SUSITNA REGIONAL FOREST PLAN

FISH AND WILDLIFE RESOURCES

January, 1990

This DRAFT report summarizes the distribution, habitat requirements, food habits, and potential logging impacts to a number of fish and wildlife species found in the Susitna Regional Forest Plan area. Background information is also summarized from which management guidelines were developed to avoid or ameliorate impacts to the fish and wildlife resource in the planning area.

Introduction

The primary goal of this document is to provide an integrated discussion of timber and wildlife habitat management and to identify most of the necessary wildlife habitat components which can be maintained or enhanced while allowing for the development of a forest products industry. This goal can only be achieved by recognizing the habitat requirements for healthy wildlife populations and then incorporating those requirements into a comprehensive timber management plan.

Purpose

The department believes that biologically sound timber management practices can be compatible with most population/habitat management goals of moose and could also improve habitat quality for other wildlife species. This compatibility can be realized from a better understanding of the interactions between wildlife species and the forest community, how those interactions change over time, and how wildlife populations respond to various silvicultural practices.

The timber industry is in a unique position to influence the future abundance wildlife resources, especially moose, in southcentral and interior Alaska. It can manipulate timber harvesting practices to enhance areas of deteriorating or marginal moose habitat or conversely, degrade currently productive moose habitat through the conversion of forest habitats to less desirable forms. The main purpose for developing this document is to provide some basic guidelines to wildlife habitat management and forest management compatible.

Objectives

* To summarize knowledge appropriate to southcentral Alaska that describes moose habitat requirements, and their relationships to timber harvest activities.

* To develop specific guidelines to maintain and enhance the capability of the available land base to efficiently produce and sustain moose and other wildlife resources desired by the Alaska Department of Fish and Game in response to public demand.

* To maintain and improve coordination and communication with all agencies that may have land management responsibilities that include timber harvest activities.

* To provide input to the appropriate agencies to enable the orderly development of wood products on commercial forest lands in a manner consistent with current and anticipated future demand for those products, the existing land capability, and the protection of the wildlife resource.

MANAGEMENT GUIDELINES FOR IMPROVING MOOSE HABITAT THROUGH FOREST MANAGEMENT IN THE SOUTHCENTRAL REGION

by

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1.0 INTRODUCTION

Leopold (1933) defined wildlife management as " . . . the art of making land produce sustained annual crops of wild game for recreational use." With respect to moose, one aspect of this process involves the management, or direct manipulation, of populations to increase or decrease numbers of animals depending on the state of balance between the animals and their habitats. Another aspect of moose management deals with management of habitat to increase or better support desired numbers of moose. Management of habitats and of populations are closely linked.

In southcentral Alaska, the available area of high quality moose habitat is shrinking rapidly. In the next few decades lands will be lost to further urban expansion, second home development, mineral development projects such as coal strip mines or mining of construction materials (gravel, limestone). Fire suppression efforts by various agencies prevent stands from returning to early seral stages. Other land uses such as agriculture and/or timber production may also be competitive in varying degrees. Concurrently, public interest in sport hunting and nonconsumptive recreational use of moose has increased substantially greatly increasing demand for moose. Large increases in recreational activities such as photography, hiking, and nature studies are expected in which moose or caribou, are a major attraction.

In the past, moose habitats in southcentral Alaska were often improved by wildfire, land clearing, or abandonment of homesteads and croplands. Presently, game managers cannot rely on such factors to create or improve habitat. The creation or enhancement of moose habitat in the future must be planned and coordinated with other land uses. Cooperative interagency forest management and planning may provide opportunities to partially meet future habitat needs for moose. The following set of management guidelines is offered to planning agencies to be used in that context.

Any major moose habitat management program requires a definition of purpose, goals, and objectives, the latter of which can involve an evaluation of values because certain objectives may be incompatible. For example, although a moose habitat management program may bring about increased moose production, it may also reduce the perceived "naturalness" of the landscape and consequently the quality of the sport hunting or wilderness experience of nonconsumptive users.

1.1 Goal

The primary goal of this project is to provide an integrated discussion of timber and moose habitat management to identify all of the necessary moose habitat components which can be maintained or enhanced while allowing for the development of a forest products industry. This goal can only be achieved by recognizing the habitat requirements for a healthy moose population and then incorporating those requirements into a comprehensive timber management plan.

1.2 Purpose

The department believes that biologically sound timber management practices can be compatible with most moose population/habitat management goals and could also improve habitat quality for other wildlife species. This compatibility can be realized from a better understanding of the interactions between moose and the forest community, how those interactions change over time, and how moose respond to various silvicultural practices.

The timber industry is in a unique position to influence future moose abundance in southcentral and interior Alaska. It can manipulate timber harvest practices to enhance areas of deteriorating or marginal moose habitat or conversely, degrade currently productive moose habitat through the conversion of forest habitats to less desirable forms. The purpose in developing this document is to provide some basic guidelines to wildlife habitat management and forest management compatible.

1.3 Objectives

1.3.1 To summarize knowledge appropriate to southcentral Alaska that describes moose habitat requirements, and their relationships to timber harvest activities.

1.3.2 To develop specific guidelines to maintain and enhance the capability of the available land base to efficiently produce and sustain moose populations and distributions desired by the Alaska Department of Fish and Game in response to public demand.

1.3.3 To maintain and improve coordination and communication with all agencies that may have land management responsibilities that include timber harvest activities.

1.3.4 To provide input to the appropriate agencies to enable the orderly development of wood products on commercial forest lands in a manner consistent with current and anticipated future demand for those products, the existing land capability, and the protection of the wildlife resource.

MOOSE

Leopold (1933) defined wildlife management as " . . . the art of making land produce sustained annual crops of wild game for recreational use." With respect to moose, one aspect of this process involves the management, or direct manipulation, of populations to increase or decrease numbers of animals depending on the state of balance between the animals and their habitats. Another aspect of moose management deals with management of habitat to increase or better support desired numbers of moose. Management of habitats and of populations are closely linked.

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<u>General Distribution</u>: Moose are widely distributed throughout the planning area with some of the highest densities recorded along the Susitna River and in its major tributary drainages. Moose distribution is mainly influenced by the availability of habitats that can offer a mosaic of cover- and food-producing units.

<u>Food Habits</u>: Moose are browsers and feed primarily on trees and

shrubs. Browse (deciduous woody plants) is the most important form of vegetation eaten by moose in southcentral Alaska and comprises 75-80% of the diet on normal winter range but declines in use as herbaceous vegetation becomes more available in spring and summer (LeResche et al. 1974b).

In the Susitna valley, Chatelain (1951, 1952) found that willow, birch, cottonwood, and aspen, in decreasing order, comprised practically all the winter food of moose in this area. Based on a study of moose rumen samples collected between Willow and Talkeetna, Shepherd (1958) found that willow and birch comprised almost 90% of the total identifiable volume. Aspen, Populus spp., and highbush cranberry and 12 other plant species made up the remaining 10% volume. Spencer and Chatelain (1953) conducted spring browse surveys on the Kenai Peninsula and reported willow, birch, aspen and cottonwood supplied 95% of the winter forage for moose. LeResche and Davis (1973) described seasonal food habits of three semi-tame moose from the Kenai Peninsula. In early winter when snow depths were less than 30 cm (12 in), sedges (Carex spp.) were sought out wetland areas. In late winter, birch (72%) and lowbush cranberry (21%) were the most important food items. In Denali National Park, willows were the major summer and winter foods along with dwarf birch and aspen (Murie 1944). Conifers are not an important component in moose diets, primarily because the two major species present, white spruce and black spruce, are considered unpalatable to moose (Murie 1944).

In addition to the previously mentioned browse species, moose utilize a variety of terrestrial and aquatic herbaceous plants. In early spring, newly emergent sedges, horsetail (Equisetum spp.), and pondweed (Potomogeton spp.) are consumed in boggy areas and lakes and ponds (LeResche and Davis 1973). Aquatic plants are eaten with decreasing frequency throughout the summer as palatability decreases (Peterson, 1955). Summer foods, as observed by Spencer and Chatelain (1953), were comprised of almost two-thirds birch leaves, one-fourth forbs, such as fireweeds (Epilobium angustifolium and E. latifolium), lupine (Lupinus nootkatensis), and cloudberry (Rubus chamaemorus). Mushrooms, grasses, sedges, and aquatics constitued the remainder of the diet. LeResche and Davis (1973) noted that in summer 65, 25, and 10% of all bites taken were parts of deciduous woody plants, forbs and a combination of grasses, sedges, and aquatics respectively.

Cushwa and Coady (1976) observed that snow conditions, particularly snow depth, can influence food availability and lead to variable patterns of food preferences. For example on the Kenai Peninsula, LeResche and Davis (1973) recognized the importance of lowbush cranberry, a nonbrowse food, especially when it becomes unavailable under the snow. During the winter of 1971-72, early snow covered all of the lowbrush cranberry resulting in an almost complete loss of calves. Dead calves were found with rumens full of birch and severely decreased body weights indicating that a lowering of diet diversity may limit moose densities.

