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Identifying and Evaluating Techniques for Wildlife Habitat Enhancement in Interior Alaska

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FEDERAL AID
FINAL RESEARCH REPORT

ALASKA DEPARTMENT OF FISH AND GAME
DIVISION OF WILDLIFE CONSERVATION
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PROJECT TITLE: Identifying and evaluating techniques for wildlife habitat enhancement in Interior Alaska

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I. PROBLEM OR NEED THAT PROMPTED THIS RESEARCH

Vegetation in boreal forest is rejuvenated largely by stand-replacement fire on upland sites 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 (Viereck 1973, Chapin et al., in press). Large wildland fires produce a mosaic of unburned vegetation and areas of different burn severity because of spatial variation in live vegetation type, dead fuels, topography (including water bodies), and soil moisture plus the effect of changing weather and fuel moisture as fires continue over long periods. Fire suppression by humans became common and widespread in interior Alaska by the 1960s, particularly with the increasing use of smokejumpers in remote areas. By the 1980s, recognition of the ecological value of wildland fire and increasing cost of remote fire suppression relative to human values needing protection led to creation of area fire management plans that were eventually consolidated statewide (Todd and Jewkes 2005, in press). Decisions on when and where to suppress wildland fire have a major influence on dispersion and productivity of wildlife habitat, particularly in areas underlain by permafrost. Most wildland fires are suppressed near Alaskan settlements where human resources are at risk of burning. In these areas, land managers use timber harvests, prescribed fire and mechanical treatments to periodically reduce the amount of coniferous fuels (or fragment continuity). These treatments help maintain early-successional vegetation for wildlife (Haggstrom and Kelleyhouse 1996). Besides logging, common mechanical treatments to stimulate deciduous regeneration include crushing with a dozer and clearcut felling by chain saw or dozer shearblade. Felling or crushing is done 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). Markets for deciduous trees in interior Alaska are currently limited to local use (Wurtz et al., in press; Wurtz and Gasbarro 1996), so harvest for revenue generation is not a widespread option for habitat management in broadleaf forest. Although some habitat management activities are initiated to benefit selected game species, returning disturbance to the boreal forest benefits a wide range of species. This “coarse filter” approach to conservation biology (Noss 1987) is largely responsible for maintaining the natural diversity of species and ecosystem functions in many areas.

An active habitat enhancement program will mitigate the negative impacts of human development on wildlife and meet the growing demand for wildlife to observe or harvest, particularly near populated, road accessible areas in 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 socially acceptable must be developed to optimize use of limited funding and address often conflicting public concerns over wildlife and associated land management practices. The cost of using machinery in forest practices varies widely with local availability and competing seasonal uses when there is no hardwood market to mobilize heavy equipment. Replication of field experiments at the scale dictated by resource management objectives is justified because it advances knowledge of natural processes and applied science (Johnson 2002) while providing operational guidelines on cost efficiency.

The DWC seeks to increase public awareness and acceptance of habitat manipulation as a means to maintain or increase wildlife populations and restore a more natural disturbance regime where wildland fires are suppressed. The DWC wants land, forest, and fire managers to integrate habitat manipulation techniques into their programs for public benefit while meeting other resource objectives. To accomplish these goals, we need habitat enhancement techniques that are both effective and affordable. It is useful to know how well various techniques meet wildlife habitat objectives when planning future projects and seeking funding. Identifying operational guidelines for biologists, foresters, land managers, heavy equipment contractors, and fire professionals will enhance the planning, conduct, and evaluation of cost-effective vegetative treatments. The purpose of this study is to evaluate the success of current and future projects in meeting those objectives.

II. REVIEW OF PRIOR RESEARCH AND STUDIES IN PROGRESS ON THE PROBLEM OR NEED

Because of the prevalence of wildland fire, many studies of forest succession in interior Alaska have examined post-fire regeneration, particularly in the expansive black spruce ecosystem

(Viereck 1973, Van Cleve et al. 1986). The Fairbanks area has been the focus for much of this research. Demand for hardwood pulp has driven silvicultural research on broadleaf forest regeneration in boreal Canada and the Great Lakes region (Marquis et al. 1969, Perala 1983, Doucet 1989, Peterson and Peterson 1995). Deciduous hardwood and shrub regeneration was studied to a lesser extent in interior Alaska, often coincident to greater silvicultural interest in white spruce regeneration and volume production (Zasada et al. 1992, Wurtz and Zasada 2001). Hydroaxing was used to improve moose browse on the Copper River Delta, Alaska (Stephenson et al. 1998). The authors noted the importance of maintaining abundant forage with treatments before alder and spruce succession reduced willow density through competition, thus requiring scarification to expose mineral soil for seed germination. Collins (1996) evaluated rejuvenation of hardwoods in southcentral Alaska by mechanical treatment (logging, post-logging scarification, shearblading, crushing, and hydroaxing) and prescribed fire and the effectiveness with which bluejoint grass competition could be controlled with mechanical, chemical, and biological means. His research provided a basis for vegetative evaluations in the present study.

Willow crushing for moose cover and forage was first done by DWC near Tok (Nellemann 1990), and small trials with willow and aspen crushing and propagation of willow cuttings were done near Fairbanks in the late 1980s. The present habitat enhancement program was initiated in 1994 to experiment with a broader range of techniques and address on-going habitat needs across Region III (Fig. 1). Initial funding to evaluate cost efficacy of treatments and response by vegetation and wildlife was obtained in 1996. Interim progress on this study and a more detailed review of literature was reported by Paragi and Haggstrom (2004).

III. APPROACHES USED AND FINDINGS RELATED TO THE OBJECTIVES AND TO PROBLEM OR NEED

OBJECTIVE 1: Gain a working knowledge of sampling designs and statistical estimators potentially suited for evaluation of habitat enhancement techniques being considered for use in the boreal forest of interior Alaska.

Literature reviews were conducted for each job through the electronic database Wildlife and Ecology Studies Worldwide, 1935–2005 (Biblioline), which is available online to ADF&G staff through the Alaska Resources Library and Information Services (ARLIS). Additional searches were done through services provided by the UAF Libraries Catalog (Goldmine), which provides access to numerous online databases.

Citations, abstracts or full-text articles relating to the current study were entered into a ProCite® database. Similar databases maintained by other biologists on a variety of wildlife topics (ungulates, carnivores, bears, fire, arctic research) were combined. This master database currently contains over 6,300 citations, of which about 25% have a full abstract.

OBJECTIVE 12: Analyze and publish results.

Each year we analyzed data to assess progress toward meeting study objectives. An interim technical report (Paragi and Haggstrom 2004) was published online to provide preliminary results to land managers and help with preparation of this final report. We are preparing a manuscript on aspen response to prescribed fire and mechanical treatments (Objective 2). We intend to produce manuscripts on forest type conversion after prescribed fire (Objective 8) and response of vegetation and wildlife to post-logging site treatments in riparian white spruce (Objective 3) upon completion of the studies, although the timber sale at Tok River has not yet occurred.

Some facets of this study were post-hoc analysis (little or no pre-treatment data) or had a compromised study design (little or no treatment replication among sites) because of early program emphasis on management objectives instead of research. These evaluations provided limited inference on treatment effects and have a lower potential for peer-reviewed publication than experiments with robust study designs. Nonetheless, these evaluations provided practical knowledge of use to land managers in interior Alaska, so our findings were often disseminated during informal presentations or field trips.

OBJECTIVE 13: Involve and inform other professionals and the public.

Each year we made several presentations on wildlife habitat, fire ecology, forest management, and vegetative succession following disturbance in boreal forest to local schools, UAF, State agencies, local government, Alaska Native organizations, and other public venues where wildlife habitat was of interest. We also attended scientific conferences to present preliminary results of our studies; were interviewed by radio, television, and newspaper media; and participated in various forums on fire and forestry planning statewide to ensure that wildlife habitat remains a prominent consideration in resource management activities in boreal forest. Details of these presentations were noted in annual activity reports.

Vegetation response on stand-scale habitat treatments

OBJECTIVE 2: Determine the relative efficacy and cost of using felling and shearblading (with and without removal of trees) and low-severity prescribed burning to stimulate root sprouting of suckers in mature stands of quaking aspen.

Paragi and Haggstrom (2004:16–19) reported on sprouting response by treatment type. During 1996–2003, stand-scale prescribed fire and mechanical treatments were applied throughout the region on 321 ha (793 ac) of aspen at costs ranging $190–800/ha ($75–320/ac), depending on treatment type (Table 1).

OBJECTIVE 3: Determine the relative efficacy and cost of using postlogging site preparations (e.g., disk trenching, blade scarification, and broadcast burning) to improve establishment of willow shrubs and hardwood saplings after timber is harvested from riparian white spruce stands.

In 2000 we established 6–10 transects uniformly throughout the 12 proposed treatment sites (Fig. 2) to inventory pre-treatment hardwood density and permafrost depth in floodplain forest at Tok River (Paragi and Haggstrom 2004:9–10). Evaluation of postlogging treatments will be conducted once the timber is sold and harvested.

OBJECTIVE 4: Determine the relative efficacy and cost of using postlogging site preparations (e.g., disk trenching, blade scarification, broadcast burning, and willow planting) to improve establishment of willow shrubs and hardwood saplings after timber is harvested from upland forest stands.

Study plots were established at three upland sites (Delta, Nenana Ridge, Standard Creek) with thick organic layers during autumn in 2002 and 2003 to evaluate the effectiveness of disk trenching and blade scarification in hardwood enhancement. We are delaying evaluation of these treatments until summer 2006 because initial hardwood sprouting is often high, followed by high seedling mortality from drought stress or bluejoint grass competition (Collins 1996). The intent is to see whether scarification will increase hardwood survival beyond stem initiation resulting in habitat features of use to wildlife.

OBJECTIVE 5: Determine the relative efficacy and cost of using crushing or other appropriate mechanical treatments, or prescribed burning, to rejuvenate willow stands with various species compositions and site characteristics.

Riparian shrubs such as feltleaf willow are capable of prolific sprouting of leaders when physically disturbed by ice scouring and flooding events. This response has been emulated by crushing during the dormant season with dozers to enhance moose habitat (Nelleman 1990). Approximately 118 ha (293 ac) of tall shrubs were crushed during 5–21 March 1996 in the Goldstream Creek valley near Fairbanks at $150/ha ($60/ac) to increase availability of forage for moose on a damp lowland site where wildland fire is aggressively suppressed because of nearby homes. Initial reconnaissance found almost no sprouting by Bebb willow but sprouts up to 1.5 m by feltleaf and redstem willows in mid-summer 1996, with evidence of moose browsing on essentially all stems of the latter two species by mid-summer 1997 (Haggstrom 1999a).

