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Spruce Beetle Effects on Wildlife

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Research Final Performance Report
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STUDY TITLE: Spruce Beetle Effects on Wildlife

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SUMMARY

A total of 594 point counts of breeding birds were conducted in Kenai lowland forests during the 1998 season, using the variable circular plot method. Townsend's Warbler (*Dendroica townsendi*) and Golden-crowned Kinglet (*Regulus satrapa*) may be most negatively affected by habitat changes caused by bark beetles (*Dendroctonus rufipennis*). Further, these two species are essentially absent from salvage-logged areas, and Townsend's Warblers are rare in mixed birch (*Betual papyrifera) -spruce* (*Picea glauca*) forest. Three-toed Woodpeckers (*Picoides tridactylus*) benefit from bark beetle infestation but decline when the infestation subsides and availability of beetle larvae decreases. Solitary Sandpipers (*Tringa solitaria*), an easily overlooked species, may be affected by spruce mortality and logging. Species diversity in selectively logged stands is maintained in direct proportion to remaining tree densities, with a shift toward species preferring open habitats. Selectively logged mixed birch-spruce forests maintained higher bird diversity than logged spruce stands because of greater tree density and vegetative diversity. We completed a literature review of northern owl survey and census methods and an owl survey protocol, with accompanying amphibian survey protocol, for standardization of Alaska owl surveys.

Eighty-nine percent of small mammals trapped in Kenai lowland forests were Northern red-backed voles (*Clethrionomys rutilus*). Red-backed vole populations were highest in pure spruce stands infested with bark beetles, but lowest where beetle-killed stands had been salvage logged. In either pure spruce or mixed hardwood-spruce stands, logging produced dense stands of bluejoint grass (*Calamagrostis canadensis*) and reduced abundance of many shrub and herbaceous understory species. Overall, relative abundance and numbers of reproducing female red-backed voles were positively correlated with berry abundance and moss cover but negatively correlated to bluejoint grass cover. However, neither beetle infestation nor logging significantly impacted red-backed vole populations in mixed hardwood-white spruce habitat, presumably because the hardwood component of the overstory was retained and much less understory was directly affected. During 2000, a thesis detailing the small mammal portion of this study was completed.

Regeneration of browse by paper birch and willows was relatively poor, probably due to lack of scarification. Combined with insufficient sampling methods, failed or extremely poor berry crops in all sites masked any potential differences in berry productivity.

Key words: berries, breeding birds, habitat, logging, moose, owls, small mammals, Spruce beetle, vegetation.

CONTENTS

BACKGROUND

A current epidemic of spruce bark beetle (*Dendroctonus rufipennis*) has killed white spruce (*Picea glauca*) on more than 2.5 million acres in Alaska. Approximately 500,000 acres of new and ongoing infestation is present on the Kenai Peninsula. This scale of infestation has not occurred in more than 100 years, and the level of salvage logging associated with it is unprecedented. However, the effects of canopy reduction by bark beetles and salvage logging on wildlife are poorly documented.

Spruce beetles primarily attack white spruce by boring through the bark, feeding, and breeding in the phloem. Their entry through the bark introduces a bluestain fungus (*Ceratocystis*) that causes tree mortality. Spruce beetles are endemic in Alaskan forests, preferring windthrown or other recently downed spruce. In the absence of downed spruce, or when weather favors high populations of beetles, the beetles attack old, large-diameter spruce (Holsten 1990). In severe outbreaks, the beetles may move into small-diameter trees when larger trees have been eliminated. In the current epidemic, some areas have lost most spruce larger than 10–15 cm diameter at breast height (dbh).

In response to beetle-killed spruce forests, private landowners and Native corporations in South-central Alaska have developed large-scale salvage logging operations. State and federal agencies are following suit as quickly as legally possible. Under the Timber Salvage Bill passed by Congress in 1995, the U.S. Forest Service and other federal land managers are required to salvage timber.

Beetle infestation and logging potentially affect structure, productivity, and composition of understory plants used by small mammals for food and cover. Beetle infestation, however, is unique from logging disturbances in that (1) large trees in older stands are selectively killed; (2) understory and soil layers are not directly affected by disturbance; (3) plants and nutrient cycling respond slowly; (4) repeated epidemics help maintain a mosaic of uneven-aged stands; and (5) tree mortality is usually moderate with about 50% of the canopy cover altered (Stone and Wolfe 1996). Small mammals can adapt to some short-term environmental modifications (Bourliere 1975). This ability, coupled with these small mammals' sheer numbers and amount of energy they represent in the system, enables small mammals to significantly affect vegetation consumption, forest decomposition, and predator dynamics (Johnson et al. 1990; Stoddart 1979; Maser et al. 1978).

In a Kenai Peninsula small mammal study (1979), Bangs found a single species, the northern red-back vole (*Clethrionomys rutilus*), dominated the small mammal community. However, northern red-backed voles were less abundant on mechanically disturbed sites, as were berries, mosses, lichens, and mushrooms on which voles depend. Additionally, a recent vegetation study on the Kenai Peninsula showed that *D. rufipennis* infestation and fire increased the abundance of bluejoint reedgrass (*Calamagrostis canadensis*) and fireweed (*Epilobium angustifolium*), while many of the northern red-backed voles' primary food species remained the same or slightly decreased in abundance (Holsten et al. 1995).

A decrease in forest overstory increases light and nutrients, making them available to understory plants (Stone and Wolfe 1996, Holsten et al. 1995). An increase in understory vegetation decreases predation on small mammals by decreasing visual detection and providing more opportunities for escape. However, an increase in light to the forest floor, or mechanical disturbance, may decrease the abundance of moss, lichens, and other species used by small mammals for food and thermal cover.

OBJECTIVES

The interagency Forest Ecology Study Team identified the determination of wildlife effects as first priority before scientifically based management of beetle-impacted forests can be developed. They identified effects of canopy reduction on breeding birds, small mammals, moose browse, and production of berries important to wildlife as priorities for research. Alaska Department of Fish and Game adopted these research priorities for this study:

BREEDING BIRDS

Determine differences in breeding bird density, composition and diversity between infested, logged, and undisturbed stands.

H_o: Breeding bird densities in beetle-killed, logged, and undisturbed stands are equal.

H_o: Diversity of breeding birds in beetle-killed, logged, and undisturbed stands is equal.

SMALL MAMMALS

Determine differences in small mammal density, recruitment, or survival between infested, logged, and undisturbed stands.

H_o: Small mammal densities in beetle-killed, logged, and undisturbed stands are equal.

H_o: Small mammal survival in beetle-killed, logged, and undisturbed stands is equal.

H_o: Small mammal recruitment in beetle-killed, logged, and undisturbed stands is equal.

MOOSE BROWSE

Determine if overstory reduction by beetles or logging reduces productivity of browse species.

H_o: Browse densities in beetle-killed, logged, and undisturbed stands are equal.

H_o: Browse production in beetle-killed, logged, and undisturbed stands is equal.

BERRIES

H_o: Densities of berry-producing species in beetle-killed stands, logged stands, and undisturbed stands are equal.

H_o: Berry production by species in beetle-killed stands, logged stands, and undisturbed stands is equal.