Habitat Requirements: Moose habitat needs include a source of food, cover, and water interspersed evenly throughout the landscape. Forage and nutient requirements are provided by a diverse mixture of deciduous trees and shrubs, aquatic and herbaceous vegetation and a source of mineral elements. Forest cover provides security from predation and shelter from severe winter conditions.

Winter Habitat Preferences in the Susitna River Valley

Chatelain (1951) concluded that the most important limiting factor to moose in the Susitna River valley was the quantity and quality of winter range. In southcentral Alaska many studies have demonstrated the importance of riparian habitats for the winter survival of moose (Spencer and Hakala 1964, LeResche et al. 1974a, Modafferi 1984, Machida 1979, Albert and Shea 1986). Riparian willow stands provide most winter forage with maximum use of these areas occurring during periods of greatest snow depth. The value of these wintering areas is enhanced by adjacent upland coniferous forests that provide thermal cover and shallower snow depths.

LeResche et al. (1974a) and Modafferi (1984) recognized the importance of upland climax communities as winter habitat for moose. These communities are dominated by willow and/or shrub birch (Betula glandulosa) and are found at or near timberline. The availability and use of alpine wintering areas is likely governed by snow depths. In years of deep snow the loss of these wintering areas increases the importance of lowland wintering habitat as greater numbers of moose are forced to concentrate in lowland riparian habitats.

As winter progresses with greater snow depths, there is an increase in moose use of coniferous habitats, especially, dense-canopy stands dominated by white spruce. In addition to providing shelter, Moen (1973) found that conifer stands provided a more stable thermal balance for some ungulates by reducing wind velocities and subsequent heat loss during extreme cold. In Ontario, McNicol and Gilbert (1978, 1980) noted that moose used residual stands of coniferous cover in cutovers as a wind break and appeared to bed in the shallower snow depths on the leeward sides of these stands.

Cover

Forest management activities can influence forest wildlife habitats on a broad scale by significantly changing patterns of forage and cover areas over the landscape. In southcentral Alaska interest in intensive management of commercial forest land is increasing rapidly. This course of action could result in a rapid conversion of old-growth forest to intensively managed second-growth forest.

Initially it is expected that clearcut logging would create new foraging areas adjacent to high quality cover provided by the residual virgin forest. Moose populations would then increase in response to the improved habitat conditions. However, further rapid cutting of the remaining forest and accelerated development of existing second-growth forests could lead to comparatively large acreages of immature second-growth forest cover with limited forage production with minimal residual cover that would lead to an overall decline in moose numbers. Biologists often refer to this as the "boom and bust" phenomenon because neither the forage nor the cover necessary to support large moose populations can be sustained over time. The department believes that forests in southcentral Alaska can be managed for wood products and also provide sustained quality habitat values for moose and some other wildlife species. For this to occur, a coordinated and interdisciplinary approach to forest management is necessary.

As previously stated, moose require areas that satisfy both the summer and winter energy requirements of the animals. During summer moose occupy energy-rich areas, but are usually forced by winter conditions to move to areas where conditions are more favorable for conservation of the energy stored during summer. The well being of the population will depend on availability of adequate forage and cover on both summer and winter ranges to meet annual energy requirements.

Unfortunately, there is very little detailed information describing how moose respond to varying ratios of harvested/unharvested areas. In northeastern Ontario, Welsh et al. (1980) found higher use by moose in areas where less than 40% of all timber had been removed. Such areas consistently provide both cover and forage. Schwab (1987) suggested that retension of at least 50% of all standing timber by alternating 4 ha (10 ac) logged and unlogged patches resulted in nearly ideal year-round moose habitat for north-central British Columbia. Markgren (1974) attributed high moose densities in Sweden to similar logging patterns. Based on results from from these studies, the existing knowledge of moose habitat requirements in the planning area, and observations by department biologists, it appears that relatively large uncut areas in association with harvested areas are a necessary component of good winter range.

Cover areas are important to moose because of the manner in which cover modifies microclimates. In cover moose and other wildlife are less susceptible to extremes in temperature, solar radiation, windspeed, humidity, rain throughfall, and snow accumulation (Geiger 1965, Brusnyk and Gilbert 1983). In addition cover reduces the potential for predation and human disturbance.

Security cover.

The need for security cover by moose has been poorly defined. Moose are more vulnerable to predation and hunting because of increased visibility resulting from the removal of forest cover by logging. Several studies in Ontario have documented significant declines in local moose populations due to increased access and hunter kill following logging operations (Eason et al. 1981, Timmerman and Gollat 1982, and Eason 1985).

In the boreal forest, moose prefer to use secluded habitats for calving to minimize the potential for predation and human disturbance. Stephens and Peterson (1984) suggested that the use of coniferous cover during the summer calving season was attributable to the survival advantage accruable to very young calves and reflected anti-predatory behavior. In southcentral Alaska, these calving areas include isolated patches of black or white spruce forest associated with open bog-meadow complexes (Bailey and Bangs 1980, LeResche et al. 1974), upper elevation coniferous forest and other small isolated forested sites. Franzmann and Schwartz (1986) implied that moose preferred secluded areas of coniferous cover to minimize black bear predation on calves.

Security cover or hiding cover will be defined as vegetation capable of hiding 90% of a standing adult moose from the view of a human at a distance of 61 m (200 ft) or less (adapted from Thomas et al. 1979). This is the distance at which an animal is essentially hidden. It may include some shrub stands and all forested stands with adequate stem densities of overstory (trees), understory (shrubs) or a combination of the two that will hide animals.

Snow Interception Cover

Moose gain and lose energy continuously, and their survival and reproduction are related to their net energy balance. Moose can obtain the same net energy balance by increasing their energy gain (forage intake) or by decreasing their energy losses (moving less, moving through shallower snow, or conserving heat). Deep snow affects this energy balance as well as moose habitat use by increasing energy demands for movement and by decreasing energy intake by limiting availability and accessibility of forage (Coady 1974). Moose are forced to move to habitats where coniferous cover results in shallower snow depths and greater ease in movement and select areas of shallow snow for travel.

There is an abundant amount of published literature that supports the hypothesis that moose prefer to occupy browse-producing areas (open areas) except when snow exceeds a critical depth. When snow exceeds this critical depth, moose will retreat to cover types with closed canopies and reduced snow depth. Nasimovitch (1955) observed that adult moose abdomens were in contact with the snow surface while running in snow depths of 85-90 cm (34-36 in) and concluded that snow depths greater than 90-100 cm (36-40 in) were critical limits for moose. Moose were unaffected by snow depths of 40-50 cm (16-20 in), but were impeded by depths of 60-70 cm (24-28 in)(Nasimovich 1955). DesMeules (1964) reported that snow depths between 77-86 cm (31-33 in) caused moose to leave clearcut areas and areas with snow depths exceeding 107-122 cm (43-48 in) were avoided. Ritcey (1967) and Prescott (1968) noted that depths of 60-70 cm (24-28 in) reduced moose mobility in British Columbia and Nova Scotia, respectively.

Throughout the range of North American moose, animals generally select dense cover when snow depths exceed some critical depth. New Brunswick moose moved from open to dense forests when snow depths exceeded 100 cm (40 in) in open areas and were confined to dense conifer habitat types when snow depths outside these types averaged 113 cm (45 in)(Telfer 1970). In eastern Canada, Kelsall and Prescott (1971) reported that moose tracks were generally not observed in areas lacking forest canopies. Moose movements beyond those necessary for obtaining food were not evident. Prescott (1968) observed that moose in Nova Scotia appeared to concentrate in specific areas when snow depths approached 76 cm. Van Ballenberghe and Peek (1971) and Peek et al. (1976) observed moose shifting from open areas to dense cover as snow depths increased. In Alaska, Coady (1973) observed that when snow depths of 90 cm or greater lasted for several months, substantial winter dieoffs occurred in several areas of the state.

Bunnell et al. (1985) documented 16 features of the forest overstory that influence snow interception and can be modified by forestry practices but the most important were tree species composition, stand patchiness, crown size and form, and canopy closure (Nyberg et al. 1986). McNay et al. (1988) also found that canopy closure and snow storm size and intensity were the best determinants of a stand's capability to intercept snow. For southcentral Alaska, the same forest canopy characteristics that will maximize thermal cover (discussed below) will likely satisfy the needs of moose for shallower snow depths.

Thermal cover.

Forest stands that function as thermal cover reduce energy expenditures of moose by ameliorating the adverse effects of weather. Moose require thermal cover to moderate adverse climatic conditions during both summer and winter (Schwab 1987). Moose are well adapted to withstand extreme cold (Renecker et al. 1978) but are sensistive to heat stress in all seasons (Kelsall and Telfer 1974). In controlled experiments with moose, Renecker and Hudson (1986) reported that upper critical temperatures were 14 to 20°C (57-68°F) or more in summer and between -5 and 0°C (24-32°F) degrees in winter. Heat stress in moose leads to increased levels of metabolism, heart and respiratory rates and may even cause lower food intake leading to weight loss.

