr BP (MacDonald and Cwynar 1991). A similar increase in the pollen occurred about 2,490 years ago at Flamingo Pond near the Summit Roadhouse north of the Pelly River (MacDonald and Cwynar 1991). West of Whitehorse, at Two Horsemen Pond, the pollen chart provided by Cwynar et al. (1987) suggest the first arrival of lodgepole pine in that area occurred after the more recent of the White River Ash deposits, about 1,250 years. Pine is thought to have reached its northern limit in the Yukon less than 500 yr BP (MacDonald and Cwynar 1991). This certainly indicates that pine arrived in the Yukon much later than the other tree species.

The tree colonization of the Yukon has not been simply a straight advance. There have been warm and cool periods during the Holocene. This caused the advance of tree species to speed up, slow down, and in some cases retreat. Furthermore, there are two apparent routes for tree recolonization of the Yukon. An older route north of the Ogilvie, Wernecke and Selwyn Mountains and a more recent route from the south and southeast. These two corridors are like gates. Add to these two major gates the smaller gates related to the physiographic features of the landscape as suggested by the high country that controlled colonization and the transfer of genetic material.

The fluctuation in the advance of the species and the effect of the gates on the genetic composition of the tree species must be considered in management activities. This is particularly true where environmental conditions are tenuous for tree growth: in the area of non commercial forest, especially north of the Ogilivie, Wernecke and Selwyn Mountains, high elevations, the subalpine zones in the south, and rain shadow area that is centered on the Aishihik basin that includes Whitehorse. In the north and at the higher elevations reversion to tundra (Cwynar and Spear 1991) is possible and in the Aishihik basin conversion to grassland is possible. The combination of topographic barriers that act as gates to gene flow and the two colonization routes indicate that genetic considerations are important. Most critical is the movement of seed; seed source must be carefully matched to the site. This is amply demonstrated by the Swedish careful evaluation and selection of Yukon lodgepole pine sites for seed collection. I have been to two of those sites (near Mayo and on the road west of Carmacks) and, indeed, the trees were spectacular, but the harvesting of those trees for easy seed collection was most disturbing to me as well as the Swedes!

Colonization or recolonization of the Yukon by trees in the late Pleistocene and Holocene clearly state that the ecosystems of the Yukon are evolving. The forests of the Yukon are part of the northern edge of the forest in North America. They are changing. They certainly are not the old growth type of forests of coastal British Columbia, Washington, Oregon or California. New habitats are being invaded by new colonists. Some early colonists are being squeezed out of old habitats.

VEGETATION

Rowe (1972) recognized two basic vegetation regions in the Yukon Territory: Tundra and Boreal Forest (Northern Forest); in recognizing two forest sub-regions, Forest and Forest and Barren. He emphasized the differences between the forests north of the Ogilvie, Wernecke and Selwyn Mountains and those to the south. He divided the Yukon into six Forest Sections:

- B.23b: Lower Mackenzie
- B.24: Upper Liard
- B.26a: Dawson
- B.26b: Central Yukon
- B.26c: Eastern Yukon
- B.26d: Kluane

The Ecoregions Working Group of the Canada Committee on Ecological Land Classification (1989) divided the Yukon into five Ecoclimatic Provinces:

- Arctic;
- Subarctic;
- Subarctic Cordilleran;
- Cordilleran; and
- Pacific Cordilleran

More recently, the Ecological Stratification Working Group (1994) came up with yet another classification, "Terrestrial Ecozones and Ecoregions"; this effort also divided the Yukon into five units called ecozones. They are:

- Southern Arctic;
- Taiga Plain;
- Taiga Cordillera;
- Boreal Cordillera; and
- Pacific Maritime

At the present time, the effort by Oswald and Senyk (1977), "*Ecoregions of Yukon Territory*" provides the best basis for forest resource management planning, decision making, and prescription development. Their effort recognizes 22 ecoregions. It is straightforward. Undoubtedly, it needs refinement, but every such classification and resulting maps need updating. The Ecological Stratification Working Group (1994) and The Ecoregions Working Group of the Canada Committee on Ecological Land Classification (1989) maps offer some suggestions on improvement and where boundaries might be changed. The real question, is "Which is the best for forest management (in the broadest sense)"?

There is a need to manage the vegetation resource on an ecological basis; ecoregions as set out by Oswald and Senyk (1977) is an excellent starting point. Their ecoregions are the basic management tool, the second tier of the building blocks. Boundaries will be changed as more knowledge becomes available. They can be the basis for seed zones and seed transfer rules, for limiting or encouraging various silvicultural practices, for wildlife management. What is not needed is a new classification every decade or less. Changing unit terminology or using the same name to describe somewhat different but similar units leads to confusion.

I would be remiss not to mention the fine work that has been done in British Columbia. Meidinger and Pojar (1991) provide a most useful tool in their "Ecosystems of British Columbia"; look at this, it contains much pertinent information for the southern Yukon. It provides a model as to how the resource managers of the Yukon might want to proceed. Three Biogeoclimatic Zones of British Columbia adjoin and for all practical purposes enter into the Yukon; from low to high elevation they are:

- Boreal White and Black Spruce;
- Spruce, Willow and Birch; and
- Alpine Tundra

Ecological classifications systems are a useful and important tool for resource managers. Oswald and Brown (1986) and Stanek and Orloci (1987) have identified ecosystem units called plant communities for the southern portion of the Yukon. Both provide species composition, growth, and environmental information. Stanek and Orloci (1987) provide some very minimal broad brush silvicultural prescriptions. Such information should never be treated as the gospel; the on site resource evaluator must make the final decision. However, having some guideline with the right to override is a cost effective approach. You can transfer ideas from one stand to another in the same plant community and even across lines of similar communities. Ecosystem classification units are not just a timber management tool. They can be used for identifying wildlife potential, forest protection concerns, watershed considerations, and recreational opportunities and carrying capacities.

What is needed in the Yukon is a concerted effort to catalogue all of the ecosystem (plant communities, plant associations, vegetation types) units identified and described in the Territory and adjacent parts of the Northwest Territory, Alberta, British Columbia, Alaska. Once this is complete, then correlate the units so that there is one standard set. Undoubtedly, more will be found and will have to be added. The initial set now becomes a management tool that is open ended in the sense there will be additions and it is shared across the Territory by all resource managers. Prescriptions from elsewhere or developed specifically for the Yukon are then plugged into these units.

THE TREE SPECIES

The Northern Forest occurs on three continents (Europe, Asia, and North America); it is circumpolar. It is commonly referred to as the "Taiga" or "Boreal Forest." However, within this Northern Forest are readily discernible, vast, regional communities. These regional communities are recognized by a plethora of distinct names: tundra forest, pre-tundra forest, mixed-wood forest, boreal forest, taiga, open forest, closed forest. Some of this variation is demonstrated by the Canadian map of vegetation regions (Ecoregions Working Group 1989). In North America, the eastern portion of the forest is distinctly different from the western portion. This is obvious from species distribution (Table 5). Within the western portion of the forest, distinct differences occur between the forests of Alaska, the Yukon Territory, and the Northwest Territories. Unifying the Northern Forest as an ecological unit are the tree genera: *Picea* (spruce), *Betula* (birch), *Populus* (aspen and poplars), and commonly *Pinus* (pine) and *Larix* (larch or tamarack).

Within Alaska and the Yukon, the idea of an extensive, somewhat uniform Boreal Forest has led to ecological misunderstandings in terms of species richness, forest stand structure, ecosystem processes. This simplistic, conceptual idea of a "Boreal Forest" or "Taiga," has limited or confused resource management efforts. Let us look at the Northern Forest in the Yukon.

Tree species composition is limited. The Yukon Territory has nine naturally occurring tree species (Hosie 1979): five conifers:

- Alpine fir (*Abies lasiocarpa* (Hook.) Nutt.);
- Tamarack (*Larix laricina* (Du Roi) K.Koch);
- White spruce (*Picea glauca* (Moench) Voss);
- Black spruce (*Picea mariana* (Mill.) B.S.P.);
- Lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) and four hardwoods;
- Paper birch (*Betula papyrifera* Marsh.);
- Balsam poplar (*Populus balsamifera* L.); and
- Trembling aspen (*Populus tremuloides* Michx.)

The presence of western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) in the Lake Bennett and Tagish Lake area and the Alsek River drainage as suggested by Hosie's (1979) range map is incorrect. Oswald and Senyk (1977), Rowe (1972), and Hultén (1968) do not mention it as occurring in the Yukon.

Western black cottonwood is a different story. DeBell's (1990) range map indicates that black cottonwood extends across the border into the Yukon in the Lake Bennett and Tagish Lake area. Hosie's (1979) map indicates that it occurs not only in the Lake Bennett and Tagish Lake area but also Alsek River drainage. Hultén (1968) indicates that two collections or identifications were made farther north between the Yukon and Pelly Rivers. Sudworth (1908) states that it extends "into the interior in British territory down Lewes, Pelly, Frances, upper Liard" rivers where it is "[locally] noted at the mouths of Lewes, Pelly,...rivers, Lake Frances." Black cottonwood is now considered to be a subspecies (*Populus balsamifera* L. ssp. *trichocarpa* (Torr. & Gray) Brayshaw) of balsam poplar (Brayshaw 1965; Viereck and Foote 1970). This suggests important genetic variation in this species and most likely other species of the Yukon that must be considered in moving seed and planting stock.

The eight native tree species are not uniformly distributed across the Yukon. Major topographic features (mountain barriers with or without glaciers and ice-fields, valley orientation, aspect, and permafrost) affect their distribution and their genetics. The range maps, presented for each species are based on various range maps, and especially the descriptions of the ecoregions of Oswald and Senyk (1977), and personal observations. No attempt was made to address the elevational range (absence or presence) of species; this is patently obvious in the southwestern corner of the Territory where the range maps suggest the species occur on the glaciers and ice field. What is important is the recognition that tree species are limited in the Yukon and this limited number of species, especially on a regional basis, limits what can be done silviculturally. Options available where there are many more species, each with a specific set of ecological requirements, such as in southern British Columbia, just do not exist in the North.

Tables 6 through 9 provide information on fruit (cone and catkins) production and seed yields. These data are from two sources:

- Dobbs et al. (1976) *Guideline to collecting cones of B.C. conifers.*
- Schopmeyer (1974) *Seeds of woody plants in the United States.*

Neither are adequate for the Yukon. There is a major need for refinement. Dates and frequency of crops are uncertain. Use these as guidelines. The importance of seed cannot be over emphasized. Without prompt and adequate regeneration, the sustainable development of the resource is called into question. If artificial regeneration is planned, not only is there a need for cost-effective production of high quality seedlings or cuttings, but there is an equally important need to ensure that the regeneration material is of the correct source. Seed zone maps must be prepared and elevation transfer rules must be established. This is essential for ecologically sound forestry. For genetically sound forestry, the material from the best portions of the gene pool must be selected and the selection pool must be sufficiently broad to avoid significantly reducing the variability. If natural regeneration is to be used, diameter limit cuts can result in selection of the poorer genotypes as the source of seed for the new stand. The Yukon must establish phenological studies to determine the dates of such things as bud burst, pollination, stages of fruit development, and seed dispersal. It is quite embarrassing to go out to collect cones only to find they have all opened and dispersed the seed.

I provide community data from Oswald and Brown (1986) and Stanek and Orloci (1987) for each species to show that there are distinct communities in which each species does quite well. The community data also show how much work is still to be done. Some species have no communities associated with them. Undoubtedly, there are many communities not described. Many of the communities described by Stanek and Orloci (1987) are the same communities described by Oswald and Senyk (1986); names may be similar or different—there is a need to correlate; and the correlation must include the work from elsewhere such as Viereck and colleagues' (1992) communities from Alaska. Finally, the successional status of each community is not understood in relation to the others; some are basically the same ecosystem at a different stage of successional development. Stanek and Orloci (1987) provide productivity information, harvesting suggestions, and rudimentary silvicultural prescriptions; these need to be verified and refined. What is important, the framework of community types exists and it is so important. The Territory is expanding this work in the southeast.

ALPINE FIR (*Abies lasiocarpa*)

Alpine fir, more appropriately referred to as subalpine fir, is a western Cordillera species. Sometimes it is referred to simply as balsam and is not to be confused with balsam fir (*Abies balsamea* L.) that is found farther south and east and not found in either the Yukon or Northwest Territories. Alpine fir extends northward from Arizona and New Mexico into the Yukon to the Stewart River (Viereck and Little 1972; Hultén 1968) (Figure 2). It extends westward to within about 200 km of the Alaska-Yukon Border. It is found at the higher elevations, in the upper portions of the montane forest, subalpine forest, and subalpine parkland zones. Oswald and Brown (1986) report it as a dominant at elevations between 900 and 1,370 metres with it reaching tree line between

1,350 and 1,500 metres (Oswald and Senyk 1977).

Alpine fir, a small to medium-sized tree, attains heights commonly of 18 to 27 metres and possibly 40 metres on best sites. Diameters range up to at least 34 centimetres (Oswald and Brown 1986). Typical ages of mature stands exceed 150 years; Oswald and Brown (1986) report one stand with an average total age of 176 years. Ages most likely can exceed 200 years.

Alpine fir regenerates by seed and layering. Cones mature in one year. When mature, cones disintegrate on the tree. Seeds are heavy, small-winged and do not travel far.

Alpine fir is very shade tolerant (Alexander et al. 1990); Krajina (1969) states that it is the most shade tolerant tree species in the western Northern Forest. It will be a member of the climax plant community on any site in the Yukon where it is present. In the Lake Laberge Ecoregion, it occurs on colluvium and morainal materials (Oswald and Brown 1986). On better sites in the Yukon, stands supporting alpine fir can have a M.A.I. of 3.08 m^3/ha/yr (Oswald and Brown 1986).

There are six community types in which alpine fir is present (Oswald and Brown 1986); others are also known to exist:

Abies lasiocarpa/Alnus crispa/Hylocomium.
Abies lasiocarpa/Betula/Empetrum/Cladina.
Abies lasiocarpa/Ledum/Hylocomium.
Abies lasiocarpa/Hylocomium-Pleurozium.
Abies lasiocarpa/Cetraria-Cladina.
Picea glauca-Abies lasiocarpa/Betula-Ledum/Hylocomium.

TAMARACK (*Larix laricina*)

The range of tamarack is transcontinental, but is discontinuous in the Yukon and eastern Alaska. There are two distinct populations of tamarack in the Yukon (Figure 3): 1) southeastern Yukon in the Liard River drainage and 2) north of the Ogilvie-Wernecke-Selwyn Mountains below elevations of 750 metres. Douglas (1974) observes that several workers noted the unexplained absence of tamarack in the southwest corner of the Territory.

Tamarack is unique among the conifers of the north in that it is deciduous; except as a young seedling, it sheds its needles annually. Tamarack, a small to medium-sized tree, commonly attains heights of 9 to 20 metres and even 24 or more metres on good sites. Diameters at breast height typically range between 10 and 12 centimetres; one tree at Liard River Hot Springs, British Columbia is 50 centimeters. Typical ages of mature stands are between 100 and 200 years.

Tamarack regenerates by seed and by layering. Seeds are winged and can travel considerable distances in the air or on the surface of the snow. Johnston (1990) states that layering is important in Alaska and northern Canada near the tree line.

The shade tolerance of tamarack is practically nil (Krajina 1969). Johnston (1990) states that it is very shade intolerant; he notes, however, that it can tolerate some shade during its first few years. Tamarack is so shade intolerant that it cannot grow in its own shade; thus it is a pioneer species or relegated to open forest stand conditions.

Neither Oswald and Brown (1986) nor Senyk and Orloci (1987) identify plant communities in which tamarack is dominant. This is a sampling problem.

WHITE SPRUCE (*Picea glauca*)

The range of white spruce is transcontinental. It extends across the Yukon (Figure 4) from east to west and is the northern most conifer in the Territory. It is found in the Firth River drainage of the northwestern corner of the Yukon. It is both an Arctic and Alpine tree line species. It appears to have entered.

White spruce, a medium-sized tree, attains heights commonly of 18 to 27 metres and even 40 metres on best sites. Oswald and Brown (1986) measured breast height diameters up to 61 centimetres (Oswald and Brown 1986); diameters may exceed 80 centimetres. Typical ages of mature stands are between 100 and 200 years; (Oswald and Brown 1986) found one stand in the subalpine with an average total age of 287 years. Occasionally, trees over 300 and even 400 years can be found in riparian areas.

White spruce regenerates from seed and to a limited extent by layering. Cones take one year to mature. Cones are non-serotinous. Seeds are winged and can travel great distances in the air or on the surface of the snow. Layering occurs at or near tree line; elsewhere it is uncommon.

The shade tolerance of white spruce is intermediate to tolerant (Krajina 1969). Nienstaedet and Zasada (1990) state that it is intermediate in shade tolerance, being less tolerant than black spruce and alpine fir but more shade tolerant than its lodgepole pine, trembling aspen, and paper birch. Because of its shade tolerance it can remain in the understory for 50 or more years. White spruce does not self-prune well. To get small knots or clean boles requires maintaining high numbers of stems per hectare. On better sites, recent flood plains , in the Yukon, stands supporting white can have a M.A.I. of 2.59 m^3/ha/yr (Oswald and Brown 1986). Farr (1967) suggests a m.a.i of 3.6 m^3/ha/yr for the better sites in Alaska.

Community types in which white spruce is a dominant and identified by Oswald and Brown (1986) are:

Picea glauca-Abies lasiocarpa/Betula-Ledum/Hylocomium.
Picea glauca/Alnus incana/Hylocomium.
Picea glauca/Betula/Cetraria.
Picea glauca/Betula-Salix.
Picea glauca/Betula-Salix/Hylocomium.
Picea glauca/Salix/Hylocomium.
Picea glauca/Ledum/Hylocomium.
Picea glauca/Ledum/Cladina.
Picea glauca/Rosa/Hylocomium.
Picea glauca/Empetrum/Peltigera
Picea glauca/Arctostaphylos/Calamagrostis.
Picea glauca/Calamagrostis-Festuca.
Picea glauca/Calamagrostis/Hylocomium.
Picea glauca/Equisetum/Hylocomium.
Picea glauca/Hylocomium-Pleurozium
Picea glauca/Cladina
Picea glauca-Picea mariana/Betula/Hylocomium.
Picea glauca-Picea mariana/Salix/Cladina.
Picea glauca-Picea mariana/Ledum/Aulacomnium.
Picea glauca-Picea mariana/Hylocomium-Cladina.
Picea mariana-Picea glauca/Salix/Aulacomnium.

Picea mariana-Picea glauca/Salix myrtillifolia.

Stanek and Orloci (1987) identified the following community types as containing white spruce as a dominant:

Picea-Viburnum-Drepanocladus
Picea-Hylocomium-Peltigera
Picea-Carex
Picea-Cornus-Hylocomium
Picea-Ledum-Hylocomium
Picea-Arctostaphylos-Thuidium
Picea-Arctostaphylos-Aulacomnium
Picea-Salix-Aulacomnium
Picea-Salix-Carex-Aulacomnium
Picea-Salix-Rubus-Aulacomnium
Picea-Ledum-Aulacomnium
Picea-Rhododendron-Aulacomnium
Salix-Picea

BLACK SPRUCE (*Picea mariana*)

The range of black spruce is transcontinental. It extends across the Yukon (Figure 5) from east to west; its northward distribution is not quite that of white spruce. It is not typically an alpine tree line species; however, it does get into the subalpine (Oswald and Brown 1986). Its distribution or abundance appears to be reduced in the Kluane Lake, Alsek River drainage, Aishihik River drainage, and areas south of Whitehorse; this is supported by Douglas (1974) who also states that several workers noted the unexplained absence of black spruce in the southwest corner of the Territory.

Black spruce, a small to medium-sized tree, commonly attains heights of 10 to 18 metres and occasionally exceed 22 metres. On poor sites and permafrost-dominated sites, it can be less than 3 metres tall. Diameters at breast height commonly range between 8 and 23 centimetres and occasionally may exceed 30 centimeters. Typical ages of mature stands are between 100 and 200 years. Oswald and Brown (1986) report the average total age of one stand to be 206 years.

Black spruce regenerates by seed and layering. Cones take one year to mature. Cones are semi-serotinous. Seeds are winged and can travel great distances in the air or on the surface of the snow. Layering is quite common throughout much of Alaska and the Yukon.

Black spruce is shade tolerant (Viereck and Johnston 1990). It is more shade tolerant than white spruce. Krajina (1969) considers it to be the climatic climax of the boreal forest of British Columbia. It is typically climax on the poorly drained soils of the Territory. On better drained soils, especially those on warmer aspects, it appears to share the climax role with white spruce. On better sites in the Yukon, stands supporting black spruce can have a M.A.I. of 1.75 m^3/ha/yr (Oswald and Brown 1986).

Community types containing black spruce as a dominant and identified by Oswald and Brown (1986) are:

Picea mariana/Ledum-Betula
Picea mariana/Ledum/Hylocomium

Picea mariana/Ledum/Cladina
Picea mariana/Hylocomium-Pleurozium
Picea mariana/Cladina
Picea mariana-Picea glauca/Salix/Aulacomnium
Picea mariana-Picea glauca/Salix myrtillifolia
Picea glauca-Picea mariana/Betula/Hylocomium
Picea glauca-Picea mariana/Salix/Cladina
Picea glauca-Picea mariana/Ledum/Aulacomnium
Picea glauca-Picea mariana/Hylocomium-Cladina

Stanek and Orloci (1987) identified the following community types as containing black spruce as a dominant:

Picea-Ledum-Hylocomium
Picea-Arctostaphylos-Aulacomnium
Picea-Salix-Aulacomnium
Picea-Salix-Carex-Aulacomnium
Picea-Salix-Rubus-Aulacomnium
Picea-Ledum-Aulacomnium
Picea-Rhododendron-Aulacomnium
Picea-Arctostaphylos-Festuca, Populus balsamifera variant

LODGEPOLE PINE (*Pinus contorta* var. *latifolia*)

The range of lodgepole pine is the western Cordillera. Lodgepole pine extends northward from Baja, Mexico and Colorado to the central Yukon (Figure 6). It is most important and abundant in the eastern one-half of the Territory. There are reportedly a few isolated trees west of Champagne; Douglas (1974) observes that several workers noted the unexplained absence of pine in the extreme southwest corner of the Territory.