Sites photographed during crushing in March 1996 were revisited 5 April 2005 to examine willow and paper birch regeneration and take follow-up photos. Snow cover was complete, with an average depth of 75–100 cm. Feltleaf willow near the creek or ponds was 2–3 m tall with a growth form indicating a history of intensive browsing by moose (proportion of leaders per stem affected and proportion of individual leaders removed). Poor sprouting response and growth by Bebb willow was evident by the presence of large open areas with few stems showing above the snowline. However, the few Bebb willow stems extending above the snowline also showed a history of heavy browsing. Paper birch regeneration to 3 m was scattered with a growth form that indicated a moderate to heavy browsing history. Alder sprouting was prolific in some areas but was rarely browsed.

OBJECTIVE 6: Contrast the feasibility and statistical properties of plot and plotless (nearest-neighbor) techniques for estimating stem density of deciduous hardwoods on disturbed sites at the stand scale.

Plot-based sampling during the course of post-treatment measurements was more precise and time efficient than pre-treatment plotless sampling in estimating the pre-treatment density of aspen trees (Paragi and Haggstrom 2004:17).

OBJECTIVE 7: Evaluate techniques for estimating vertical and horizontal cover.

Pre-treatment data on cover were collected on vegetation transects (Objective 3) in 2000 using methods developed by Collins and Becker (2001). Time efficiency of the technique in dense regeneration will be evaluated once the timber is sold and harvested.

Vegetation response on landscape-scale habitat treatments

OBJECTIVE 8: Develop a true-color or color-infrared aerial photography technique to evaluate the success of landscape-scale prescribed burns in converting spruce-dominated stands to early-successional forbs, shrubs or hardwood saplings.

We are comparing the cost efficiency of high-resolution aerial photography to high-resolution satellite imagery for detecting vegetation changes following fire (Paragi et al. 2003, Paragi and Haggstrom 2004:11–12,21). Vegetation identified on pre- and post-fire images of the 45,000 acre East Fork prescribed burn (1998) was verified (ground truthed) during onsite visits by helicopter during July 2003 and September 2004. We expect DNR to complete the vegetative classification by during winter 2005–06, allowing progress on the change detection and analysis of contributing environmental factors.

Wildlife response to stand-scale habitat treatments

OBJECTIVE 9: Evaluate the feasibility of indices to presence and relative abundance (e.g., drumming by male ruffed grouse, furbearer and prey track intersections along transects in winter, pellet groups for moose) and of estimator techniques (e.g., flushing counts for grouse broods, line transect estimators for snowshoe hares) for animals at the stand and landscape scales.

Methods for grouse drumming surveys and brood flushing counts at Nenana Ridge, harvest reporting at Nenana Ridge, and moose pellet counts at Tok River have been reported previously (Paragi and Haggstrom 2004). Overall, the biological indices of the breeding grouse population and local brood production at Nenana Ridge demonstrated extremely low abundance in spring through mid-summer. Only 2 ruffed grouse were heard drumming during five years of surveys and only 1 brood of sharp-tailed grouse was observed in two years of flushing counts with dogs. Additionally, we only observed 1 ruffed grouse and heard 1 drumming male during twice-weekly visits to artificial grouse nests at Nenana Ridge in spring 2004 (Objective 10). However, hunter observations and the reported harvest from late August through October indicated a substantial number of birds in the study area and along its access road (Fig. 3). Juvenile birds composed 34–62% of the harvest in the Fairbanks area (Game Management Unit 20B) during autumns 2002–04 (annual n = 32–72; ADF&G files). We presume that road-accessible areas devoid of breeding birds because of intensive harvest the previous autumn were replenished with juvenile birds dispersing from adjacent, less accessible areas. Heavy hunter use of the study area occurred during the 1–15 September moose season (Paragi and Haggstrom 2004:23–24) and continued until snowfall hindered travel in mid-late October. The focused harvest pressure at Nenana Ridge due to the limited road network near Fairbanks may preclude use of population indices and harvest data to infer the effects of habitat enhancement on local grouse populations.

A pilot study in August 2004 was conducted to evaluate the feasibility of using a mark-recapture technique to estimate pre-treatment rodent density among post-logging treatment blocks at Tok River (Appendix A). Rodent response to post-logging site treatments will be evaluated once the timber is sold and harvested.

OBJECTIVE 11: Estimate and compare relative abundance of furbearers (potential grouse predators) among treatment types.

Winter track counts in stand-scale aspen treatments (Nenana Ridge) and proposed logging sites in floodplain white spruce (Tok River) yielded small sample sizes because of the small scale of treatments relative to furbearer home ranges and the decline in furbearer abundance as snowshoe hare abundance declined in the region starting in the late 1990s (Paragi and Haggstrom 2004:22).

Wildlife response to on landscape-scale habitat treatment.

OBJECTIVE 10: Evaluate the effect of felling debris (aspen trees not removed) on ruffed grouse use of sites that have adequate densities of young aspen stems.

Gullion (1984:2) presented a conceptualized figure of how aspen stem density decreases and height increases with time after disturbance (stand initiation) and how various life needs of ruffed grouse are met as an aspen stand ages in the Great Lakes region. Lacking data for boreal forest, we used this model to evaluate whether our treatments produced “adequate” aspen density after two growing seasons (30,000 stems/ha = 12,500/ac; Objective 2), recognizing that growth rates and other seral changes may be slower at higher latitude. Habitat managers in boreal regions also need to understand how grouse respond to forest stand type and structure to optimize habitat benefits from costly stand-scale treatments.

We attempted to use drumming counts as an index to numeric changes in male grouse inhabiting the Nenana Ridge study area, where 213 ha (526 ac) of aspen had been treated (Fig. 7). However, intensive autumn harvest was presumed to consistently produce low spring density of ruffed grouse, complicating a study of population dynamics (Objective 9). We also attempted to evaluate how structural characteristics of the treatment area might influence mortality factors, such as terrestrial predator abundance, but the small study area and influence of the snowshoe hare cycle precluded meaningful inference of furbearer abundance at the small scale of the study site (Objective 11). Because low bird density during spring would preclude direct study of habitat selection by marked hens and broods, we conducted a study of predation on artificial nests in 2004 (Appendix B).

IV. MANAGEMENT IMPLICATIONS

Prescribed fire and forest practices using mechanical treatments can be designed to meet site-specific habitat objectives more precisely and perhaps effectively than wildland fire, but the directed treatments require funding. Small projects at a stand level (<25 ha) are relatively easy to fund because the cash outlay for each is small (hundreds of dollars up to several thousand dollars), but the cost/hectare is high (Table 1). Conversely, large projects to maintain early-seral habitat at a scale that would influence moose populations (thousands of hectares) are expensive, but often more cost-effective (Table 2).

Funding for DWC initiated habitat projects comes from Capital Improvements Projects (CIP) established by the Alaska Legislature and RGS contributions. The RGS has funded aspen enhancement projects (small prescribed burns, felling, and shearblading) on 20–40 ha (50–100 ac) per year in the Tanana Valley since 1994. CIP funding is used for landscape-scale prescribed burns and to augment RGS funding for stand-scale treatments. A second CIP containing both state and federal funds was passed in 1996 and renewed in 2001**.** Access to CIP funds was recently restricted due to statewide fiscal issues within DWC, exacerbating the already complicated requirements for prescribed burning that require advanced agency coordination, public notification, and flexibility in timing. Mechanical treatments generally require less agency coordination and public notification can more easily be delayed to accommodate temporary fiscal shortages. Development of an economic value (e.g., biomass fuel) for hardwoods and small diameter conifers will reduce dependency on state and federal subsidy and greatly enhance our ability to manage boreal forest near communities for wildlife habitat and fuels management needs.

Vegetation changes on stand-scale habitat treatments

All three treatments (felling, shearblading, burning) met the stem density objective (30,000 ha = 12,500/ac) that Gullion (1984) recommended for grouse in the Great Lakes region within two growing seasons. Prescribed burning of aspen was the most expensive treatment method and only possible during 4 of 7 years because of climatic and human factors. Annual and seasonal climate variation affects fuel dryness, leaf emergence, and road condition. In addition, the short burn window between spring snowmelt and leafout sometimes conflicted with firefighter training requirements and the seasonal demand for firefighters to manage wildland fires. Burning postponed the accumulation of debris on the forest floor because the top-killed trees remained standing for several years. Debris accumulated over several years and varied among sites, likely because some units were more susceptible to wind throw due to topography (location on an exposed hillside facing the prevailing wind) or alteration of the adjacent forest (open, felled unit upwind of the burn unit).

In contrast, shearblading on flat sites and felling on steep sites were the least expensive ways to top-kill aspen at the stand scale and both methods were readily achievable. However, these methods resulted in an immediate accumulation of debris.

There was little utilization of debris because of tree species (lower quality lumber and fuelwood), alternative sources of firewood (logging debris, fire or insect kill, and higher quality fuelwood species), and distance of treatment sites from communities. Debris from mature aspen (10–20 cm dbh boles) generally does not pose a fire risk because few intermediate sized branches exist to develop the heat necessary to ignite the large boles and vegetation of low flammability quickly develops. However, the debris hinders access by hunters unless windrowing occurs. Windrowing or removing the debris would be an additional cost that further reduce treatment efficacy.

In areas where moose forage limits population productivity, dozer crushing can be a highly successful and cost effective means to rejuvenate older stands of feltleaf and redstem willow that have grown out of reach by moose in river floodplains (Nellemann 1990, Objective 5 this study). Growth beyond moose access (ca. 3 m) can occur rapidly if ice-scouring floods in spring are infrequent and browsing pressure is low. Crushing holds promise for moose browse enhancement in road accessible areas and near rural villages, where dozer access could occur over ice and frozen ground or by barge along larger rivers during high water in spring. Bebb willow responded poorly to crushing. Burning or scarification to expose mineral soil may be required for stand initiation. Bebb willow is not as preferred by moose as feltleaf or redstem willow but composes a substantial proportion of diets at high moose densities in the Interior (Seaton 2002). Diamondleaf willow is a preferred forage species for Interior moose (Seaton 2002) that often grows in large open meadows, but it was rare to nonexistent on our crushing sites, so we could not evaluate its response to crushing.

