.laska Department of Fish and Game
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Federal Aid in Wildlife Restoration
Research Progress Report

Wildlife Habitat Enhancement in the Spruce-Hardwood Forest of the Matanuska and Susitna Valleys

by

William B. Collins

Grant W-24-2
Study 1.44
December 1994

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PROGRESS REPORT (RESEARCH)

State: Alaska

Grant W-24-2 Grant Title: Wildlife Research and Management

Study 1.44 Study Title: Wildlife Habitat Enhancement in the Spruce-Hardwood Forest of the Matanuska and Susitna River Valleys

Period Covered: 1 July 1993-30 June 1994

SUMMARY

A 365 ha black spruce (Picea mariana) site was burned by prescription in July 1993.
76 kg of the 78 kg/ha total browse utilized in early successional stands was feltleaf willow.
Rose (Rosa acicularis) and high bushcranberry (Viburnum edule) were utilized at 19 and
During this reporting period, techniques for enhancing wildlife habitat through prescribed burning, livestock grazing, timber harvest activities and other mechanical methods were tested.
Suckering of aspen (Populus tremuloides) and scouler willow (Salix scouleriana) has been stimulated. Approximately 20% of the moss/duff layer was burned to mineral soil potentially providing a seedbed for birch (Betula papyrifera) and willow (Salix) seedlings. An 1820 ha black spruce site has been prepared for prescription burning in 1994. Both sites are adjacent to the Susitna River floodplain and should increase browse availability for moose (Alces alces) wintering there.

A 12-year study of Susitna River vegetation/habitat succession was completed. Early successional willow/balsam poplar (Salix spp/Populus balsamifera) stands were the most productive for wintering moose, followed by mature balsam poplar stands. Approximately 34 kg/ha, respectively, for a total of 53 kg/ha in mature balsam poplar stands. Even though biological potential for rejuvenation of browse growing out of reach in early and mid successional stands is high, the cost cannot be justified, given the unpredictable life of those sites in an unstable, braided river floodplain. Harvest of mature balsam poplar within the floodplain does not increase browse for moose, even if harvesting and site preparation is done properly.

High intensity, short duration grazing by livestock was continued a second year to determine its value for controlling bluejoint (Calamagrostis canadensis) grass competition and stimulating natural regeneration of birch and willows. Bluejoint carbohydrate reserves, important to spring greenup and as indicated by etiolated growth, were reduced 63% and 93% by one and two seasons, respectively, of short duration, high intensity grazing. Reserves were reduced 73% after one season of continuous heavy grazing. Reduction in litter and exposure of mineral soil by hoof action has produced numerous

microsites for hardwood seed germination. However, competition from bluejointwill not have been adequately reduced for new hardwood seedlings to survive, until potential grass regeneration by seedlings has been significantly reduced. Water quality downstream from grazing paddocks remained unaffected.

Studies of timber harvest practices, browsing influences on reforestation, and browse stand maintenance were continued.

A pilot project for determining the role of experience and maternal behavior in the distribution and welfare of moose was begun.

Key Words: boreal forest succession, logging, livestock grazing, browse, prescribed fire, *Alces alces*.

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BACKGROUND

Most wildlife in the boreal forest benefit from presence of hardwood species and associated early successional vegetation. Since boreal forest succession leads toward domination by spruce, presence of hardwood species is largely dependent upon retrogressive disturbances.

Historically, the two principal forces responsible for retrogression of forests and maintenance of habitat diversity have been fire and erosion by rivers and streams (Rowe 1961). Both of these remove overstories and expose mineral soil, creating ideal conditions for hardwood seedling establishment (Viereck and Schandelmeier 1980, Zasada et al. 1983, Perala 1987).

One significant problem faced by managers of moose populations today and in the future is maintenance of adequate habitat (Franzmann 1978). Traditional winter range is the most likely portion of moose range to be encroached upon by man.

Of much greater significance than loss of habitat to development are the far-reaching effects of land management policies which unwittingly cause extensive, yet insidious, disruptions in the diversity and productivity of habitats and their wildlife. Fire suppression to protect scattered, remote inholdings established by state land disposals is a case in point.

