Timber Management Guidelines For the Provision Of Moose Habitat

February 1988 Wildlife Branch

Ontario

Ministry of
Natural
Resources

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Printed in Ontario, Canada

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Room 1640, Whitney Block
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Summary of
Timber Management Guidelines
For The Provision Of
Moose Habitat

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The purpose of the guidelines is to assist resource managers in maintaining or creating through timber management the diversity of age classes and species of vegetation that provide habitat for moose.

The attached Background Document indicates more fully the purpose and rationale for the guidelines and the major components of the Ministry's Moose Management Program. As well, it summarizes moose habitat requirements and the possible impacts of various timber management operations on moose. Finally, guidelines are recommended to provide moose habitat in timber management.

This is a summary of those recommended guidelines.

The guidelines approach the subject in two ways. First, they address the general needs for moose habitat in a manner that acknowledges the fact that moose range over the whole forest and require various habitat components throughout that area. Furthermore, they recognize that timber management activities can have a positive influence on moose habitat. This aspect of the guidelines provides recommendations for timber managers to consider and use when determining which stands, or portions of stands, should be allocated for harvest during the planning period.

Secondly, the guidelines discuss specific needs for moose habitat that can be identified on discrete geographic areas. These needs allow for the identification of Areas of Concern to moose habitat management that are site specific, and the guidelines provide specific directions for setting timber management prescriptions within these areas. Areas of Concern may become reserves where timber management will not be permitted because of the potential for significant adverse effects on moose habitat. In other instances timber management may have to be modified to provide specific habitat requirements.

Specific Areas of Concern include existing and potential early and late winter concentration areas, aquatic feeding areas, mineral licks, and calving sites. Within each type of area of concern, prescriptions which protect or enhance particular habitat requirements, such as shelter, or quality and abundance of browse, must be developed. In addition, protection of moose from disturbance while in calving areas or using special feeding sites may require restrictions on access or scheduling of operations. However, moose habitat requirements vary with time of day and year, as well as topography and climatic factors, both of which vary across the province. Timber management practices also differ throughout Ontario.

General Guidelines

To meet the present and future habitat needs of moose throughout their range the following general guidelines apply:

1. Boreal Forest Region

(a) Potentially large clear cuts, that would not allow moose utilizing portions of the planned cutover to be within approximately 200 m (650 feet) of suitable shelter, should be broken into smaller, irregularly shaped cuts. Clear cut and shelterwood harvesting are best to produce the desired patterns.

Clear cut in blocks of 80-130 ha (200-320 acres) and leave buffer zones between cuts and scattered patches of trees within cutovers. Average cut size is optimal at about 100 ha (250 acres).

(b) Where clearcuts will exceed 100 ha (250 acres) and the 'edge of cover' to 'edge of cover' distance will be potentially more than 400 m (1300 feet), provide shelter patches within the cut area (See General Guideline I (c)).

(c) Shelter patches should be of conifer, but could be mixed wood, and be at least 3-5 ha (7-12 acres) in size, at least 6 m high, have a basal area of about 11 square meters/ha (50 square feet/acre) with at least 113 in conifer. The stocking of immature and mature stands with this basal area will be approximately 70% and 40% respectively. If the objective of the shelter patches is to provide late winter cover for moose, shelter patches should be conifer with stocking of 70% or greater. Where these shelter patches are composed of mature conifer, basal areas will be greater than 11 square meters/ha. The shelter patches should be spaced 300-400 m (1000-1300 feet) apart. Leaving shelter patches larger than 3-5 ha may be desirable to encourage future harvest of timber and provide greater protection from predators, including hunters. Such shelter patches could function as travel corridors between habitat components.

(d) Selection harvesting can occur within mixed wood shelter patches provided that adequate semi-mature or mature conifer cover remains for winter shelter.

2. Great Lakes - St. Lawrence Forest Region

Similar habitat requirements exist in the southern part of the moose range as in the north, but the nature of the forest requires emphasis on protecting and creating different components. However, few large clear cuts occur, and hence are seldom if ever a problem, because of the nature of the forest and the selection and shelterwood techniques usually practised.

(a) When cutting in hardwoods stands, cuts should be large enough to stimulate the growth of early successional species and some conifer regeneration should be encouraged.

(b) At least 15% of the total area should have mature conifer cover, preferably in patches or clumps at least 3-5 ha in size.

Specific Area of Concern Guidelines

For the protection of identified site specific habitat components such as early and late winter concentration areas, mineral licks and calving sites, the following guidelines apply:

1. (a) Access roads should be routed to avoid aquatic feeding areas, mineral licks, and calving areas.

(b) If it is desirable in special circumstances to reduce hunting pressure, carefully consider access road location and measures to limit vehicle use eg. winter extraction, the signing of roads, or the scarification and removal of roads after timber operations.

2. (a) During timber harvest within winter concentration areas, apply the General Guidelines to maintain the habitat value of these areas.

(b) If required, early winter concentration habitat may be created or maintained by selection harvesting of some large conifers in mature conifer or mixed wood stands.

(c) In early winter concentration areas, remaining shelter patches may be cut when adjacent vegetation has reached 2 m in height.

(d) In late winter concentration areas cuts should not exceed 400 m (1300 feet) in width. Uncut areas of semi-mature or mature conifer or mixed wood equal in size to cut areas should be left. Remaining shelter patches may be cut when nearby regeneration has reached 6 m in height.

(e) A reserve is generally recommended around aquatic feeding areas, mineral licks and calving sites. The shape and extent of the reserve will be determined by the nature of each site and by the need to maintain its integrity and safe access to it by moose from surrounding forest stands. In general, a 120 m (400 ft) reserve should be left around these areas in certain circumstances some merchantable trees may be selectively removed.

3. The potential impact of site preparation, regeneration and maintenance treatments should be considered in the context of the quantity and quality of moose habitat that surrounds the harvested site.

4. (a) Prescribed burning, if it leaves needed protective shelter components, is the preferred site preparation method

(b) Mechanical site preparation should not destroy shelter patches of conifer or mixed wood left within the cut area, nor should residual clumps be removed unless they seriously threaten the success of regeneration.

(c) For chemical site preparation or tending, managers should carefully consider the anticipated effectiveness of the herbicide in controlling woody plants (browse), and the amount and proximity of deciduous growth outside the treatment area.

5.(a) Natural regeneration of browse species should be allowed where moose browse is, or will be, in short supply.

(b) Artificial regeneration to conifer species should be used where shelter is, or will be, in short supply.

Application of Guidelines

It is not feasible to provide too rigid a set of guidelines specifying precisely how timber should be harvested to maintain a good moose population. Local managers must decide how best to adapt the principles contained within the Guidelines to meet the needs of both moose and the forest industry in their area. As not all wildlife species can be managed to maximize populations on the same land area, neither can all areas be managed in a way that maximizes both moose and timber production. Discussion and compromise among government and industry managers is essential to the management process in order to obtain the best protection, enhancement and use of both valuable resources.

In general, if individual harvest blocks do note exceed one hundred hectares, concerns for moose should be restricted to known specific areas (concentration areas, mineral lick sites, calving sites, aquatic feeding areas).

If cuts are proposed which exceed the general guidelines over large areas, the District must receive the Regional Director's approval prior to agreeing to the plan. If a Region intends to routinely sanction deviation from the guidelines, the Assistant Deputy Minister's approval must be obtained before approving the plans.

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1.0 Preface

Not all wildlife species can be managed for maximum populations on the same land area. Thus managers must often make local decisions about which species warrant special forest prescriptions. The legitimate concerns for other wildlife will often be accommodated to a large degree within the prescription for the key species. These particular guidelines deal with moose in the context of timber management. The timber management terms used in this document (eg. selection cutting, shelterwood cutting) are as defined in the "Class Environmental Assessment For Timber Management on Crown Lands in Ontario" (MNR, Dec. 1985).

The purpose of this set of guidelines is to assist forest and wildlife managers in planning timber management activities. Virtually all efforts designed to manage moose habitat will involve working with timber companies to manage the forest in order to produce good moose habitat with a minimum loss of wood fiber. In many circumstances, the practice of good timber management is consistent with good wildlife habitat management. For example, disturbances to the forest cover by timber harvesting will create the kind of openings and young growth that are necessary elements of good moose habitat. Without such disturbance, moose populations would be lower. There is not usually a concern over whether timber is harvested, or how much timber is harvested. It is mainly a question of how and when harvesting takes place and the relative sizes of cut and uncut blocks that is of concern in moose habitat management. The challenge of integrating timber and moose management is to retain all of the necessary habitat components for moose while extracting the available merchantable timber.

These guidelines include general requirements and specific suggestions for providing habitat, although it is impossible to foresee every conceivable situation the manager might encounter. The attached papers provide more complete information concerning moose habitat.

Essentially, the guidelines are designed to produce good moose habitat by cooperating with forest managers. It must be emphasized, however, that moose management involves many variables other than the actual habitat work itself. For instance, the best habitat will not necessarily contain good moose populations if hunting pressure is excessive or if wolf predation is extensive. The goal should be to achieve a proper combination of moose population management, control of hunters and careful habitat manipulation.

Moose range in Ontario encompasses a wide variety of physiographic site conditions. It extends from the western boundary of Ontario to the eastern border, and south to the edge of the Precambrian Shield. Habitat management for moose in northwestern Ontario may be substantially different from habitat management in eastern Ontario due to the diversity of site, climatic factors and other environmental conditions across the Province. Prescriptions for management thus vary. These guidelines provide the principles for moose habitat management which local managers can adapt to meet needs within their own district or region.

Moose habitat guidelines will also be used in wildlife planning processes. Wildlife plans may not coincide in time period and area with forest plans, but wildlife objectives and habitat strategies should be consistent among these plans.

2.0 Moose Program Development

On October 22,1980, the Government of Ontario adopted specific objectives, targets, guidelines and management policy for moose in Ontario (for a complete listing of these items, see Policy WM.3.01.02, 1980 12 15).

THE BROAD PROGRAM OBJECTIVE IS: To protect and enhance the moose resource and to provide opportunities for recreation from moose for the continuous social and economic benefit of the people of Ontario.

The program targets are:

1. To increase the moose population from 80,000 to 160,000 animals by the year 2000.
2. To provide from this herd an annual harvest of 25,000 animals by the year 2000.
3. To provide a hunter success rate of at least 12 percent.
4. To provide 1.2 - 1.4 million viewing opportunities at 24 - 30 sites by the year 2000.

The policy for moose habitat management is: "...to ensure that the quality of moose habitat is maintained or enhanced by direct involvement in the timber management planning process." and, "to ensure that timber production will not reduce the quality of moose habitat, wildlife managers will emphasize upper limits on sizes of clear-cutting operations, within the planning process for timber management." Regional targets are:

	Population	Harvest
Northwestern	47,500	7,300
North Central	44,500	7,000
Northern	37,500	5,600
Northeastern	30,500	4,600
Algonquin	5,000	500
	165,000	25,000

Moose inventories by wildlife management unit may be obtained by reference to current regional data. Moose population targets by wildlife management unit (WMU) are listed in strategic land use plans for Northwestern and Northeastern Ontario, and are reproduced here with the inclusion of the Algonquin Region (Appendix 1).

Population targets for WMUs may change over time, but these occurrences are expected to be accompanied by compensating target revisions in nearby WMUS.

Much of the target for viewing opportunities may be satisfied from use of wildlife management areas, Crown Game Preserves, Areas of Natural and Scientific Interest (ANSI's) or provincial parks. This will be dictated to some extent by the presence of visible moose in relation to existing or potential aggregations of people, and our abilities to provide security for moose and onlookers under these circumstances.

3.0 Summary of Moose Habitat Requirements

Moose are found predominantly in the Boreal Forest Region, though they also live in the Great Lakes-St. Lawrence Region. Moose are generally absent in southern Ontario because of the clearing of land and perhaps overlap with white-tailed deer that carry a brainworm that is fatal to moose. Moose are generally animals of the forest edge, living in proximity to young deciduous stands which provide food, and semi-mature and mature conifer which provide shelter from weather and predators, including hunters. They are well adapted to extreme cold and snow when food and shelter conditions are adequate. Their large bodies are well insulated and their long legs make movement through snow relatively easy. Unless they are hampered by very deep snow (greater than 80 cm), their size and strength is sufficient to cope with most factors in their environment.

In spring and early summer, moose feed extensively on selected species of aquatic plants whenever they are available. These plants contain important dietary items and may supply certain nutrients (e.g., sodium), not found in other items of their diet. Travel to these aquatic feeding areas is often along well-defined routes or corridors. Mineral licks are also used at this time of year. In summer, fall and early winter, most feeding occurs in early successional, terrestrial plant communities. Cutovers and burns are especially important. In winter, moose seek out areas of conifer for shelter, and may use portions of nearby cutovers or burns for feeding provided that snow is less than about 80 cm (35 inches) and is not heavily crusted. During the winter months, moose feed almost exclusively on twigs and branches of woody plants, such as willow, birch, aspen, hazel and mountain ash. In addition, their metabolic rate is lower than in summer and they use their own stored body fat to supplement food sources. Moose conserve energy by decreasing their movements to a minimum. These adaptations to cold and snow help them to survive in northern forest areas.