Lodgepole pine is a medium-sized tree. It reaches heights of 23 metres in the western part of its range. In the western portion of its range it reaches diameters of about 30 centimetres (Oswald and Brown 1986). Anecdotal information suggests that some trees may reach diameters of 60 centimetres or more.

Lodgepole pine reproduces by seed. Cones take two growing seasons to mature. Cones are serotinous (require heat to open) and non-serotinous. Cone serotiny must be verified by ecoregion or stand. Seeds are winged and can travel considerable distances in the air or on the surface of the snow.

Lodgepole pine is shade intolerant (Krajina 1969) to very shade intolerant (Lotan and Critchfield 1990). It is typically a pioneer on most sites. On some very dry sites, it may be the climax species. On better sites in the Yukon, stands supporting lodgepole pine can have a M.A.I. of 5.92 m^3/ha/yr (Oswald and Brown 1986).

Community types containing lodgepole pine as a dominant and identified by Oswald and Brown (1986) are:

Pinus contorta-Picea mariana/Peltigera
Pinus contorta/Alnus crispa/Hylocomium
Pinus contorta/Shepherdia/Hylocomium

Pinus contorta/Betula/Festuca
Pinus contorta/Betula/Hylocomium
Pinus contorta/Salix/Calamagrostis
Pinus contorta/Ledum-Empetrum/Hylocomium
Pinus contorta/Ledum/Vaccinium vitis-idaea
Pinus contorta/Linnaea-Vaccinium vitis-idaea
Pinus contorta/Vaccinium vitis idaea/Hylocomium
Pinus contorta/Vaccinium uliginosum/Cladina
Pinus contorta/Arctostaphylos
Pinus contorta/Arctostaphylos/Calamagrostis
Pinus contorta/Calamagrostis-Festuca
Pinus contorta/Hylocomium-Pleurozium
Pinus contorta/Cladina

Stanek and Orloci (1987) identified the following community types as containing lodgepole pine as a dominant:

Pinus-Arctostaphylos-Festuca
Pinus-Festuca-Peltigera
Pinus Vaccinium-Hylocomium
Pinus-Vaccinium-Festuca

PAPER BIRCH (*Betula papyrifera*)

The range of paper birch is transcontinental. It also extends southward along the Cordillera and is scattered into Oregon, Idaho, Montana, Wyoming, and Nebraska. It occurs throughout most of the Territory (Figure 7) except in the far north in the Northern Mountains and Coastal Plain Ecoregion of Oswald and Senyk (1977). Douglas (1974)notes its apparent absence in the Alsek drainage area and observes that several other workers noted the unexplained absence of pine in the extreme southwest corner of the Territory. Trees reach heights of 20 metres or more and diameters of 30 to 35 centimetres occur.

Paper birch reproduces from seed and stump sprouts. Large diameter stumps, 25 centimetres and larger appear to have a lower stump sprouting capacity. Seeds are winged and can travel some distance in the air and greater distances on the surface of the snow.

Paper birch is considered to be shade intolerant (Safford et al. 1990); balsam poplar, trembling aspen, and tamarack are less shade tolerant (Safford et al 1990; Zasada and Phipps 1990). Natural pruning is excellent; lower boles are commonly branch free.

Neither Oswald and Brown (1986) nor Senyk and Orloci (1987) identify any plant communities in which tamarack is dominant. Traveling across the Yukon, the abundance of paper birch appears to be much less than what is observed in Alaska where paper birch is the dominant tree on many thousands of acres (Viereck et al. 1992).

BALSAM POPLAR (*Populus balsamifera*)

The range of balsam poplar is transcontinental. The subspecies, western black cottonwood, has a western Cordillera range and, where present, is typically found at lower elevations along the valley floors of major drainages. Hultén (1968), states that balsam poplar is the northern most American hardwood. In the Yukon (Figure 8), it approaches the Arctic shore along rivers where it forms a narrow band on river banks.

Balsam poplar, a medium-sized to large tree, commonly attains heights of 20 to 30 metres and even 40 metres on best sites. Diameters commonly range between 30 and 60 centimetres and may exceed on 150 centimetres. Typical ages of mature stands are between 100 and 175 years; occasionally individual trees older than 200 years can be found. Age determination of old trees is difficult because of the common occurrence of decay.

Balsam poplar reproduces by seeds, stump sprouts, and suckering from the root system. Cuttings produce roots readily in moist soils. Trees are either male or female. Seeds are extremely small and have a mass of silky hairs (cotton) attached to them. Wind blows seed considerable distances. Seed is also transported down stream by floating on the surface of the water.

Balsam poplar is classed as very intolerant of shade (Zasada and Phipps 1990). It is typically a species of the flood plain and lower, well-watered slopes. It is commonly a pioneer on fresh sand and silt bars of major rivers. Balsam poplar stands in the Yukon have M.A.I.'s that reach at least 2.33 m^3/ha/yr (Oswald and Brown 1986). Data from Alaska (Zasada and Phipps 1990) suggests higher M.A.I.'s can be expected in the Yukon.

A community type containing balsam poplar as a dominant and identified by Oswald and Brown (1986) is:

Populus balsamifera/Rosa/Equisetum

Stanek and Orloci (1987) also identified one community type with balsam poplar as a dominant:

Picea-Arctostaphylos-Festuca, Populus balsamifera variant

TREMBLING ASPEN (*Populus tremuloides*)

The range of trembling aspen is transcontinental and also the western Cordillera. It is found throughout most of the Yukon (Figure 9) except on the coastal plain in the north. It does not tolerate permafrost near the soil surface. It seems to do best on southerly slopes that are well-drained.

Trembling aspen, a small to medium-sized tree, typically attains heights of 6 to 18 metres; individual trees occasionally approach 26 metres in height on best sites. Diameters at breast height typically range between up to 30 centimetres; exceptional trees may reach 50 centimeters. Typical ages of mature stands are between 100 and 150 years; between ages of 60 120 years stem decay begins to develop.

Trembling aspen reproduces by seed and suckering from the existing root system. Cuttings due not produce roots. Trees are either male or female. Seeds are extremely small and have a mass of silky hairs (cotton) attached to them. Wind blows seed considerable distances. Most reproduction is by the suckering from roots; fire and clearcutting encourage suckering. Immediately following major disturbance, trembling aspen suckers can exceed 200,000 per hectare. Moose and elk utilize such material as browse.

Trembling aspen is considered to be very intolerant of shade (Perala 1990). Natural pruning is excellent and results in long clean boles. Oswald and Brown (1986) report M.A.I.'s up to 2.61 m^3/ha/yr.

Community types containing trembling aspen as a dominant and identified by Oswald and Brown (1986) are:

Populus tremuloides/Shepherdia
Populus tremuloides/Salix/Linnaea
Populus tremuloides/Salix/Arctostaphylos
Populus tremuloides/Salix/Calamagrostis
Populus tremuloides/Arctostaphylos
Populus tremuloides/Arctostaphylos/Calamagrostis
Populus tremuloides/Vaccinium/Calamagrostis
Populus tremuloides/Calamagrostis-Festuca

Stanek and Orloci (1987) identified the following community types as containing trembling aspen as a dominant:

Populus-Arctostaphylos-Shepherdia

TIMBER MANAGEMENT CONSIDERATIONS

As a forester, I am concerned with managing the forest for all its commodities and benefits. I go back to my introduction where I define forestry. As an ecologist, I have the same concern. Simply put, I believe that management of the forest for timber and wildlife is not impossible. I can say this about the other uses of the forest as well; space and time only allows for limited elaboration. I do not know what the working arrangement is in the Yukon between the wildlife and forestry effort, but I assure you that you do not need political in-fighting as is present in some of the provinces and states. If efforts are to maximize fiber or select species of wildlife, there is a problem.

Throughout the paper, I have mentioned concerns regarding timber. I would now like to just briefly shift the focus to wildlife. Wildlife is of great interest to the people of the Yukon. For many it is essential in terms of subsistence. It also is of great interest from the tourism perspective. Finally, watching wildlife can be fun.

DeLong et al. (1991) provide wildlife information for the Boreal White and Black Spruce biogeoclimatic zone in northern British Columbia. They identify representative wildlife species and "wildlife species at risk" by major habitats: mixed deciduous and coniferous forests; mature coniferous forests; peatlands or muskegs; wetlands, shallow basins, and streams, riparian areas and flood plains; south aspect grassland and scrub in the Alberta Plateau; south aspect grassland and scrub in the mountains; and agricultural areas. Looking only the habitats that might be impacted by timber harvesting, the following species are listed as at risk:

- Mixed deciduous and coniferous forests: caribou, northern long-eared myotis, black-throated green warbler, Canada warbler;
- Mature coniferous forest: caribou, gray-cheeked thrush;
- Riparian areas and flood plains: grizzly bear, mourning warbler;
- South aspect grassland and scrub in the mountains: Dall sheep, grizzly bear.

"At risk" does not imply imminent danger of extinction; it suggests the need for more careful consideration of the impacts of timber management on these species where they occur.

What impact will timber harvesting have on these species? Or species that depend upon the forest. When one considers ecosystem changes in North America during the Holocene (Webb 1987; Jacobson et al. 1987) one must wonder about species' adaptability. Hunter (1992) postulates that many animals and birds had to be quite adaptable to survive in a disturbance driven ecosystem such as the Northern Forest. He further postulates that many migratory Neotropical-Northern Forest birds "exhibit considerable latitude in habitat selection and, to a lesser degree, style of habitat exploitation, primarily foraging behavior." In addition, many of migratory birds seek out and utilize early seral forest communities. In contrast, many non-migratory species are sensitive to the loss of late seral communities. However, there are no data nor evidence to suggest extirpation of any bird species in Yukon Northern Forests. What must be recognized is the reality that bird populations fluctuate, sometimes widely, especially near the limits of their range.

This does not mean that birds or mammals genuinely at risk should be ignored. It does not mean that "not at risk" should be ignored either. It does suggest that there are ways to cope with the situation and that disturbance is not necessarily bad.

Now I would like to look briefly at two closely related furbearers, the marten and the fisher. Both are native to the Yukon (Figure 10). The fisher's range is limited to the extreme southeast corner of the Territory and that of the marten is essentially throughout the Territory except on the non-forested coastal plain (Gibilisco 1994). The range maps again ignore elevational distribution. Neither species is at risk in British Columbia and the marten is not at risk in Alaska. However, there is concern for each. Locally, the marten population was greatly reduced or extirpated in the Yukon; they were reintroduced in the Haines Junction and Takhini areas in the mid 1980's(Slough 1994).

The range map suggests that timber management in the southeast corner of the Territory should consider seriously the impact of harvesting on fisher if the fisher populations are resident and viable and not just an edge of the range situation; management for marten is a concern throughout the Territory. Thompson and Harestad (1994) discuss habitat management models for American marten. They suggest:

- Marten will use forests with a canopy of at least 30 percent and prefer canopies of 50 to 70 percent;
- Marten prefer large-diameter downed wood for dens; such trees are also prey habitat;
- Marten require large-diameter standing cull or dead trees for natal dens.
- Marten prefer forest with a complex understory or gaps;
- Large cutovers (contiguous areas over a 40 year period) negatively impact martens;
- Patch cuttings up to 3.0 hectares that are evenly distributed and harvest only 20-25 percent of the stem basal area in the short term;
- Selective logging, including shelterwood, should not reduce marten carrying capacity if removal of trees is kept below 30 percent of stem basal area every 50 years;
- Mature or "old-growth" second-growth, conifer-dominated forest can be equivalent to natural forest of the same age in terms of supporting marten populations. They add "(Actually, we do not believe this to be the case under current forest management regimes and suggest that a substantial amount of research is needed on this question.)

The first four items listed are pretty straightforward. Questions arise as to how big a large tree is. I have provided some information on tree sizes in the Yukon, they sure do not come up to the desired size of large. But on a landscape basis I think there is potential. Riparian zones often carry the most valuable timber of the largest size. These forests often have relatively complex stand structure. They are often dominated by white spruce that attain a rather large size. Uplands with the fire frequency, rarely develop and old growth characteristic. Commonly they are still in the stem exclusion phase when the next catastrophic event occurs. Selective or shelterwood silvicultural systems are possible where there is spruce and spruce is the desired species; pine is not well adapted to partial harvests. Can these same guidelines or prescriptions, if valid, be adopted for the fisher?

Table 10 shows what can be done using silvicultural systems with various forest cover types in Alaska; pine and alpine fir are not included. These guidelines are, nonetheless applicable to large portions of the Yukon. These can be modified to address such things as habitat for marten. Obviously, the riparian area and spruce dominated stands hold promise. Leaving very large, old trees, often cull to the timber operator, should provide preferred habitat for marten or fisher. Leaving brush piles of small diameter material (tops of trees) can provide habitat for prey. Managing for a stand structure that is complex may be entirely possible. Managing for large diameter trees, those not naturally occurring throughout much of the range of marten, however, is unrealistic in much of the Yukon. Marten and fisher seem to do quite well with smaller diameter trees, our objective should be to find out and create those kinds of conditions that substitute for the ideal trees. It is the idea of not trying to maximize fiber production at the expense of the other resources; but this does not mean creating forest stands that do not produce usable fiber either.

Treating the riparian zone from a different perspective than the upland pine forests provides and opportunity to begin to manage on a landscape basis and not simply on a stand by stand basis. Disturbance in the riparian zone is much different from disturbance in the pine uplands. Use of small patch clearcuts or well-planned selection cuts in the riparian zone may be desirable; the patches can be entire islands of the same stand to small patches typical of windthrow or flooding damage. On the other hand, do not use small patch clearcuts in a landscape where fire or other disturbance factor created large patches of several thousand hectares. However, recognize that large burns contain areas of unburned forest, jackstraw piles of snags, standing dead trees. The unburned forest occurs as patches—just the reverse of patch logging.

The interior of the forest is very different from edge of the forest. Often we only think of the edge of the forest, "the roadside look", as being a representation of what is on the inside—it is not. Managers and biologists and ecologists have to know the forest, interior and edge, and GIS does not do that either. Remember, GIS is a tool; to be a good tool, GIS requires good field data. GIS solves no management problems except to shuffle data around.

Good, prompt reforestation with the right species for the right site is essential for maintaining habitat, sustainability, and biodiversity. Full stocking, not settling for a minimum, is a must. Full-stocking, to be successful, requires the seedlings to be in a position of "free-to-grow". If you are going to manage for stand structure you need stems to manipulate. If you are going to manage for fiber production, you need stems on which to grow the fiber.

I reiterate the words of Heady and Child (1994): "The manager's approach should be one of guiding, not replacing, the natural processes of ecosystem succession toward societal goals as rapidly as possible."

I am now at the stage of bridging the gap from the realm of ecology to the realm of silviculture. Silviculture is the topic of our next speaker.

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Fig.1

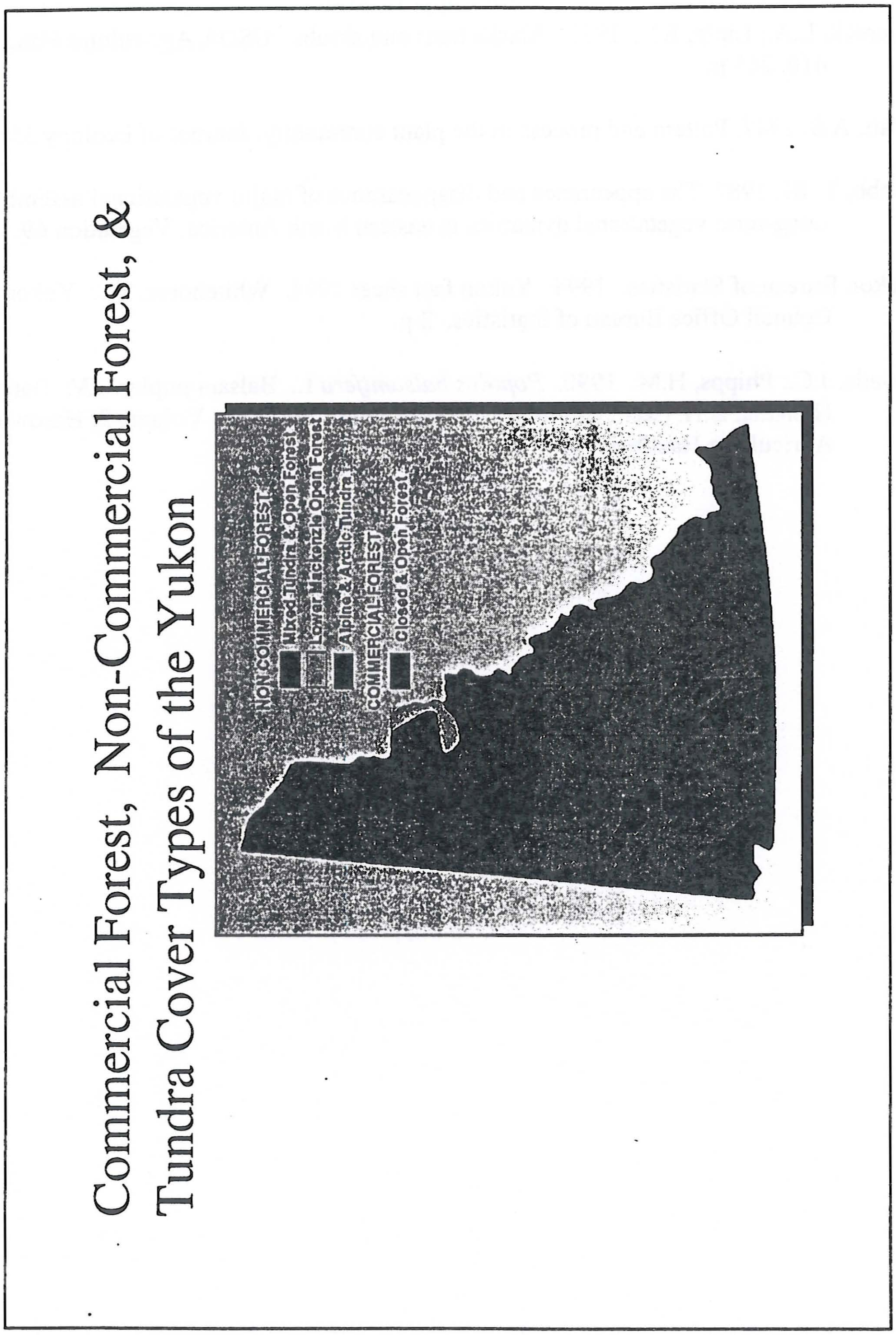
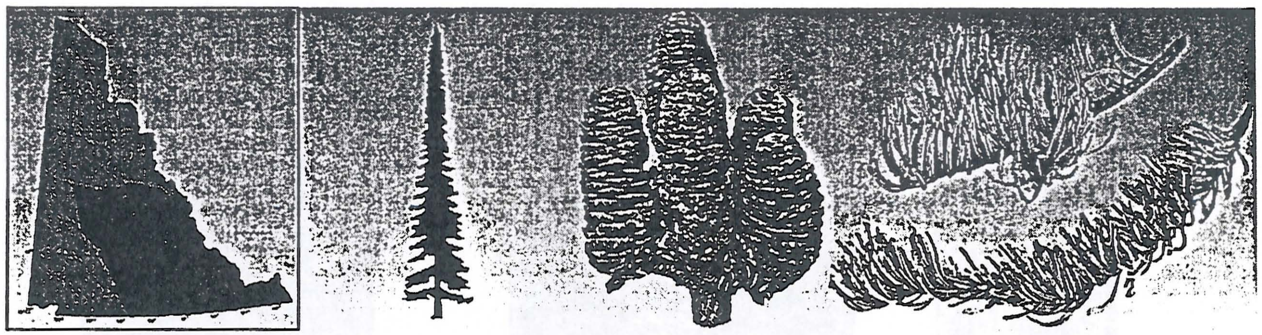

Commercial Forest, Non-Commercial Forest, & Tundra Cover Types of the Yukon
NON COMMERCIAL FOREST
Mixed Tundra & Open Forest
Lower Mackenzie Open Forest
Alpine & Arctic Tundra
COMMERCIAL FOREST
Closed & Open Forest

Fig.2

ALPINE FIR, SUBALPINE FIR

ABIES LASIOCARPA (Hook.) Nutt.