STUDY AREA

The study area is the Kenai Lowlands, bounded by Skilak Lake and Swanson River to the north and Kasilof River to the south. We examined effects of overstory reduction by beetles and by logging on wildlife in 2 upland habitat types within the lowlands, spruce and mixed spruce-hardwood. Spruce stands being studied comprise 90%, or more, white spruce or white spruce/Lutz spruce hybrid. Mixed stands being studied include 40 to 60% spruce; hardwoods-paper birch (*Betula papyrifera*), aspen (*Populus tremuloides*), and black cottonwood (*Populus triohcarpa*) compose the remainder. Observations of infested forest are limited to those stands that experienced canopy mortality by bark beetles 3–5 years before the study began. Observations of logged stands are limited to stands logged 3–5 years before the study in a way most common to private operations on the Kenai Peninsula. Undisturbed stands included in the study are those that have not experienced major disturbance, including fire, for at least a century. All study plots are between 60 and 250 m elevation, located on flat ground or slopes less than 5%, and dominated by trees >100 years old.

METHODS

BREEDING BIRDS

In 1998 we conducted forest bird surveys during the breeding season from 26 April to 24 June. This is the period when nearly all breeding for land bird species takes place in Southcoastal Alaska. Surveys were conducted during 4 nonoverlapping periods to distinguish between singing periods for early and late arriving species as follows: 26 April–7 May, 13–21 May, 26 May–6 June, and 11–24 June 1998.

Twenty-two 36-ha breeding bird survey plots (600 m x 600 m) were randomly located within 4 treatments in each of 2 forest types, mixed spruce-deciduous and pure spruce. Treatments were classified on the amount of spruce mortality as (1) none to light (0–10%), (2) moderate (11–40%), and (3) heavy (>40%). A fourth treatment in each forest type was selectively logged stands, presumed to have had heavy spruce mortality before logging. Three replicate plots were established for each treatment type, except the moderate and logged mixed-forest treatments for which only 2 replicate stands could be found, a total of 22 plots (Table 1). Survey plots for each treatment, both within and between forest types, were matched as closely as possible with respect to slope, aspect, elevation, understory, and stand age, and within habitat composition of stand. Two general age classes of stands are prevalent on the study area. Older mature stands that established in the late 1800s were selected for treatments. Selected mixed-forest stands were approximately a 60:40 mix of white spruce (*Picea glauca*) and deciduous, predominantly paper birch (*Betula papyrifera*). Selected spruce stands tended to be greater than 90% white spruce/Lutz spruce (*P. glauca x sitchensis*).

Within each survey plot, 9 census stations were systematically located in a 3 x 3 matrix grid. Each station was 200 m from any adjacent station and 100 m from the perimeter of the plot, except for the center station that was 300 m from the plot perimeter. We used aerial photographs to center plots within stands and, to the extent possible, to maintain a minimum buffer of 150 m from ecotones. Birds were surveyed using the variable circular plot method.

We visited plots once each survey period. Observers and starting points were rotated to balance the effects of observer and diurnal variability in detections. Surveys were begun as close to 15 minutes after sunrise as possible and continued until each station had been censused for 8 minutes. Observers recorded the number, behavior (singing, calling, drumming, flying), sex, and type of detection (aural, visual, or both) of birds of each species and the distance of the bird from the station center when first detected. Birds were recorded within 10-m bands to 100 m and within 25-m bands from 100 m out to an unlimited distance.

We are describing vegetation characteristics relevant to bird habitat according to protocol established by the National Biological Survey's Alaska Neotropical Migratory Bird Project (ANMBP) to enable comparison with data collected by ANMBP in other regions of the state.

Results from plot counts are being analyzed for density of singing males using Program Distance and ANOVA and other nonparametric tests. These data will be incorporated into a regression analysis with vegetation data to develop a model for breeding bird density by species relative to spruce mortality.

Nocturnal owl surveys were conducted from 17 March to 1 May 1998 and again from 1 March to 1 May 1999 when owls were establishing territories and breeding. Using the variable circular plot method, we conducted these surveys independently of point count censuses because owls are not normally active postdawn when censuses were conducted. The owl-breeding season also occurs earlier than that of most other forest bird species, further necessitating a separate sampling effort. Six species of owls are known to breed in Southcoastal Alaska: Great Horned Owl (*Bubo virginianus*), Northern Hawk Owl (*Surnia ulula*), Great Gray Owl (*Strix nebulosa*), Short-eared Owl (*Asio flammeus*), Boreal Owl (*Aegolius funereus*), and Northern Saw-whet Owl (*Aegolius acadicus*). The Snowy Owl (*Nyctea scandiaca*) occurs infrequently in Southcoastal Alaska during the nonbreeding season.

Dual objectives of nocturnal owl surveys were (1) to examine habitat use by forest owls and (2) to test field methods for censusing and monitoring owl populations in Alaska. Four species were targeted by nocturnal surveys: Great Horned, Great Gray, Boreal, and Northern Saw-whet Owl. Snowy and Short-eared Owls inhabit open country and are not effectively sampled by nocturnal roadside surveys. The Northern Hawk Owl is active during twilight and daytime in semi-open country.

Five routes following forest access roads were selected on the study area. Routes were 5 miles (8 km) in length with listening stations every .5 mile (.8 km), totaling 10 stations per route. We attempted to maintain the same observer for a route for consistency and to reduce observer variability, assuming these routes may be established for long-term monitoring similar to the North American Breeding Bird Survey. We surveyed routes in opposite order from the previous survey to vary the start times at each station. Each station was censused twice in a given night to adequately census different species that vary in times of peak calling activity. After the first pass through the stations, observers paused 15 minutes and then resampled the stations in reverse order. Census routes were begun at local sunset and continued until completion, usually 4 to 5 hours. Listening at each station was for 8 minutes. Routes were surveyed once a week, weather permitting. Acceptable weather conditions included little or no precipitation and light wind or no wind. We recorded starting time of observation, time period (first 5 minutes or last 3 minutes), distance, and direction to calling owls.

Census routes were established to sample both mixed- and spruce-forest types at varying levels of spruce bark beetle infestation. The Swan Lake Road route passes through lightly infested mature mixed-forest, while the 1200 Road routes are in mixed-forest with moderate to heavy infestation and in salvage-logged areas. The East Road route passes through lightly infested spruce forest with some open muskeg. The latter has since been salvage-logged to a large degree. The Oil Well/5000 Road route is bounded by moderately to heavily infested spruce forest with salvage-logged stands on one side and Deep Creek canyon on the other.

SMALL MAMMALS

We used mark–recapture techniques to estimate small mammal population abundance. We obtained temporal, behavioral, or individual heterogeneity in capture probabilities by simultaneously capturing and marking a sufficient number of individuals (Rexstad 1996). This method of capture-recapture will allow survival and recruitment to be evaluated as factors of abundance, which in turn will provide a better predictive population model.

The small mammal trapping design was modified in 1998 to provide better comparisons between stands. Each site was trapped 4 times May through August to include the lowest population level (early spring), reproduction rates, and juvenile survival (early and midsummer), and the population peak (late summer). This schedule also provided data for both endpoints of the intervals being used to estimate survival and abundance (Rexstad 1996).

All small mammal sampling was based on randomly located 90-m square grids having 100 traps systematically spaced at 10-m intervals across the grid. All grids were surrounded by at least a 30-m buffer to control possible edge effects. Since natural phenomena like spruce bark beetle outbreaks cannot be replicated, this study focused on differences between forest stands instead of treatment effect.