The time and expense needed to do mechanical crushing is prohibitive for treatment of large areas. The feltleaf and redstem willow stands commonly on river floodplains contain few fine fuels, such as grass, and tend to not burn. However, it is possible to rejuvenate willows where they are mixed with other vegetation that contains the fine fuels necessary to carry fire. A 2,736 ha (6,760 ac) prescribed fire was conducted during mid-May 1999 on Mosquito Flats north of Tok to enhance grass, sedge and willow production (Haggstrom 1999b). Large prescribed fires created with aerial ignition in spring to rejuvenate existing stands of willows, can be more cost effective than crushing when there is other vegetation to help carry the fire. There is also less risk compared to summer burns in black spruce stands where the goal is site conversion to deciduous species. Response of diamondleaf willow to low-severity prescribed or wildland fire should be evaluated because spring burns can be conducted safely and cost-effectively in willow habitats when the ground under the conifers is still snow covered or wet.

Planting willow sprouts on upland logged areas to improve forage and cover for wildlife required substantial labor. This technique has proven successful for riverbank stabilization and localized landscaping on moist sites but incurs risk of poor survival on drought-stressed upland sites (Paragi and Haggstrom 2004:19–20). Fertilizing during planting (slow release tablets) or watering after planting may improve survival, based on experiences elsewhere (Roseann Densmore, USGS – Biological Research Division, personal communication). Watering is impractical due to access, distance from water source, and the scale needed to significantly improve forage and cover for wildlife. Fertilizer tablets were purchased but not used before planting was discontinued. Further projects on willow planting should focus on moist upland microsites to establish a localized seed source for future scarification treatments. The addition of fertilizer tablets at planting may be practical and cost-effective at this scale, and should be evaluated.

Vegetation changes on landscape-scale habitat treatments

The 1998 prescribed fire that occurred on >90% of the area within the perimeter of the East Fork burn demonstrated the ability of fire specialists to understand fire behavior, devise a practical prescription, and safely and cost effectively spread fire over a target area. The East Fork burn was among three landscape-scale burns conducted with aerial ignition near Tok in 1998–99 that treated approximately 33,400 ha (82,540 ac) at <$0.91/ha ($0.37/ac), excluding planning time (Haggstrom 1999b). Fire suppression specialists have increasingly used aerial ignition to backburn from control lines (e.g., rivers, lakes, hardwood stands) to remove fuels ahead of a wildland fire when direct attack is not safe. Aerial ignition could also be used to spread wildland fires under specific circumstances (vegetation type, wind direction, forecasted rainfall) to achieve resource and suppression objectives, including habitat enhancement and fuels management. Thus, the technical knowledge and skills for precise and effective aerial ignition exists in both state and federal suppression agencies. However, no new large prescribed burns have occurred on state lands since 1999 despite having three additional burn plans (Farewell in GMU 19C, Robertson River in 12 and 20D, and Tanana Flats in 20A) approved for implementation. Likewise, the politics of wildland fire management have not yet evolved to where fires can be actively managed for resource benefits; currently “fire use” only involves allowing wildland fires to spread naturally without any assist for management purposes.

Impediments to large prescribed burns included short duration of prescription conditions (only a few days in some years), lack of dedicated infrastructure for prescribed fire, limited availability of wildland fire personnel and equipment during summer, and increasing complexity of political considerations with proximity to population centers. The record area burned by wildland fires in Alaska during 2004 (2.7 million ha = 6.7 million ac, unknown proportion burned within perimeters) has heightened concerns about fire and the health risk of prolonged exposure to smoke in Interior communities. Greater awareness of fire risk near homes has increased homeowner interest in reducing site flammability through management of forest fuels, choice of building materials, and more careful storage of petroleum fuels. These actions might ultimately reduce anxiety about prescribed fire. Conversely, smoke concerns have increased anxiety over prescribed and wildland fire management. Additionally, smoke exposure has led to greater oversight of prescribed fire smoke management and imposition of new fees for permitting and emissions monitoring by the Alaska Department of Environmental Conservation.

Intensive management of ungulate populations includes explicit reference to habitat enhancement (Alaska Statutes, Section 16.05.255(h)(4)), but our ability to effect large treatments in specific areas where research has indicated improvement is needed in forage quantity (e.g., GMU 20A; Boertje et al. 2000, Seaton 2002) is hindered by factors mentioned previously. Large prescribed burns to enhance ungulate forage and create diversity in stand type and age class for terrestrial wildlife in interior Alaska are designed to also reduce continuity in fire prone species such as black spruce. This reduces risk from wildland fires for nearby communities. Prescribed fire also has promise for reducing fuels immediately outside the wildland/urban interface under chosen conditions and thereby reducing peoples’ fear of fire spreading into communities. This will increase our options for managing wildland fires in areas near communities where they are currently largely suppressed.

Completing the evaluation of factors associated with site conversion from black spruce to shrubs or hardwoods in the East Fork prescribed burn (Objective 8) remains a high priority because our greatest leverage may be to demonstrate the value of prescribed fire to fuels management. Until large prescribed burns can be carried out in areas targeted to benefit ungulate populations that are accessible to larger communities during the hunting season, the staff time and cost of planning additional burns large enough to improve moose population parameters is not warranted.

Wildland fire is unpredictable with respect to timing, location, or effect on vegetation in comparison to prescribed fire or mechanical treatments. However, until some of the sociopolitical and operational obstacles to prescribed fire are overcome, working with the public and private landowners to maximize the area in the Limited Management Option under the Alaska Interagency Wildland Fire Plan (AWFCG 1998) remains the least expensive and most practical means of maintaining habitat for early-successional species at the landscape scale.

Wildlife response to stand-scale habitat treatments

Nichols (2005) noted that felling debris generally did not hinder moose access to forage at Nenana Ridge, although percentage of browsed leaders per stem declined from 23% (4-yr-old) and 59% (2-yr-old) within 3 m of the edge to near zero beyond 75 m from the edge. Weixelman et al. (1998) found moose diet selection among four browse species to be lower at 40–60 m from cover than at 0–20 m from cover in 7–10 year old stands on the Kenai Peninsula, presumably a behavior to reduce duration of exposure to predation risk in open habitats. Nichols (2005) recommended that aspen felling treatments at Nenana Ridge not exceed 75–100 m from any edge to optimize forage availability for moose forage and develop brood cover at a scale most beneficial for ruffed grouse production. If the same total acreage is reconfigured into smaller or narrower treatment units without increasing the total number of moose, browsing pressure will be more evenly distributed, reducing localized overbrowsing that slows stand development to the stage needed for brood cover. Smaller or narrower patch sizes are also more optimal for ruffed grouse production (Gullion 1984).

Wildlife response to landscape-scale habitat treatments

Creating a few hundred hectares of dense young aspen patches among mature stands at Nenana Ridge and the Delta Bison Range will increase brood rearing habitat for grouse when stem density declines through competition or browsing pressure and height increases to an optimal level (Gullion 1984). However, the extent that brood rearing habitat was limiting grouse abundance prior to treatments is not known. The limited road system seems to concentrate harvest pressure on grouse at Nenana Ridge, particularly because the area is well known by moose hunters. Immigration from adjacent inaccessible habitats may be compensating for the seasonal removal of the breeding population. Hunter harvest per effort corroborates the trend in abundance based on drumming surveys from adjacent areas in the region. Finding study sites to evaluate how habitat enhancement influences chick survival and trend in grouse population will be a challenge with a limited road system unless study sites are chosen far from population centers, which increases cost of both treatments and research logistics.

The East Fork prescribed burn treated approximately 18,000 ha (45,000 ac) within a larger perimeter to enhance moose forage in a drainage within which few wildland fires had been allowed to burn since the late 1960s. Several large wildland fires have occurred in the Fortymile drainage since 1998, with approximately 227,000 ha (560,800 ac) within the burn perimeters (proportion burned within each perimeter is unknown) in 2004 alone. Moose population estimation surveys are attempted annually in GMU 20E to determine trends in abundance and age-sex composition for managing a sustainable harvest. However, it would be difficult to separate influences of habitat enhancement at the population level (e.g., improved twinning rates soon after parturition) caused by the East Fork burn without marked cows to verify seasonal movements and habitat selection. The long-term research program in GMU 20A (Boertje et al. 2000) has the greatest potential to evaluate effects of habitat enhancement on moose in the Interior by monitoring movements and habitat selection relative to two large fires in 2001 (ca. 48,000 ha = 120,000 ac burned within 80,000 ha = 200,000 ac of perimeter). Future moose research in GMU 20A should incorporate a design to evaluate moose response to a large prescribed burn that is planned for the Tanana Flats (Haggstrom and Kurth 2001).

V. SUMMARY OF WORK COMPLETED ON JOBS IDENTIFIED IN ANNUAL PLAN FOR LAST SEGMENT PERIOD ONLY

JOB 1: Continue a literature review of habitat management techniques and maintain peer contacts to learn about related research.

We continued to obtain current literature on topics germane to study projects. In addition, a monthly summary of recent citations with abstracts is imported into a ProCite® database for staff use in research and report writing. University and agency researchers and managers were contacted for new information.

JOB 2: Design and conduct long-term studies to evaluate the effectiveness of different habitat management techniques and applications.

Vegetation response on stand-scale habitat treatments

The post-logging broadcast burn of logging slash scheduled for summer 2004 at one of the research plots in the planned timber sale NC-837-T was not completed because timber on the site has not yet been harvested. The DOF now anticipates putting the sale out for bid in autumn 2005.

On 5 April we revisited sites photographed during the 1996 crushing project to enhance willows in the Goldstream Creek valley near Fairbanks to examine regeneration by willows and paper birch and take follow-up photos.

Vegetation response on landscape-scale habitat treatments.

The study area northeast of Tok was visited by helicopter during September 2004 to collect data necessary to ground truth the Quckbird satellite imagery.

JOB 3: Design and conduct long-term studies to determine the response of wildlife populations to habitat treatments.

Wildlife response to stand-scale habitat treatments.

- We continued gathering baseline data in the 12 units selected for study in Block B of the planned NC-837-T timber sale along the Tok River. A density estimate for small mammals from livetrapping and an estimate of woody debris abundance on the livetrapping grids were done in August 2004. Spring counts of moose pellet groups along transects begun in 2000 were not done in this reporting period because of the time involved, small variability in groups/transect among previous years, and the continued postponement of the timber sale.