Changes in habitat utilization and behavioral patterns may be attributed to heat stress. Knorre (1959) observed that moose required shade or water to lie in on summer days with air temperatures greater than 20°C. Moose were in better condition after a cool summer than a hot summer and calf weights were almost 50% greater after a cool summer when compared to a hot summer. In Minnesota, Berg and Phillips (1970) observed that moose were more active at night than day, presumably because of lower temperatures. Belovsky and Jordan (1978) found that summer foraging activities peaked at sunrise and sunset and time spent foraging decreased as daily air temperatures increased. During warm weather, Belovsky (pers. comm. in Allen et al. 1987) determined that moose selected bedding sites with lower soil temperatures than the average for the surrounding area. Substrates chosen were generally damp and under dense conifer canopy. In summer moose in southcentral Alaska are likely responding to summer heat by frequenting cool mesic cover types consisting of a relatively large spruce component.

Coniferous cover also can provide thermal advantages to moose in winter. Renecker et al. (1978) found that temperatures below -20°C (-4°F) with some wind elevated metabolic rates in moose calves in response to cold stress. There are many observations of moose moving into coniferous cover to retreat from winter storms, winds and/or cold temperatures (Hatter 1950, Eastman 1978, Telfer 1978, Phillips et al. 1973, Knowlton 1960, Rolley and Keith 1980, Brusnyk and Gilbert 1983). McNicol and Gilbert (1978, 1980) proposed that moose used clumps of residual coniferous cover as a wind break. Moen (1973) observed that conifers reduced wind velocities and subsequent heat loss during extreme cold periods. In regions, like southcentral Alaska, that are subject to severe winter conditions, the protection provided by coniferous cover is a critical component of moose habitat (Peek and Eastman 1983).

Thermal cover quality is a function of the percent tree canopy cover which reflects tree density, the proportion of tree canopy comprised of coniferous species, and the mean height of coniferous trees. Deciduous stands may serve as thermal cover in summer, but not in winter. Proulx and Joyal (1981) found that most forest stands used for winter cover in Quebec had a canopy cover ranging from 41 to 80% and a height of 9 to 21 m (30 to 69 ft). Peek et al. (1976) reported that moose preferred the tallest and most dense stands in midwinter. Almost 72% of moose bed sites were in stands with coniferous trees <3 m (10 ft) apart equivalent to a stocking rate of approximately 225 stems/ha (550 stems/acre). Almost 69% were adjacent to balsam fir trees, and 57% were in stands with a canopy height >15 m (49 ft).

Forest canopies function like a thermal blanket by increasing the downward flux of thermal radiation towards the forest floor. Therefore winter nighttime temperatures are warmer under a canopy than in the open. Because canopy permeability increases rapidly as trees are removed, lower canopy closure means poorer nighttime thermal cover. Stands with a large amount of canopy cover are assumed to provide maximum protection from low temperatures and wind chill. Because cover values increase with the percentage of canopy closure, ideal late winter thermal cover occurs when coniferous tree canopy closure is $\geq$75% (Allen et al. 1987).

The quality of winter cover increases as the proportion of conifers in the stand increases. A stand composed of >70% coniferous species is assumed to represent optimal winter cover.
Stands with an increasing proportion of deciduous species still maintain some winter cover value, albeit declining, and will also have some value for moose during hot temperature periods.

Thermal cover in winter is considered unsuitable if the coniferous component of the stand is of insufficient height to trap longwave radiation at moose height and provide adequate cover for moose. Ideal cover occurs when the mean height of the coniferous trees is $\geq$ 10.6 m (35 ft) (Allen et al. 1987).

Calving Habitat

Calving habitat for moose consists typically of wet marshy lowland areas with such as tidal flats, bogs created by fire, areas flooded by beavers, shallow partially filled lakes or lowlands associated with major rivers (Rausch 1967). Bailey and Bangs (1980) described the following characteristics of moose calving areas on the Kenai Peninsula: flat terrain, high water table with much surface water visible during the calving period, vegetation consisting of low-lying shrubs, mosses, grasses, and sedge interspersed with various sized stands of black spruce. Many calving sites occur on islands in waterbodies, peninsulas, and lake shores. Modafferi (1982) found that pregnant female moose often moved to islands in the Susitna River to bear their young and avoid predation by bear, coyotes, and wolves. Leptich and Gilbert (1986) and Smith et al. (1988) described similar characteristics for calving areas in northern Maine and Ontario, respectively. Calving areas in the lower Susitna Basin often have openings with abundant early spring forage and are generally interspersed with dry upland islands of dense stands of shrubs and trees. Calves are usually born in the islands of dense cover.

Some of the more traditional calving areas found in the planning area include some areas along the Little Susitna River, along the Susitna River and its mouth, Kahiltna River flats, the muskeg bogs below Little Peters Hills.

Summer Range
[TO BE ADDED LATER]

Rutting Habitat

Rutting habitat includes a wide variety of habitats. Breeding groups of moose may concentrate in riparian habitats of the larger rivers and streams (Didrickson et al. 1977). Lent (1974) reported observations of breeding groups at or above timberline in the Alaska Range and on edge of small clearings or bogs on the Kenai Peninsula.

Habitat Diversity

Habitat diversity or the degree of interspersion of plant communities is an important component of high quality moose habitat. A diverse mixture of plant communities results in relatively large amounts of shrub-forest ecotones, along with shrub-sedge and shrub-aquatic ecotones. Because of the nature of the 1947 Kenai burn, LeResche et al (1974) found that the large number of stands, their irregular shapes, and the diversity of stand types and ages resulted in large amounts of edge ecotones which led to the high moose densities observed in the burn area. In northeastern Minnesota areas with the highest moose habitat potential consisted of highly diverse habitats with large amounts of edge (Peek et al. 1976).

Natural Mineral Licks

Natural mineral licks are used by moose to ingest water and/or earth containing high concentrations of mineral elements (Tankersley 1987). Licks are an important component of moose habitat because they can provide mineral elements essential to the health of a moose population. Large proportions of moose populations are known to use mineral licks (Best et al. 1977, Tankersley and Gasaway 1983). Most lick use occurs in spring and early summer and is probably linked to the change in diet associated with the flush of green vegetation in early spring. Best et al. (1977) noted that moose in Alberta used licks from April to early June. Moose have been observed making excursions out of their normal home range to visit mineral licks (Best et al. 1977, Risenhoover and Peterson 1986).

Human Use: Because the planning area includes only portions of Game Management Units (GMU) 13E, 14A, 14B, 16A, and 16B, it will be difficult to calculate hunter harvest of moose. In GMU 16, the annual reported sport harvest has averaged 615 moose during the last three regulatory periods including 1987-88. This level of harvest is comparable to that of most recent years. Hunter effort has remained fairly constant over the last three reporting periods averaging 2,150 hunters. In GMU 16A, most of the moose harvest (224 animals in 1987-1988) occurs in the Petersville Road corridor, along the Parks Highway, and in the Kroto Creek, Moose Creek, Gate Creek, and Peters Creek drainages (Faro 1988). In GMU 16B, the Susitna River floodplain below the Yenta River confluence, the Alexander Creek, Lake Creek, Twentymile Slough, Skwenta River drainages, and the Yenlo Hills provided a large portion of the total harvest (428 animals in 1987-1988). According to Fall (1983), these areas also contain year-round residents and are important subsistence hunting areas.

The Little Susitna River and the east bank of the Susitna River in GMU 14A are also heavily used by moose hunters and have produced a significant portion of the total moose harvest in this unit. In GMU 14B, the Birch Creek, Montana Creek, Goose Creek, Sheep Creek, Kashwitna River, Little Willow Creek, and Willow Creek drainages receive most of the hunter effort. Except for the Little Willow Creek and Willow Creek drainages where the majority of moose are taken at timberline, most moose are harvested within the planning area.

The non-hunting use of moose has not yet been measured but interest in this species occurs mainly during the summer (tourists) months. The actual harvest of moose is usually significantly greater than the reported harvest, because not all hunter report their take.

Timber Harvest Impacts: The department believes that many of the practices used in intensive forest management can improve moose habitat values in southcentral Alaska if they are applied with the basic ecological requirements of moose in mind. The most important influences affecting the quality, quantity, and arrangement of moose food and cover include the following:

* Logging road construction can directly impact moose populations by increasing human access (Eason et al. 1981, Pierce 1983, 1985, Scaife 1980, Timmerman and Gollet 1983). Increased human disturbance resulting from additional access may displace moose from preferred winter ranges or alter normal activity patterns during this critical period (Modafferi 1988).

* The increased road density associated with timber harvesting activities will likely result in the increased frequency of moose-vehicle collisions (Grenier 1973).

* Valuable moose habitat will likely be lost or habitat quality diminished because of increased road density and human disturbance.

* Loss of important upland mature forest stands used by moose at various times for relief from extreme climatic conditions, escape cover, and security cover will likely reduce local moose numbers.

* Because of increased levels of human disturbance, some moose will likely be prevented from using traditional seasonal use areas such as calving areas or mineral licks.

