Review of forestry practices in caribou habitat in southeastern British Columbia, Canada

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Abstract: Woodland caribou (*Rangifer tarandus caribou*) in southeastern British Columbia feed mainly on arboreal lichens in winter. Some modified forestry practices that have been used or proposed for caribou ranges are reviewed. Partial cutting results in the retention of some forage lichens. Partial cutting and small patch harvesting may improve lichen growth on the remaining trees. Retention of advanced regeneration and some residual trees may improve lichen growth in the remaining stand. Extension of the rotation age increases the amount of harvestable forest useful to caribou at any one time. Progressive cutting minimizes road access to caribou ranges, and may be combined with partial cutting. Most forestry practices intended to maintain lichen production will result in increased human activity in caribou ranges, unless road access is controlled. The management strategy selected depends on site conditions and on the relative importance assigned to the impact of habitat alteration and human activity on caribou.

Key words: *Rangifer*, caribou, forestry practices, lichens, British Columbia, Canada.

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Introduction

In British Columbia, there are broad geographic areas in which certain forage types predominate in the winter diet of woodland caribou (*Rangifer tarandus caribou*). In northern and western British Columbia, the snowpack is usually shallow enough to permit cratering for terrestrial lichens and vascular forage. In the southeast, the snow is much deeper, and caribou feed mainly on arboreal lichens. This paper is limited to a consideration of caribou habitat in southeastern British Columbia (Fig. 1). There, caribou occupy forested mountain slopes and plateaus, avoiding the most rugged terrain. Heavy precipitation results in snowpacks of 3 m or more on high elevation ranges. The major tree species are western red cedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), and lodgepole pine (*Pinus contorta*) at low elevations, and Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) at high elevations. The transition from low- to high-elevation forest types ranges from 1000-1500 m, depending on latitude.

Two broad patterns of winter habitat use by caribou occur in southeastern British Columbia. When snow is soft, as in early winter, the animals use low-elevation forests. They feed on vascular plants and on lichens that are available as litterfall, on windthrown trees, and on trees felled by loggers (Edwards and Ritcey, 1960; Freddy, 1974; Bloomfield, 1980; T. Antifeau, pers. comm.) At low elevations, lichens are rarely abundant on the lower branches of trees. In high-elevation forests, where the canopy is more open, lichens are usually abundant in both lower and upper portions of the crowns. When a deep, settled snowpack is present, caribou usually use high-elevation forest, where they feed almost exclusively on arboreal lichens. The crusted snowpack supports caribou and improves access to lichens. The strategy of feeding on

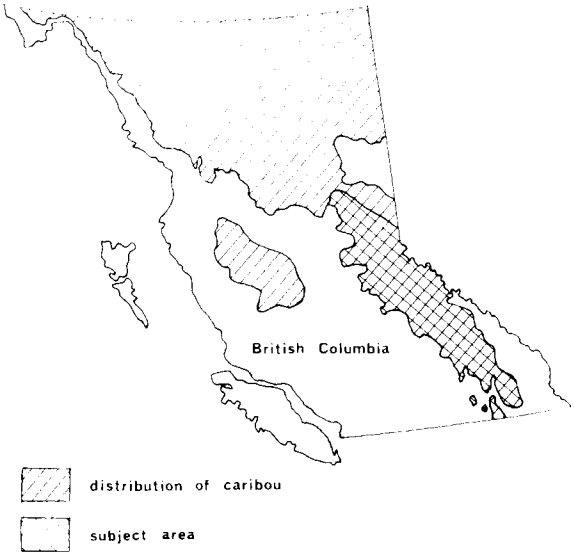

Fig. 1. Caribou range in British Columbia.

arboreal lichens in subalpine forests during winter removes caribou from the ranges of other ungulates, reducing competition and predation.

The arboreal lichens used by caribou, such as *Alectoria sarmentosa* and *Bryoria* spp., are markedly more abundant in older forests than in second growth. When a lichen-bearing stand is harvested, large amounts of lichen are briefly available on felled trees, and are readily used by caribou. After clearcut logging, arboreal lichens from adjacent stands of mature timber colonise the regenerating trees, but do not become abundant for at least 100 years, and often longer (Scotter, 1962; Edwards *et al.*, 1960; T. Antifeau, unpublished data). It is unclear why the lichens do not become abundant earlier. Microclimatic conditions in the young stand, unsuitability of the bark of rapidly growing young trees as a substrate, dispersal limitations in large clearcuts, and the slow growth rates of lichens may all play a part.