- No track surveys of furbearers and their prey were conducted at Nenana Ridge (low count rates in recent years of the snowshoe hare cycle are insufficient for statistical purposes) or Tok River (low count rates and timber sale continues to be postponed).

Wildlife response to landscape-scale habitat treatments.

A kiosk with hunter reporting cards was again used to sample grouse hunting success at Nenana Ridge. Wing barrels were again used at three locations near Fairbanks (Bonanza Creek, Nenana Ridge, Standard Creek) to obtain harvest samples for age and sex inference on the grouse population. In addition to our study needs, these data corroborated trends in grouse populations inferred from spring drumming surveys in the Interior that are used for adjusting bag limits during the spring portion of the hunting season.

JOB 4: Write annual progress reports and a final report, publish selected topics in scientific journals, and participate in professional and public forums relating to study results.

- Paragi continued to serve as a founding co-chair of the Alaska Northern Forest Cooperative to promote communication between forest landowners and researchers on management issues. He took a lead role in organizing the workshop “Managing Small Trees in the Northern Forest” held during 12–14 October 2004 in Fairbanks. The workshop included reduction of hazardous fuels, subsistence usage (including habitat), value-added wood utilization, and silviculture.

- As president-elect of the Alaska Chapter of The Wildlife Society (AK TWS), Paragi chaired the organization committee for the 2nd joint meeting between the Alaska Society of American Foresters and AK TWS in Fairbanks (21–23 April). He gave an invited talk on maintaining wildlife habitat while mitigating fire risk in the urban interface, presented his research on small mammals at the Tok River timber sale, and led a field trip on wildlife habitat assessment in a recent burn.

- Paragi gave invited presentations to the Institute of Arctic Biology at UAF in February 2005 on the small mammal research at Tok River (co-presenter was Eric Rexstad of UAF) and separately on the need for collaboration between researchers and managers to address societal needs in boreal forest.

- Paragi presented posters on grouse population indices and on the predation study with artificial nests at Nenana Ridge during the annual fundraising banquet by the Interior Alaska Chapter of the Ruffed Grouse Society in Fairbanks (26 February).

- A FY04 research performance report, FY06 work plan, and FY06–10 study proposal were submitted to Federal Aid, and a budget request was submitted for FY06.

VI. ADDITIONAL FEDERAL AID-FUNDED WORK NOT DESCRIBED ABOVE THAT WAS ACCOMPLISHED ON THIS PROJECT DURING THE LAST SEGMENT PERIOD, IF NOT REPORTED PREVIOUSLY

Paragi coordinated hunter donations of grouse and ptarmigan gizzards (3rd and final year) for a baseline study of grit contamination near roads by a professor at Swarthmore College, Pennsylvania (data on age and sex augmented harvest data obtained separately from wing barrels). He also assisted a U.S. Fish and Wildlife Service toxicologist with necropsies for tissue contaminants analysis on 10 spruce grouse for which associated grit samples were collected.

VII. PUBLICATIONS

None during the reporting period.

VIII. RESEARCH EVALUATION AND RECOMMENDATIONS

Initial experimentation with prescribed fire forest practices provides limited inference on how landscape context influences treatment effects because new management scenarios are often not widely replicated because of cost or perceived risk. Further replication of habitat enhancement treatments across the Interior is desirable to characterize variation in shrub and hardwood response to disturbance as a function of disturbance type, vegetative community, soil type, and topographic position. We established permanent plots at several treatment sites to allow study of vegetation changes with reduced error when sampled over time. Global Positioning Systems (location accuracy) and Geographic Information Systems (attributes linked to spatial location) will facilitate re-sampling and data management. For example, aspen density and height will be re-sampling a decade after the felling, shearblading, and burning treatments (Objective 2) to determine whether stand characteristics necessary for the site to function as brood cover for grouse have developed or, if not, whether current annual growth of browse has exceeded the height available to moose. The challenge will be inferring whether changes in brood rearing success can be attributed to site enhancements given the complicating effect of harvest intensity in the accessible treatment areas.

The vegetative classification needed for change detection in the East Fork prescribed burn is a substantial undertaking that requires specialized equipment and expertise from other agencies. Although ADF&G could acquire the aerial photos inexpensively with State aircraft and equipment used for caribou herd census, expensive digital scanning was required for comparison to satellite imagery. Second, the remote location lacked a base map for ortho-rectification of raw imagery or aerial photos, so we had to obtain ground control points (precise locations of finely recognizable features). Finally, progress on the classification was complicated by learning trials in the use of emerging technology (high-resolution imagery, specialized analytical software) and time allocation of specialists in other agencies. The advent of seamless classifications statewide for fuel mapping and other needs in the near future (e.g., LANDFIRE: http://www.landfire.gov/About/landfirecharter.pdf) may preclude the need to undertake individual classifications in remote areas unless pixel resolution less than 30 m is required.

Research identifying the characteristics of forested sites and treatment factors that enhance type conversion from black spruce to deciduous woody species is urgently needed for projects that intend to enhance hardwood browse and cover through burn prescriptions or creation of fuel breaks by mechanical means. The change analysis for the East Fork prescribed burn (Objective 8) is addressing the initial type conversion, and evaluations with new imagery at subsequent time intervals will define extent and rate of type change as vegetative succession occurs coincident with site factors. The challenge will occur where the sites most desired for conversion (such as in the wildland-urban interface) have poor potential for conversion because of high soil moisture, low soil temperature, or northerly aspect. In FY06 we will begin a 2-year pilot study in the greater Fairbanks area with the UAF Forest Sciences Department and the DOF to examine fuel breaks being created by mechanical treatments to reduce fire risk. The objective is to develop effective ways to convert black spruce sites to early-seral hardwoods while retaining late-seral features (snags, cavity trees, spruce rust brooms) and mitigating risk of vehicle collision with moose.

IX. PROJECT COSTS FROM LAST SEGMENT PERIOD ONLY

Stewardship Investment items: None

FEDERAL AID SHARE $50,700 + STATE SHARE $16,900 = TOTAL $67,600

X. APPENDICES

A. Effects of forest management treatments on small mammal density in floodplain white spruce, August 2004 (Cooperators: Eric Rexstad and Edward Debevec, UAF).

Wildlife response to debris following various combinations of timber harvest, mechanical treatments, or prescribed fire is poorly understood in boreal forest. Identifying population changes in rodents, particularly relative to habitat features, is important in understanding ecosystem dynamics. Arvicolines are the primary prey for small and medium-sized carnivores and can influence boreal forest regeneration through seed predation (Radvanyi 1970) and girdling damage. Radvanyi (1980) reported up to 95% girdling mortality of birch and aspen seedlings at a mine reclamation site in Alberta where grass had been planted to stabilize slopes.

Changes in vegetative cover (species, vertical structure, debris loading) caused by timber harvest, mechanical felling, scarification, or burning will influence site productivity (soil temperature, water availability, nutrient cycling) most dramatically soon after disturbance because successional changes occur more slowly over time as the forest regenerates. Several studies in southern boreal forest (e.g., Sullivan et al. 1999) have examined how clearcutting and burning have influenced small mammal communities. One of the only studies in northern boreal forest on how silvicultural practices (clearcut and shelterwood) influence small mammal distribution and abundance (West et al. 1980) occurred only during the first year post-treatment at the stand scale. With the exception of a roller crushing study by Bangs (1979) on the Kenai Peninsula, no data exist on how potential fuel treatments (shearblading, roller chopping, crushing); the most common harvest method for white spruce (diameter-limit); or post-logging scarification techniques (blade, disk trench, broadcast burn) have influenced small mammals in interior Alaska.

Arvicoline rodents will be our model for testing how forest practices influence energy flow and population dynamics in boreal forest wildlife of interior Alaska. Our goal is to test hypotheses germane to developing operational guidelines for forestry practices, particularly the effects of debris loading and prescribed fire on small mammal communities the first four years after treatments are applied. This baseline information may guide silvicultural prescriptions in the near future and provide an empirical framework for the monitoring effort needed to detect changes of a defined magnitude over longer periods of vegetative succession.

We will test three hypotheses at the proposed Tok River timber sale in floodplain white spruce (see Paragi and Haggstrom 2004:20–21 for description of the randomized block design):

1) Debris loading (kg/ha) and debris height will be positively correlated to arvicoline density and biomass across all mechanical treatments and all forest types for the first 4 years after treatment, regardless of relative population abundance among years

Woody debris can provide habitat value as both vertical structure and moist refugia on dry sites, often changing in structure and function over time. Vertical structure provides escape cover and subnivean access to forage plus shade on open sites, particularly after timber harvest or burns. Wood in contact with moist organic soil hastens decay, which allows penetration by burrowing species, reducing thermal stress and evaporative water loss from small animals. During post-logging site preparation or fuel treatments, each successive pass by heavy machinery further reduces space between woody debris and the ground surface, regardless of whether debris removal is part of the treatment.

2) Fire treatments to reduce fuel loading or coniferous fuel type subsequent to mechanical treatments will reduce density by a greater extent for red-backed voles than other boreal voles

Red-backed voles are a widespread species commonly associated with moist cover and favoring seeds, fungi, and fruit in its diet compared with other boreal voles that inhabit drier sites and subsist on monocots (grasses and sedges) and secondarily on dicot leaves (West 1979:41). Vegetation and woody debris influence microclimate (including subnivean) and available forage, the latter providing dietary water. Moss often occurs on the forest floor beneath mature coniferous canopy and retains soil moisture favorable to red-backed voles. Use of fire to reduce woody debris or coniferous fuels will remove cover and forage and blacken the ground surface, allowing solar radiation to produce high surface temperatures and drought.

3) Tree damage rate (proportion of stems chewed per ha) will be positively correlated to rodent density; positively correlated to debris loading, grass cover, and moss cover; and higher on treatments than on the control site

Methods

Livetrapping occurred in late August 2004 on hollow grids having 40 traps in a chevron pattern (perpendicular 90 m legs, parallel legs 20 m away, traps every 10 m along boundary that includes midpoint of ends) to facilitate visits by a crew of two. The apex location and axis orientation of the chevrons were randomly chosen within the 12 treatment and a control sites, and portions of these grids will be allowed to extend beyond treatment sites. Because of treatment size limitations, only one grid will be established per harvest site at Tok River (three grids per treatment block), which will permit an estimate of precision for mean density per treatment or control. Distance between harvest and control sites and presence of river or old slough habitats between most of them (Fig. 2) should help ensure independence among sampling sites.

