MOOSE RANGE UNDER PRESETTLEMENT FIRE CYCLES AND FOREST MANAGEMENT REGIMES IN THE BOREAL FOREST OF WESTERN CANADA

E.S. Telfer

Canadian Wildlife Service, Environment Canada, 4999-98 Avenue, Edmonton Alberta, T6B 2X3

ABSTRACT: To evaluate the impact of large-scale forest management on moose (*Alces alces*), yield of deciduous woody browse was modelled for fire cycles of 38, 50, 75 and 100 years (the range of historic fire cycles in the closed boreal forest) on a hypothetical 50,000 km2 area of northwestern Canadian boreal forest. Browse yield was also estimated for the Alberta forest of the 1980's and for managed forest alternatives including 60 and-80-year rotations accompanied by (a) a reserve of 5% for old forest and (b) a separate group of stands on a 250-year rotation sufficiently large to keep 5% >150 years old. Low carrying capacities for moose were estimated for the long (250 year) rotation and for forests in Alberta as they were in the 1980's. Estimated moose carrying capacities in the managed rotations were in the same range as those in the presettlement forest fire cycles, suggesting that future forest management in the region should be adequate to sustain moose populations at historic levels. Uncontrolled access to managed forests, and/or stand conversion to conifers with intensive control of deciduous vegetation could, however, limit moose numbers.

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Until recently, the boreal forest of northwestern Canada has escaped intensive timber harvest. However, large forest industries have been established in the region and most of the commercial forest (which is almost totally owned by provincial governments) has been licensed to industry in large forest management areas (FMA's). The increased activity in the forest industries has been opposed by some environmentalists and has aroused concern among the public at large about the potential impact of large-scale timber harvesting and silviculture on wildlife, waters and ecosystem processes. The important ecological role of late-successional forest (>150 years) and the need to maintain this habitat is often central to this controversy. Although there are as yet few data for the boreal forest, it is widely believed that late-successional stands contain many plants, invertebrates and birds that are unable to survive in other habitats.

The controversies surrounding increased timber harvesting in the boreal forest have led to much public discussion and to a willingness on the part of the forest industries to try innovative approaches to forest management. Several management alternatives have been proposed that would insure the maintenance of at least a limited percentage of late-successional forest in managed stands. These include: 1) reservation of a small percentage of the managed forest where late-successional forest currently dominates; 2) management of a separate "working group" (sensu Meyer *et al* 1952) of stands on a long rotation (250 years) so as to perpetually maintain a percentage of the area in late-successional forest stands; 3) a selection system of management for riparian buffer strips; and 4) two-cut systems to manage mixedwoods for both aspen (*Populus tremuloides*) and white spruce (*Picea glauca*) production. The concept of ecosystem management and its application to forests for the preservation of biodiversity is also under examination. Under that alternative, forest age-class distribution, cover type proportions and range of sizes of disturbed areas under forest management would approximate those of presettlement wildfire regimes.

To those of us concerned about the future of moose populations under changing forest management regimes it is of interest to see what those regimes may do to moose habitat. The focus on presettlement or "natural" fire regimes as a guide to forest age class distributions under ecosystem management has also raised questions about their relative value as moose range. The purpose of this paper is to compare the effects of several forest management alternatives and natural wildfire regimes with regard to one key dimension of moose habitat, the deciduous browse supply. Comparison of carrying capacity for moose, as influenced only by browse supply, are then made.

STUDY AREA

The present study focuses on the boreal forest region of the northern Prairie Provinces of Canada - Manitoba, Saskatchewan and Alberta. The climate features short summers, which can be hot and dry, and long, cold winters. The forest cover of the region has been described by Moss (1955) and Rowe (1972). The boreal forest in its present form is new in geological time - between 6,000 and 10,000 years (Ritchie 1976, Prentice *et al.* 1991). It is undergoing continual change due to variations in climate and advance and retraction of the range of distribution of plants and animals.