The impact of logging on lichen abundance has caused conflict over the management of caribou ranges. Researchers and managers have sought forestry practices that allow timber extraction while maintaining caribou habitat. Although most concern has focussed on maintaining arboreal lichen production, it is important to consider other consequences of logging. Increased road access, direct disturbance, altered snow conditions, and changes in numbers of other ungulates and predators may affect caribou. Research needs regarding those relationships have been identified by Stevenson and Hatler (1985). In this paper, several proposed techniques for integrating forestry and caribou management are reviewed. The special logging practices are assessed for their impact on arboreal lichen production and other aspects of caribou habitat, and their forest management implications.

Standard forestry practices

All timber harvested in southeastern British Columbia is old growth. Before 1966, a variety of partial cut systems were used, all of which left considerable amounts of residual timber. Since 1966, when new utilization standards were introduced, clearcutting has been the usual practice. Clearcutting is done in patches, leaving mature timber between patches for later harvest. Patches range from 40 to several thousand hectares. After clearcutting, logging debris is usually burned, and commercial tree species are planted.

Partial cutting

Partial cutting is a term applied to a variety of logging systems that leave a residual stand of trees distributed throughout the cutblock. Diameter-limit logging, a partial cutting system in which only trees above specified diameter limits are felled, has been applied in some caribou ranges.

The use of partial cutting rather than clearcutting is thought to reduce adverse impacts of logging on caribou for three reasons. First, some arboreal lichen remains available as forage. Taking into consideration the removal of harvestable trees, felling of snags, damage to residuals, and loss of forested areas to roads and landings, Stevenson (1979) estimated that in three spruce-fir stands, a cut to 51 cm minimum diameter at stump height would result in the retention of 20-32% of the lichen biomass that was originally available. The value of that forage supply to caribou is unclear. Caribou have been observed to travel through logged areas in winter and to feed on lichens from residual timber (Stevenson, 1979). However, the consequence of a reduced and dispersed forage supply is an increase in the energetic cost of feeding.

The second advantage of partial cutting is that lichens should regenerate more quickly than after clearcutting. Lichens on residual trees provide a

source of propagules for dispersal to the remaining timber. Advance regeneration left after harvesting will provide a suitable substrate for lichen colonisation sooner than would new seedlings. Third, partial cutting may increase lichen growth rates in the lower part of the residual canopy. Improved growth of *Alectoria* and *Bryoria* spp. is expected in moist or dense stands, but not in xeric or open-canopied stands, which would become too dry for optimum lichen growth after partial cutting.

The potential effects of partial cutting on caribou range must be assessed within the overall harvesting plan. If a second cut is planned within 20-40 years, lichens may never recover to preharvesting levels, and the period during which they are abundant is likely to be brief. The long-term effect on lichens of successive partial cuts is even less certain. Also, any partial cutting system is likely to result in larger areas being harvested at any one time, so that government commitments of timber volume to industry can be met. The concomitant increase in road access may offset benefits to caribou derived from partial cutting. Furthermore, where successive entries are planned, roads must be maintained for a long time.

The use of diameter-limit logging and other partial cutting systems rather than clearcutting has implications for forestry. Road and harvesting costs increase, and windthrow may be a problem. Alexander (1973, 1974) prepared detailed recommendations for achieving a windfirm, partially cut stand in spruce-fir types through a series of light preparatory cuts which open the stand gradually.

Several silvicultural problems may result from partial cutting. First, the residual stand may be damaged during logging or may fail to release. Alexander (1974) recommended measures for protecting residuals. Second, the presence of an overstory tends to favour subalpine fir, a species of lower commercial value than spruce. However, an overstory may benefit spruce on some sites. At high elevations in the Rocky Mountains of the United States and southern Canada, mortality of spruce seedlings has been related to high light intensity, high soil surface temperatures, summer drought, and frost damage (Alexander, 1974; Utzig and Herring, 1974). In contrast, high soil temperatures and soil moisture deficits are not problems in the northern part of the study area (McMinn, 1982). Because a residual stand can help prevent damage to spruce seedlings from temperature extremes, partial cutting is suggested as a viable silvicultural option on suitable sites in the southern part of the study area.

Partial cutting has the potential of minimizing the loss of lichens, but not without some costs to timber management. If partial cutting is accompanied by an increase in the area harvested at any one time, then the benefits to caribou of lichen retention must be weighed against the risks that result from increased access.

Retention of advanced regeneration and non-merchantable trees

An alternative to partial cutting is managing for future lichen crops by protecting the advanced regeneration and by retaining as many lichen-bearing snags and low-value subalpine fir trees as possible. Some mature, lichen-bearing subalpine fir trees are not merchantable, and could be left standing with no short-term loss. Stevenson (1979) reported that 13-25% of the lichen biomass available to caribou in three mature spruce-fir stands occurred on snags. Acknowledging that some dead trees present a safety hazard to workers, retention of as many lichen-bearing snags as possible is recommended. From the standpoint of caribou management, this approach offers an advantage over other harvesting systems: since successive entries are not required, closure of roads after harvesting is an option.