Moose and other wildlife are active throughout the entire forest. The ability of the forest to support moose changes through time. These changes can occur slowly as a forest develops and matures, or they may occur quickly as a result of such events as fire, insect damage or logging. Such factors acting throughout moose range affect the type, quantity and quality of vegetation, and thus affect the numbers, location and physical condition of moose that the forest will support.

Prime moose areas are those that produce or attract, or have the potential to produce or attract, a significantly higher number of moose than surrounding areas at certain times of the year. These areas can be identified as being key components of moose habitat on a local basis.

Boreal Forest Region

There are two main types of prime moose areas in the Boreal Forest Region. The first type is seasonal high-use or winter concentration areas which are known to be important to moose for a wide variety of reasons (see the attached papers for details). The second type includes special sites such as mineral licks, calving areas, and aquatic feeding areas that may require reserves of timber to protect the special nature of the site. The second type will remove a small percentage of the land base from timber production. The first type will not remove any land from timber production, but will require modified harvesting techniques and may require removing the allowable cut for the 5 year operating period from a larger planning area.

Early winter concentration areas may be typified by mature or over mature, open canopy, mixed-wood stands of relatively low stocking (less than 60 percent). Stocking is an expression of the relationship between actual basal area as measured in the field and normal basal area obtained from normal yield table. The need is to leave portions of these stands uncut for a period of time to allow the animals to continue to use them. As well, bums and cutovers, usually from 5 to 20 years of age, are also often used. Because of the open canopy, early winter concentration areas usually have considerable browse. These sites are also important to moose as they provide some lateral protection from winds as well as predators. The shape, abundance and nature of these areas is so variable that each must be treated on an individual basis.

Late winter concentration areas, usually fairly large in size, are those where the average moose density is higher than the surrounding area. Generally, they are well stocked stands of mature conifer (greater than 70 percent stocking) with complete crown closure which provides overhead protection from snow accumulation and severe cold. These areas are most functional when near early winter or other feeding habitat so that travel distance between food and shelter is minimal.

Aquatic feeding areas, mineral licks and calving sites are important to moose because they attract moose and contain critical components of their diet or important life history features. Identification of these areas, their shape and importance must be determined by district staff. It is important to maintain both the integrity of the sites and sheltered access by moose to them.

Great Lakes - St. Lawrence Forest Region

Moose populations in the Great Lakes - St. Lawrence Forest Region have the same basic habitat requirements as those in the Boreal Forest Region, a diverse series of plant communities in early to late successional stages. Tolerant hardwood forests may have relatively little browse available to either moose or deer, and often insufficient, semi-mature and mature conifer shelter. In the mixed wood (eg. poplar-pine) areas browse and shelter are more abundant. Group selection cutting and shelterwood cutting have contributed to browse production in both tolerant hardwood and mixed wood forests.

Summary

Although much remains to be learned about the ecology of moose, here is a brief summary of their known needs:

1. Moose populations need the early successional plant communities which follow a major disturbance such as a forest fire, insect damage or a logging operation. Populations may expand after disturbance provided that excessive hunting or predation does not occur and adequate shelter remains.
2. Moose also require semi-mature or mature stands of conifer in winter. These stands provide protection from severe weather and predation, and minimize snow depth and crusting thereby allowing easier access to food.
3. Aquatic plant communities in certain waterbodies are used extensively during spring and summer. Both preferred emergent and submergent vegetation is utilized.
4. Mineral licks are important in certain areas.
5. Calving sites such as islands and peninsulas are important in certain areas.
6. The best moose habitat contains food (early successional plant communities) and cover (semi-mature and mature conifer) in close proximity such that the animals need not travel far between these important items.

4.0 Impacts of Timber Management on Moose

In many situations the practise of good timber management is consistent with good wildlife habitat management. For example, disturbances of forest cover by timber harvesting will generally create young growth that is a necessary element of moose habitat. If an adequate amount of shelter eg. unallocated areas, protection forest, remains nearby, then good moose habitat can be provided. The challenge of integrating timber and moose management is to retain all of the necessary vegetation components for moose while extracting the available merchantable timber. There is not usually a conflict over whether timber is harvested. It is a question of how and when harvesting occurs and the relative sizes of cut and uncut blocks that is of concern in moose habitat management.

The timber management undertaking involves five basic processes. These are: (i) forest access, (ii) harvest operations, (iii) site preparation, (iv) regeneration, and (v) maintenance operations. The last four steps (ii-v) are referred to as the silviculture system. Each of these procedures may directly impact the quality of moose habitat and indirectly affect the size of the moose population. The impacts cited below are normally related to the immediate areas of the treatment. They are concerns of a general nature and in practice the impact may be substantially mitigated by vegetation surrounding the area of timber operations. The real potential significance of these impacts must be assessed within the entire context of each operating plan. Local managers must try to balance potential negative impacts by positive ones.

As well, the implications to moose of nearby, past and future silvicultural operations may also influence decisions when developing an operating plan.

4.1 Forest Access

Forest access, principally by roads, may have both positive and negative impacts on moose management. While roads may subject newly accessed moose populations to local over exploitation, they also allow for distribution of hunting pressure over a wider geographic area. As permanent access stabilizes, within a Wildlife Management Unit, the moose harvest will stabilize and the benefits of road access to moose management will outweigh the adverse effects. Within the concept of Ontario's Selective Moose Harvest Program general overharvest of moose within a Wildlife Management Unit (WMU) should not occur. If local overharvest occurs in one part of the WMU it should be offset by underharvest in another part. If an overharvest of moose from the entire WMU occurs or is anticipated the harvest quotas for the Unit can be established to correct or avoid the problem.

Road construction and use within or near aquatic feeding sites, mineral licks, calving site and winter concentration areas could destroy habitat or disrupt normal moose activities, and possibly result in an increase in vehicle accidents.

In the Great Lakes-St. Lawrence Forest Region concerns relating to access and silviculture are similar to those in the boreal forest, although the impacts are probably less significant because of the shelterwood and selection harvesting systems more commonly practiced in the southern portion of the moose range.

4.2 Harvest Operations

The effects of harvest operations may also be either beneficial or detrimental to moose populations, depending on the manner in which food (young deciduous vegetation) and shelter (semi-mature to mature conifer) are left, or Produced, by timber harvesting. When cutting operations produce irregularly shaped cuts, scattered shelter patches, and a high diversity of age-class and species composition, moose populations will benefit. In the Boreal Forest where clear-cutting is a common timber harvesting technique, some standing timber with its associated subordinate vegetation should be retained to provide a variety of plant communities close to each other.

Generally, the greater the amount of edge produced between food and shelter habitat components, the better will be the quality of habitat.

43 Site Preparation

Preparing the site to accept seeds or seedlings may have an impact on moose, particularly in the Boreal Forest where clear cutting and site preparation are commonly practiced. The objective of site preparation is to bare some mineral soil and if possible reduce potential competition from broadleaf species. These are often preferred browse species and an important source of nutrition to moose. Except on more infertile soils, site preparation often encourages the establishment of herbaceous or deciduous plants.

Mechanical preparation may remove residual clumps of vegetation within a cut, which could contribute to good wildlife habitat by providing diversity and visual barriers as protection from hunters and predators. The value of residual vegetation to wildlife increases with the size of clear cut. Some types of mechanical preparation encourage coppicing or root suckering which increase browse.

The effect of chemical site preparation depends largely on the chemical being used. Chemicals, such as 2, 4-D used at approved rates, suppress growth but generally do not kill most deciduous woody plants and they can encourage root suckering. Recently approved chemicals, such as "Roundup/Vision" (glyphosate), appear to be very effective at killing herbaceous and woody plants and may substantially reduce browse species for an extended period.

Prescribed bunting, where it leaves needed shelter and does not damage the soil, benefits moose by quickly returning nutrients to the soil thereby increasing the nutritional quality of the browse growing on the site. Mechanical site preparation may have advantages where the retention of needed shelter components cannot be assured by prescribed burning.

4.4 Regeneration

The objective of forest regeneration is to return the cut over area to desirable commercial species in a manner that minimizes competition and maximizes growth of the desired tree species. Regeneration in the boreal forest strives for even-aged stands of coniferous species. Artificial regeneration, along with tending, attempts to increase the growth of the crop species by reducing competing vegetation. Where regeneration is very effective, there could be a negative impact on moose in the initial stages. This could be partially compensated for by leaving residual or nearby stands of young deciduous vegetation.

4.5 Maintenance

Maintenance of the forest includes tending, protection and improvement activities.

The objective of tending is to further reduce competition and in most respects the impacts of tending are the same as for site preparation. Manual, mechanical and some chemical treatments do not kill most deciduous growth, but will set it back. Later, coppicing and root suckering may occur. Forest improvement by converting mixed wood stands to more pure conifer may create winter shelter but remove a significant source of browse for moose.

In the Great Lakes-St. Lawrence Region there are often too few stands of semi-mature and mature conifer to provide shelter. Silvicultural treatments which produce these will often benefit both moose and deer.

5.0 Providing Moose Habitat in Timber Management

The objective of habitat management is to provide all of the necessary habitat components within the area of activity normally inhabited by moose. The size of this area will be dictated to a large extent by topography, the nature of the forest, and the size of the moose population. The purpose of these Guidelines is to demonstrate how to produce good vegetation patterns necessary to meet moose requirements.

Moose are animals of the forest edge requiring young deciduous growth for food, and semi-mature and mature coniferous forest as shelter from weather and predators. To benefit moose, timber management should produce irregularly shaped cuts with scattered shelter patches and a high diversity of age classes and species of vegetation.

Following are a set of general principles which will lead to the maintenance or improvement of moose habitat in Ontario, recognizing prevalent timber harvesting practices. Moose habitat needs vary during the day, different times of the year, and across their range. Also, the topography and climatic conditions in Ontario are not uniform and timber management practices vary widely across the Province. Because of this variation, the Guidelines for use in planning timber management are set down in a general way to ensure that average habitat conditions are provided. Local managers and planners will decide how to best apply the principles to meet local situations. In addition, not all areas can be managed in such a way that maximum timber production will coincide with maximum wildlife production. Compromise and discussion among managers is essential to the management process.

Figure 1 illustrates a possible scenario resulting from the implementation of these principles.

5.1 Boreal Forest Region

5.1.1 Forest Access. Where new access is created to harvest the forest, the potential for local overharvest of moose exists. Although legislation (eg. Public Lands Act, Game and Fish Act), may be used to inhibit or prevent hunting within these areas for either short or long periods of time, it tends to postpone problems of overharvest rather than solving them. In special cases where it is desirable to minimize hunting by controlling access, roads may be closed by signing or they may be kept away from the area of concern, or wood may be extracted using winter roads. As well, in some circumstances it may be appropriate to scarify and remove access roads after extraction is complete.

Access roads should avoid mineral licks, aquatic feeding areas, and calving sites to protect these important habitat features and minimize disturbance and accidents to moose using these areas.

Road use and location must be addressed as early as possible in the planning process so that field examinations can identify possible alternatives.

Moose Habitat Management in Ontario

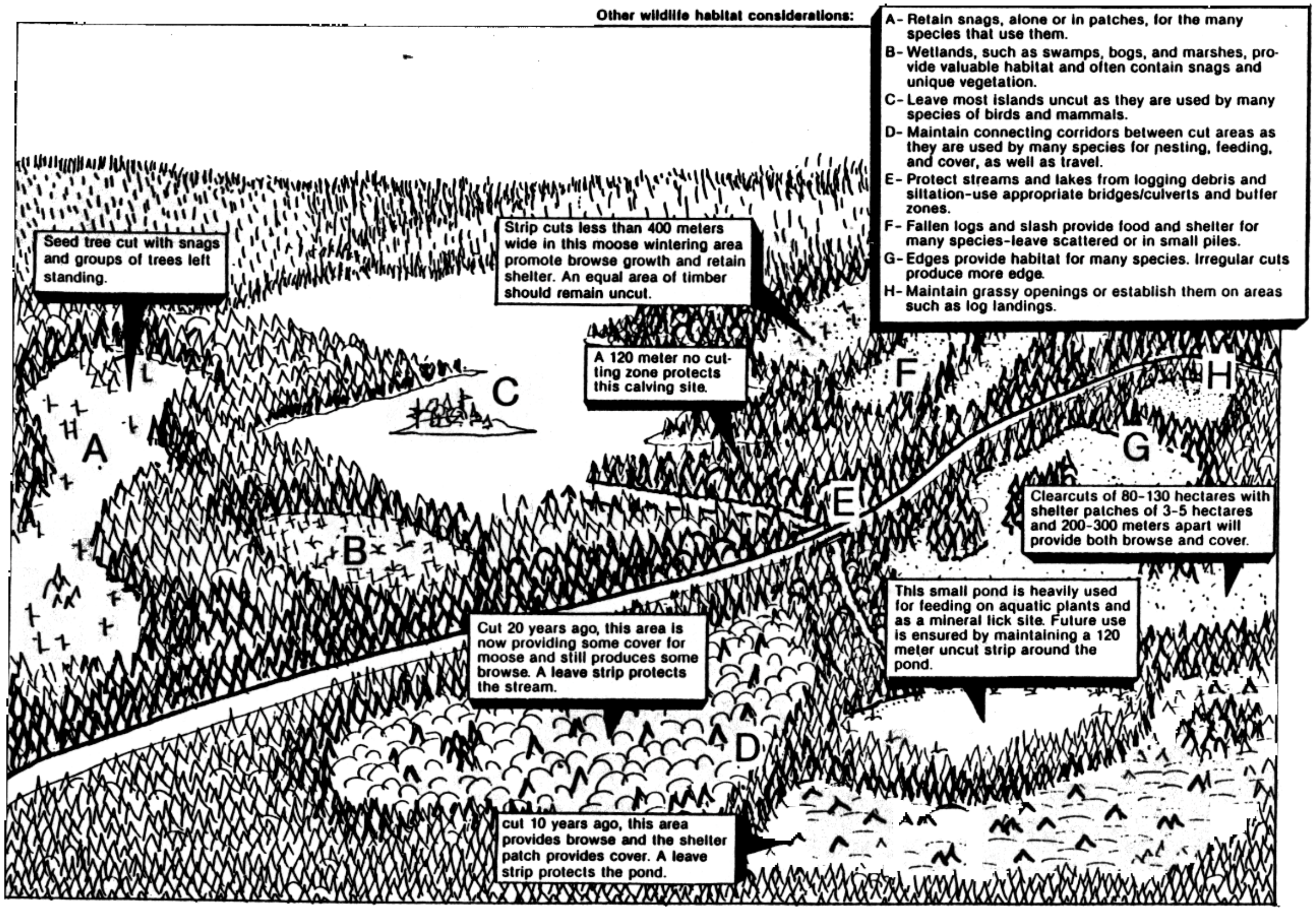


Figure 1.