The boreal forest, particularly where summers are as dry as in north-central Canada, are subject to periodic fires (Booth *et al.* 1993). The "fire cycle" is the length of time required for an area to burn that is equal to the total area of the region (Heinselman 1981). Some sites may burn several times during that period while others do not burn at all during any particular cycle. In the boreal forest of the prairie provinces, fire cycles under presettlement conditions ranged from less than 20 years in the Parkland Region (Heinselman 1981) along the southern border with the grasslands, through ca 38 years in much of the aspen-dominated forests of northern Alberta (Murphy 1985), to 100 years in the northern, conifer dominated, zone and as much as 250 years in the more open crown cover of the forest/tundra ecotonal zone (D. Thomas, Canadian Wildlife Service, personal communication). Fire cycle length is responsive to climatic changes and has been shown to change in response to historic changes in summer temperature and precipitation (Johnson 1992).

Following fire, the usual course of vegetational succession on mesic upland sites in the boreal forest is through a shrub and herb-dominated stage to a young forest dominated by deciduous tree species, mostly trembling aspen or white birch (*Betula papyrifera*). Seedlings of coniferous species, largely white spruce (*Picea glauca*) or jackpine (*Pinus banksiana*) invade in increasing numbers over time (Moss 1955). Forty to 60 years after the stand-renewing fire, a mid-successional forest of sawlog-sized trees begins to form with conifers becoming increasingly prominent. Tree mortality, especially of the short-lived aspen, begins to open the stand after about 60 to 80 years, allowing some shrub and herbaceous growth establishment. Forest stands over 150 years may be considered late-successional and consist of spruce-dominated stands. Very old stands in the boreal forest are those over 250 years. While such stands occur on areas unburned for ca. 250 years, few of the existing trees may actually be that old.

The effect of wildfire is to create a mosaic of stands of different age classes and cover types. Proportions of forest area among the year classes approximates a negative exponential distribution (Van Wagner 1978, 1983). Consequently, it is possible to reconstruct a hypothetical presettlement age class distribution for large areas. Because of the changes of species dominance from deciduous species to spruce over time following fire it is also possible to estimate the proportion of area dominated by deciduous, mixedwood and conifer cover types.

These models of age-class distribution assume that a roughly stable mosaic of fire-created stands existed. Baker (1989) examined data on historical landscape mosaic for the 4,000 km2 of the Boundary Waters Canoe Area in Minnesota and did not find a stable mosaic at any scale including that of the total 4,000 km2. However, stability is more likely to exist on larger scales, probably on areas over 10,000 km2 and for time periods of 200 years or more.

METHODS

This study uses a hypothetical 50,000 km2 segment of the boreal forest as a model. This hypothetical segment was subdivided as follows to estimate browse production and project moose densities under four presettlement wildfire regimes: 65% (32,500 km^2) was considered productive upland forest; 30% (15,000 km^2) was considered unproductive for timber crops; and 5% (2,500 km^2) consisted of core riparian areas. To generate area estimates under three forest management alternatives, the hypothetical segment was subdivided as follows: 60% (30,000 km^2) productive upland forest; 30% unproductive; and 10% riparian reserves. Browse production and moose carrying capacity were also estimated for the hypothetical segment assuming that it was similar to the Alberta boreal forest of the 1980s (using data from Bonner 1982).

The 30% estimated to be unproductive for timber harvesting is believed to be highly conservative. However, it is intermediate between the 20% estimated for the Weldwood Canada FMA in westcentral Alberta (Weldwood Canada Limited, personal communication) and the 49% of the Alberta-Pacific Forest Industries Incorporated FMA in northeastern Alberta (D. Hebert, personal communication). This portion of the hypothetical forest was further divided into: 1) one-third (5,000 km^2 or 10% of total forest area) as muskeg or peatland supporting trees and/or shrubs; and 2) two-thirds (10,000 km^2 or 20% of total forest area) consisting of water bodies, fens and treeless peatlands (bogs).

The 5% core riparian area is that which would have been largely spared from presettlement wildfires because they are on seepage sites and located in valley bottoms interlaced with water bodies. The 10% riparian zone estimate was used when evaluating forest management alternatives based on the area of mandatory reserves existing on harvested compartments on the Weldwood FMA at Hinton (R. Bonar, personal communication).