Loss of early successional habitat is aggravated by the fact that clearing and road building often stimulate development of early successional species in and near areas of greatest human presence. Such situations are highly attractive to moose experiencing browse shortages where forest succession has progressed beyond browse-productive early stages. This results in unnecessarily high numbers of moose/vehicle collisions, property damage, and dangerous moose/human confrontations.

Principal hardwood species--birch, balsam poplar and most willows--require full sunlight and exposure to mineral soil to regenerate from seed (Rowe 1961, Argus 1973, Viereck and Schandelmeier 1980, Perala 1987). Density of root and/or stump sprouts by these species is often marginal or insufficient for hardwood forest regeneration. By contrast, aspen regenerates well by root sprouting, if apical dominance for the clone is eliminated by total removal of standing trees.

Complete removal of forest canopy by logging provides the same full-light conditions and elimination of apical dominance as does overstory removal by fire. However, with the exception of aspen, it is critical soils be scarified following logging, so that hardwood seeds will have exposure to mineral soil. It also appears that timing of scarification relative to seed availabilities of various species has considerable effect on which species dominate early succession.

Competition from bluejoint grass represents a major problem for hardwood reestablishment in cutover areas in Southcentral Alaska. Bluejoint readily monopolizes cutover areas of the boreal forest (Mitchell and Evans 1966, Collins 1992a) and greatly limits opportunities for successful hardwood germination. Bluejoint not only competes for soil nutrients, but reduces their availability by insulating soil and limiting soil microbial activity. It also competes for light, and is primarily responsible for snow press damage or mortality where it lays over the top of new hardwood seedlings (Kabzems 1992).

Although logging may represent a useful tool for maintaining diversity and productivity of boreal forest where fire is excluded, little attention has been given to regeneration of hardwood species. Most commercial timber operations have not had any concern for the future of sites harvested. From observation of the few sites where some form of scarification occurred, it is apparent that proper site preparation can increase hardwood density 40-100x or more. However, incorrect methods of scarification can also devastate a site by too severely disrupting its nutrient, moisture and temperature relationships.

Bluejoint is intolerant of intensive cropping, particularly if grazing begins in early spring and the grass is completely cropped 3 times or more during the growing season (Mitchell 1979, Rieger and Wunderlich 1960). Thus, intensive grazing should open the community to entry by other species, including browse. In fact, overgrazed pastures have developed into some of the best moose winter range in the Matanuska and Susitna Valleys. Potential for livestock competition with other foragers in bluejoint-fireweed disclimax communities is extremely limited, since bluejoint is essentially the only livestock forage species present (Mitchell and Evans 1966) and is excessively abundant throughout the region.

In the planning and development of habitat enhancements for moose, wildlife managers need to confidently predict which moose will exploit enhanced habitats. This is particularly important if the purpose of enhancement is to modify winter distribution of a specific subgroup of moose by "intercepting" them along the course of their seasonal migration.

At present, we do not know if new food patches are exploited primarily by moose which traditionally winter in the same general area, or if moose migrating through the area modify their movements to include the new food patch in their winter range. We understand little regarding how age, sex or maternal influence may affect the likelihood of moose using new food resources. Major obstacles to addressing these questions are that habitat enhancement is a bureaucratically and biologically lengthy and uncertain process. Consequently, it is difficult to predict with much certainty where pretreatment behaviors of moose should be identified. An alternative approach to addressing some aspects of this question may be to take moose to already enhanced habitat rather than to count on being able to take enhanced habitat to a preassessed group of moose.

Related to the exploitation of enhanced habitat is the question of how orphaning affects seasonal migration and home range establishment in calves. Both vehicle and hunter kills of cows are relatively concentrated geographically. Do calves establish their winter range in close proximity to where their mothers are killed in fall/winter migration across major transportation corridors, thereby perpetuating or increasing the problem of vehicle/moose collisions? Are calves that are orphaned by hunting more likely to exploit new winter food patches than non-orphaned calves?

On a related matter, wildlife managers are increasingly criticized for the effect legal harvest of cows has on calf survival. Yet, little is known about the fate of calves under such management.

During the 1980s, increasing concern regarding losses of wildlife habitat to human encroachment and by vegetation succession and potential impacts of commercial timber harvests led to the initiation of this project.