Capture and handling methods followed Rexstad (1996) and protocols of the Institutional Animal Care and Use Committees according to an ADF&G permit. Sherman livetraps baited with sunflower seeds and containing cotton batting for thermal bedding were set during 5 consecutive 12-hour periods (trapping events). Only arvicoline rodents (voles and lemmings) and dipodids (jumping mice) were marked. Individuals were uniquely marked by dorsal subcutaneous injection of a 2.1 mm x 11 mm Passive Integrated Transponder (PIT) tags (Schooley et al. 1993), which were scanned during trap checks to verify recaptures.

We estimated vole density, assuming a closed population, with mark-recapture methods that are not influenced by trap layout (Efford 2004). This new method produces unbiased estimates by incorporating simulation and inverse prediction with more traditional estimates of population size ($\widehat{N}$), population-level capture probability ($\overline{p}$), and mean distance between successive captures of the same individual ($\overline{d}$) to estimate a spatial detection function (a measure of home range size [g_0] and the probability of individual capture if the trap is at home range center [σ]) and true density (D). Any appropriate closed-population estimator may be used to obtain $\widehat{N}$ and $\overline{p}$. The method assumes that home ranges are stationary in two dimensions during the trapping occasion (sequence of consecutive open trap events) and that individual capture events may be simulated as competitive processes where there are N animals and k traps. With data from the 2004 pre-treatment sampling, we can estimate the boundary strip width (W) for effective trapping area (Efford 2004) and thus better define the patch size required for placement of grids to reduce habitat edge effects once treatments are completed. Simulations with livetrapping data from Denali National Park using Efford's free software Density© 2.1 (http://www.landcareresearch.co.nz/services/software/density/) suggested that 10 m spacing of traps minimizes bias in density estimates.

A potential covariate of rodent density is density of woody debris, which is expected to differ among post-logging site treatments. Fuel loading (kg/ha) on the forest floor is a component of fire behavior models and used to estimate smoke emissions, but fire behavior in boreal forest is gauged more from duff depth and standing fuels such as cured grass and dense black spruce (Robert Schmoll, DOF, personal communication). Our goal was to estimate indices to debris loading (density and size distribution) from post-logging site preparation or fuel reduction treatment relative to cover for small mammals and subnivean access for forest mustelids (martens and weasels). To allow inference on the scale of treatment effects, debris pieces were tallied as intercepts of the vertical plane along perpendicular 100 m transects that bisect each of the arms of trapping grids (chevrons). Volume (m^3) calculated from diameters at both ends and length (Harmon and Sexton 1996:16) will allow reporting of debris distributions by diameter class and length as potential runway cover and subnivean galleries. For consistency with other studies, we defined debris as ≥7.6 cm diameter on the large end, ≥1 m long, and ≤45° above horizontal, with tally rules following Brown (1974). Debris will be tallied by height class (<0.5, 0.5–1.0, 1.0–1.5, >1.5 m) for inference on subnivean access relative to snow depth (Sturtevant et al. 1997). Decay class was noted as sound or decayed (outer layer fragmented by hand or branches pulled free, indicating hear trot; Sturtevant et al. 1997). We also recorded ground cover type every 5 m along transects. Upon completion of the study, we will combine data from all grids and all years to further evaluate whether debris loading and ground vegetation are predictive of arvicoline density, regardless of treatment.

Results

Red-backed voles were numerically dominant (94% of 264 individual rodents captured across 5 species; Table 3), so we modeled their density from 300 recaptures. Point estimates for pre-treatment density varied among sites, but pooled estimates for treatment blocks were similar (Fig. 4), giving us confidence in the randomized block design with respect to the small mammal community. Variability in debris length (Fig. 5) and diameter (Fig 6) was relatively even among treatment blocks except for sites proposed for prescribed burning. Note that the wide confidence limit for both length and diameter in one proposed burn site (caused by a low density of debris) corresponded to the lowest point estimate for rodent density (Site 78).

B. Evaluating the relationship between habitat features and predation risk for grouse by use of artificial nests, May–June 2004 (Cooperators: Mark Lindberg and Carl Roberts, UAF).

Aspen treatments from 1996–2001 are maturing into grouse brood cover at Nenana Ridge, which contains aspen-dominated stands dispersed among mixed deciduous-coniferous stands. However, heavy felling debris in some treatments may hinder access by grouse and provide cover for rodents (see Appendix B) that would attract predators, incurring mortality risk to grouse broods. During winters 1999–2002 we recorded a higher frequency of tracks by forest mustelids in felling debris than in burns at Nenana Ridge (Paragi and Haggstrom 2004:22). We sought to understand whether persistent debris might encourage more frequent use of felling areas area by mammalian predators and the consequences for nesting and brood rearing success on felling sites compared to other forest habitats at Nenana Ridge. Ruffed and spruce grouse are not migratory, so understanding nest predation by habitat type at the stand scale is desirable to predict how forest practices that may become more common for fuel management near communities will influence grouse nesting success. With low grouse density in spring (Objective 10), we needed an alternative to studying marked hens and broods.

Methods

Our objectives were to use artificial nests to infer which forest cover types produce a higher predation risk for grouse nests at Nenana Ridge and to identify the most common predators of simulated grouse nests by assigning cause-specific fate from egg remains (Bumann 2002, Sargeant et al. 1998). Based on studies of nest predation in aspen and coniferous (Darveau et al. 1997, D’Eon 1997, Fenske-Crawford et al. 1997), we expected red squirrels, weasels, martens, red foxes, and black bears to be the most common mammalian predators of grouse nests at Nenana Ridge, with ravens and gray jays being potential avian predators. We used a GIS coverage of DOF type classes produced from aerial photos in the 1970s to stratify the study area into six habitat types: birch and aspen; white spruce, birch and aspen; black and white spruce, birch and aspen; young aspen (felling); young aspen (burned); and mature birch and aspen (control). We overlaid a 100 m grid over the study and control areas and randomly assigned nest sites, plus a few extra sites in the event a habitat type is incorrectly assigned. After navigation to chosen points by GPS (15 m field resolution under full canopy), we established 20 nests (three small chicken eggs and a secured clay egg to collect tooth or beak marks) in each of three treatments (felled, burned, undisturbed mature aspen matrix) and a mature aspen control (Fig. 7). Nests were placed $\leq$1 m from the base of the largest tree or beneath shrub canopy with good visibility for an incubating hen. To minimize transfer of human scent at the site, blue flagging was placed 2 m north to allow observation of nests from a distance.

We visited nests twice weekly during 12 May to 15 June to determine fate and assign cause of mortality when possible, creating new nests as necessary to maintain sample size. Leaf eruption was beginning on deciduous trees when nests were first established, and herbaceous vegetation was beginning to obscure nests completely at many burn or felling site nests by the first week of June. Eggs were replaced every two weeks to avoid scent from spoilage in the warm conditions. Disturbance was assigned as the midpoint of 3-day exposure period. Frequent raven predation of the light-colored eggs occurred early in the study because there was no hen incubating, so we began covering eggs lightly with leaves and twigs beginning 20 May. After predation, or on the last nest visit to recover clay eggs, we counted standing stems within 2 m (mostly live) and debris within 1 m radius of the nest by size classes standard in local forest mensuration (diameter at 1.4 m: seedling <2.5 cm; sapling 2.5–11.25 cm; pole 11.25–22.5 cm; sawlog >22.5 cm"). We used the nest survival option in computer program MARK (http://www.cnr.colostate.edu/~gwhite/ mark/mark.htm) to create a maximum likelihood estimate of daily survival for the artificial nests. Five possible models were created to interpret the data, and we used the Akaike Information Criterion (AIC) to select the best model. Two estimates of daily survival were conducted for each of the treatments because of change in methods after 20 May.

Results and Discussion

We followed the fate of 102 nests (Table 4). Missing eggs with no shell remains or predator sign occurred at 35 nests (52% of all nests destroyed), which is atypical of smaller mammalian and avian predators. Raven beak prints were found on clay eggs in 4 nests, a coyote likely found one nest between 21 and 25 May in mature forest, and a black bear was observed near a nest site in the control area on 11 June. Based on AIC values and weights, the model that best supported the data was Pre- and Post-22 May (Table 5). This model provided nest survival estimates for all habitat types from 12 to 21 May and 22 May to 15 June for a total of 8 estimates of nest survival (Fig. 8). Covering the nests after 20 May possibly improved nest survival in the mature forest between felling and burn treatments (Fig. 8). Felling sites tended to have higher density of live stems and debris than burn sites (Table 4), which may explain the lower crude frequency of nest destruction in felling sites (50%) compared with burn sites (79%) if visual detection by predators is important.

Common raven predation was not anticipated to occur at the level at which it did when developing the study to compare mustelid predation of nests among the differing habitats. Ravens were observed watching a person during nest visits in burns on 21 and 25 May and likely accounted for most of the nest destruction we observed. These adaptive birds could hear our approach on ATVs, watch us move through the young forest in the burn and felling sites, and patrol the entire study area in a short period. Predation by corvid species has been shown to be a significant source of predation on ground nesting bird species. Erikstad et al. (1982) demonstrated that territorial hooded crows visually identified the nests by observing hen movements. Further, Sullivan & Dinsmore (1990) showed that nests within 700 meters of American crow nests had a higher predation risk than nests outside of 700 meters. We do not know the location of raven territories or nests in the study area.

We found little evidence of mustelid predation, which often results in small eggs fragments remaining in or near the nest bowl. Predation was nonexistent on the control area until late in the study, when several nests were destroyed in a short period. We infer that a person walking into the control site beneath a mature aspen canopy was rarely observed by ravens but then a mammal was able to follow their scent trail left during nest visits.

We cannot make direct inference from our results to predation risk in our treatments without knowledge of bird habitat selection during nesting and brood rearing or predator abundance during spring at our study site. Because of the assumptions made when using artificial nests, the survival rates may not be accurate enough for management but will indicate trends in predation (Wilson et al. 1998). Artificial nests provide only a crude approximation to predation risk during incubation, when a hen would normally be covering the eggs from sight of avian predators. However, hen presence on the nest would increase detection by mammalian predators with a keen sense of smell.