Management Guidelines: It is anticipated that intensive forest management activities will increase rapidly in the next 5-10 years in southcentral Alaska. The Alaska Department of Fish and Game (ADF&G) is concerned that forestry practices could have adverse impacts on moose habitat in this region. Studies conducted in the boreal forest zone worldwide have shown that forestry operations can influence moose utilization of habitat. Although research investigating timber harvest impacts on moose in Alaska is lacking, impacts are likely to be similar to those recorded in other boreal forest locations.

Presently, the department is actively participating in the development of the Susitna Regional Forest Plan, the Matanuska-Susitna Borough Forest Plan, and the review of current state forest practices regulations. In addition to regularly scheduled timber sales on state lands, the department has been notified of several relatively large, long-term logging plans throughout southcentral Alaska. The existing value of these lands as sources of moose habitat, recreational use, and commercial forest value can be greatly enhanced. Consequently, timber harvest management plans should incorporate appropriate measures to protect resource values. One practical means of accomplishing this end is the use of recommended guidelines for forest management practices.

These guidelines should not be inflexible rules but standards or biological principles which foresters and biologists must consider when planning for timber harvest activities. Most areas cannot be managed to maximize both fish and wildlife habitat and timber production. Discussions and compromises among foresters and biologists are a vital part of the management process. After documenting the importance of specific areas for moose habitat, it is important that biologists have the opportunity to evaluate and suggest reasonable management practices that will provide the greatest level of protection feasible and, where possible, the opportunity for enhancement of vital fish and wildlife habitat values.

The purpose of this section is to describe forest management guidelines and practices as they apply to southcentral Alaskan topography, climate, and soils. It is the department's goal to develop management guidelines that are based on sound silvicultural principles as well as moose habitat management techniques which not only maximize moose habitat but will also be consistent with the management and economic objectives of timber operators. In many cases, properly planned timber harvest operations can lead to the achievement of multiple resource management objectives, including development of the forest products industry and the enhancement of both non-consumptive recreation (moose viewing, nature photography, etc.) and consumptive recreation (sport hunting of moose). Other fish and wildlife resources and their user groups also benefit from wisely designed timber harvest operations.

1. Logging Road Location

Management Consideration

Avoid disturbance to regularly-used moose movement patterns, protect important seasonal use areas and other sensitive locations, and refrain from disruption of critical moose activities (e.g., calving, rutting, etc.).

Recommended Management Options

* A preliminary road system plan should be developed for the entire sale area prior to harvest activity.

* Align logging roads to avoid sensitive vegetation cover types such as riparian zones, wetlands, aquarian feeding sites (i.e. ponds), and naturally occurring forest openings.

* Use natural terrain features and vegetation to insure the usability of moose forage areas, as well as other important seasonal use areas, by shielding these areas from road traffic. Logging roads should be located in dense timber away from forest openings.

* Roads should be laid out to facilitate closure with gates or other access control structures to protect moose from harassment, prevent road damage, or insure quality hunting.

* Avoid locating straight stretches of road of more than 0.25 mi (0.4 km) in forested areas to increase the cover value for moose and minimize the effects on local moose numbers of hunting from roads.

* Locate log landing areas to minimize the amount of road and skid trail construction.

* Secondary logging road systems should not be designed to interconnect, thus reducing access and impacts from road hunters, and allowing greater control of access in local areas.

2. Logging Road Construction and Design

Management Consideration

Maintain moose migration routes and protect key seasonal use areas.

Recommended Management Options

* Maintain maximum amount of roadside vegetation to serve as protective cover for moose.

* Schedule road construction times to avoid seasonal use periods.

* Minimize the width of the road right-of-way.

* Roads should be designed so that they can easily be closed either on a permanent or temporary basis at a low cost.

* Maintain cover where moose trails cross roads.

* Dispose of road right-of-way slash so as not to inhibit moose movement.

* In important moose areas, roads should be constructed to minimum standards to discourage high volume vehicle use but maintain safety and environmental conditions and meet management objectives. This implies slow speed, single track roads without large cuts and fills.

* In appropriate areas topsoil resulting from road construction should be stored for later use in restoration.

* Steep cuts and fills should be avoided to not preclude blocking moose travel routes.

* Establish vegetative cover on all cuts and fills to reduce erosion and runoff, improve wildlife habitat, and enhance visual quality. Plant species selected for cover should not include preferred moose browse species that may attract moose to the road thereby increasing chances of moose-vehicle collisions.

3. Logging Road Management

<u>Management Consideration</u>

Reduce human disturbance and prevent unnecessary harassment of moose.

<u>Recommended Management Options</u>

* Develop only temporary short-term access roads into the immediate area of a timber harvest operation.

* Restrict public use of sensitive moose areas by closing primary and/or secondary spur roads during critical seasonal periods.

* All non-permanent roads and skid trails should be retired and

revegetated with accepted moose browse species immediately after timber removal has been completed. In southcentral Alaska these browse plants include most of the willow species (Salix spp.), birch (Betula spp.), aspen and cottonwood (Populus spp.), high-bush cranberry (Viburnum spp.), labrador tea (Ledum spp.), and other woody shrubs and forbs (see Cushwa and Coady 1976 and LeResche and Davis 1973).

* Develop procedures that establish areas and times of use for ORVs in harvest areas. This would include closure of certain areas used by moose during sensitive seasonal use periods.

4. Scheduling Harvest Activities

Because disturbances associated with logging are generally cumulative, timber sales should not be planned as isolated events; all past and future activities must be evaluated and harvest planning efforts should consider long term consequences.

Management Consideration

Proper scheduling of silvicultural prescription treatments can be an effective means of meeting wood production goals and at the same time emphasizing and improving habitats important to moose and other wildlife species. In this manner, the beneficial effects of incremental silvicultural treatments can be maximized.

Recommended Management Options

* Timber sales should be planned to produce a continuous mosaic of mature, close-canopied timber stands intermixed with cuts of varied sizes that range between 5 and 25 years old.

* Logging activities on recognized moose winter range should be concentrated into the shortest possible time frame for each area. Intensive harvest activity in a single season is far less detrimental than a low level of activity over several seasons.

* In a situation where several timber sales may consecutively progress from one drainage to the next, harvest activity should be confined to a single drainage or location at a time with completed sales being converted to security areas of non-disturbance for moose as quickly as possible.

* Timber harvesting should be scheduled to optimize vegetational responses beneficial to moose. For example, consider shortening timber harvest rotations to minimize the time period in which second-growth forests produce little or no moose browse.

* Timber harvesting schedules should be coordinated with other

types of land activities to reduce simultaneous impacts.

* Where possible, the clearing of aspen sites should be done in winter when sucker production is stimulated to the greatest extent because of high carbohydrate reserves (Usher 1978).

* It is strongly urged that in units scheduled for future harvest, an evaluation of moose browse quantity, quality, and utilization be completed where practical by the ADF&G. These data can be used to better define moose range distribution and quality.

* Harvesting early in the annual growth cycle (before July) means that regrowth of birch and balsam poplar will occur the year of harvesting. Regrowth is delayed until the following year if harvesting occurs later in the annual growth cycle (Zasada et al. 1981).

* Harvesting during the period of active growth can reduce a tree's ability to regenerate through vegetative reproduction (e.g., root suckering, basal sprouting), because the tree's food reserves, which fuel the regrowth response, are at a low point at this time (Zasada 1986). Therefore, winter harvesting is recommended for hardwood stands not used by moose.

* Winter logging is preferable in areas with a relatively high density of aquatic feeding sites. Human disturbance during summer can prevent moose from obtaining critical nutrients available from aquatic sites that may be deficient in the terrestrial diet (Crossley 1985).

5. Location and Shape of Harvest Units

Management Consideration

Siting of harvest units should consider the effective use and availability of adequate forage and cover blocks for moose.

Recommended Management Options

* Shape and blend areas to be cut with the natural terrain to the extent practicable.

* The geographic position of mature stands relative to cut areas provides year-round security cover, thermal cover in summer, and refuge from deep snow conditions, and may contain alternate food sources. Their position, relative to potential harvest areas, should be considered in the design of these harvest areas. Maintenance of mature coniferous cover (late winter habitat) in close proximity to any early winter

concentration areas will benefit wintering moose.

* The orientation of clearcuts probably will not influence moose production or use. Nevertheless, a variety of cut orientations should be included in any timber harvest plans to cover the range of conditions that may be important to moose. In areas of heavy snow accumulations, drifting may bury browse. In these areas, clearcuts should be oriented downwind.

* If timber removal is to occur on moose winter ranges, the harvest of south-facing slopes is preferred over north slopes. Snow accumulations are less and the duration of snow cover is shorter leaving more browse exposed to moose. Moose also experience savings in energy by having more sunlight available during the cold months of the year.

* Clearing of timber areas adjacent to, <u>but not in</u>, riparian zones may be warranted only if the adjacent areas are not heavily used by moose and if the integrity of the riparian/aquatic habitats can be maintained.

* The timbered fringes of ponds and lakes should be maintained to a width of 100 m (330 ft) to provide security cover for moose feeding on aquatic plants (Brusnyk and Gilbert 1983). Selective removal of merchantable timber from these fringes would be encouraged to maintain shorter (< 15 m) stands with less crown closure (< 60%) as reported by Crossley (1985). A more open canopy would encourage the establishment of shade-intolerant browse species such as willow or aspen.