5.1.2 Harvest Operations. The moose management objective of maintaining or enhancing the quality of moose habitat includes the concept of protecting key features (eg. aquatic filling areas) and providing food (early successional plant communities) close to shelter (semi-mature or mature conifer stands).

This objective may be met by no or modified cutting in the vicinity of key features, by reducing the size of planned clear cuts or by providing shelter patches within cutovers. Additionally, a diverse vegetative pattern may be obtained if cutting is dispersed among all eligible stands rather than cutting them in a contiguous manner during the planning period.

In some areas, clear-cutting in blocks of 80-130 ha (200-320 acres) with buffer zones between cuts, and scattered clumps of trees within the cutovers, will provide the desired conditions. Clear-cuts greater than 100 ha (250 acres) should have scattered shelter patches within the cut area. This would keep the overall vegetative diversity of the area high and still provide a reasonable timber harvest.

The best habitat should provide conditions enabling a moose to be within 200 m (650 feet) of shelter patches or other cover. These shelter patches should preferably be of conifer but could be of mixed-wood, with at least 1/3 in conifer. They should be at least 3-5 ha (7-12 acres) in size, be spaced 300-400 m (1000-1300 feet) apart, be at least 6 in (20 feet) high, and have about 11 square metres/ha basal area (50 square feet/acre). The stocking densities of immature and mature stands with this basal area will be approximately 70% and 40% respectively. If the objective of the shelter patches is to provide late winter over for moose, shelter patches should be conifer with stocking of 70% or greater. Where these shelter patches are composed of mature conifer, basal areas will be greater than 11 square meters/ha. It may be beneficial to moose and advantageous to the timber industry to leave shelter patches large enough to inhibit blowdown problems and to warrant future harvest (eg. > 8 ha).

If late winter habitat will be adequate in the area, a return cut of shelter patches can occur when nearby regeneration has reached 2 metres in height. Regeneration of Us size will provide lateral shelter, and function as early winter habitat if the regenerated site contains sufficient browse.

If late winter habitat will be inadequate in the area after an early return cut, the cutting of shelter patches should not occur until nearby regeneration has reached 6 metres in height, thereby providing overhead cover for moose.

Clear cut and shelterwood harvesting techniques can produce these patterns, but selection cutting, seldom practiced in the Boreal Forest, may not disturb the forest canopy enough to create significant successional growth. Some selection harvesting of conifer could be practiced within mixed wood shelter patches provided adequate protection remains. There may be a need or opportunity to provide early winter habitat where it does not currently exist. This can be achieved by selection cutting within mature conifer and mixedwood stands to remove some of the larger conifers.

In late winter concentration areas, width of individual cuts should not exceed 400 m (1300 feet). Uncut areas equal in size to cut areas should be left.

To protect aquatic feeding areas, mineral licks and calving sites, generally reserves are required with the shape and extent dictated by surrounding habitat conditions. Usually a 120 m reserve should be left around these areas. Some merchantable conifer may be removed by selection cutting provided the general nature of the reserve remains intact.

Figure 2 is a stylized illustration of some of the principles of timber harvesting impacts on wildlife and timber production.

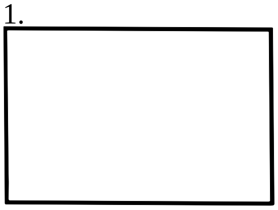
5.1.3 Site Preparation To benefit moose, mechanical preparation should not destroy shelter patches. Residual clumps of conifer or mixed wood within the cut should not be destroyed unless these seriously threaten the success of regeneration. Chemical site preparation is acceptable provided there is adequate browse in nearby stands.

5.1.4 Regeneration Natural regeneration, on suitable sites that produce deciduous woody growth, is of benefit to moose where food supplies are inadequate. Harvest methods which facilitate this should be encouraged in these areas. Artificial regeneration to conifer may be best where moose shelter is in short supply.

5.1.5 Maintenance This aspect of the silviculture system, as those above, should be considered in relation to the vegetation surrounding the treatment area.

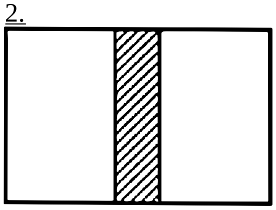
Figure 2.
Stylized Illustration of Principles of Timber Harvesting Impacts on Wildlife and Timber Production

1.



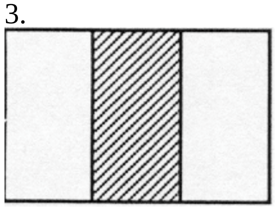
Large clear cut. Total timber utilization, no shelter of any kind for wildlife.

2.



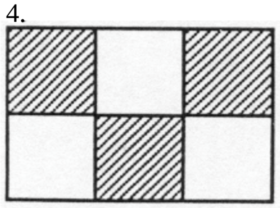
Narrow travel corridor or uncut block (eg. <120m) Some blowdown possible. Possible return for remaining wood. Shelter good for visual barrier, wind and possibly snow depth. Some edge provided.

3.



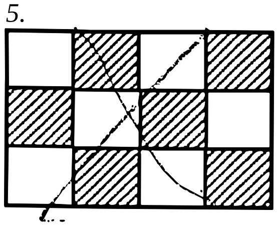
Wide corridor or uncut block (eg. 400m). Timber volume warrants future harvest. Shelterwood for visual barrier, wind, snow and radiation. Same edge as #2.

4.



Large cut block pattern. Timber volume warrants future harvest. Shelter good for visual barrier, wind, snow and radiation. Much more edge than #2 and #3. Browse and shelter nearly equal and available.

5.



Small block pattern. Same timber volume as #4, but small blocks particularly if scattered may make future harvest impractical. Shelter good for visual barrier wind, snow and radiation. Strip and shelterwood cuts are variations of this. Much more edge than#4.

6.

Large uncut, irregular patches (eg. >5 ha.) Some loss of Umber unless patches are connected. Shelter good for visual barrier, wind, snow and radiation. Large amounts of edge.

Note: A rigid checkerboard harvest pattern is not desirable to produce the best wildlife habitat nor is it practical on most sites. This is a stylized representation.

Where browse is abundant, most tending is acceptable. Where shelter is or will be in short supply, and browse is adequate, tending is encouraged.

Tending efforts should not destroy deciduous growth within shelter patches. Treatments which increase browse in these areas are beneficial. The use of herbicides that suppress deciduous growth for long periods of time should be carefully considered for their potential negative impacts on the quantity of moose browse.

Some chemicals, notably 2, 4-D, can have the effect of encouraging browse production (coppice growth).

5.2 1 Great Lakes - St. Lawrence Forest Region

5.2.1 Forest Access. There are similar concerns about access in both the Boreal and Great Lakes - St. Lawrence Forest Regions. See section 5.1.1 for appropriate recommendations.

5.2.2 Harvest Operations. In the Great Lakes - St. Lawrence Forest Region the emphasis in forest operations is primarily on natural regeneration through the selection or uniform shelterwood systems. Since these systems obtain regeneration under the shelter of a residual stand, they normally provide optimum moose habitat.

Cutting in tolerant hardwoods can create good habitat if it produces sufficient disturbance to stimulate early succession species growth. Cutting should not remove, and it may help regenerate, conifer that is necessary for shelter from extreme weather.

At least 15 per cent of the total area should have mature conifer cover at all times, preferably in patches or clumps at least 3-5 ha in size. This objective can be met using the shelterwood harvest system and, if feasible, by undertaking some artificial regeneration to conifer.

The principles for protecting winter concentration areas, aquatic feeding areas, mineral licks, and calving sites are the same as in northern forest regions. Each area should be identified, its importance determined and the site treated on an individual basis by district staff. See Section 5.1.2 for appropriate harvesting recommendations.

5.2.3 Site Preparation. Recommendations for site preparation in the Boreal Forest Region (Section 5.1.3) are applicable in a few isolated cases to the Great Lakes - St. Lawrence Forest Region. As harvest blocks are generally small, site preparation operations are seldom implemented over large enough areas to have a significant impact on moose habitat.

5.2.4 Regeneration. Because conifer shelter is frequently lacking in the Great Lakes - St. Lawrence Forest Region, regeneration to conifer will generally benefit both moose and deer. Also see Section 5.1.4.

5.2.5 Maintenance. The recommendations for tending, protection and improvement operations in the Boreal Forest Region apply here as well. See Section 5.1.5. Most maintenance in the Great Lakes - St. Lawrence Region is in the form of thinning and improvement of established stands which has little impact on moose habitat.

6.0 Application of Guidelines

Moose habitat needs vary during the day, different times of the year, and across their range. Also, the topography and climatic conditions in Ontario are not uniform and timber management practices vary widely across the Province. Because of this variation, the Guidelines for use in planning timber management are set down in a general way to ensure that average habitat conditions are pro- vided. Local managers and planners will decide how to best apply the principles to meet local situations. In addition, not all areas can be managed in such a way that maximum timber production will coincide with maximum wildlife production. Compromise and discussion among managers is essential to the management process.

In general, if the individual harvest blocks in the proposed five year allocation do not exceed approximately one hundred hectares, there should be no or few moose concerns. In such cases concerns should be restricted to known specific areas (concentration areas, mineral lick sites, calving sites, aquatic feeding areas).

If cuts are proposed which exceed general guidelines over large areas, the district must consider existing and potential moose habitat requirements prior to approving the plan. When a district proposes a cut that greatly exceeds the general guidelines they must, in advance, receive the Regional Director's approval. In addition, if a region intends to routinely sanction deviation from the general guidelines, the Assistant Deputy Minister's approval must be obtained in advance of approving the plans.

7.0 Basis for Guidelines and Sample Plans

These guidelines are based upon a body of scientific literature which is summarized in two appended papers, Thompson and Euler (Swedish Wildlife Research: Viltrevy. in press), and McNicol and Timmermann (1981. in Boreal Mixedwood Symposium Proc. p. 141 - 154). Examples of plans are provided in Appendix 11.

Moose Population Targets for the year 2000. By Wildlife Management Unit*

WMU No.	Population Target	WMU No.	Population Target	WMU No.	Population Target
1	21,092	21	10,337	41	3,560
2	4,575	22	2,722	42	2,210
3	4,536	23	3,627	46	50
4	3,825	24	2,833	47	110
5	3,340	25	1,111	48	800
6	1,393	26	3,977	49	60
7	2,662	27	3,133	50	300
8	1,748	28	3,769	51	3,000
9	2,655	29	2,698	53	30
10	150	30	5,169	54	260
11	2,993	31	3,948	55	210
12	3,592	32	4,500	56	40
13	4,386	33	2,565	57	30
14	465	34	720	58	30
15	9,610	35	3,495	59	30
16	7,677	36	2,015	60	50
17	3,036	37	1,895		
18	4,207	38	4,010		
19	4,015	39	2,170		
20	152	40	3,475		

*From: Northwestern Ontario Strategic Land Use Plan, May 1982; Northeastern Ontario Strategic Land Use Plan, April 1982; Algonquin Region, 1984

The maps that follow illustrate some actual examples of fish and wildlife concerns that have been addressed through alteration of timber management plans. For each example a description of the area, the concerns involved and their solutions are given. These examples are of a specific area and may not be duplicated exactly elsewhere, but they am typical of solutions that are encountered in timber management planning.

Map 1- Big Ghee Lake and Mowe Lake

Site

This area is predominantly mixed jack pine, black spruce, poplar, and white birch. There are many large and small lakes and other wetlands. A large number of moose make use of this area.

