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Identifying and Evaluating Techniques for Wildlife Habitat Enhancement in Interior Alaska

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Research Interim Technical Report
16 August 1999–30 June 2002

Project 5.0

Al Keech, DWC Wildlife Technician, stands in a 1986 willow crushing site on the Tok River floodplain. Counts of moose fecal pellets indicate that regenerated feltleaf willow continues to provide substantial browse to wintering moose. (ADF&G photo)

This is a progress report on continuing research. Information may be refined at a later date. Please reference as: Paragi, T. F. and D. A. Haggstrom. 2004. Identifying and evaluating techniques for wildlife habitat enhancement in Interior Alaska. Alaska Department of Fish and Game. Research Interim Technical Report. Project 5.0. Juneau, AK.

RESEARCH INTERIM TECHNICAL REPORT

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SUMMARY

An active habitat enhancement program is needed to mitigate the negative impacts of human development on wildlife and adequately respond to the growing human desire to observe or harvest wildlife. This is particularly true near populated, road accessible areas of Interior Alaska (Haggstrom and Kelleyhouse 1996). Wildlife and land managers must weigh the costs of habitat manipulation (and its evaluation) against costs for monitoring population status of harvested and nongame species, law enforcement, and research on recruitment and mortality factors in wildlife populations (Thompson and Stewart 1997). Enhancement techniques that are effective, affordable, and acceptable must be developed to optimize use of limited financial resources and to address often conflicting public concerns over wildlife and associated land management practices.

Vegetation in boreal forest is rejuvenated largely by stand-replacement fire and secondarily by smaller disturbances such as flooding, erosion, ice scouring during river breakup, mechanical damage from ice and wind, insect defoliation, and tree disease. Decisions on when and where to suppress wildland fire has a major influence on dispersion and productivity of wildlife habitat, particularly in areas underlain by permafrost. Prescribed fire and mechanical treatments (i.e. timber harvest, clearcut tree felling without salvage and willow [*Salix* spp.] crushing) often supplant wildland fire near settlements as the desired technique to maintain early-successional vegetation for wildlife. These methods also serve to periodically reduce the amount or dispersion of fire fuels (Haggstrom and Kelleyhouse 1996). Fiber markets for deciduous trees in Alaska are currently limited to local use, largely as fuel wood, so harvest (revenue generation and bole removal) is not a widespread option for habitat management in broadleaf forest. Nonharvest treatments are applied during the dormant period (Sep–Apr), when substantial reserves in deciduous trees are below ground and available for subsequent nourishment of sprouts (Daniel et al. 1979). Although habitat management is done

to benefit selected game species on some sites, we recognize that returning disturbance to boreal forest benefits a host of species and we understand that habitat maintenance is a large component of maintaining the natural diversity of species and ecosystem functions (the “coarse filter” approach to conservation biology; Noss 1987).

This report provides evaluation on habitat management and research efforts from mid-August 1999 to 30 June 2002. The present habitat enhancement program was initiated in 1994 to experiment with a broader range of techniques and address on-going habitat needs across DWC Region III (Interior Alaska). In August 1999, Tom Paragi was hired as a regional biologist in DWC to help plan and carry out habitat enhancement projects (particularly in rural areas) and to evaluate whether projects had achieved their objectives. Evaluation includes developing or identifying techniques for cost-effective monitoring of enhancement projects.

During this reporting period, we began reviewing literature on sampling stem density in shrub communities, monitoring habitat use through furbearer track counts in winter, indexing the population dynamics of ruffed grouse (*Bonasa umbellus*) and moose, and response of vertebrate species to timber harvest in boreal forest. At the stand scale, we evaluated sprouting response by quaking aspen (*Populus tremuloides*) after prescribed fire and mechanical treatments near the road system. We also evaluated survival of feltleaf willow (*Salix alaxensis*) stems planted after broadcast burning in a timber sale at Standard Creek, west of Fairbanks. At a proposed timber sale in white spruce (*Picea glauca*) along the Tok River, we documented baseline conditions of browse stem density, horizontal and vertical cover, and depth of soil active layer above permafrost, and established transects to sample track intersections of furbearers and their prey during winter (relative abundance among habitats) in 12 of 51 proposed harvest sites. The efficacy of postlogging site treatments (disk trenching, blade scarification, and broadcast burning) for regenerating woody browse and cover will be evaluated by randomized block design in the 12 study sites at Tok River. Transects for sampling the abundance of moose pellet groups (index to habitat use) were also established within the 12 study sites and in adjacent riparian areas.

Sampling at the landscape scale to date has been to establish baseline conditions against which posttreatment changes in vegetation or wildlife populations will be compared to infer treatment effects. Prescribed burning to increase forage quantity and dispersion for plains bison (*Bison bison*) and moose is proposed near Farewell, southeast of McGrath. In this area, aerial photos of vegetation were systematically taken in May 2000 within a 18,210-ha (45,000 ac) perimeter. In cooperation with the Alaska Bird Observatory (ABO), breeding surveys of passerine birds were conducted in June 2000 and 2001 near the Tok River to establish species diversity and habitat associations prior to the proposed timber harvest. ABO also conducted the first of 2 similar passerine surveys at Nenana Ridge in June 2002 where we are creating age diversity in broadleaf forest to benefit early-successional wildlife.

Key words: Alaska, aspen, birch, bison, boreal forest, browse, cavity trees, debris, forestry, furbearers, habitat, logging, moose, prescribed fire, ruffed grouse, silviculture, snags, songbirds, willow.

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BACKGROUND

The habitat enhancement program in Division of Wildlife Conservation (DWC) Region III focuses on the inventory and management of boreal forest vegetation to achieve objectives for wildlife populations. We consider ecological processes and enhancement projects at 2 scales: stand and landscape. The *stand* concept was developed by foresters to define groups of trees having similar species composition and age classes and a consistent site index (height or diameter of tree at a given age) indicative of site productivity (Daniel et al. 1979). Stands in Interior Alaska may range up to 40 ha (100 ac; EC Packee, University of Alaska Fairbanks, personal communication). The size, shape, and composition of stands are influenced by landform, disturbance history, tree regeneration strategies, seed dispersal, and other features of tree ecology (Oliver and Larson 1996).

Silviculture is an applied science premised on managing the dominant (canopy) vegetation in stands. Silviculture indirectly influences understory communities, soil processes, water flow, and other ecological functions in a forest. The set of guidelines and practices for influencing stand composition over time to meet objectives is the *silvicultural prescription* (Daniel et al. 1979). Although silviculture is typically associated with mechanical treatments, prescribed fire may be used to achieve vigorous forest regeneration where the fate of individual trees is not important. When fire is used to rejuvenate existing vegetation or change cover type, the *burn prescription* is the set of weather parameters (wind, relative humidity, fuel moisture conditions) under which a given fuel type is ignited to produce a desired fire behavior (flame length, rate of spread, *fire intensity* [heat released per length of front]; Taylor et al. 1996) and *burn severity* (extent to which organic layer is consumed) to favor root sprouting or seed germination by the desired species.

In the vernacular, "forest" describes an area with trees. A more specific definition of forest is a *landscape* comprised of multiple stands that together have emergent properties greater than those of the individual stands. Forest management requires understanding of how stand-scale management influences ecological properties or human–wildlife interactions at the landscape scale because management decisions may have different results at different spatial and temporal scales (Hunter 1990, 1999). Landscape scale refers to ecological processes from hundreds to tens of thousands of hectares. The large prescribed burns designed by DWC to maintain natural diversity in wildlife habitat are spread by aerial ignition to minimize cost and incorporate spatial features such as variation in fuel type and burn severity associated with large wildland fires that periodically occur in boreal forest. Large areas of timber harvest or mechanical treatments, where several sites are grouped along access roads, may have cumulative effects on habitat and populations at the landscape scale.

One challenge in applied research on habitat enhancement will be to learn how forestry practices (harvest and regeneration) and other mechanical treatments can or cannot emulate natural disturbance such as flooding or ice scouring along rivers or wildland fire. For example, vegetation diversity of Interior forests differs between logged and burned sites during the early-to-mid successional stages but then convergence after several decades (Rees and Juday 2002). The goal of applied research should be practical guidelines that minimize detrimental effects of mechanical treatments to wildlife habitat and populations (Bunnell 1997). Further, although the biological responses of wildlife populations to habitat changes are important to understand, social responses of people to changes (such as creating road access in roadless areas) can greatly affect human–wildlife interactions and public perception of habitat enhancement projects (Decker et al. 2001).

Finally, replication of field experiments has been recognized as a means to advance knowledge of natural processes and applied science in renewable resource management (Johnson 2002). Substantial knowledge of silviculture already exists in other areas, but our management projects and applied research are focused on efficient and effective application in Interior Alaska. Development of cost-effective procedures for evaluating management projects will allow quasi-replication of treatments that should improve predictions of vegetative and animal responses to habitat manipulations over a range of scales and site conditions.

STUDY OBJECTIVES

1 Work with state and federal agencies and the private sector to plan, coordinate, and implement forest management activities to maintain or improve wildlife habitat.

2 Encourage prescribed burning and other appropriate forestry practices in developed areas to offset the negative ecological effects of increased suppression of natural fires.

3 Evaluate biological and economic efficacy of prescribed burning and silvicultural practices for maintaining or enhancing wildlife habitat in boreal forest.

JOB OBJECTIVES

Job 1: Develop operational knowledge necessary to conduct habitat enhancement projects and monitor effectiveness in meeting management objectives.

Job 2: Plan, design, and conduct habitat management projects to maintain, enhance, or restore wildlife populations.

Job 3: Design and conduct long-term studies to evaluate the effectiveness of different habitat management techniques and applications.

Job 4: Design and conduct long-term studies to determine the response of wildlife populations to habitat treatments.

Job 5: Facilitate greater and more effective use of prescribed burning and other appropriate forestry practices by other state and federal agencies and the private sector, and the subsequent use of cost-effective and appropriate monitoring techniques to evaluate progress toward meeting management objectives.

Job 6: Involve and inform other professionals and the general public.

Progress on Job Objectives 3 and 4 is research related and is described in this report. Progress on Job Objectives 1, 2, 5, and 6, which are partly management related, are reported by

Haggstrom and Paragi in their 2000 Federal Aid Performance Report. (Haggstrom and Paragi, 2000).

STUDY AREAS AND TREATMENT OBJECTIVES

Habitat projects have been conducted since 1994 in several locations of Region III in Interior Alaska (Fig 1). Project evaluations are in progress at Farewell, Nenana Ridge, Standard Creek, Heritage Forest, Two Rivers, Delta, and Tok River. Treatment sites are partially or entirely forested and contain various proportions of coniferous and deciduous trees and shrubs. Many of the sites are underlain by discontinuous permafrost (Washburn 1973:Fig 3.6), with upland stands commonly of postfire origin in the early-to-mid twentieth century.

Farewell

A prescribed burn to maintain early-successional forage for plains bison and moose was planned during winter and spring 2000 for the region north of Farewell Station, which is about 100 km (60 mi) southeast of McGrath. The 18,210 ha (45,000 ac) maximum allowable perimeter (MAP) for the burn is located between Bear Creek and South Fork Kuskokwim River. The relatively flat terrain is lowland forest with open canopy and dominated by black spruce (*Picea mariana*) interspersed with treeless bogs, with wet areas underlain by discontinuous permafrost (Drury 1956). The most productive sites for vegetation in the upper Kuskokwim region are along major drainages and glacial moraines, where soils are well drained and warm (Hanson 1992). The prominent vegetation on south-facing slopes is usually shrubs, hardwood trees, a mixture of white spruce and hardwoods, or white spruce dominated stands. Slopes with easterly or westerly aspects have soil conditions and vegetative patterns that are transitional between those described for north-facing and south-facing aspects. Sedges, willows, bogs, and water bodies characterize valley floors (Drury 1956).

The treatment goal at Farewell is to burn at least 9100 ha (22,500 ac) on the winter range of the Farewell Bison Herd during 2000–2005 to maintain suitable habitat for bison and moose on a 20-year disturbance rotation. Short-term objectives are to:

- Reduce the coniferous cover type within the burned area by at least 75% to increase the proportion of herbaceous or deciduous woody cover types.

- Produce vegetative sprouting on at least 75% of the burned areas that were deciduous woody cover type before the burn to maintain younger age classes as accessible browse for bison and moose.

- Produce sufficient forage in the prescribed burn to maintain at least 300 bison on winter range in the Farewell area.

- Relative to current moose density, maintain or increase the number of moose seen per hour from aerial surveys.

Nenana Ridge

Nenana Ridge is a 2430-ha (6000 ac) habitat enhancement area within the Tanana Valley State Forest (TVSF) southwest of Fairbanks where aspen is managed to benefit ruffed grouse and other species that utilize early-to-mid successional deciduous forest. Mature aspen trees were felled in September or October during 1995–2001, and mature trees were treated with prescribed fire in mid-May during 1998–2001 (Table 1).

Two Rivers

Two Rivers has similar habitat compared to Nenana Ridge but is a much smaller area, also within the TVSF, in which chain saw felling occurred in autumn 1998. Aspen, white spruce, and occasionally balsam poplar (*Populus balsamifera*) are the predominant species growing on south-facing slopes, whereas paper birch (*Betula papyrifera*) and black spruce are common on north-facing sites. Sites dominated by aspen are silt loams composed of glacial loess (Furbush and Schoephorster 1977). The influence of soils and aspect on forest composition in a nearby area was described by Krause et al. (1959).

Delta

There is also a 2340-ha habitat enhancement area designated within the Delta Junction Bison Range for management to benefit ruffed grouse and other early-to-mid successional species. White spruce and black spruce regeneration was present to various degrees in the understory, with moss becoming a dominant ground cover on more heavily shaded sites. The initial treatment on this flat area was harvesting mature aspen with a feller-buncher in July 1997 and stacking tree boles (debris) in scattered piles. Shearblading (cf. Perala 1983) was conducted in March 2000 and 2002, with debris pushed into parallel windrows (concentric circular pattern) to allow sunlight to reach about 50% of the treatment area. This area is a glacial outwash plain of loamy soils with embedded silts, sands, and organics over well-drained gravels lacking permafrost (cf. Jorgenson et al. 2001).

Heritage Forest

Heritage Forest is a 1032-ha (2550 ac) flat area adjacent to the floodplain of the Chena River about 6 miles north of North Pole. The federal land is on long-term lease to the Fairbanks North Star Borough for education and recreation, and habitat manipulation is permitted for demonstration purposes. Old river meanders are a common landform with willows and balsam poplar abundant on wet sites, whereas aspen and white spruce are present on better drained soils. Shearblading was done on several aspen, paper birch, and willow sites in late March and early April 1997.

Tree felling and prescribed fire have been used to kill mature aspen trees during the dormant period to stimulate the production of aspen sprouts or suckers from the root system, a regeneration system known as coppice (Daniel et al. 1979). The objective is to kill existing aspen stems that send auxins down to the roots and suppress sprouting. General guidelines for aspen regeneration, including factors to avoid that decrease sprouting response, are known from lower latitudes (Peterson and Peterson 1995). Aspen saplings undergo substantial self-thinning over time (Doucet 1989; Mallik et al. 1997). The treatment objective at Nenana Ridge, Two Rivers, Heritage Forest, and Delta was to produce ≥30,000 aspen stems/ha (12,500/ac) by the end of the second growing season after disturbance to ensure adequate stem density for various cover and forage needs of ruffed grouse over several decades (Gullion 1984:Fig 1; Atwater and Schnell 1989:320). Dense young aspen also provide cover and abundant browse for snowshoe hares (*Lepus americanus*), moose, and other early successional wildlife (Wolff and Zasada 1979).

Standard Creek

Standard Creek is a timber harvesting area within the TVSF southwest of Fairbanks. This upland site is composed of white spruce and mixed stands of spruce with paper birch and aspen. As part of experimentation with postlogging site treatments to enhance wildlife habitat after white spruce harvest, feltleaf willow stems were planted in timber sale NC-1085-F. This site had been logged of white spruce during winter 1995–1996 and was subsequently broadcast burned on 25 July 1996. The treatment objective was to establish willow as supplemental browse for moose in addition to postlogging regeneration of paper birch from existing sources on site.