* Maximize the amount of forage-producing edge in cuts by delineating irregularly shaped borders to cut areas (Scaife 1980). Long, narrow, and meandering cut units provide a greater amount of edge distance and benefit more moose than do units having a circular or square configuration. Moose use on larger cuts can be maximized if the use of square or rectangular units is minimized while using an undulating-shaped cut instead of one with straight edges.

* When managing for the enhancement of moose habitat, well-drained upland sites that produce abundant amounts of browse are best suited for clearing, whereas poorly-drained upland sites that do not produce as much browse should be maintained as areas of cover.

* The size of cuts should range between 5 and 40 acres (2-16 ha) with the preferred size being approximately 8 ha (20 acres). The relatively wide range in size provides flexibility to accomodate the many factors that could influence the size of cuts, such as, local moose densities and distribution patterns, spatial relationships between browse and standing

timber, topography, access, economic factors, etc. For example, an 8 ha (20 acres) rectangle cut is 400 m (1,320 ft) long and 200 m (660 ft) wide. Cuts of too large a size preclude moose use of the total area while cuts that are too small may encourage high-density concentrations of animals leading to over-browsing.

* Although no upper limit to the distance moose will move away from cover to forage has been defined, researchers have demonstrated declining use of browse at greater distances from cover. For maximum utilization, the configuration of individual cuts should be such that the distance to cover does not exceed 100 m (330 ft) throughout the unit.

* In cases where maximum clearcut widths cannot be kept to 200 m (660 ft) or in clearcuts larger than 16 ha (40 acres), residual islands of dense cover should be left within the clearcut boundaries. Residual islands ranging in size from 0.2-2.0 ha (0.5-5.0 acres) can be used by moose for cover, bedding and shelter (Monthey 1984, McNicol and Gilbert 1978, Euler 1987). Residual patches of cover should be spaced 200-300 m (660-990 ft) apart within the clearcut, stocked by at least 1/3 in conifers to provide some relief in years of deep snow, and at least 4-6 m (13-20 ft) high for good hiding cover.

* Maintain a minimum leave strip width of at least 330 ft (100 m) between cutting units (Matchett 1985).

* Harvest units should be oriented to avoid blowdown and loss of moose habitat.

6. Harvesting Methods

Management Consideration

Utilize and conduct timber harvest methods and associated activities in a manner that will protect, increase and enhance moose habitat values in the cutting unit.

Recommended Management Options

* Clearcutting of small harvest units (2-16 ha) should be the preferred method of timber harvest in white spruce stands.

* Clearcutting with seed trees (seed tree cuts) should be the preferred method of timber harvest in paper birch stands.

* In known moose forage areas, limbs from all felled logs should be removed to minimize any damage to residual standing moose browse as logs are skidded to a landing area.

* In clearcut areas with relatively large amounts of moose browse undergrowth, a shortwood harvesting system could minimize loss of the valuable shrub undergrowth. In areas without moose browse understory, and where its growth is desirable, tree length and full-tree skidding may be more appropriate harvesting systems. The latter two systems result in less slash residue, much greater disturbance to the shrub undergrowth and provide more favorable growing conditions.

* Where possible, trees should be felled away from possible moose foraging areas.

7. Debris Management

Logging slash disposal can be done mechanically, by burning or by a combination of both methods. Slash not piled, windrowed, or burned may physically hinder moose use of an area or may limit establishment of moose food items. Slash can be broadcast burned or piled and then burned. Moose will also be attracted to piles of hardwood slash with branches and tops.

Management Consideration

Maintain access to available forage for moose, eliminate barriers to travel, and make use of debris for cover.

Recommended Management Options

* Coniferous logging debris/slash can be windrowed or piled adjacent to logging roads to serve as visual barriers and protective cover for moose. This practice is not recommended for paper birch operations because moose may be attracted to the slash piles as a food source and would be more susceptible to moose/vehicle accidents.

* In relatively large clearcut areas, openings should be cut through windrowed slash to allow passage by moose, especially on established moose trails.

* Slash and other small debris should be burned while the ground is damp to protect root systems of forage species.

* Logging debris that has fallen into the adjacent uncut forest and slash within the openings should be cleaned up or removed by the operator as they may reduce moose use of the area because of lower forage production or more difficult access to security cover areas. Valuable moose forage plants may be screened by a tangle of broken tree limbs and uprooted debris.

* The growth of early successional shrubs preferred by moose would be encouraged by broadcast burns in clearcuts rather

than burning piles of slash.

8. Site Preparation

Management Consideration

It is generally recognized that softwood (white spruce) and hardwood browse species (birch, aspen, balsam poplar, and willow) regeneration can be improved after timber harvesting by some form of mechanized seedbed scarification.

Recommended Management Options

* Areas should be scarified just prior to peak annual seedfall or prior to application of artificial seeding techniques. Scarified seedbed receptivity tends to decline moderately over time.

* Larger-sized seedbed areas will have greater regeneration success than smaller patches (Arlidge 1967).

* Depending on soil type, areas of soil compaction may reduce seedling growth or even cause mortality due to water retained in depressions created during scarification treatment (Lees 1964). Therefore, operators should avoid creation of an uneven ground surface and soil compaction by using appropriate machinery.

* On logging sites where the surface has been compacted due to the operation of heavy machinery common to logging operations, various forms of mechanical discing (possibly disc trenching or scalping) may be used to alleviate such problems.

* On aspen sites, it is suggested that cleared areas be heavily scarified or lightly burned to produce maximum sucker response (Stoeckler 1948, Usher 1978, Scaife 1980).

* Distribute the areas of exposed mineral soil <u>uniformly</u> over the site so that regeneration of trees and/or browse shrubs will be uniformly distributed (Zasada 1986).

* Fertilization of mineral soils with nitrogen to improve the seedbed environment should also be considered early in the post-logging period.

* For paper birch areas, scarification on logged sites should expose <u>only</u> the upper mineral soil layer (A horizon) (Densmore 1988).

9. Prescribed Burning

Management Consideration

Management Options

* Controlled burning techniques are recommended when climatic, soil, and fuel load conditions are conducive to remove logging slash, maintain forest openings, and to improve the quality and quantity of moose forage.

10. Tree Harvesting Systems

In southcentral and interior Alaska, three tree harvesting systems predominate - log length, tree length, and full tree logging. The log length system removes only the merchantable portion of the tree from the cutting site. Tree length logging leaves the limb material on the site, but the entire trunk is harvested and either bucked at the landing or hauled full length to the mill. Full tree logging involves removal of the entire tree from the site. Limbing occurs at the landing and bucking at either the mill or the landing. Full tree logging will result in the greatest amount of physical disturbance to the organic layers and exposure of mineral soil, while destroying more competing vegetation such as grasses and herbs (Zasada 1972). The opposite is true for log length logging - it results in comparatively minimal soil disturbance. Treelength logging rated closer to full tree logging in its ability to aid site preparation. Logging activities generally do not expose sufficient amounts of mineral soil to ensure birch seed establishment.

Management Consideration

Harvesting alone rarely creates those conditions necessary for successful forest regeneration, especially in most areas of southcentral and interior Alaska where organic layers are usually thick and much timber removal occurs on frozen and snow-covered ground. Careful management of harvest operations can provide some site preparation benefits.

Recommended Management Options

* The full tree logging system should be used where feasible to obtain maximal disturbance of the organic soil layers for natural regeneration.

* On dry upland sites, logging activity should be conducted during the summer period to maximize surface disturbance. In wet areas, logging should be conducted soon after the ground has frozen.

* Timber operators should attempt to maximize surface disturbance. If no site preparation work can be completed, logging activity should be conducted during the summer period.

11. Herbicides

Management Consideration

Herbicides are often used to reduce competition between conifers and hardwood shrub species, herbaceous vegetation, and grasses. These chemicals can indirectly impact wildlife, particularly moose, by altering the existing deciduous flora. Changing the mix of available plants influences the amount of moose browse. In fact, browse may be reduced to the extent that moose can no longer use an area.

Recommended Management Options

* Herbicides should not be used as a seedbed preparation technique to encourage regeneration of conifer stands until a long-term evaluation of herbicide effects on moose habitat has been completed.

* If glyphosate is applied by means of aerial spraying, a minimum buffer strip width of 75 m (250 ft) should be maintained in the vicinity of aquatic areas to protect habitat for moose and anadromous fish from significant direct toxicological effects (Payne et al. 1987). However, a buffer strip width of 150 m (500 ft) will increase the probability of obtaining an acceptable degree of habitat protection.

12. Forest Regeneration

Management Consideration

Silvicultural prescriptions should be written to improve the quantity and quality of available forage and cover for moose while still maintaining forest management objectives for final stocking rates of merchantable trees.

Recommended Management Options

* It is imperative that detailed regeneration plans be developed well in advance of all timber harvests. These plans should be based on a thorough evaluation of the total forest ecosystem, particularly the wildlife component. Timber removal can greatly impact local moose populations. These plans should be developed cooperatively and agreed upon by forest and wildlife managers.