This report contains information collected from 1 July 1993 through 30 June 1994. Jobs include: black spruce type enhancement, Susitna River vegetation/habitat succession, livestock grazing to stimulate hardwood establishment, browse stand maintenance, stimulation of hardwood regeneration on logged sites, and establishment or modification of moose home range relative to enhanced habitats.

OBJECTIVES

Study Objective

1. To test and evaluate techniques for enhancing or maintaining wildlife habitat in the boreal forest of Southcentral Alaska.

Job Objectives

2. To determine methods of converting upland black spruce forest to productive stands of browse.

3. To document vegetation succession and associated habitat characteristics on the Susitna River floodplain for evaluation of habitat enhancement potential.

4. To evaluate livestock grazing as a means of stimulating hardwood regeneration in cutover forest.

5. To determine the effectiveness of hydroaxing and burning to maintain the availability and productivity browse within hardwood stands.

6. To test the effectiveness of different mechanical and chemical means for enhancing the establishment of hardwoods on logged sites.

7. To determine the effects of prior experience and maternal influence on the winter distribution of moose and their utilization of new food patches.

METHODS

Black Spruce Type Conversion (Job 2)

In cooperation with Division of Forestry, we burned by prescription 365 ha of upland black spruce adjacent to prime moose winter range near Willow, AK. The forest was ignited in strips using the Canadian "ping pong ball" system.

Prior to the burn, I established a grid of 200 sensors to monitor fire intensity relative to fuel accumulations, vegetation, soil moisture and atmospheric conditions. Fire-sensitive paints (developed for foundry uses) were applied to aluminum tags 1 m above ground for recording temperature at 56o C increments (Cole et al. 1992) and to thermal insulative boards and tiles for measuring heat penetration into ground cover/soil. Paint which changes in appearance at 60o C was also applied to ground sensors to record the penetration depth of killing heat. Vegetation recovery will be assessed relative to these data.

I continued monitoring hardwood establishment and herbaceous recovery in upland black spruce stands mechanically cleared in 1991.

Susitna River Vegetation/habitat Succession (Job 3)

Vegetation/habitat succession plots established within the Susitna River floodplain between Deshka River and Chase in 1982 were revisited to determine changes in plant species dominance and physical development of sites. I prepared two manuscripts for publication.

Livestock Grazing to Stimulate Browse Establishment (Job 4)

Two grazing paddocks were fenced within wet, clear-cut stands of birch-spruce forest. Both sites are on poorly drained soils overlying glacial till. All reforestation efforts have failed due to extreme competition from bluejoint grass. Previous reforestation efforts included intense scarification with a root rake, followed by burning, followed by planting of 60 cm-tall seedlings of spruce and balsam poplar.

High intensity, short duration grazing by cattle and/or horses heavily and uniformly utilizes bluejoint through the growing season. A second paddock is being heavily grazed continuously through the growing season. Grazing treatments will be maintained for at least 3 years to eliminate seed production and reduce viability of residual seeds, and to radically deplete grass carbohydrate reserves and competitive vigor. Grazing was begun on the first paddock in spring 1992, the second in spring 1993.

Grass productivity and phenology are documented between each grazing period. Carbohydrate reserves of bluejoint grass are indexed by measurement of etiolated growth each spring. Forage quality (crude protein, digestibility and crude fiber) is determined biweekly through the growing season. Water upstream and downstream of both paddocks are monitored for total nitrogen and E. coli.

Hardwood seedling density and development is measured at the end of each grazing season.

Browse Stand Maintenance (Job 5)

Old stands of feltleaf willow (Salix alexensis) along
the Gulkana River north of Paxson, AK were hydroaxed in early spring 1993 prior to leafout. Even though this area had been heavily used by wintering moose, most willows had grown beyond the browsing reach of moose. Availability and winter utilization were measured in spring 1994 using the Shafer (1965) twig count method.

Browse production and utilization in birch and aspen stands in the Matanuska Valley which were hydroaxed in late winter 1991 and 1992 are measured annually.