Four presettlement fire cycles were selected for this analysis: 38 years (from Murphy, 1986, for all of northern Alberta); 50 years (from Van Wagner, 1978, for westcentral Alberta; and 75 and 100 years (from Heinselman, 1981, for the northern part of the boreal forest). The proportions of each of six forest age classes (0-20 years, 21-50 years, 51-80 years, 81-150 years, 151-250 years and >250 years) under those fire cycles were calculated for the productive upland portion of the hypothetical forest using the negative exponential described by Van Wagner (1978). Actual areas (km^2) were then calculated.

Three potential forest management regimes were selected for comparison. Those regimes were chosen based on the premise that future forest management will have to provide for the maintenance of late-successional stands in percentages which can be predicted to have existed under the shorter fire cycles. The regimes selected were: 1) manage the entire forest on a 250-year rotation; 2) create uncut reserves from existing late-successional forest while managing the remainder in traditional <100-year rotations; and 3) divide stands in productive upland forest into two working groups, one managed on a rotation of 250 years and consisting of enough area such that the desired amount of late-successional forest is maintained, while the other is managed on a traditional rotation of less than 100 years. For this analysis, 5% of the productive upland forest was maintained in late-successional forest while 60- and 80- year rotations were used in the second and third alternative regimes.

In traditional forest management, rotation age is usually selected to equal age of culmination of mean annual increment (MAI) per unit area (Meyer *et al.* 1952). Set rotations were used for simplification in this analysis. In a real forest, site quality would vary leading to different periods of time to reach culmination of MAI and to the creation of additional working groups of stands managed on rotations appropriate to their productivity.

The biomass of deciduous browse (the annual production of woody twigs within reach of browsing ungulates) produced in all subdivisions of the hypothetical forest under natural wildfire and forest management regimes was used as an index to the value of the various landscapes to moose and was expressed as carrying capacity (moose/km^2). This is based on studies by Spencer and Hakala (1964) and Telfer (1978) which show that moose use of areas is proportional to browse availability and also to evidence that increases in browse supply has often been followed by increases in moose numbers (Lutz 1960, Spencer and Hakala 1964, Loranger *et al* 1991).

Values used to estimate the biomass of twigs produced per unit area are for current annual growth of twigs and were derived from Telfer (1976 and 1977) from Elk Island National Park and the Weldwood Canada Limited FMA in westcentral Alberta, respectively, Usher (1981) from the Sand River area of northeastern Alberta, Westworth and Associates (1984) from westcentral Alberta, and Florkiewicz and Henry (1993) from southeastern Yukon. Browse Production for riparian habitats of a variety of age classes and cover types in interior Alaska (Wolff and Zasada 1979) were also used. The biomass values for deciduous browse assigned to various forest age classes in these studies were for different years and sites. For that reason, I used the median of the values rather than the arithmetic mean to represent browse production. While the resulting browse production estimates are in not an inventory of the winter forage resource for moose, they do provide a basis for comparing the effects of wildfire and forest management regimes on moose populations. Lastly, browse yield in post-wildfire stands was assumed similar to that in post-logging stands. this assumption would probably not apply in stand-level comparisons but was considered reasonable at the large scale of this analysis.

Other studies of deciduous browse yield from Alaska reported similar ranges of browse production values (Oldemeyer 1983, McCracken and Viereck 1990). Although their results were not incorporated in the present study, their similarity to the values used reinforced confidence in the general approach.

Coniferous browse was not included in the present study. In the eastern North American boreal forest, balsam fir (*Abies balsamea*) is a major food species for moose (Parker and Morton 1978). However, the amount of balsam fir is limited in the forests of northwestern Canada (Forestry Canada 1988) and the alpine fir (*Abies lasiocarpa*) found along the western margin of the region seems little eaten by moose (Telfer 1977).

Moose carrying capacity was estimated based on several assumptions: 1) that the maximum annual allowable rate of woody twig utilization was 50% (that value is between the 40% browse utilization recommended by Murphy and Crawford, 1970, and 60% suggested as the upper sustainable limit by Telfer and Scotter, 1975); 2) that available browse should be further reduced by 20% in the presettlement fire regime alternatives to allow for reduced use by moose of forage more than 200m from cover (Eberhart 1986). This reduction was not applied to browse estimates under the forestry management alternatives since it was assumed that the patchy nature of clearcuts ensures that most of their area is within 200m from cover; 3) that moose require an average of 5kg (ovendry weight) of woody browse per day (Gasaway and Coady 1974); and 4) that moose have a 210-day season of browse dependancy.