[* Natural regeneration should be the primary reforestation practice for logged areas in southcentral Alaska.]

* Tree stocking rates should be developed that allow the maximum period (approximately 25 years) before canopies close and shade out understory forage species.

* Precommercial thinning techniques, when economically feasible, may be employed before closure of the canopy (ca. 20-25 years) reduces forage species values in the understory. By lowering tree densities, early successional community types can be maintained for a longer time period. On winter range areas, the number of trees per hectare should still meet multiuse objectives of maintaining snow interception capabilities as well as adequate stocking rates for regeneration.

* On sites with nutrient-poor soils, fertilization could improve the nutritional status and make the site more hospitable to seeds and seedlings of shrubs and trees.

BACKGROUND INFORMATION

A. Road Management

Forest roads are constructed to harvest forest stands and, once in place, are maintained to manage regenerating stands and provide access for fire protection and suppression. Roads can have a significant impact on moose populations and their habitat. Logging roads affect the frequency, rate, and quantity of surface erosion and slope failure which can reduce important moose habitat. Road construction can disrupt natural drainage patterns thus affecting water quality that may in turn affect the quantity and quality of aquatic forage plants.

Roads can directly influence moose populations by increasing hunter access as well as recreational vehicle use within critical habitat areas such as winter range. Road management may be one of the most important factors influencing moose populations in habitats affected by logging. Scaife (1980) reported that 70% of the moose harvest in a north-central Manitoba study area were shot by hunters standing on forestry roads. In the Alberta white spruce habitat type, Lynch (1973) found that 28% of the moose kill was taken within one mile (1.6 km) of roads; 80% of the hunting pressure and 18% of the land occurred in this same zone. Stelfox (1984) reported that road access and harassment from human activity greatly affected big game use of clearcuts in west-central Alberta at a time when big game carrying capacity was considered high. In British Columbia, observations also show that the success rate and distribution of the moose kill is strongly correlated with access corridors (Murray 1974, cited in Bunnell and Eastman 1976).

Although some big game species such as elk or black-tailed deer tend to avoid roads even without traffic, some moose subpopulations may use roads as travel routes. Grenier (1973) showed that the moose kill by highway vehicles in Laurentides Park in Quebec was directly correlated with traffic intensity and accounted for 15-20% of the population mortality. However, Bunnell and Eastman (1976) reported that logging roads in British Columbia did not appear to contribute significantly to wildlife road kills.

A permanent forest road system may occupy 8-10 percent of the forest land area (Froehlich 1978). In the Susitna Regional Forest Plan (SRFP) study area, it is estimated there are approximately 450,000 acres (1821 km^2) of commercial forest land. Larsen (1974) estimated that each square mile (2.59 km^2) of intensively managed forest will contain approximately 6 miles (10 km) of road. Using a conservative average of 3 miles (5 km) of road and skid trails per square mile of harvested land, the total length of roading necessary to harvest all of the commercial forest land would approximate 2,100 miles . If a 40 foot road corridor is constructed, 4.8 acres will be cleared for each mile of road, and approximately 10,000 acres of forest land would be disturbed. A portion of the area used for roads will certainly include important moose habitat.

More than any other single facet of intensive forest management, road construction and the post-logging management of those roads is expected to be a major problem in moose management. Road construction may remove valuable moose habitat, affect their distribution and movement patterns, and increase potential for harassment and other disturbance factors. In many areas forest roads are often characterized by: 1) public accessibility; 2) little screening cover along the edges; 3) wide rights-of-way with steep high cut banks; and 4) locations adjacent to or passing through valuable riparian habitat.

Many studies have shown that optimal use of logged areas by some big game species has been adversely influenced by the existence of roads left open to vehicular traffic (Leege 1976, 1984, Perry and Overly 1977, Thiessen 1976, Tomm et al. 1981, Ward 1976, Willms 1971, Witmer 1981, Lyon 1979, 1983, Lyon et al. 1985, Pederson et al. 1980).

Increased public access via new logging roads was highly correlated with increases in human-induced mortality to moose in northern Idaho (Pierce 1983, 1985). Matchett (1985) suggested that road closures and a limiting of access could prevent excessive or unregulated human-induced mortality of moose in the Yaak River region of northwestern Montana. Ritchie (1978) noted that increased road access and human activity was a likely factor in the declining trend of moose numbers in southeastern Idaho. In a study of the responses of moose and deer species to logging practices in central Alberta, Tomm et al. (1981) found that human disturbance was the most important factor influencing the use of clearcuts by moose. It was also suggested that if harassment could be minimized by controlling access, this could allow greater variability in the shape and pattern of cutting units and also give moose a greater opportunity to gain the presumed benefits of timber harvesting.

B. Timber Harvest and Removal

B.1 Research Findings

The amount of empirical data describing the relationship of moose to logging practices in Alaska is meager. Specific information on moose forage production and forest succession following clearcut logging has not been collected in Alaska. The ADF&G is not aware of any research documenting actual moose population responses to post-logging succession following commercial timber harvest and removal. Because of the relatively small scale of activity, commercial timber harvesting activities have had a relatively minor impact on moose habitat in Alaska. However, throughout the boreal forest zone of Canada and in portions of the United States logging activities are, and have been, a primary influence on the status of local moose populations (Berg and Phillips 1974, Telfer 1972).

The fact that clearcut logging can change the productive capacity of mature forests in southcentral and interior Alaska is obvious. Historically, early seral plant communities have been established after natural or man-caused fires, river flooding and erosion, logging and land clearing, beaver activities, and/or natural blowdown by wind storms (Wolff 1976, Spencer and Hakala 1964, Viereck 1970).

It is generally believed that most logging operations in late sucessional boreal forest stands are beneficial to local moose populations if they retain all riparian habitat and result in a highly diverse mixture high in forage species regrowth and forested winter range (Telfer 1974, Peek 1974). Most logging activity uses clearcutting, where all stems are removed at once except where non-merchantable patches occur. Thus, logging may act similar to fire, which causes relatively large areas of forest to revert to young stands, most often consisting of early seral plant communities characteristic of secondary succession. Moose prefer to utilize the early seral stages of forest succession that provide abundant amounts of woody browse. Clearcut logging coupled with scarification can produce these early seral community types. Post-logging site preparation treatments such as scarification, broadcast burning, revegetation, or seeding may be used to influence the rate at which vegetation reestablishes itself on the site.

B.1.1 Moose utilization of riparian communities and clearcuts

Moose in southcentral and interior Alaska are primarily associated with early successional stage forest, the upland shrub and lowland bog climax communities and riparian shrub habitats. Riparian shrub communities consisting mainly of willow, and/or juvenile birch and aspen or a combination of these and other browse species are thought to be the habitat types most preferred for moose winter forage in Alaska ((Chatelain 1951, LeResche et al. 1974, Mould 1979, Taylor and Ballard 1979, Milke 1969, Masters et al. in press, Grauvogel 1984, Modafferi 1984, Albert and Shea 1986).

On a Tanana River floodplain site near Fairbanks, Milke (1969) found that willow production available as browse for moose averaged 203.8 kg/ha (181 lbs/ac). Wolff (1976) estimated the amount of hardwood browse produced and the amount consumed by moose in 8- and 15-year-old willow-dominated riparian shrub stands in the Tanana River floodplain near Fairbanks. The two stands produced 38 and 113 kg/ha (34 and 101 lbs/acre), respectively, with approximately 55% of available browse being consumed in one year. This illustrates the importance of early seral plant communities as winter habitat for moose. Maximum use of these riparian areas usually occurs from mid- to late winter and is directly related to maximum snow depth. Dense stands of spruce adjacent to riparian communities enhance their value by providing cover. Although most riparian areas are seral communities, they are self-perpetuating through alluvial processes and, thus, provide a permanent source of seral habitat.

Seral habitat important to moose may also be created by wildfire, clearcut logging and other human disturbances that remove climax vegetation (Le Resche et al. 1974, Davis and Franzmann 1979). In areas where riparian habitat is limited, creation of early seral habitat by logging may result in rapid and large increases in moose populations (Cowan 1950). In northeastern Saskatchewan, MacLennan (1975) reported that monthly winter moose densities in a clearcut area averaged 2.4 times greater than that of the surrounding area. Hunt (1976) enlarged upon MacLennan's (1975) study and found that moose densities were 56% higher in clearcuts than uncut areas and attributed differences in the two studies to differing levels of winter severity. Moose tended to prefer clearcuts 9-10 years old over more recent cuts (3-6 years old) because of the increased amount of available residual cover and browse.

Year to year snow conditions can also influence how clearcuts are utilized. For example, greater snow depths may force moose to venture further into an open clearcut than they might in shallower conditions. Moose utilization patterns were found to differ according to size, shape, and configuration of the clearcuts (MacLennan 1975, Hunt 1976)..

Crete (1976) concluded that logging operations in Quebec were a valuable tool for managing moose habitat. Logged stands of paper birch and aspen were utilized in winter more frequently than uncut stands in Pontiac County while the opposite was true in Mont Tremblant Park. A slower and less abundant regeneration of the feeding stratum resulted in less use of harvested stands in the Park study area. The speed and abundance of regeneration of the feeding stratum, the density of uncut coniferous stems, the rate of closure of the canopy stratum, and the degree of winter severity can influence levels of moose utilization of logged areas (Crete 1976:50).