Mechanical and Chemical Site Preparation (Job 6)

Hardwood seedling density and herbaceous plant recovery were monitored on different hardwood-spruce stands which had been scarified to enhance hardwood regeneration. The scarification methods used were summer skidding, flat blading, root raking (clearing blade), disk trenching, and whole-tree clearing. A disk trencher is an implement developed in Finland for creating planting sites for conifers. Its use in Canada for preparation of planting sites in the boreal forest became popular in the early 1980s (Coates and Haeussler 1987). Whole-tree clearing involves uprooting of the entire tree by a dozer, bunching, and removing stumps and limbs after skidding the tree to a landing. The process of whole-tree clearing creates a relatively high degree of scarification, with minimal displacement of nutrient-rich soil into piles.

Hardwood seedling densities, bluejoint grass height and productivity were monitored on three clearcuts treated with glyphosate in 1991 and 1992 (Collins 1992b).

Exploitation of Enhanced Habitats by Moose (Job 7)

Initially, this job was approached opportunistically as a pilot project. As moose arrived on winter range, cows with calves and orphaned calves were collared and relocated from populated areas of Palmer and Wasilla to recently enhanced habitat at Point MacKenzie. When possible, cows (with calves) which previously had their home ranges determined through earlier radiotracking studies were relocated. Calves orphaned in late May and September were also relocated to Point MacKenzie. Calves orphaned in late May were bottle fed for 30 to 35 days prior to relocation. Locations of all individuals are determined monthly to establish if there are differences between the two groups in terms of their affinity toward highly productive browse areas and establishment of home ranges. I am also determining the differences in calf mortality between the two groups.

RESULTS AND DISCUSSION

Black Spruce Type Conversion (Job 2)

A 900 acre area near Rolly Creek was burned by prescription on 13 and 14 July 1993. Ignition of the main fire was preceded by a 2.5 acre test fire. The main fire was started at approximately 1730 on 13 July. Most burning was accomplished in the first 5 hours. After that, rapidly rising relative humidity restricted attempts to burn out unblackened areas. The fire was declared out on 18 July, although smoldering continued for two more weeks in isolated interior portions of the burned area. After that, rain extinguished remaining hot spots.

The fire was ignited in a series of strips in advancing succession into the wind. At the time of ignition, wind was SSE, variable at 3-5 mph at tree-top level. Ignition proceeded rapidly while relative humidity was below 35%. Fuels had dried for two days under northwesterly air flow and low relative humidity, but we could not ignite the fire until winds shifted to the south to carry smoke away from populated areas. Upon wind shift to the south, relative humidity began to rise, only falling below 35% in the late afternoon of 13 July. In terms of actual burning conditions, prescribed fires in the Susitna Basin will probably always be limited to a similar sequence of conditions, since low relative humidities are generally associated with airflows out of the interior and smoke management will always require southerly flows.

Fire rapidly carries through this type of vegetation when fuels are dry and relative humidity is less than 35%. Surface materials, consisting primarily of feather moss, dead needles, ericaceous shrubs and foliose lichens are the principal fuels involved. In 1994 Ottmar and Vihranek (pers. commun.) reported the Rolly Creek fire consumed 47-54 metric tons of fuel per hectare, of which 40-44 metric tons were surface material. Standing dead trees and living twigs with needles accounted for most of the remaining fuel consumed.

Use of temperature-sensitive paints on aluminum tags were not adequate for recording temperatures 1 m above the forest floor, and limited our interpreting fire intensity. Seventy-seven percent of tags melted during the fire, indicating temperatures in excess of 631oC (1180oF), the melting point of aluminum. However, none of the copper wires affixing tags to stakes were melted, indicating fire temperature did not exceed 1071oC (1980oF).

Surface temperature monitors were much more useful in recording biologically significant characteristics and effects of the fire and will be useful as I interpret subsequent vegetative recovery of the site.

The significance of surface materials in the spread and effect of fire was reinforced by the way ash accumulations from the 1992 Mt. Spur eruptions retarded spread of this fire. Volcanic ash accumulated up to 5 mm deep on top of fallen deciduous leaves and foliose lichens, whereas it dispersed down through the living profile of feather moss. Fire did not burn ash-covered aspen leaves nor did killing temperatures penetrate those profiles, whereas fire did consume mosses. In many locations volcanic ash also retarded fire in mosses where it was able to consolidate into a suffocating layer as the fire burned successively deeper into the moss.