Tok River

In 1996 the Alaska Department of Natural Resources, Division of Forestry (DOF) proposed an 365 ha (880 ac) timber sale (NC-837-T) composed of 51 harvest sites in white spruce along the Tok River within the TVSF (Fig 2). Harvest sites were laid out by DOF after consulting with DWC staff to minimize negative effects of harvest or road construction on wildlife populations and to enhance habitat where possible. The floodplain forest is mixed white spruce and balsam poplar, with spruce 80–200 years old and having substantial snow breakage and insect damage (Appendix A). Proposed harvest sites are along the active channel and old river meanders. The soil in these relatively productive stands is a deposit of silty loess with a thin organic surface mat over a silt loam horizon or fine sandy loam (Rieger et al. 1979:92). Periodic flooding deposited silt over the lower lying sites, and evidence of fire is present in many stands (Appendix A). Timber harvest is scheduled to begin during winter 2002–2003, contingent on sale negotiations.

DWC objectives for postlogging site treatments at Tok River are to:

- Increase the density of young deciduous saplings and shrubs accessible as moose browse (<3 m tall) to ≥15,000 stems per hectare within harvested stands by the seventh summer after treatment (Wolff 1976; Curtois et al. 1998).
- Relative to preharvest, increase the use (pellet groups per belt transect) of harvested stands as winter range by moose.

METHODS

VEGETATION CHANGES ON STAND-SCALE HABITAT TREATMENTS

Coppice Regeneration of Aspen

In autumns 1999 through 2001 we estimated sprouting response on 6 chain saw felling sites of 3–10 ha (8–24 ac) each at Nenana Ridge and Two Rivers, 6 burn sites of 2–12 ha (5–30 ac) each at Nenana Ridge, 5 shearblading sites of 4–11 ha (9–28 ac) at Heritage Forest and Delta, and a feller-buncher harvest of 3 ha (7 ac) at Delta.

Where sprouting was inconsistent across a treatment site, we stratified sampling between continuous dense stems and patchy/sparse stems. Stratification was done in 4 of the burns and a 3-ha (8 ac) felling site treated in 1997 at Nenana Ridge that had some boles inadvertently skidded to a deck about one year after felling. We stratified the felling site into "skidding" and "nonskidding" areas to determine whether postsprouting disturbance had a detrimental effect on stem density. Within strata we sampled stems by using 1×5 m quadrats to efficiently characterize density in the clumped distribution of hardwood regeneration typical of spruce–birch–aspen forest (Oldemeyer and Regelin 1987). Rectangular plots invoke more of an edge effect (decisions to include or exclude stems on the border) than circular or square plots but tend to reduce variance of the density estimate by crossing more vegetation patches (Hays et al. 1981; Krebs 1999). For this size of plot, 15 stems extrapolates to the threshold density of 30,000/ha desired for grouse brood cover.

We used equal sampling effort between strata in burns because differences in stem count variability between strata and proportional size of strata were not known ahead of time. To approximate the number of plots needed per strata for estimating density with 95% confidence limits ± percent relative error (r.e.) of the mean, we assumed that stem counts were normally distributed and used the formula

$$n \approx (200\ \text{C.V./desired relative error})^2 \quad (1)$$

provided by Krebs (1999:234), where the coefficient of variation is S.D.(mean)/mean and the factor of 2 denotes a 2-tailed statistic. Using a conservative C.V. of 0.376 for paper birch on the Kenai Peninsula (Oldemeyer and Regelin 1980:Table 3), a r.e. of 25% of the mean (sample size = 18 for both strata combined) appears feasible to achieve for management evaluations:

r.e. (%)	*n* required
5	226
10	57
15	25
20	14
25	9

Based on this preliminary power calculation, 10 plots were sampled per strata (i.e., 20 plots in stratified sites). Sampling occurred prior to complete leaf fall so that estimates of mature tree mortality were possible. An empirical l0-m buffer along the boundary was excluded from sampling to avoid the edge effect of uncut trees suppressing sprouts within the treatment area. Scaled maps produced from following the site boundaries and strata with a GPS (Trimble GeoExplorer 3® or equivalent) were printed from a Geographic Information System (GIS) for plot allocation in the office. We located plots uniformly throughout sites or strata along north–south or east–west lines on the map (to simplify distance pacing in dense debris and vegetation) because spreading samples throughout the treatment site can increase precision over stratified random sampling (Cochran 1977:205). With a fixed number of plots per site, sampling intensity ranged from 0.9 to 9.1 plots per hectare (mean 3.8, median 3.1) because of some small burn treatments in 1998 (1.5–2.5 ha) that were stratified and some unstratified shearblading treatments to 11.4 ha.

After arriving at an approximate plot location, the precise corner location was randomized by compass direction (0–359) and number of steps (0–9). The first corner was permanently marked with 0.5 m × 1.3 cm galvanized steel pipe painted bright blue for resampling of stem density during the natural thinning period (20–30 years). A GPS was used to archive the pipe location and record plot attributes. Plot orientation was randomized from 0 to 359 degrees on the long axis and laid out counterclockwise; this will be followed in the future to reduce sampling error. A 12-m rope with loops for the plot corners was placed around the pipe and 3 removable stakes by threading down between stems. All stems of quaking aspen, balsam poplar, paper birch, and willows were counted. Area of the plot is small (0.0005 ha); thus, correction of area for slope is inconsequential (Loetsch et al. 1973:317–323). Within strata, the variance per hectare of stem counts (based on 5-m^2 plots) was

$$\text{var}\ (D_{ha}) = \text{var}\ (k\ D_{m2}) = k^2\ \text{var}\ (D_{m2}), \qquad (2)$$

where *k* = the conversion factor of 2000 5-m^2 plots/ha. Overall density per treatment site for the stratified systematic design was calculated (Cochran 1977:227) as

$$D_{st} = \Sigma W_h\ D_h, \quad (3)$$

where sampling effort among h strata is weighted by the number of sampling sites (N) per strata ($W_h = N_h/N$); variance per treatment site for strata combined was

$$\text{var}\ (D_{st}) = \Sigma (W_h)^2\ \text{var}\ (D_h). \quad (4)$$

Knowledge of how sprouting responses are influenced by stand features, felling debris, and fire behavior (residence time, intensity, and severity) may suggest practical guidelines that improve the planning and effectiveness of treatments. We estimated tree density prior to burning on 4 treatment sites at Nenana Ridge in 1998 by using a modification of a systematic survey for browse density. Nearest neighbors (by species) were measured for the closest tree every 10 steps along parallel transects spaced about 100 m apart in a treatment site. Tree density was calculated from nearest neighbor distance (Engeman et al. 1994:Table 2) as

$$D_{cm} = 1\ /\ (2.778\ [\Sigma d_i/n]^2), \qquad (5)$$

where d_i is the distance (cm) between the i^{th} pair of nearest neighbors. Variance of tree density per hectare can be estimated with the Delta method as

$$\text{var}\ (D_{cm}) = 4\ \text{var}\ [\Sigma d_i/n]\ /\ 2.778\ [\Sigma d_i/n]^6, \quad (6)$$

with a conversion factor of 106 cm^2/ha subsequently applied as k^2 for estimating variance.

The proportion of trees killed by scorching was estimated from the number of live (leaves present) and dead aspen trees in a 10-m radius centered on the pipe, excluding trees obviously dead before the fire and counting trees visibly joined at the base as one. The slope (degrees on compass clinometer) and aspect (azimuth corrected for declination) were also recorded, as was a list of woody and herbaceous species. Because of herbaceous regrowth and leaf fall from saplings, estimates of burn severity were not feasible after 2 growing seasons. Predictive analysis of tree mortality and sprout density from site attributes were examined graphically and, when appropriate, by simple linear regression. The latter analysis included plots of normalized residuals and reanalysis of data transformed by log (x+1) when heteroschedasticity was evident (Zar 1999:353–357). Density of felling debris (percent ground cover and multiple layers) was visually categorized for mechanical treatments as low, moderate, or high with respect to potential shading of the ground.

Soil temperature has been shown to be positively correlated to aspen sprout density (Doucet 1989), and aspen suckering is inhibited when soil temperature is less than 15° C (59° F) (Maini and Horton 1966). Two physical factors we can control to some extent in mechanical treatments are the density and height of woody debris that induces shading and the thickness and dispersion of ground cover that insulates soil from solar radiation. We tested the effect of removing debris shading on soil temperature and sprouting density in 2 experiments in which felling debris was pushed into parallel piles (windrows), which emulates a harvest removal on about 50% of the treatment area. In March 2000, 7 ha (18 ac) of mature aspen were treated with a bulldozer shearblade (Rome K/G®) at Delta Junction, and half of a 30-acre felling treatment at Nenana Ridge in October 2000 had the debris bulldozed into windrows. (Shearblades are suitable for cutting mature hardwood trees at the root collar when the ground is frozen and are safe for operation on relatively flat areas, whereas chain saw felling and skidding are safer on steeper terrain.) Battery-operated data loggers (Onset Computer Corporation, Borne, Massachusetts, USA) were buried in the organic layer and at the organic-mineral soil interface to record temperature in the rooting zone throughout the growing season in windrowed and cleared areas. We sampled sprouting density beneath debris in windrows and on cleared sites (contrasting between sites where moss was and was not removed in clearings) at Delta in 2001 and will sample on debris and cleared sites at Nenana Ridge in autumn 2002.

Survival of Willow Stem Plantings

Feltleaf willow was chosen for planting because it propagates from cuttings (Densmore and Zasada 1978), produces large leaders (high forage biomass), and is a relatively preferred browse of moose (Seaton 2002). Stems 1.5–4.0 cm diameter were harvested in March and stored beneath snow until early summer. Just prior to planting, stems were cut on a 45° angle into 20–30 cm lengths with a circular saw to increase absorptive surface and make it easier to push them in the ground. Stems were planted upright to two-thirds depth into mineral soil after soaking in rooting hormone solution (indole-3-butyric acid) for 2 days before planting. (We subsequently learned that hormones are unlikely to stimulate formation of additional root buds in willows [J Zasada, US Forest Service, personal communication]). Planting was done on the lower east–southeast slope of the burned portion of the timber harvest site to enhance moisture availability and provide shade from adjacent forest during part of the day. About 6.1 ha (15 ac) were planted in 1997, and in 1998 another 3.2 ha (8 ac) were planted upslope of the 1997 planting. Willows were planted on a grid spacing of about 3.1×3.7 m (10×12 ft) during 17–19 July 1997 for an intended stocking density of 1682 stem per hectare (681/ac). Sampling of stem density gave an estimated stocking rate of about 1210 per ha in 1997 (A Frizzera, Alaska DNR, Division of Forestry, personal communication to D Haggstrom).

On 11 September 2000 we established a 0.49 ha permanent plot on a ridge spine at the southern edge of the timber sale, with metal stakes marking the upslope and downslope corners and the boundary between 1997 plantings (downslope) and 1998 plantings (upslope). The perimeter of the test area was recorded using a GPS for visual reference and area calculation in a GIS. Temporary flagging was used to orient observers along planting rows that roughly followed elevation contours; the tallest stems were about 2 m. All live and dead stem plantings were counted within the plot to determine a crude survival rate (proportion alive) for the 2 planting cohorts, and a 95% confidence interval was estimated using the *F* and binomial distributions (Zar 1999:527–529).

Hardwood Regeneration After Harvesting White Spruce

Twelve of the proposed harvest sites in Block B at Tok River (Appendix A) were selected for study of how postlogging site treatments (3 sites each: disk trenching, blade scarification, broadcast burning, and control) influence hardwood regeneration and retention of late-seral features. All 3 treatments have utility for hardwood regeneration in Alaska (Collins 1996; Wurtz and Zasada 2001). Harvesting and transport of logs will occur primarily when the ground is frozen, at least for sites east of the river (opposite side from the Glenn Highway). Mechanical scarification should proceed the summer following timber harvest when soils have dried enough to avoid compaction (EC Packee, University of Alaska Fairbanks, personal communication). Although willow seeds disperse in late May or early June (Densmore and Zasada 1983), summer scarification in the year following harvest should still optimize availability of sites for hardwood germination and spruce planting before invasion by bluejoint grass (*Calamagrostis canadensis*) (Collins and Schwartz 1998). As an alternative to scarification, broadcast burning (Zasada and Norum 1986) will likely be done in late summer or early autumn, when labor and resources for prescribed fire are typically not preempted by wildland fire suppression elsewhere in the state. Choice of burn treatment sites was subjective to reduce the risk of escaped fire, but selection of the 9 remaining treatment and control sites will be random.

During May–July 2000 we established 6–10 belt plots (2×50 m) uniformly spaced across each of the 12 study sites to sample browse density, cover, and depth of soil active layer prior to harvest disturbance. We paced to approximate locations, randomized azimuth (0–359^{o}), and laid out line transects with a 50-m reel tape. Long thin plots will incorporate the spatial patchiness of shrubs and hardwood saplings to reduce variation of estimated density relative to circular or square plots (Hays et al. 1981; Krebs 1998). We counted stems of deciduous shrubs and saplings (*Salix, Populus, Betula)* available as winter browse (0.5–3.0 m tall) within plots and noted other woody and herbaceous species. Germinated individuals were distinguished as stems when distinct at the ground surface, and vertical sprouts off older material lying prostrate were counted individually. Postharvest sampling of browse density and cover will occur during the first, fourth, seventh, and tenth summer posttreatment. Depending on the density of seed germination and root sprouting, stem counts after harvest may be done in a permanent 1×5 m plot placed on a site that received the treatment (burn or scarify) within or next to each belt transect, closest to a randomly-chosen distance (0–50 m) along the transect. In the event of extreme seedling density, the 1×1 m plot closest to the random point will be sampled. Depth of active layer was estimated by probing to frozen ground with a 1-cm diameter T-handled metal rod every 7 m along the edge of the belt transect (n = 8 depths per transect) during browse sampling; future sampling will occur roughly in the same season on the same schedule as for browse. Following harvest, sites to be broadcast burned will have wire pins inserted so tops are level with ground surface every 2 m along transects to estimate duff consumption.

Changes in overstory and subsequent regeneration of woody species can have a strong effect on vegetative cover used for predator avoidance and thermoregulation. In 2000 we estimated the proportional extent of horizontal and vertical cover by crosshair-point interception every 2 m along one edge of the 50-m belt transect using the methods of Collins and Becker (2001). To gauge baseline cover parameters relative to moose, we measured visual point obstruction of overhead canopy through a leveling prism eyepiece (Geographic Resource Solutions, Anchorage, Alaska) from 1.5 m above ground. Horizontal cover was measured at 1.5 m above ground by use of features on source and target poles 15 m apart, with the target moving perpendicular along with the observer on the transect and the target clockwise from the transect start. Sampling will again occur at the end of the first, fourth, seventh, and tenth growing seasons.

For white spruce and balsam poplar that remain standing as snags or cavity trees on harvested sites, we intend to test whether persistence is similar to that for these features on adjacent nonharvested sites. We will estimate the falling rate (trees per ha per year) of residual snags and cavity trees on the 12 study sites beginning after harvest and site preparation have been completed and on a proportional sample of trees on nonharvest sites. Metal tags will be affixed to residual snags and cavity trees ≥20 cm dbh on the 12 sites, and we will record species, height, diameter at breast height, height and size of cavity opening, opening aspect, evidence of wildlife use, and GPS location. Trees would be revisited on years 4, 7, and 10 postharvest to determine fate and wildlife use. Tags will be left on trees for long-term monitoring beyond the end of this study.