Undisturbed, beetle-killed stands (60–90% canopy mortality at least 3 years before the study) and logged stands in the pure spruce habitat type were each sampled with 3 replications. In mixed, we sampled the spruce-deciduous habitat type, 3 logged stands, but only 2 beetle-killed stands because accessible beetle-killed stands were limited. All stands within either habitat type were of the same approximate elevation, aspect, age (established in late 1800s), and understory composition before disturbance

As dramatic fluctuation in small mammal populations can occur within even a few weeks, all replications within each stand were trapped simultaneously. Stands trapped simultaneously were spruce-control and spruce-logged, spruce-infested and mixed-logged, with mixed-infested trapped separately.

All traps were set and baited with rodent food cubes and bedding the evening of day 0. Each trap was then checked 2 times daily for 5 days. We marked animals by implanting a subcutaneous Passive Integrated Transponder (PIT) tag. The individual PIT code, weight, sex, reproductive status, approximate age, and location of capture were recorded for each animal before release. The PIT code, weight, reproductive status, and location of capture were subsequently recorded for all recaptures. Food and bedding were changed after each capture.

We sampled vegetation with 20 2 x 30-m belt plots on each trap grid. Start points for each plot were systematically located along 4 base transects, evenly distributed across the trapping grid and buffer zone. Direction of belt plot layout was determined by random selection of direction (0–45^{O}) from base transects. We collected vegetation data in July after herbaceous vegetation had matured.

Overstory cover by species in each plot was measured with a single point densiometer at every third meter along the length of each belt plot. Diameter at breast height (dbh) of the first 2 individuals of each tree species in the plots was measured using calipers. Tree density was estimated by counting all trees greater than 2.5 cm dbh. Tree regeneration was estimated by counting all trees and seedlings less than 2.5 cm dbh.

We determined understory groundcover in 0.25-m quadrats, located at random locations within each plot, assigning cover classes 1–6 (Daubenmire 1959) to all species. All berries within each quadrat were counted; all units of large woody debris (logs or slash piles) lying across transects were counted as an index to availability of that form of cover. Moss and litter depths were measured every 3 meters along the length of the belt plots.

MOOSE BROWSE

We sampled breeding bird and small mammal plots for browse productivity and quality to relate browse characteristics to associated overstory and understory conditions. We determined stem densities of all browse species greater than 50-cm height by count in 2 x 30-m plots selected as described under “Small Mammals.”

BERRIES

We estimated densities of berry-producing species and berry production important to bears. We counted all berries within each 0.25-m quadrat (See Small Mammals section above.). Stems of berry-producing species taller than 50 cm were counted within 1 x 30-m belts within each plot. The total number of berries was then counted on all stems taller than 50 cm. We determined mean dry weight of berries from each replication.

RESULTS AND DISCUSSION

BREEDING BIRDS

During 1997/98, a total of 97 bird species were observed in all habitats of the study area (Table 2), using the variable circular plot method. Identification of two additional species, Peregrine Falcon (*Falco peregrinus*) and Great Gray Owl were unconfirmed. Two other species, Snowy Owl and Say’s Phoebe (*Sayornis saya*) were observed near the study area. There are a number of additional species that may be expected to occur in appropriate habitats which are rare or occasional. Table 2 summarizes bird species presence by plot.

We conducted 66 plot surveys during the 1998 breeding season, for a total of 594 point counts, using the variable circular plot method. We were unable to sample all treatment replicates in the first three survey periods of 1998, due to bureaucratic restrictions on hiring qualified technicians.

Preliminary analysis indicates that 2 species, Townsend's Warbler (*Dendroica townsendi*) and Golden-crowned Kinglet (*Regulus satrapa*) may be most negatively affected by habitat loss in areas with heavy spruce mortality. Further, these species are essentially absent from salvage-logged areas, and Townsend's Warblers do not occur in any significant numbers in mixed-forest habitats. Stands with live mature spruce may be critically important in the maintenance of these two species, especially Townsend's Warbler. Other species such as the Northern Goshawk (*Accipiter gentilis*) may also be critically impacted by habitat loss from spruce mortality and salvage logging. Only the Three-toed Woodpecker (*Picoides tridactylus*) appears to benefit from spruce bark beetle-infested stands. However, their numbers begin to decline in stands several years after spruce mortality when trees have been "worked over" and beetle larvae are no longer present.

At least 1 Solitary Sandpiper (*Tringa solitaria*) was heard singing on or near almost every plot surveyed. This species was usually heard singing near wet forest gaps 10–20 m wide. Solitary Sandpipers utilize deserted, occasionally new, passerine nests often of Rusty Blackbird (*Euphagus carolinus*), American Robin (*Turdus migratorius*), and Gray Jay (*Perisoreus canadensis*) in conifers or occasionally deciduous trees (Ehrlich, et. al. 1988). Because of their biology, they may be affected by spruce mortality and salvage logging. Their low density on the study area may make interpretation difficult. Nevertheless, this may be an easily overlooked species.

Preliminary analysis also indicated that species diversity is maintained in selectively logged stands directly proportional to remaining stem densities, with a shift toward more swallows (*Hirundinidae*), thrushes (*Turdidae*), and sparrows (*Emberizidae*), species that prefer relatively open habitats. It appeared that selectively logged mixed-forest stands maintained higher bird diversity than selectively logged spruce stands because of higher stem densities and vegetative diversity provided by deciduous tree species left unlogged.

Three species of owls were recorded during nocturnal surveys: Great Horned, Boreal, and Saw-whet (Table 2). Great Horned Owls called most actively within approximately 2 hours of sunset, while the smaller Boreal and Saw-whet Owls began calling later and continued later into the evening. Calling by Great Horned Owls diminished in April, while Boreal Owls were actively calling until mid-April. Saw-whet calling activity began in earnest at the beginning of April, declined in late April, but continued into May.

Frequently poor weather conditions throughout the census period prevented survey routes from being sampled consistently each week or sometimes prevented completion of a survey evening. On 17 March 1998 snow cover was 0.5–1.0 m depth, depending on elevation, and evening temperatures were 0 to -7° C. Patches of snow as deep as 1.0 m were still present on 1 May, but evening temperatures were +2 to +7° C.

A literature review of northern owl survey and census methods (Appendix A) was completed. A notebook/protocol for monitoring breeding nocturnal forest owls in Alaska (Appendix B) was then developed with the objectives that it should standardize methods to (1) assess relative breeding abundance of forest owl species (in the case of Boreal and Northern Saw-whet owls, this would be breeding males only), (2) document distribution of forest owl species in Alaska, (3) determine species-specific habitat associations, and (4) monitor multiannual trends and document population fluctuations of breeding forest owls.

Target species for the nocturnal forest owl surveys are Western Screech-Owl, Great Horned Owl, Northern Pygmy-Owl, Barred Owl, Great Gray Owl, Long-eared Owl, Boreal Owl, and Northern Saw-whet Owl. Target species for off-road point counts and BBS Surveys are Northern Hawk Owl and Short-eared Owl.

The following life-history characteristics of breeding nocturnal forest owls are particularly important to the design and implementation of owl surveys. Pairs of great horned owls establish territories by vocalization duets. These duets begin 1 to 2 months before the first egg is laid. Male great horned owls often roost and hoot from the immediate vicinity of the nest. Territorial calls are given by both sexes of great gray owls during breeding and near a nest site. Male boreal owls sing from within 100 m of potential nest cavities, but usually cease singing shortly after pair formation. Male northern saw-whet owls give advertising calls from potential nest-holes. Production of song falls off after clutch completion.