RESULTS AND DISCUSSION

Median values for browse yield in the various age-class categories ranged from 20.5 kg/ha in mature forest (81-150 years) to 205.5 in the 0-20 year regeneration stage (Table 1). The single value for muskeg with trees and shrubs was 37 kg/ha while a median value of 50 kg/ha was derived for riparian habitats.

Total browse production under the natural wildfire cycles decreased as the cycles lengthened (Table 2). Total yield under the 38 year cycle totalled 308,178 tonnes, decreasing by a third to 203,701 tonnes under the 100 year cycle as a greater land area moved into the less-productive older age classes. The 51-80 year age class formed a "hinge" for the negative exponential curve. Areas in that class remained at about 5,000

Table 1. Biomass of current annual growth of deciduous twigs from several areas in the northwestern boreal forest, by age classes of forest (kg/ha).

Age classes (years)					Riparian	Muskeg
0-20	21-50	51-80	81-150	>150	various ages	
37[5]	175[4]	20[1]	4[5]	11[4]	6[6]	37[5]
62[2]	40[1]	32[1]	6[2]	28[4]	40[6]	
84[4]	4[2]		15[2]	31[4]	48[6]	
103[1]			19[2]		50[6]	
201[1]			20[2]		50[6]	
210[1]			21[2]		98[6]	
228[4]			25[2]		113[6]	
253[2]			27[3]		201[4]	
259[1]			29[2]			
454[2]			43[3]			
median: 205.5	median: 40	median: 26	median: 20.5	median: 28	median: 50	median: 37

[1] Westworth and Associates 1984 (Medicine Lake, west central Alberta).
[2] Usher 1981 (Sand River, northeast Alberta).
[3] Telfer 1976 (Elk Island National Park, north central Alberta).
[4] Florkiewicz and Henry 1993 (southeastern Yukon).
[5] Telfer 1977 (west central Alberta)
[6] Wolff and Zasada 1979 (Tanana floodplain, interior Alaska).

Table 2. Land categories and deciduous browse production in a hypothetical 50,000 km² segment of the northwestern boreal forest under four presettlement fire cycle regimes.

	39 Years		50 years		75 years		100 years	
Land category	Area (km²)	Browse (tonnes)	Area (km²)	Browse (tonnes	Area (km²)	Browse (tonnes)	Area (km²)	Browse (tonnes)
Unproductive:								
Muskeg with trees & shrubs (10%)	5,000	18,500	5,000	18,500	5,000	18,500	5,000	18,500
Water, fen & open bog (20%)	10,000	—	10,000	—	10,000	—	10,000	—
Productive:								
Riparian core areas (5%)	2,500	12,500	2,500	12,500	2,500	12,500	2,500	12,500
Upland forest								
0-20 years	13,000	213,717	110,750	176,31	77,475	122,887	5,850	96,153
21-50 years	10,500	41,600	9,750	39,000	8,450	33,800	6,825	27,300
51-80 years	4,875	12,675	5,525	14,365	5,525	14,365	5,200	13,520
81-150 years	3,875	7,329	4,875	9,994	6,500	13,325	7,475	15,3241
51-250 years	585	1,639	1,300	3,640	3,250	9,100	4,550	12,740
>250 years	65	192	325	956	1,300	3,822	2,600	7,644
Totals	50,000	308,178	50,000	275,351	50,000	228,393	50,000	203,701

1 Browse estimates in the 0-20 year age class are reduced 20% to allow for portions of burned areas >200m from cover and therefore little used by moose (Eberhart 1986).

km² while increasing lengths of the fire cycles drew land area from the younger age classes and added it to the older classes. Yield on the muskeg and riparian core areas was assumed steady at 31,000 tonnes. This contribution from wetland and somewhat fire resistant terrain was 10.1% of the yield in the 38 year cycle but comprised 15.2% of the yield under the 100 year cycle.

Modelling the 50,000 km² using area values for the Alberta forest as it was during the 1980's showed a relatively low browse yield, 189,949 tonnes, compared to the other scenarios (Table 3). Of that amount, 16.3% was contributed by the riparian core and by muskeg.