McNicol and Gilbert (1980) studied late winter moose utilization of upland mixed-species clearcuts of varying size but similar age (10-15 years old). Moose preferred clearcut areas with scattered trees over completely open clearcuts, uncut areas, or open clearcuts with small planted trees. Preferred clearcuts had 52% more browse stems per hectare available, a greater diversity of browse species and the largest number of browse stems present. Eastman (1974) evaluated winter habitat use by moose in north-central British Columbia and concluded that partially logged stands 11-20 years old had the greatest use; burns were used at almost comparable levels, then forests, with 3-year old clearcuts having the least amount of use. Based on study results, Eastman pointed out the need for site-specific evaluations regarding logging practices and their resultant impacts on moose. Partial logging practices were studied including cut and leave strips, individual tree selection, and minimum tree-diameter limits. This type of logging created mosaics of small cover- and food-producing units that closely resembled highly productive, natural winter ranges. Because, at the time of the study, clearcutting had only been recently introduced in that part of British Columbia, Eastman cautioned that clearcutting could eventually produce habitat of similar quality to partial cutting methods. Welsh et al. (1980) also found that winter utilization of clearcuts in Ontario by moose was greatly influenced by forest harvesting practices and the age and history of the clearcut. Large uncut areas contiguous to clearcut areas appear to be a necessary component of good winter habitat. These authors also concluded that timber harvesting practices could be used to improve moose habitat quality.

B.1.2 Increased forage yields from timber harvesting

Quantitative information describing the effects of logging on forage production for moose in North America is limited. In Alaska, young seral stages of boreal forest have been produced more often by wildfires than logging. There is ample evidence of dramatic increases in moose populations in areas burned during the 1930's and 1940's (Lutz 1956, Spencer and Hakala 1964, Spencer and Chatelain 1953). Willow, birch, and aspen are often the first recolonizers of burned or logged areas. Seemel (1969) reported annual shrub production of 500 kg/ha (445 lbs/acre) with 82,000 shrub stems/ha (33,184 stems/acre) in the most dense paper birch stands 21 years after the 1947 burn on the Kenai Peninsula.

Increases in browse production following logging may be similar to those which follow fire. For some areas of eastern Canada, Telfer (1970) showed that logging may have resulted in a greater than 50-fold increase in browse yield 7 years after the cut. Telfer (1972) estimated browse biomass on logged areas in New Brunswick at 440 kg/ha (392 lbs/acre) at 10-12 year post-logging compared to 23 kg/ha (20.5 lbs/acre) 2 years after logging. Vallee et al. (1976) found that the optimal age of clearcuts for maximum browse production (as measured by stems/ha) was between 5 and 10 years of age in stands of softwood or mixedwood origin, and between 10 and 15 years of age for hardwood stands. These findings were similar to and corroborated those of Telfer (1972).

Stelfox (1974) evaluated browse production and utilization by moose, elk, and deer after clearcut logging in a white spruce forest in the western Alberta foothills. The number of browse plants decreased 44% during logging and scarification. After 6 years, browse plant numbers had doubled and were 30% more numerous than in the uncut areas. Seventeen years after logging, numbers of browse plants had grown three times more numerous in the clearcuts than in the mature forests. Unscarified logged areas had 25% more browse plants than scarified areas [[WHY]]. Browse production decreased from 529 lbs/acre (green weight) in the mature forest to

187 lbs/acre after logging and 101 lbs/acre after scarification. Browse production in the scarified areas aged 1, 5, 9, 17 years averaged 101, 860, 1,438, and 1,702 lbs/acre, respectively. The one unscarified area had slightly higher production values. Big game use of the logged areas was 19 and 65% greater than in the adjacent mature forest.

McNicol et al. (1980) described the extensive utilization of a 1965 clearcut by a high density moose population in Ontario. Moose densities were $1/km^2$ ($2.5/mi^2$) in 1970, $5/km^2$ ($12/mi^2$) in 1976, and 9/km2 ($22/mi^2$) in 1980.

B.1.3 Clearcut size, shape, and coniferous cover requirements

Where clearcutting is the chosen timber-harvesting technique, vegetation should be managed to provide a variety of plant communities within close proximity to each other. Moose require a combination of diverse habitat conditions that contain early successional stages for food and late successional stages for cover.

Mature forest cover fulfills varied habitat requirements for moose including a means of escape or a refuge from predators and hunters, areas of mechanical and thermal protection from winter storms or summer sun, and a secure area for parturition and calves (Thompson and Vukelich 1981).

Unfortunately, in interior and southcentral Alaska, no studies have been conducted that provide specific information documenting optimal clearcut size and shape and their relationship to the cover requirements for moose. In Sweden, prior to the early 1960's, clearcut sizes of about 2 ha (5 acres) indicated favorable regrowth of preferred browse species and an increasing moose population (Markgren 1974). Through the mid 1970's, clearcut size increased to over 5 ha (12 acres), but moose numbers apparently declined (ibid.). However, it should be cautioned that the lower moose numbers could not be attributed solely to increasing clearcut size. Telfer (1974) suggested that moose may use clearcuts up to 140 ha (350 acres) but larger clearcuts are probably not used until the stand has regenerated sufficiently to provide minimal cover (10-15 years). Peek et al. (1976) recommended clearcuts of approximately 80 ha (200 acres) for providing good moose habitat. In British Columbia, Eastman (1974) recommended that square clearcuts should not be greater than 115 ha (285 acres) based on Telfer's (1972) guidelines.

In a very limited study of the relationship of browse utilization by moose and distance from cover, Hamilton and Drysdale (1975) concluded that clearcuts less than 200 m (650 ft) in width were small enough such that distance from cover did not alter moose utilization patterns. They also found that clearcuts greater than 300 m (975 ft) in width showed decreasing use, especially beyond 40 m (130 ft), with no use beyond 100 m (325 ft) from the edge of the cut. Hunt (1976) concluded that differences in clearcut size, shape, and habitat configuration could affect patterns of moose utilization. Severity of winter conditions can influence how much of a clearcut is utilized in a given year. For example, MacLennan (1975) reported that distances moose were observed from cover averaged 89 m (97 yds) in a severe winter compared to 48 m (53 yds) in a mild winter on the same cut (Hunt 1976). Thompson and Vukelich (1981) observed that most cows with calves were less than 60 m (66 yds) from cover regardless of snow depth and conditions.

Any negative effects of large clearcut sizes may be offset by numerous patches of residual cover which enable moose to use a greater proportion of a clearcut. Hamilton et al. (1980) found no correlation between distance from cover and browse abundance or its distribution, indicating a uniform distribution of browse vegetation. Approximately 95% of all browsing activity occurred within 80 m (88 yds) of some form of cover. Along with coniferous vegetation, even small, deciduous islands and heavy shrub growth provide an attractive means of escape from hunters and animal predators. Moen (1973) demonstrated that wind flow in the middle of a large clearcut was more "chilling" to white-tailed deer than wind flow next to tree islands or clearcut edges where the flow pattern can be broken. McNicol and Gilbert (1978) found that moose used residual tree patches as wind breaks and appeared to derive benefits from shallower snow depths on the leeward sides of these stands.

B.1.4 Increased forage species diversity from logging

A diverse selection of browse species is advantageous in areas where snow conditions can limit the abundance and availability of a preferred browse species (McNicol and Gilbert 1980:368). Peek et al. (1976) discussed a shift in browse species used by moose as winter progressed and suggested that it was due to changes in availability.

Removal of the forest canopy by logging temporarily increases plant species diversity (Wallmo et al. 1972). Miquelle and Jordan (1979) documented the importance of plant species diversity in the summer diet of moose on Isle Royal. Le Resche and Davis (1973) found that approximately 35% and 22% of the food consumed by moose on the Kenai Peninsula consisted of <u>non-browse</u> food items such as lowbush cranberry, lichens, sedges, grasses and aquatics. This suggests that southcentral Alaskan moose may require access to a diverse diet of browse and non-browse plants.

B.2 Timber Harvest Systems

Silvicultural methods commonly used in timber management are clearcuts, seed-tree cuts, shelterwood, single-tree selection and group-tree selection. These methods span a continuum in the degree of exposure a site experiences, with the clearcut method providing the most exposure and the selection method the least (Daniel et al. 1979).

Clearcutting involves the removal of all trees before regeneration occurs and results in an even-aged second-growth stand. Clearcutting methods are of several types, including simple clearcuts, alternate-strip clearcuts, and progressive-strip clearcuts with the assumption that the width of each exposed strip is optimal for the natural establishment of seedlings.

The seed-tree cut consists of leaving a sufficient number of good seed-producing trees scattered over the cut area to ensure adequate stocking in a reasonable time period. This method ensures an even distibution of seed, and allows for a larger area to be cut with natural regeneration than clearcutting. This method is also favorable for intolerant tree species.

