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Effect of Ecosystem Disturbance on Diversity of Bark and Wood-Boring Beetles (Coleoptera: Scolytidae, Buprestidae, Cerambycidae) in White Spruce (*Picea glauca* (Moench) Voss) Ecosystems of Alaska

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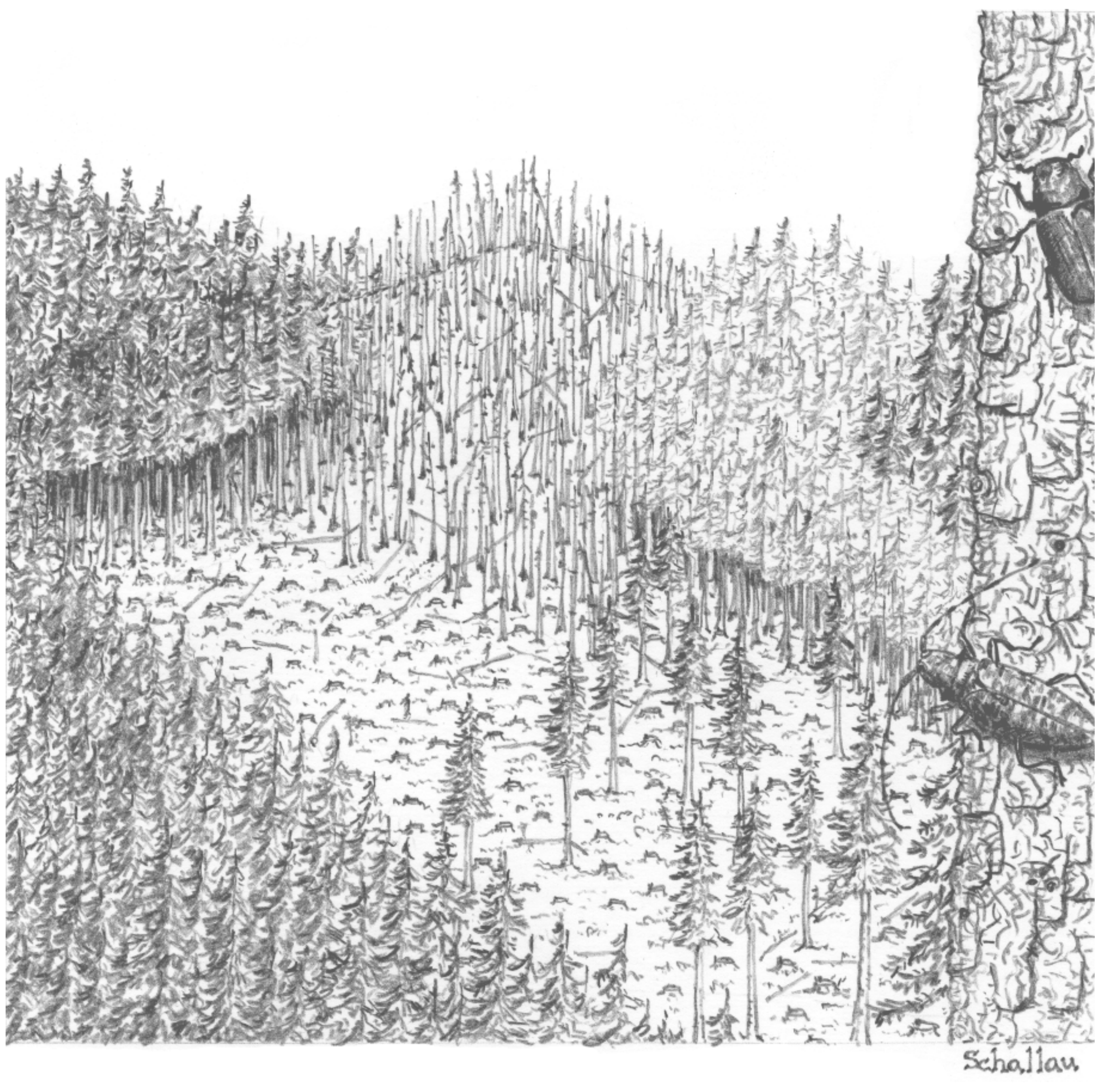

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Abstract

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Fire and timber harvest are the two major disturbances that alter forest ecosystems in interior Alaska. Both types of disturbance provide habitats that attract wood borers and bark beetles the first year after the disturbance, but populations then decrease to levels below those in undisturbed sites. Populations of scolytids, buprestids, and cerambycids are compared 1, 5, and 10 years after burning and timber harvest on flood-plain and upland white spruce sites. This paper reports the effects of ecosystem disturbance, such as silvicultural practices and prescribed fire, on the diversity of wood-inhabiting bark beetles and wood borers in upland and flood-plain white spruce stands in interior Alaska.

Keywords: Bark beetles, wood borers, prescribed fire, timber harvest, silvicultural practices, white spruce, *Picea glauca*.

Summary

Data from 15 years of field work on the effects of ecosystem disturbance on populations of wood-boring beetles (Buprestidae and Cerambycidae) and bark beetles (Scolytidae) are summarized. Twenty-eight species of cerambycids were caught in upland sites compared to 21 species in flood-plain sites; 12 species of buprestids were caught in the upland sites and 8 species in the flood-plain sites. Twenty species of scolytids were found in the upland sites and 21 species in flood-plain sites. Species lists of insect and vegetation are provided by site and length of time after disturbance.