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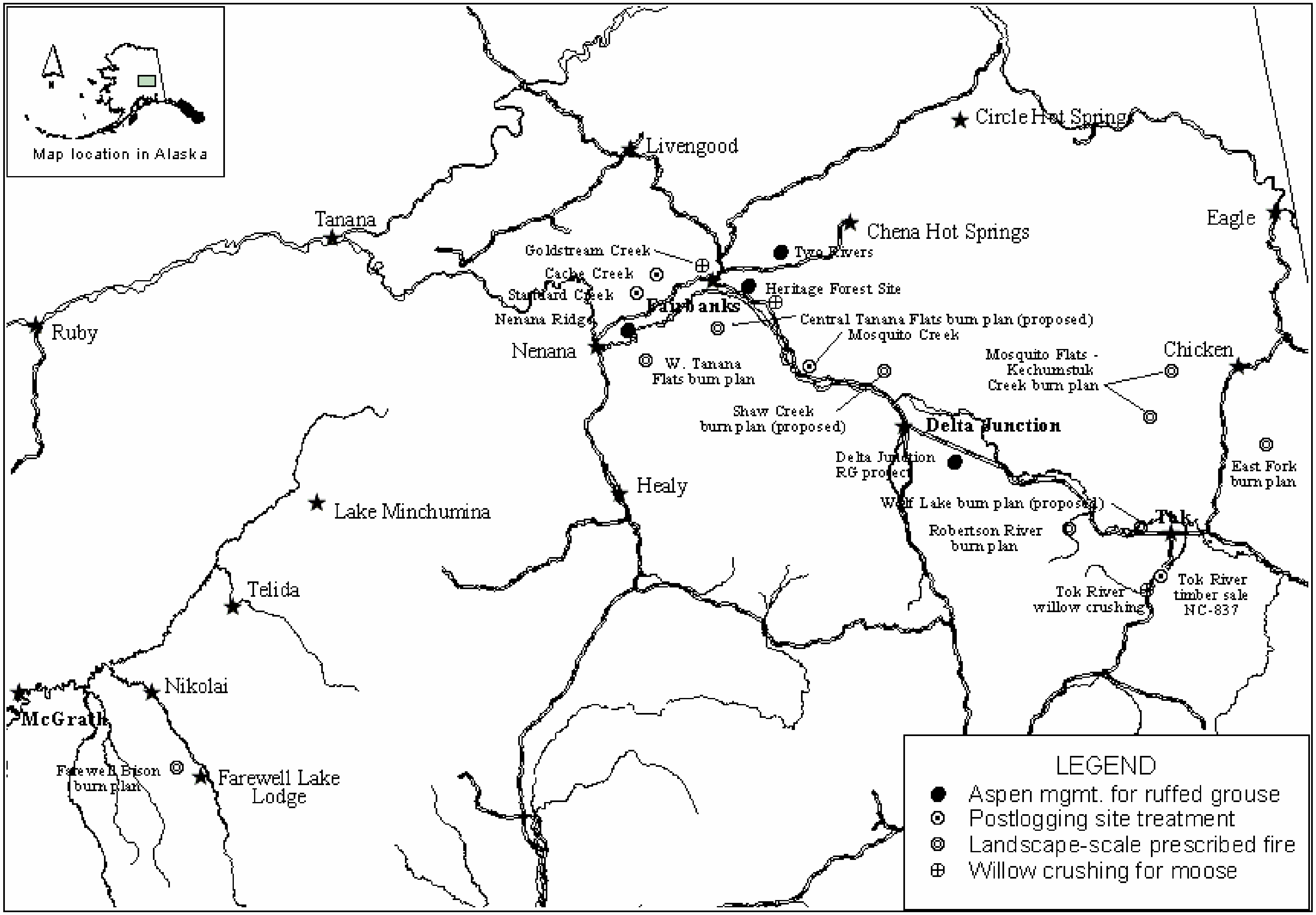

FIGURE 1. Location of ADF&G/DWC Region III habitat enhancement activities

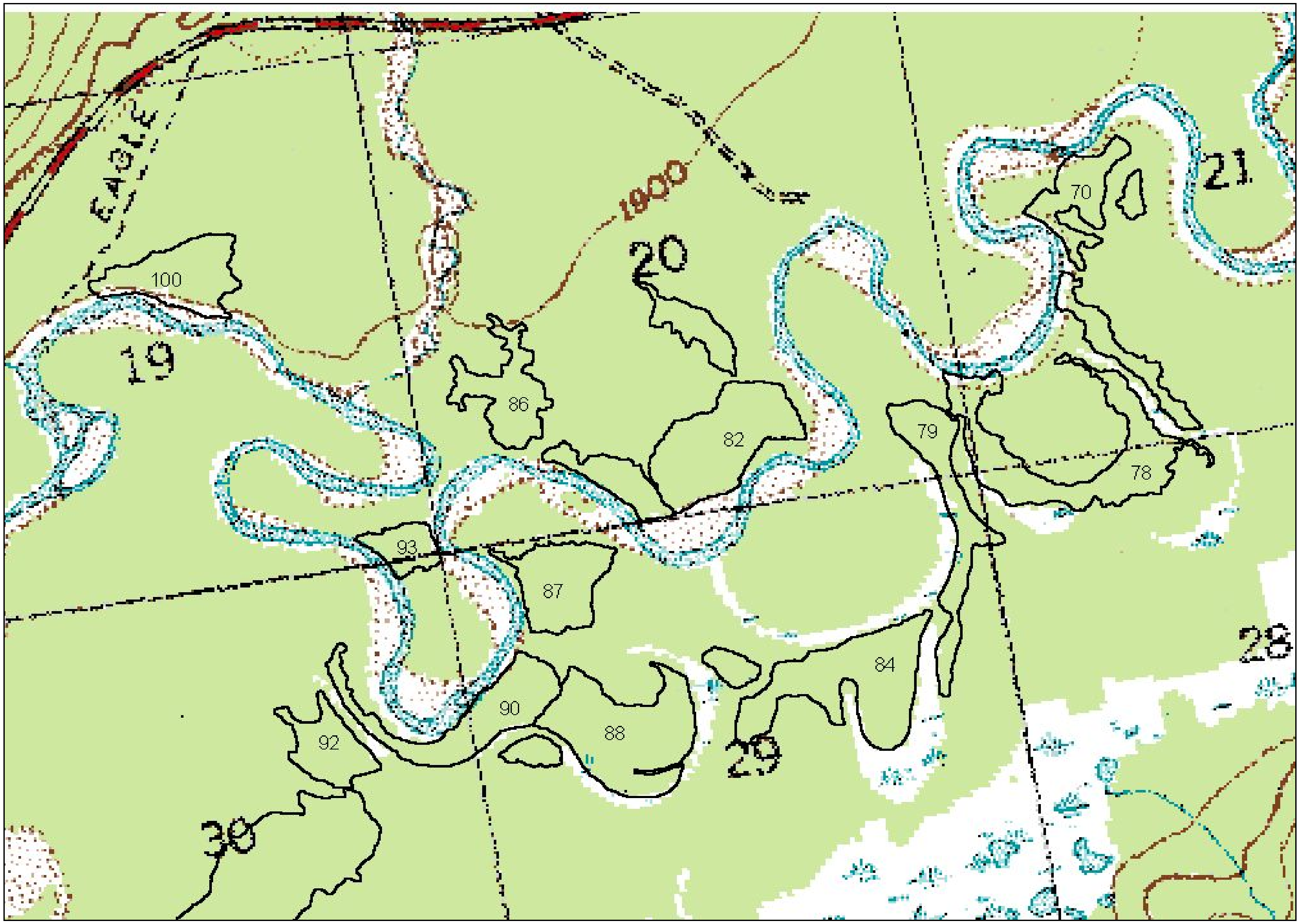

FIGURE 2. Twelve study sites at the proposed timber sale NC-837-T (Tok River) about 15 miles south of Tok along the Glenn Highway. One mile section lines of T16N, R12E, Copper River Meridian, are visible on the 1:63,360 scale Tanacross A-5 map.

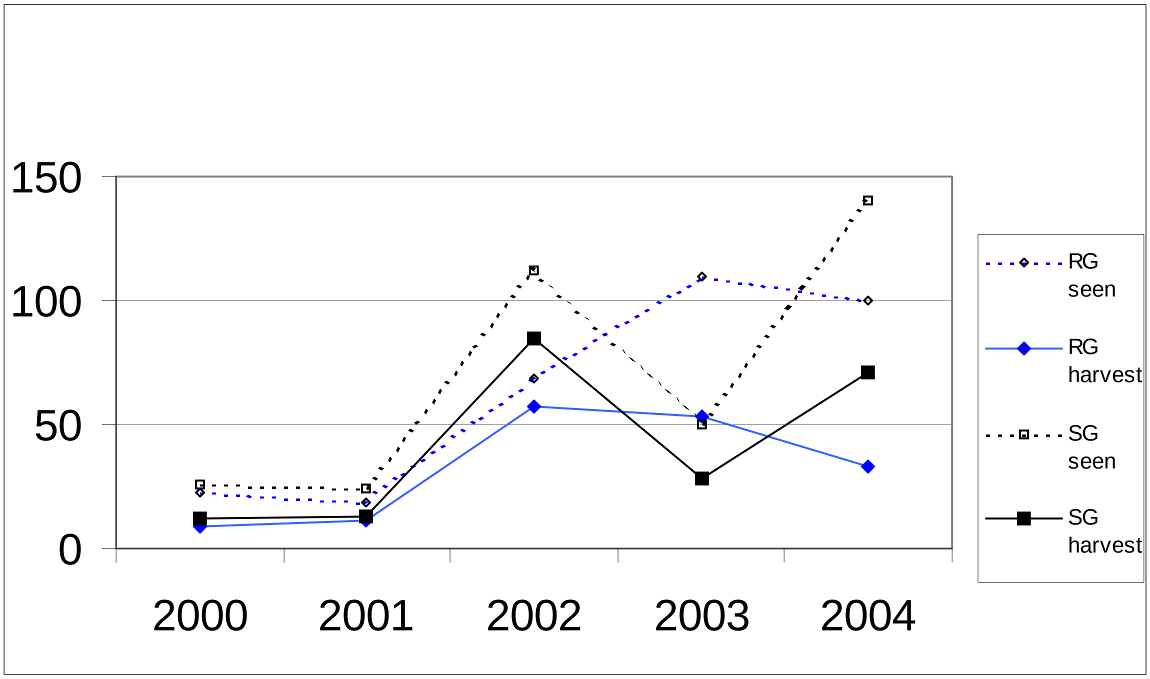

FIGURE 3. Birds seen per 100 hours of hunting and reported harvest of ruffed grouse (RG) and spruce grouse (SG) at Nenana Ridge, Alaska, 2000–04. Data reporting on cards was voluntary and represented the minimum harvest.