VEGETATION CHANGES ON LANDSCAPE-SCALE HABITAT TREATMENTS

Farewell Prescribed Burn

We propose to conduct systematic sampling for vegetative change detection with aerial photography of the same sites at similar seasonal phenology before the burn and 1–3 growing seasons after the burn. For each pair of photos, we will draw one or more line transects nonrandomly between discernable topographic features to reduce postburn sampling error. We will then interpret vegetation cover type along transects and measure the cover distance to estimate proportion before and after the burn. (This technique underestimates available forage range because bison may feed in the understory of cover types we would classify as woody based on photo interpretation.) Goals for analysis are to 1) estimate change in proportion of vegetative cover types (coniferous tree, deciduous tree, shrub, and forb/grass/sedge) on individual transects at burned sites and the overall change within the actual burn perimeter; and 2) discern spatial patterns to change in cover type as a gross function of fire extent (% of transect burned) and the fuel environment (physiographic-vegetative stratum), the latter for potential use in optimizing fire prescriptions in future burn planning.

The photo will be a sample unit, and a lack of randomized sampling will be incorporated by modeling for autocorrelation of data among sample photos (J. Ver Hoef, ADF&G, personal communication). Possible covariates to the compositional estimates (proportions of the 4 cover types) might be continuous (proportion of burned area on photos; estimated with dot-grid in office) or categorical (broad physiographic-vegetative strata; assigned during flight). The advantage of continuous covariates is that they can be modeled as functions. Collapsing the 4 cover types to 3 (coniferous, deciduous woody, herbaceous) for analysis further permits depiction of 3-parameter space in 2 dimensions for visual interpretation.

On 7 May 2000, true color photographs at 1:2000 scale were taken systematically throughout the MAP of the proposed burn as a baseline for vegetative change detection. A large format camera (Zeiss® RMKA, 9.5-inch film) was mounted over a belly porthole in a fixed-wing DeHavilland Beaver aircraft and flown 70 mph at 1000 feet aboveground level with the precision assistance of a radar altimeter. Exposure of the Agfa® Aviphot color N 400 film at 1/600 second and F8 was done every statute mile along north–south flightlines through computer and GPS control of the camera shutter (Photoman software, R DeLong, ADF&G). Roughly 16% of the MAP was sampled at this scale and frequency. Sampling occurred during 12:00–14:30 with direct sunshine on vegetation; snow remained on <5% of the study area. Two test frames were shot both before and after the sampling to allow color and exposure adjustment during film development. Transects will be drawn after the postburn photography so that topographic features are confirmed on both photos in the pair.

East Fork, Kechumstuk, and Mosquito Fork Prescribed Burns

In 1998 and 1999, DWC and DOF conducted 3 prescribed burns near Tok that burned nearly 36,500 ha (90,000 ac). The East Fork of the Dennison Fork of the Fortymile River was burned in July 1998 (21,440 ha [52,000 ac]), and Kechumstuk Creek was burned in early August 1999 (12,460 ha [30,780 ac]). These summer burns had similar treatment objectives:

- Burn 50–70% of each treatment area under weather and fuel moisture conditions that produce moderate to maximum duff removal, allowing shrubs and deciduous trees to proliferate by root or crown sprouting in sites of lower burn severity and by seeding in more severely burned sites.
- Kill at least 50% of the black spruce occurring in the final burned area.
- Top-kill at least 50% of the aboveground stems of aspen, poplar, and willow occurring in the final burned area.

Mosquito Flats was burned in late May 1999 (2736 ha [6760 ac]) when the ground was still wet or frozen; thus, it had different treatment objectives:

- Burn 50–100% of the area within the outer perimeter resulting from the prescribed fire, with a fire of low-to-moderate intensity.
- Top-kill 50–100% of the existing and decadent willow and deciduous trees in burned portions of the final burn area to promote root or crown sprouting.
- Consume grass and sedge thatch and organic duff in burned portions of the final burn area to the extent possible given existing water and frozen soil levels.

Evaluating success in achieving vegetative objectives on landscape-scale prescribed burns requires remote sensing of adequate precision to conduct change detection. Planning began in summer 2001 for comparing the resolution and cost efficiency of using color infrared (CIR) photography and high resolution satellite imagery (2.6 m multispectral/0.6 panchromatic Quickbird imagery; DigitalGlobe™, Longmont, Colorado, USA) to classify vegetative cover on prescribed burns in 2002. We will work with DOF staff experienced in computer-based GIS to import digitally scanned photos into a GIS, rectify the image with ground control points, and merge imagery with a digital elevation model for enhanced resolution. Ground truthing for aerial photos imagery and the satellite imagery will be done the following summer (2003) for type mapping of vegetation polygons (from photos) or pixel groups (from satellite imagery). In addition to comparing the 2 methods of postfire typing for resolution and cost efficiency, we will compare the postfire imagery with prefire CIR imagery already in the GIS database maintained by DOF to conduct the change detection.

Testing of film exposures and filter combinations for a new CIR film (Kodak® type 1443) was done in preparation for photographing the 1998 East Fork prescribed burn in late summer 2002. The DeHavilland Beaver and Zeiss RMKA camera with a D filter (535 nm) were flown at 70 mph approximately 6300 feet aboveground level over the Nenana Ridge project area (predominantly aspen–birch–white spruce forest on hillsides) and over sections of Minto Flats State Game Refuge northwest of Fairbanks (lowland conifer-deciduous forest, tussock tundra, and wetland) on 7 September 2001 during peak of autumn vegetation colors. Solar angle during the CIR photography was 31 degrees above the horizon. We varied F-stops (5.6 and 8) and shutter speed (1/125 and 1/250 sec) to provide 4 combinations of exposures for comparison of image contrast and clarity on film developed to negative.

WILDLIFE RESPONSE TO STAND-SCALE HABITAT TREATMENTS

Habitat Use by Moose

Shifts in winter use of habitat by moose that are caused by browse enhancement in harvest sites at the Tok River timber sale should be detectable with use indices. We estimated relative change in moose habitat use during winter by counting pellet groups ≥50% within 2×50 m plots (Collins and Helm 1997). Pellet groups were cleared from each transect after counting and, starting in 2001, pellet groups were noted as summer (soft, misshapen, dark) or winter (hard, uniform shape, light-colored). Sampling began in summer 2000 during vegetation sampling and will occur each spring after snowmelt for 10 years postharvest. Sampling occurred in the 12 study sites (102 transects; see section on *Hardwood Regeneration After Harvesting White Spruce* for sampling design) and on 45 transects established in adjacent riparian stands of willows and balsam poplar, where moose currently spend most of their foraging time in winter (C Gardner, ADF&G, Tok, personal communication). Snow depth along furbearer track transects (see next section) in harvest sites and in riparian areas will be measured periodically during each winter as an annual index to mobility hindrance for moose between these 2 habitat types (cf. Coady 1974).

Habitat Use by Furbearers and Their Prey

Changes in vegetative composition and structure (including woody debris) caused by fire or mechanical treatments can affect the suitability of forest habitat for forest carnivores such as red foxes (*Vulpes vulpes*), lynx (*Lynx canadensis*), and martens (*Martes americana*). Track intersection counts along permanent transects have been standardized by transect length and time since snowfall to infer patterns of use among habitat types for furbearers and their prey during winter (Thompson et al. 1989; Paragi et al. 1996; Paragi 1997). Transects across felling units were cleared to ca. 1-m width with a chain saw to enable safe transit by foot or snowshoe. During winters 1999–2000 and 2000–2001, we estimated the relative abundance (tracks per km × days after snowfall) of several species among various treatment types at Nenana Ridge and on sites slated for treatment at Tok River, plus adjacent untreated habitats in both study area. Counts were conducted 3–7 days after sufficient snowfall to cover previous tracks and after as many suitable snowfall events as possible per winter to infer use patterns from a variety of climate conditions that influence track deposition (Golden 1994).

WILDLIFE RESPONSE TO LANDSCAPE-SCALE HABITAT TREATMENTS

Large prescribed or natural fires and groupings of stand-scale disturbances (e.g., the multiple habitat treatments at Nenana Ridge or the proposed timber harvest at Tok River) provide the spatial scale needed to make inferences on population-level responses in wildlife. To date we are attempting to implement population indices as a low-cost means of gauging how habitat treatments influence long-term changes in abundance, age or sex composition, and habitat selection of species or species groups.

Ruffed Grouse

In 2000 we began standardized index surveys of ruffed grouse population dynamics and hunter harvest at Nenana Ridge. Occupation of drumming sites by male ruffed grouse has been used to infer population trends within certain weather conditions (Gullion 1966). We conducted 1 drumming survey on 10 May 2000, 3 surveys during 8–9 May 2001, and 3 surveys during 8–10 May 2002 by stopping every 0.8 km (0.5 mi) along the dirt roads in the treatment area and listening for 4 min. The route was started 30 min before sunrise or 2 hr before sunset and comprises 16 fixed stations. Four drumming surveys were planned each year (2 morning and 2 evening), but wind or precipitation precluded some. On 7 August 2000 and 8 August 2001 (prior to opening of the bird hunting season on 10 Aug), an experienced hunter and his trained Brittany pointing dogs were used to conduct flushing counts along 10.4 km (6.5 mi) of dirt road among the aspen treatments and untreated mature forest during 08:05–13:25. The dogs were directed back at least 100 m off the road in aspen or mixed forest containing mature aspen or birch. This period coincides with peak molting in adult ruffed grouse, when birds seek thick cover and males may exhibit restricted ranges (Grange 1948:170).

In autumn 2000 and 2001 we erected a kiosk 3.5 km in from the highway along the single 15 km dirt road that provides access to the Nenana Ridge habitat management area to solicit voluntary reporting of grouse harvest by hunters, including spruce grouse (*Falcipennis canadensis*). Signs on the kiosk explained the harvest survey and showed a map of the management area. A box with a hinged lid was attached to the kiosk and provided reporting cards and pencils. The back of the reporting card had drawings of tails found on ruffed and spruce grouse and a verbal description on species identification.

A checkstation was established in autumn 2000 for sampling grouse hunters as they exited Nenana Ridge to cross-validate reporting of harvest at the kiosk. The station was 50 m in from the dirt road junction at the highway at a turnaround. Sampling was stratified into 12 time periods likely to affect hunter participation and harvest success. Three sampling periods were designated during the 24-hour period: morning, day, and evening. The 4-hour periods were assigned according to available daylight for the day, with the morning period starting 1 hour after sunrise (few hunters likely to be exiting at daybreak) and the evening period ending 1 hour after sunset (time for hunters at dusk to exit). Periods during the week were stratified as weekday (Mon–Fri) and weekend (Sat and Sun). Because of the anticipated traffic increase just before and during the 1–15 September hunting season for moose, 2 additional strata were identified: moose season (26 Aug–15 Sep) and outside the moose season (10 Aug–25 Aug and 16 Sep–24 Sep).

The checkstation was operated at randomly selected times within the 12 periods during 10 August to 24 September. We asked hunters exiting along the road to volunteer information with a few questions (essentially those on the reporting card: sightings and harvest of ruffed or spruce grouse, time spent hunting, if dogs were used, number in party), and sampling staff also recorded traffic and weather during the session. Each sampling session took about 5.5 hr total (4 hr of sampling + 1 hr roundtrip highway driving + 30 min to empty the drop box before and after each session). Cards at the kiosk were picked up before the checkstation was operated and afterwards for each sampling session to determine compliance and cross-validate information.

The Alaska Department of Transportation and Public Facilities (DOT) provided a cable operated vehicle counter near the road and highway junction during the study period and subsequently provided hourly vehicle counts (crossing only, not direction). The counter validated observations by checkstation staff and provided traffic trends for the study area.

Harvest estimates and variance calculations are carried out using stratified multi-stage sampling design (Bernard et al. 1998). The first stage of the multi-stage design is a day randomly selected in the strata, and the second stage is the hunter-trip(s) recorded as they arrive at the checkstation. At least 2 sampling units must be sampled from each sampling stage to estimate variance (precision) of statistics. To calculate the variance in this study, 2 days were randomly chosen from each stratum, and 2 hunters had to have presented themselves at the checkstation during each sampling event. For the first stage, 2 sampling events per each of the 12 strata were randomly selected.

Passerines

In spring 2000 we facilitated a cooperative project "Habitat selection of birds breeding in the Tok River watershed" with the Alaska Bird Observatory (ABO) to determine how the proposed timber sale NC-837-T at Tok River might influence passerine habitat selection. Study objectives were to:

- Determine landscape-scale habitat characteristics (patch size and shape, amount and spatial arrangement of forest in surrounding landscapes) selected by breeding birds nesting in the Tok River drainage.

- Develop a model that will allow land managers to predict the occurrence of priority landbird species among forest habitats in Interior Alaska.

- Determine the microhabitat variables used by breeding birds in the Tok River drainage.

- Determine whether the density and distribution of birds using the Tok River drainage varies before and after timber harvest.

ABO stratified the area surrounding and including the proposed timber sale by habitat type using proportional allocation of sampling units (point-count surveys). GIS maps of stand types created by the DOF were used to stratify the proposed sale area into 14 habitat classifications. Habitat classifications were based on Viereck et al. (1992) Classification Level IV and further grouped to type classes appropriate for forest management by the DOF. ABO randomly selected 300 point-count locations in proportion to habitat availability and sampled these points during 5–28 June in 2000 and 2001, the peak period of singing rates by passerines in Interior Alaska (Paton and Pogson 1996). Surveys were conducted between 02:00 and 09:00 based on work by Swanson (1999). Field technicians received 5 days of training in distance estimation and point-count techniques in different habitat types. Observers recorded all visual and auditory cues of birds and estimated distance and azimuth to each individual during 0- to 5-min and 5- to 8-min intervals at each sampling point. Birds not using the surveyed area but flying overhead were counted and recorded separately. Birds detected during the count but not identified were identified after the count if more careful observation was required, as time permitted. Individuals suspected of being counted at another census point were not recorded, and notes were made on whether individuals were suspected to be a breeding pair or if a clutch of birds was counted.

For each point, habitat was characterized immediately after the bird surveys. During the 2000 field season, ABO conducted a vegetation survey at each point, immediately after the bird survey. The vegetation survey focused on features most likely to influence habitat selection by breeding birds. Survey plots were circular and included all area within a 50-m radius of the associated survey point. On each plot, observers coded and recorded tree species composition and average height; tree canopy cover; conifer percentage; standing dead tree percentage; shrub species composition, height, and percent cover; herb and ground layer species composition and percent cover. They also recorded relevant abiotic factors: presence/absence and type of water (stream, pond, lake, ephemeral); presence/absence and type of disturbance; and slope and aspect, if the point was on a slope. Weather variables were coded and recorded. Because judging height and cover of vegetation was a subjective process, these values were bracketed and coded as well. Samples of unknown plant species were collected and identified later.

In June 2002 we facilitated another cooperative project with the ABO to determine how increasing the age diversity of broadleaf forest at Nenana Ridge might influence passerine diversity and habitat selection. Ninety-one of 110 generated random points were surveyed at treated sites (mostly felled and burned aspen, some harvested birch), and 83 of 109 generated random points were surveyed at untreated sites of mature forest. Bird sampling methods were similar to those used at Tok River and will be replicated in June 2003. Tok River and Nenana

Ridge are part of a larger effort by ABO to examine how forest management practices influence passerine populations and habitat selection in the Tanana Valley.

RESULTS AND DISCUSSION

VEGETATION CHANGES ON STAND-SCALE HABITAT TREATMENTS

Coppice Regeneration of Aspen

Understory vegetation on the various treatment sites was typical for closed quaking aspen forest (≥60% canopy cover; Viereck et al. 1992:89–90): prickly rose (*Rosa acicularis*), buffaloberry (*Shepherdia canadensis*), and high bushcranberry (*Viburnum edule*) were found on most plots in all sites, whereas bunchberry dogwood (*Cornis canadensis*), mountain cranberry (*Vaccinium vitis-idaea*), red-fruited bastard toad flax (*Geocaulon lividum*), and bluejoint grass (*Calamagrostis canadensis*) were present on some plots in all sites. Aspen leaves and twigs dominated the detritus layer on south-facing slopes and provide fine fuel for carrying spring fires.