In the area knocked down 1 year prior to burning, fuel moisture in 2.5-7.6 cm diameter stems had only declined to 42%, versus 61% for living trees. Stems 0.6-2.5 cm in diameter had dried to 19 % moisture, versus 41% for standing forest, adding significantly to the accumulation of combustible fuel on the knocked down site. Fuels on the knocked down site were also concentrated closer to the forest floor, providing an environment for hotter and longer-lasting fire.

Both moss and duff in the knocked down area had dried to less than 25% of their moisture in undisturbed forest. Even so, greater fuel loading, combined with significantly drier moss/duff in the knocked down site, resulted in only 13% more reduction of forest floor depth (Table 1). In either case, reduction of forest floor material (moss and duff) occurred primarily in the moss layer. The slight increase in consumption of forest floor and the fact that percentage of mineral soil exposed (Table 1) was roughly equivalent in both standing and knocked down forests suggests that little was accomplished by slashing 1 year prior to burning. An additional year of drying would have resulted in much more downed material being consumed, since 2.5-7.6 cm stems contained 26% moisture after two years of drying. However, it is questionable whether additional drying of larger stems would have greatly increased exposure of mineral soil. The final value of pretreatment by slashing will not be determined until vegetation has had a chance to respond. Consolidation of fuels by slashing would be of value where restrictions in burn prescriptions and/or lack of carrier fuels would not support spread of the fire.

Table 1. Characteristics of black spruce forest floor before and after burning.

site	preburn				postburn				
	% moisture moss	% moisture duff	cm depth moss/duff		cm moss/duff consumed		cm depth killing heat		% bare ground
slashed (1 day)	17	110	11.8	(3.2)	7.6	(3.1)	1.6	(0.6)	22.4
slashed (1 year)	5	21	11.9	(3.7)	8.4	(3.2)	2.4	(1.6)	23.5
forest hot fire	20	110	11.3	(4.4)	7.3	(3.8)	1.5	(0.7)	22.2
forest creeping fire	19	102	11.3	(3.6)	4.4	(4.9)	2.3	(2.3)	20.0

Work indicates there are no economically justifiable options for habitat enhancement in glacial river floodplains. While browse within early and mid successional stands could be rejuvenated and production greatly increased through crushing or hydroaxing (see Job 5), the life expectancy of floodplain sites in early and mid successional stages is too unpredictable to justify expenditures for enhancement.

Floodplain stands of mature balsam poplar and birch-spruce can be reverted to earlier successional conditions through logging and scarification. However, intense competition from bluejoint grass has caused almost complete failure of hardwood regeneration in floodplain stands not scarified in a timely manner.

Logging of floodplain stands of mature balsam poplar primarily for the purpose of habitat enhancement does not seem justifiable, since those stands are second only to early successional hardwood stands in browse production, and properly logged stands have not
It is noteworthy that exposure of mineral soil and depth of heat penetration in areas where the fire crept along the ground were roughly equivalent to what occurred where the fire rapidly consumed the overstory and where the forest had been pretreated by slashing. This is one more indication of the importance of forest floor characteristics in the effects of fire on seedbed preparation. Overstory functioned primarily to spread the fire rather than affecting the preparation of seedbed. Ability of the overstory to carry fire was also essential in reduction of shading effects.

By the end of September 1993, aspen and willow were resprouting vigorously, ranging in height from a few centimeters to more than 40 cm. High soil temperature, resulting from reduced cover and a black surface, coupled with early summer dryness, precluded germination of most herbaceous species by late June 1994. One significant exception was seen in the profuse germination of Rock Harlequin (Corydalis sempervirens) in late August 1993. These annual/biennial plants grew to 1 cm in height before winter, but overwintered and grew to 90 cm by mid June 1994, completely dominating the site. This species was never observed in any of my surveys of undisturbed forest, and its occurrence in the burn area is slightly beyond the range described by Hulten (1968).