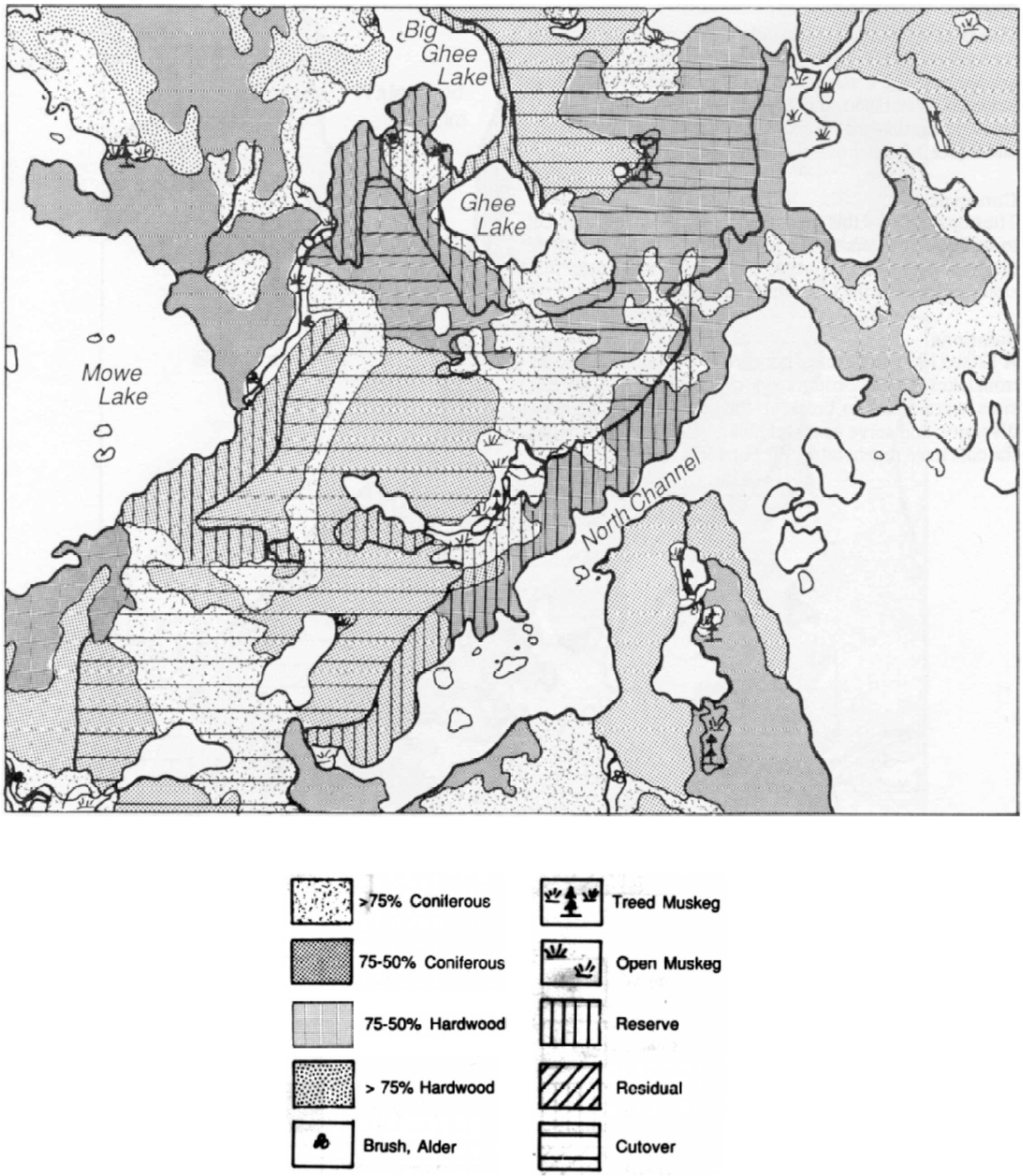
Concerns

The main concerns for this site were: that after cutting the area would be susceptible to overhunting because of the large waterbodies to the east and west, that a complete clearout would greatly reduce the moose population inhabiting the area, and that early and late winter habitat would be eliminated.

Solutions

Reserves of 30.5m (33 yards) were left along the water to tie into residual stands and to provide a partial east-west corridor between Mowe Lake and North Channel. The combination of reserves and residuals creates another partial corridor in the north and northwest that breaks up the cut, "buffers" an older cut in the northwest, and protects winter habitat. The area was closed to hunting for 3 years to provide protection from overhunting.

Map 1 – Big Ghee Lake – Mowe Lake



Map 2 - Watershed Lake and Squeers Lake

Site

This large tract of predominantly poplar was to be clearcut for kraft pulp. The areas to the east provide a good mix of species and age classes, there is a natural travel corridor between Watershed and Squeer lakes, and there are 2 small ponds that are suspected lick sites. Both Watershed and Squeers lakes provide habitat for lake trout.

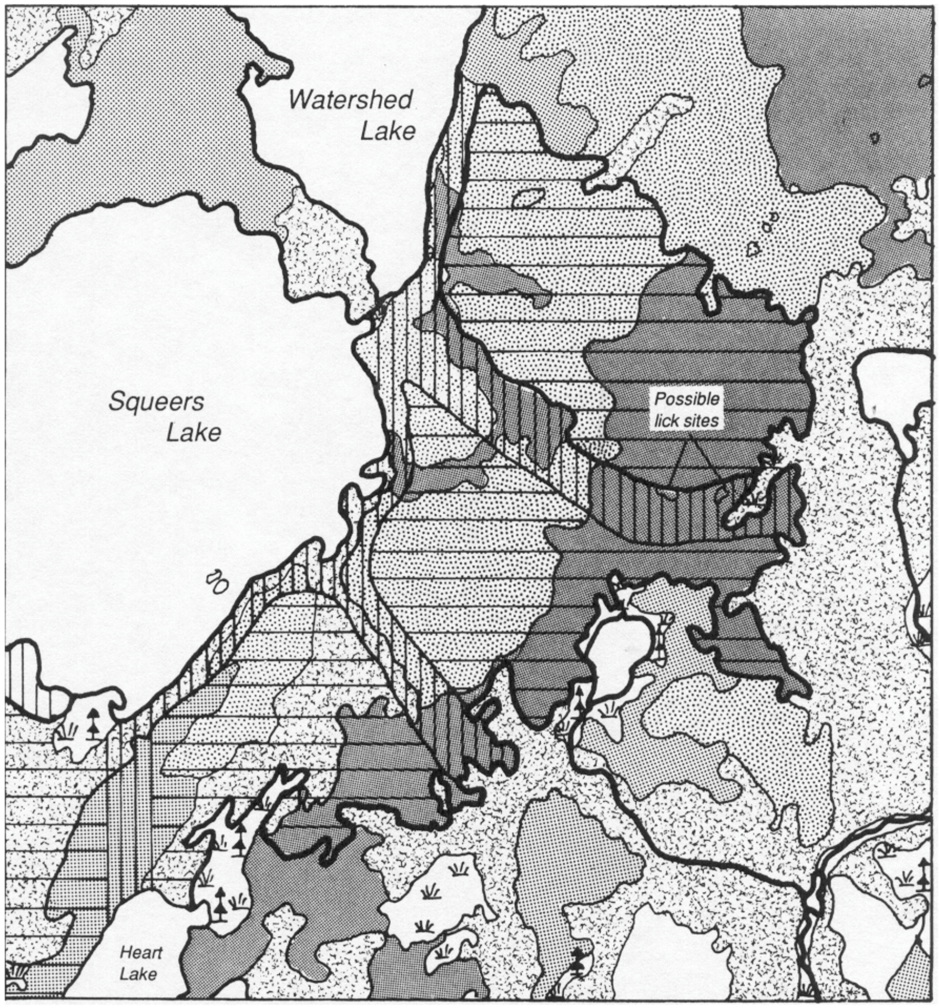
Concerns

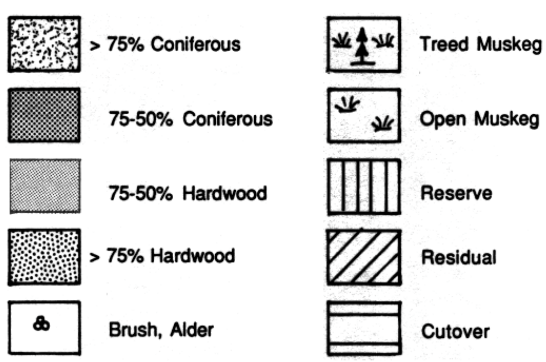
The objectives for this tract were to: break up the large cut to maintain a diversity of age classes, maintain the travel corridor between the takes, protect the suspected lick sites, and protect the lake trout habitat.

Solutions

A 120m (130 yard) area of concern is required around lake trout lakes. Three corridors, one of which includes the lick sites, were added to break up the cut, provide age class diversity, and serve as travel lanes. After 10 years, when the cuts have regenerated, the corridors can be cut.

Map 2 Watershed Lake Squeers Lake





Map 3 - Three Island Lake and Jack Lake

Site

Essentially a mature to oven-nature conifer monoculture with little mixedwood, Us area is quite different from the previous two and generally less productive for moose. Clearcutting in large blocks was the proposed treatment.

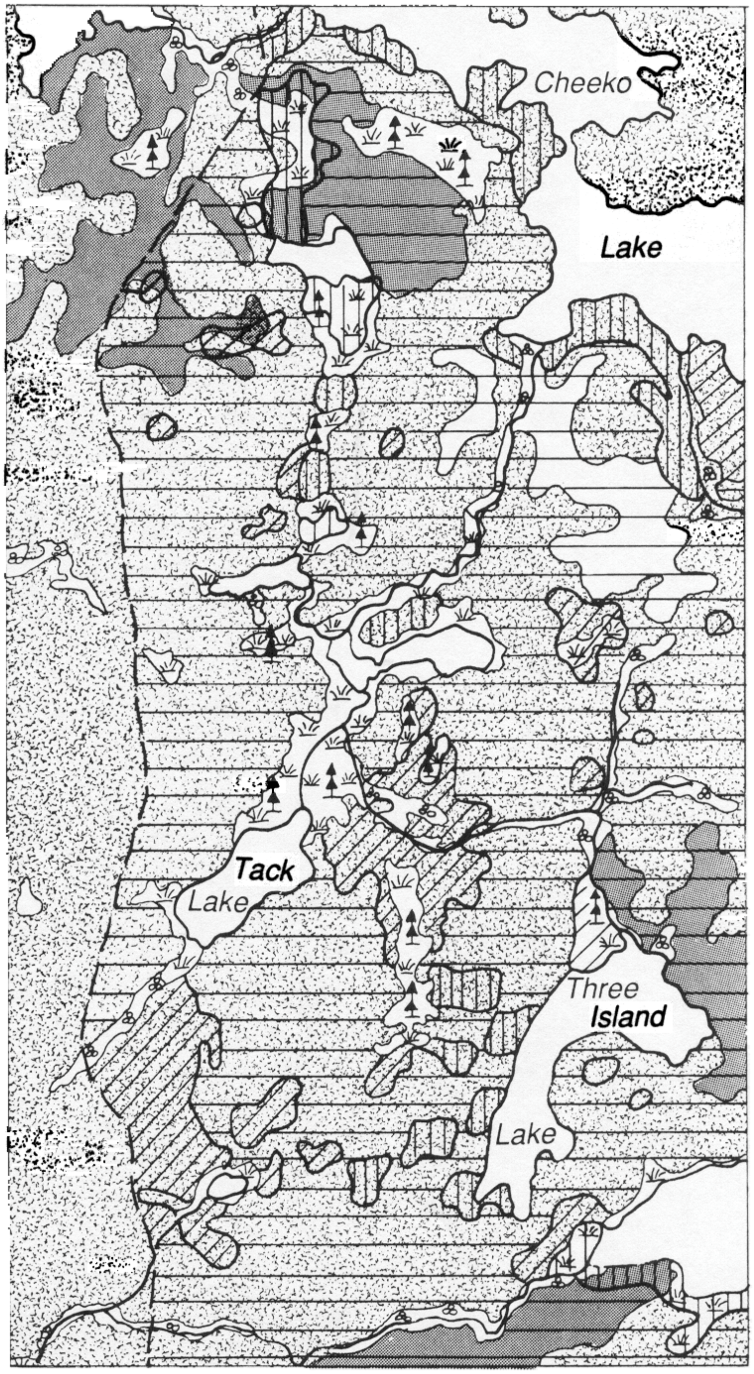
Concerns

Age class diversity in this area is lacking both before cutting and with a plan for large clearcuts. The objective, therefore, is to provide some diversity, paying particular attention to areas with some mixedwood because any moose that are in the area will tend to centre their activity at these sites.

Solutions

A combination of residual stands and conifer reserves containing some mixedwood were used to address the age class diversity problem. The area was also closed to hunting. Subsequently, numbers of moose and their use of the area improved.

Map 3 – Three Island Lake – Tack Lake



- > 75% Coniferous
- 75-50% Coniferous
- 75-50% Hardwood
- >75% Hardwood
- Brush. Alder
- Treed Muskeg
- Open Muskeg
- Reserve
- Residual
- Cutover

Moose Habitat in Ontario: A Decade of Change in Perception

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Introduction

Moose *(Alces alces)* management has changed dramatically in Ontario both in philosophy and substance in the past decade. An integral part of this change has been an attempt to understand what constitutes good habitat for moose and to apply this knowledge within the framework of a comprehensive moose management program. Timber and land use management planning have also changed during the period and have often placed conflicting interests on the land base. The task of integrating these activities is difficult and moose managers still have much to learn before these programs successfully complement each other.