Regulation of the forest under a very long rotation period (250 years) (Management Alternative)would eventually shift a large proportion of the forest into older age classes with almost 25% in the 151-250 year class (Table 3). This was projected to drop total browse production to 157,534 tonnes. The browse yield of the muskeg and riparian reserve now assumes a major importance at 27.6% of the total supply.

Management Alternative #2, the reservation of 5% of the area to maintain or create forest older than 150 years combined with rotations of 60 and 80 years for the rest of the area, would eventually leave no stands in the 81-151 year age class (Table 4). Total browse yield estimates were slightly higher than under the two-rotation system (Alternative #3),

Table 3. Land categories and deciduous browse production in a hypothetical 50,000 km^2 segment of the northwestern boreal forest as regulated under a 250-year rotation under Management Alternative 1.

	Alberta forest ca 1980[1]		Regulated forest on 250-year rotation	
Land category	Area (km^2)	Browse (tonnes)	Area (km^2)	Browse (tonnes)
Unproductive:				
Muskeg with trees & shrubs	5,000	18,500	5,000	18,500
Water, fen & open bog	10,000	—	10,000	—
Productive:				
Riparian core areas (5%)	2,500	12,500	5,000	25,000
Upland forest				
0-20 years	4,550	74,800	2,400	39,456
21-50 years	9,750	39,000	3,600	14,400
51-80 years	12,025	31,265	3,600	9,360
81-150 years	4,550	9,328	8,400	17,220
>151-250 years	1,625	4,550	—	—
Totals	50,000	189,949	50,000	157,532

1. From Bonner (1982).
2. Browse estimates in the 0-20 year age class are reduced 20% to allow for portions of burned areas >200m from cover and therefore little used by moose (Eberhart 1986).

305,795 for the 60-year rotation and 259,845 for the 80-year rotation.

Management Alternative #3 would create two working groups of stands. One group would be on a 250-year rotation and would contain sufficient area to maintain 5% of the 50,000 km^2 (or 2,500 km^2) in stands over 151 years old. The other working group would contain the rest of the productive unreserved upland in either an 60 or an 80-year rotation. Total browse yields compared favourably with those under the natural fire rotations. The 60-year rotation providing 289,796 tonnes (Table 5). The longer, 80-year rotation yielded somewhat less browse at 240,269 tonnes.

Moose carrying capacities based on the browse estimates ranged from 1.5/km^2 in the 250-year rotation to 2.9 in the 38-year natural fire rotation and in the 5% reserve with 60-year rotation under Management Alternative #2 (Table 6). Carrying capacities in the managed forest regimes other than the 250-year rotation were in the same range as those in the natural forest fire cycles. The carrying capacity for the Alberta forest of the 1980's was comparatively low at 1.8 moose/km^2.

The most significant point brought out by this analysis is that the browse supply predicted by the various managed forest alternatives on the scale of 50,000 km^2 is in the same range as that for the natural fire-controlled regimes (Table 6). Forest management in the northwestern boreal forest can therefore maintain moose carrying capacity at historic levels. However, this conclusion is based on the assumption that managed regimes will be based largely on natural regeneration. Coniferous plantations on a large scale and/or intensive chemical control of deciduous trees and shrubs would be likely to reduce browse production and eventually moose carrying capacity. Managers should be aware that continuous pressure of man-

Table 4. Land categories and deciduous browse production in a hypothetical 50,000 km² segment of the northwestern boreal forest under Management Alternative 2, regulated under rotations (R) of 60 and 80 years with 5% reserved in late-successional (>150-year) stands.

	60-yr. rotation with 5% late-successional forest reserve.		80-yr. rotation with 5% old forest reserve	
Land category	Area (km²)	Browse (tonnes)	Area (km²)	Browse (tonnes)
Unproductive:				
Muskeg with trees & shrubs (10%)	5,000	18,500	5,000	18,500
Water, fen & open bog	10,000	—	10,000	—
Productive:				
Riparian core areas (5%)	5,000	25,000	5,000	25,000
Upland forest				
0-20 years	9,167	188,379	6,875	141,279
21-50 years	13,750	55,000	10,313	41,252
51-80 years	4,583	11,916	10,313	26,814
81-150 years	—	—	—	—
>151-250 years				
> 250 years	2,500	7,000	2,500	7,000
Totals	50,000	305,795	50,000	259,845

agement actions that favour conifers against aspen and other deciduous trees, and against shrubs such as willows (*Salix* spp.) and beaked hazel (*Corylus cornuta*), could have the cumulative effect of a long, slow reduction in moose carrying capacity even on very large landscape units. However, the increasing importance of aspen as a commercial species is reducing the pressure to convert to conifers.