By mid June 1994, dense mats of a large thalloid liverwort (Marchantia polymorpha) had established in knocked down portions of the burn where mineral soil had been exposed. Scattered individuals of fireweed (Epilobium angustifolium), bluejoint grass and an unidentified Carex sp. were also resprouting by mid June 1994. Additional herbaceous species should begin to establish in late summer 1994. In fall 1994 I will measure browse production and herbaceous cover relative to surface fire intensities.

The Rolly Creek fire was successfully accomplished primarily because Division of Forestry personnel from Big Lake were willing to try to work prescription fire needs around their first priority, fire suppression. The fact that the Big Lake DOF staff fortuitously included all personnel necessary for a prescription fire also favored implementation and success of the burn. Last, but not least, weather cooperated, falling within prescription when necessary firefighting personnel were not committed to wildfires.

Final cost for the fire was $38,160.65 or $104.77/ha. By comparison, mechanical clearing of an identical black spruce stand of equivalent remoteness cost $514.78/ha. Since Rolly Creek was the first prescribed fire of this magnitude by Big Lake DOF, many extra backups and controls were implemented which were responsible for most of the cost. Future fires of equivalent size and having natural barriers to fire spread similar to those at Rolly Creek will likely cost 70 percent less per hectare. One additional cost not incurred at Rolly Creek will be a new EPA-mandated charge for emissions scheduled to take effect in 1995. If such a mandate had been implemented in 1993, the Rolly Creek fire would have cost an estimated additional $4000.00 ($10.97/ha).

The Rolly Creek fire provided a good opportunity for DOF to test its organization and resources in a prescription fire. Consequently, DOF has established a solid basis from which to prepare future prescriptions. In fact, preparation of the Trapper Lake prescribed fire (scheduled for 1994) was greatly simplified by experience from the Rolly Creek project, and there is a greater willingness to tackle this type of project. Availability of personnel for assignment to prescription burning while fire suppression needs are high is still a problem, however, and will probably remain so unless a prescription burning program becomes of sufficient size to warrant hiring personnel for that priority.

Susitna River Vegetation/habitat Succession (Job 3)

Two manuscripts relating to this job have been prepared for publication. In summary, this created more browse than precut conditions. In mature balsam poplar stands moose consumed 19 kg/ha of rose and 34 kg/ha of high bushcranberry. In early successional browse stands moose utilized 78 kg/ha of browse, 76 kg/ha of which was feltleaf willow. Limited availability of principal browse species (high bushcranberry and rose) in balsam poplar stands during winters of greater-than-normal snowfall may be a concern, depending on when moose typically make their greatest utilization of those species. This should be investigated.

Concern that islands vegetated by mature balsam poplar, birch or spruce would lose their integrity, becoming more subject to erosion following overstory removal, is unwarranted. Root systems of boreal trees do not protect island substrates from erosion by river currents. Most islands are destroyed by currents cutting alluvium from beneath root systems (which in late succession tend to be perched above all but the highest flows). In fact, erosion more readily breaks apart root systems of intact trees, because gravity and river currents are able to leverage tipping boles and branches to pull roots from banks.

Livestock Grazing to Stimulate Hardwood Establishment (Job 4)

Beginning in spring 1992, cattle were grazed in one experimental paddock for short durations (8 days or less) to utilize 90 percent of bluejoint regrowth during that grazing period. Three periods of grazing were established, the first within the first week of greenup in spring, the second in early July, and the last in late August. A continuous grazing schedule was initiated in a second paddock beginning in spring 1993, using horses in place of cattle. The entire sequence will be repeated for three or more years in each paddock.

Cattle weights did not vary significantly from beginning to end of any grazing period. It seemed grazing intake rapidly declined during the last two days of each period with excessive utilization, thereby canceling any gains made early in the grazing period.

Cattle and horses consumed much of the standing dead grass from the previous year, and their hoof action accelerated breakdown of remaining litter, resulting in approximately 15 percent of the site being adequately exposed for hardwood seedling establishment. New birch and spruce seedlings were observed in the first paddock in early September 1992. However, it is still uncertain if remaining potential for competition from bluejoint will prevent survival of those seedlings.