In the early 1950s the basic question in moose management was ... can the moose herd support an annual hunt? Based on the best data available, unlimited hunting was permitted and habitat or predator management was not a major activity. By 1974, it seemed clear that the possibility of over-hunting was remote and, if it did occur, the herd could quickly recover from any excessive exploitation (Cummings 174a, b). However, several local managers expressed concern over the welfare of the population with regard to both hunting pressure and the impact of timber-harvest on moose habitat. From 1975 to 1980 an examination of available data revealed a decline in the Provincial population. Over the past twenty-five years, a 35 percent reduction in herd size occurred (Euler 1984). The reasons for the decline have been controversial, but there is general agreement that hunting was a major factor. A new management program was developed to increase the herd based on manipulation of hunting pressure, improvement of habitat and selective control of predators (Euler 1983).

In this paper we will summarize knowledge gained about moose habitat in Ontario during the past ten years and try to portray moose habitat attributes as we now view them.

Description of Ontario Moose Range

Moose inhabit two forest regions in Ontario: the northern part of the Great Lakes-St. Lawrence Forest region and the Boreal Forest Region (Rowe 1972, Fig. 1). The first region forms the southern area of moose range from the Manitoba border to Thunder Bay and continues east of Lake Superior through Sudbury to the Quebec border. Moose are generally absent in southern Ontario due to the clearing of land in these areas and probable overlap with white-tailed deer *(Odocoileus virginianus)* which carry brainworm *(Paralaphostrongylus tenuis)* (Anderson 1963, 1972). Most moose range in this Province is the Boreal Forest.

The Great Lakes-St. Lawrence forest region is a transitional type from southern deciduous areas into the boreal region and has components of both. Important coniferous species include: white *(Pinus strobus)* and red pine *(P. mesa), hemlock (Tsuga canadensis), white (Picea glauca)* and black spruce *(P. Mariana),* balsam fir *(Abies balsamea)* and jack pine *(P. banksiana).* Abundant deciduous species are yellow birch *(Betula alleghaniensis),* sugar maple *(Acer saccharum),* red maple (A. *rubrum),* red oak *(Quercus rubra), beech (Fagus grandifolia*), trembling aspen *(Populus tremuloides),* balsam poplar *(P. balsamifera)* and white birch *(B. papyrifera).* The entire Great Lakes-St. Lawrence forest type is rolling to rugged with areas of exposed bedrock. Logging in this region has been extensive since the late 1800s, although it has been largely selective for white pine saw logs and veneer quality hardwoods. Large scale clear-cutting has not generally been employed, except in the western areas between Thunder Bay and Manitoba and to some extent east of Lake Superior. Regeneration of stands is predominantly to boreal hardwood types (aspen and white birch) in northern areas and to sugar maple and yellow birch on deep, dry soils in southern areas.

Lowland areas are characterized by black spruce, white cedar *(Thuja occidentalis)* and tamarack (Larix *laricina).* The common regeneration pattern in lowlands is to speckled alder *(Alnus rugosa)* with black spruce and balsam fir on better drained sites.

The boreal region can be subdivided into three main sections based on soils:

1) the clay belt in the east;

2) the southern and central area of glacial tills and sandy soils; and

3) a large northern section of more or less poorly drained marine clays. The latter area is poor moose range and is generally not managed for habitat; it will not be discussed in this paper.

The clay belt is an area of flat terrain lying in the basin of post glacial Lake Objibway. Tree cover is dominated by black spruce, both on uplands and on the extensive poorly drained lowlands. Less abundant trees species include balsam fir, balsam poplar, white birch, trembling aspen, jack pine and white spruce (Carleton and Maycock

1978). Regeneration after logging in upland areas is to aspen, balsam fir, mountain maple *(Acer pensylvanicum),* beaked hazel *(Corylus cornuta)* and to a lesser extent white birch. There are large areas of organic soils overly gleysols, and in upland sites both humo-ferric podzols, and grey soils have developed. Bedrock outcrops are generally absent.

The southern and central area of the Boreal zone varies considerably, ranging from an area of some southern influence in the east, over a central plateau area north of Lake Superior, through a large sandy area northwest of Thunder Bay to an intensely glaciated area of thin glacial soils east of the Manitoba border. Bedrock exposure is common throughout. The central and eastern section is well-drained by large rivers and the western area contains many lakes. Soils are predominately humo-ferric podzols, overlying Precambrian granites and gneisses. Tree species are the same as in the clay belt but since there is more relief, upland species are dominant. Mixed woods are common in the east and central area, jack pine and spruce covers much of the area west of Thunder Bay, and black spruce is again dominant to the northwest. Cutover areas regenerate to a mixture of shrubs including mountain maple, beaked hazel, white birch, trembling aspen, mountain ash *(Sorbus americana),* green alder *(Alnus crispa),* some balsam poplar and balsam fir. Pin cherry *(Prunus pensylvanica)* and willows *(Salix spp.)* are common in drier areas.

In both the claybelt and the south-central area of the boreal forest logging tends to convert stands from spruce and mixed wood to aspen, balsam poplar and balsam fir on uplands or mesic sites, and to speckled alder in lowlands. In the past, scarification and planting operations covered less than 30 percent of the cut area, although this has improved over the past five years to about 60 percent of the annual cut.

Management Problems

As late as 1960, much of Ontario was still being logged with horses. These operations produced excellent moose habitat much like that described by Telfer (1978). However the change to mechanical logging which occurred in the early 1960s probably resulted in habitat of poorer quality. By the 1970s, when the mechanically logged habitat was regenerating, it was probably not as capable of supporting as many moose as habitat created prior to 1960. From approximately 6,000,000 hectares of moose range in Ontario in the general area of forest exploitation, about 200,000 ha each year are cut using the clear-cut technique. No statistics exist to ascertain how many of these are large cuts and how many are small. Cutting thus affects 2 to 3 percent of the moose range each year.

The most commonly assumed habitat management problem during this period concerned large clear-cuts by the forest industry. Many hunters and wildlife managers observed extensive large clear-cuts and wondered how they affected the moose population. Moose require the secondary succession produced by disturbance, yet some evidence suggests that large disturbed areas may not be as useful as smaller ones (Telfer 1978; Hamilton *et al.* 1980, Peek *et al.* 1976). If large areas of moose range are changed into poor habitat by logging operations, a decline in the moose herd would be the result.

Evidence to support the concern that large clearcuts, by themselves, have reduced Ontario's moose population is not convincing. The most instructive example is in the Chapleau Crown Game Preserve where intense logging and large clearcuts both occur. Aerial inventories show this area supports one of the highest moose densities in Ontario (NINR unpublished aerial surveys).

Bergerud *et al.* (1983) suggested that wolves were responsible for a moose decline in Pukaskwa National Park. A reassessment of the aerial survey data reported by these authors does not indicate a decline moose numbers or support the idea that wolves were responsible for keeping the herd from increasing (Parks Canada 1980).

The only other evidence to give instruction in this case is the Management Unit 23 and Unit 31 example. If wolves were the prime factor in keeping those moose populations from expanding, as was found in. Alaska (Gasaway *et al.* 1983), then the moose herd should not have increased when hunting pressure was reduced by approximately half (Table 2, Euler 1983). While the increase in moose in these units was not statistically significant, the general trend over a four year period seems to be increasing. In the light of evidence available, most of which is not as definitive as would be desirable, it is reasonable to base a management decision on the assumptions that predators played a relatively minor role in the decline of moose in Ontario during this time period.

Thus, while moose habitat in general may not have been the very best, the major causes of the moose decline undoubtedly involved hunting (Euler 1983), climate (Thompson 1980) and perhaps predation (Euler 1983) rather than habitat loss. Even though managers did not believe habitat loss was the most important cause of the herd decline in Ontario, habitat management is still an important technique for future moose management.

Despite the foregoing conclusion, it is important to remember that logging activities affect moose populations in two ways. They change vegetation but they also provide access to animals which would not otherwise be available to hunters. Three separate studies in Ontario have documented the problem of the impact of timber harvest on moose because of access roads, and all concluded that the access provided by logging roads was important in the herd decline (Flemming 1976, Eason *et al.* 1982, Timmerman and Gollat 1983).

An important component of the effort to change moose management was to establish how many moose could be carried on the available land area. The Chapleau Crown Game Preserve has not had hunting for some 50 years, but has an active forest operation, involving some clear cuts over 4,000 hectares in size. Further, the wolf density is about normal for that part of Ontario (Kolenosky 1981).

It has been observed for some time from Ontario Ministry of Natural Resources aerial surveys that moose density on the Preserve is about 0.30 - 0.35 moose per square kilometer, about two times the density in most hunted areas outside the Preserve. Thus, managers concluded that although this might not be the maximum carrying capacity, it did represent a reasonable judgement as to the ability of the land to support moose over the long term in the presence of predators. Similarly, Quetico Provincial Park in Northwestern Ontario showed moose densities in good habitat, with naturally regulated wolf populations but without hunting, approximately equal to Chapleau Preserve. From the 600,000 square kilometers of moose range available, using a figure on the low side of known capacity to carry moose, we expect a moose potential of at least (600,000 x 0.3) = 180,000 animals. In an effort to be realistic, conservative and allow for unexpected events, the goal for the moose population was set at 160,000 animals (approximately double the 1982 herd size), but somewhat less than the present habitat can probably support.

Moose Habitat Use

Moose have a range of habitat requirements which change with the season and life history events. Habitat should be viewed as a series of components, each with intrinsic variables. Winter habitat is probably the most critical component, and the winter severity varies with snow accumulation and crust conditions (Des Meules 1964, Poliquin *et al.* 1977, Welsh *et al.* 1980, Thompson and Vukelich 1981).

Winter habitat can be divided into early and late components, and use may differ for separate age and sex classes of moose. A strong desire for sodium in spring and early summer indicates that aquatic feeding areas and mineral licks constitute extremely important aspects of moose habitat (Jordon *et al.* 1973, Fraser and Reardon 1980). Less known but possibly significant features of good range also include calving habitat, areas to escape from wolves, and rutting and post-rutting habitat. These components of moose habitat are best examined at 3 scales:

1) a broad scale approach which considers the needs of an entire local population,

2) a smaller scale which includes basic needs of the animals, and

3) an individual scale which refers to food requirements.

Broad Scale Habitat Requirements

Rather than view moose habitat on a local basis which considers few animals as the working group (for example, an annual cut plan of 700 ha), the larger scale needs of a population must be considered. That is, at a scale of several hundred square kilometers.

Seasonal movements by moose appear universal in North America (LeResche 1974) and are common in Ontario (Goddard 1970, Saunders and Williamson 1972, Addison et al. 1980). Although movements, between summer and winter ranges are known, the extent of these movements and broad scale characteristics of winter range has only been examined for Ontario in the unhunted Chapleau Crown Game Preserve (Welsh *et al.* 1980). They clearly demonstrated a movement by the majority of the local population (about 260 animals) from cutover areas to a 200 square kilometre tract of uncut mixed and coniferous forest adjacent to the cutovers. Residual stands of timber, even those occurring in 30 year old cutovers, were not heavily used in the late winter. Movement appears associated with time of year but is enhanced by heavy short-term snow falls (Peek 1971, Welsh *et al.* 1980, Addison *et al.* 1980). However, not all moose move long distances to late winter habitat; for example, some cows with calves were found to over-winter in cutover habitat in the claybelt (Thompson and Vukelich 1981).

Although not specified by their authors, other studies in Ontario suggest movement to large blocks of uncut forest. For example, McNicol and Gilbert (1980) found fewer moose in the cutovers during a year of deep snow and crust compared to February of the previous year when the snow was not so deep. Residual stands of conifer within cuts were equally used in both years. Adjacent uncut tracts of coniferous forest were probably used by the missing moose. Also aerial surveys for moose flown after late February generally result in fewer moose seen than earlier because of the shift to heavier cover. This is not new, but the size of the areas used in late winter and the extent of movement as demonstrated by Welsh et al. (1980) was not previously documented.

Since natural regeneration of cutover moose range in Ontario is to deciduous species or a deciduous-dominated mixed association, and because moose use large uncut areas in late winter, it is possible that local populations are limited by an insufficient amount of late winter habitat. Further research on movements and winter requirements on a macro-scale need to be carried out to resolve this question.

Basic Habitat Requirements

Over the past decade, investigations into use of. mineral licks and/or aquatic feeding areas for sodium, summer feeding areas, early winter and late winter habitat and early and late winter concentration areas have occurred. Since not all animals change areas in different seasons, the late winter component can be subdivided into uncut forest and preferred habitat in cutover areas. Similarly, early winter areas may or may not be areas of concentrated and traditional use.

Aquatic Feeding Areas and Mineral Licks - Moose in Ontario are believed to have **a** strong annual requirement for sodium (Fraser and Reardon 1980). To fulfill their needs, mineral licks and/or aquatic macrophytes are used as sources of this element (Fraser *et al* 1980). Apparently, few mineral licks exist in Ontario, undoubtedly due to the igneous and metamorphic rock which underlies most moose range. Where licks do occur, they are used most heavily in late May to early June when aquatic plants are not yet available. Certain species of aquatic macrophytic plants provide a better source of sodium than mineral springs, and moose switch to aquatic feeding in June once these plants are large enough. These areas are frequented until late July when use declines markedly. Males apparently predominate at both licks and in aquatic feeding areas early in the season, with females arriving slightly later (Cobus 1972, Fraser et al. 1980, 1982).