In conjunction with development of the owl survey, we incorporated a protocol for simultaneously surveying amphibians, which was developed by the North American Amphibian Monitoring Program (NAAMP) coordinated by the US Geological Survey, Biological Resources Division, Patuxent Wildlife Research Center. We did so because there currently are no coordinated efforts to monitor amphibians in Alaska (Keith Boggs, personal communication).

Since protocol developed by the NAAMP utilizes similar methods to the nocturnal forest owl survey and is fairly simple, owl surveys present a good opportunity to collect incidental data on frogs and toads from around Alaska annually. Alternatively, nocturnal owl survey routes that pass through wetlands could be used to survey amphibians in May if local conditions are not favorable when routes are surveyed in April.

In Alaska, there are 2 species of frogs and 1 species of toad. The wood frog, *Rana sylvatica*, is distributed throughout Alaska in many different habitats and is the only species found in the Northern, Western, Central, and Southwestern biogeographic regions. The spotted frog, *Rana pretiosa*, occurs only in Southeastern Alaska and is a highly aquatic species found along the coastal transboundary river corridors, such as the Taku and Stikine Rivers, originating in Canada. The only species of toad in Alaska is the Western Toad, *Bufo boreas*, and has been found from Southeastern Alaska as far north as Prince William Sound.

Breeding male frogs and toads in Alaska begin calling from wetlands, lakes, and ponds in April and May shortly after ice-out, often within only 1 or 2 days (Trapp, personal observation). As nocturnal forest owl surveys may coincide with this amphibian activity, frog and toad singing may easily be recorded incidentally to these surveys. Amphibian populations have been declining in many regions around the globe and suffering from high rates of birth defects due to a number of hypothesized causal factors including habitat loss; changing pH of wetlands, lakes, and ponds; ozone depletion resulting in increased ultraviolet radiation; pesticides; ground water contamination; and global warming. Amphibian populations at the high latitudes may be among the most severely impacted due to concentration of airborne contaminants at the poles and seasonal ozone holes. In addition, amphibians may serve as indicator species of environmental health.

SMALL MAMMALS

Northern red-backed voles accounted for 89% of 532 individuals collected in 1998 (Table 3) and 88% of the 351 individuals collected in 1997 (Table 4). Of the few shrews (*Sorex sp.)* that were captured, most occurred in mixed and spruce logged sites in 1998. A species of *Microtus* was captured on the spruce-logged sites in 1997, but no captures were made in 1998 (Table 3). Red squirrels (*Tamiasciurus hudsonicus*) were incidental in 1997, and no captures were made in 1998 (Table 4). Weasels (*Mustela sp.*) were caught in undisturbed and beetle-killed spruce sites and in logged spruce-deciduous sites in 1998.

In pure stands of white spruce, spruce bark beetle infestation positively influenced red-backed vole numbers, while logging had a negative effect. However, within mixed hardwood-white spruce stands, neither logging nor beetle infestation impacted the vole population. Relative abundance of red-backed voles was negatively correlated to bluejoint grass, whereas number of reproductive females was positively correlated to moss abundance and berry abundance. A thesis detailing the small mammal aspects of this study was completed (Williams 1999). See Appendix C for chapter abstracts.

MOOSE BROWSE

Shade-intolerant species, paper birch and willow spp., were favored by overstory removal only where soil was scarified. Since most harvested areas were logged in winter, very little scarification has occurred as a byproduct of harvest. Industry-standard logging practices in this region do not call for postlogging scarification. Without timely scarification, regeneration of paper birch and willows in Southcentral Alaska is extremely poor (Collins and Schwartz 1998). Hardwood regeneration in the Kenai lowlands was favored when harvested sites were scarified during harvest or within the first snow-free period following harvest. Otherwise, browse seedling establishment was severely suppressed by increasing cover of bluejoint grass.

Aspen regeneration was not as dependent on site scarification, as long as all aspen were cut and shade from competing tree species was significantly reduced. Retention of just a few aspen within a site, either by accident or by design, effectively suppressed resprouting by the entire clonal root system to which they were connected.

BERRIES

Poor berry production by dogwood (*Cornus* canadensis), crowberry (*Empetrum* nigrum), lowbush cranberry (*Vaccinium vitis*-idaea) and trailing raspberry (*Rubus pedatus*) in 1997 probably hurt productivity and overwinter survival of redback voles *Clethrionomys. rutilus*, a species that relies heavily on berries in its diet. Berry production in the study area almost completely failed as a result of a hard frost in early June (Table 6). Fall migration by bears to areas rich in devil's club indicated seasonal significance of berries in diets of bears (Schwartz and Franzmann 1991). Poor berry production adversely affected reproductive performance of black bears Rogers (1987), Elowe (1987) and Schwartz and Franzmann (1991). In all years, variability in berry production was too great for estimation of production by methods we used.

RECOMMENDATIONS

Breeding Birds

Distance analysis should be completed and manuscripts detailing conclusions should be prepared for publication by January 2002.

Small Mammals

Small mammal (particularly rodent) populations vary from habitat to habitat. Seasonal population patterns emerge as a function of breeding cycles. Yearly cycles are related to changes in weather, resource availability, and pressure from predators. Multiannual cycles may occur due to lagged response to environmental changes or in response to population density (French et al 1975; Smith et al 1975; Flemming 1979; Southern 1979; Batzli 1991).

In Alaska, several small mammal studies have found what appears to be a 3-year cycle for most arvicolines, northern red-backed voles in particular. Populations reach a peak, crash, and begin to rise again. Theories on the cause of the cycle are inconclusive and range from food shortage and overpopulation to snowless winters that prevent the animals from building tunnels to food caches (West 1979; Furtsch 1995; Staples 1995; Rexstad 1996).

Recent burns and logged areas are considered habitat sinks for many small mammals. These sinks provide an important dispersal area for juvenile or less dominant animals when densities in optimum habitat become too high (Sullivan 1979). The order in which optimal and suboptimal habitats are filled and abandoned may provide important clues to understanding the effects of management actions on relations between small mammals and their habitat (Krohn 1992).

We recommend that beginning in a yearlong effort of trapping, a 7-day interval every 3 months be implemented. Population data from all seasons will help determine survival rates and whether each treatment is providing a habitat sink, or source, for small mammals. Having yearlong small mammal population data would also be an important base for extending research from arvicolines to other mammals, such as hares (*Lepus americanus*), porcupines (*Erethizon dorsatum*), and predators such as birds of prey, weasels, coyotes (*Canis latrans*), fox (*Vulpes vulpes*), and lynx (*Felis lynx*).

Moose Browse

Harvested sites should be scarified during harvest or within the first snow-free period following harvest to favor regeneration of hardwoods, and Aspen and cottonwood should be felled in conjunction with spruce harvest to stimulate suckering (Collins and Schwartz 1998).

Berries

We believe it is beyond the scope of this study to accurately assess the berry resource relative to wildlife, given the degree of variability we have observed. We recommend a more extensive sampling scheme that incorporates transects of sufficient length to reduce sample variability. Such sampling is not compatible with our other vegetation sampling procedures and will require unique effort.

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Table 1. Breeding bird survey plots.