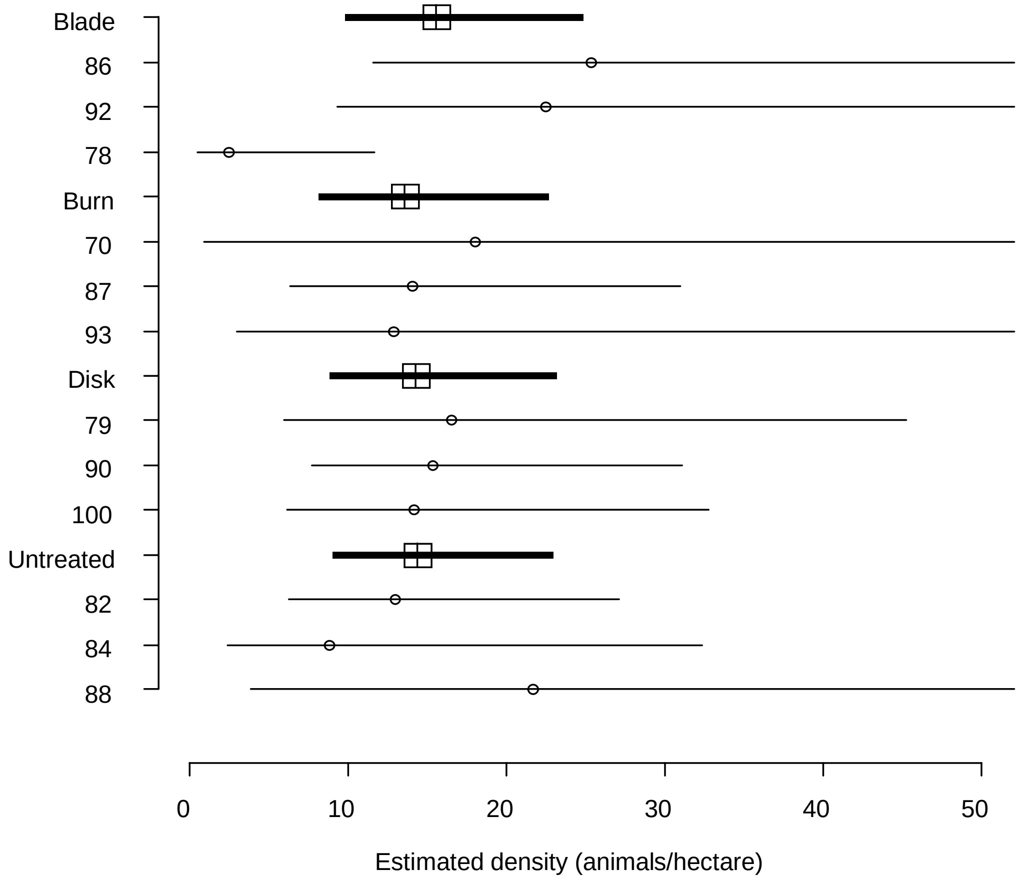

FIGURE 4. Point estimates and 95% confidence limits for density of red-backed voles in the 12 study sites at Tok River, Alaska, August 2004. Numbers on left represent the proposed areas of white spruce harvest shown in figure 2. Pooled estimates by treatment block are dark lines above the lines representing the component sites. Untreated sites are to have timber harvested but no post-logging site treatments.

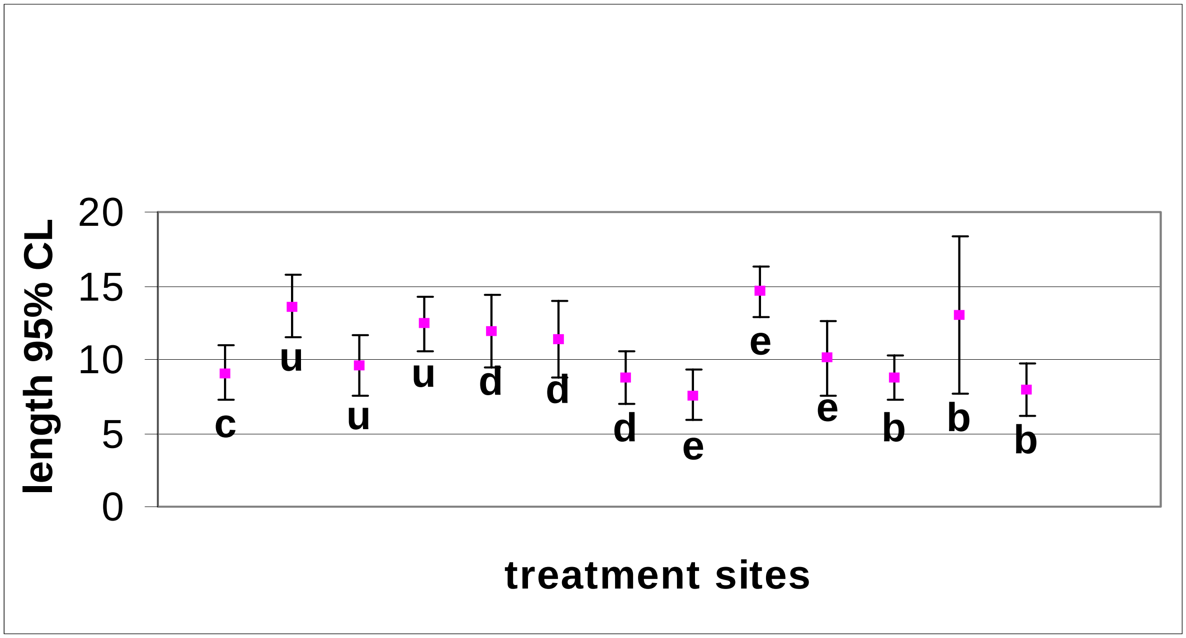

FIGURE 5. Mean estimates and 95% confidence limits (CL) of length (m) for woody debris ≤0.5 m high among 12 study sites and a control site used for rodent livetrapping at Tok River, Alaska, August 2004. Letters beneath estimates denote treatment: c=control, u = untreated, d = disk, e = blade, b = burn.

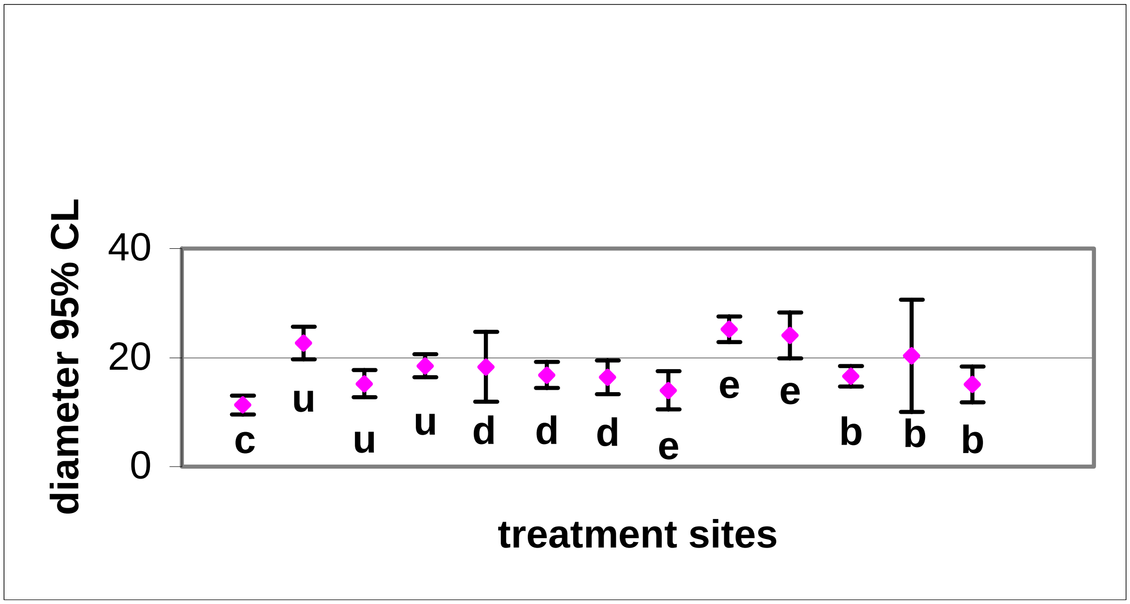

FIGURE 6. Mean estimates and 95% confidence limits (CL) of diameter (cm) for woody debris $\leq$0.5 m high among 12 study sites and a control site used for rodent livetrapping at Tok River, Alaska, August 2004. Letters beneath estimates denote treatment: c=control, u = untreated, d = disk, e = blade, b = burn.