The short-term cost of the approach is limited to the measures required to protect the advanced regeneration. The silvicultural consequences are variable. Advanced regeneration in Engelmann spruce-subalpine fir stands is dominated by subalpine fir. Although reforestation programs at high elevations have generally been aimed at spruce, they have suffered from inconsistent seed sources for natural regeneration, and high failure rates in planted stock (Utzig and Herring, 1974). On some sites, the use of advanced regeneration may be a cheaper and more reliable method of restocking (Utzig and Herring, 1974). Recent studies indicate that on appropriate sites, management of subalpine fir advanced regeneration is a viable silvicultural option (Herring, 1981). On the other hand, retention of large, unmerchantable subalpine fir trees is silviculturally undesirable - they occupy growing sites

without contributing to the value of the stand, and may be a source of poor genetic material.

Retention of advanced regeneration and non-merchantable trees would not significantly increase short-term lichen availability, but would probably hasten lichen recovery. The technique is suggested where management for lichen crops is important, but where partial cutting is unacceptable.

Harvesting of very small patches

Clearcutting of very small patches (1-2 ha) has been recommended for subalpine forests where water yield is a primary consideration (Alexander 1973, 1977). The practice also has the potential of enhancing lichen production.

Creating a number of small, dispersed openings would increase light penetration into the remaining stand of mature timber. Except in stands that are already open or very dry, increased sunlight should improve the microclimate for lichen growth. Dispersal of lichen propagules would not be a limiting factor, as it might be in large clearcuts. As in the case of partial cutting, the long-term consequences for caribou would depend on the timing of later cuts, as well as on the response of the lichens to the changed microclimate. Small patch harvesting requires more road access than does block cutting — a serious drawback from the standpoint of caribou and forest management.

In terms of timber economics, Alexander (1977) rated small patch clearcutting as less favourable than block clearcutting, but more favourable than any partial cutting system. Initial road costs are high. Silviculturally, the chances of natural regeneration are greater in very small openings than in larger clearcuts (Alexander, 1974). Small patches should be favourable to spruce regeneration. Since the wind does not normally reach ground level in openings of that size (Alexander, 1973), windthrow should be minimal. On sites where slash burning is required, fire control may be a problem.

Small patch harvesting, like partial cutting, may enhance lichen production in the remaining timber, but would result in increased harvesting costs and increased road access.

Extended rotation

The second-growth spruce-fir forests of the future will ordinarily be harvested when their growth rate culminates, at age 120-150 years. Because arboreal lichens are not abundant in stands younger than 100-150 years, logging will occur before or shortly after stands become useful to arboreal lichen-eating caribou. For that reason, an extended harvesting rotation of 250 years has been proposed for caribou ranges (Ritcey, 1976).

Assuming that only stands older than 150 years are useful to caribou and that all stands are clearcut, Ritcey (1976) calculated that under a 200-year rotation, 25% of the harvestable forest would be useful to caribou at any one time; under a 250-year rotation, 40% of the harvestable forest would be useful to caribou. Extended rotations could also be used with a partial cutting system, so that harvested areas had value to caribou for a longer period.

The cost of extending the harvest rotation is high in terms of growth and yield of timber. If no growth is assumed after 150 years, then changing the rotation from 150 to 250 years would decrease the contribution of a stand to the annual rate of harvest from 1/150 to 1/250 of the mature volume — a drop of approximately 40%. Although the assumption of no growth after 150 years is incorrect, it is true that the annual increment of volume decreases after the optimum rotation period — older forests grow slowly. Furthermore, older forests are more susceptible to windthrow, disease, and insect infestations than are young forests.

Despite the cost to the timber resource, some sort of extended rotation, perhaps in combination with other special practices, is the technique most likely to ensure long-term lichen production. It is unlikely that special practices, such as partial cutting or very small patch logging, will ensure a usable supply of forage lichens if the stands are harvested as soon as they become merchantable.

Progressive partial cutting

In large unlogged areas where caribou management is a high priority, progressive cutting, at least some of which must be partial cutting, is an option to consider.