In burn treatments, 2 people flagging a reference line from a known point through the site (for pacing relative to map) and then stratum boundaries took about 15–60 min per site, depending on complexity of fire pattern and clarity of strata boundaries. Pacing out to the approximate location of a plot took about 5 min. Finding and staking the randomized plot location, counting dead and live trees, noting ground cover, measuring slope and aspect, and counting woody stems took about 30 min per plot once we were familiar with the routine. Excluding travel time to the study site, each plot took 45–90 min to establish and sample. Although mechanical treatments often had debris that hindered our movements, the lack of need to stratify beforehand or estimate mortality of standing trees allowed faster sampling compared to burns. Excluding travel time to the study sites, time per plot to establish and sampling stems was about 30–40 min for mechanical treatments compared to about 60 min per plot on average for burns that require stratification.

Prior to burning, balsam poplar was codominant with quaking aspen in small sections of some sites, and white spruce or black spruce occurred as a minor component in the subcanopy on most sites. Most dead aspen at the time of treatments were smaller stems whose mortality was likely the result of self-thinning through resource competition. We observed that smaller trees seemed to die more rapidly from fire, perhaps because of being weakened by such competition. We noted on one site that poplar seems to scorch easier than aspen but we did not quantify mortality across the site. Small numbers of poplar and paper birch stems sprouted from stumps of top-killed trees in all treatments, and willows resprouted after their tops were killed in burns.

Difficulty in visual stratifying stem density varied across the 6 burn sites. All of site 7 was deemed high density (sampling results: 58–214 stems per plot) and was not stratified (Table 2). Only 5 high-density plots were placed in site 9 because the high stratum was a relatively small proportion of the site (ca. 8%). Visual stratification was borne out by no overlap in stem counts between strata in site 9 (upper low = 32, lower high = 51) or site l0 (upper low = 61, lower high = 67); both sites had evident transitions between strata. However, there was substantial overlap in stem counts between plots in the low stratum (range: 1–42) and the high stratum (range: 12–64) in site 2. Site 8 also had overlap between strata: 4 plots from low (13–29 stems) overlapped 6 plots from high (13–29 stems). The transition between strata was sometimes vague in sites 2 and 8 or subject to small-scale heterogeneity. Prior to fieldwork, our samples were equally allocated between high and low density strata, regardless of potential stratum size. We did not directly estimate the proportion of burn treatment that exceeded threshold density. Nonetheless, the proportion of plots exceeding the threshold density of 15 stems (site 7: 100%, site 8: 60%, site 9: 60%, site 10: 55%) gives a rough idea of our spatial success in regenerating sprouts under spring burn conditions typical of aspen stands in Interior Alaska.

Sprouting response was higher but more variable in burns than in mechanical treatments. All 6 burns had mean stem counts well above the desired threshold of 30,000 stems/ha (Table 2), and half the low-density strata met the threshold (Fig 3a). For the 4 stratified burn sites, stem counts in the low-density stratum were more variable and prone to having nonnormal distributions compared to high-density strata (Table 2).

Compared to burns, sprouting response was relatively uniform among felling and shearblading sites (Figs 3b–d), and stem samples were normally distributed for all mechanical treatments (Table 3; Lilliefor's test, $P \geq 0.11$). When balsam poplar, paper birch, and willow stems were added to aspen at Heritage Forest, the combined stem counts were 50–100% higher than for aspen alone. Most felling sites had southerly aspects (136–244^{o}) and relatively steep slopes (13–23^{o}). The skidded part of felling site N12 had nearly twice the stem density of the felled-only part (Table 3, Fig 3b); both parts were flat. At the 2000 Delta shearblading treatment, the extra work of windrowing debris produced greater sprouting in the cleared sites with little additional effect from moss scraping (Fig 2c). Felling treatments with high debris density had fewer stems than such treatments with moderate or low-density debris (Table 4).

Flat shearblading sites, because of lower productivity and the equivocal effect of debris, had a lower sprouting response compared to the sprouting response on loess hills.

When strata were combined for a weighted mean (n = 15–20 plots per treatment), the relative error of quadrat estimates often met our presampling criteria of producing estimates within 25% of the mean for management purposes (Table 2). Plot-based sampling was more precise than a plotless method in estimating preburn tree density (Table 2, Fig 4). Plot-based sampling for trees after the burn was also more efficient (did not require a separate event) and more readily allowed prediction of stem density from surrounding terrain features and tree mortality.

Fire behavior determines the fire intensity that kills trees by damaging the cambium layer of the bole (Miller 2000). Our preliminary results defined how terrain features (slope and aspect) that influence fire behavior have affected surrounding tree mortality and subsequent sprouting by aspen. Almost all sprouting above the threshold density in burns was for plots with >40% aspen mortality within 10 m; most of these plots had >80% mortality (Fig 5b). The poorest sprouting response, at burn site 2, is explained by the low tree mortality (40% in low stratum and 59% in high stratum) compared with the other burns (43–67% in low and 61–100% in high; Table 2), despite ignition at site 2 during low relative humidity and high FFMC (Table 1). Site 2 was relatively flat with an overall more northerly aspect (Table 1) because of a shallow drainage, and its sprouting response was low compared with the other burns (Fig 3a). Other burns had a strong southerly aspect (Table 1); however, variation in mortality response for a given aspect was substantial (Fig 6a). Variation in mortality was also substantial for terrain slopes less than about 15° (33% slope), whereas all but one plot with >15° slope had >90% mortality (Fig 6b).

Although terrain has a strong influence on burn behavior, weather conditions during ignition also influence fire behavior in a given fuel type, such as aspen prior to leaf emergence (Taylor et al. 1996:17). For example, a felling site downslope of burn site 10 allowed winds to occur at ground level and help push the fire upslope despite high relative humidity (Table 1). With each burn, fire managers continue to gain the empirical knowledge of how static terrain variables interact with stochastic weather variables in aspen stands to safely yet effectively conduct prescribed burns in Interior Alaska.

Sprouting density in mechanical treatments is affected by the same terrain features as burns, and treatments that lack wood salvage are additionally influenced by abundance of felling debris. Although we did not quantify it, we observed a marked contrast between the physical appearance of standing dead trees at prescribed burn sites and the volume (m^3/ha) and vertical structure (height) of deadfall at felling or shearblading sites. Prescribed burning emulates natural fire in that treefall rate (conversely, accumulation of debris) is a function of time since disturbance, fire severity (damage to root anchoring), wind vector (velocity and direction), and storm events. We intend to estimate crude treefall rate in our burns over time by tallies of standing snags and trees within 10 m of permanent plot corner during subsequent stem sampling. In contrast, felling all trees in a stand into a jackstraw at once creates unnatural vertical structure in this stand type that may persist for 2–3 decades as hard boles because many trees are not in contact with ground moisture. Dense horizontal structure may impede grouse movements on the ground and reduce their ability to spot predators (Atwater and Schnell 1989:321). The attraction of small mammals to harvest debris (reviewed in Simon et al. 2002) in turn attracts avian and terrestrial predators, which would be counterproductive to enhancement of nesting and brood rearing habitat for grouse (see *Habitat Use by Furbearers and Their Prey*). Additionally, this debris can exceed 1 m above ground in places, posing a potential hindrance to forage access by moose (T Nichols, UAF Forest Sciences Department, personal communication) and certainly to grouse hunters or their dogs.

Pushing debris into windrows allowed the cleared sites to become warmer in the soil-rooting zone compared to sites covered in debris (Table 5). The south-facing aspect of Nenana Ridge resulted in greater soil temperatures during the growing season compared to Delta, but even the cleared sites on Nenana Ridge had relatively few days above the 15° C threshold attributed to productive sprouting (Table 5). At Delta, the presence of moss as a groundcover may also have insulated the site from early or prolonged heating. The feller-buncher site in Delta showed a relatively poor response despite having boles and some debris piled in decks, which greatly reduced shading (the boles were intended to be salvaged). First, it was cut during the latter part of the growing season (because of the brief local availability of equipment in mid-July) instead of during the dormant period. This may have reduced the maximum nutrient transfer back into the root system (Doucet 1989). Second, aspen on this site are being overtopped and shaded by black spruce and white spruce, and a moss ground cover to 15 cm has developed beneath the coniferous sub-canopy. Crown mortality has increased in the aspen since the habitat area was designated in 1993 (A Edgren, Alaska DNR, Division of Forestry, personal communication). Finally, continued browsing by moose and snowshoe hares in this relatively small pocket of young growth within mature forest may have decreased stem survival. To assess the last factor, in August 2000 we constructed an 10×10×2 m tall herbivore exclosure of welded wire in the feller-buncher site to observe the survival and growth of aspen stems free from browsing by these herbivores. Although we chose an exclosure location that appeared representative of the site, total count of stems within the exclosure (312) extrapolates to 56,976 stems/ha (23,058/ac), which was substantially greater than the estimated density on this site (Table 3). Future sampling on this treatment site and counts within the exclosure will address whether hare and moose browsing has had a substantial influence on the rate of aspen thinning and achievement of free-to-grow status.

Survival of Willow Stem Plantings

Crude survival rate to autumn 2000 was 0.43 (95% CL: 0.34, 0.51; $N = 145$) for the 1998 cohort and 0.46 (0.37, 0.55; $N = 136$) for the 1997 cohort. The average annual survival rate for these cohorts was 0.66 for 1998 and 0.77 for 1997. Because the physical site conditions are similar between the cohort areas, the slightly higher survival observed for the 1997 cohort might be attributed to better conditions for establishment during the first growing season. Perhaps the earlier plantings experienced lesser competition from grass or forbs or had a more favorable moisture regime during the first growing season. Browsing appeared to be of similar proportional occurrence (high) and extent (stem diameter) between cohorts. Future sampling for long-term survival should focus on counting live stems as a proportion of what was alive within the test area in 2000.

We chose a test area that was largely lacking dense grass so we could find the dead stems. However, we found only 47% of the 593 willows that we expected to find in the test area based on the estimated stocking rate in 1997. This detected number was only 34% of the expected stocking rate from a 3.1×3.7 m spacing, which in turn was less than the intended stocking rate specified in the planting contract (3.1×3.1 m spacing). We observed that willow stems were not as regularly spaced nor were rows as linear as were planted white spruce seedlings. Further projects on willow planting should be administered more stringently to ensure compliance with the target planting density and configuration, particularly to aid in finding stems for survival studies.

We examined willow cuttings only on the south end of the planting area, where they were surviving and relatively visible. We were able to find small (<100 m^2) scattered sites within the planting area where a few live stems existed and some dead stems were detectable in rows. Compared to the relatively small test area, willow survival appeared to be substantially lower on the remaining area that was planted.

Although the planting area had been burned prior to willow planting, variation in aspect, topography, and fuel influenced site-specific fire severity. Grass (predominantly *Calamagrostis canadensis*) was well established in depressions on the planting site and subsequently flourished after the burn. Competition with established grass and herbaceous species hindered initial survival of planted willows (D Haggstrom, ADF&G, personal observation). Paper birch is coming back well on some parts of the burn site where the burning was presumably severe enough to kill or consume grass rhizomes and expose mineral soil for germination. Moose were not browsing the young birch, which appeared to be densely covered with resin nodules. Few willows appeared to be sprouting from preexisting root stock in this timber sale, which reflects their relative scarcity on the site.

Hardwood Regeneration After Harvesting White Spruce

Sampling estimates on the 12 sites chosen for study at Tok River are presented by site to describe the preharvest conditions in the understory of mature white spruce on the study area (Table 6). Once timber harvest and postlogging site treatments have occurred in the randomized block design, parameter estimates will be reported by postlogging site treatment (3 replicates per treatment) with respect to browse and cover enhancement.

Browse stem density was relatively low (equivalent to $\bar{x}$ = 3730 stems/ha and median 850 stems/ha for all transects on all sites combined) and highly variable among sites (Table 6); both characteristics appear to be typical for understory browse in the study area. Variability among sites in the depth of the soil active layer above permafrost was relatively low (Table 6). In 811 probes on 102 transects, we struck gravel or rock at least once on 38% of transects (141 probes) and exceeded 1 m at least once on 48% of transects (111 probes); thus, our estimates represent minimum depths. Because we expect the depth of active layer to increase after harvest, we will obtain a 1.5 or 2.0 m probe for future sampling. Recording thermometers were buried at 4 study sites (one per treatment) in May 2002 to characterize soil temperature in mature forest prior to harvest and site treatments. Variability among sites was also relatively low for horizontal and vertical cover (Table 6).

We expected that the exposure of mineral soil by the 4 treatments (fire, disk trenching, blade scarification, control) is the strongest influence on how browse species will respond. To facilitate randomized blocking in the study design and reduce the effect of potentially confounding effects when assigning treatments, we sought to objectively characterize the 12 study sites for similarities or differences by use of ecological criteria. Based on our knowledge of vegetative response in boreal forest, we chose 5 parameters that should indicate site productivity and propensity for browse and cover enhancement on a given site. Positive factors include mean depth of active layer (warmer surface soils), mean counts of willow and poplar stems (sources of local propagules), and mean count of alder stems (source of soil nitrogen). A negative factor is the presence (count frequency) of moss on the ground surface, which insulates soil from warming in summer. We standardized these 5 variables and ran a Principal Components Analysis (PCA; SYSTAT®9, Wilkinson 1999) to maximize the differences among sites in 2 scenarios: all 12 sites and 9 sites that exclude the 3 identified as having the least risk for escaped fire (sites 70, 87, and 93). For our study design, ideally the 12-site PCA would identify 4 groupings of 3 replicate sites each that we could randomly assign to each of the 4 treatments, and the 9-site PCA would produce the same groupings for the nonfire sites.

Factor plots showed that the 5 ecological variables each had explanatory value within each PCA (Figs 7 and 8). Plots of the component loading factors based on these 5 variables produced the same general groupings among study sites for both scenarios (Figs 7 and 8). Two of the burn sites (70 and 93) were ecologically similar (Fig 7), but that is a constraint we can acknowledge when interpreting the results of the field experiment. These are the groupings of ecologically similar sites that we inferred from the loading plots:

PCA #1 (all 12 sites, B designates burn site):

78, 88, 100	70B, 93B	79, 84, 92	82, 86, 87B, 90

PCA #2 (excludes burn sites):

78, 88, 100	79, 84, 92	82, 86, 90

Using PCA #2, we randomly assigned one from each block to disk trenching, blade scarification, and control so that each treatment, other than fire, is distributed among different ecological conditions in the study area. With the currently low market value of white spruce, we were also asked by the Division of Forestry to consider an option to harvest only about one-third of the study sites per year instead of all 12 in one winter. Thus, we also randomized assignment of treatment sites among years if this design is needed:

	Burn	Blade	Disk	Untreated
Year 1	87	86	90	82
Year 2	93	62	79	88
Year 3	70	78	100	84

Annual variation in seed crops among years can be substantial in boreal forest (Juday et al., in press) and a confounding effect on treatment response if we have to spread treatments over 3 winters. In autumn 2002 we intend to place 5 seed traps per study site along a transect aligned with prevailing wind, with traps starting at the edge and ending near the center of the site. Traps will be emptied of coniferous and deciduous seeds in spring and fall to provide an index to annual variation in seedfall by tree species.

VEGETATION CHANGES ON LANDSCAPE-SCALE HABITAT TREATMENTS

To date only baseline photographs of habitat are available for the proposed burn at Farewell. An attempt to ignite a fire during May 2000 was unsuccessful, so no inference on vegetation change caused by fire is possible at this time. Test photographs with CIR film near Fairbanks produced the best clarity for prints at F5.6 and 1/125 sec.

WILDLIFE RESPONSE TO STAND-SCALE HABITAT TREATMENTS

Habitat Use by Moose

Preharvest sampling of moose pellet groups at the proposed Tok River timber sale showed that moose use riparian habitats more often than mature coniferous forest, primarily in winter, but that variation in pellet groups was higher and less consistent in the spruce forest than in riparian habitat (Table 7). Snow depth was not precisely measured during the winter 1999–2000 but was <0.5 m in late January 2000. In early January 2001, snow depth averaged about 30 cm in both spruce forest and riparian habitats during our only visit to the study area. By late January 2002, snow depth averaged 26 cm in mature forest and 34 cm in open riparian habitats. Once timber harvest and postlogging site treatments have occurred, pellet counts and snow depth will be reported by treatment type (3 replicates per treatment) and contrasted between spruce forest and riparian habitat. We intend to incorporate duration of snow depth into a winter severity index for moose that may explain differences in habitat-use patterns among winters and among treatments.