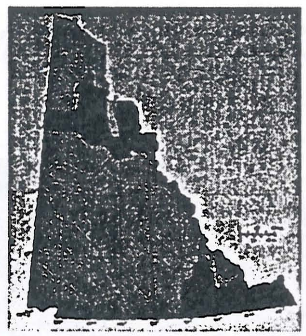


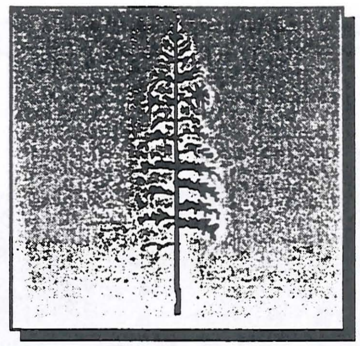
- SHADE TOLERANCE: VERY TOLERANT
- HABITAT: Subalpine, Alpine tree line
- REPRODUCTION: Seed, Some layering

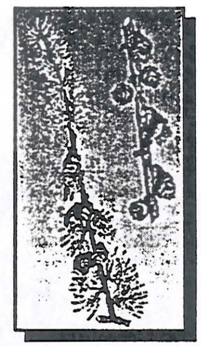
Fig.3

TAMARACK

LARIX LARICINA (Du Roi) K. Koch





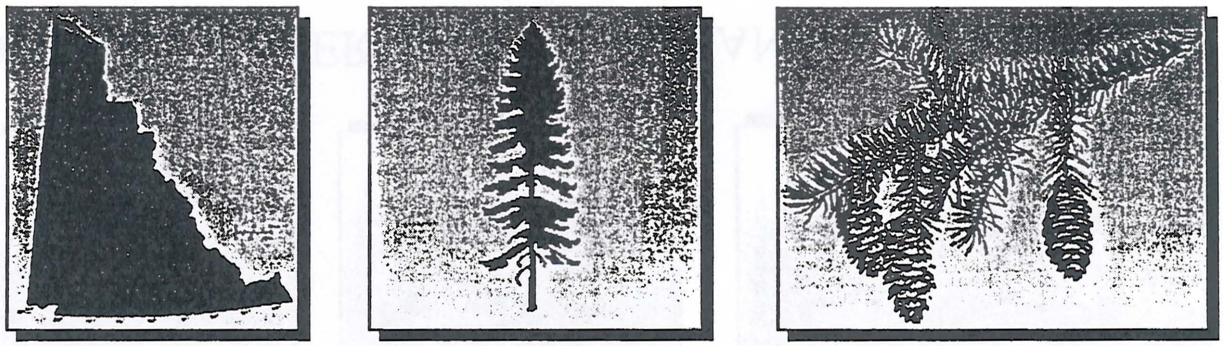


- SHADE TOLERANCE: VERY INTOLERANT
- HABITAT: Riparian, Wet soils, Uplands
- REPRODUCTION: Seed, Some layering

Fig.4

WHITE SPRUCE

PICEA GLAUCA (Moench) Voss

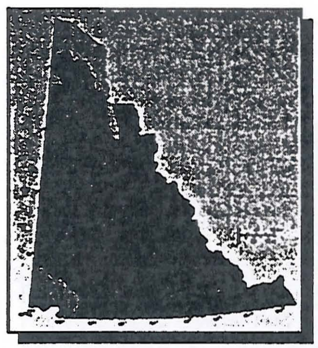


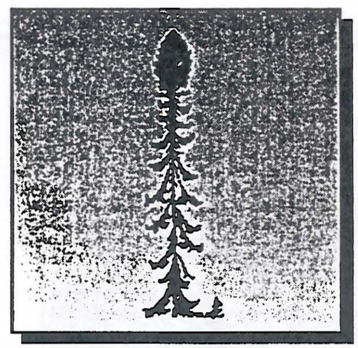
- SHADE TOLERANCE: MODERATELY TOLERANT
- HABITAT: Riparian, Uplands, Subalpine, Tree line
- REPRODUCTION: Seed, Some layering

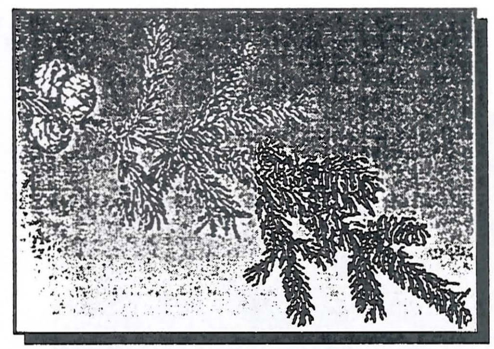
Fig.5

BLACK SPRUCE

PICEA MARIANA (Mill.) B.S.P.





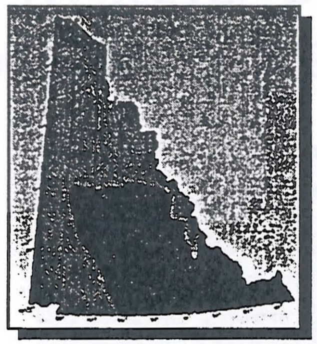


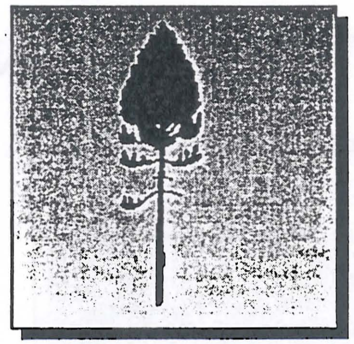
- SHADE TOLERANCE: TOLERANT
- HABITAT: Wet soils, Muskeg, Uplands,
- REPRODUCTION: Seed (Semi-serotinous cones), Layering

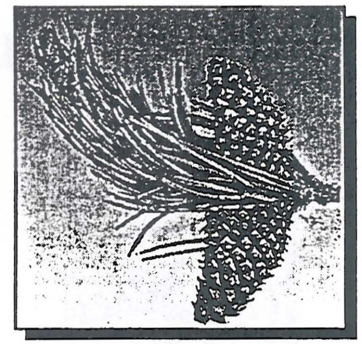
Fig.6

LODGEPOLE PINE

PINUS CONTORTA Dougl. ex. Loud.





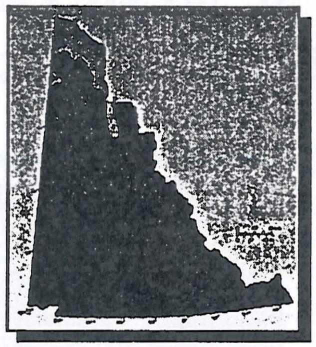


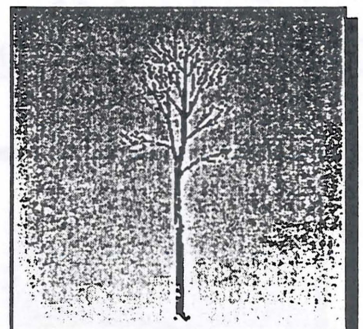
- SHADE TOLERANCE: VERY INTOLERANT
- HABITAT: Riparian, Uplands, Subalpine
- REPRODUCTION: Seed (Serotinous cones)

Fig.7

PAPER BIRCH

BETULA PAPYRIFERA Marsh.



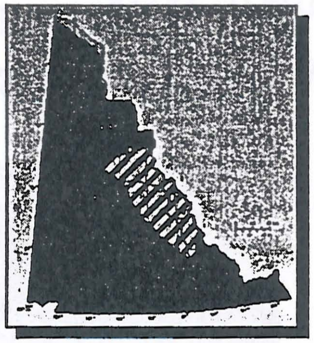


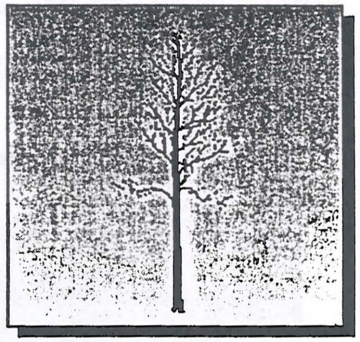
- SHADE TOLERANCE: INTOLERANT
- HABITAT: Riparian, Uplands, Muskeg
- REPRODUCTION: Seed, Stump sprouts

Fig.8

BALSAM POPLAR

POPULUS BALSAMIFERA L.



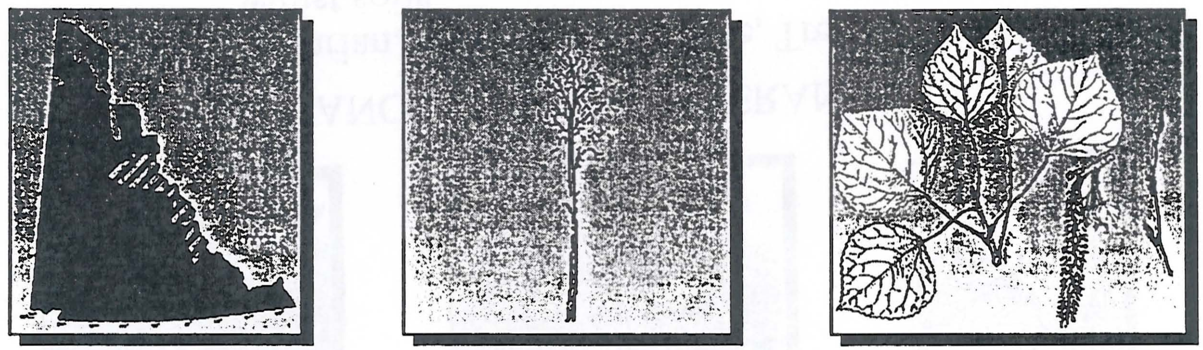


- SHADE TOLERANCE: VERY INTOLERANT
- HABITAT: Riparian, Uplands, Subalpine, Tree line, Moist soils
- REPRODUCTION: Seed, Stump sprouts, Root suckers, Cuttings

Fig.9

TREMBLING ASPEN

POPULUS TREMULOIDES Michx.



- SHADE TOLERANCE: VERY INTOLERANT
- HABITAT: Warm sites, Mesic to dry soils, No permafrost
- REPRODUCTION: Seed, Root Suckers

Fig.10

Range of MARTEN (*Martes americana*) and FISHER (*Martes pennanti*) in the Yukon

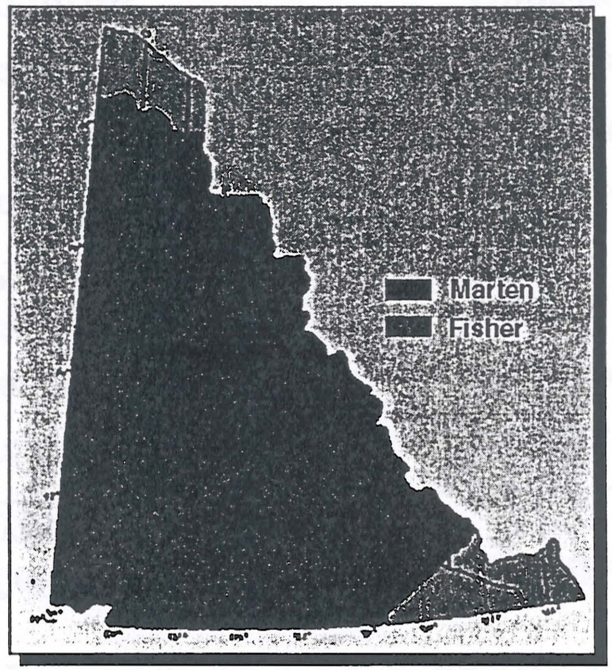


Table.1a

Fire Frequency in the Boreal Forest (from Chandler et al. 1983)

Bioclimatic Zones/ Ecosystem Types	Location	Fire Frequency (years)
Open forest of *Picea* and lichens	Alaska, Yukon	130
Open *Picea* forest	Northwest Territories	120
Close forest *Picea* and *Betula* or *P. mariana*	Alaska, Yukon	100
Picea mariana/*Picea glauca* forest	Northwest Territories	100
Picea forest	British Columbia	100
Picea mariana forest	Ontario	100
Picea mariana forest	Hudson Bay	150
Open *Picea mariana* forest	Quebec	150

Table.1a

Fire Frequency in the Boreal Forest (from Chandler et al. 1983)

Bioclimatic Zones/ Ecosystem Types	Location	Fire Frequency (years)
Picea glauca forest on flood plains	Alaska	200+
Picea glauca forest on flood plains	Northwest Territories	200+
Picea mariana/Abies balsamea forest	Newfoundland	150
Picea mariana/Pinus banksiana forest	Quebec	100
Picea mariana/Pinus banksiana forest	Ontario	60
Open *Pinus banksiana* forest	Northwest Territories	25-100
Pinus contorta forest	British Columbia	50
Pinus contorta/Picea forest	Alberta	50
Mixedwood forest	Alberta	50

Table.1b

Recent Holocene Glacial Maxima in Non-Coastal Alaska (from Péwé 1975)

Location	Stade/Advance	Year, A.D.
Kenai Peninsula	Tunnel II Advance	1550 ±150
Upper Matanuska Valley	Unnamed advance	1898
Delta River Valley	Black Rapids surge	1937
Black Rapids	II	1830
Black Rapids	I	1650?
Upper Tanana River Valley	Unnamed advance	475
	Unnamed advance	245
Brooks Range – Alatna River	Head of valley advances	<950
Brooks Range – Anaktuvik Pass	Fan Mountain II	1775-1875
	Fan Mountain I	1000-1200

Table.2

Age of Tree Macrofossils Found in and Adjacent to the Yukon Territory

AGE (YR. B.P.)	MATERIAL	LOCATION
TAMARACK		
7,520 ± 120	wood	Mackenzie Delta, NWT
SPRUCE		
6,240 ± 70	wood	south bank of Count Cr., YT
7,710 ± 140	cones, seeds	Twin Lakes near Inuvik, NWT
8,030 ± 120	wood	north bank of White R., AK
8,110 ± 160	needles	Old Crow R., YT
8,400 ± 135	needles	road cut near Kluane Lake, YT
9,540 ± 170	needles	Whitefish Lake, YT
11,510 ± 160	cones, seeds	Twin Lakes near Inuvik, NWT
13,510 ± 310	spruce needles	Bell Basin, upper Porcupine R., YT
15,910 ± 160	spuce needles	Bell Basin, upper Porucpine R., YT

Table.3

Age of Tree Macrofossils Found in and Adjacent to the Yukon Territory (continued)

AGE (YR. B.P.)	MATERIAL	LOCATION
COTTONWOOD OR ASPEN		
8,280 ± 140	wood	Old Crow Flats, YT
8,880 ± 90	wood	tributary of Bluefish R., YT
9,050 ± 140	wood	east bank of White R., opposite O'Brien Cr., YT
9,200 ± 90	wood	Bell Basin, upper Porcupine R., YT
9,500 ± 90	wood	near Frog Cr. on road to Ft. McPherson, NWT
9,950 ± 90	wood	coastal bluffs southeast of Sabine Point, YT
11,510 ± 160	leaves	
	bud scales	Twin Lakes near Inuvik, NWT
BIRCH		
13,500 ± 310	seeds?	Bell Basin, upper Porcupine R., YT

Table.4

Age of Lodgepole Pine Increase in the Yukon Territory

AGE (YR. B.P.)	MATERIAL	LOCATION
LODGEPOLE PINE		
<500	pollen	northern limit of current range
1,250 (est.)	pollen	Two Horsemen Pond, west of Whitehorse
2,490+(est.)	pollen	Flamingo Lake, near Summit Roadhouse
4,360+ (est.)	pollen	Kettlehole Pond, near BC border west of Teslin

Table.5

Northern Forest Tree Species in North America

	NFLD, LAB	NS, NB	QUE, ONT	MAN, SASK, ALB, NWT	BC, YT	AK
Picea glauca	√	√	√	√	√	√
Picea mariana	√	√	√	√	√	√
Larix laricina	√	√	√	√	√	√
Abies balsamea	√	√	√	√		
Pinus banksiana	√	√	√	√		
Thuja occidentalis		√	√			
Picea rubens		√				
Abies lasiocarpa				√	√	
Pinus contorta			√	√		
Betula papyrifera	√	√	√	√	√	√
Populus balsamifera	√	√	√	√	√	√
Populus tremuloides	√	√	√	√	√	√
Fraxinus nigra	√	√	√			

Table.6

CONE PRODUCTION FOR YUKON CONIFERS

■ CONE PRODUCTION CHARACTERISTICS

SPECIES	CONE BEARING AGE BEGINS (years)	PERIOD BETWEEN COLLECTABLE CROPS AVE. (years)	PERIOD BETWEEN COLLECTABLE CROPS RANGE (years)	CONES PER HECTOLITRE (number)	COLLECTION PERIOD
Alpine fir	20	3	2-5	850	mid-Sept.
Tamarack	40	5-6	---	---	Aug.-Sept.
White spruce	20	6	2-12	11,000	mid-Aug.-Sept.
Black spruce	10	4-5	2-6	---	Sept.
Lodgepole pine	10	3	2-4	8,300	Oct.-Mar.

Table.7

SEED YIELD FOR YUKON CONIFERS

■ AVERAGE SEED YIELD

SPECIES	CLEANED SEED WEIGHT/ HECTOLITRE OF CONES (kilograms)	TOTAL SEEDS/KG OF CLEANED SEED AVE. (number)	RANGE	VIABLE SEEDS/ HECTOLITRE OF CONES AVE. (number)	RANGE	STORAGE PERIOD (years)
Alpine fir	2.33	105,000	100,000-146,000	72,600	8,000-98,000	5-15
Tamarack	0.17	629,000	595,000-694,000	32,300	21,000-42,000	6-10
White spruce	0.67	513,000	414,000-878,000	183,900	23,000-582,000	15-20
Black spruce	0.07	855,000	683,000-1,056,000	40,700	22,300-67,500	17-20
Lodgepole pine	0.22	336,000	273,000-460,000	46,100	8,000-166,000	20

Table.8

FRUIT PRODUCTION FOR YUKON HARDWOODS

■ FRUIT PRODUCTION CHARACTERISTICS

SPECIES	FRUIT BEARING AGE BEGINS (years)	PERIOD BETWEEN COLLECTABLE CROPS AVE. RANGE (years)	SEED DISPERSAL PERIOD
Paper birch	15	2	late Aug.-Mar.
Balsam poplar	8-10	1	early June-early July
Quaking aspen	10-20	4-5	mid-May-mid June

Table.9

SEED YIELD FOR YUKON HARDWOODS

■ AVERAGE SEED YIELD

SPECIES	CLEANED SEED WEIGHT/HECTOLITRE	TOTAL SEEDS/KG OF CLEANED SEED	
	RANGE (kilograms)	AVE. (number)	RANGE (number)
Paper birch	2.6-4.4	3,043,000	1,345,000-9,085,000
Balsam poplar	---	---	---
Quaking aspen	---	---	5,512,000-6,615,000

Table.10

Table 10. Silvicultural systems and reproduction methods for forest cover types of the Northern Forest of Alaska, a first approximation.

Forest Cover Type	Desired Species	Clearcut	Seed Tree	Shelterwood: Uniform	Shelterwood: Group	Shelterwood: Irregular	Shelterwood: Strip	Selection: Uniform	Selection: Group	Coppice: Simple	Coppice: w/ Stand.
White Spruce	Sw	Yes	(Yes)	Yes	Yes	Yes	Yes	(Yes)	Yes	No	No
Black Spruce	Sw	Yes	No	No	No	No	No	No	No	No	No
	Sb	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Tamarack	T	Yes	No	No	No	No	No	No	No	No	No
	Sw	Yes	No	No	No	No	No	No	No	No	No
Paper Birch	B	Yes	Yes	(Yes)	No	No	(Yes)	No	No	(Yes)	No
	Sw	Yes	Yes	Yes	No	No	No	No	No	No	No
	B/Sw	Yes	Yes	Yes	Yes	Yes	Yes	No	No	(Yes)	Yes
Aspen	A	(Yes)	No	No	No	No	No	No	No	Yes	No
	A/Sw	(Yes)	No	No	No	No	No	No	No	Yes	Yes
Balsam Poplar	P	Yes	(Yes)	No	No	No	No	No	No	Yes	Yes
	Sw	Yes	No	No	No	No	No	No	No	No	No
	P/Sw	Yes	Yes	No	No	No	No	No	No	Yes	Yes
White Spruce-Black Spruce	Sw	Yes	No	No	No	No	No	No	No	No	No
Black Spruce-Tamarack	T	Yes	No	No	No	No	No	No	No	No	No
	Sb	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Paper Birch-White Spruce	B	Yes	Yes	(Yes)	No	No	No	No	No	(Yes)	No
	Sw	Yes	No	No	No	No	No	No	No	No	No
	B/Sw	Yes	Yes	Yes	Yes	Yes	Yes	No	No	(Yes)	Yes
Paper Birch-Black Spruce	B	Yes	Yes	No	No	No	No	No	No	(Yes)	No
Aspen-White Spruce	A	(Yes)	No	No	No	No	No	No	No	Yes	No
	A/Sw	Yes	(Yes)	No	No	No	No	No	No	Yes	Yes
Balsam Poplar-White Spruce	P	Yes	Yes	(Yes)	No	No	(Yes)	No	No	(Yes)	No
	Sw	Yes	No	No	No	No	No	No	No	No	No
	P/Sw	Yes	Yes	No	No	No	No	No	No	Yes	Yes
Paper Birch-Aspen-White Spruce	B/A/Sw	Yes	(Yes)	No	No	No	No	No	No	(Yes)	Yes

Sw = white spruce
Sb = black spruce
T = tamarack
B = paper birch
A = aspen
P = balsam poplar

SILVICULTURE IN THE WESTERN BOREAL FOREST--SOME CONSIDERATIONS

by

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INTRODUCTION

The North American boreal forest spans the entire continent from east to west and about 22° of latitude, an area larger than any other forest region on the continent. It is a part of the global boreal forest that accounts for 29 percent of the world's forest land. Although the level of development is increasing, the boreal forests in Canada and Alaska contain large expanses that have been relatively unaffected by European settlement. Although the major interest in these forests has been for wood and fiber products, their value goes far beyond that. The wildlife, water/wetland, plants, clean air, and scenic values provide unparalleled opportunities for recreation, hunting, fishing, and simply the joy of being in an area little affected by human activity. As population increases and open space becomes less available and less attractive in southern Canada, the United States, and, for that matter, other parts of the world there will be increasing use of these other resource values. The challenge is to manage these forests such that all values are maintained and that forest exploitation does not reduce future commodity and non-commodity values in a way that jeopardizes revenue, jobs, life style opportunities and enjoyment for local folks and remains attractive for visitors.

The role of silviculture in forest management is to provide options for achieving management objectives. Landowners may be society at large, various sized groups or individuals and the land may range from large tracts of public land to community forests and private woodlots. The goals of each of these groups may be similar in a general way, for example, to maintain forests on their lands, but the methods by which these goals are achieved can differ significantly. A silvicultural system developed for one group may have no relevance for another group. The purpose of this presentation is to discuss some of the things that determine the nature of silviculture in the boreal forest and to describe some of the silvicultural options available for management.

HISTORY

The forest resource that is available is the result of historical natural events and human activities and the future forests are being created by our activities. The history of management in the boreal forest has been covered in by others (Bernsohn n.d., Bisset et al. 1994). Some important points are mentioned here. Markets have driven silvicultural practices. The ability to market various sized trees determined what was removed from the woods and utilized. The standard of utilization increased greatly with the advent of pulp and paper mills in the 1960's making removal of all but the smallest material possible. Utilization of small material marks the time that clearcutting was adopted almost exclusively in the boreal forest. Silvicultural practices were geared to regenerating conifers in clearcuts. During the 60's, 70's, and 80's, there were major advances and innovations in site preparation technology, technology for growing and handling seedlings, and methods for managing unwanted vegetation but all in the context of the environment created by clearcutting. There were also great advances in the understanding of the structure, function and dynamics of the boreal forest.