As would be expected, not all waterbodies are preferred equally and, even within preferred lakes or streams, certain bays are used more gm others as a result of differing concentrations of minerals (Fraser *et al.* 1980, 1982). Preferred lakes generally appear to have a mineral soil substrate and are traditionally used. While moose may deplete preferred plants in these areas, they continue to use them probably because of the superior quality of plants which remain (Fraser and Hristienko, 1983).

Aquatic feeding areas and mineral licks draw moose from considerable distances. Fraser et al. (1980) estimated 35 different moose used a single lake which they studied in the Chapleau Crown Game Preserve. While it is impossible to directly assess distances moved by these animals, an estimate of up to 30 kilometres is reasonable based on distribution and densities of moose in this area.

In Ontario, many waterbodies are protected by the use of shoreline reserves (strips of uncut timber 30 to 150 metres wide) left along edges of lakes or streams during logging of surrounding areas. A study designed, in part, to assess the value of these reserves to moose using lakes for aquatic feeding failed to detect any difference between use of lakes with or withoutstanding timber at the shores (Brusnyk and Gilbert 1983). However, the sample sizes were very small, it was unknown if all lakes were used equally before logging of the area, no sex and age information was presented, and there was considerable variability in the amount and species of plants available in the lakes studied. More work needs to be done on this subject. At the population level, no data exist as to the potentially limiting nature of sodium or preferred aquatic macrophytes as has been suggested for Isle Royale by Jordan *et al.* (1973).

Summer Habitat - This is perhaps the least known component of moose habitat due in part to the difficulty in studying moose at that time of the year. It appears that until mid-July habitat use is strongly influenced by areas used for aquatic feeding (Keamey and Gilbert 1976, loyal and Scherrer 1978, Brusnyk and Gilbert 1983). Kearney and Gilbert (1976) showed increased use of open, upland Deciduous habitat types in late summer, as did Addison *et al.* (1980_. In the latter case, 3 radio collared animals made, use of a ten-year old bum with deciduous and jack pine regeneration.

Although several studies have indicated only localized movement in summer, large summer ranges of 90 square kilometres for an adult male and 32 square kilometres for a yearling in northwestern Ontario have been shown (Addision *et al.* 1980).

Early Winter Habitat - Early winter habitat is defined here as habitat used until snow and/or crust forces moose into heavy coniferous areas. It is not necessarily a simple function of time of year.

Generally early winter habitat differs from early winter concentration areas. These latter sites are small areas (2-10 km2) used traditionally by large numbers of moose during the November to early January period (eg. densities of up to 10moose/km2) (Thompson *et al*. 1981). Concentration areas are topographically discrete, upland open sites with abundant browse. An apparent early winter concentration area in the Quetico Park showed heavy traditional use over at least eight years. Them, moose were depleting the available browse (McNicol *et al.* 1980) indicating such areas would benefit from management for shrub species.

In general, early winter moose habitat may not differ from areas used in late summer and fall, although few data exist for the latter period. The majority of data on winter habitat comes from logged areas and indicate open, upland areas are used most. Welsh *et al.* (1980) showed little selection for age of cut in November but heaviest use of younger cuts in early winter with a progressive tendency to use older cuts and in cut areas as winter progressed. Areas used most heavily were those with most topographic relief and with less than 40 percent of the original time cover removed. McNicol and Gilbert (1980) found greatest use of stands characterized by a relatively open canopy with scattered conifers and deciduous trees with a basal area of 2.5 metres square per hectare, averaged for the cutover.

The presence of coniferous trees as uncut residual (McNicol and Gilbert 1980, Thompson and Vukelich 1981), in shoreline reserves (Brusnyk and Gilbert 1983) or as uncut border (McNicol and Gilbert 1980, Hamilton *et al.* 1980) appears to influence use of logged areas in most years. The influence may be more important in hunted than unhunted populations. While this interspersion of edge and open area appears important, Hamilton *et al.* (1980) found browsing by moose was unaffected by cover in the second year of their study. They attributed this to more difficult snow conditions in the first year. Similarly McNicol and Gilbert (1980) found little pattern in use of cutovers when snow did not impede movements. Cows with calves are more restricted in movement from cover even in easy winters, generally wandering less than 60 metres from edge either as uncut or residual stand.

(Thompson and Vukelich 1981).

Novak and Gardner (1975) noted fewer cows with calves in moose concentration areas than were known to be in their population near Kirkland Lake. This indication that different social classes of moose may have differing habitat requirements was suggested also by Peek (1971) and Peterson (1977). Thompson and Vukelich (1981) working in the claybelt region of the boreal forest zone were able to discriminate between areas used by cows with calves in early winter, late winter, and from sites never used by this social group. Cutovers used by cows with calves in early winter averaged 64 ha and were most often in lowlands, differing somewhat from large cuts on upland sites generally reported used by other moose in Ontario. Best early winter habitat was in areas cut more than 18 years ago containing several small residual stands of mixed or coniferous trees with an average coniferous basal area of 9.5 metres square per hectare (mostly in trees under 10 metres) and a maximum distance between uncut edges of half a kilometre.

Late Winter Habitat -Late winter habitat is defined here as those areas used by moose once movements are restricted by snow conditions. Animals may still use cutover areas during Ns period, but most abandon them entirely in favour of uncut forest, especially in March. Some areas used in late winter contain high moose density and have variously been called yards, winter concentration areas or high density areas. As with early winter concentration areas, late winter yards are generally found in upland habitat but are more density forested (Telfer 1967, Poliquin *et al.* 1977). These areas may be more or less heavily used in successive years, although the reason for this different rate of occupancy is not understood.

There is in general, reduced use of open areas in late winter caused apparently either by a rapid accumulation of snow and/or crusted deep snow conditions (Des Meules 1964, Hamilton *et al.* 1980, McNicol and Gilbert 1980, Welsh *et al.* IP80). Even use of residual stands within cutovers decreases during this period and Hamilton et al. (1980) reported browsing only up to 80 metres from over. Cows and calves are greatly affected, moving only about 12 metres from cover (Thompson and Vukelich 1981).

Welsh *et al.* (1980) showed use of older cuts on more rugged terrain in later winter, and finally a movement out of cutovers altogether into an extensive area of uncut forest. Late winter ranges in an uncut area reported by Addision *et al.* (1980) were in black spruce swamp for 2 yearlings and an adult male, and in a rolling upland area of tall aspen over younger, dense balsam fir for an adult female.

Cows with calves in the claybelt area may not migrate out of cutovers during later winter, although there is no empirical evidence to support this assumption. Habitat used in cutover areas by cows with calves during late winter had several small cut areas averaging about 16 ha, with a maximum distance between cover edges of 370 metres. They were generally in lowland areas with mesic or upland components on sites cut at least 25 years ago. Residual stands of uncut or partially cut timber were larger than those used in early winter and had more conifer, mostly large and small balsam fir (Thompson and Vukelich 1981).

Late winter is an extremely sedentary period for moose with a substantial reduction in the size of home range (Goddard 1970, Phillips *et al.* 1973). Addision *et al.* (1980) using radio telemetry reported winter ranges of 2,3 and 12 square kilometres for an adult female, a yearling male and an adult male respectively. Cows with calves averaged only 29 ha activity areas in late winter (Thompson and Vukelich 198 1).

No effort has been made on a broad scale to assess whether adequate late winter habitat is available to moose generally in Ontario or for cows with calves in particular. Also there remains a need to characterize uncut stands used by moose in March and April.

Food Requirements

Within the broader context of major habitat units and components of these, food requirements must also be considered. This is the most refined, or third scale, of understanding moose habitat with which managers must work.

Aquatic Plants - There is strong evidence that moose feed on aquatic plants due to a seasonal sodium hunger (Jordan et al. 1973, Fraser *et al.* 1982). Species which are highest in sodium content or most abundant, although containing slightly less sodium, are most important. In some traditionally well-used lakes certain preferred species, such as *Potamogeton filiformis and Nuphar variegatum***,** have largely been eliminated. Sodium rich species from Sibley Provincial Park include *Utricularia vulgaris, Sparganium angustifolium, Myriophyllum exalbescens, Potamogeton epihydrus, P. gramineus, P. filiforimis and Nuphar variegatum.* One other species, *Eleocharis acicularus,* was reported as high in sodium in the Chapleau Game Preserve but low at Sibley, (Fraser *et al.* 1980, 1982) indicating some regional differences in species ability to concentrate this element.

Aquatic plants are richer in protein early in the season and, although this declines later, they maintain values equivalent to woody species. On Isle Royale it appears that sodium may be a critical and limiting factor to moose (Belovsky and Jordan 198 1) but Fraser *et al.* (1981) suggested this is not likely for Ontario. However, the claybelt region is relatively poor in aquatic feeding areas and further studies are needed to determine if perhaps sodium is limiting in that area.

Browse Species - Preferences, Importance and Abundance - Recent studies where use of available browse by moose was assessed are summarized in Table 1. While the methods of collection differed among all studies, prohibiting direct comparison, certain generalizations can be made. In early winter, when snow does not impede movement and does not cover many stems, *Salix* spp. are the most important (% of total eaten) browse species. In late winter shade tolerant species become important, including *Corylus cornuta and Amelanchier* spp. The wide range of other abundantly eaten species reflects the variety of micro-site types and cosmopolitan nature of the diet of the moose. Among the preferred browse species (% removed greater than % available), *Sorbus americana and Salix spp.* are commonly eaten over Ontario's boreal range.

Generally, percentage of stems removed of what was available is low indicating no shortage of food (Table 1). In two cases percentage use was high: an apparent early winter yard in Quetico Park (McNicol *et al.* 1980) and late winter sites used by cows with calves in the clay belt. In the latter study, data represent areas where feeding occurred and did not randomly assess availability. The work in Quetico Park suggests extensive use and the need to manage traditional early winter areas if managers wish to maintain them. However, in general it does not appear that the amount of browse is limiting to moose in Ontario. This is the same conclusion reached by Crête and Jordan (1983) in Quebec.

Research is needed to assess browse availability in traditionally used late and early winter areas, and to compare this to areas where animals are not found. While browse over the entire range is not limiting animals, they may need specific nutrients; no data exist for this difficult problem. Also little information exists on use of leaves in summer or on the observed importance of dogwood to moose after the rut period.

Summary of Moose Habitat

Moose in Ontario apparently can be grouped into those which undergo seasonal movements and those which do not; those which concentrate and those which do not; and, within the latter, a subgroup of cows with calves which require isolation

Movements by moose are influenced by several factors during the year. In the spring their requirement for sodium may cause the animals to move to a traditionally used mineral lick and/or a particular waterbody with preferred aquatic plants. Use of habitat at this time is strongly influenced by location of these licks and lakes. A general spring movement from winter to summer range probably also occurs. After early summer, a more gradual movement likely occurs to upland or mesic sites when feeding is largely on leaves of preferred species. Feeding patterns and preferred plant types during this period are not well known. If specific habitat requirements exist during the rutting period, they are also unknown as are habitat use and browse preferences immediately after the rut. However, if animals are active and eat less during this period, post-rut feeding may be important in building nutrient reserves prior to winter. Early winter concentration areas and use of dogwood *(Cornus stolonifera),* especially along rivers, may actually be post-rut feeding areas. Movement of animals which concentrate in these latter sites probably begins in late October with a movement out by mid-January. Use of this type of yard differs from the use of late winter yards, as habitat occupancy in late winter concentration areas is not consistent among years. Further, it is unclear whether late winter areas in cutover sites are well used until April, or if these animals also move into the uncut forest. Use and characteristics of uncut forest in late winter have not been studied.

Not all moose concentrate or move and some animals will always be found in apparently less than optimal habitat, such as cutovers in late March. Cows with calves may be one exception to generalized movements. They appear to select suitable habitat in isolated areas and continue to use cutovers in late winter. In both early and late winter habitat in logged areas, the amount of conifer present influences the amount of use by moose. Few estimates are available as to how much conifer left in a cutover after logging is optimal, but Welsh *et al.* (1980) found higher use in areas where less than 40% of all timber had been removed.

Habitat in general in Ontario is probably not limiting to moose populations. However, in local situations late winter habitat and sodium availability may be critical. Other micro-aspects of moose range, such as nutritional quantity of browse, are important locally in influencing habitat use and perhaps population levels and deserve further attention.

Managers in Ontario should view moose habitat at three scales:

1) the population level which encompasses large areas of management units to ensure late winter habitat, particularly maintaining large blocks of uncut predominantly coniferous forest in rolling upland areas in association with early seral areas;

2) a general level which considers individual cut plans to ameliorate these into producing good moose habitat through both general knowledge of where upland mixed ridges occur and specific knowledge of early and late winter concentration areas, mineral licks and prime aquatic feeding areas, and,

3) an individual level which reflects knowledge of preferred foods and where these am likely to be found in a management area before or after cutting.