Habitat Use by Furbearers and Their Prey

Though yet uncorrected for transect distance and time since snowfall, track counts at Nenana Ridge (Table 8) and Tok River (Table 9) show general patterns in habitat (treatment) occupancy among animal species and high variability in track abundance among temporal sampling events. Forest diversity in proximity to treatments at Nenana Ridge attracts a mix of gallinaceous birds that may shift distribution among habitats as snow depth (hence food availability) changes over the winter. Two sites presently sampled as untreated forest are destined to be felled or burned, thus will provide a direct measure of treatment response. As an example of standardized counts, marten tracks at Nenana Ridge show martens consistently use burns less than felling sites or mature aspen (Fig 9). Mammalian predators of ruffed grouse potentially could use felling debris in treatment areas as stalking cover and escape terrain from their own avian predators. If weasels (*Mustela erminea* and *M. nivalis*) and martens also occupy felling treatments during the snow-free brood rearing period, creation of favorable carnivore habitat could be counterproductive to enhancing grouse habitat. In a few years when aspen regeneration achieves cover metrics typical of brood habitat (cf. Gullion 1984:Fig 1), we intend to evaluate the effect of felling debris on grouse by estimating cause-specific mortality in grouse chicks combined with indirect evidence such as predation on artificial grouse nests, habitat relationships of small mammals (primary prey for forest mustelids) during the brood-rearing period, or seasonal habitat selection by forest mustelids. Compared to Nenana Ridge, the mature spruce canopy and coniferous regeneration beneath canopy gaps at Tok River provide cover for snowshoe hares and abundant seed cones as forage for red squirrels (Table 9).

The relatively short transects (ca. 200–600 m) across these stand-scale treatments may provide a low probability of detection for carnivores because of their low density and the relatively small area being sampled. Short transects further limit inference on habitat use at the population level because the few tracks encountered on these small study sites may belong to only 1 or 2 individuals. This sampling at Nenana Ridge and Tok River is being done partly to define how often tracking conditions are suitable (adequate snowfall beneath mature canopy in a single storm event, not extreme cold after snowfall) during short daylight periods and partly to determine patterns in habitat use that might lead to closer investigation of specific hypotheses with more direct or intensive sampling (cf. Paragi et al. 1996). Sampling to date has been during a regional decline in snowshoe hares after a peak in abundance during August 1999 (Flora 2002).

WILDLIFE RESPONSE TO LANDSCAPE-SCALE HABITAT TREATMENTS

Ruffed Grouse

No drumming birds were heard at listening stations at Nenana Ridge in 2000 or 2001, nor were any birds flushed during the late summer survey in 2000 or 2001. A single drummer was heard just outside the sampling area in 2001, and a single drummer was heard on a station in 2002. We attribute the lack of detection to periods of marginal weather during drumming surveys, ruffed grouse being in the low period of their abundance cycle, and hunting harvest possibly removing a substantial proportion of birds from the survey area in autumn. Despite the harvest of ruffed and spruce grouse during the autumn moose season (see next paragraph), tracks of gallinaceous birds have been seen in this area during the winters prior to surveys, and we have observed ruffed grouse within treatment areas during winter track counts (see *Habitat Use by Furbearers and Their Prey*). Given that we expend only 4 person days per year of staff time for these 2 surveys, we intend to continue them with the expectation that birds will begin to be detected as grouse abundance increases as part of its inherent population cycle (Keith 1963) and improvements in brood rearing conditions as our aspen treatments mature into better brood habitat.

We received 34 hunter response cards at the kiosk between 10 August and 2 December 2000 (only 2 in Nov and 1 in Dec). In this minimum harvest sample, 39% of 23 ruffed grouse seen by hunters were taken (0.2 seen per hour hunted), whereas 46% of 26 spruce grouse were harvested (0.3 seen per hour hunted). Low response rate was expected during the first year of sampling, particularly because this type of repeated on-site reporting is rare in Alaska. We received 51 response cards between 10 August 2001 and 24 February 2002 (none in Nov and Jan, 1 each in Dec and Feb). In this sample, 38% of 29 ruffed grouse seen by hunters were taken (0.2 seen per hour hunted), whereas 34% of 38 spruce grouse were taken (0.2 seen per hour hunted). Because the kiosk takes minimal staff time to put back on site and keep stocked with cards, we intend to operate it each autumn as an index to relative abundance among years (birds seen per hour hunted) and minimum estimate of harvest. We expect that participation will increase over time as hunters become familiar with the reporting program.

Report cards were deposited at the kiosk in only 3 of 25 sampling periods (one card deposited in each period) when the checkstation was operated. These cards were validated with the hunter interview on harvest: 2 spruce grouse were seen by 1 hunter, but only one of them was reported killed. Exiting hunters stopped at the checkstation during an additional 8 sampling periods in which no report cards were deposited at the kiosk. Seven of these 8 events were during the moose hunting season. Four ruffed grouse and 12 spruce grouse were seen by these hunters, but only 2 of each species were reported shot. The remaining 14 sampling periods had no hunters reporting and no report cards deposited. Total harvest estimated across all strata was 15 ruffed grouse (95% CI: 15, 43) and 16 spruce grouse (no CI). Weather conditions during the 2000 study were cooler and wetter than normal (Alaska Climate Research Center, University of Alaska Fairbanks). Year 2000 was the second coldest August on record for Fairbanks since 1906, and precipitation was 38% above normal. In September 2000 the average temperature was nearly 4°F below normal and precipitation 45% above normal. These conditions may have inhibited hunter activity because of discomfort and muddy roads.

Daily means for traffic entry into the study area during 2000 were substantially higher during moose season (46 vehicles) than outside of moose season (13 vehicles). This pattern occurred for both the weekly (45 vehicles per day during moose season, 6 outside moose season) and weekend strata (50 during moose season, 24 outside moose season). Traffic counts increased until near the end of moose hunting season and dramatically dropped after moose season ended. Outside of the moose season, mean traffic counts were higher postseason (18 vehicles per day) than preseason (6 per day). With the exception of the weekend of 16–17 September, Sunday traffic counts are higher than Saturday counts, with many weekends recording 1.5–2 times the traffic on Sunday than Saturday. Mean daily traffic was relatively constant at about 16 vehicles during the moose season. Traffic outside of the moose season varied from 1 per day during weekday evenings to 6 for weekend days.

Relatively low numbers of grouse and poor weather during the checkstation sampling contributed to low hunter participation in 2000. The high number of moose hunters using the study area in September is likely a major source of harvest for grouse seen on the roads. Many moose hunters also carry a .22 caliber rifle or shotgun for grouse but may not stop at the kiosk because they don't consider themselves primarily as grouse hunters. We intend to repeat the checkstation in 5 years, when the 1995–2000 aspen treatments will have grown into more suitable brood habitat and bird populations likely will have rebounded from the present cyclic low. We expect that normal weather conditions and a greater number of birds will result in greater hunter participation and harvest, which in turn should allow us to better validate harvest estimates from reporting cards with a checkstation.

Passerines

ABO detected a total of 53 bird species over both years at Tok River. In 2000, observers visited 304 census points and detected 46 bird species. In 2001 they detected 44 species when revisiting 272 of these points. To compare the data between years, they examined the sets of all independent observations (e.g., individuals, pairs, broods) made by each point's primary observer. This was necessary because some points were surveyed by only 1 person, whereas others were surveyed by 2. Detections made by secondary observers were included when compiling the species lists.

The total number of individual observations differed greatly between years at Tok River, with over twice as many detections made in 2001 as in 2000. In both years, dark-eyed junco (*Junco hyemalis*) was the most abundant species, with 294 detections recorded in 2000 and 482 in 2001. Swainson's thrush (*Catharus ustulatus*) and yellow-rumped warbler (*Dendroica coronata*) followed as second and third most abundant. These species were also the most widespread; in both years, all 3 species occurred in at least 13 of 14 habitat types. Townsend's warbler (*Dendroica townsendi*) was notably absent from white spruce stands. Although this species is common in similar habitats in this region, ABO crews detected only 1 individual in 2000 and 4 in 2001.

ABO detected 29 species (7 individuals unidentified) in treated habitats and 15 species (4 unidentified) in the untreated habitats at Nenana Ridge during 2002, with the 3 most frequently detected species the same for both habitats. On treatment sites, dark-eyed junco was the most frequently detected species (134), followed by yellow-rumped warbler (132) and Swainson's thrush (62). On untreated sites, yellow-rumped warblers were most frequently detected (95) followed by dark-eyed juncos (91) and Swainson's thrush (31). The density (birds/point) at treatment sites (6.5) was nearly double that of untreated sites (3.7). Densities in the birch–aspen saw and pole timber stratum were higher in the treatment site (5.5) than in the untreated site (3.7), as were the densities in the birch–aspen sapling and burn stratum (5.3 in treatment sites compared to 3.7 in untreated sites). Alder flycatcher (*Empidonax alnorum*) and white-crowned sparrow (*Zonotrichia leucophrys*) were the fourth and fifth most common species detected at the treatment sites but were absent from the untreated sites. There were 13 orange-crowned warblers (*Vermivora celata*) detected at the treatment site but none at the untreated sites. The differences in birds detected between treatment sites (mostly felled or burned aspen, some harvested birch) and untreated mature forest were probably attributed to differences in habitat types. Requests for additional preliminary data should be directed to Kevin Hannah at ABO in Fairbanks (khannah@alaskabird.org, telephone 907-451-7159).

PRELIMINARY CONCLUSIONS

COPPICE REGENERATION OF ASPEN

Understanding short-term responses of aspen to disturbance may suggest practical guidelines that improve the planning and effectiveness of future treatments. Maximizing density of initial aspen regeneration may not have a major effect on stem density at a given time in the future because early differences in stand density will be reduced by death of surplus stems through competition (Doucet 1989). "Excess" stems beyond those needed for cover are utilized as forage; we have observed intensive browsing by moose in most treatment areas (both proportion of total stems browsed and proportion of individual stems removed), particularly the first winter after the initial growing season. Most aspen treatments are now designed to be ≥8 ha (20 ac) to spread out browsing pressure, which is also happening as more sites are treated in a given habitat management area such as Nenana Ridge. The ultimate demonstration of habitat value will be assessed from animal use of the sites when desired forest conditions have developed in a few years. We particularly hope to study whether persistent debris on felling sites increases nest predation or mortality of grouse chicks from terrestrial predators relative to that observed on burned or untreated sites.

Both prescribed burning and felling of aspen during its dormant period have stimulated sprouting from the roots well above the desired stem density after 2 growing seasons. Postfire sprouting density often varies within burns and is positively correlated with the proportion of surrounding trees killed, which is a function of fire intensity (heat produced per length of fireline front). Increased fire-caused mortality is associated with steeper slopes and more southerly aspect. Whenever feasible, sites for future spring burns in mature aspen will continue to be laid out in stands with southern aspect so sunlight can dry surface fuels and exposure to winds can help carry flames near the ground. Ruffed grouse broods are normally associated with flat to moderately-steep terrain (D Dessecker, Ruffed Grouse Society, personal communication), but moose and other early-successional wildlife will benefit from young forest on the steeper slopes that facilitate burning in spring.

Sampling sprout density with 10 quadrats (1×5 m) per treatment stratum seemed to be suitable in efficiency (a 2-person crew can sample 1 treatment stratum per day in most habitats) and statistical rigor for management purposes when sampling burns with 2 strata (20 plots total). Future sampling of the larger mechanical treatments may be increased to 20 plots for adequate precision. The quadrat method was more precise for estimating preburn tree density than the plotless method and did not require a separate sampling event because it could be done after the burn. Thus, we will no longer estimate density of mature trees prior to treatments.

If further technique refinement is required, uniform sampling within density strata can again be used, with resolution a function of sample size. For purposes of habitat management, estimating the proportion of a treatment that meets or exceeds the threshold stem density may be sufficient to evaluate project success. Our strata designations for sampling were relative; indeed, stem counts in some of the "low density" plots exceeded the threshold density by >100%. An experienced observer could use visual estimation of threshold density (cf. Collins 1996:10) and a GPS to estimate the percentage of a treatment area that met or exceeding the threshold. Counting stems on a few subjectively placed quadrats may be sufficient for training observers or recalibration of visual estimation skills prior to fieldwork, and this technique can also be applied to later successional stages with lower stem densities. Patches of regeneration less than the threshold objective are reasonable to expect in burns and provide within-stand structural diversity for a variety of microhabitats for species other than grouse and may appear more visually "natural" to persons unfamiliar with site history.

To the extent that site selection (aspect, shading, drainage, ground cover) influences soil temperature, we can choose the best sites (south-facing, steep slopes, no moss) for optimal sprouting response to restore age diversity among aspen stands. Although revenue generation and removal of boles with timber harvest is desirable in this process, we can control dispersion of felling debris in nonharvest treatments to reduce shading and potential predator cover on part of the treatment area. We intend to experiment with coppice regeneration in young aspen (ca. 15- to 20-years old and 5 cm dbh) by shearblading or crushing in recent wildland fires near the road system. Debris from these treatments should be small enough to decompose in a decade or 2 and not provide the vertical structure attractive to terrestrial predators of grouse.

SURVIVAL OF WILLOW STEM PLANTINGS

Cost-effectiveness of planting willow stems should be evaluated relative to other hardwood regeneration techniques because of the labor involved in cutting, storing, transporting, and planting willows and the apparent poor survival of planting willow stems in burns, except on optimal sites. Scarification with a disk trencher is a relatively common postlogging site treatment for white spruce regeneration from seed or planted seedlings in Interior Alaska (M Lee, Alaska DNR, Division of Forestry, personal communication). Disk trenching is much less expensive per area treated than present costs for stand-scale burns in timber management areas and might overcome the variability of fire in exposing mineral soil and reducing grass competition in the immediate vicinity of planted stems. Willows could be planted midway between white spruce seedlings in the furrows as an experiment to estimate survival. The furrows will also provide a germination bed for willow (and paper birch) seed landing on the site the first year after treatment. Blade scarification with a dozer or skidder can serve a similar purpose but requires operator skill to not remove too much organic soil and should not be done on wet sites where grass is present and could proliferate (Collins 1996).