Forest harvesting technology changed dramatically in the last 3 decades. It is now possible to clearcut forests faster and with less manpower than in the past. This does not equate to good forestry practice. An important point to note is that much of this harvesting technology can be adapted to partial cutting and provides a powerful silvicultural tool for creating a broad variety of stand conditions.

Prior to adoption of clearcutting, partial cutting occurred to various degrees in the boreal forest. These early operational and research efforts provide information on response to partial cutting systems that are of increasing interest today. It is unfortunate that silvicultural systems utilizing something other than clearcutting were not continued as it would have greatly broadened the scope of boreal silviculture. In my view, the profession of forestry and forest industry were remiss in not advocating a broader range of silvicultural systems and overstory treatments. In not using more silvicultural alternatives, an important part of the profession's history was ignored.

The results of harvesting and silvicultural practices have been mixed. The greatest success has been with natural and artificial regeneration of lodgepole and jack pine and black spruce--species with serotinous cones. These species have an ever present supply of seeds and are well-adapted to clearcutting followed by site preparation techniques that scarify mineral soil and distribute cones. The sites on which these species grow also tend to be drier and have less problem with rapid development of competing plants. The most difficult sites to regenerate are those which are relatively rich in nutrients, have a mesic soil water regime, and support mixed wood stands primarily of aspen and white spruce. Aspen suckers quickly from roots and other species (Calamagrostis, raspberry, fireweed) also rapidly occupy these sites by sexual and asexual reproduction making it difficult to establish white spruce regeneration. The lack of adequate white spruce regeneration has been a matter of concern and great effort has gone into establishing spruce on these sites. Past harvesting and inadequate regeneration have created a backlog of poorly regenerated areas (millions of hectares in Canada) and there has been a major effort to restore these areas to productive forest.

One of the hopes is that we learn from our past activities and that we maintain an historical perspective regarding silvicultural and management activities. This is extremely important because of the length of time necessary to grow forests for whatever value and the great cost of trying to remedy past mistakes. Have we learned from the past? In Alaska, Yukon, and NWT there are signs that we are not taking advantage of the lessons from other parts of the boreal forest to the extent possible. Several examples illustrate this. D.J. Weir (Northern Forest Products, Hay River NT.), indicated that harvesting was being done on a diameter limit basis (all trees larger than 22 cm) to the exclusion of other methods in parts of the Northwest Territories. This method has been tried in the past with poor results because many of the trees left are not able to survive following harvesting. At the very least a variety of methods should be used and an adaptive management strategy followed. In the Yukon, there was little concern for reforestation following harvesting until recently. The result, a backlog of poorly stocked cutovers--a repeat of the past. In Alaska, there appears to be no serious silvicultural planning as has evolved elsewhere, although forest practices regulations exist. There is no reason to ignore the lessons from northern Alberta and northern British Columbia. Every effort should be made to adopt state-of-the-art silvicultural planning and practices.

INFORMATION TRANSFER IN THE BOREAL FOREST

There has been a great deal of thought about silvicultural planning, and operational experience and research with forests that are similar to the western boreal forests. There is sometimes the attitude that if operational results and research are not from the local area that it is of little value. This attitude has some basis in fact, but one cannot generalize to all information and all applications of that information. There are different kinds of information available--for example, concepts and models, technology, and site- and species-specific information.--and different ways of using it.

The information most easily transferred is of a conceptual nature. For example, there has been a great deal written on reforestation planning in the last decade. This is in the form of conceptual models and various types of computer software. Much of this information could be used directly in the boreal forest. There is no difference in the essential elements of a reforestation plan for Oregon, British Columbia, Yukon or Alaska. Much of the harvesting and site preparation technology in use was developed outside the North American boreal forest, mainly in Sweden and Finland, and it has been adopted successfully without a great deal of modification.

It is more difficult to assess the relevance of specific biological and ecological information. The boreal forest has relatively few tree species, but the ranges of these species are among the greatest for trees in North America. Is information for aspen or spruce from northern Minnesota applicable to Yukon and Alaska for example? The basic biology is similar for a species throughout it's range, but there are often differences in the biotic and abiotic environment in which the species grows. Knowing what information can be used reliably from one area to the next is important for silvicultural planning. There are no absolute answers to this question, but basic to answering this is understanding the environment of the area from which data are available and the area to which one would like to apply the information. The availability of multi-factor site classification systems in a number of areas in the boreal forest makes comparisons easier and more reliable. Better coordination among these systems will undoubtedly occur in the future and make these comparisons even more reliable. Several brief examples how one might evaluate information are given below.

The presence or absence of species will affect successional patterns. For example, in interior Alaska there is no fir or pine species as in other parts of the boreal forest. Thus application of any of the forest succession research from that area to other parts of the boreal forest must consider this factor.

Harvesting of aspen has increased dramatically in the last decade in Alberta and British Columbia and there is little management experience with the species in this area. Aspen has, however, been managed for decades in northern Minnesota and Wisconsin. Comparison of results of studies from these areas suggests that much of the information on suckering following harvesting applies throughout the species range. However, aspen longevity differs considerably among areas. It has a relatively short live span in Minnesota and Wisconsin and a longer life in northern Alberta, British Columbia, Yukon and Alaska, being more similar to that of the Rocky Mountains. This may be related in part to pathogens, particularly Hypoxylon canker, being present in the south but not the north. Thus one might be reasonably confident in predicting early stand development in Alaska and Yukon from experience in Wisconsin and Minnesota but cautious about applying information on growth and development in older stands.

A final example is for vegetative and reproductive growth of white spruce. Gregory and Wilson (1968) found that white spruce in Alaska and Massachusetts produced the same number of cells in the annual ring, but that Alaskan trees produced these cells in one-half the time of those in Massachusetts. The rate of cambial division in Alaskan trees was twice that in Massachusetts trees. This difference in growth rate does not seem to exist in cone and seed development. From the data available it appears that the phenology of flowering and seed maturation varies little on favorable sites through out the range. Limitations to reproductive growth occur as the amount of summer heat declines at higher elevations and latitudes. In the most extreme case, seeds do not mature because the amount of heat available during the growing is not enough for seed maturation. These comparisons suggest that comparing annual ring formation and diameter growth across the species range may be more problematic than comparing reproductive growth.

THE BOREAL ENVIRONMENT AND SILVICULTURE

All regions have some unique aspect of the environment that distinguishes it and is important in defining forest management activities. The boreal forest is a cold-dominated region with short summers and long winters. Silvicultural activities must be carried on within this context and seek to alter those environmental factors that are manageable in order to maintain the range of potential forest conditions possible. For example, from work by Van Cleve, Viereck, Chapin and others in Alaska, it is fairly clear that the soil temperature regime, determined by the interaction of climate, forest cover and condition of the forest floor, is very important for forest reproduction, development, and productivity because of the effect on soil development, nutrient cycling and root development. It is possible to manage soil temperature to some degree by treatments that alter forest floor depth, and overstory density and composition.

The winter is certainly what many think about when the boreal forest is considered. It is significant from a silvicultural standpoint. Snow cover, frozen soils, frozen lakes and rivers, short winter days and the very cold air temperatures affect silviculture in several ways. Access to many areas is only possible in the winter and this limits the site preparation and reforestation options for those sites. On sites accessible year around, the choice to harvest in summer or winter significantly affects forest floor disturbance, probability and severity of damage to residual trees, distribution of logging residue, regeneration options, and disturbance of shrub and herbaceous vegetation as well as other things that may be important to post-harvest conditions. The main point here is that boreal forests have a productive capacity set by climate and site, but within these limits there is significant variation in forest development and silvicultural practices can be used to realize the potential that exists.

ECOLOGICAL REALITIES

Packee has described the important aspects of boreal forest ecology (see paper in this volume). I would like to mention what seem to me to be important realities derived from ecological observations and research that need to be taken into consideration in the planning and execution of silvicutural systems.

First, forests are constantly changing. Changes can be as subtle as the annual growth of a cone, development of a common insect or death of a single tree, or as dramatic as a fire racing through the forest consuming thousands of hectares in a matter of hours. Trees, associated plants, animals--all biota--are continually growing, dying, and migrating in relation to interactions among themselves and the physical environment in which they are growing. Silvicutural practice seeks to manage and direct this change within limits of economics, technology, and the goals of landowners and society.

Because forests grow in the natural environment and are subject to natural forces, there is always a degree of uncertainty associated with any level of planning or treatment. Uncertainty must be recognized and planning flexible enough to adjust to it or compensate for it. The fact that uncertainty exists must be communicated to the public.

Boreal forests grow slowly and the results of a treatment will be apparent for many years. Thus planning of activities and articulation of treatment effects are critical aspects of silvicultural activities.

The most productive forest sites are scattered among a much larger area of forests with lower productivity. The areas of lower productivity can be managed to provide values not available in the more productive areas.

SPECIAL FOREST PRODUCTS

Silviculturists often only consider wood production for traditional industrial purposes. Although aware of other values of trees and associated plants they are often not adequately considered. The potential exists to gain a significant amount of additional value from the plant resources of boreal forests. These values are such things as berries for local use and export, mushrooms, willow stems for basketry and furniture, birch bark, spruce roots for basketry, balsam poplar bark for carving, birch sap/syrup, cones and greens for floral and decorative purposes, and medicinal values. Admittedly, these products do not generate the revenue and jobs that large scale harvesting and wood manufacture provide at least in the short-term. However, they are important to individuals and communities, and generate value added products from materials that often go to waste in forestry operations. Although these products are available within a forest area or region as a whole, they are often difficult to gather because of poor access or limited availability. Through the use of silvicultural practices that manipulate the tree canopy and forest floor it would be possible to manage areas for special forest products that are near communities. In these areas, the interest of residents and value of the product may permit more intensive silvicultural practices than can be done on a large scale.

One personal observation--having been gone from the "real" boreal forest for a decade, I miss the special delights such as lingonberries, Alaska blueberries and other special forest products. On a trip to Fairbanks last September, I was heartened to see that birch syrup and local berry products, raw and in the form of jams, jellies and syrups, were available and popular in the local farmers market. For special occasions, we still like to have lingonberries and cloudberries which do not grow in northern Wisconsin. They are available, however a small jar costs $6-10 and comes from the forests of Sweden and Finland. There is a market for special products from the boreal forest in Alaska and Canada, we just have to develop efficient ways of producing, manufacturing, and marketing them.

SILVICULTURAL SYSTEMS

Silvicultural systems are an integrated series of treatments to achieve the forest condition and management objective of the landowner (Figs. 1 and 2). They are usually referred to by the name of the regeneration cutting method , e.g., clearcut, shelterwood, seed tree, and selection systems. The preharvest silvicultural prescription (PHSP), developed before treatments occur, is a document that qualitatively or quantitatively describes the silvicutural system. The following briefly discusses the essential elements of a PHSP.

1--Identify goals and objectives. Without well-stated management or silvicultural objectives there is no way to know what treatments are appropriate. Objectives can take the form of growing trees to a specific diameter, producing a desirable forest structure wildlife habitat condition, berry production, and others. There usually are multiple objectives for a given stand. For example, I recently read a management plan for 200,000 ha of Native lands on the Yukon River in Alaska that called for increasing moose populations by 25 percent, creating and maintaining 400 ha of land in high quality berry production, and harvesting one million board feet of trees for lumber production during a 10 year period.

2--Preharvest stand examination. The purpose of this exam is to gather information about the stand or site and use it to classify the site in relation to productivity, stand condition, special forest products, wildlife habitat or any one of a number of other areas of interest. The information collected should provide an indication of what the post-treatment environment will be with regard to development of plants following treatment, animal use and effects on other forest values.

3--Stand/forest conditions to meet objectives. This describes a desired future condition. The approximate year or a general time frame for achievement of particular conditions should also be included.

4--Treatment regime. Identify all of the treatments necessary to achieve the desired forest condition over the initial 10-20 years of the plan.. It is also desirable to identify some alternative ways of achieving the desired condition.

5--Modeling/prediction. There are a number of models available that can be used as guides for determining the effectiveness of the proposed treatments. The predictions from these models should be used more as guides than as absolute answers. They provide a means of examining and comparing results of different treatment regimes.

6--Monitoring. A key to the success of any prescription is an assessment process. The only way to determine the effectiveness of treatments is to quantitatively evaluate response of key ecosystem variables to the treatment.

Several things need to be stressed about the PHSP. It is not a rigid set of steps to be followed blindly and at any cost. It should be a plan for adaptive management. That is, as new information and experience become available, it should be updated and altered as necessary. Because every treatment affects the future condition, treatments prescribed early in stand development should be compatible with those planned for the future.

REGENERATION SYSTEMS

Regeneration following harvesting has been the major concern of land managers in the boreal forest and will continue to be important as long as there is a desire to sustain forest ecosystem production for specific products and conditions. The characteristics of the regenerated forest will determine to a large extent the desirability of the forest in the future. The regeneration system is a part of the silvicultural system (Fig. 1) and all of the information necessary to develop a PHSP is relevant to regeneration. In many cases, the major consideration in the PHSP is regeneration and attainment of free-to-grow status for trees and other vegetation. The purpose of this section is to briefly consider some aspects of the regeneration system.

REGENERATION CUT

The regeneration cut or series of cuts removes the mature overstory and provides conditions necessary to meet short- and long-term management objectives. Clearcutting has been used almost exclusively with little regard for other biota. The rationale for clearcutting is both economic and ecological. Economic thinking is simplistic--it is easier and more profitable in the short-term to harvest every merchantable tree. In ecological terms, the environment created by clearcutting has often been equated to that following natural fire, the disturbance most often resulting in stand replacement. This is now recognized to be an inaccurate generalization. The post-fire environment always has standing and down dead trees and sometimes groups of living trees, and a more heterogeneous physical and chemical seed bed environment due to shade from the dead trees and variation in the amount of organic matter consumed and mineral soil exposed than is usually present following clearcutting.

There is no question that there are many more options for the regeneration cut than have been used in the boreal forest. Clearcutting is certainly a viable option depending on the site, species, and management objectives. There are excellent examples of clearcutting where standing trees are left in different patterns within the harvest unit to meet wildlife and other objectives. (Coates and Steventon 1195) has done some very innovative work with patch and group retention (retain up to 10 percent of the stand in uncut patches of various sizes and shapes) in the sub-boreal spruce zone in British Columbia. He finds that loggers readily understand the silvicultural objectives and can achieve the desired conditions with little supervision. Using these methods requires meeting with loggers periodically and giving them feedback on their work, but it is a very feasible and acceptable alternative to clearcutting as usually practiced. Coates' and Steventon's observations and those of others indicate that loggers are often willing to try something new and should be considered partners in the attainment of silvicultural goals.

The use of other forms of even-aged silvicultural systems (shelterwood and seed tree) has been mostly ignored for the past 20 to 30 years and experience is very limited. Research in the 1950's and 60's (Jarvis et al. 1966, Lees 1964) provided some information and we used this design experiments started in the late 1960's in Alaska. These studies have shown that shelterwoods can be used to regenerate white spruce on a site-specific basis and that the overstory can be removed without destroying the regeneration (Zasada and Grigal 1978, Zasada 1990, Youngblood and Zasada 1991, Youngblood 1990). The full tree processors that are now used in some areas should make it possible to remove the overstory with little damage to the regeneration. Research and semi-operational trials of alternative regeneration cuts in spruce forests are being planned for northern British Columbia (R. Negrave, Brit. Col. Min. For., Res. Br., Fort St. John BC., personal communication).

One of the concerns about use of shelterwoods, or more generally partially cutting in mature spruce stands, has been the wind firmness of the residual stand. Some windthrow and tree mortality is to be expected following partial cutting in mature forests. This can be minimized by selecting the most wind firm dominants and codominants, leaving groups of trees rather than uniformly distributed individuals, protecting residual trees from damage, using the most suitable harvesting equipment, and, obviously, not using the system on sites where it is not appropriate. Navratil et al. (1994) have presented a good discussion of factors to consider in relation to leaving wind firm trees. Vigorous residual spruce as old as 180-200 years old will respond with increased diameter growth. We also observed excellent seed production in shelterwoods on upland sites in interior Alaska.

There is always interest in using group or individual tree selection systems to manage spruce thus creating uneven-aged forests. There is no information available on use of these methods in the boreal forest to my knowledge. A major concern with application of these systems is managing soil temperature so that forest floor development does not reduce soil temperature to the point that nutrient cycling, tree root development and, ultimately, tree vigor are negatively affected. Silvicultural practices that reduce forest floor build-up include maintenance of mixed conifer-hardwood stands, management of overstory density to permit light to reach the forest floor, and periodic mechanical treatments that reduce depth of these layers. There are examples of multiple-aged natural stands in the boreal forest, but they are usually mixed species stands with a hardwood overstory and conifer understory or a spruce overstory and a balsam fir understory.

Shelterwoods can also be used to create several aged stands in white spruce (referred to as a deferred shelterwood) for part of a rotation for those areas where it is desirable to have this stand condition (Fig. 2). White spruce seedlings grow under an open shelterwood (50 to 80 trees/ha) with dominants attaining 1.5 to 2.5 m after 15 years.

A major concern with partial cutting is tree mortality from insects and diseases. A further concern is that insect species such as the spruce bark beetle will build up in harvested areas and cause mortality in adjacent uncut stands. One only needs to look at the Kenai Peninsula in Alaska and parts of the Yukon to see the damage that spruce beetles can cause. It is possible to minimize the chances that beetles will become a problem (treatment of logging residue, minimize damage to residual trees), but it becomes more difficult the older the forest and the less able it is to respond to treatments that increase tree vigor and ability to withstand insect attacks.

There is a great deal of interest in salvaging trees/forests killed by the bark beetle in Alaska and Yukon. The tendency has usually been to harvest all merchantable material. However there are other options available. For example, leaving the scattered trees not killed by the beetle could be important for regeneration. Likewise leaving various sized patches of living and dead trees could be important for wildlife habitat, regeneration and long-term site productivity. Dead trees have a role to play on any site and this should be considered in planning salvage operations.

Harvesting System

The harvesting system determines the way in which trees are cut and removed, the season of logging, and the type of equipment used to harvest. It will affect the size and distribution of logging slash, forest floor condition, damage to residual stand, ease of accessibility following harvest, distribution of serotinous cones and other factors.

Harvesting is often considered as a separate operation with no relation to silvicultural considerations. It has been viewed more as an engineering practice and the major consideration was cutting and removing trees as quickly and economically as possible. There is no question that harvesting is an integral part of the silvicultural system and should be used to meet the silvicultural objectives even if harvesting costs are increased to some degree. The economics of harvesting and regeneration are related and should not be treated separately. For example, there are often opportunities to meet some vegetation management objectives with the harvesting system but at increased cost to the harvesting operation. This increased harvesting cost should be viewed in the context of stand establishment and if it reduces the overall cost of harvesting plus stand establishment it should be viewed favorably. The difficulty in integrating these costs is that harvesting and reforestation are often separated by organizational boundaries--these are ridiculous limitations if they are a barrier to improved forest management. An excellent recent example of integration of harvesting and silviculture is described by Navratil et al. (1994) for a project that studied the effects of aspen overstory removal on the survival of the white spruce understory. In this case, harvesting was done at increased cost to save the white spruce understory and thus forego the cost of establishing regeneration.

The study reported by Navratil et al. (1994) and the work of Coates (D. Coates, Brit. Col. Min. For., Res. Br., Smithers BC.) are excellent examples of using harvesting technology, previously used primarily for clearcutting, to create conditions that meet a broader silvicultural objective. In this case, the improved harvesting technology is used for more than the simple objective of rapid extraction of trees from the forest.

Being able to use harvesting to create conditions for regeneration may be particularly important in more remote areas. It is only during the harvesting operation that adequate machinery will be available and thus any work done will be accomplished at that time.

Vegetation Management

Vegetation management refers to the treatments necessary for seedlings to achieve free- to-grow status. These can be divided into site preparation, weeding, and regeneration materials. The regeneration cut, harvesting system, and vegetation management are interrelated. Vegetation management should strive to be proactive. That is, the PHSP should identify potential problems and prescribe treatments that will minimize problems such that drastic remedial action is not necessary. For example, Calamagrostis can be a significant detriment to regeneration in the western boreal forest. The level of post-harvest response of this species can be predicted to some degree based on preharvest stand conditions. These predictions can be used to prescribe the most appropriate regeneration cut, site preparation method, regeneration material and other practices. The ability to prescribe preventive measures is particularly important when herbicide use is limited or forbidden.

Site preparation. Site preparation includes all of the treatments necessary to provide conditions favoring germination and initial growth of natural or planted seedlings. They are necessary when harvesting alone does not provide a suitable environment. This is most often the case for conifer regeneration. Harvesting alone provides adequate conditions for vegetative reproduction of aspen and other boreal broadleaved species. The objectives of site preparation are one or more of the following: creation of seed beds or planting spots, soil warming, improved drainage, control of interfering vegetation, and distribution of serotinous cones.

Is site preparation necessary? It is assumed that following clearcutting some type of post-harvest treatment will be required for natural or artificial regeneration. General experience has shown that regeneration periods are unacceptably long and species composition not acceptable without site preparation. Site preparation is most commonly done mechanically and equipment is available to provide a wide variety of microsite conditions. Orlander et al. (1990) provide a good overview of the methods available and the types of microsites created by each. Multi-factor site classification, such as used in British Columbia and Alberta, provides an excellent way to assess temperature, drainage, potential competition and other factors that determine post-harvest environment and the type of site preparation needed. There is no easy formula and each site must be assessed separately.