Etiolated bluejoint growth inside paddock 1 was reduced by 63% and 93% after 1 and 2 years of grazing, respectively. Etiolated growth in Paddock 2 showed a 73% growth reduction following continuous grazing for 1 season. No significant reduction in etiolated horsetail production occurred, and sample size was not adequate to test for differences in fireweed production. Grass greenup inside paddocks preceded that outside by 8-10 days with no evidence of grass mortality. Early greenup inside paddocks resulted from earlier soil warming enabled by litter reduction.

Although paddocks have been severely grazed, total NO3 in pasture runoff has remained below 1 ppm. E. coli counts in water above paddock 2 increased to a high of 133/100 ml in midsummer while downstream it increased to 170/100 ml; both values are well within natural levels for that time of year. No runoff was observed from paddock 1.

Browse Stand Maintenance (Job 5)

Within 3 growing seasons, birch density in a hydroaxed 23-year-old birch-dominated stand increased from 10998 to 59583 stems/ha. Scouler willow and balsam poplar in the same stand increased from 507 to 8125 stems/ha and from 126 to 875 stems/ha, respectively. Browsable current annual growth of birch increased from 0 to 93 kg/ha; scouler willow, 5 to 49 kg/ha; and balsam poplar 0 to 6 kg/ha.

Stem density of feltleaf willow hydroaxed along the Gulkana River in late winter 1993 increased 47x by stump sprouting in the first season, with total available browse above snow depth increasing by more than 3x. Such high stem densities are expected to decline significantly each year for the first few years, but at the same time, surviving stems will produce increasing amounts of browse within reach of moose. Maximum net gain in browse production probably will not be realized for 4 or 5 years.

Mechanical and Chemical Site Preparation (Job 6)

I am continuing to monitor plots treated with glyphosate in 1990 and 1992 for hardwood density and growth rates and bluejoint productivity. At this time, glyphosate appears most beneficial for control of bluejoint competition with planted tree seedlings, if the resultant grass aftermath is left undisturbed to serve as a mulch for retarding germination of bluejoint. Reestablishment of bluejoint and other herbaceous plants is much more rapid on sites where aftermath is burned or scarified following herbicide kill. On highly productive wet sites, dense bluejoint aftermath is still blocking reestablishment of all plant species 3 years after treatment.

While dense accumulation of killed bluejoint is effective in reducing competition with planted trees, it does not support natural regeneration by hardwoods. At this time, I cannot conclude if there is an advantage to scarification being preceded by a single glyphosate kill of bluejoint, since bluejoint recovery from seeds is rapid and profuse where soil has been disturbed. However, there does appear to be a distinct advantage for natural hardwood establishment where secondary treatment by glyphosate is used to kill new bluejoint established from seeds following kill of the original bluejoint stand.

Exploitation of Enhanced Habitats by Moose (Job 7)

Twelve orphaned calves were relocated to Point MacKenzie. Regardless of the date of relocation, all calves remained in the vicinity of their release sites until May 1994. Since then, all but two have begun to migrate to the north and west and one to the southernmost tip of Point MacKenzie. One small but apparently healthy male calf died of pneumonia in mid January 4.5 months after it was relocated.

Four cows with their calves were relocated in winter. One cow was killed by a car on a high speed but lightly traveled stretch of road 2 days after it was relocated. A male calf of a pair of twins separated approximately 5 km from its cow and twin in March and died in early April of unknown cause (there was no evidence of predation). By May each of the 3 remaining cows and their calves had begun migration to the east or north, but by June it appeared that none had allowed enough time to reach former calving areas.

All relocated moose alternately utilized dense hardwood regrowth in abandoned fields and adjacent forest, remaining primarily within 1.5-2 km of the place of release until snow cover began to dissipate in spring.