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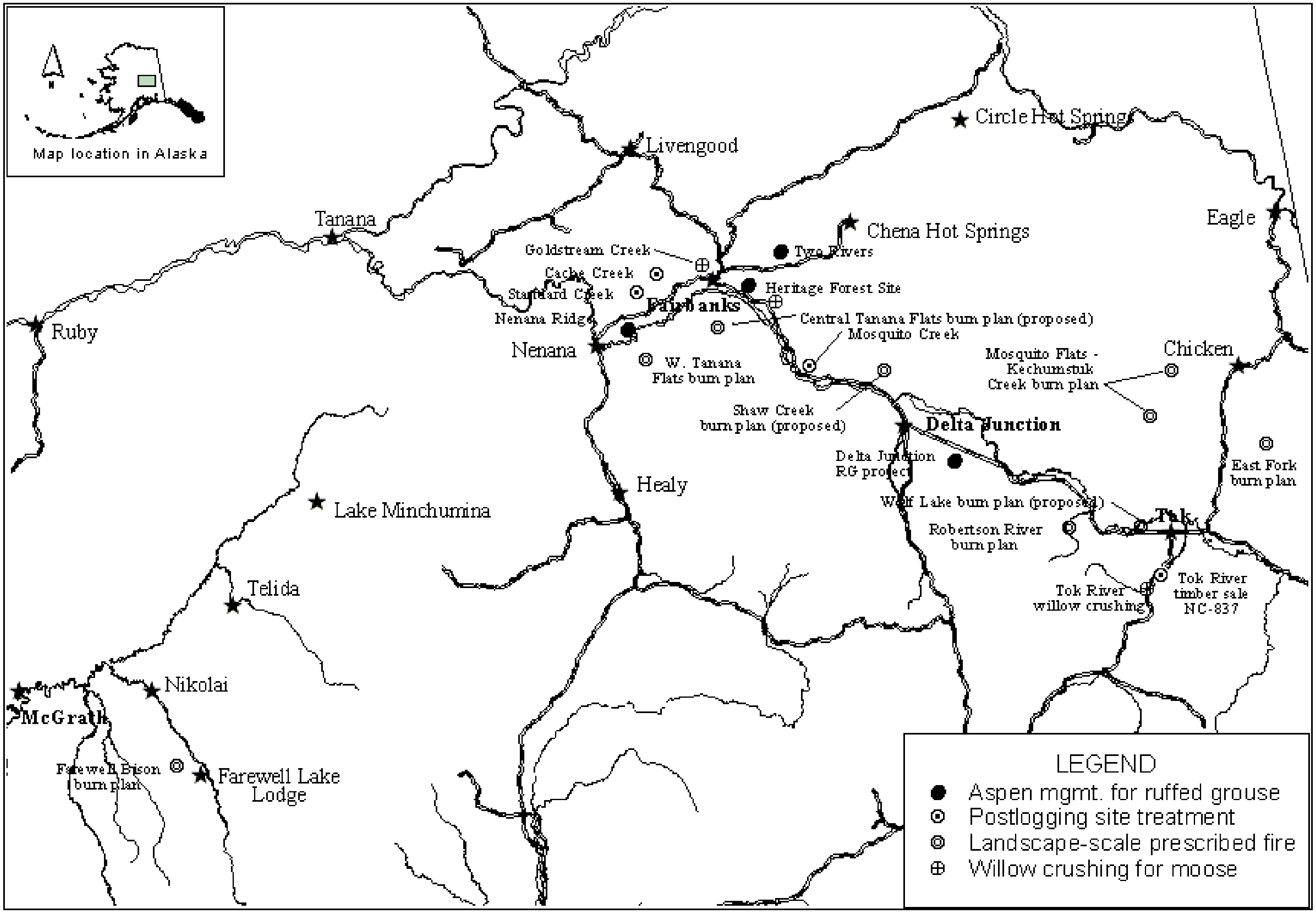


FIGURE 1 Location of ADF&G/DWC Region III habitat enhancement activities

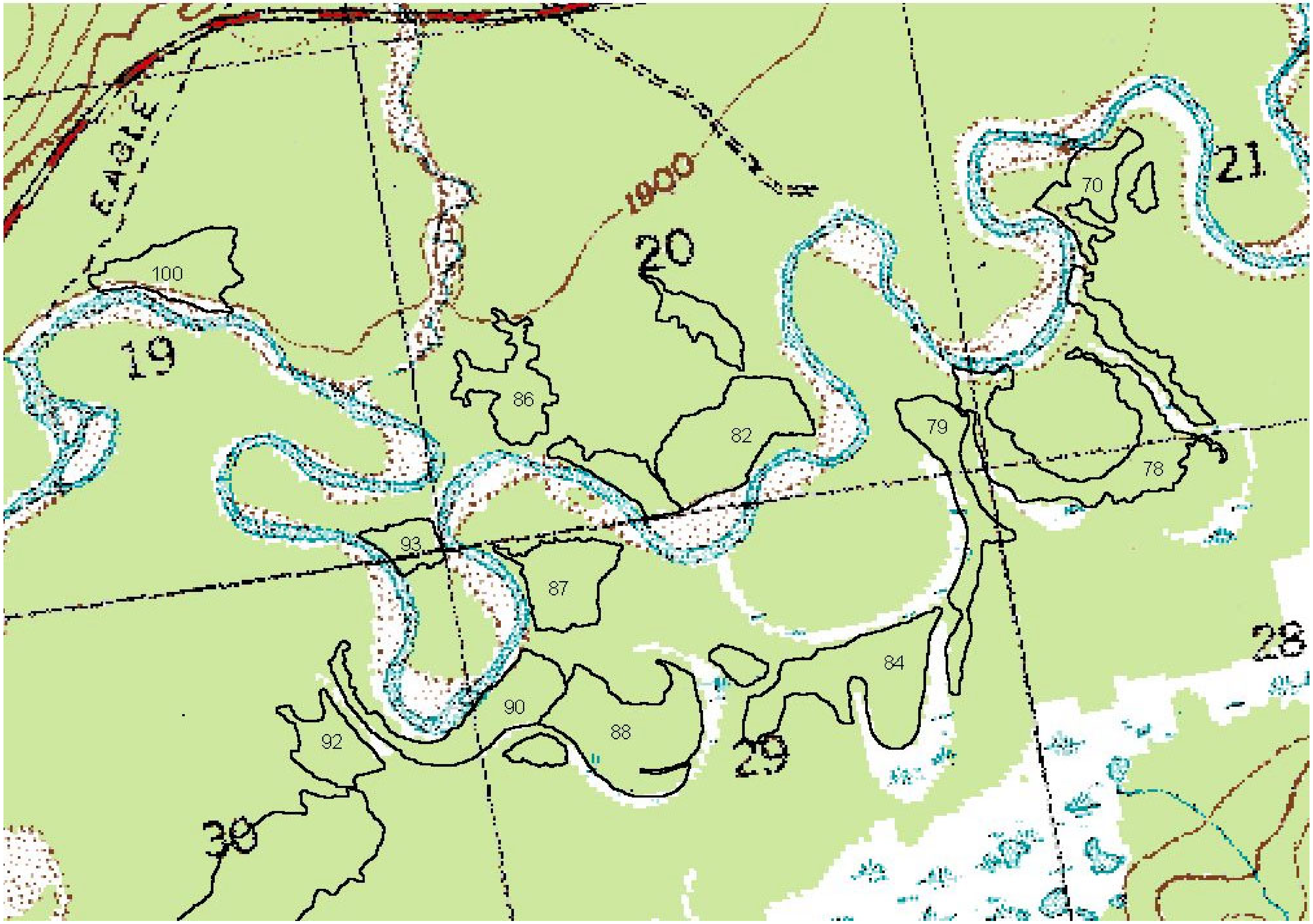
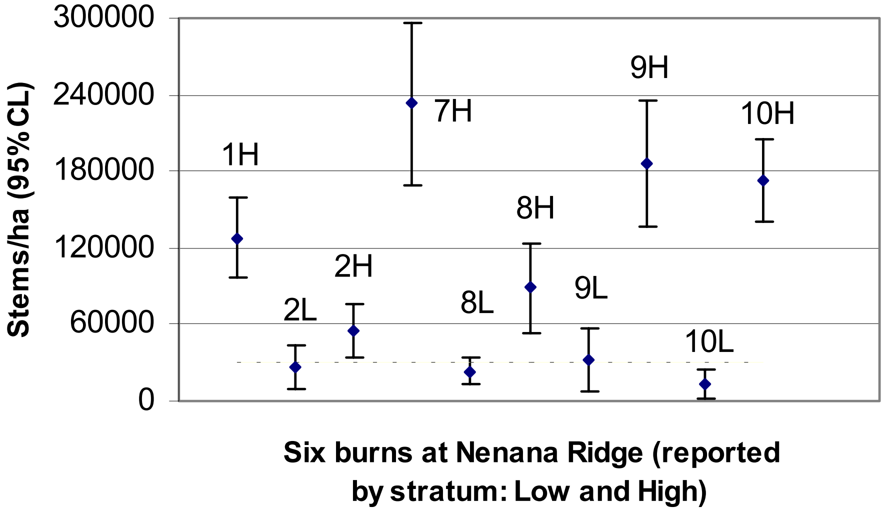


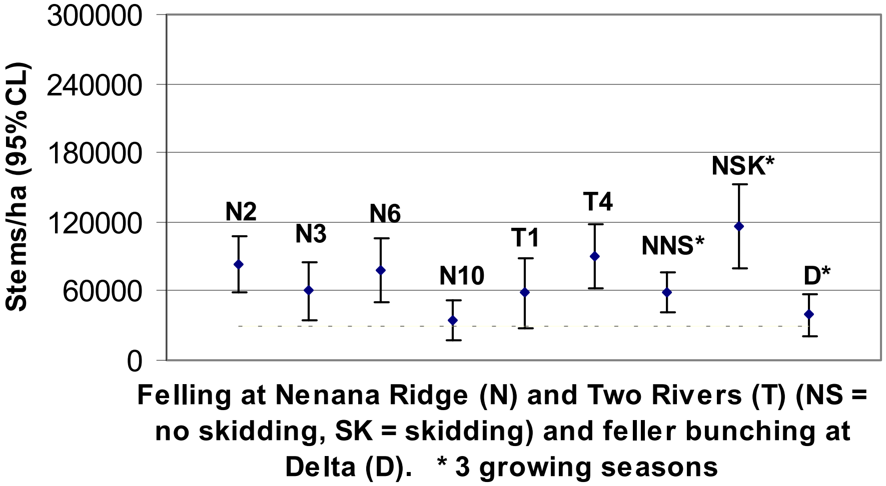
FIGURE 2 Twelve study sites at the proposed timber sale NC-837-T (Tok River) about 15 miles south of Tok along the Glenn Highway. One mile section lines of T16N, R12 E, Copper River Meridian, are visible on the 1:63,360 scale Tanacross A-5 map.

a



300000
240000
180000
120000
60000
0
Stems/ha (95% CL)
1H
2L
2H
7H
8L
8H
9L
9H
10L
10H
Six burns at Nenana Ridge (reported by stratum: Low and High)

b



300000
240000
180000
120000
60000
0
Stems/ha (95% CL)
N2
N3
N6
N10
T1
T4
NNS*
NSK*
D*
Felling at Nenana Ridge (N) and Two Rivers (T) (NS = no skidding, SK = skidding) and feller bunching at Delta (D). * 3 growing seasons

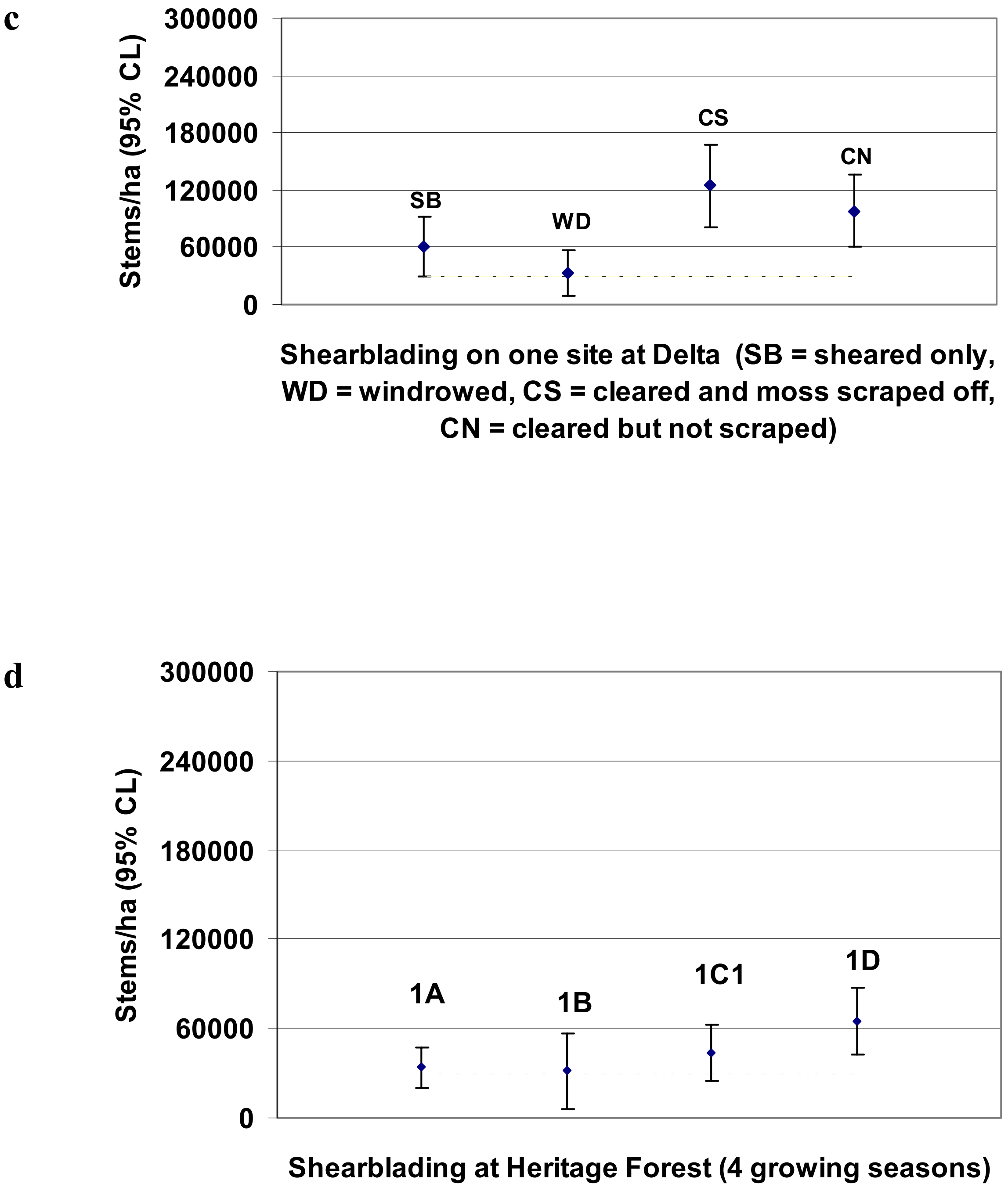


FIGURE 3 Density of aspen stems after 2 growing seasons (except as noted) following prescribed fire (A), chain saw felling and feller bunching (B), and shearblading (C and D) in Interior Alaska, 1997–2001. Dashed line is objective of 30,000 stems/ha.