A substantial part of the browse supply (10 to 27%) came from forested muskeg, riparian core areas, and the larger riparian reserves of the managed rotations. In the hypothetical forest envisioned in the present exercise the proportion of area assigned to muskeg, other unproductive forest and to riparian areas is probably minimal for the northwestern boreal forest, especially for the Boreal Shield Ecozone (Ecological Stratification Working Group 1993). Thus on most FMA's in the region, the area of land unproductive or inoperable for timber but producing some browse would be even greater. The possibility of managing riparian reserves on the selection system to salvage large timber is being studied (R. Bonar, personal communication). Opening stands on such high-quality sites by partial cutting would increase browse yields.

The low carrying capacity of the Alberta forest in the 1980's resulted from the small proportion of the area in regeneration stages. Fire suppression began to substantially affect burning rates in the 1950's (Murphy 1985). At that period the limited amount of logging in northern Alberta was insufficient to create much regenerating forest. Thus when the large areas of browse-producing early-succession forest created by the presettlement fire regime grew into the mid-aged and mature categories, they were not replaced. The forests of Saskatchewan and Manitoba also exhibited large percentages of surveyed area in the immature or mid-aged class during the 1980s (Forestry Canada 1988).

Table 5. Land categories and deciduous browse production in a hypothetical 50,000 km^2 segment of the northwestern boreal forest under Management Alternative 3, (a) regulated on a 250-year rotation and, (b) with two stand working groups to keep 5% of the area in late-successional (>150 years) stands.

	Regulated forest in 2 working groups, one with 250-yr. rotation (R) to keep 5% of area >150 years and the rest with a 60 year rotation				Regulated forest in 2 working groups, one with 250-yr. rotation to keep 5% of area >150 years and the rest with a 80 year rotation			
Land category	Area (km^2) 250 yr. R.	Area (km^2)	Total area (km^2) 60 yr. R.	Browse (tonnes)	Area (km^2) 250 yr. R.	Area (km^2) 80 yr. R.	Total Area (km^2)	Browse (tonnes)
Unproductive:								
Muskeg with trees & shrubs (10%)	5,000		5,000	18,500	5,000		5,000	18,500
Water, fen & open bog (20%)	10,000		10,000	—	10,000		10,000	—
Productive:								
Riparian reserve (10%)	5,000		5,000	25,000	5,000		5,000	25,000
Upland forest								
0-20 years	500	7,917	8,417	172,967	500	5,938	6,438	132,2992
1-50 years	750	11,875	12,625	50,500	750	8,906	9,656	38,624
51-80 years	750	3,958	4,708	12,241	750	8,906	9,656	25,106
81-150 years	1,750	—	1,750	3,588	1,750	1,750	1,750	3,5881
51-250 years	2,500	—	2,500	7,000	2,500	—	2,5007	,000
>250 years	—	—	—	—	—	—	—	—
Totals			50,000	289,796	6,250		50,000	240,269

Another silvicultural option under study in the boreal forest is "natural shelterwood" or two-stage harvesting of mixedwood forest (Brace and Bella 1988, Navratil *et al.* 1994). Under that system logged areas would be allowed to regenerate normally to aspen. White spruce (*Picea glauca*) seeds in naturally under the aspen. The aspen is harvested at 60 years in an operation that protects small spruce. During the succeeding 60 years management focuses on the spruce component of the stand. Nevertheless, a substantial regrowth of aspen is to be expected (Navratil *et al.* 1994). At 120 years from establishment the stand would be clear cut for the predominantly coniferous crop and the cycle would start again. Browse production would probably be similar to that in stands with 60 year rotations in Tables 4 and 5 but might be somewhat less because half the area would be in conifer-dominated stands where browse yield can be expected to be less than in aspen stands. However, the natural shelterwood could be better overall moose range by providing additional coniferous cover.