Are there ways of regeneration cutting and harvesting that may reduce the need for site preparation? The majority of experience would indicate that some type of site preparation is a necessity for prompt regeneration--the large backlog of poorly stocked clearcuts attests to this. There are some indications that successful regeneration can be achieved without site preparation other than disturbance that results from logging, but the observations are limited and should be viewed with caution. Our research in Alaska has shown that natural regeneration of white spruce can be successful in small clearcuts and shelterwoods on seed beds disturbed by summer harvesting activities (Zasada and Grigal 1978; unpublished data). Kabzems (R. Kabzems, Brit. Col. Min. For., Res. Br., Fort St.John BC.) has observed good spruce regeneration in stands partially cut with no site preparation in the 1950's and 60's. The early work described by Jarvis et al. (1966) and Lees (1964) indicates that natural regeneration was reasonably successful in partially cut areas. The fact that we have conifer forests in Alaska and the Yukon speaks strongly to their resilience after natural disturbance--we need to understand the process that created these forests in terms of microsites for regeneration. At this point the main recommendations for regeneration without site preparation are; keeping harvest units small (1 ha or less) so that seed reach all parts of the area; maintain residual trees as a seed source and as a source of shade to reduce surface temperatures; maintaining an overstory to reduce growth of understory vegetation; and harvest in the summer to disturb and break the continuity of the forest floor layer.

Prescribed burning following harvesting is used for site preparation. Under the right conditions of fuel loading and moisture, and weather, this creates excellent microsites. However, when conditions are not right, burning may have to be followed by mechanical treatment to get adequate site preparation. Burning will always have a place in site preparation but its use will be restricted because of air quality, uncertain results, and a hesitancy on the part of some managers to use fire.

Weeding. The objective of weeding is to assure that trees or other desirable species achieve a "free-to-grow" status. The amount of weeding will be determined by the site conditions, species composition, and tolerance and growth rate of the desirable species. Species causing the most problem for conifer regeneration in the western boreal forest are aspen and Calamagrostis and in some cases alder, willow, raspberry, fireweed, and other grasses. In the past herbicides were used to the maximum extent possible to accomplish weeding objectives. This is no longer possible on many sites because of public concern over the use of herbicides. Herbicides remain the most efficient treatment and should be used in a way that utilizes the least amount of herbicide to achieve the desired result.

There has been an attempt in recent years to adopt a new way of looking at competition control and the need for weeding. There are three main aspects to this new approach. First, there is a better understanding of how much competition a conifer seedling can be subjected to and still achieve a free-to-grow status. Using this information, fairly reliable predictions can be made of how much competition control is needed and what methods are appropriate to create them. Second, there is increasing experience that indicates that planting large, vigorous seedlings immediately after harvesting and site preparation increases the chance that the seedling will become free-to-grow without weeding treatments. The hope is that these seedlings will become established before the associated vegetation occupies the site. Finally, forest managers can more accurately predict the response of non-crop species based on pretreatment surveys of vegetation composition, structure, and density and an improved knowledge of species response to the treatment. Using this information they can chose the most appropriate treatments to minimize future problems.

Regeneration material. The choice of artificial or natural regeneration is based on management objectives, site conditions, species to be regenerated, browsing pressure, competition and other considerations unique to a given site. Some species are inherently easier to regenerate naturally because of seed availability, seedling growth patterns, ability to regenerate vegetatively, and the biotic and abiotic conditions of the sites on which they grow. Lodgepole/jack pine and black spruce, species with serotinous cones, are commonly regenerated naturally.

Aspen and other hardwood species regenerate vegetatively and can rapidly occupy a site following disturbance. The recognition of aspen as a desirable species will result in the acceptance of more natural regeneration of this species--in the recent past it was unacceptable and viewed as an undesirable weed. There is a danger in the wholesale acceptance of aspen as acceptable regeneration. A landscape comprised totally of aspen stands does not provide the diversity that a mixed wood forest provides. It seems that a component of conifer regeneration should be maintained in most stands.

Natural regeneration of conifers does not mean that trees, like Phoenix, arise after harvesting with no planning or post-harvest treatment. The decision to use natural regeneration often means that some degree of site preparation is necessary to prepare the seed bed, distribute cones or generally make the site more favorable for germination and seedling growth.

Natural regeneration of white spruce has been difficult to achieve throughout the boreal forest. There have been several cases of good natural regeneration of white spruce in Alaska (Zasada et al. 1978, Zasada and Grigal 1978, and Packee 1992). Common to all of these cases were the following: a readily available seed source on the site or within 75 m of any point in the small clearcuts, mineral soil seed beds, and a good to excellent seed year within 2-3 years of site preparation. Natural regeneration is a viable option for white spruce on some sites but not under the current methods of clearcutting.

Protecting advanced, natural regeneration present in the understory of hardwood and conifer stands is gaining support in both the eastern (black spruce) and western boreal forest (white spruce). Navratil et al. (1994) describe an excellent example of protecting the understory white spruce during removal of the mature aspen overstory. Here is a case where coordination of harvesting and regeneration considerations has resulted in an excellent silvicultural option.

Although natural regeneration is still used on the majority of land in the boreal forest, the trend in the boreal forest has been toward increased artificial regeneration, mostly by planting but seeding has been used in some areas. There are advantages to artificial regeneration and the experience and knowledge available on seedling production, storage, handling, planting, and tending to the free-to-grow standard provides many options for successful reforestation. Detailed consideration of artificial reforestation can be found in Regenerating British Columbia's Forests and similar publications.

There is the impression that competition exists between those advocating natural and artificial reforestation. This is true to some degree where large investments have been made in seedling production facilities and the number of seedlings produced determines the unit cost of planting stock. Natural and artificial regeneration should, however, be viewed as a continuum of options. There is good sense to be made of using various combinations of natural and artificial regeneration for meeting forest regeneration objectives. This decision should be a part of the silviculture prescription and not something that happens by default.

ECOSYSTEM MANAGEMENT

Ecosystem management and sustainable forestry provide a framework for a more holistic approach to the management of forest resources. Although sustained yield has always been a basic tenet of forestry, it was applied primarily to wood production and only secondarily to other forest values. Some key elements of ecosystem management that distinguish it from the more traditional view of sustained yield forest management are: management of landscapes and not just individual stands; management based on natural patterns of forest development; silvicultural treatments simulate natural disturbance; structure in the form of living and dead trees in harvested/disturbed areas is important to productivity and diversity; adaptive management is important; and a concern for the maintaining a diverse forest in terms of species and habitats within stands and landscapes.

Ecosystem management has obviously had a significant impact on the way land managers and the public think about forest management and silviculture. In fact, I believe that we are at a major crossroads in the philosophy and application of silviculture. The application of these ideas is just beginning. It is obvious that there is no single or simple way to apply these concepts. Rather each landscape and it's composite stands/sites should be managed based on it's potential, as defined by site conditions and the biotic community, both current and potential.

There are several areas that I want to discuss that are important to the implementation of ecosystem management. First, there is a lot of frustration regarding the current and perceived need for wood products. The projected increase in population in the decades ahead means a much greater demand for wood products even if the per capita consumption declines. This need for more wood seems to argue for more land devoted to forest production and more intensive forestry. However the trend seems to be very different as more land is being removed for conservation purposes thus eliminating from the land base for forest production. Furthermore, the use of some of the most important tools, e.g., herbicides, clearcutting, and planting, for intensive forestry is being restricted for various reasons. Resolution of these conflicts will only occur when society realizes that resources are not infinite and that difficult decisions have to be made regarding prioritization of the values desired from forests.

A second area concerns the scale at which silvicultural practice is applied. Ecosystem management advocates planning and coordinating efforts at the landscape or watershed scale of resolution to take into account those species and processes that work at a scale larger than a stand. The application of silvicultural systems will necessarily be at the individual plant and stand level even though the planning is at the larger scale. With the information and equipment currently available, it is possible to create many types of stand conditions with a landscape. The main factor will be understanding how to arrange them in space and time to achieve ecosystem management objectives.

Boreal forests are an ideal place to implement ecosystem management because there are large areas under the stewardship of society in the form of public lands. This is particularly true in Canada where provinces or the federal government are responsible for land management on the majority of the land. In this landownership situation, it is possible to implement landscape level planning without the complications of private ownership.

Finally, there is a question regarding the place of intensive management in the concept of ecosystem management. In order to meet the needs of society, there will have to be a range of management intensities. Intensive management does not mean that all of the ecological principles that are important to sustainability are ignored in the pursuit of fiber production. Rather it means that forest managers have to recognize the ecological limits to productivity and manage within those limits. Society at large also needs to understand that there are limits to the values that forests can provide and that intensive management may be necessary on some lands.

RESEARCH NEEDS

The achievements of silviculture research in the past 20 years have been great and have changed the practice of silviculture in the boreal forest (Doucet and Weetman 1990). Doucet and Weetman (1991) describe priority research needs. For areas like Yukon and Alaska, it is important to develop a research philosophy that meets long- and short-term needs. The following are some important elements of this philosophy. The immediate effort has to be to apply all that is known. This means a well-planned series of demonstrations and operational trials that will serve as the basis for an adaptive management strategy. Operational forest operations should also be conducted with adaptive management in mind and new things should be tried, tested and incorporated into silvicultural systems.

A conceptual or more formal model should be developed to serve as a guide for identifying gaps in information. In this way the highest priority work can be done with the limited funding that will be available for research. This high priority research should be conducted on experimental or model forests dedicated to research activities. This is the most efficient means of assuring long-term research projects--the backbone of silvicultural research.

Finally applied and basic research should be directed by scientists living in the area. They must experience and understand both the physical environment and social context in which the work will be applied.

SUMMARY

1. There are a variety of commodity and non-commodity values in the boreal forest that provide communities and residents with income, jobs, construction materials, special forest products, food, recreation, life-style options, and other necessities. These forests are also valued by nonresidents and visitors for wood products, recreation, hunting, fishing, open space, clean air and so forth. Forests should be treated in such a way that short-term, economically driven exploitation does not

jeopardize long-term needs of society.

2. There are always a range of silvicultural options to develop a forest condition for a given stand, site, or landscape to meet specific management objectives. The treatments selected to harvest, regenerate, and tend a forest constitute a silvicultural system for that site. There are many more silvicultural options for the boreal forest than have been used to date. There is an appropriate silvicultural system for all types of lands and landowners.

3. The preharvest silvicultural prescription (PHSP) establishes a silvicultural plan/system for a specific area and is based on the owner's management objectives and the characteristics of the forest and site. The silvicultural plan is a flexible document that will change as more experience is gained or as new information becomes available.

4. There is always some degree of uncertainty associated with forest development and silvicultural activities. This results from a lack of knowledge, economic considerations, and inability to predict and prevent natural events (fire, insects outbreaks, wind storms, etc.). Uncertainty needs to be recognized at all levels of decision making and articulated to society.

5. Ecosystem management provides an important framework to evaluate and apply silvicutural systems whether for intensive or extensive forest management. Although ecosystem management advocates planning and coordination of management activities at the landscape or watershed scale of resolution, management at the individual tree/plant and stand scales using currently available technology and information will be critical to implementation of the concept. Boreal forests provide an excellent place to understand the structure, function and process of natural forests and to develop silvicultural systems that simulate natural forest development.

6. Beware of the term sustainability as bantered about by scientists, politicians and bureaucrats. Question the context, time frame, economic assumptions, biological realities and other pertinent information before accepting a plan that "assures" sustainability.

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Figure 1. This figure depicts the various treatments that make up a silvicultural system. The top of the figure indicates the various types of regeneration cuts that are possible based on preharvest conditions and management objectives. The treatments indicated in the cross-hatched areas occur during the harvesting and regeneration phases of stand development. The established stand or free-to-grow condition is the end of the regeneration phase. Intermediate treatments such as thinning and fertilization may or may not occur depending on management intensity and objectives (Figure from Zasada 1990).

Figure 2. Illustration of some options for regenerating white spruce forests. Even-aged stands can be created by removing the mature stand in one (clearcutting) or more harvests (shelterwood). The shelterwood can be gradually removed gradually over a long period or in two harvests separated by only a few years. It is important to select dominant and co-dominant trees for the shelterwood as they will be the most wind firm and the best seed producers. Shelterwoods can be retained indefinitely for the purpose of creating multiple-aged stands. Growth of the regeneration will be suppressed to some degree by the shelterwood (Figure from Zasada 1990).

QUESTION PERIOD

Topic: **Ecology of the Northern Forest**
Speaker: **Ed Packee**

and

Topic: **Silviculture in the Western Boreal Forest - Some Considerations**
Speaker: **John Zasada**

There are a couple of things I think that are real important to realize here. I probably have the equivalent of a PhD., course-wise, in straight ecology. Everything that I have read, I cannot find -- unless it was real stupid -- any serious damage that has been done to the boreal forest of the northwestern parts of North America. These are not the only remaining boreal forests. There's some extensive areas -- far more extensive -- in a little place called Siberia. I think we have to keep that in mind. So, this is not the last remaining in the world. I also ask about a carbon sink, and I keep hearing that. I don't think that a dead spruce forest, due to the beetles, is a very good carbon sink anymore. It's not growing, and if it goes to grass, it certainly isn't growing the way a forest would grow, let's say, of carbon.

I think the thing that upset me more in that comment that I responded so violently to -- catastrophically to, if you would like -- was the fact that I have worked in private industry, and my record stands. Ecological reserve areas: I fought, and I got them, based on logic. I stopped a corporation from having one of the best hardwood control programs. The objective was to eliminate alder -- to working with alder as a source of nitrogen, instead of putting fertilizer down. I got the corporation -- and I didn't think of the fancy word, called ecosystem management, at the time, but my thesis was "An Ecological Approach to Yield Optimization through Species Allocation". Simply put, manage the ecosystem for the species -- and that's plural -- most suited for the site. If you want me to manage for beetle stands, I can manage for those. If you want me to manage for wilderness aesthetics; if you want me to manage for an old drill structure -- forget the timber, I can try and come up with a way to do this. I will argue, however, very strongly, that there is some science involved and there are some biological limitations. And, all too frequently, a segment of the public has on a pair of rose-tinted glasses, or something else they're using -- I don't know what -- that thinks that they can maintain a stand, which they see as what they want, in perpetuity.

And the name of the game in this northern forest is change. The name of the game, whether they like it or not, and the Rocky Mountain forest, is change. I can show that to you in Colorado, Wyoming, Yellowstone National Park -- burn, change. And it's not all coming back to lodgepole pine. I can show you the beetle in Yellowstone Park. The great grey owl -- when I worked down there, I used to be able to go out from the ranger station and walk 100 yards in the woods and have better than a 50/50 chance of seeing a family -- at least one of them -- of great grey owl. That forest is no longer there. Somewhere at home, I've got matched slides of 1959 and 1981 that shows what happened over that period of time. I used to be able to ride in Yellowstone National Park anywhere I wanted on a cutting pony. The pony used to go after the elk herd all the time. Man alive, you don't want to do that. You get brushed off pretty easily. There's no way a cutting pony could go through those stands today. You couldn't walk in a straight line through those stands today.

So, if you tell me what you want from management, as a silviculturist, I think John and I could turn around and make recommendations on how to achieve it. And I'm certainly not here saying that the Yukon -- and I thought I made that very clear yesterday and again today -- I'm not here to tell you what your policy should be. That's for you people to sort out. If the reality is that the public wants timber -- I don't know how many of you have watched the news, but CBC does have pretty good coverage. They're talking about: is there going to be a tax increase, and how are the provinces and territories going to deal with this $200 million -- I can't remember the number this morning -- decrease? If we're going to go back to subsistence ways, fine. Give me a pistol -- they're not legal in Canada, but give me a pistol and, if it's every other person, I'll make damn sure I'm not one of every other person. I think I'm speaking for a large number of people.

Q: I'm understanding that each site is specific. That's fairly obvious. I think we saw two types of clear-cutting, or I did anyway. One was a kind of landscaping clear-cut, and the other was block cuts. It would seem to me that there would tend to be a lot more benefits to the landscape type of clear-cutting than the other. I want to know if, in fact, that's been proven and, if so, if that's becoming more of the trend. It's certainly more aesthetically pleasing. Basically, that's the question.

A: I can't say. I know that there is a trend throughout Alberta and B.C. toward "not business as usual" and leaving more structure, irregular shapes, and that sort of thing. People that are here from elsewhere can answer that better than I can. I got the impression yesterday from one of the talks that there's irregularity, and there's some material being left, and that sort of thing, here. That's the nature of these flood plain stands. They're not regular boundary stands, anyway. I don't know.

Q: It wasn't so much the irregularity of the shapes. It was when we were seeing islands left, and lines left, and, kind of following the natural flow of the landscape -- more than, say, an oval or a kidney.

A: Two examples. If I've got two burns, side by side, and both of them are irregular in shape, and there's an island in one and an island in the other one. One is 1,000 hectares, and the other is 10,000 hectares, and it's even age, I would say you want to try and mimic that. There's no basic science behind that at this stage of the game, but at least you're trying to emulate, reasonably closely, what Mother Nature did. What I'm saying there is don't go to squares. And don't cut and fragment up those stands because there's such a thing as an interior of a stand, and you don't get that interior of that, despite my reputation of never getting more than 100 metres off a road. I do get back into these stands, and they are very different. The animal, plant life, everything is quite different that far off the road.

The second one to think about, however, is: what is effectiveness? I'm not talking about dollars and cents, but to achieve your objectives. If I have a seed tree approach -- which is individual trees scattered around -- I would rather have groups of seed trees that create a micro-environment in the stand, rather than something that is perfectly uniform across it. So, I'd have a combination of small clear-cuts, individual seed trees, and grouped seed trees going across and taking advantage of the landscape features that are there. Does that answer your question?

Q: I have two questions: one on wildlife, and the other on the spruce beetle infestation. In the wildlife, was there an increase in the moose browsing or caribou in that area that had the silviculture done, or was there an increase in wildlife activity there?

A: First of all, in these studies, the plot size wasn't large enough to assess big animals that require bigger areas and have larger home ranges. In terms of the browse availability, which is maybe some indicator -- it's the same sort of thing that you find here. There was no difference between the shelterwoods and the clear-cuts. We had new willow regeneration; we had new willow sprouting; we had aspen regeneration; we had birch. In a very rudimentary sort of way, we trapped small mammals, we followed bark beetle populations, and that sort of thing. The red squirrels all continued to use the small shelterwoods. The red-back voles freely moved between all three forest conditions: the shelterwood, the clear-cut, and the adjacent uncut stands. That pattern that we created didn't seem to -- well, the squirrels obviously left the small clear-cuts, but in terms of other interchange, there was plenty of it between them.

Q: In the spruce bog infestation you showed in that one stand on that one slide, was there an infestation in that area beforehand, or did some of the logs that were left in the area -- there is a method of catching spruce beetles and they use the dead trees to trap them -- trap trees, they call them. Were there any trees down that could have attracted the spruce beetles in that area?

A: The area that you are talking about, we were real lucky. There is a beetle population there, very small, and it didn't respond. Where it has happened -- and I will give you a good example -- are seismic lines. Those lines you saw in Alberta the other day, if they didn't clean slash on those, we've got bark beetle explosions along those lines. It sprouted out all over the place. The bark beetles along the Kenai Peninsula -- often tied to slash, often tied to disturbance. Like, people put in subdivisions and homes with driveways that cause distress.

But specifically, the concern that I hear you saying is if you've got a potential for bark beetles -- and there's another beetle out there called an Ips beetle that does a little different job, but essentially, the end result is the same, you're putting your stand at risk. If you don't have those, or if you use trap logs to get them out, which would be difficult in some of those cuts where you have the blowdown. But you've got to look at doing something. I don't know if I've answered your question or not.

Q: I would just like to make a few comments, following on the past question, and maybe Valerie would like to, as well. Depending on the silviculture prescription used, you could be shortening the time that wildlife, such as moose, can use an area, simply because with brushing of the understory, you are removing moose browse. So, looking at the landscape perspective, in a fire-driven system, you would have a longer period of time where the system is offering moose browse, compared to a, sort of, fibre-maximum production-type system, where you want to enhance growth of those larger trees. So, you may want to comment on that.

I just want to give another perspective on the spruce beetle infestation, and that's a purely wildlife perspective, from the bird's perspective. This conference is looking at all aspects of forestry in the Yukon. From a bird's perspective, spruce beetle is great -- for woodpeckers, in particular. It's a big banquet, and all the wildlife that feed on those birds, their eggs, avian predators that feed on the adults, it's great. It's also part of the nutrient cycling process that goes on in the boreal forest. From the fibre-production perspective, it's not so great because the value of that timber is going to decline the longer the trees are left standing after a spruce beetle infestation. The human, sort of, consumption-driven perspective is to go out and take the timber. I think there should be some allowance for that.

But, in Yukon -- and this is where my personal perspective comes in. There's a lot of wilderness still intact in Yukon. Once you start managing an area for timber production, it can become an intensively managed area, and it loses that wilderness aspect. I can't put a dollar value on wilderness because once it's gone, it can't be replaced. That's why, I think, we just have to be really careful in identifying what areas we will accept timber production to carry on in the Yukon and what areas we would like to be preserved.

A: There's a policy question that's being raised. As I indicated, we are certainly not here to discuss policy. At the same time, some very good, basic questions have come up. I would like to hit both of the ideas brought forth here. But before I do that, I want to point out something. At no time do I think that we are saying that we should maximize, for every stick of wood, the fibre potential out of it. Unfortunately, oftentimes, from the other perspective, it's the timber that is being subjected to all of the constraints for the benefit of these other resources. I'm not saying that is good, and I'm not saying that's bad. I think that depends on which pair of glasses you're wearing.

Some of the statements that were just made, theoretically, I think, are correct; in reality, they're wrong. I've done a search of the literature on beetle and insects. I've got 900 and some references tied to birds, trying to sort that out. I have found that, if it's the foliage-eating insects -- like budworms, caterpillars, inchworms, and that type of thing -- you definitely have an increase. And if the insect doesn't kill the tree, that population increase in birds stay with it as long as that infestation is there. When it comes to the bark beetle and the Ips beetle, you've got specialists -- they're called woodpeckers. You may have a few that clean up behind them -- you know, the lucky guys. But they've got to be able to get under the bark, and a woodpecker will clean the bark off of a tree, getting at those beetles.