Habitat Type	Plot Number	1997 Plot Number	Township	Range	Section	Name	Access	Ownership[1]	Year Logged
Mixed-Light	1	5	T.7N.	R.8W.	6	Lake Sabaka	Swan Lake Road	KENWR	
Mixed-Light	2	6	T.7N.	R.8W.	8	Waterfowl Lake	Swan Lake Road	KENWR	
Mixed-Light	3		T.7N.	R.9W.	1	Cashka Lake	Swan Lake Road	KENWR	
Mixed-Moderate	4		T.1S.	R.14W.	36	Lower Ninilchik River 1	Brody Road	CIRI	
Mixed-Moderate	5		T.1S.	R.14W.	36	Lower Ninilchik River 2	Brody Road	CIRI	
Mixed-Moderate[2]	6								
Mixed-Heavy	7		T.2N.	R.12W.	32,33	Clam Gulch	Sterling Highway	NNAI/State/UA	
Mixed-Heavy	8		T.1N.	R.11W.	4	Border Lake 1	Falls Creek Road/Border Lake Trail	CIRI	
Mixed-Heavy	9		T.2N.	R.11W.	32	Border Lake 2	Falls Creek Road/Border Lake Trail	CIRI	
Mixed-Heavy	Alternate	1	T.1N.	R.12W.	32	Ninilchik River	1200 Road/Small Lakes Tract	CIRI	
Mixed-Heavy	Abandoned	2	T.1S.	R.12W.	6	Ninilchik River Bend	1200 Road/Small Lakes Tract	State	
Mixed-Logged	10	4	T.1N.	R.12W.	3	Swan Lake	Falls Creek Road	CIRI	1993
Mixed-Logged[2]	11	3	T.2N.	R.12W.	36	Crooked Creek	Falls Creek Road	CIRI	1993
Mixed-Logged	12		T.1N.	R.12W.	11	Upper Ninilchik River	Falls Creek Road	CIRI	1993
Spruce-Light	13	13	T.3S.	R.14W.	12,13	Stariski Creek	7000 Road	Borough Selection	
Spruce-Light	14		T.3S.	R.14W.	9,16	Happy Valley	Happy Valley Road	CIRI/Private	
Spruce-Light	15		T.3S.	R.14W.	2,3	East Road	East Road	Borough Selection/Borough	

Habitat Type	Plot Number	1997 Plot Number	Township	Range	Section	Name	Access	Ownership[1]	Year Logged
Spruce-Light	Abandoned	15	T.7N.	R.8/9W.	7,18/12,13	Dolly Varden Lake	Swanson River Road	KENWR	
Spruce-Moderate	16		T.3S.	R.14W.	2,11	Happy Creek	7000 Road	Borough Selection	
Spruce-Moderate	17		T.2S.	R.14W.	16	Anderson Hill	Sterling Highway	CIRI/State	
Spruce-Moderate	18		T.2S.	R.14W.	14,15	Clam Creek	Deep Creek Farm Road	UA/CIRI	
Spruce-Heavy	19	8	T.1S.	R.11W.	20	Falls Creek Trail	1200 Road	State	
Spruce-Heavy	20	7	T.1S.	R.11W.	1,12	KENWR/Crooked Creek	1200 Road	KENWR	
Spruce-Heavy	21		T.2S.	R.11/12W.	30/25	Deep Creek Dome	Oil Well Road/5000 Road	CIRI/State	
Spruce-Logged	22		T.3S.	R.14W.	25	Chakok River East	7000 Road	NNAI	1994
Spruce-Logged	23		T.3S.	R.14W.	22,23,26,27	Chakok River West	7000 Road	NNAI	1993
Spruce-Logged	24		T.2S.	R.11W.	18,19	North Fork Deep Creek	Oil Well Road/5000 Road	CIRI/State	1994

[1]Borough = Kenai Borough
Borough Selection = Kenai Borough Selection Patent Pending
CIRI = Cook Inlet Region, Incorporated
KENWR = Kenai National Wildlife Refuge
NNAI = Ninilchik Native Association, Incorporated
P = Private
State = State of Alaska
UA = University of Alaska

[2]Plot was either not selected or surveyed.

Table 2. Breeding bird species list.

Species	Habitat Plots[1]																							Nocturnal Owl Survey Routes					
	Mixed-Light			Mixed-Moderate			Mixed-Heavy			Mixed-Logged			Spruce-Light			Spruce Moderate			Spruce-Heavy			Spruce-Logged			Swan Lake Road	1200 Road East	1200 Road West	Oil Well Road	East Road	Breeding Status2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						
Family *Gaviidae*																														
Common Loon																														PO
Family *Podicipedidae*																														
Red-necked Grebe																														PC
Family *Anatidae*																														
Trumpeter Swan																														CR
Canada Goose																														X
Green-winged Teal																														X
Mallard																									X					X
Northern Pintail																														X
Northern Shoveler																														X
American Wigeon																														X
Scaup spp.																														M
Harlequin Duck																														PO,R
Oldsquaw																														M
Surf Scoter																														M
Common Merganser																														PO

Table 2. Continued

Species	Habitat Plots[1]																								Nocturnal Owl Survey Routes					
	Mixed-Light			Mixed-Moderate			Mixed-Heavy			Mixed-Logged			Spruce-Light			Spruce-Moderate			Spruce-Heavy			Spruce-Logged			Swan Lake Road	1200 Road East	1200 Road West	Oil Well Road	East Road	Breeding Status2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						
Family *Accipitridae*																														
Osprey																														PO
Bald Eagle							A										X	A				A		A						CY,R
Northern Harrier																														X
Sharp-shinned Hawk													X		X?			X												PO
Northern Goshawk	X												X		X															PA,R
Red-tailed Hawk																					X			A	X?					CO
Rough-legged Hawk																														M
Family *Falconidae*																														
American Kestrel																														X
Merlin				X			X																							PA
Peregrine Falcon[3]																														O
Family *Phasianidae*																														
Spruce Grouse		X		X	X		X			X		X	X	X	X	X	X	X	X	X	X									CE,CR,R
Family *Gruidae*																														
Sandhill Crane																														PC
Family *Charadriidae*																														
Killdeer																														X

Table 2. Continued

Species	Habitat Plots[1]																								Nocturnal Owl Survey Routes					
	Mixed-Light			Mixed-Moderate			Mixed-Heavy			Mixed-Logged			Spruce-Light			Spruce-Moderate			Spruce-Heavy			Spruce-Logged			Swan Lake Road	1200 Road East	1200 Road West	Oil Well Road	East Road	Breeding Status2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						
Family *Scolopacidae*																														
Greater Yellowlegs																														X
Lesser Yellowlegs												X												X						CD
Yellowlegs spp.		X		A				X						X						X										
Solitary Sandpiper		X	X		X							X		X		X		X			X			X						PT
Spotted Sandpiper																														X
Whimbrel																														M
Black Turnstone																														M
Western Sandpiper																														M
Least Sandpiper																														PC
Common Snipe	A	A	A	A	A		A	A	X			A	A	A		A	A		A	A				X		X		A	A	CE
Family *Laridae*																														
Bonaparte's Gull																														PA
Mew Gull							A																							PA
Herring Gull																														X
Glaucous-winged Gull																														X
Arctic Tern																														PA
Family *Alcidae*																														
Murre spp.																														O