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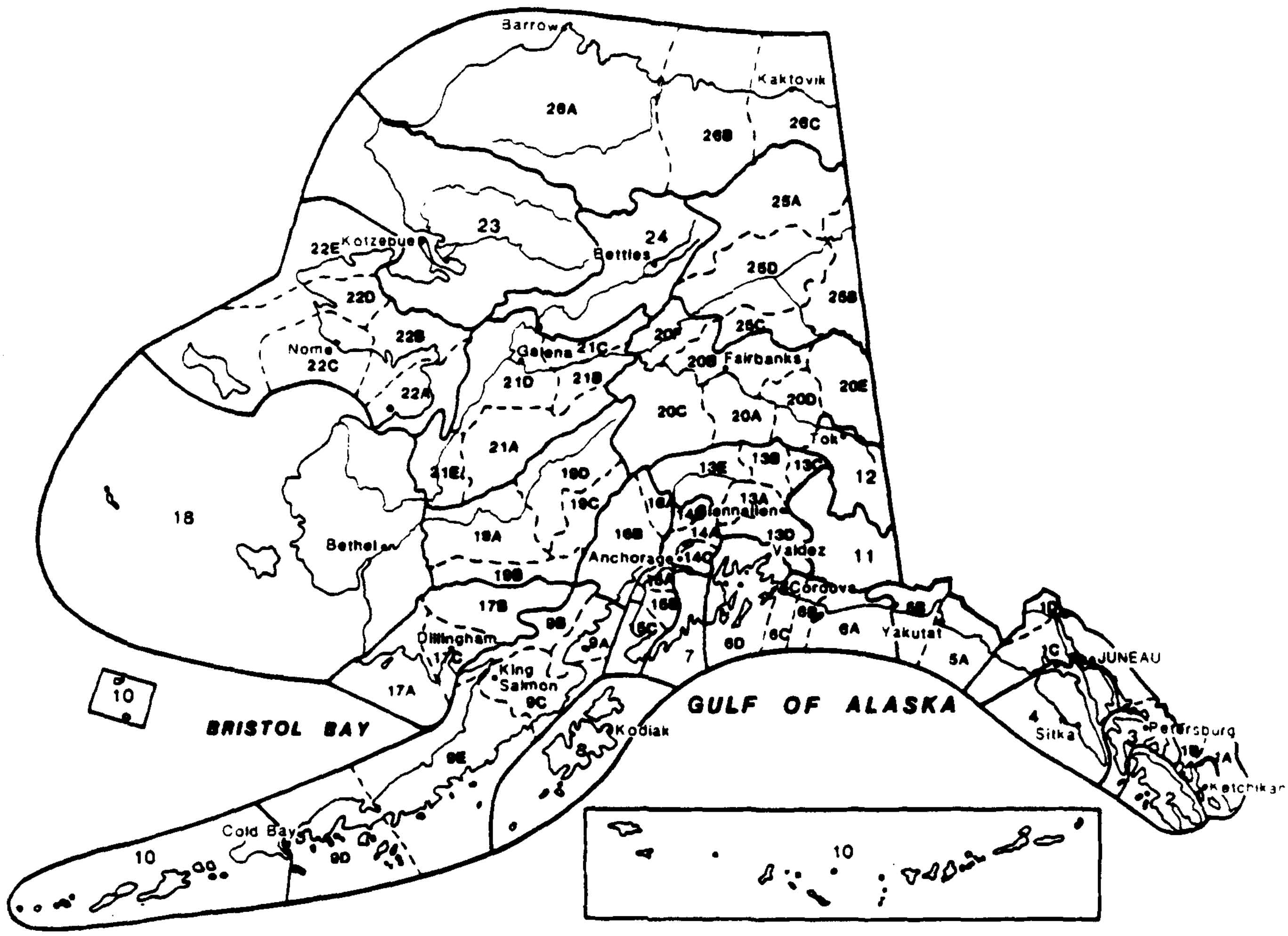
Alaska's Game Management Units



Federal Aid in Wildlife Restoration

The Federal Aid in Wildlife Restoration Program consists of funds from a 10% to 11% manufacturer's excise tax collected from the sales of handguns, sporting rifles, shotguns, ammunition, and archery equipment. The Federal Aid program then allots the funds back to states through a formula based on each state's geographic area and the number of paid hunting license holders in the state. Alaska receives 5% of the revenues collected each year, the maximum allowed. The Alaska Department of Fish and Game uses the funds to help restore, conserve, manage, and enhance wild birds and mammals for the public benefit. These funds are also used to educate hunters to develop the skills, knowledge, and attitudes necessary to be reponsible hunters. Seventy-five percent of the funds for this project are from Federal Aid.