Now, I was in a stand this fall and a graduate student, was there with me. I swear that I was in a CP railyard telegraph office about 1960. That's how many woodpeckers I had down there. When the beetles die, where do the woodpeckers go when the beetles leave the tree? And these spruce trees that I see -- and I've got one in my backyard that's now been dead 13 years. I've lived in that house for just about 13 years. I have yet to see a woodpecker on that tree after it is dried out. What happens is that the spruce beetle goes up fantastically, and right behind it, the woodpecker population goes up. When the beetles disappear, the woodpecker population disappears. I'm not saying that there may not be opportunities for an increase in birds, but it is not providing a structure for that particular group of birds. On the other hand, it may be improving the structure for a bunch of ground-nesting birds, like wrens and sparrows. The moose question is a different one. Again, it's a question of: are you maximizing moose populations, or are you maintaining good moose populations?

I can assure you, if we plant, we will probably reduce the number of years the browse is available. I don't know how long. But if we rotate, some stands are always coming into that stage. Instead of having a boom, and a plateau, and a bust for awhile, until the next major disturbance goes through, you should be able to average it out over a period of time. And moose do move. It's been a long time since I've had two cows in the yard with yearling calves, but I've always had one, just about every year. One year, I had three. They do move in, and they move out. The bird populations move in; they move out.

So, I think we're getting into a situation of asking questions here that have to be asked, but there are no real answers to it. And I really get concerned when people make it sound like it is factual. I'm not going to go any further than that. As I said earlier, you might not like what you're hearing from me. But realities are, a lot of the things we're concerned about are Chicken-Little-and-the-sky-is-falling-out scenarios.

Q: I'm not sure what you meant by brushing. I guess that's weeding and making sure that the spruce trees come through, right? Okay. Just a couple of perspectives on that. In the last decade, the amount of information that's become available on the effects of associated vegetation -- I don't like to call it competing vegetation, so I call it associated vegetation -- on the growth of spruce or other conifer species has really exploded. And there are now good ideas about how much you have to remove to get a tree to grow -- certainly, not perfect information -- to a certain height in a certain amount of time. I would say that there are as many options for bringing those trees to that point as you want to think about. You could say, we want X amount of trees per hectare, and make sure that those trees get to the point that they're free to grow. Maybe, to maintain moose browse, you only want half of those trees to go to that point. It's not an either/or situation. What I found on those sites in the interior of Alaska is that anything you do to encourage spruce tree generation, you also encourage invasion of willows. So, you increase the genetic diversity of the willows on those sites. That often doesn't happen after fire, particularly if you don't get really severe burns. All you get is the re-sprouting of what was there beforehand.

So, I think that wildlife biologists, ecologists and silviculturists need to sit down and come up with different scenarios about how much browse you need, what density of spruce you need on a site to meet these for whatever -- for community forests. There are options. You can't shut one another out. We need to solve some of these problems and be concerned about them. Nothing is wrong, as far as I'm concerned, with planting willows. I've planted a lot of willows. I've planted aspen. I've planted birch. It can be done. There's nothing to it.

Q: Thanks very much for your presentations this morning. It certainly inspired a lot of thinking on my part. My question -- actually, I've got a few, but the one that I'd like to get some comments on has to do with, basically, levels of protection versus that of forest land that we do want to look at managing, to some extent. I kill trees for a living. I do selection logging in the interior of B.C. The more I work in forests, the more I realize -- the more I read, and the more conferences, and that sort of thing, I'm not a practicing forest or anything -- that there are a lot of things going on out there that we are just beginning to touch the surface on, in terms of understanding. I've come to realize -- and a lot of the members of our association have come to realize -- that we really need to look at this debate of extending the whole ecological reserve program -- some sort of wild forest reserves is the idea that we've come up with -- in order to really be able to understand on a larger, landscape, watersheds kind of levels what's going on there, and the kind of interactions that are happening. The more I thought about it, in terms of foresters, the whole science of forestry, without those kinds of checks and balances, I think it's very difficult to suggest that you're practicing that science without major support for larger scale, basically, reserves -- letting those natural or wild areas go through the kinds of processes that happen without management. I'm wondering how that fits with your feelings and what we should be looking at, in terms of that kind of reserve concept.

The other thing I'm interested in is, in your studies -- I know there's a lot more going on in this field in B.C., Washington and Oregon. That is the larger, landscape-scale management that First Nations were involved in pre-contact, in many respects, with a larger population base that was suggested at that time. I know in southern B.C. there's been a lot of looking at this question, just how large-scale, cool burning, and a whole variety of different techniques that First Nations used for larger landscape management. I was wondering if there's been that level of research, or what is the feeling, in terms of the management techniques of First Nations historically had on the boreal forest up here? Those two questions, I'd like some comments on.

A: Let's start with the last one first. I thought, when I made my presentation, I was giving some idea to start to look at this thing, in terms of ecosystem process and the way things happen. I tried to hit disturbance to give you an idea of how big these disturbances were, and that is an ecosystem landscape management approach. Now, I point out very clearly, that you have to start looking at riparian zones differently than upland areas. You have different age structures and stand structures. That is the first step in this thing.

Where I get very uptight -- and I'll make it very plain because I'm very tired of it in Alaska -- is where these are the arguments that are brought up deliberately, to block any development. I will argue that the human is part of the ecosystem. I'm hearing ideas -- on that board over there -- and I've read them, where we don't know how to regenerate, we should do the studies up here, I hear this, I hear that, now I'm hearing the other side of the coin, that we should be trying what they're doing in British Columbia, or we should try to apply this and tie these areas up.

When I was introduced this morning -- I worked for a private company, and that company has a good reputation and a bad reputation, depending on which side of the line you stand on. I worked my tail off for that company. Before I left, I had made some recommendations on where they should start looking at ecological reserves. Very bluntly, those reserves were not looked at in terms of aesthetics, or maintaining wildlife populations because people wanted maximum numbers, but because of process. That was where I was concerned about.

I look at the Yukon, and I hear the story about big drainages. How many do we need to tie up? I look at the Kluane system and everything feeding into Kluane Lake. If you forget international boundaries and agency boundaries, you've got one of the largest ecological reserves in North America, and possibly the temperate world -- Kluane, Wrangell/St. Elias, the Kluane sanctuary, the Tetlit wildlife refuge, the Russell Fjords wilderness area and Glacier Bay National Park -- and never do you see in the literature any of those hooked together as one big unit. I've got stuff that, essentially, goes from way up high, with Logan, down to sea level. So, start to look at this. Most interestingly, who is going to look at it? Nobody goes and looks at this thing -- not even the ecologists, not even the biologists -- unless they do it modelling, sitting behind a computer. They're not out in the field to see what's going on. I forgot the first question.

Q: It was to do with the level of ecological reserves, or wild forest reserves, that we should plan for, considering that the practice of forestry is a manipulative kind of science. The need for checks and balances of that science -- there are certainly some of the things that I see when I'm working in the forest. So, I'm just wondering what you feel about what's required that way.

A: Okay, I'll put it in real simple terms for the Yukon. I don't think there are enough of them; I don't know where they should be; I don't think they should be humongous in size; I would like to see something, possibly hooked up with B.C. in the southeast corner somewhere; I would like to see something that hooks Nahanni into the west side of the Selwyn Mountains. There's a wildlife sanctuary right in the middle of the Pelly River plateau country in there. I've got one on the southwest side. I think that there may be some unique kinds of situations that would tell us about process and function scattered around. I'm looking at maybe several thousand hectares in size, but I'm not looking at them to preserve old growth. It could be second growth, or it could be a grassland. It could be a rock outcrop that has a certain kind of community on it.

On Vancouver Island, I tried and I got them -- I got two sub-alpine lakes, and they were paired up with one in Washington, where things were being studied very carefully. Haley Lake was essentially barren of fish. They have planted fish. They had a marmot colony. We don't know anything about the marmot colony. That was set up on fee simple land. There was another one that was set up in the Sitka that didn't have fish and didn't have marmots. So, we could look at processes. I think there is a need for that, but not a large need that you lock up -- you know, this 12 percent. Who the Hell are we to say that 12 percent of this ecoregion, or that ecoregion, should be tied up? We may not even know where the lines are.

Q: I guess my concern is that in our region, in the Cariboo region, it's very diverse. It goes right from interior Douglas fir, very dry areas, right out to interior cedar hemlock. I've seen numerous variants of some of the timber types in between that have, basically, been managed out of existence, in terms of having those natural checks. I guess I'm sort of searching for what kind of recommendations --

A: You're confusing something, and I tried to make that very clear. You're working with a completely different set of ecosystems, a bunch of State (Inaudible) species. I can have 8-9 species in the stand down there. Up here, I'm really working hard, in a lot of areas, to have more than 2-3 at a particular time. When you've got that kind of variability, I agree you need more. But when I'm working with a very -- and don't take this the wrong way -- simple set of species, I don't need as much as you do, when you've got eight, nine, ten species floating around. Plus the vegetation zonation. We've got three zones up here, essentially on a mountain -- four, if you want to split one of them: tundra, alpine tundra, sub-alpine parkland, sub-alpine forest, and montane forest. Then you've got a grassland -- sort of. Down in the Rockies: Ponderosa pine zone, Douglas fir zone, grand fir zone, spruce zone, sub-alpine fir zone, mountain hemlock zone, western hemlock zone, western red cedar zone -- let's not start confusing complexities. I hear about the rain forest of the Amazon, and then I found one of these wonderful biologists types refer to the rain forest of southeast Alaska as the boreal rain forest. You can't do it.

Q: Do you think, as an alternative, could you tell me if you can mix your species when you replant? Or, if you replant, can you go with a straight forest?

A: Most of the stands that I know of that have been planted, the white spruce end up as being a mixed stand, no matter what they try -- at least, in Alaska, and I would expect it that a lot of the areas here will end up being a mixed stand if I get the site disturbance that I need. That's the critical factor. I tried to show one of those where I had birch and spruce coming in -- a couple of classes of spruce were scattered in there. Does that answer it?

Q: Yeah.

A: When you talk about mixed stands, mixing species, and that sort of thing, the broad, general stages that Ed showed -- stand initiation, stem exclusion, and those kinds of things. If you look at that, particularly at the early stages of that, you always have multiple species in there. You have different -- from herbs to woody plants. You have to look at the different stages. I think that it's becoming more and more apparent that mixed woods, where they occur in the boreal forest, are the things that we should strive to develop. There's no use spending huge amounts of money to eliminate birch in Alaska, or spruce, when 40, 50, or 60 years down the road, they may be as valuable as the spruce is. I think it's the diversity, and I think Ed mentioned it in his talk that you want the complex of species on the site, to take advantage of whatever way things go.

Q: So, is it feasible to plant two different species?

A: Absolutely.

Q: Alright.

A: Three species. As a matter of fact, all you have to do, like Ed says, if you've got hardwood seed sources around -- I used to fool around a lot with seed production. In interior Alaska, on the flood plains, there is no populus trembuloides aspen. You can be 3-4 miles from the nearest seed source, and I've measured, on those sites, as many as 300 aspen seeds per square metre, that just get floated in. The hardwoods are really difficult to keep off the site if they belong in the area.

Q: How much of a difference does permafrost make on the replant, when you have fire? Does it drive it down quite a bit?

A: Folks around here that work with fire may have some observations, too, but we had a large fire near Fairbanks in the early 1970s, I think it was. Les Viereck, who is a pre-eminent plant ecologist in Fairbanks, has studied the permafrost situation on that fire. I believe it's still going down, and this is about 15 years later. The aggregate clearing and all that's gone on in Alaska is truly remarkable, in terms of permafrost dynamics.

I remember one site, in particular. It depends on the soil types that you're working on, but it's a toe-slope soil type that has a lot of finds, and that sort of thing. A group cleared it and grew carrots for a long time right in the middle of a sea of black spruce. That came back to one of the finest young aspen stands I've ever seen. So, there are options there. I don't recommend that we go about bulldozing every black spruce stand in the country, but there are options.

Q: Another question on the spruce beetle. We've left out the wood wasp. Does it hit dead trees or live trees? With the spruce beetle, how much can it multiply? I've worked in the Prince George little kind of clear-cut there. It was good money. They say it was multiplying much too rapidly, and we moved a lot of wood. Do you take it out of there, or do you just let nature take its course? Does that work?

A: There's a policy decision there. The policy decision is: do you want to let nature take its course, or do you want to try to get something for human society? In terms of how fast does it explode -- which, I think, is what you're saying. When I came to Alaska in 1983, to the University of Alaska -- I'd been up here before, on the coast -- I could show you scattered stands where there was an occasional beetle tree that was dead, and that they were starting to build on the Kenai. I was flabbergasted when I really looked at the Kenai two years ago. I've watched it move up the Matamooska Valley in less than five years. The entire valley now has infected stands up and down it. It's moved across the Kenai like you can't believe; it's now in the Fairbanks area; it's in the Delta area; it's in the Tok area; you guys have it over here in the Kluane area. I think the stands are getting to the age where somebody does a house cleaning job. It's going to be fire, disease, bark beetles, or a windstorm -- something like that. So, I'm looking at a five-year period, maybe going from 100,000 acres to 1.25 million that we've got now.

Q: I have a question for John. I was wondering if you could talk a little more about the operation details with the shelterwood harvesting you've done and seen in white spruce -- things like intensity and return rates. When were you back in there? Were you in there just to pass, or have you been in there for three or four pass systems? What kind of sites have you been working on for this?

A: It's all pretty rudimentary, to tell you the truth. The sites that we worked on were high for interior Alaska -- high productivity upland sites. The soil is of lacustrine origin -- deep lacustrine soils. The mantle on those things is at least 3 metres deep and sometimes up to 50 metres, or more -- 100 metres maybe. So, these are really good, prime soils. You saw the flood plain sites which, according to what Scott said the other day -- that idealized successional model pretty well fits some of your flood plains around here. We made the first cut in those stands. The second cut on the uplands study was made about 15 years later. There are two papers on that by Andy Youngblood that show the amount of damage to the regeneration using two different systems: a small cable system and a ground base system, and the growth of the shelterwood. The flood plain sites, they eliminated the silviculture program in the forest service in Fairbanks. So, those probably will never get removed, unless Ed does it, or somebody else.

If you look at the shelterwood system and the way that it can be practiced, the sky is the limit. You don't put bounds on your imagination. These forests are really neat things. They grow, they reproduce, they're dynamic. Don't get yourself into a corner, that you cookbook things or -- there is something that is called the irregular shelterwood, which means that you leave it on forever. You develop two- or three-storied stands. You have your regeneration layer, and then you have your mature canopy layer. You can leave that on forever. In a situation where the horse logger -- that would be a perfect situation to go in and periodically take out these trees. I think there are just lots of options.

Q: I recognize all the options that are available and applicable. I guess, I'm coming at it -- I have a bias. I work for forestry here in the Yukon. I am just wondering, if I have 20 operators who come in tomorrow and all want to do selection, what are the opportunities or barriers, in terms of ensuring that a good job is done in the end? You can say selection and go and do a high grade. Right now, we don't have much in the way of legislation to govern how these people are operating. I'm wondering how it's done in Alaska. Is it encouraged there?

A: It's one of those selection cuts that's now called ecologically correct high grading. Diameter limit cuts are not the way to go. That goes on the principle that smaller trees are younger. In a lot of these stands, there's a reason for that. I'll argue that it's a combination of the environment and the genotype. We don't know how strong the genotype is, but I feel that we're tampering with genetics in a negative way. If you want a recommendation, don't get yourself locked into diameter limit cuts. That's the worst that you can do. John pointed out that you want to leave behind the better and best trees. It doesn't make the timber operator too happy.

The other thing is that there are a couple of places to really look into literature. There are very few of them. I've got another graduate student right now who is pulling her hair out because there's nothing in the literature. There's a book by Keltey and Oliver, Kloor Press, which means that it's $100 and some. It's the Dutch taking us to the cleaners. The title of it is *Mixed Species Management*, I believe. You've got some good ideas in there on how to do things and how to look at these forests, in terms of structure. The other one that I use is a textbook very strongly. I cover exactly the questions in one of the classes I teach: are there advantages and disadvantages? Maybe not with concrete numbers but, at least, with thinking. That's Matthews book, *Silvicultural Systems*. That's Oxford Press, and you can get a paperback copy for about $40.00 U.S. I don't know how to convert pounds into Canadian dollars. Does that help you out a little bit?

One other thing, every logger is different, just like every forest site is different. In talking with Dave Coates down in Smithers, and some of my experience, there are certainly excellent loggers out there who can do the job for you. There's some that aren't so good, too. I think that we have to foster a much closer relationship because, in these northern forests, maybe that's the only time that we're going to be able to have some treatments on these sites.

Q: Dr. Zasada, you ended your talk with a few comments on intensive forestry. I just read a few things lately that are suggesting that the productivity in intensively managed forests is declining. I wonder if you could make any comments on that, and if you have any ways of avoiding that?

A: I get hit with that all the time. Intensive forest management, if carried out properly, should not have an impact on the long-term productivity that cannot be addressed under sustainability ideas. The cautions? Don't cut your rotation too short. If you do that, you don't give the system enough natural time to build up the nutrient base. It's been well-documented elsewhere. Nitrogen? You've got a lot of nitrogen fixers out there. Shepherdia does a real slow job. They looked very closely at that over in the tar sand country in Alberta. Alder has been looked at, and is still being looked at, to see what it's doing. Binkley wrote a whole book on the nitrogen dynamics in forest ecosystems. There's a book, Fricker and Ball, out of France, I believe, that really puts some ideas into it. There are ways to address the nitrogen. There is no evidence, at this time, to suggest that the next two normal rotations that we're going to have any serious problem with the minerals end of this situation. The availability question, on the other hand, with nitrogen is very critical. If you don't disturb the organic matter and get it breaking down, it's locked up. It's like putting your money in a sock under the pillow. So, it's not breaking down, it's not going into the system. You lose total nitrogen, but you gain on the available nitrogen. You get the bank account working. So, that would be the first thing.

One of the big concerns in intensive forest management is taking too much of the tree. If you're only taking the bowl and the bark associated with it, you're not creating a serious problem. I like leaving as much of the branches, the tops and the woods, as I can. Smash them down, whatever you do to get around a fire hazard. If I look at Europe, one of the complexes involved in forest decline, is the fact that they, in the past, have taken out everything, including the branches, the twigs, the leaves for feed or fuel, or whatever it was. That is where you're really raiding into the capital of the site, as far as nutrients go. So, I'm not too worried about intensive forest management -- unless you do something really dumb. That's a point, though. I can show you people who have this idea that you go out with a brush blade, get all the brush and all that organic matter, and you put it over here on a pile, and then you burn the Hell out of it. They say that all they're doing is redistributing the nutrients. Bull on that. That's terrible. I can show you that, if you plant on the middle of that line that they planted on, you'll have seedlings this high at 10-12 years of age, whereeas if you plant on the edges, they'll be as tall as I am or taller.

Q: I guess the only thing I would say is that I don't think that ecosystem management principles don't apply to intensive management. That's basically what I'd say. You have to worry about soil carbon; you have to worry about your nutrients. More and more, even the big companies are starting to look at this.

Q: We've heard a fair number of different people here, and quite a few of them had different slants to what they said, and quite a few of them were fairly obvious -- either industrial or protectionist, I guess, would be the word. We had a politician who told us that he hopes that forestry is going to become the number two industry in the Yukon. We had the industrialist from Watson Lake, who told us, with glowing emphasis, that it is going to be. In fact, it is growing so big that we can't stop it. There's nothing we can do to thwart this industrial monster that's coming. I use that term "monster", because I am scared of it. We've had the local scientists, most who said, "Be careful. Go with caution into this." The exception was the soil scientist, who said that the boreal forest was extremely resilient; that we don't need to worry about it. We can just go in and hammer it, and it'll come back. Heck, we had 2 or 4 metres of volcanic ash dumped on it, and it just changed things a little bit. Well, maybe if we just go in and clear-cut everything and have industrial logging, that, again, will be the result -- we'll just have a little bit of change. I'd suggest to that soil scientist, though, that he should have a look at the soils of northern Ontario, where the boreal forest was clear-cut, and the extreme sedification that has occurred because of it.

We've had a lot of outside experts, most of whom -- with the exception of Dr. Zasada now -- have supported the industrial paradigm all the way. We have been told that selective logging isn't necessarily a good way to go. We've been told that we have to industrial log, if we're going to log at all. I say, "Let's log." I'd like to see the timber supply come from the Yukon. I would like to ask my question of Dr. Zasada. I think that Dr. Packee's answer would be fairly much expected.

A: I object to that, from a professional standpoint. That is your opinion, and let's maintain objectivity between one another, please.

Q: I accept that, and I think you're absolutely right. We had an excellent talk from Gary Merkel yesterday, and he said much the same. I'm sorry. Let me direct my question to both of you, then. Do we here, in the Yukon -- I realize that you don't want to talk policy -- when we're assessing our management plans, do we take timber extraction as the number one forest concern, or do we put that down as a secondary, or a tertiary concern? I ask that question, and I want you to keep in mind that Yukon's forest is perhaps the last forest left in the world, in the temperate climates. And as such, the economic potentials are just being realized, in terms of what future tourism demands are going to have on that wilderness that does exist -- not managed forest.

A: I can't answer that. I can give you a little bit of perspective. I live, and have lived, for the last 3 years in northern Wisconsin. Those forests were absolutely devastated in the late 1800s and early 1900s. They've never returned to the stature and status that they had before. Ed knows them better than I do. He grew up there, and has spent every summer in western Wisconsin for all his life, I think. I have another 50- or 60-year history because my dad is a forester. He's in his late 80s now, but still stays active. He came into Minnesota in the 1930s, when you could see for miles. There weren't any trees at all. It's all grown back, the forest. But the forest doesn't resemble what was there before. We have a, really, an aspen-based economy, with some red pine. So, it's the options. Unfortunately, the people who live here don't have a Hell of a lot of choice, it doesn't seem like sometimes. The forests are going to come back, but they will be different. There's a certain level of certainty and a

certain level of uncertainty in that
whole thing. We just have to realize that and understand what we're getting ourselves into. I think forestry is a really good use of these lands, but there are limitations. We're not going to see 180 year old spruce forests on these sites again for a long time. I don't know. That's just, kind of, drivel, I guess.