Table 2. Continued

Species	Habitat Plots[1]																								Nocturnal Owl Survey Routes					
	Mixed-Light			Mixed-Moderate			Mixed-Heavy			Mixed-Logged			Spruce-Light			Spruce-Moderate			Spruce-Heavy			Spruce-Logged			Swan Lake Road	1200 Road East	1200 Road West	Oil Well Road	East Road	Breeding Status2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						
Family *Strigidae*																														
Great Horned Owl																			X						X	X		X		CR,R
Snowy Owl[4]																														M
Northern Hawk Owl																														CO,R
Great Gray Owl[3]																														O,R
Short-eared Owl[5]																														
Boreal Owl																									X	X	X	X	X	PT,R
Northern Saw-whet Owl																			X							X		X		PT,R
Family *Trochilidae*																														
Rufous Hummingbird[5]																														
Family *Alcedinidae*																														
Belted Kingfisher																														PT
Family *Picidae*																														
Downy Woodpecker										X		X																		CN,R
Hairy Woodpecker		X																												CY,R
Downy/Hairy Woodpecker	X		X	X	X			X	X			X			X	X														
Three-toed Woodpecker	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X						CY,R
Black-backed Woodpecker																														PO,R
Northern Flicker[5]																														

Table 2. Continued

Species	Habitat Plots[1]																								Nocturnal Owl Survey Routes					
	Mixed-Light			**Mixed-Moderate**			**Mixed-Heavy**			**Mixed-Logged**			**Spruce-Light**			**Spruce-Moderate**			**Spruce-Heavy**			**Spruce-Logged**			**Swan Lake Road**	**1200 Road East**	**1200 Road West**	**Oil Well Road**	**East Road**	**Breeding Status2**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**						
Family *Tyrannidae*																														
Olive-sided Flycatcher	X	X	X					X	X	X		X		X			X													PT
Western Wood-Pewee								X		X		X										X								PT
Alder Flycatcher	X	X	X				X			X		X	X						X				X	X						PT
Say's Phoebe[4]																														CR
Family *Laniidae*																														
Northern Shrike																														PO,R
Family *Corvidae*																														
Gray Jay	X	X	X	X	X		X	X	X	X		X	X			X		X	X	X	X			X						CR,R
Steller's Jay[5]																														
Black-billed Magpie			X																											X,R
Northwestern Crow																														X,R
Common Raven	X		X	X	X		X							X					X	X	A	X		A		X	X			X,R
Family *Hirundinidae*																														
Tree Swallow																														X
Violet-green Swallow		A	A	A			A		A?					A			A					A	X	A						CO,CF
Bank Swallow			A?																											CO
Cliff Swallow																														X
Swallow spp.					X																									

Table 2. Continued

Species	Habitat Plots[1]																								Nocturnal Owl Survey Routes					
	Mixed-Light			Mixed-Moderate			Mixed-Heavy			Mixed-Logged			Spruce-Light			Spruce-Moderate			Spruce-Heavy			Spruce-Logged			Swan Lake Road	1200 Road East	1200 Road West	Oil Well Road	East Road	Breeding Status2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						
Family *Paridae*																														
Black-capped Chickadee	X	X	X				X		X				X								X									X,R
Boreal Chickadee	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X			X						CO,R
Family *Sittidae*																														
Red-breasted Nuthatch	X		X	X	X		X	X	X								X	X												X,R
Family *Certhiidae*																														
Brown Creeper	X	X	X	X	X		X	X	X			X	X	X	X	X	X	X	X	X	X			X			X			CO,CR,R
Family *Troglodytidae*																														
Winter Wren[5]																														
Family *Cinclidae*																														
American Dipper																														PA,R
Family *Regulidae*																														
Golden-crowned Kinglet	X	X	X	X	X		X	X	X				X	X	X	X	X	X	X	X	X									CF,R
Ruby-crowned Kinglet	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X					X	PA

Table 2. Continued

Species	Habitat Plots[1]																								Nocturnal Owl Survey Routes					
	Mixed-Light			Mixed-Moderate			Mixed-Heavy			Mixed-Logged			Spruce-Light			Spruce-Moderate			Spruce-Heavy			Spruce-Logged			Swan Lake Road	1200 Road East	1200 Road West	Oil Well Road	East Road	Breeding Status2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						
Family *Turdidae*																														
Gray-cheeked Thrush																					X			X						PT
Swainson's Thrush	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X		X							PA
Hermit Thrush	X		X	X			X					X	X	X	X	X?	X	X	X		X			X						PT
American Robin	X	X	X	X	X		X		X	X		X		X		X	X			X		X	X	X						PA
Varied Thrush	X	X	X	X	X		X	X	X				X	X	X	X	X	X	X	X	X		X			X			X	PA
Family *Motacillidae*																														
American Pipit																														M
Family *Bombycillidae*																														
Bohemian Waxwing[5]																														
Family *Parulidae*																														
Orange-crowned Warbler	X	X	X	X	X		X	X	X	X		X		X	X	X	X	X	X	X	X	X	X	X						PA
Yellow Warbler		X								X											X??									X
Yellow-rumped Warbler	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X						PA
Townsend's Warbler	X			X	X		X						X	X	X	X	X	X	X	X	X			X						PA
Blackpoll Warbler																								X						X
Northern Waterthrush	X																X													PT
Wilson's Warbler		X			X		X	X	X				X	X	X		X		X		X		X	X						PT

Table 2. Continued

Species	Habitat Plots[1]																								Nocturnal Owl Survey Routes					
	Mixed-Light			Mixed-Moderate			Mixed-Heavy			Mixed-Logged			Spruce-Light			Spruce-Moderate			Spruce-Heavy			Spruce-Logged			Swan Lake Road	1200 Road East	1200 Road West	Oil Well Road	East Road	Breeding Status2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						
Family *Emberizidae*																														
American Tree Sparrow[5]																														
Savannah Sparrow							X												X		X	X	X	X						PA
Fox Sparrow																X														PT
Song Sparrow																														X,R
Lincoln's Sparrow			X	X			X			X		X		X			X	X	X			X	X	X						PA
Golden-crowned Sparrow																	X	X	X			X	X	X						PT
White-crowned Sparrow		X			X					X		X							X			X	X							PA
Dark-eyed Junco	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X						CE,CR
Lapland Longspur																														M
Snow Bunting																														M
White-crowned Sparrow		X			X					X		X							X			X	X							PA
Dark-eyed Junco	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X						CE,CR
Lapland Longspur																														M
Snow Bunting																														M
Family *Icteridae*																														
Rusty Blackbird																														X

Table 2. Continued

Species	Habitat Plots[1]																								Nocturnal Owl Survey Routes					
	Mixed-Light			Mixed-Moderate			Mixed-Heavy			Mixed-Logged			Spruce-Light			Spruce-Moderate			Spruce-Heavy			Spruce-Logged			Swan Lake Road	1200 Road East	1200 Road West	Oil Well Road	East Road	Breeding Status2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						
Family *Fringillidae*																														
Pine Grosbeak			X					X							X					X		X								X,R
Red Crossbill[3]		X																												X,R
White-winged Crossbill	X	X	X	X					X					X																PO,R
Crossbill spp.	X		X		X		X		X							X														
Common Redpoll																				X				X						PO,R
Pine Siskin																														X,R
Common Redpoll/Pine Siskin	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X						
Unknown Fringillidae								X							X			X												

[1]Only those species associated with the habitat of a plot are checked (X = Present, A = Aerial Detection).
[2]O = Observed
X = Possible
P = Probable: PO = Pair Observation, PT = Permanent Territory, PC = Courtship Behavior, PN = Nest-site Visitation, PA = Agitated Behavior
C = Confirmed: CN = Carrying Nesting Material, CB = Nest Building, CU = Used Nest, CO = Occupied Nest, CD = Distraction Display, CP = Physiological Evidence, CE = Nest With Eggs, CY = Nest With Young, CG = Precocial Young, CF = Carrying Food,
CS = Fecal Sac Removal, CR = Recently Fledged Young, CI = Feeding Recently Fledged Young (USFWS, 1995)
R = Resident
M = Probable Migrant
[3]Identification was uncertain.
[4]Species was observed adjacent to study area.
[5]Species was not observed but is expected to breed in appropriate habitats at low density (i.e., rare in abundance).