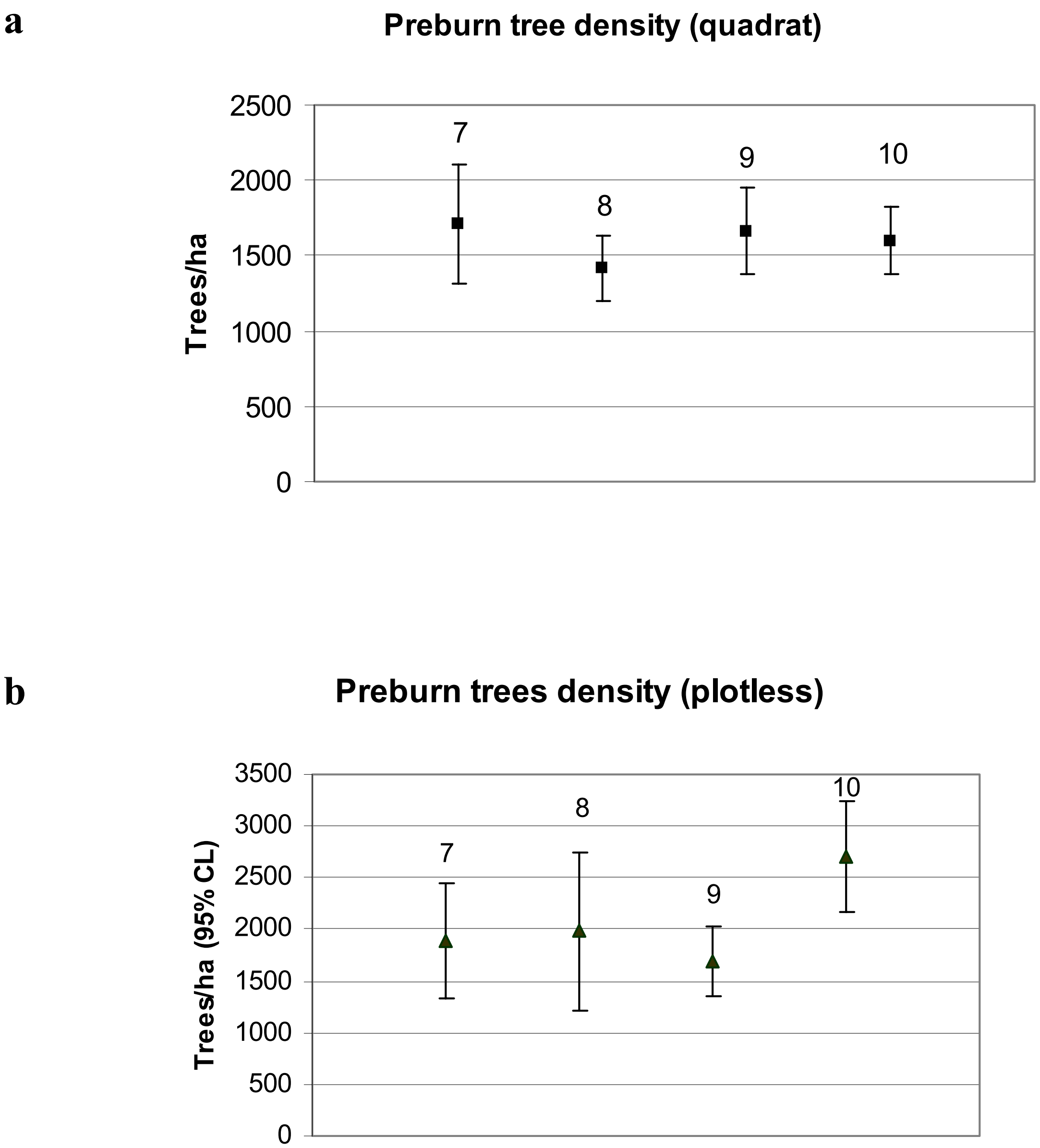


FIGURE 4 Density of aspen trees on sites prior to prescribed burning in May 1998 at Nenana Ridge, Alaska

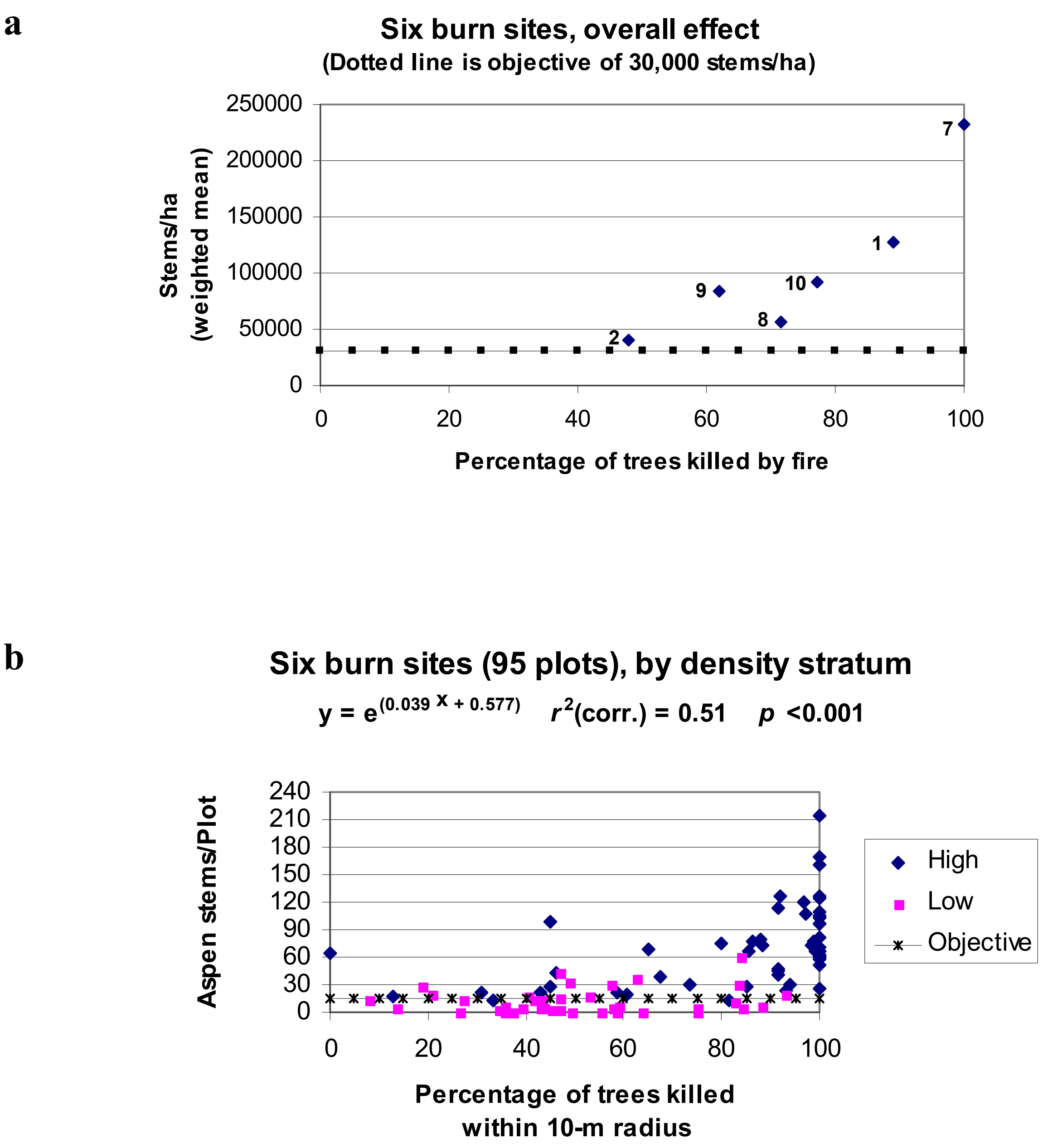


FIGURE 5 Effect of tree mortality on the density of second year aspen sprouts on 6 prescribed burns at Nenana Ridge, Alaska, 1998–2001. Combined sample size is 95 plots.

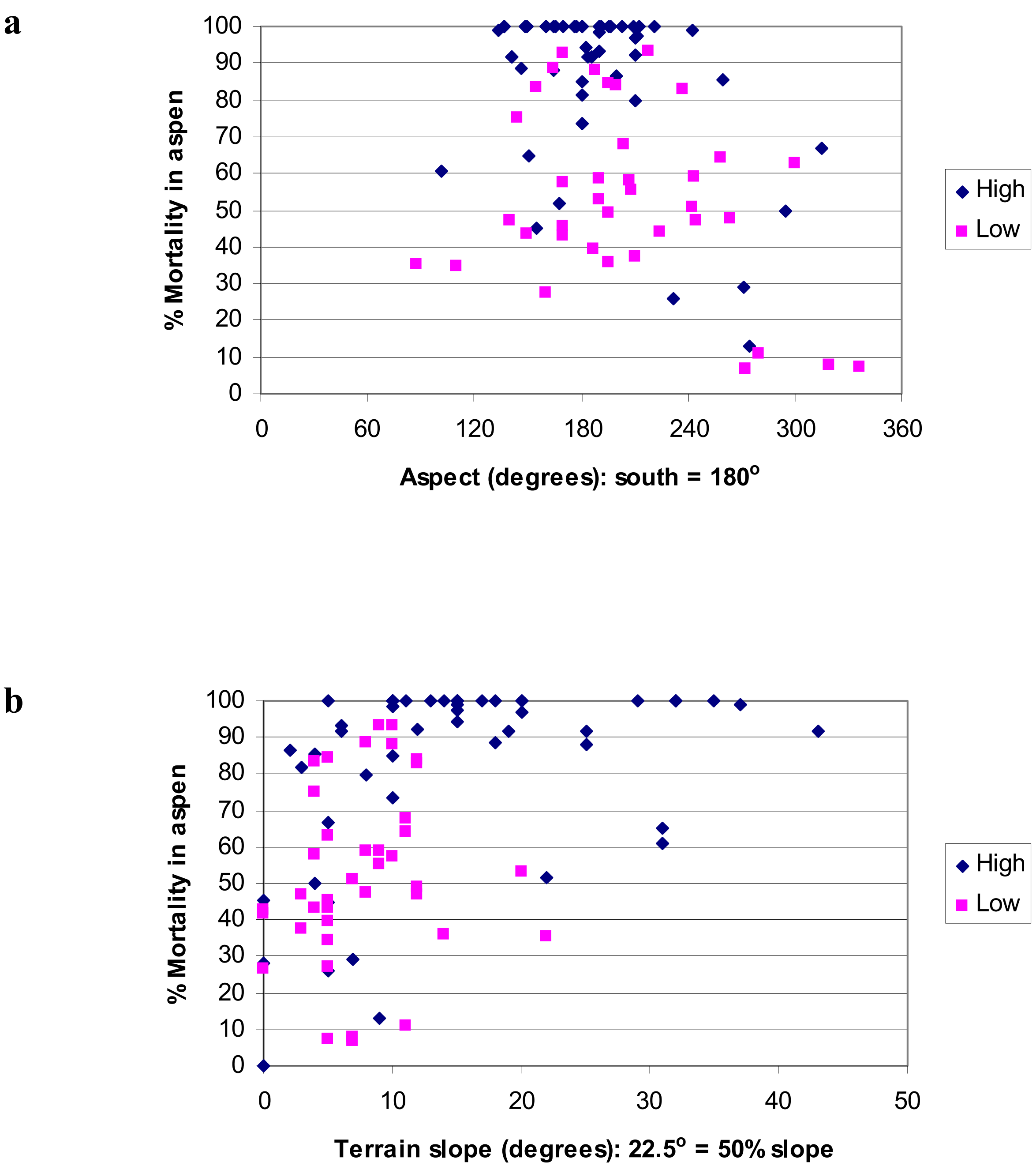


FIGURE 6 Effect of terrain aspect (*n* = 88 plots) and slope (*n* = 95), both of which can influence fire behavior, on fire-caused tree mortality within 10 m of sampling plots at 6 prescribed burns at Nenana Ridge, Alaska, 1998–2001. Plots were stratified by postfire density of aspen sprouts; flat sites (slope = 0°) had no aspect.

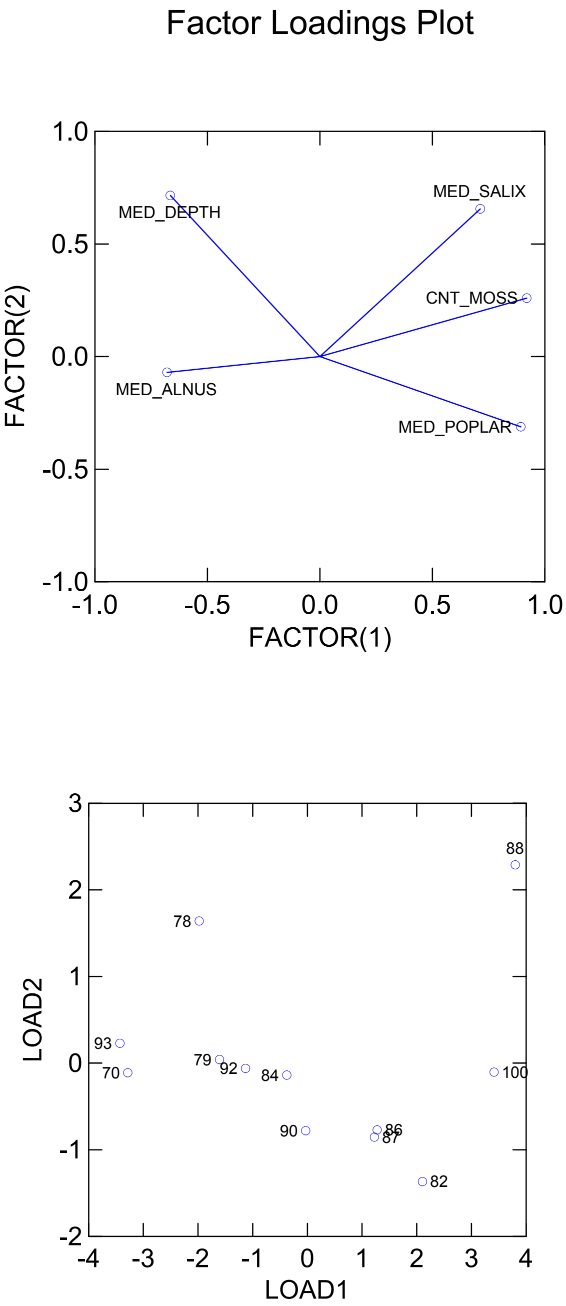


FIGURE 7 Principal components factors (see text for description) and loadings for all 12 study sites at Tok River, Alaska. Sites 70, 87, and 93 are proposed for burning as a postlogging site treatment.

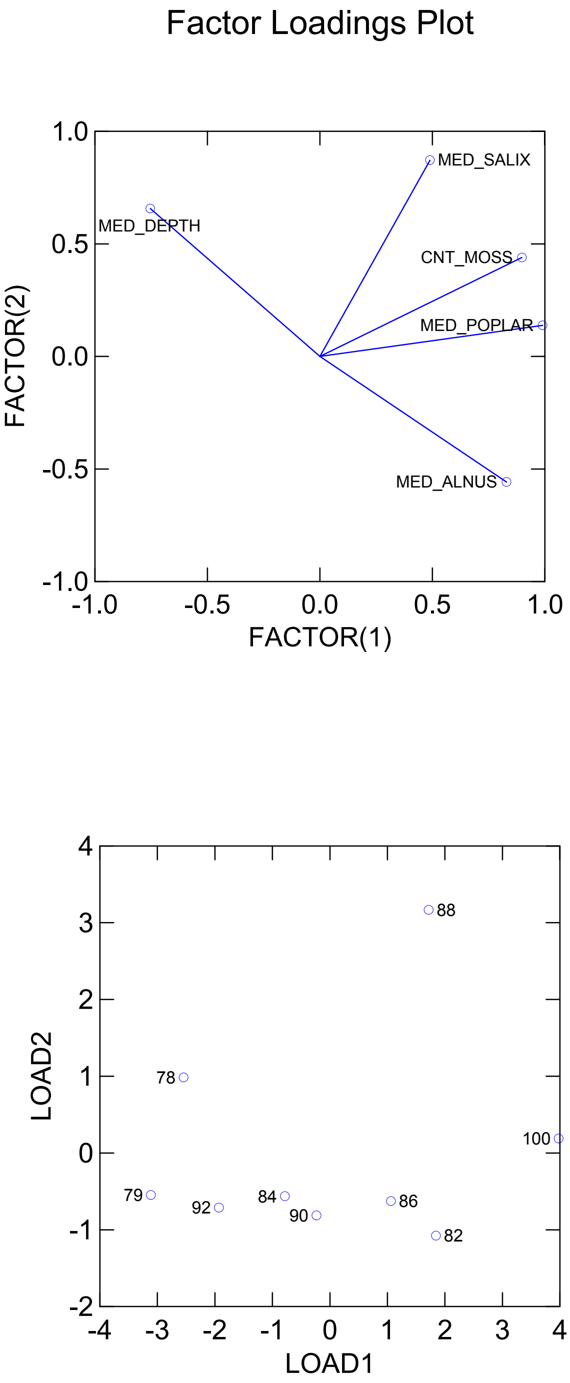


FIGURE 8 Principal components factors (see text for description) and loadings for the 9 study sites that do not include fire as a postlogging site treatment at Tok River, Alaska

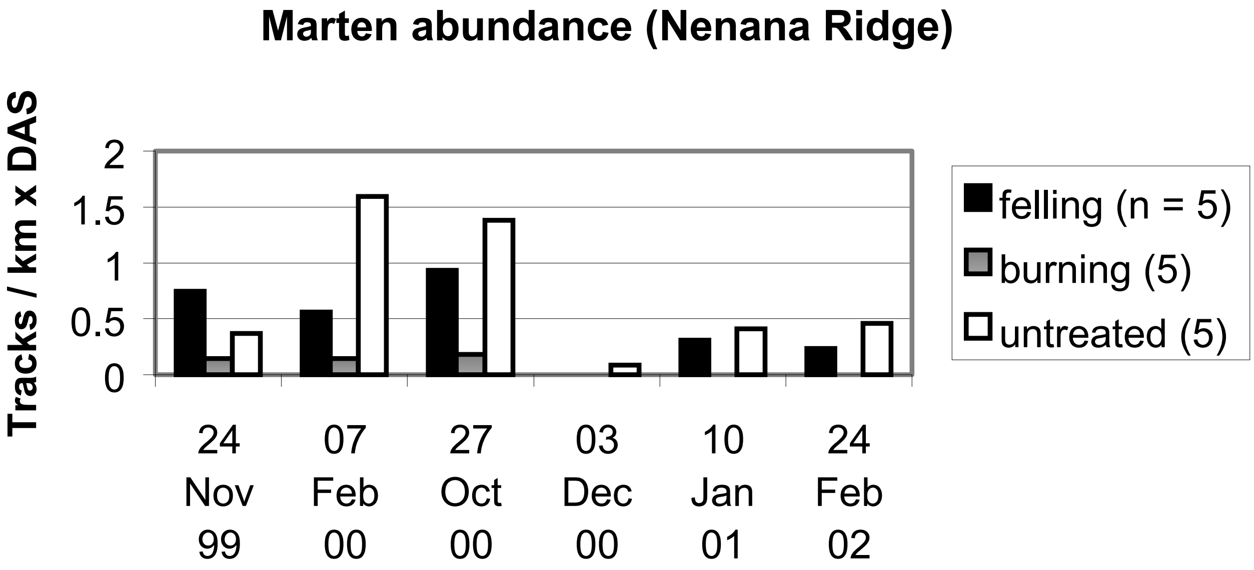


FIGURE 9 Habitat use by martens inferred from relative abundance of track intersections standardized for length of transects (km) and days after snowfall (DAS) at Nenana Ridge, Alaska, 1999–2002.