ECOSYSTEMS CLASSIFICATION

by

PETER HENRY

There are increasing numbers of studies being conducted in Yukon examining the impacts of development and management activities on resource values. Unfortunately, the information and conclusions from these studies are not readily and widely available for application by resource managers and developers. The difficulty has been in ensuring that the results from a particular study are applied under similar ecological conditions in new areas. A common classification of ecosystems will facilitate the use of study results by laying down a common framework for describing the sites to which the results apply. Users who are familiar with the classification system can then go to new sites and apply the same results based on the ecological similarity of the sites. An ecosystem classification is being developed for the southeast Yukon to facilitate the application of site-specific management information. The classification system will be presented in a field guide format designed to allow users to easily classify ecosystems in the field. Resource management guidelines based on the classification will be developed and presented in a similar format to facilitate their application by a broad spectrum of users.

QUESTION PERIOD

Topic: **Ecosystems Classification**
Speaker: **Peter Henry**

Q: Does forestry have any plans to produce land cover maps based on the research?

A: The initial product, basically, for broad scale mapping right now, we have a forest inventory. I know you're familiar with it, and I know Rob in Watson Lake, for moose studies, gets a lot of use out of it. Part of the current contract is to develop an equivalency table. The classification system is hierarchical, so you have multiple levels, going down to your final ecosystem type. We kind of envision that we should be able to take the database from the forest inventory, which covers a large area -- and we may not be able to get down to the final types for all of them, just because we do not collect that kind of information. But we will be able to convert it and go at least halfway down the tree to give you more ecological information about what we have mapped as tree cover. So, that will be the first product. Again, because of the site-specific level of it, I don't think you're going to see a huge cover at the southeast Yukon at 1:20,000 using it, just because of costs. Again, the main aim is site-specific -- you walk on the site and you can classify it. The main aim is not the mapping. We want it to be mappable, but that's secondary.

Q: Has the ecosystem classification allowed you to extrapolate into other regions of Canada and the forestry practices there, and see how they apply to the Yukon example?

A: That is what we would also like is, again, an equivalency table or system, to take what we found in the southeast Yukon, compare it to the classifications in B.C. and Alberta, in particular, and eventually into Alaska, which is a long way away from us right now. If we have some equivalencies there, then we can more easily translate, okay, B.C. had a research experiment on clear-cutting. What types did they cut, and what impact did it have? We can then translate some of that. As John said, you have to be fairly careful about what you're taking and whether the processes are similar. One of the cases he cited was that the process may be similar, but the time frames might be different. So, again, healthy caution there, but we're hoping that it will make a lot more information readily accessible for application.

Q: I was wondering if the public will be shown the inventory list and where all your database is coming from.

A: You can come into my office and see it just about any time. I'm not sure how you would like to see it. Certainly, the product, and it will have information there about what sampling was done and where it was done. But I don't imagine you're going to get much use out of seeing a list of the species by plot. Again, the classification is trying to be very objective. The management interpretations, which is where we all come into the controversy, that's to be developed separately and after. We want a common, objective classification that's going to stand the test of time, that's not going to change as soon as our social values change. The ecosystem is still going to be there. So, the management interpretations, which have not been developed, are, I think, going to be the more contentious issue and then how that gets developed or vetted through the public process.

MUD PIES AND FORESTERS

THE APPLIED USE OF ECOLOGICAL ASSOCIATIONS

IN

OPERATIONAL FOREST MANAGEMENT

by

Cliff Kowalsky

INTRODUCTION

Thank you Mr. Chairman, Ladies and Gentlemen and fellow foresters.

I managed to suggest to Deb (probably at the wrong time) about the symposium needing some input from people actually applying the ecological associations in the field. When I recovered consciousness, I was on the agenda and am now about to expound the virtues of ecological associations.

For the most part I'm preaching to the converted and in talking to the delegates over the last two days most are familiar with the system. My talk basically will expand how I use EA's not only in the types of work I do but also on field examples. I'll also touch on field guides and their usefulness, etc.

I only hope these OH's show up.

INTRODUCTION - Who am I?

Why the title? Well my wife sees me come home - mud all over - soil texturing makes a mess. Mud on face, pants, everywhere - even when its not raining. She says you're out making mud pies again! Dirt to dung, well ungulates are an important part of the process - droppings/beds/lichen/browse/ thermal cover all are incorporated into the overall assessment of the ecosystem and the resultant cut block design. In short, the ecosystem is a symphony of all components each having a bearing on, or in cases a restriction, on the decisions made. In short, the ecology is not just plants etc., but all factors influencing the decision process - even tourists - one fellow from the States said "lovely country but can't see it, y'all. You need to cut more trees." And here we have visual landscape quotients and can we please anyone!!

When I moved to the Peace River country, the first year (we only came up in 1979 for 2 years from the banana belt), the initial licencee large scale planting program of approximately 300,000 trees took place east of the Rocks, which we ran by the seat of our pants. A V-plow (with foot) and cat blading was our first attempt at treatment and site degradation - (I shouldn't say that, those are some of our best plantations. The planted trees didn't work but the areas seeded in naturally on the exposed mineral soil). Ripper plows were developed for the frozen remote sites (also because of access). Excavator mounding and bedding plows etc., have been added to the stable of normal treatment options. The basic concept was dry feet, lots of heat (old farmer philosophy for corn in the Peace). With poor drainage but with a lot of utilizable nutrients, planting untreated was causing poor survival. The grass and brush outperformed our trees. The basic concept hasn't changed but where we apply it has, mainly based on eco-class and our understanding of it. Same with stocking levels and stock types. What I'm saying is that initially little effort was made to match treatments and stock types, etc, to the harvested blocks. With the developments and understanding of the reaction of the EA's to treatment we are now better able to manipulate the reforestation productivity and the site.

HOW DO I USE THE CLASSIFICATION IN MY WORK?

To be blunt almost daily. From site restoration plans (with oil and pipeline companies); to reconnaissance surveys on older plantations that have not reached the stocking levels required; to new harvesting plans for both small and large clients. It affects either directly or indirectly every silvicultural process or decision we're involved in.

In the older plantations the ecological association is similar to a clue as to why the plantation did not perform as planned. Were the treatments or stock types not in keeping with the association? I'm going to briefly touch on an example. A cut block logged in the early 1980's - original cover was pine @ ± 110 years old and having a volume of 180 - 200 m³/ha. The topography is such that it could be typed into 2 treatment units, one well drained with ± 20% coarse fragments and the other on a lower slope, poorly drained, with a very rich nutrient level. Both units (in my wisdom at the time) were drag scarified for natural regeneration. Cones were more than ample for a heavy chain drag. Ten years later the first treatment unit was well stocked with pine, spruce and has a low brush component, (mostly alder and some *Calamagrostis canadensis*). The second treatment unit has low stocking, very little pine and dense *Calamagrostis canadensis*. No herbicide treatment was carried out. Why one and not the other? If we had had the full PHSP system and the ecological associations in place, these treatment units would have been separated and treated much differently. With the site treatment options available at that time I would have prescribed ripper plowing and planting large stock (2 year old 415 plugs) on the highest prepared micro sites at a minimum of 1600 stems / ha. Today I'd use excavator mounds. Follow-up brushing and weeding treatments would still be required but if you don't have the trees to work with, on site release is not really an option.

Why such harsh treatment? A field prescription would have shown a deep duff layer in excess of 20 cm and *Calamagrostis canadensis* well established throughout the stand. By tieing in with the associations and the nutrient / moisture regime I would have realized that dragging would only warm the soil enough to allow *Calamagrostis canadensis* to flourish and shade the cones so they would not reach the temperature required to open. It would also have indicated that given the moisture and nutrients that a raised micro site was required with exposed mineral soil (dry feet and heat). Overall it's probably going to cost 1200 - 2000 dollars / ha to rehabilitate the site.

In the Yukon, even with my brief exposure, I am seeing several distinct associations from the river flats to upland spruce to upland pine, black spruce, etc., with areas in the Beaver La Biche similar to the Fort Nelson zones and areas in Contact Creek or Rancheria that have distinctive types. Now's the time to start to define these associations while basic reforestation is in it's growth stages here. If you wait 10 years and have several thousand hectares of NSR or brush, due to failed plantations, it's going to cost big dollars. We've also seen this year the shortage of southern fibre being manifest in the value and demand for Yukon timber. One should also note that the fiber we're producing from our mill at Watson Lake could be pre-sold several times over, not only due to southern demand but also due to the high quality of the wood. In short the demand for the raw logs is accelerating every day and reforestation must follow.

FIELD GUIDES

I would like to briefly touch on the usage of field guides. Field guides are an operational necessity even once you're familiar with the plants, shrubs, mosses, etc., from each association. They provide a concise guide and for my part I refer to the sections on soils, edatopic grids and nutrient regimes more than the plants. They can be both a blessing and a curse. - how many do you carry - (list off some guides!)

- Ecological Association of B.C. Hand Management Guide #22.
- Prescribed Fire
- Plants of Northern B.C.
- Site Sensitivity / Degradation Ratings
- Spatial Distribution of Moose Poo - A Lay Man's Guide
- etc.

With experience I find now that what I can't interpret in the field, for example a plant or herb that I've forgotten, I take pictures and bring the plant home. Photos are very important especially where some of the soils present different than normal moisture levels, textures, horizons etc. Your field data cards can be completed using the guides - if you carried all the guides with you but aside from developing very strong shoulder muscles the net benefit is not worth the effort. You carry enough gear in the field. The guides have to be looked at for what they are!! - guides not the bible - they direct you to other sources but cannot answer all the questions - experience in operational techniques is equally important.

The guides are a tool and a very effective one - I know we've run without them but we've also made some very expensive mistakes, not solely the lack of guides but as part of the overall process. As shown in the previous example the use of the guides for soils, moisture, nutrients, etc would have shown the two distinct types and have suggested different treatment regimes. Blanket prescriptions can work but usually only in rare instances.

I'm going to run through a brief example on one of Discovery's areas - Contact Creek Coal River. I've chosen an upland pine site with relatively low volume 140 - 160 m³ / ha. The overall area contains a mix of spruce sites - black spruce bogs, creeks, lakes etc. The one block in particular is almost like a park with alder and white spruce regen forming the lower level. The pine is mature and starting to die out, but spruce is regenerating. My first step was to take the aerial photos and stratify sub units in the block. Luckily I had 1:20,0000 photos and this is minimal scale for sub typing, 1:10,000 would be best but most of the Yukon has only 1:40,000 and to stratify blocks as small as 8 - 10 ha is difficult. The sub units on this block consist of the knolls of pine and minor drainages, with a lake and black spruce area to the northeast. Once typed and identified on the map I drew transects and identified where I will put my plots. When walking the block, both the inside and the surrounds are important. The transects are not carved in stone and I may vary them in the field. I used the data collection cards we've developed for our clients. Fairly simple and straight forward but they contain all the factors we require to fill in the PHSP. On these smaller blocks I'll establish at least one plot per treatment unit.

On site steps are as follows:

- identify shrubs/herbs/mosses
- photograph (I use a panorama camera)
- dig your soil pit. - minimum 30 cm (I like 30 cm x 30 cm opening and try for 40 cm.
- Measure and record LFH horizons/soil texture
- record contents - ie: sand, coarse fragments
- identify from guide - soil type, eg: silty clay loam
- using the guide identify your association, alternatives and your nutrient moisture regime.

Sit down and chew cud. Go through your card and record remaining data, then think about what you have. What is the preferred species. Present and future brush competition. Write down your thoughts, eg: a relatively dry well drained site with pine - good seed source but spruce regen establishing, also good nearby seed sources / what stock, duff layers, slash, types, (moose browse, other wildlife, recreational visual impacts). I make separate notes in my field note book.

Back from the field complete the formal write up - should be done soon, memory lapses, ie: was this block 1 or 2 etc.. Now as for our block on Contact Creek.

APPLICATION

Treatment Unit A

My initial thoughts are to log in the winter using conventional systems, ie: fall and skid the whole tree to landings. Why winter - the cones don't break off as readily in the summer so summer logging means less cones on site. If it were a dense pine stand I would recommend a summer or fall logging. Too much regen can be a pain as well. The following spring carry out a cone survey - B.C. has a decision guide. From this we can look at whether or not there are too many cones or too few, what equipment to use etc.. IE: Heavy or light drags, shark fin etc., and what other options are available.

In this unit I prefer pine as it can have sufficient initial growth to get above the alder etc. Spruce however is a viable option and an alternative would be to disc trench or bracke mound and plant large spruce stock. What I'm saying is that although the guide may say this association requires pine as the preferred species, experience has shown that alternatives such as white spruce will produce a vigorous healthy plantation. Spruce being slower in the initial stages will mean that brush may, however, be a problem and brush control methods such as herbicide may be required to ensure a free growing status.

APPLICATION

Although *Calamagrostis canadensis* may not be a problem the alder could. Overall my prescription is to survey / drag scarify (as dictated by interpretation of the survey) and manage for pine. Re-survey in 5 years for stocking and assess for brush competition and over stocking. The final product is your PHSP.

Treatment Unit B

The drainages should be kept machine free with a 10 metre buffer. These are small portions of the area and should be protected as they feed into fish bearing streams and lakes. This treatment unit should be excluded from the block due to water/habitat considerations.

SUMMATION

I've referred to ecological associations and ecosystems. The associations are a large part of the system but by itself cannot yield the prescription.

In keeping with the symposiums theme, "a sustainable resource", the applied use of ecological association is one key to understanding and implementing how to maintain the sustainablity of the forest in all aspects. Knowing which association relates to the site yields the clues as to what silviculture prescription should be applied and the potential results. A lot depends on documented trials and operational assessments. As I found out drag scarification is not effective on an BWBSmw1 05 spruce association even though the original forest cover was pine. The result, I now have reduced growth rates and poor stocking. In maintaining sustainablity, reforesting the logged areas is essential and development of ecological associations is critical to the reforestation process.

Originally, in my draft outline, I was going to sum up with a recipe to cook a perfect plantation. Each treatment unit or association has individual characteristics and once I started getting into it I found that it would take several hours to discuss and still one could end up with a flat souffle'. The various factors including ecological, environmental and economic all have their influence and one man's perfect plantation may be a disaster for others. Ecological associations help to avoid the disasters.

QUESTION PERIOD

Topic: **Mud Pies and Foresters: The Applied Use of Ecological Associations in Operational Forest Management**
Speaker: **Cliff Kowalsky**

Q: I have two concerns, and I'm really addressing the first concern to three people: Peter Henry, Murray and Scott Smith. That talks about the session this afternoon about the eco-regions and the eco-zones, and all the rest of those things. I'm concerned about your zones being used for seed zones. I don't think the way things have been broken down currently are as good as what Oswald had originally. I'm also concerned with trying to marry, on the Canadian side with British Columbia, or on the Alaskan side with the Alaskan classification, which is a federal classification, and I'm not sure Bailey has ever been in Alaska. I think what I'm trying to say here is: do you have an adequate field to be able to use those zones that you now have -- the new version -- to help develop seed zones? The second one is: did you blindly follow the leader of British Columbia, who was working on the very edge of their territory? Maybe what you really have are two vertical zones in there, instead of those nice, thin ones.

I'll make the other comment, which is applicable across the board again. That is, that I really liked this idea of trying to make it simple. Keep it simple and short, or short and simple, is the kiss rule. But when you come to bureaucrats, you've got to change that around and it's to keep it short, or keep it simple, but stupid, when you're referring to them, because they don't understand the mess that paperwork can create. You end up spending more time filling out paperwork than you do the other thing. That's just a warning. There's a role for this ecological classification, but, man, keep it short and sweet in the field.

Q: This is a question to Cliff. I was interested in your comments with regard to selection systems and some of the timber types that you're dealing with. I found that it was quite typical -- a lot of the brush-off kinds of rationale for, basically, maintaining standard, conventional clear-cut systems. I was wondering about the extent of your experience with research and on-the-ground matters of, particularly lower volume removal selection systems when you're dealing with spruce. I wonder if you can comment concerning the extent of blowdown problems, that I certainly see a lot of in boundaries or borders of clear-cut blocks -- even better, they may be up to certain landscape design techniques and stuff. I've seen a whole lot more, basically, growth of cut blocks, even if they're very, very well designed, for salvage operations because of blowdown along clear-cut edges than I have, in terms of seeing the blowdown that can occur from properly, low volume selection systems. I'd just like your comments on that -- whether your comments and your presentation were based on what kind of experience and what kind of experimentation research.

A: My comments are based or pertaining, particularly to the Peace region. You're from somewhere down south there -- Cranbrook, was it? Cariboo, okay. I've had experience down there with the dry belt for the multi-level, multi-age. It's the low volume and the fir can come out. It works like a charm down there. My comments were aimed mainly at the Peace country, particularly with Alberta plateau.

My experience has been mainly on a small-scale basis. Like I said, I have been on a woodlot (Inaudible) that I go and skid with once in awhile. I'm not very good with horses. Basically, I've tried small patch selection. I've tried some low volume removal. The moment I make a hole in that stand -- any type of a hole -- be it 10 or 20 trees, I've suffered blowdown. I do a little bit here, a little bit there. I try and take my cut blocks and design them -- like, what I'm saying, the woodlot, you're probably familiar with the scale of the operation. I try to design it so that I actually come up against, say, a 20-30 year old spruce stand, birch, aspen, or something. You're going to get blowdown in and around. We've tried selection -- anywhere from 10-30 percent removal on an area of the Peace valley, where one of my friends is a woodlot owner, as well. We've tried working that. He's still having problems with blowdown, even though it's theoretically totally protected from the southwest winds. We turned around, and the north winds came and got him. I haven't had a lot of success with selection or low volume removal in the Peace country. There's some success we're having right now with horse logging. There's one particular type that's not be typed-out in the ecological associations. I hope they will eventually. But, basically, it's a mature pine stand that spruce is regenerated underneath, and we're taking off the older, mature pine to allow the spruce regen to come up. Mixed wood, we're trying strip selection. One other fellow has worked a strip removal basis. You have to be so careful because now he's going back and he's having to remove probably another 50 percent of that stand.

Q: Cliff, I can easily see where certain people in the group might say, "Hey, that's just the thing we want to do here." How do you think what you're doing is, first of all, applicable to the Yukon, but also in context of one-year permits, and that type of development?

A: The ecological association -- one-year permit would really have no bearing on being able to reforest or coming up with a prescription. The thing is, you've got no continuity. If our company had the tenure, basically, we'd be taking on responsibility like that for a 15-year period, or whatever. If it's a land-based tenure, then we could probably go into intensive management or reforestation. You can do some planning. The short-term, one-year CTP is very difficult to operate and manage a forest under -- if not impossible.

MANAGEMENT OF THE SPRUCE BEETLE

THE SCOURGE OF NORTHERN SPRUCE FORESTS

by

Robert Hodgkinson, R.P.F., R.P.Bio.
Regional Forest Entomologist
B. C. Ministry of Forests

Good afternoon. I'm pleased to be in Whitehorse and I wish to thank Debra Wortley and Dr. Pauline Hamamoto and the organizing committee for inviting me to speak. This speech will essentially address the habits of the spruce beetle and its detection and management in the Prince George Forest Region of British Columbia.

Impact and Extent

The first slide indicates that the gross annual volume depletion losses in B.C. from 1983 - 1987 (from harvesting, fire, and pests) averaged 118 million m^3 per year. Of the pest-caused losses, bark beetles accounted for approximately 28%. In 1994, approximately 110,000 ha of spruce forests were infested by the spruce beetle, *Dendroctonus rufipennis* (Kirby) in B.C. The Prince George Region sustained 72,000 ha of this total or 65% of the Provincial total (Humphreys 1995). The infestation in the Yukon comprized approximately 32,538 ha in 1994 and is depicted in this slide (Appendix 1) as three categories of percent spruce visible from the air during aerial sketchmapping: light (10% or less), moderate (11 - 29%), and severe (30% +) (Garbutt 1995).

Hosts

The spruce beetle attacks all species of spruce (*Picea spp.*) in western North America. In the southern and central Rockies, Engelmann spruce (*Picea engelmanni* Parry) is the principal host. White spruce (*P. glauca* (Moench) Voss), hybrid spruce, *P. glauca* x *P. engelmanni*, and Sitka spruce (*P. sitchensis* (Bongard) Carr) are its main hosts in B. C., the Yukon, and Alaska (Schmid and Frye 1976). Lodgepole pine can be attacked during outbreak conditions, but trees are not killed nor are brood produced (McCambridge and Knight 1972). Dispersing spruce beetle adults have been known to fly up to 48 km if they disperse above the canopy and are carried by winds aloft (Nelson 1954, Wygant 1956, 1959).

Symptoms of Attack During Aerial Reconnaissance

This slide depicts discoloured spruce foliage from a spruce beetle attack in the Bowron River Valley east of Prince George, B.C. in 1981. You can see crowns that appear off-green, rusty-brown, or grey. Other crowns appear green and healthy but this can be misleading. In northern B.C., foliage on attacked trees can take 24 - 30 months to fade so it becomes noticeable from the air.

Causes of Outbreaks

Spruce is a shallow-rooted species which is susceptible to blowdown during windy periods. According to Dyer and Safranyik (1977), windfall averaged 1-2 trees/ha over a 3-year period on 766 ha. This was more than enough to maintain a spruce beetle population. In inaccessible areas, all documented major outbreaks have originated from blowdown (Wygant and Lejeune 1967).

Scattered individual blowdown which falls into good shading is much more attractive to spruce beetle than sheet or patch blowdown. The latter often lies in hot sun, is attacked by other secondary beetles, and is unattractive to the more shade-loving spruce beetle.

Logging operations have also caused spruce beetle population increases (McCambridge and Knight 1972) if harvesting utilization is poor and edge or reserve blowdown is not recovered. Whenever possible, block layout should include windfirm boundaries. If spruce blowdown falls into a shaded edge and it is not recovered, it can be attacked by spruce beetle during the next flight.