Table 3. Total 1998 individual session captures of small mammals in logged, and spruce bark beetle infested mixed hardwood-spruce and logged, infested and undisturbed pure spruce stands on the Kenai Peninsula, Alaska.

	Treatment[a] and Session [b]																				
	SC				SL				SI				MI				ML				
Species	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	5
Clethrionomys rutilus	11	17	41	47	0	7	23	25	14	54	87	83	19	23	22	20	2	20	36	66	42
Sorex sp.[c]	0	1	1	0	0	1	14	13	1	0	0	1	0	0	1	2	0	0	2	11	9
Mustela sp.	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	1

	Total individuals for 1998 Season				
	SC	SL	SI	MI	ML
Clethrionomys rutilus	87	36	170	61	117
Sorex sp.	2	27	2	3	22
Mustela sp.	1	0		0	1

	Total captures for 1998 Season				
	SC	SL	SI	MI	ML
Clethrionomys rutilus	449	206	751	279	542
Sorex sp.	2	27	2	3	22
Mustela sp.	1	0	3	0	1

[a] Treatments are: SC = pure spruce no treatment; SL = pure spruce logged; SI = pure spruce infested;
MI = mixed hardwood-spruce infested; ML = mixed hardwood-spruce logged.

[b] Sessions are: SC and SL (1) 5/24-5/28, (2) 6/15-6/19, (3) 7/7-7/11, (4) 7/29-8/2;
SI (1) 6/1-6/5, (2) 6/22-6/26, (3) 7/14-7/18, (4) 8/5-8/9;
ML (1) 5/17-5/20I (2) 6/1-6/5, (3) 6/22-6/26, (4) 7/14-7/18, (5) 8/5-8/9;
MI (1) 5/17-5/20, (2) 6/8-6/12, (3) 6/30-7-4, (4) 7/21-7/25.

[c] Specimens have not been identified to species.

Table 4. Total 1997 individual captures of small mammals in logged, burned and undisturbed mixed hardwood-spruce stands, and spruce bark beetle infested, logged and undisturbed pure spruce stands on the Kenai Peninsula, Alaska.

	Treatment[a] and Session [b]											
	SC		SL		SI		MC		ML		MB	
Species	Individual	Captures	Individual	Captures	Individual	Captures	Individual	Captures	Individual	Captures	Individual	Captures
Clethrionomys rutilus	124	406	70	323	48	144	28	75	26	96	14	31
Microtus sp.[c]	0	0	14	33	0	0	0	0	0	0	0	0
Sorex sp.	0	0	1	1	0	0	0	0	1	1	0	0
Tamiasciurus hudsonicus	0	0	0	0	n/a	5	0	0	1	1	0	0

[a] Treatments are: SC = pure spruce no treatment; SL = pure spruce logged; SI = pure spruce infested; MC = mixed hardwood-spruce no treatment;
ML = mixed hardwood-spruce logged MB = mixed hardwood-spruce wildfire burned.

[b] Sessions are: SC and SL 7/5-7/9/1997
SI and ML 6/12-6/17/1997
MC 6/24-6/29/1997
MB 5/24-5/29/1997

[c] Specimens have not been identified to species.

Table 5. *Clethrionomys rutilus* abundance per session on logged, infested and undisturbed pure spruce, and logged and infested mixed hardwood-spruce on the Kenai Peninsula, Alaska, 1998.

	Treatment[a]									
	SC[b]		SL		SI		MI[b]		ML[b]	
Species	μ	SE	μ	SE	μ	SE	μ	SE	μ	SE
Clethrionomys rutilus	29.0	6.1	12.0	5.6	56.7	11.2	30.5	10.6	38.3	12.3

[a] Treatments are: SC = pure spruce no treatment; SL = pure spruce logged; SI = pure spruce infested; MI = mixed hardwood-spruce infested;

ML = mixed hardwood-spruce logged.

[b] For statistical tests, means with same letter were not different (Multiple comparison ANOVA P > 0.05). LSD = 2.26.

Table 6. Berry production in spruce stands in the Ninilchik River drainage in 1997. Frequency of species occurrence is followed by berries per stem in parenthesis. N = 120 in each type.

species	spruce type			
	uninfested	infested	logged	burned
shrubs[1]				
Ribes laxiflorum	3 (0.00)	3 (0.00)	0 (0.00)	3 (0.00)
Rosa acicularis	0 (0.00)	0 (0.00)	3 (0.00)	0 (0.00)
Rubus idaeus	1 (0.00)	0 (0.00)	4 (2.20)	3 (0.00)
Sambucus racemosa	1 (20.00)	2 (0.00)	1 (0.00)	3 (0.00)
Streptopus amplexifolius	31 (2.22)	35 (5.80)	17 (3.90)	3 (0.00)
Viburnum edule	23 (0.00)	30 (0.00)	32 (0.97)	0 (0.00)
Vaccinium uliginosum	2 (0.00)	3 (4.50)	2 (0.00)	0 (0.00)
ground cover[2]				
Cornus canadensis	18 (0.00)	35 (0.00)	25 (0.03)	5 (0.00)
Empetrum nigrum	0 (0.00)	6 (0.00)	0 (0.00)	0 (0.00)
Ribes	28 (0.18)	59 (0.18)	13 (0.75)	2 (0.00)
Rubus arcticus	1 (1.00)	8 (0.00)	3 (0.00)	7 (0.00)
Rubus pedatus	35 (0.05)	44 (0.11)	35 (0.00)	14 (0.00)
Vaccinium vitis-idaea	1 (0.00)	0 (0.00)	1 (0.00)	1 (0.00)

[1] Frequency determined with 30 m^2 plots.
[2] Frequency determined with 1/4 m^2 plots.

Appendix A

Literature Review of Survey/census Methods for Northern Owls

Short-eared Owl (*Asio flammeus*)

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Appendix B

Owl survey notebook

(cover page)

ALASKA NOCTURNAL OWL SURVEY

Route Name: ___________________________________

Observer: ______________________________________

Date: ____

(inside front cover)

DETECTION CODES:

P Detected at a *Previous* stop.

S Detected earlier at the *Same* stop.

Indicate *Previous* and *Same* detections with the superscript P or S and the ID # for the individual to which it refers (e.g., GHOW ^{P13} or BOOW ^{S2}, respectively.

Note: 0.5 mile = 0.805 km ≈ 800 m

WIND SPEED CODES: (Enter Beaufort numbers, not m.p.h.)

Beaufort Number	Wind Speed (miles/hour)	Indicators of Wind Speed
0	Less than 1	Air calm; smoke rises vertically.
1	1 to 3	Direction of wind shown by smoke drift but not by wind vanes.
2	4 to 7	Wind felt on face; leaves rustle; wind vanes moved by wind.
3	8 to 12	Leaves and small twigs in constant motion; wind extends light flag.
4	13 to 18	Raises dust, loose paper; small branches are moved.
5	19 to 24	Small trees in leaf begin to sway; crested wavelets form on inland waters.