Under the shelterwood method a stand is removed in a series of cuts several years apart with the most mature and defective timber taken first in the preparatory cutting. The best trees left may then grow rapidly for a period of time, but more importantly, will supply seed for adequate growth of seedlings on the ground. A second cut, the seed cutting, in which 30-60% of the remaining volume is removed, usually occurs after a good seed production year. Only the very best windfirm dominants are left for the final or removal cutting. However, it is unlikely that shelterwood cuts would be applicable to intolerant pioneer species like paper birch, aspen or cottonwood which require a seedbed of mineral soil exposed to full light (Smith 1962). Shelterwood cuts require multiple entries and roads constructed under higher standards. Although this method has hardly been used in Alaska, if at all, it may have some benefits for moose when harvesting mature even-aged or uneven-aged birch stands because of its capability of producing a large number of birch seedlings with hiding cover nearby.

Selective cutting occurs when each tree (or group of trees) cut is chosen with regard to its present position in the stand and future possibilities for growth (Stoddard 1978). Selection methods are generally applied in uneven-aged stands. The regeneration never loses the protection or competition from the adjacent older age classes. Single-tree selection involves the frequent removal of mature individuals or small groups of trees with a new generation occuring in their place. Group-selection cuts result in larger openings but not so large as to lose the site protection of the surrounding trees.

C. Post-logging Site Preparation

The creation and maintenance of productive multiple use forests is a goal common to forest managers and wildlife managers. The reforestation of commercial forest lands in Alaska is mandated by the Forest Resources and Practices Act (1979). This statute requires that a regeneration program be developed that will ensure a sustained yield from forested lands from which the timber has been harvested.

The regeneration and establishment of forest trees and tall shrubs after timber harvesting is influenced by numerous biotic and abiotic variables. The interactions between the seed available for regeneration and the condition of the organic layers and surface soils of the seedbed are particularly critical to vegetative reestablishment. Seed sources must be planned prior to harvesting. Seed availability is probably the more restrictive of these two variables (Zasada 1986). If adequate seed sources are not left, regeneration will not be successful even if surface conditions are optimal for germination and seedling establishment. However, proper seedbed conditions greatly influence the degree of seed germination and vegetative reproduction (i.e., root suckering, layering, basal sprouting, and regrowth from detached vegetative parts such as stem or root segments). Numerous studies have shown that seedbed surfaces consisting of thick organic material (humus) are generally poor environments for seedling germination and establishment because they tend to dessicate rapidly in direct sunlight (Zasada and Gregory 1969).

There are two alternative forms of reforestation - artificial seeding or planting and natural regeneration. In southcentral and interior Alaska, natural regeneration has been the most common means of forest renewal. No matter which reforestation technique is used, some form of site preparation is necessary to provide optimal seedbed conditions (Gardner 1980, Zasada 1980, Zasada and Gregory 1969). Alaskan and Canadian experience has demonstrated that abundant natural regeneration can be obtained given a good seed source and a mineral soil seedbed (Zasada and Grigal 1969). In the last ten years most post-logging regeneration efforts have been aimed at exposing mineral soil for the natural seeding process. This type of seedbed substrate most closely approximates the necessary germination conditions of a stable, adequate moisture regime, favorable soil temperatures, and a sufficient nutrient supply (Zasada and Gregory 1969).

Proper site preparation is fundamental to the establishment of plants and seeds. Competition from unwanted vegetation is reduced, the supply of soil nutrients improves, soil temperatures increase, drainage improves, the risk of plant loss from frost diminishes, and the growth of planted seedlings is enhanced.

Zasada and Grigal (1978) reported that the initial stages of plant succession on their study sites was influenced by site preparation. Scalped surfaces contained numerous seedlings of birch, aspen, alder, and willow, while unscalped areas supported low shrubs and herbaceous species that were common prior to timber harvest and of low value to moose.

C.1 Mechanical Scarification

Scarification is an old, and fairly common, method of soil preparation. However, the technique has not been widely used in Alaska because of high treatment costs, unfavorable economic conditions in the timber industry, and blatant disregard of sound silvicultural practices in past years. In this method, the moss and organic layers are removed exposing the mineral soil for the natural seeding of forest trees and shrubs. Mineral soil exposure may be exposed over the entire harvested area, in random patches with considerable intermixing of soil components, in parallel furrows, or in uniformly spaced scalps. Many kinds of heavy equipment can be used for scarification and include: 1) bulldozer and tractor blades, multiple disks, drums, and anchor chains for random scarification; 2) plows, rippers, and disk trenchers that produce furrows; and, 3) spot cultivators for scalping patches.

The many kinds of site-preparation equipment have naturally led to many different site-preparation methods. Probably the most common methods are shearing and raking. This involves use of a bulldozer or tractor with a straight blade or a raking blade. After logging has been completed, most of the slash is windrowed or piled to one side of the clearcut. This also removes or intermixes the top organic layer with mineral soil. Root raking, also known as rock raking and grubbing, involves rather severe site disturbance because tree stumps are torn out of the ground and piled or windrowed. This can be a risky procedure because of the possible removal of the nutrient-holding upper soil layer. Roller chopping crushes and breaks up most woody material up to about 3 inches in diameter but usually does not cause sufficient disturbance to the soil organic layer nor provides adequate control of resprouting competing vegetation. Because the chopped material is scattered over the soil surface, some additional mechanical activity is needed to expose areas for regeneration. Discing results in mixing the organic and mineral soil layers instead of just scraping off the top organic layer. Disc trenching produces a furrow and scalping or shearing results in a small spot where the organic soil layer has been scalped off and thrown into an adjacent berm.

C.2 Prescribed Burning

Prescribed burning can be an effective and economic means of removing accumulated slash and logging debris from clearcut areas. Bunnell and Eastman (1976) reported that prescribed burning resulted in less severe site damage than natural wildfires and that burning slash would extend early successional stages. Prescribed burning of logging slash on Maine clearcuts resulted in greater production of hardwood stems and shrubs than in clearcuts where debris was not removed (Rinaldi 1970). Light burns can stimulate vegetative reproduction of some hardwood browse species favored by moose. The beneficial effects for moose of prescribed burning may last up to 15 years before the canopy begins to close over the understory.

Prescribed burning has only been used in Alaska in recent years. Fire creates a great variety of microsites for germination and establishment of trees and shrubs (Friedman 1981, Zasada et al. 1983, Dyrness and Norum 1983). Zasada et al. (1983) described the use of controlled burning on an upland black spruce site in interior Alaska. The low costs (sometimes one-third that of mechanical scarification) associated with this technique have increased its attractiveness as a site preparation technique. However, experience in Canada has indicated that prescribed fire alone often does not always create adequate seedbed conditions and that it may have to be used in conjunction with some form of mechanical site preparation.

On white spruce sites, clearcutting is the only silvicultural system that can accommodate prescribed burning because white spruce is so susceptible to fire. The method of timber harvesting will also influence the burn prescription because the amount of fuel accumulation will vary greatly between the log length, tree length, and full-tree harvesting systems. Generally, field observations from mixed-forest stands tend to indicate that residual organic layer depth combined with some measure of burn severity are necessary to estimate the degree of future regeneration response and relative importance of seed and vegetative reproduction (Zasada 1986).

C.3 Herbicides

The use of herbicides (e.g., glyphosate; 2,4,5-T; atrazine; 2,4-D; and simazine) and other chemicals in forest management involves a myriad of technical, biological, social, and legal problems. Social concerns regarding possible impacts of herbicide use together with strict legal restrictions on use have constrained use of this technique. The objective of herbicide treatment is to temporarily reduce the dominance of an undesirable vegetation component thereby allowing the desired vegetation to attain greater site occupancy more rapidly (Daniel et al. 1979).

Since glyphosate was introduced in the early 1970's, it has become widely used by forest managers in Canada, Norway and in the United States, because of its effectiveness in shrub competition control.

In southcentral Alaska, the use of glyphosate (Monsanto product name - Roundup), a relatively new broad spectrum herbicide, has been advocated to control the large amount of bluejoint grass (<u>Calamagrostis</u> <u>canadensis</u>) that rapidly develops in many clearcut sites. Although Sutton (1978) reported that hundreds of efficacy studies have been carried out in North America and Europe, the majority of these studies have been agriculturally oriented with little attention given to forests or their associated wildlife. There are no published studies evaluating the effects of glyphosate on the habitats of northern boreal wildlife species, especially moose in Alaska, under operational field conditions.

Krefting and Hansen (1969) and Mueggler (1966) stated that carefully planned herbicide treatments could increase browse production on big game range. Conversely, some herbicides can be used to reduce or eliminate broad-leaved shrub densities. In fact, Braathe (1978) recommended use of glyphosate to reduce available food resources as a means of controlling moose numbers in Norway. Kennedy and Jordan (1985) found that glyphosate treated stands in northern Minnesota averaged half the available browse of 2,4-D treated areas. Because glyphosate has no residual effects, it may actually encourage growth of grasses and forbs in the next growing season (ibid.). In British Columbia, Sullivan and Sullivan (1979) reported that black-tailed deer showed did not avoid eating glyphosate-treated forage in simulated feeding trials.

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