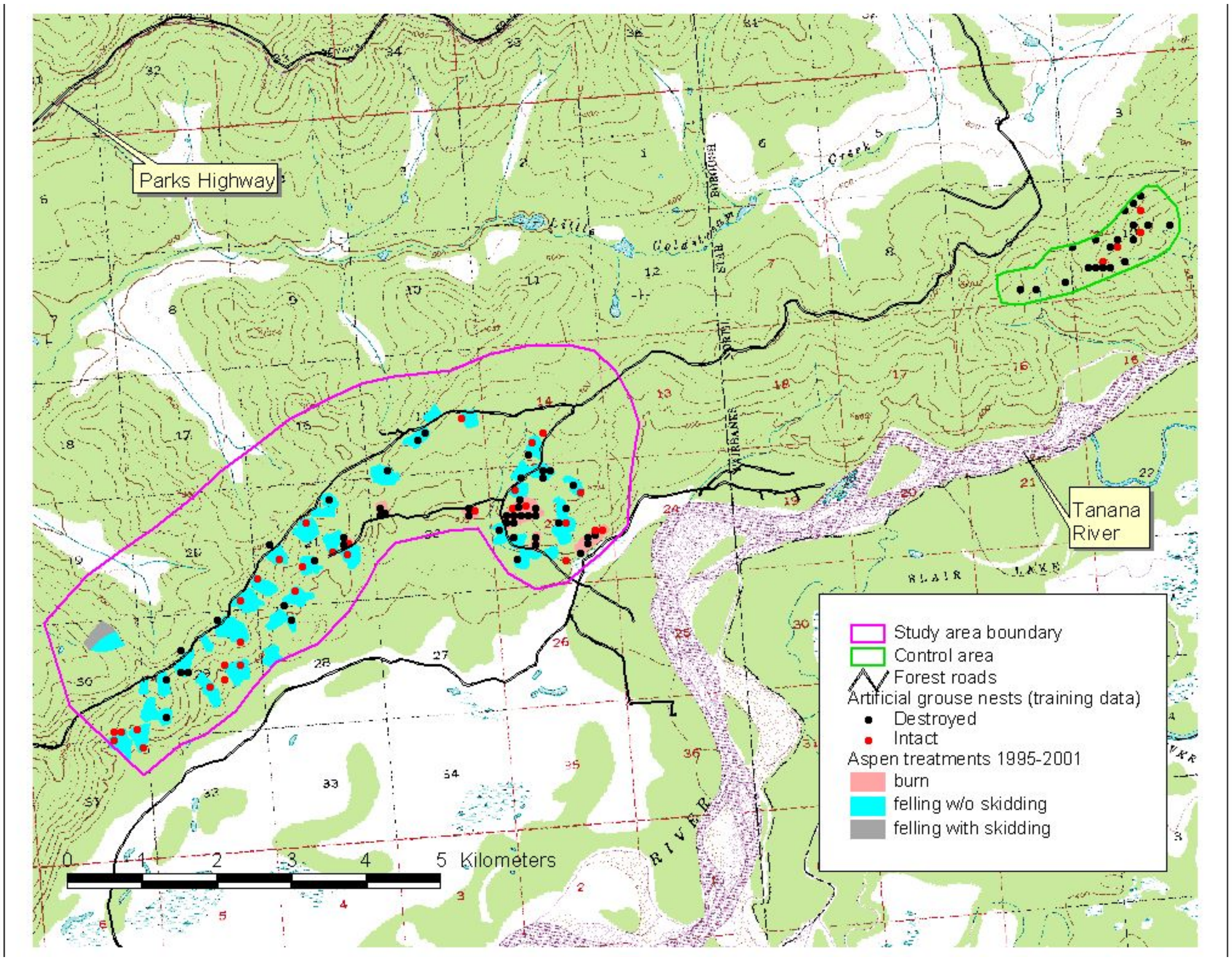

Figure 7. Location of aspen treatments, control area, and artificial grouse nests for the spring 2004 predation study at Nenana Ridge, Alaska, 30 km southwest of Fairbanks. Mapping is North American Datum 1983, Albers 154 projection over 1:63,360-scale Fairbanks C-4.

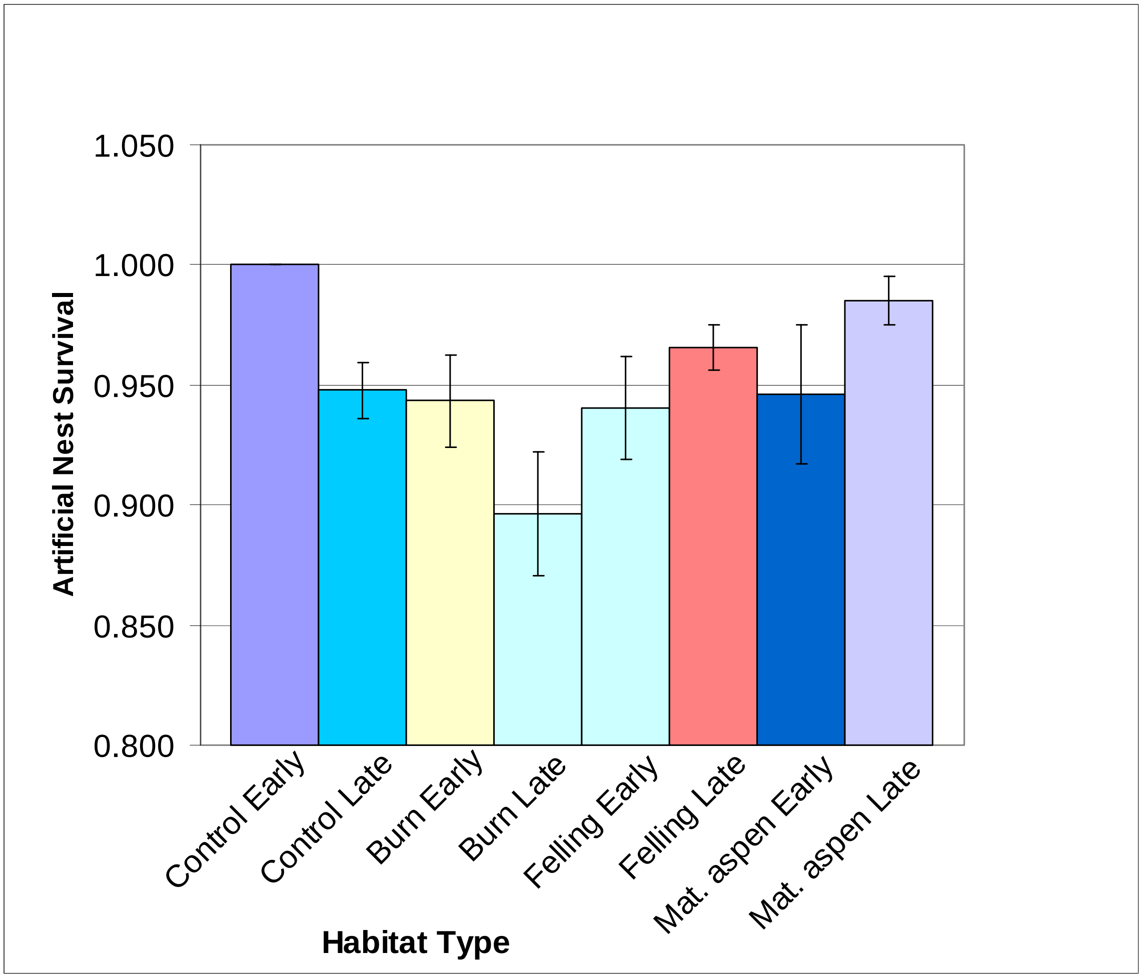

Figure 8. Daily survival rate of artificial nests among habitat strata at Nenana Ridge, Alaska, 2004. Early indicates 12–21 May, whereas Late indicates 22 May–15 June. The bands indicate 95% confidence limits.

TABLE 1. Cost per unit area for various stand-scale mechanical and prescribed fire treatments to top-kill mature aspen in interior Alaska, 1996–2003 (Nenana Ridge, Two Rivers, Heritage Forest, and Delta Junction; Fig. 1). Heavy equipment rates include fixed cost of mobilization, thus incorporate distance from operator base. Costs will vary by geographic region, but relative differences are expected to remain consistent for treatments of similar size.

Treatment	\$/ha	\$/ac
Dozer shearblading[a]	185	75
Dozer shearblading plus windrowing[b]	310	125
Hand felling by chain saw[c]	570	230
Prescribed fire[d]	790	320

[a] Treatments were 7–18 ha (17–44 ac, *n* = 10) and produced with dozers using a Rome K-G blade; limited to relatively flat ground.

[b] Parallel concentric circles produced on second pass so that 50% of site was free of debris (*n* = 6).

[c] Treatments were 3–10 ha (7–25 ac, *n* = 34).

[d] Fires were 2–12 ha (5–30 ac, *n* = 6) and conducted with drip torches by DOF fire suppression crews, often as training prior to the wildland fire season. Cost reflects overtime or equipment needs beyond normal pre-season training exercises.

TABLE 2. Cost per unit area for landscape-scale prescribed fire treatments in interior Alaska, 1998–1999 (only includes ADF&G costs for supplies, equipment, and fire personnel overtime wages and benefits).

Treatment	\$/ha	\$/ac
1998 East Fork prescribed fire (18,200 ha)	0.74	0.30
1999 Mosquito Flats and Kechumstuk Creek prescribed fires (15,193 ha)	1.12	0.45

TABLE 3. Individual captures and total recaptures of small mammals on 12 study sites and a control site at the proposed Tok River timber sale, August 2004, Alaska.

Common name	Scientific name	Individuals marked and released (mortalities)[a]	Total recaptures
Red-backed vole	*Clethrionomys rutilus*	248 (16)	300
Singing vole	*Microtus miurus*	10 (2)	0
Tundra vole	*Mictrotus oeconomus*	4 (0)	2
Northern bog lemming	*Synaptomys borealis*	1 (0)	0
Northern jumping mouse	*Zapus hudsonicus*	1 (0)	0
Shrews	*Sorex* spp.	0 (18)	0

[a] Except in one instance where 2 red-backed voles were caught at once (one was cannibalized), most mortalities were attributed to hypothermia in juveniles despite use of cotton bedding for insulation and covering traps with plastic sheeting. Shrews were not marked and released alive when possible ($n = 4$).

TABLE 4. Median counts of live woody stems and debris associated with artificial grouse nests at Nenana Ridge, Alaska, May–June 2004. Size class diameters at 1.4 m: seedling <2.5 cm; sapling 2.5–11.25 cm; pole 11.25–22.5 cm; sawlog >22.5 cm.

			Live stems within 2 m of nest-----				Dead wood within 1 m of nest---			
Treatment	**Nest fate**	***n***	**Seedling**	**Sapling**	**Pole**	**Sawlog**	**Seedling**	**Sapling**	**Pole**	**Sawlog**
control	destroyed	19	68	0	1	1	24	3	0	0
control	intact	4	32.5	0.5	0.5	0	18	1	2	0
study area	destroyed	6	4	2	2	0	0.5	2	2	0
study area	intact	7	48	1	0	0	8	3	0	0
burn	destroyed	23	11	1	0	0	1	1	1	0
burn	intact	5	12	0	0	0	1	0	0	0
felling	destroyed	19	8.5	1	0	0	0	2	2	2
felling	intact	19	52	0	0	0	0	1	2	1

TABLE 5. Model selection in program MARK using Akaike Information Criterion (AIC) for survival of artificial ground nests at Nenana Ridge, Alaska, 2004.

Model	AIC Value	AIC Weight	Model Likelihood
Pre and Post May 22nd	376.74	0.886	1.000
Time Specific	380.86	0.113	0.128
Strata Specific	390.99	0.001	0.001
Single Group	396.03	0.001	0.000
Individual	426.31	0.000	0.000