CLOUD COVER CODES:

- **0** *Clear*, less than 10 percent cloud cover.
- **1** *Scattered*, 10-50 percent cloud cover.
- **2** *Broken*, 50-90 percent cloud cover.
- **3** *Overcast*, more than 90 percent cloud cover over entire sky.

PRECIPITATION CODES:

- **0** *None.*
- **1** *Fog.*
- **2** *Drizzle*.
- **7** *Moderate snow.*
- **8** *Heavy snow.*

3 *Showers* (intermittent rain).
4 *Rain*.
5 *Sleet*.
6 *Light snow*.

<u>SELECTED SPECIES CODES:</u>

COSN Common Snipe (Arrives month of April.)

WESO Western Screech-Owl ✓
GHOW Great Horned Owl
SNOW Snowy Owl
NHOW Northern Hawk Owl
NOPO Northern Pygmy-Owl ✓
BDOW Barred Owl ✓
GGOW Great Gray Owl
LEOW Long-eared Owl ✰
SEOW Short-eared Owl
BOOW Boreal Owl
NSWO Northern Saw-whet Owl

WOFR Wood Frog (Begins calling in April.)
WETO Western Toad (Begins calling in April; SE/Southcoastal Alaska.)
SPFR Spotted Frog (Begins calling in April; SE Alaska only.)
✓ RARE (Annual or probably annual in small numbers; most such species occur at the perimeter of Alaska, in season; a few are scarce residents.)
✰ CASUAL (Not annual; these species are beyond the periphery of annual range, but recur in Alaska at irregular intervals, usually in seasonal and regional patterns.)

<u>FROG CALL INDEX CODES:</u>

0 No frogs can be heard calling.
1 Individual calls not overlapping.
2 Calls are overlapping; but individuals are still distinguishable.
3 Numerous frogs can be heard; chorus is constant and overlapping.

(page 2 of booklet)

ALASKA NOCTURNAL OWL SURVEY

Biogeographic Region:

Northern ☐ Central ☐ Southcoastal ☐

Western ☐ Southwestern ☐ Southeastern ☐

Study Area: ____

Route Name: ______________________________ Route No. ☐☐☐

Starting Point: Lat ☐☐ ° ☐ . ☐☐☐ ' N

Long ☐☐☐ ° ☐ . ☐☐☐ ' W

Date Month ☐☐ / Day ☐☐ / Year ☐☐ Visit No. ☐ of ☐

Start Time ☐☐☐☐ End Time ☐☐☐☐ (24 hours)

Start Temp ☐☐ °C °F End Temp ☐☐ °C °F

Start Wind ☐ End Wind ☐ Snow Cover ☐☐☐ %

Start Sky ☐ , ☐ End Sky ☐ , ☐

Sunset ☐☐☐☐ (24 hours) Mean Snow Depth ☐ . ☐ m

Moonrise ☐☐☐☐ Moon Set ☐☐☐☐ (24 hours)

Moon Phase: New ¼ ½ ¾ Full ¾ ½ ¼

Observer: ____
First Name Middle Initial Last Name

Contact: ____
First Name Middle Initial Last Name

Address: ____

City: ________________________ State: ______ Zip: __________

Telephone: ____________________ (W) ____________________ (H)

Assistant Recorder: ____________________________________
First Name Middle Initial Last Name

(multiples of this sheet are included in the survey booklet)

Moon Visible: Y N (at start)

Stop No. [ ][ ] Start Time [ ][ ][ ][ ] (24 hours) Illuminance [ ][ ][ ][ ][.][ ] lx

Wind: 0 1 2 3 4 Cloud: 0 1 2 3 Precip: 0 1 2 3 4 5 6 7 8

ID #	**Species**	**Distance (meters)**	**Direction (0-360°)**	**Time 0-8 minutes**	**Comments**

	Frog Call Index			
Species	**0**	**1**	**2**	**3**

Comments/Background Noise:

(inside back cover)

NARRATIVE / MISCELLANEOUS FIELD NOTES

To find times of sunrise/sunset, twilight, and moonrise/moonset, as well as moon phase and illumination for your area see: http://aa.usno.navy.mil/AA/data/

Appendix C

Response of *Clethrionomys rutilus* Populations to Disturbance on the Kenai Peninsula, Alaska

Abstract: We examined differences between populations of northern red-backed voles (*Clethrionomys rutilus*) in unlogged, logged, and spruce bark beetle (*Dendroctomus rufipennis* Kirby) infested forests in pure white spruce (*Picea glauca*) habitat, and logged and spruce bark beetle infested forests in mixed hardwood-white spruce habitat. Small mammals were livetrapped in each habitat type four times between May and August 1998 to estimate population abundance, survivability, and recruitment. Capture rates of northern red-backed voles differed among habitat types, treatments, and trapping sessions. Numbers of reproducing females and juvenile-adult ratios were also different among habitats, treatments, and trapping sessions. Populations of red-backed voles in all areas were similar in sex composition. Our results suggest that within the pure white spruce habitat, spruce bark beetle infestations positively influence red-backed vole numbers, while logging has a negative effect. However, within the mixed hardwood-white spruce habitat type, neither logging nor spruce bark beetle infestation impacted red-backed vole population dynamics.

Response of White Spruce Forest Vegetation to Logging and Spruce Bark Beetle Infestation on the Kenai Peninsula, Alaska

Abstract: Spruce forests on the Kenai Peninsula are currently experiencing high rates of canopy tree mortality from a large-scale insect infestation. Intensive logging efforts have followed the path of the infestation in an attempt to reduce the risk of wildfires and salvage timber value. Our objectives in this study were to assess the impact of spruce bark beetle (*Dendroctomus rufipennis* Kirby) infestation and logging on vegetation and wildlife habitat. Plot locations corresponded to two habitat types: pure white spruce (Picea glauca) and mixed white spruce-deciduous (i.e., *Betula papyrifera*. Vegetation measurements included canopy tree composition and density, understory shrubs, and understory herbaceous species. The mixed white spruce-deciduous habitat retained a higher percentage of overstory canopy cover following logging and beetle infestation and had a more uniform composition of shrub species than the pure spruce habitat. Logging in both habitat types produced dense stands of bluejoint reedgrass (*Calamagrostis canadensis*) and a reduction in the abundance of many shrub and herbaceous understory species.

Habitat Factors Affecting Northern Red-backed Vole (*Clethrionomys rutilus*) Populations on the Kenai Peninsula, Alaska

Abstract: We examined differences between populations of northern red-backed voles (*Clethrionomys rutilus*) in unlogged, logged, and spruce bark beetle (*Dendroctomus rufipennis* Kirby) infested forests in pure white spruce (*Picea glauca*) habitat, and logged and spruce bark beetle infested forests in mixed hardwood-white spruce habitat. Small mammals were livetrapped on each habitat type and forest treatment 4 times between May and August 1998 to estimate relative population abundance. Capture rates differed significantly among habitats, forest treatments, and trapping sessions. Numbers of reproducing females were also significantly different among habitats, forest treatments, and trapping sessions. Relative abundance was negatively correlated to bluejoint reedgrass (*Calamagrostis canadensis*), while number of reproductive females showed a positive relationship with moss abundance. Relative abundance and numbers of reproducing females were positively correlated with berry abundance.