TABLE 1 Site and weather conditions for 6 prescribed burns in mature aspen at Nenana Ridge, Alaska. Weather parameters were at time of ignition (12:30–14:30 local). Duration of active burning ranged from 20 minutes on smaller sites to 1.5 hours on site 2.

Site	Date	Size (ha)	Slope[a]	Aspect[b]	Temp (^{o}C)	RH[c]	Wind (km/hr)	Sky	FFMC[d]
1	21 May 2001	6.6	30	144	18	32	light/variable	overcast	90.1
2	18 May 1999	12.0	9	240	13	21	6 NE w/gusts	clear	91.1
7	18 May 1998	1.5	12	168	18	25	5–8 SE	clear	90.0
8	15 May 1998	2.5	7	174	18	26	light/variable	clear	90.0
9	21 May 1998	2.5	8	202	19	26	8 E	high overcast	90.0
10	15 May 1998	2.1	15	194	16	32	16 gust 24 SE	clearing	88.0

[a] Degrees above horizontal; estimated from 10–20 plots subsequent to burn.

[b] North = 360^o and south = 180^o; estimated from 10–20 plots subsequent to burn.

[c] Percent relative humidity.

[d] Fine fuel moisture code (Taylor et al. 1996); value for sites 1 and 2 from Division of Forestry (DOF) records, other values calculated post facto using DOF weather data and a starting value of 85 for the previous day (Canadian Forestry Service 1987).

TABLE 2 Preburn tree and second-year sprout density (number/ha) of quaking aspen on burn treatments at Nenana Ridge, Alaska

			Preburn density									
			Quadrat[a]		Plotless[b]			Fire-killed trees[a]		Postburn density (quadrat)		
Site[c]	Stratum	Plots	Trees	% r.e.[d]	*n*	Trees	% r.e.[d]	%	*n*	Sprouts	C.V.	% r.e.[e]
1	High[e]	10	--	--	--	--	--	89	757	127,400	0.39	24
2	Low	10	--	--	--	--	--	40	413	26,600	1.00	62
2	High	10	--	--	--	--	--	59	303	55,200	0.59	37
2	Both[f]	20	1529	21	--	--	--	48	716	40,900	0.51	23
7	High[e]	10	1894	21	65	1886	29	100	624	233,000	0.44	27
8	Low	10	--	--	--	--	--	67	449	23,200	0.74	46
8	High	10	--	--	--	--	--	86	442	89,000[f]	0.63	39
8	Both[g]	20	1418	15	62	1985	38	76	891	56,100	0.53	23
9	Low	10	--	--	--	--	--	53	462	32,600[f]	1.24	77
9	High	5	--	--	--	--	--	88	337	186,400	0.31	27
9	Both[g]	15	1299	22	78	1687	20	68	799	83,867	0.56	28
10	Low	10	--	--	--	--	--	57	561	13,000[f]	1.47	91
10	High	10	--	--	--	--	--	100	444	172,200	0.30	19
10	Both[g]	20	1600	14	72	2702	20	76	1005	92,600	0.30	13

[a] Within 10-m radius of permanent plot corner; extrapolated from grand mean of all trees within all plots at a site. The grand mean of tree counts was normally distributed (Lilliefors test, $P \geq 0.18$) except for site 2 ($P = 0.02$).

[b] Nearest-neighbor technique (*n* measurements) based on systematic sampling along parallel transects before prescribed fire; thus, treatment unit was not stratified by sprout density.

[c] Site 2 was burned in 1999 and Site 1 was burned in 2001, whereas all other sites were burned in 1998; sampling occurred after 2 growing seasons.

[d] Relative error = 95% confidence interval divided by the mean.

[e] Sprout density was uniformly high in sites 1 and 7, thus they were each considered a single stratum.

[f] Stem counts were nonnormal (Lilliefors test, $P \leq 0.03$); all other strata were normally distributed ($P \geq 0.12$).

[g] Means estimated jointly from strata based on sample weights; see text for methods.

TABLE 3 Estimated sprout density (number/ha) of aspen following mechanical treatments (1997–2000) in Interior Alaska after 2 growing seasons, except where noted differently

Site[a]	Treatment	Plots	Sprouts	C.V.	% Relative error[b]
N12	Fell/Skid	5	116,400	0.35	31
N12	Fell/No Skid	5	59,200	0.32	28
N2	Felling	10	83,000	0.46	29
N3	Felling	10	60,400	0.67	42
N6	Felling	10	77,800	0.59	36
T1	Felling	10	58,200	0.86	53
T4	Felling	10	89,800	0.57	31
D1	Feller bunch	10	39,200	0.73	45
DS1	Shear	10	60,400	0.83	51
DS1	Windrow	10	32,800	1.20	74
DS1	Cleared/Scraped	9	124,400	0.47	34
DS1	Cleared/Not scraped	9	98,000	0.54	39
H1A	Shear	10	33,200	1.06	73
H1B	Shear	10	63,000	0.29	18
H1C1	Shear	10	30,600	1.57	98
H1D	Shear	10	47,200	0.58	36

[a] Letter denotes study area (N = Nenana Ridge, T = Two Rivers, D = Delta, H = Heritage Forest). Sites N12 and D1 represent 3 growing seasons, and the 4 H sites represent 4 growing seasons. All Delta and Heritage sites were flat, as was N12.

[b] Relative error = 95% confidence interval divided by the mean.

TABLE 4 Sprout density (number/5m^2 plot) of aspen by category of debris density, Interior Alaska, 1997–2000. The objective is 15 stems per 5-m^2 plot.

Treatment[a]	Debris	*n* Plots	Range	Median	Mean	95% CL
Felling	Low	2	25–49	--	37.0	--
Felling	Mod	17	13–85	43.0	44.1	35.1–53.1
Felling	High	26	1–65	20.5	23.7	16.9–30.5
Fell-bunch	Low	5	11–50	21.0	23.4	--
Fell-bunch	Mod	4	0–31	21.5	18.5	--
Fell-bunch	High	1	--	--	5.0	--
Shearblade	Low	17	1–64	29.0	27.5	18.6–36.4
Shearblade	Mod	22	0–80	12.5	19.8	11.5–28.1
Shearblade	High	10	1–56	12.0	23.2	10.1–36.3

[a] Felling treatment is comprised of no skidding stratum at sites 3a and 12, site 3 at Nenana Ridge, and sites 1 and 4 at Two Rivers; the feller-buncher treatment was site 1 in Delta; and shearblade treatments (without windrowing) were 4 sites at Heritage Forest (see Table 2 for number of growing seasons for each treatment) and 1 site at Delta. Confidence intervals >50% of mean are not shown.

TABLE 5 Number of days that soil temperature[a] exceeded thresholds and the cumulative degree-days during 2001 as indicators of how debris shading influenced growing conditions for quaking aspen relative to debris-free cleared sites at Delta (shearblading and windrowing, Mar 2000) and Nenana Ridge (felling and windrowing, Oct 2000). Aspen sprouting is inhibited when soil temperature at 7–12 cm depth remains below 15°C (Maini and Horton 1966).

	Delta (flat)			Nenana Ridge (aspect 231–281°, slope 11–19°)							
	Cleared	Debris		Cleared				Debris			
Soil temp (°C)	INT	INT 1	INT 2	INT1	INT2	MIN1	MIN2	INT1	INT2	MIN1	MIN2
≥15	0	0	0	7	6	0	0	0	0	0	0
≥14	0	0	0	28	24	0	6	4	0	0	0
≥13	0	0	0	46	47	26	28	33	4	0	0
≥12	11	0	0	54	54	44	45	43	24	2	0
≥11	25	0	0	57	60	47	49	47	44	31	2
Degree-days >0	800	555	574	1107	1072	819	835	970	954	681	631

[a] Organic-mineral interface (INT, site #) was 5–10 cm below ground surface, whereas mineral layer (MIN, site #) was another 10 cm deeper. Delta data were collected 23 May–19 Aug, whereas Nenana Ridge data were collected 10 May–28 Aug (INT) and 20 Jun–28 Aug (MIN).

TABLE 6 Estimates of browse stem density (number/100 m^2), index to horizontal and vertical cover (see text for methods), and depth of soil active layer (cm) from all transects combined on each replicate study site prior to timber harvest at Tok River, Alaska, 28 June to 25 July 2000

		Browse density[a]		% Cover		Active layer[b]	
Site[c]	Transects	Mean	Median	Horiz.	Vert.	Mean	Median
70	8	54.8	15.5	54.8	43.3	70.8	68.4
78	7	1.9	0.0	58.2	37.5	84.3	90.9
79	8	7.9	3.5	67.8	39.4	68.1	68.1
82	10	8.6	0.5	53.8	31.5	41.9	33.1
84	9	6.0	4.0	65.0	41.9	62.7	58.0
86	10	12.3	6.0	55.4	23.1	50.2	47.9
87	6	28.9	19.0	53.8	22.0	59.1	60.1
88	10	145.9	117.5	59.2	27.3	72.0	70.4
90	10	13.1	1.5	56.9	32.7	60.0	58.8
92	6	47.8	38.0	59.0	32.1	59.3	57.7
93	6	11.5	6.0	67.3	40.4	77.0	74.0
100	10	49.0	11.5	55.4	36.1	59.0	53.2
All	102	37.3	8.5	58.6	33.5	62.9	60.4

[a] Stem counts were nonnormal (Lilliefor's test, $P \leq 0.007$) for sites 70, 78, 79, 82, 86, and 90.

[b] Probe depth was nonnormal (Lilliefor's test, $P = 0.002$) for site 8.

[c] Sites 70, 87, and 93 will likely be broadcast burned because of lower risk for fire escape, whereas the other nine sites can be randomly selected for the other 2 treatments and control (3 replicates each). See text for discussion of randomized block selection.

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TABLE 7 Groups of fecal pellets (number per 100 m^2)[a] as an index to habitat use by moose from 102 plots on 12 proposed sale units (mature coniferous forest; see Table 4) and 45 plots on adjacent riparian sites prior to timber harvest at Tok River, Alaska, 2000–2002

		Pellet groups			95% Confidence limit ($\bar{x}$)		
Site	Year	$\bar{x}$	Median	C.V.	Lower	Upper	% Summer[b]
Sale units	2000	0.34	0.0	1.56	0.33	0.35	--
Sale units	2001	0.32	0.0	2.18	0.31	0.34	4
Sale units	2002	0.36	0.0	2.01	0.35	0.38	6
Riparian	2000	2.38	2.0	1.09	2.27	2.49	--
Riparian	2001	2.59	2.0	1.04	2.47	2.71	3
Riparian	2002	2.29	2.0	0.93	2.20	2.38	35

[a] Counts of pellet groups >50% within 2 × 50 m plots were nonnormal (Lilliefor's test, $P \leq 0.001$) for all sites and years.

[b] Summer pellets are distinguished as soft or deformed and indicate seasonal habitat use when herbaceous vegetation is available.

TABLE 8 Trail intersections of selected furbearers and their prey[a] at line transects of 130–515 m that span study sites (5 in felling treatments, 5 in prescribed burns, and 5 in untreated mature aspen) at Nenana Ridge, Alaska.

	Felling					Burning					No treatment				
Date	SQ	SH	GR	MA	FX	SQ	SH	GR	MA	FX	SQ	SH	GR	MA	FX
24 Nov 1999	0	0	24[b]	4	0	3	0	0	1	2	0	1	15	3	0
7 Feb 2000	0	3	36[b]	3	1	14	9	2	1	12	132	17	2	13	13
27 Oct 2000	1	0	4	4	2	65[c]	2	0	1	3	13	3	5	9	1
3 Dec 2000	0	3	9	0	0	0	0	13	0	0	1	4	0	1	1
10 Jan 2001	1	0	1	1	7	0	0	0	0	5	21	0	3	2	2
4 Feb 2002	2	0	0	1	0	0	0	4	0	0	2	0	3	3	0

[a] SQ = red squirrel, SH = snowshoe hare, GR = gallinaceous birds (spruce grouse, ruffed grouse, willow ptarmigan, or sharp-tailed grouse), MA = marten, FX = red fox.

[b] Likely ptarmigan tracks from a flock that moved through the site after snow had drifted over the felling debris.

[c] Plus a squirrel runway with >3 trails.

TABLE 9 Trail and runway[a] intersections of selected furbearers and their prey at line transects of 315 to 640 m that span 12 sites of timber harvest and 3 nearby sites not slated for harvest at the proposed timber sale NC-837-T, Tok River, Alaska.

	Red squirrel	Snowshoe hare	Gallinaceous				
Date	Trail runway	Trail runway	birds	Marten	Weasel	Red fox	Lynx
4–6 Dec 2000	339	882	0	1	7	18	12
8–9 Jan 2001	51	128	0	0	4	17	1
19–21 Nov 2001	477	272	38	0	18	29	4
24–25 Jan 2002	478	108	1	3	353	0	5

[a] Runways are >3 trails.

APPENDIX A Attributes of the 12 replicate treatment and control sites at the proposed Tok River timber sale (NC-837-T)

Site	Area (ha)	Spruce age (yr)	Spruce bark beetles	Moss depth (cm)	Tree snap	Windthrow at roots	Spruce regeneration	Disturbance	Edge[a]
70	4.8	190	moderate	9	heavy	heavy	stagnant/abundant	flood	460
78	11.8	115	moderate	13	moderate	moderate	healthy/abundant	logged	414
79	7.2	77	none	5	none	moderate	suppressed/scarce	flood + fire	428
82	10.4	125	heavy	13	heavy	heavy	suppressed/scarce	logged+fire	188
84	11.6	96	moderate	5	none	moderate	suppressed/scarce	flood + fire	254
86	5.6	125	none	14	none	heavy	suppressed/moderate	flood	440
87	6.3	118	none	5	none	moderate	healthy/moderate	flood	271
88	11.9	106	heavy	8	none	heavy	healthy/abundant	flood	222
90	8.1	102	heavy	5	none	none	stagnant/scarce	flood + fire	359
92	4.3	96	moderate	5	none	moderate	healthy/scarce	flood + fire	344
100	6.6	133	moderate	5	none	none	suppressed/moderate	flood	266

[a] Index (perimeter/area) where higher values denote a lower proportion of "Interior" forest. All sites are overall relatively flat. Data courtesy of the Alaska Department of Natural Resources, Division of Forestry, Tok area office.

Tom Paragi, DWC Regional Biologist, looking over the 2000 shearblading treatment in aspen on the Delta Junction Bison Range. Debris windrows are barely visible after four growing seasons. (ADF&G photo)