It is our view that while habitat is not presently known to limit the moose population, when new hunting regulations permit a population increase then habitat and habitat-predator interactions will become key elements influencing moose density.

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TABLE 1:

Summary of browse species preference and most important (abundant) species in diets of moose in Ontario.

Percentage of stems available that were browsed is in brackets. From published studies, 1974-1983. Author/Area (methods)

Author/Area (Methods)	Time of Winter	Important Species (% use)	Preferred Species (% use)
Hamilton and Drysdale (1975) - south and central (2m2 plots every 25 m along transects)		*Salix* spp. (41.4) *Prunus* spp. (32.4) *Populus tremuloides* (14.8) *Amelancier* spp. (13.4)	n/a
McNicol *et al.* (1980) - south and central (.6m x 20m plots 80m intervals on transects	early	*Corylus cornuta* (62.3) *Acer pensylvanicum* (49.7) *Salix* spp. (84. 1) *Betula papyrifera (60.7)*	*Sorbus americana* (73.3) *Salix* spp. (84. 1) *Prunus* pensylvanica (50.0*)* *Betula* papyrifera (60.7)
McNicol and Gilbert (1980) - south and central (12.2 x 20m plots on lines)	1) early	*Betula papyrifera ()* *Salix* spp-. () *Sorbus americana*	*Salix* spp. *Sorbus americana* *Prunus pensylvanica*
	2) early and late	*Betula papyrifera* *Sorbus americana* *Corylus corruta* *Salix* spp.	*Corylus corruta* *Sorbus americana* *Betula papyrifera* *Salix spp.*
Thompson and Vukelich (1981)-Claybelt (100 x 1 m plots placed in feeding areas)	1) early	*Salix* spp. (37.1) *Cornus stolonifera* (56.6**)**	*Cornus stolonifera (56.6)* *Acer pensylvanicum (5* 1.7) *Sorbus* americana (40.7) *Salix* spp. (37. 1)
	2) late	*Amelanchier* spp. (65. 1) *Salix* spp. (48.3) *Corylus cornuta* (22.5)	*Sorbus americana* (78. 1) *Amelanchier* spp. (65. 1) *Salix* spp. (48.3) *Prunus* spp. (37.5)
Brusnyk and Gilbert (1983) -south central (2m radius circuits plots)	unknown	*Corylus cornuta* (24.3) *Acer pensylvanicum* (12.7) *Salix* spp. (43.7)	*Sorbus americana* (24.8) *Salix* spp. (43.7) *Corylus cornuta (24.3*

Effects of Forestry Practices on Ungulate Populations in the Boreal Mixed Wood Forests*

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Moose, white-tailed deer and woodland caribou all inhabit the boreal forest but, for a variety of reasons, the moose is the most likely ungulate to be found commonly utilizing boreal mixedwoods. The paper examines how various forestry practices affect the suitability of boreal mixedwoods as moose habitat.

Si la forêt boréale héberge aussi bien l'Original et le Cerf de Virginie que le Caribou des bois, l'Original est l'ongulé que l'on rencontre le plus communément dans les peuplements mélangés de cette forêt. Dans le présent document, les auteurs étudient les répercussions des différentes mé'thodes d'exploitation sur ces peuplements mélangés en tant qu'habitat de l'Original.

Three distinct species of ungulates-white-tailed deer *(Odocoileus virginianus)*, woodland caribou *(Rangifer tarandus caribou)* and moose *(Alces alces)*, all members of the deer family, utilize portions of the boreal forest ecotone. The utilization of the mixedwood cover type in Ontario by these species is governed by their habitat requirements and by ecological and environmental factors.

Deer expanded their range northward into the boreal forest in the early 1900s following logging and land clearing (Cumming and Walden 1970). During extended periods of mild winters (i.e., winters with below-average snowfall), and where logging provided abundant food, deer moved as far north in Ontario as Kirkland Lake, Sioux Lookout and Red Lake (Euler 1979) (Fig. 1).

Leaves, stems and buds of woody plants are considered by many to be the mainstay of deer diet, mainly because they are available through the year (Halls 1973). The greater the variety of plants, the greater the chances for the whitetail to achieve its productive potential (Halls 1978). Deer feed on the leaves and tips of shrubs and trees including aspen *(Populus* spp.), cherry *(Prunus spp.)*, mountain maple *(Acer spicatum* Lain.), willow *(Salix* spp.), bearberry *(Arctostaphylos* spp.), hazel *(Corylus* spp.), honeysuckle *(Lonicera* spp.), juneberry (*Amelanchier* spp.) and a great variety of herbaceous plants.

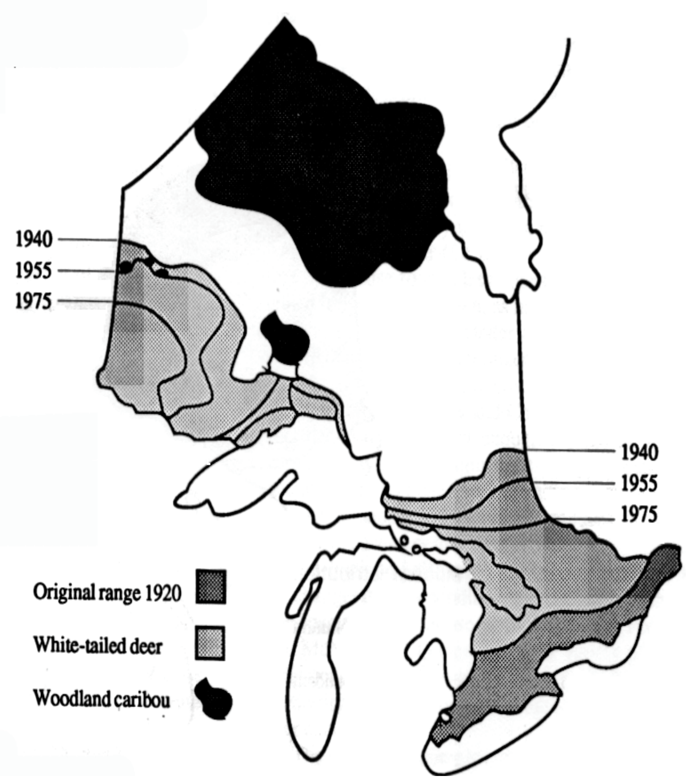


Figure 1. Changes in the white-tailed deer distribution from 1620 to 1975 (Smith and Borczon 1977) and ft present woodland caribou distribution (Bergerud 1978) in Ontario.

* Boreal Mixedwood Symposium Proc. p. 141-154)

In winter (the most critical season), they browse on the woody vegetation of trees and shrubs. During this period, the average deer requires approximately 2.3 kg of good quality browse per day (Smith and Borczon 1977).

Logging opens the forest canopy, and as a result there is more food available for deer. Adjacent mature stands of eastern white cedar *(Thuja occidentalis L.)*, spruce *(Picea* spp.), balsam fir *(Abies balsamea* [L.] Mill.) and pine *(Pinus* spp.), if left uncut, provide the shelter needed in winter. However, the population densities of deer in the mixedwood component of the boreal forest depend primarily on the depth to which snow accumulates during winter, the duration of the snow cover and the suitability of range conditions following logging. Winter weather and the increasing size of clearcuts have been generally unfavorable for deer inhabiting the boreal forest areas since 1955, and as a result both the range (Fig. 1) and local population densities have decreased.

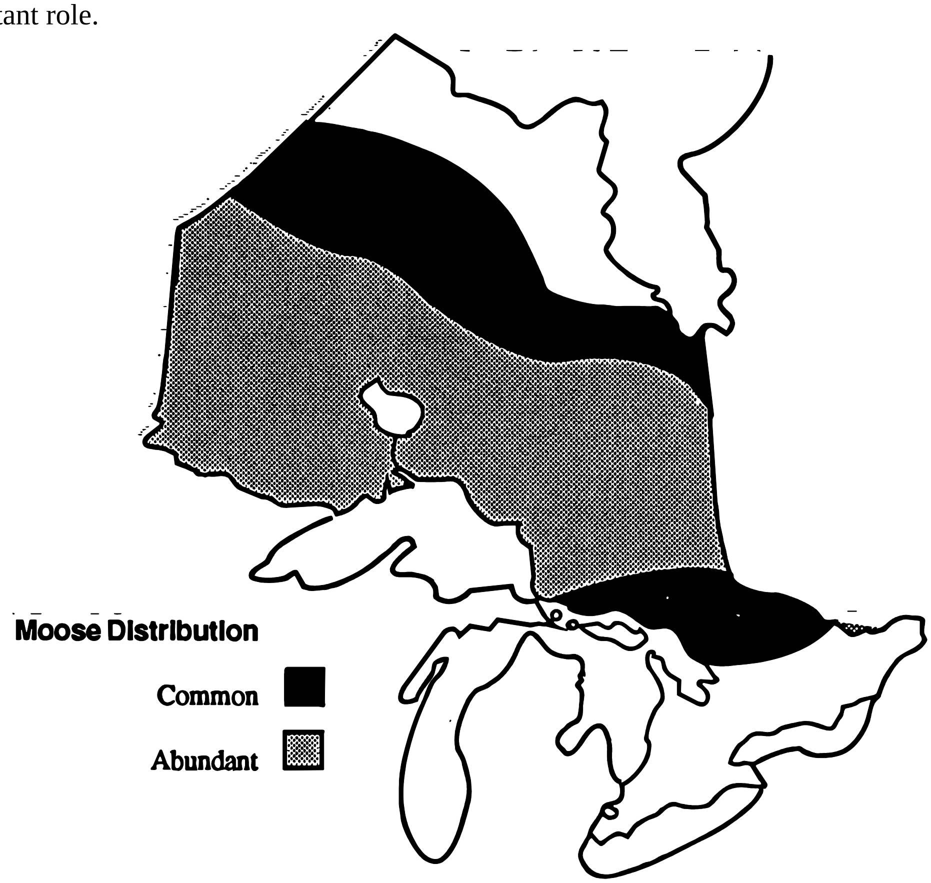
Most woodland caribou in Ontario, of which an estimated 13,000 remain (Simkin 1965), are found in the northern, unlogged boreal forest and the Hudson Bay lowlands. A few scattered local herds survive in the commercial forest zone along the north shore of Lake Superior, north of Lake Nipigon and in the Irregular Lake area northwest of Kenora (Bergerud 1978) (Fig. 1). For many years, the disappearance of woodland caribou in this area has been attributed to environmental changes such as forest fires, settlement and logging. More recent evidence suggests that hunting mortality, disease and predation also play an important role.

Woodland caribou are gregarious and prefer to use the more mature boreal forest habitats (Cringan 1957). Tree and ground lichens are important winter foods. Caribou eat a wider variety of plants than do other deer species and are highly adapted, as well as adaptable, to their environment (Bergerud 1978). A partial list of plants eaten includes 282 kinds of seed plants and 62 lichens as well as green vascular plants and mushrooms.

During summer, caribou concentrate on the leaves of deciduous trees and shrubs, especially those of willow, birch *(Betula* spp.) and blueberry *(Vaccinium* spp.). During the fall, after abscission, the animals switch to terrestrial lichens and leaves of coniferous species (Bergerud 1978). In winter, caribou frequently "crater" (dig down through the snow) to reach lichens and vascular plants. They also seek the fine twigs of browse species such as birch, willow, cherry and blueberry, and may utilize closed canopy habitats, when these are available, in search of arboreal lichens growing on coniferous and some deciduous trees.

The moose is well adapted to the boreal forest (Fig. 2), where important habitats are produced in the early seral stages of plant succession (Krefting 1974). Habitat, according to Franzmann (1978), is the primary limiting factor of moose populations throughout their North American range. The reproductive potential of moose is adapted to maintenance of the species at low densities (115 km2), rapid expansion into larger areas of good habitat following fire and logging (1/km2) and slow contraction following forest maturation (Geist 1974).

Figure 2. Moose distribution in Ontario (Cumming 1972).



Large quantities of forage (18-25 kg/day) are necessary to maintain an adult moose (Gasaway and Coady, 1974). Mixed stands of conifers and hardwoods in continuous succession are favored (Pimlott 1953, Peterson 1955, Dodds 1974). In winter, moose tend to select sites where snow depths allow for bedding in comfort and do not restrict movement to feeding areas (Dodds 1974).

Key browse species in eastern North American moose range are balsam fir, white birch *(Betula papyrifera Marsh.)* and trembling aspen *(Populus tremuloides* Michx.). Hazel, mountain maple, mountain ash *(Sorbus americana* Marsh.), willow, Juneberry, dogwood *(Cornus* spp.) and cherry are other major browse foods. In summer and early fall, habitat use is centred on upland deciduous tree stands (Krefting 1974).

In early winter, young successional mixedwood stands created by disturbances such as fire, budworm or logging are preferred. As the winter advances and snow depths increase, moose gradually shift their habitat from open mixedwood stands to denser coniferous cover (Des Meules 1965, Telfer 1970, Peek 1971). The latter, consisting primarily of balsam fir and spruce, provides the moose with shelter during this critical period of the year.