Progressive cutting concentrates harvesting in a single watershed until its timber supply is exhausted, leaving other watersheds undisturbed for some time. The advantage to caribou is that the adjacent drainages continue to provide undisturbed, unroaded habitat while the first

area is under development. If the first drainage is clearcut, then lack of suitable substrate and of propagules may prevent lichen re-establishment in the second growth. But if partial cutting is practised in spruce-fir forests where lichen abundance warrants it, and topography and stand structure allow it, then acceptable lichen crops may be present when the stands mature. There must also be a commitment to delay reharvesting past the time when the lichen supply becomes adequate; without such a commitment, this approach does nothing more than to buy time. This option is feasible only where little development has occurred previously, and unlogged areas are available to remain undisturbed for some time.

A potential disadvantage to caribou is the possibility that the presence of very large areas of unsuitable habitat within their range for many years will result in the abandonment of traditions of use. After the second growth becomes suitable as habitat, there may be a delay before caribou begin using it.

Concentration of timber harvesting through progressive cutting has advantages from the standpoint of forest management (Pearse, 1976: 279 - 284). Logging and road costs are substantially decreased. A reduction in the amount of exposed forest edge is expected to reduce losses due to escaped slash fires, unsalvaged blowdown, and epidemics of insects that breed in fallen trees. Although partially cut areas would be vulnerable to those hazards, the net losses would probably not be as great as they are under a patch logging system.

Silviculturally, the consequences of progressive cutting would be variable. Opportunities for satisfactory natural regeneration would be limited. Some foresters have argued strongly for progressive clearcutting in silvicultural grounds. However, in some areas and on some sites, especially at high elevations, growing conditions in a progressively clearcut watershed would be severe. In those situations, partial cutting might benefit silviculture as well as caribou management.

Progressive cutting is more often favoured by foresters than by other resource managers. Progressive cutting which incorporates partial cutting at high elevations is likely to be viewed less favourably by foresters. The inclusion of partial cutting in spruce-fir stands would mitigate the impact of the practice on some resources, such as watershed values. It would not mitigate its impact on the habitat of most other wildlife species. The advantages to caribou of such an approach must be weighed against its consequenses for other forest resources.

Access control

The development of roads in previously inaccessible areas is a serious consequence of logging in caribou habitat. Roads invite human activity in wilderness areas. They lead to increases in legal and illegal hunting. The negative effects of harassment on caribou, intentional and unintentional, have been described by Geist (1978) and Klein (1980).

Closure of roads after the completion of logging is inconvenient, but is generally possible. Signs, gates, felled trees, and trenches reduce public use but often do not eliminate it. Drivers of all-terrain vehicles are known for their ability to remove or circumvent obstacles. More complete physical barriers are necessary for complete closure. Closing roads is accomplished most easily if the need for closure was considered before the road was constructed. Roads can be planned to cross streams where they cannot be forded after the bridge is removed, or located along cutbanks that can be blasted onto the roadway.

Deliberate closing of roads after logging has some benefits other than the protection of wildlife: it reduces the risk of man-caused fire, and allows roads and skid trails to revert more quickly to growing sites. On the whole, it is undesirable from the standpoint of forestry because it eliminates access for purposes of stand tending, fire fighting, and other management activities. Road closure is also strongly resented by the public. Despite its drawbacks, it is technically feasible in most cases, and is an option that should be considered where caribou management is a high priority. The effects of access on caribou may be so severe that there is little value in modifying logging practices to maintain caribou habitat unless road closure is included in the management plan.

Conclusions

The special forest management practices considered here involve a tradeoff between forest economics and the objectives of caribou management. In general, those most likely to be

effective in maintaining caribou habitat have the most severe economic consequences. In caribou ranges that are managed for lichen production, it will probably be necessary to defer some harvesting past the time that is optimum for timber production. There are no easy solutions to the problem of extracting timber from caribou ranges while maintaining caribou populations, at least where arboreal lichens are judged essential.

Wildlife managers must consider the trade-off between special forestry practices intended to encourage lichen production, and increased road access to caribou ranges. Unless the rate of timber harvest is reduced, the use of practices such as partial cutting and very small patch logging will result in an increase in the area that is under development at any one time. The result will be greater human disturbance for an extended period of time, unless access control is practised. To a great extent, the management strategy selected must depend on the relative importance we assign to the effects of habitat alteration and human disturbance.

Research is currently underway or proposed on several topics that could greatly alter the conclusions presented here: the development of techniques to enhance lichen production in managed stands (Stevenson, 1985), the relationship between predation and man-caused habitat changes, the impact of access on caribou, and the winter forage needs of caribou (Stevenson and Hatler, 1985). However, given the current state of knowledge, a prudent strategy for caribou management requires that key ranges be managed conservatively. Where caribou management is a high priority and arboreal lichens are the major winter food, both access control and practices intended to enhance lichen production should be incorporated into the management plan.

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