Life Cycle and Behavior

Spruce beetle normally has a 2-year life cycle (Massey and Wygant 1954). Mature parent adults usually emerge to attack new host material in late May or early June when the flight threshold temperature in the shade exceeds approximately 16° C. (Dyer 1973). After attacking a suitable large diameter blowdown or standing spruce, the female beetle initiates a pheromone (sex attractant) which lures males and other females to the same host. The fertilized female lays a complement of eggs on both sides of the egg gallery. Eggs hatch in approximately 2 - 4 weeks (Wood 1963) and first instar larvae begin to feed on the phloem as they tunnel away from the egg galleries. Larvae overwinter as second to fourth instar and resume feeding in the spring.

During the summer of this second year, the larvae pupate then develop into immature adults. A varying proportion (3-88%) of these immature adults typically emerge from the boles of standing trees in the fall, crawl to the root collar, and bore into the phloem to hibernate over the winter (Knight 1961). The latter habit protects the new beetles from cold winter temperatures and woodpecker predation. Temperatures below the snowline are often near 0° C., while lethally cold ambient temperatures can exist above the snowline (Schmid and Frye 1977). The following spring the newly mature adults are able to emerge, fly, and initiate new attacks.

Attacking spruce beetle carry several species of fungi into host spruce. Some of these fungi impart a blue-grey colour to the sapwood and are called blue-stain. Fungi rapidly block xylem translocation and, along with destruction of the phloem by the spruce beetle adults and larvae, the tree is rapidly killed (Schmid and Frye 1976). Blue-staining and the drying and checking of the sapwood rapidly devalues the merchantability and marketability of spruce for various forest products.

On warmer sites at lower elevations throughout its range, spruce beetle may complete its development in one year, overwintering as immature adults and attacking the following year (Massey and Wygant 1954). At higher elevations or in cooler than normal climates, the beetle may take three years to complete its life cycle (rare in Prince George Region). In this case, beetles overwinter twice as larvae and once as immature adults. In the Prince George Region, approximately 85% of the population normally follows a two-year cycle, while a one-year cycle averages 15%.

Trees attacked on less than 50% of their circumference are called "strip attacks" and such trees are often able to repel beetles by exuding resinous "pitch tubes". These trees normally survive unless they are re-attacked the following year. Multiple-year attacks are extremely common in the Prince George Region.

As winter approaches, spruce beetle "supercool" by replacing water in their cells with glycerol - a sort of anti-freeze. If no unusual "cold snaps" occur before December 1, larvae and immature adults become quite tolerant to cold temperatures above the snowline in infested spruce. Observations by Miller and Werner (1987) in Alaska and those from the Prince George Region would indicate that some larvae can tolerate temperatures as low as -40°C to -41°C above the snowline in infested spruce. Immature adults are less winter-hardy and any pupae "caught" by the winter (in a late attempt to develop on a 1-year cycle) seldom survive the season.

Causes of Spruce Beetle Outbreaks

There are four main causes that lead to spruce beetle outbreaks:

1. *Favourable Habitat* includes shaded fresh spruce blowdown, high stumps, large diameter slash, and abandoned logs;

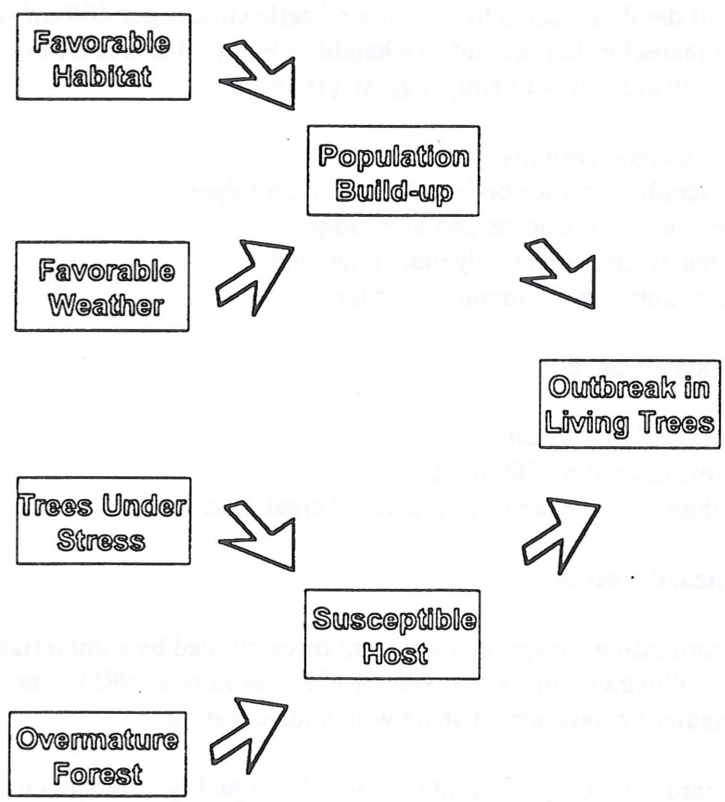
2. *Favourable Weather* includes heavy early snowfall, no unusual "cold snaps" before December 1, and mild sunny springs;

3. *Spruce Under Stress* from tomentosus root disease, mechanical damage to the bole, and root compaction; and

4. *Overmature Spruce Forests* with ages of 141 - 251 years (age class 8) or more.

Factors 1 and 2 will result in a population increase, and factors 3 and 4 will result in a susceptible host. If a population increase results and a susceptible host is present, an outbreak in living trees will result (Fig. 1).

Fig. 1. Causes of Spruce Beetle Outbreaks (from Dickens 1981)



Spruce Utilization

Proper spruce utilization can significantly reduce the amount of both infested host material and uninfested potential breeding material. The main problem in blocks being sanitation logged are infested:

- unburnt large diameter slash or "long butts" (large unmerchantable logs left because of excessive decay);
- decked logs or spilled loads with tops > 10 cm dbh; and
- high stumps (particularly from winter-logged stands within heavy "snow-belts".

Effective utilization or "good housekeeping" requires that:

- stumps be cut as low as possible;
- tree-length logging or a 10 cm diameter top utilization be used and all tops be scattered on the block or piled and burnt;
- if permitted, all long butts should be piled and burned on suitable landings or elsewhere before the beetles emerge;
- prompt removal of edge windthrow, and decked and spilled loads before they are attacked.

Host Susceptibility

Spruce will die if subjected to 2-3 spruce beetle attacks per 400 cm^2 of bark at dbh, decreasing vertically thereafter but present to a height of 9 m (Schmid and Frye 1976). The order of spruce susceptibility according to Knight et al. (1956) is:

1) spruce in creek bottoms;
2) better stands of spruce on benches and high ridges;
3) poorer stands on benches and high ridges
4) mixtures of spruce and lodgepole pine; and
5) stands containing all immature spruce.

High risk stands have:

1) an average dbh > 41 cm;
2) a volume exceeding 300 m^3/ha; and
3) more than 65% spruce in well drained creek bottoms.

Stand Hazard Rating

Stand hazard rating for spruce beetle can be calculated by summarizing the relative weights of the parameters illustrated in Table 1 (Anon 1994, Safranyik 1985). Stands having a higher rating will sustain greater damage than a stand with a lower rating.

Stand Hazard = $\sum$ (Biogeoclimatic Zone + Site Quality + % Spruce + Stand Age + DBH)

Stands with a high hazard rating that are within 2 km of a spruce beetle population are at a high risk of being attacked.

Ground Detection

Once initial aerial sketchmapping is complete, spruce beetle attacked stands must be examined via ground surveys. The B.C. Ministry of Forests conducts "walkthroughs" (non-systematic, preliminary surveys) and "probes" (systematic grid surveys) to assess infestations. Ground surveys determine rough or detailed estimates of:

- infestation size, pattern, and boundary;
- incidence and severity of infestation;
- risk of beetle spread;
- access, operability, and integrated resource management issues;
- sanitation/salvage harvesting priority rating (see pg. 239 and Table 2); and
- possible requirement for beetle management.

Table 1. Values for factors used to derive spruce beetle hazard in B.C.

Parameter	Value
Biogeoclimatic Zone*	
SBS, BWBS	1.50
ESSF, ICH, MS	1.10
SWB	0.50
Site Quality	
Good	1.66
Medium	0.88
Poor	0.36
Percent Spruce	
80 - 100%	1.33
20 - 79	1.21
0 - 19	0.59
Stand Age	
> 121	1.78
101 - 120	1.10
< 100	0.12
Spruce D.B.H.	
≥ 30 cm	1.00
< 30 cm	0.50

* SBS = Sub-Boreal Spruce
BWBS = Boreal White and Black Spruce
ESSF = Engelmann Spruce - Subalpine Fir
MS = Montane Spruce
SWB = Spruce-Willow-Birch

If harvesting is recommended from the above , there are two types:

Sanitation Harvesting - harvesting operations specifically designed to maximize the extraction of **currently infested** or infected stands in order to reduce the damage caused by forest pests and to prevent their spread.

Salvage Harvesting - harvesting operations primarily designed to recover timber damaged or degraded by fire, *an old insect attack*, wind, or fungi before the potental wood products become unmerchantable. Control of forest health factors such as bark beetles in incidental and is not the primary objective of salvage harvesting.

The new *Regulations* under the *Forest Practices Code Act of B.C.* will specify that cutblock sizes will not exceed 60 ha in the interior (40 ha in coastal and southern areas) unless the cutblocks "incorporate characteristics of natural disturbances (reserves)".

The **Sanitation/Salvage Harvesting Priority Rating Index** can be calculated once ground dectection information has been summarized (Anon 1993).

Sanitation/Salvage Index = (A + B + C) x D
where:

A = % most-recent attack in stand (e.g., 1994)
B = % 2nd most-recent attack in stand (e.g., 1993)/1.5
C = % 3rd most-recent attack in stand (e.g., 1992 or older attack)/4
D = total % of healthly and attacked spruce in stand

$$\therefore \text{Sanit./Salvage} = \left(\%\ 1994 + \frac{\%\ 1993}{1.5} + \frac{\%\ 1992\ \text{(or older)}}{4} \right) \times \%\ \text{spruce}$$

Table 2. Recommendations for further action based on walkthrough estimates

Sanitation/Salvage Harvest Index	Recommendation[1]
0 - 599	**leave** (monitor, trap trees, baits, etc..)
600-999	**probe** to obtain more precise information.
1000 +	**operational cruise** prior to sanit./salv. harvest.

[1] All recommendations must consider access and integrated resource management issues. The precise thresholds for action may vary by District or even by operating areas within a District.

[2] Assuming road access exists or could be in the near future.

Inter-District transportation of infested wood from *Small Business Sales* has been an occasional problem in the Prince George Region. Restrictions such as log hauling bans during the beetle flight and "hot milling" of infested logs at the beginning and end of the beetle flight are periodically applied in our Region.

Trap Trees

Trap trees are healthy, large diameter spruce which are felled to attract spruce beetle (Nagel *et al.* 1957). Trap trees felled into the shade and left unbucked and unlimbed may absorb up to 10 times the number of beetles a standing tree will absorb (Wygant 1960). Trap trees will effectively attract beetles from up to 0.4 km away, and less effectively for up to 0.8 km. Two types of trap trees are used depending on the availability of access to extract them: *conventional* and *lethal*.

The following trap tree characteristics apply to both conventional and lethal trap trees:

- large diameter (≥ 35 cm dbh) healthy, uninfested spruce;
- felled close to the ground;
- felled into maximum shade;
- if conventional, position butts towards the road to facilitate eventual skidding;
- leave unbucked and unlimbed;
- stumps as low as possible;
- shaded windthrow can be used as trap trees in accessible areas but must be removed with

the other traps; and
- trees should be felled as close to an infestation as possible but no further away than 0.8 km.

Conventional Trap Trees

Conventional trap trees are deployed in accessible areas as "patches" or truckloads of 20 - 30 trees. They may be hand-felled or dropped by feller-bunchers in various configurations. Wood felled on pre-developed road rights-of-way may be left to serve as trap trees. Log decks are the least desireable trap trees as they usually lack adequate shading. Trap trees are normally felled in late winter (e.g., early- to mid-March) so that such trees lie on top of most of the accumulated snow. Infested traps should be removed early in the next winter logging season (e.g., late November) before they become covered with excessive snow and frozen in place.

Lethal Trap Trees

Lethal trap trees are deployed in inaccessible locations where conventional trap trees could not be extracted. Lethal trap trees are large diameter, uninfested spruce in which a continuous axe-frill is cut in the phloem around the circumference of the tree as close to the ground as possible. The frill is injected with 1/4-strength MSMA (80 g/L a.i. of monosodium methanearsenate) at a rate of 1 ml of formulation per 2.5 cm of circumference (Hodgkinson 1985). Applications are usually conducted in mid-May once tree translocation begins. Following a two-week period to allow translocation of the MSMA throughout the bole, trees are felled into the shade and left intact. Attacking adult spruce beetles are killed and, therefore, lethal trap trees do not require further treatment. This tactic is usually undertaken to contain pockets of emerging spruce beetle and/or to protect valuable spruce stands in isolated areas until road access can be constructed (usually within 2 - 3 years).

Some advantages of lethal trap trees are:

- use in remote or inaccessible areas where no other treatment is possible;
- ease of application (e.g., approx. 4 minutes to axe-frill and treat a tree);
- relatively inexpensive labour and equipment costs (compared to more labour-intensive single tree disposal methods); and
- relatively safe for applicators, environment, non-target insects, and other organisms.

Conclusion

In managing the spruce beetle in B.C., our objective is to reduce beetle population increases by pro-actively monitoring and managing susceptible stands at risk. When inevitable outbreaks occur periodically, directed short-term sanitation and salvage logging, and conventional and lethal trap trees can greatly reduce the overall impact of the spruce beetle in managed stands.

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QUESTION PERIOD

Topic: Management of Spruce Beetle - The Scourge of the Northern Spruce Forests
Speaker: Robert Hodgkinson

Q: I have a question. I'm very impressed with this little critter's temperature resistance. You've mentioned what they can do in the winter, once they glycol their bodies. I'm assuming that's when they're in the root collar -- -41 degrees, with a snow cover, and they're root collared. All the other questions I have, have to do with temperature resistance. So, when you say a cold snap before November 30, what kind of a cold snap are we looking at? If we could get one of our bizarre October snowfalls -- which have happened, but not recently -- would that stop the critter in its tracks? And we haven't had one of those well-diggers, that's kind of winter's here for awhile. Is that the reason we have this infestation? That's it.

A: The question on the cold snap in 1985, we had kind of an unusual temperature plunge in our region. It went down to about -35 degrees the third week in October. That did a lot of damage to the spruce beetle and also a lot to the mountain pine beetle in the Chilcotin. It just about wiped it out. Those who are from the Cariboo might remember that one. That went to a great extent in finishing it off. So, when I said cold snap, those temperatures around -35 degrees early. Now, once spruce beetle experiences a winter chill, as winter sets in and it slowly gets colder, a little bit of a chill there, it starts to withdraw water and replace it with glycerol. Usually, by the end of November/December 1, they are super-cooled. They are about as winter-hardy as they're going to get. At that point, they are quite resistant to cold temperatures. The literature says there have been several studies published. I believe -34 degrees is supposed to kill all larvae, and -26 degrees is supposed to kill all adults above the snow line. There has been a recent study from Alaska in fact, I've got the paper right back there that suggests that down to about -41 degrees, you still have some surviving larvae above the snow line. That's where you're going to get those temperatures is above the snow line, it's not below the snow. So, we're not concerned about the beetles below the snow. They're going to survive very well. It's above that snow line, in the tree. I did a major bit of sampling a few years ago. We had a temperature of -49 degrees in Chetwynd, B.C. on about December 29-30 over about two or three days. In one drainage, which was quite a bit higher in elevation, I was finding about a 72 percent survival of larvae in the tree above where the snow line was. Other drainages went down to about 20 percent or so survival, so it's quite variable. We don't know all the answers yet, but they appear to be fairly winter-hardy in certain locations, and not so in other locations. Does that answer your question?

Q: The summer temperature one. Is there a low temperature in the summer that could?

A: I've got some of that data with me. I can't remember what it was, but I can show you that after the meeting.

Q: Have there been any instances where the beetle has been found to adapt, mutate, and evolve to successfully accommodate the insecticide used?

A: No, in simple terms. What happens is, the beetle attacks the tree once the tree is treated with MSMA. Once the beetles get under the bark in the spring, they don't leave. They're not repelled by the chemical. We're using such a low dosage, I guess they can't tell there's something there that's unusual, so they stay in the tree, and they slowly get poisoned and die. So, since they never leave, we have no evidence they've ever gone away. We're killing all that enter the tree. Resistance would probably only result if you had a few survivors over time that managed to leave the tree and carry on. But I see what you're driving at. There's no evidence yet that we have seen any resistance. The program is really a low type of program. We might do several hundred trees in one district, and less than 50 in another.

Q: I log in the central Yukon. The stands I log in are exclusively white spruce. Typically, we do our logging in the winter, deck our logs in the mill yard, and saw in the summer. In the stands we log in, over the years, I've never seen any evidence of, what I would term, an overwhelming infestation of beetles. We do have an endemic level within the stands virtually at all times. What happens is, when I take these logs into my yard and deck them, as soon as spring rolls around and it warms up, I have all of these logs piled up, and the beetles go to work on them. What can I do to protect the logs that I have in the yard? If I saw them up in the first season, I don't lose a lot to damage. If they sit into the second season, the sapwood is virtually shot, particularly on small logs, of course. You don't have much left if you don't have the sapwood.

A: You may have other problems besides spruce beetles. Do you have any wood borers?

A: Yes.

A: Some of them are the size of your little finger, chewing away. They go right into the sapwood, which are the most damaging. And then we can get ambrosia beetles, which look like little, black pinholes, that go straight into the solid part of the tree, about 4 centimetres, and turn the corner and make a little egg gallery.

Q: It's not just the bark beetle then. It's a combination.

A: Right. Generally, anything you can do that I'll just address the spruce beetle one quickly first. If most of those logs that you bring in are, in fact, full of larvae in the winter, you can actually physically peel the bark. It's difficult and laborious, but if you peel the bark, you'll basically kill them all. If the logs that you bring in contain the adults and they're ready to fly and you do that, in the dead of winter, you'll have a lot of effect, as well. But don't do it in early spring because you're just allowing them to escape early.

With the wood borers, anything you can do to remove the bark before wood borer adults lay eggs on them. It's often the case with people that bring logs in or try to build log cabins and leave the logs sitting there with the bark on for a season in the sun, or part of the sun. Wood borers come along, lay eggs on the bark, the larvae hatch and start to crawl around on the surface, and go straight into the log. If you take the bark off, they don't like that. They won't attack it. So, those are a couple of things you might try.

Q: Typically, I have somewhere in excess of 10,000 logs in the yard every spring. So, peeling them is a little bit long.

A: Right. Usually, we advise our major licensees, if you know you're logging in a beetle-infested area, somehow try to mark or timber mark, and put that timber mark or sort in one part of your yard, so you know where it is, and mill the worst first mill the worst-infested logs first; second-worst second, so you have a progressive plan I realize it's hard to do, if you have such a short logging season.

Q: Say you have a deck that's been hit, and you're going to transfer your wood, say, 900 miles. Is there any chance that, with road shake, and the bark falling off, that it can infest the wood down the road?

A: In our region, we have log-hauling bans that we institute from, often mid-May until mid-July for spruce beetle. If there's ample evidence that the logs that are being sanitation harvested have immature adults in them, or mature adults ready to go, the district manager has the prerogative to direct the licensees not to haul those logs for a month and a half, or whatever it is. Yes, they will fly off the truck. In fact, in one case in the Cariboo, I heard that the district manager told the truck drivers that, they were not allowed to stop for coffee at the coffee shop; that they had to keep going, if they were going to be allowed to haul logs on the toe and the heel of a hauling ban. They're going to shut them down right in the middle. So, you have some flexibility there.

Q: I have another question about the wood wasp. Do they attack live trees or dead?

A: Usually dead. They're looking for stressed and dead or dying trees, and they'll take advantage. They'll often attack trees after the spruce beetle have finished them, or some other beetle. They're not usually a primary tree-killer.

Q: How do you compare the effectiveness of that MSMA compared to, say, pheromone-trapping and fell and burn?

A: The fell and burn tactic has been used before. I'll deal with that one first. It's very expensive. We're looking at probably in excess of $200 a tree in manual labour to cut the tree, cut it up in chunks so that it can be physically carried to a pile and burnt. It's dangerous work. It has to be done in the winter, with heavy snow loads. You get high stumps. It's very labour-intensive. You need large crews to do it. You can use MSMA for usually under $60.00 a tree, all costs included, over a large area. So, there's a major cost difference. Both tactics are very effective. If you fell and burn correctly, it's just as effective, but there's just such a vast difference in cost-efficiency with the MSMA, and we consider it so safe, we often go that way. The other part of your question was?

Q: I just wanted to know the difference between, what you felt, was the effectiveness between them. But I am wondering, like the MSMA, for example, a poison is a poison. And when you lay it down, you had made an earlier statement that the beetles like to fly. They don't want to walk to the tree. So, therefore, what about having a pheromone trap, which is standing up. Do you attract more of the bugs that way?

A: When you fell a trap tree, whether it's been treated with MSMA or not, it's also attractive. We found that if we put a pheromone bait on that same trap tree, there's no difference at the end of the year in the number of beetles that attack it, because all you're trying to do is get that first female beetle to attack your trap tree, she gives off her pheromone, which has got to be better and more attractive than the artificial one, and then the tree is mass-attacked. You might get an attack a few days earlier, but "at the end of the day" there's no difference. They're working on some new pheromones, eg; MCOL . It's a new product that's being investigated, so they might come up with one that actually causes an over-attack, or more attacks than we're getting naturally. If that happens, we may, in fact, bait trees with those new products.

Q: Do you know, or can you surmise, how the beetles spread so quickly, over such a vast area, and yet be concentrated?

A: We don't know, is the answer right now. We have some guesses, and I'll let Rod maybe give you some of our guesses.