Wildfire and logging have generally benefited moose by providing large areas of early successional growth containing a much greater variety and quantity of food than mature forests (Cumming 1972). Moose populations generally increase in such disturbed areas (Aldous and Krefting 1946, Krefting 1951, Spencer and Chatelain 1953, Peterson 1955, Peek 1971). Over the past 15 years, wildfire has generally become a less important factor in the creation of early successional stages because of man's increasing efforts to prevent and suppress forest fires.

Timber harvesting, on the other hand, has increased in importance as a major disturbance factor in the boreal forest over the same period. Timber harvesting is currently the most predictable major disturbance in the boreal forest. Meaningful habitat management of boreal ungulates, primarily moose, is dependent on the recognition by forest managers of the need in some areas to maintain a variety of habitats through the modification or restriction of some forestry practices. An examination of how such practices in boreal mixedwoods affect moose will illustrate how forest management can either benefit or hinder habitat management goals.

Timber Harvesting

The preceding discussion on the habitat requirements of moose indicated the importance of a diversity of woody vegetation types and age classes within the animal's normal range. Timber harvesting in boreal mixedwood types can enhance the inherent species and age class diversity of these stands. The removal of the mature coniferous component from conifer-dominated stands, while leaving the mature deciduous component and advance coniferous regeneration, results in good moose habitat for several reasons:

1. Opening the canopy allows the establishment of important shade-intolerant browse species such as white birch and trembling aspen, which augment shade-tolerant browse species already in the understory.
2. The residual deciduous component provides immediate age class diversity on the disturbed site in addition to escape cover and increased "edge".
3. Advance coniferous regeneration in the cutover provides immediate early winter cover, escape cover and vegetational species diversity.

The boreal mixedwood forest type alone has the potential to offer moose this variety of habitat advantages, provided that only the mature coniferous component is harvested. Welsh et al. (1980) found on study areas in the Chapleau Crown Game Preserve that, in midwinter, with a choice of a variety of cut and uncut habitats, moose preferred cutover mixedwood stands from which up to 40% of the original composition had been removed.

McNicol and Gilbert (1980) reported that within 16 boreal mixedwood cutovers they studied in the Thunder Bay area, moose habitat utilization during January and February was concentrated in areas supporting a scattered residual coniferous and deciduous component (basal areas equal, at approximately 2.5 m2/ha). Results from this study showed that the scattered residual cover type produced a much greater abundance and diversity of browse species (10) than did the three other available cover types delineated within the cutovers. Except for the dense conifer cover type (residual blocks of unmerchantable conifer), the other less productive cover types were characterized by the absence of a mature or semimature residual component.

An abundant and diverse browse source is an important element of good moose range, particularly in winter. Browse consumption by moose at this time is generally lower than in summer (Le Resche 1970, Verme 1970), probably because food is less digestible and is therefore retained longer in the rumen, as had been noted for other ruminants (Corbett 1969). Under winter conditions, about one third of the energy metabolized by moose may have to be provided through the catabolization of body fat and protein reserves (Gasaway and Coady 1974). The movements necessary to collect enough browse to maintain rumen-fill may require significant energy expenditures, especially if snow conditions are limiting to moose movement. An abundant browse source reduces the energy expenditure necessary to collect browse.

A selection of different browse species is important since changes in snow conditions can cause major changes in the species which moose prefer to browse (Peek et al. 1976, McNicol and Gilbert 1980). A variety of browse species consumed in the winter diet probably enhances the digestibility of this fibrous food source as well (Mellen-berger et al. 197 1).

The coniferous component which often develops in the understory of boreal mixedwood stands seems to be important as both escape and survival cover for moose following the harvest of the mature conifer component in these stands. Moose bed an average of five times a day (Franzmann et al. 1976), probably to ruminate, as do domestic ruminants. Studies in Quebec (Des Meules 1965) and Ontario (McNicol and Gilbert 1978) show that moose prefer to bed within 2mof coniferous cover when utilizing open habitats during the winter. Indirect evidence indicates that moose select bedding sites in close proximity to immature coniferous cover on open habitats to reduce wind chill (McNicol and Gilbert 1978). Accumulated snow in the lee of these windbreaks often tends to be softer and more compressible since it lacks a wind crust (Des Meules 1965).

Advance coniferous regeneration, primarily balsam fir, is often found in close association with good browsing opportunities in mixedwood cutovers (McNicol and Gilbert 1980). Since browsing, bedding and ruminating are related activities, close proximity of food and vertical protective cover is an attractive feature of mixedwood cutovers.

The preceding discussion on the value of mixedwood stands after timber harvesting assumes a partial cut where only merchantable conifers are removed. This type of timber harvest has been common in boreal mixedwood stands in northern Ontario and has accidentally resulted in excellent moose habitat over many areas. Quite simply, the lack of deciduous fibre markets in many areas of Ontario has improved moose range. However, the same global demand for wood fibre which caused the liquidation of Ontario white pine *(Pinus strobus* L.) and red pine *(P. resinosa Ait.)* and the continued depletion of this province's spruce and jack pine *(P. banksiana* Lamb.) stands, has now focused on boreal hardwoods.

The results of the inevitable growth in the deciduous wood fibre market will be a substantial loss of age class and species diversity on boreal mixedwood sites. The loss of the mature hardwood component and destruction of browse and cover species in the understory during harvesting, will prove as negative for moose as previous cutting practices proved positive.

Clearcutting of boreal mixedwood stands will prove detrimental not only on a small scale (individual cutovers) but also on a large scale (license areas). Wildlife managers will no longer be able to rely on mixedwood stands to buffer large coniferous clearcuts. The result win give new meaning to the word clearcut, provided that timber companies do not adopt modified cutting practices on a large scale. The adverse temporal and spatial development of moose habitat on contiguously clearcut areas would limit moose populations.

Silvicultural Treatments

Boreal mixedwood forest types are often found on productive sites. A variety of silvicultural treatments may be applied by forest managers to encourage the regrowth of merchantable coniferous stands on these sites. The following comments relate to the beneficial or detrimental effects various treatments may have on moose.

Scarification

The practice of scarification after logging is common in northern Ontario. On mixedwood cutovers, scarification is generally carried out in preparation for the planting of jack pine, or more commonly black spruce *(Picea marian* [Mill.] B.S.P.) and/or white spruce (P. *glauca* [Moench] Voss) seedlings.

Scarification followed by planting of coniferous seedling stock is an attempt by forest managers to truncate the normal successional sequence following disturbance on mixedwood sites. It is the early stage of succession following fire (3-20 years) which historically has supported growth in moose populations (Geist 1974, Irwin 1975). Logged mixedwood stands have the potential for supporting increased populations of moose for a similar period. However, scarification and planting tend to shorten this early successional stage and in turn may reduce the period during which these areas can support high moose densities (Telfer 1976).

Boreal mixedwood cutovers which have been completely scarified and artificially regenerated differ from those which follow a natural course of succession and retain unmerchantable trees (Telfer 1976). Results from studies in Alberta (Stelfox et al. 1976) and Ontario (McNicol and Gilbert 1980) indicate that in scarified areas the production of deciduous browse species is reduced and much delayed. Not only is the browse component on scarified mixedwood sites altered but conifer cover is affected as well. The coniferous species which are planted will eventually produce both early and late winter cover for moose. However, artificial regeneration does not duplicate the immediate habitat advantages of interspersed advance coniferous regeneration which would have survived if scarification had not taken place.

In the past, many mixedwood cutover sites were not extensively scarified and planted because of heavy residual concentrations left after the harvest of the coniferous component. If we assume an increased demand for deciduous fibre, there will no longer be such concentrations on many mixedwood sites after harvest. More extensive scarification on mixedwood sites will likely follow, com- pounding the degradation to moose habitat initiated with the removal of the deciduous component. Forest management agreements (FMAs) between private pulp and paper companies and the government provide incentives for the companies to increase conifer stocking on cutover sites. Since mixedwood sites are often the most productive, it would seem logical for the companies to concentrate silvicultural efforts, including extensive scarification and planting, on sites that could have been good moose range.

'Tunneling", a form of scarification that is used less commonly, normally improves moose range. This technique is used by forest managers to introduce a merchantable coniferous component into hardwood stands. Heavy scarification equipment is initially driven through the stand, usually in a strip pattern, and conifers are planted in the scarified strips. Such planting introduces diversity and will eventually provide early and some late winter cover, improving the stand as moose habitat (Telfer 1976).

Herbicides

These have proved useful in forestry for controlling stand composition, particularly in the early stages following logging or fire when forest managers are attempting to establish commercial species (Telfer 1976). Boreal mixedwood cutovers, because of the inherent productivity of the sites and usually abundant deciduous regeneration after disturbance, are often prime candidates for treatment. Chemical defoliants are also used on mature or semimature mixedwood stands in an effort to release advance coniferous regeneration in the understory.

The impact of herbicide applications and the utilization of treated sites by ungulates, primarily deer, have been examined by a number of researchers in the United States (Krefting and Hansen 1969, Beasom and Scifres 1977, Tanner *et al.* 1978). Apart from a temporary reduction in use (usually just the year of treatment), utilization of sprayed areas was either the same as, or better than, utilization of similar untreated sites.

Krefting and Hansen (1969) believed that aerial applications of 2,4-D could be effective in increasing browse production in areas where access or labour costs for cutting browse were problems. In Ontario, assessment of a bum in the White River area which was subsequently treated with a combination of 2,4-D and 2,4,5-T showed no selection by moose for sprayed or unsprayed areas 3 to 4 years after treatment (Barker and Malone 1972).

The effects of recommended application rates of herbicides such as 2,4-D and 2,4,5-T differ according to the browse species treated. White birch and pin cherry *(Prunus pensylvanica* L.f.) are often killed immediately, and there is little or no suckering to compensate for the loss. Mountain maple and mountain ash remain relatively unchanged, since suckering of these species replaces stems which are killed within three or four years (Barker and Malone 1972). The most common effect on the majority of browse species is a temporary setback, followed by subsequent regrowth.

The loss of pin cherry and especially white birch from treated mixedwood cutovers could significantly affect winter browsing activities by moose. McNicol and Gilbert (1980) found that white birch and pin cherry were two of **five** species most often browsed by moose utilizing the 16 mixedwood cutovers they studied. White birch twigs alone accounted for approximately 31% of all browse consumed by moose over two winter study periods.

Discussion thus far has centered on the use of herbicides to set back deciduous regeneration temporarily and "release" conifers. A less common use of herbicides is for stand conversion, where all deciduous competition in a mixedwood stand is killed through repeated applications of herbicides or where mixedwood cutovesites are completely "sterilized" with herbicides before conifers are planted. The ramifications of this drastic intervention into natural succession for moose and a variety of other wildlife species dependent on mid-successional forests are obvious. Mixedwood manipulation of this type must be considered carefully with regard to wildlife requirements within the affected area.

Prescribed burning

Accumulated slash and logging debris can be removed economically and effectively from cutover sites through the use of fire**.** Bunnell and Eastman (1976) suggest that, after prescribed burning, site damage is generally less severe than it is after wildfire and that slash burning should extend the early successional stages. In Maine, prescribed burning of logging debris in clearcuts resulted in greater production of hardwood stems, shrubs and herbaceous plants than in clearcuts where slash was left undisturbed (Rinaldi 1970). Stoeckeler (1948) reported that root suckering of trembling aspen, an important browse species for moose, was stimulated by light burns.

The benefits of a more nutritious browse source, as a result of the rapid return of nutrients to the soil, are probably short term (Einarsen 1946, Taber 1973). However, the rapid invasion of fire-disturbed sites by ungulates (Stenlund 197 1) and heavy initial utilization of post-fire vegetation (Randall 1966) may be a response to an increase in quality as well as quantity of browse (Cumming 1972).

The beneficial effects for ungulates of prescribed burning in the Lake States may last 10-15 years before the canopy closes over (Krefting 1962). Ahlgren (1973) suggested infrequent (once per tree generation) use of fire in the Lake States forests because of thinner soils, slower accumulation of organic material, shorter growing sea- sons for competing vegetation and increased vulnerability to fire damage.

The use of prescribed burning as a silvicultural tool on boreal mixedwood cutovers could be beneficial to moose provided that most residual elements were not destroyed by the fire. The residual deciduous component with attendant understory is an important factor influencing the early use of boreal mixedwood cutovers by moose. Prescribed burning should take place when residual patches are relatively incombustible. In this way, the residuals could also help to improve fire control by ensuring discontinuity of combustible slash.

Conclusions

All forest harvesting and management activities in the boreal mixedwood forest type have an effect on boreal ungulates. The extent to which these activities are beneficial or detrimental to species such as moose or white-tailed deer is directly related to how radically and extensively the natural age class and species diversity of mixedwood stands are altered. Efforts by forest managers to short circuit natural successional sequences over large areas in boreal mixedwood stands to create monotypic coniferous stands will prove detrimental to ungulate species dependent on successional forest types. On the other hand, a forest management approach which recognizes the value to the boreal ecology of a vigorous, prominent mixedwood component in the boreal forest will prove beneficial to a wide variety of boreal wildlife.

As the demand for wood fibre and recreation opportunities on the same land base increases, competition between resource managers because of different objectives will increase. It is extremely important that wildlife and timber managers be aware of each other's objectives for the boreal mixedwood timber type so that conflicts can be avoided.

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(3 k P.R., 88 03 31)
ISBN 0-7729-3532-7
ISBN 9-7794-2338-0 (electronic)