The moose carrying capacity estimated in this exercise is substantially larger than moose densities reported for the northwestern boreal forest. Figures from a large-scale survey in the Boreal Shield Ecozone (Ecological Stratification Working Group 1993) of northern Manitoba ranged from 0.028 to 0.205 moose/km^2 (Elliott 1988). A weighted average of the data presented by Elliott was

Table 6. Summary of annual deciduous browse yield and moose carrying capacity for a hypothetical block of 50,000 km^2 of northwestern boreal forest under 12 different natural fire cycle and regulated management regimes.

Regime	Browse yield	Available browse[1] (tonnes)	Total moose days[2]	Total moose carrying capacity[3]	Moose carrying capacity / km^2
Natural fire regimes:					
39 years	308,172	154,086	30,817,200	146,749	2.9
50 years	275,351	137,678	27,535,000	131,119	2.6
75 years	228,393	114,197	22,838,300	108,759	2.2
100 years	203,701	101,851	20,370,100	97,000	1.9
<u>Managed forest regimes:</u>					
With 5% reserved for late-successional (>150 yr.) forest, on:					
a.) 60-year rotation	305,795	152,898	30,579,500	145,617	2.9
b.) 80-year rotation	259,845	129,993	25,984,500	123,736	2.5
With 10% reserved for late-successional (>150 yr.) forest, on:					
a.) 60-year rotation	290,880	145,440	29,088,000	138,514	2.8
b.) 80-year rotation	247,811	123,906	24,781,100	118,005	2.4
2 working groups: a 250-yr. rotation to maintain 5% of the area in stands >150 years old, and:					
a.) 60-year. rotation	289,796	144,898	28,979,600	137,998	2.8
b.) 80-year. rotation	240,269	120,135	24,026,900	114,414	2.3
A long, 250-year rotation	157,550	78,775	15,735,000	75,024	1.5
Estimated age-class distribution in Alberta in the 1980's.	189,949	94,975	18,994,900	90,452	1.8

[1] Available browse is total browse divided by 2 to allow for a safe utilization limit of 50% (Telfer and Scotter 1976).

[2] Moose days are based on the assumption that an average moose requires 5 kg (oven-dry weight) of browse per day (Gasaway and Coady 1974).

[3] Total carrying capacity calculation assumed a browsing period of 210 days (7 months) in an average winter.

O.0578/km^2 for the 70,763 km^2 area surveyed. Those values are in the order of 1/40th of the carrying capacities estimated above. The Boreal Plain Ecozone which contains the boreal forest of Alberta and central Saskatchewan (Ecological Stratification Working Group 1993) may be more productive. A survey that covered 328,288 km^2 of Alberta reported a density of 0.25 moose/km^2 (Lynch 1994) and similar values have been found in Saskatchewan (R. Stewart, TAEM Consultants, personal communication). The value of 0.25 moose/km^2 was about 1/7th of the estimated carrying capacity for Alberta in the 1980's (Table 6). While adequate supplies of browse are a necessary condition for the existence of high moose densities there are obviously many other factors operating to limit their numbers, including predators and hunters, (both licensed and aboriginal) parasites and diseases, and severe winter conditions.

SUMMARY AND CONCLUSIONS

Browse production estimates were similar in presettlement fire regimes and in several forest management alternatives. The management alternative of a 250 year rotation over the entire productive area gave the lowest browse values of all and the lowest moose carrying capacity. Next lowest and well below the natural fire regimes and managed forests on a 60 or 80 year rotation was the Alberta forest of the 1980's. The low current carrying capacity of Alberta's forests for moose stems from the large buildup of forest area in the 21-50 and 51-80 year age classes and the rather low proportion in the 0-20 year regeneration class. The probable cause is relatively effective fire suppression during the past 40 to 50 years and possibly to climatic conditions over recent decades. The long term outlook for moose habitat supply under the management alternatives described (with the exception of the 250-year rotation) is positive. However, moose response could be limited by large-scale conifer plantations, especially if accompanied by intensive control of deciduous species, by predators and by hunting from the denser road networks associated with active forest management

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