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Introduction

The boreal forests of interior Alaska are a mosaic of vegetation types that are the result of wildfires and characteristics of aspect, slope, elevation, drainage, and soil. Biological diversity and distribution of species within communities depend on the above characteristics. The distribution of terrestrial species of vertebrates and invertebrates depends on plant species and the vertical distribution of the plants within the communities (Werner 1996).

Boreal ecosystems are constantly undergoing change, and the long-term productivity of these ecosystems within the context of ecosystem management must be monitored to assure sustainable biodiversity. Changes in the health of forest ecosystems and the effects of ecosystem management can be measured by changes in the density, species composition, range, and behavior of terrestrial insect populations (Werner 1996).

The information reported in this paper is part of a larger study monitoring terrestrial insect populations in various ecosystems over time with emphasis on the effects of disturbance on the composition and density of species inhabiting white spruce ecosystems in interior Alaska (Werner 1994a).

A report (Werner 1983) on the diversity of boreal forest arthropods for six types of vegetation in interior Alaska found four taxonomic classes representing 94 arthropod families at the herb, shrub, and tree levels in undisturbed stands of quaking aspen (*Populus tremuloides* Michx.), balsam poplar (*P. balsamifera* L.), paper birch (*Betula papyrifera* Marsh.), white spruce (*Picea glauca* (Moench) Voss), and black spruce (*P. mariana* (Mill.) B.S.P.)). Ground herbs contained the highest densities of arthropods. In another study, Werner and Holsten (1984) monitored species diversity of scolytids associated with stands of white spruce at three geographically different sites in Alaska. They report 27 species in the Fairbanks, Alaska, area (lat. 64°37' N.), 22 species in the Brooks Range of Alaska (lat. 68°15' N.), and 20 species in the Kenai Peninsula area of Alaska (lat. 60°37' N.). Scolytids were found inhabiting all portions of the tree from the roots to small-diameter branches with the highest density in the tree bole. Werner (1979) reports on the effect of fire on arthropod density for ground inhabiting species in burned and unburned stands of black spruce. Arthropod density was lowest in the burned areas in the first 2 years after the fire; density of predatory spiders, however, increased during this time.

Diversity of wood borer species is associated with various silvicultural practices in white spruce stands (Post 1984, Post and Werner 1988) and in the fringe areas surrounding recent wildfires (Werner and Post 1985). In these sites, *Monochamus scutellatus* (Say) and buprestid populations were higher in clearcut areas than in thinned or shelterwood areas; species of *Tetropium* were more abundant in partially shaded, thinned stands. Wood-boring beetles (Buprestidae and Cerambycidae) are commonly associated with stressed or dying white spruce in Alaska (Holsten and others 1980, Post 1984, Post and Werner 1988). Several species of wood borers have been associated with white spruce in interior British Columbia and western Canada (Cerezke 1977, Rose 1957, Ross 1960, Ross and Vanderwal 1969). Trees that are freshly cut, windthrown, or burned by fire are susceptible to attack by wood borers. These insects may be considered beneficial to forest ecosystems through their important role in the initial decomposition of logging slash. Wood borers, however, can cause economic losses in the form of wood degrade and volume loss when trees destined for commercial use are heavily infested (Post 1984).

This paper reports the effects of various silvicultural practices and prescribed fire on the diversity of wood-inhabiting scolytid, buprestid, and cerambycid beetles in flood-plain and upland white spruce sites in interior Alaska.

Materials and Methods

Study Site Descriptions

This study was conducted in the Bonanza Creek Experimental Forest, 32 km west of Fairbanks, Alaska. Study sites were located in flood-plain and upland stands of white spruce. Each site consisted of clearcuts, shelterwood logged stands, burned stands, fringe areas of burned stands, and undisturbed control stands. The burned stands were further subdivided into heavily burned stands with no live trees or ground cover after the burn, and lightly burned stands in the fringe areas surrounding the burned stands. The fringe areas contained white spruce that exhibited smoke damage to the needles and had less than 10 percent of the tree roots and trunk scorched. These stands also had less than 10 percent of the ground cover burned. Sites were located within 1 to 2 km of each other in an upland and a flood-plain area with similar topographical and vegetation characteristics.

Flood-Plain Forest Type

The forest type of the flood-plain sites prior to disturbance was represented by a closed white spruce/prickly rose-viburnum/twinflower/feather moss community (table 1) (Dyrness and others 1988). This 100-year-old mature stand of white spruce had an average tree diameter of 30 cm (at breast height) and an average height of 30 m. Basal area ranged from 30 to 60 m^2 per ha. Stands were located in a low, flat area at an elevation of 122 m and were composed of white spruce (1,000 trees/ha), balsam poplar (81 trees/ha), paper birch (60 trees/ha), and tamarack (*Larix laricina* (Du Roi) K. Koch) (5 trees/ha). Tall shrub cover consisted of prickly rose (*Rosa acicularis* Lindl.), thinleaf alder (*Alnus tenufolia* Nutt.), American green alder (*A. crispa* (Ait.) Pursh), and high-bush cranberry (*Viburnum edule* (Michx.) Raf.). Low shrubs provided less than 20-percent cover and consisted of *Arctostaphylos rubra* (Rehd. and Wilson) Fern., *Linnaea borealis* L., *Potentilla fructicosa* L. and *Vaccinium vitis-idaea* L., Blue joint grass (*Calamagrostis canadensis* (Michx.) Beauv.) was also present. Mean daily temperature from June 1 to August 31 is 14.5 °C; mean weekly rainfall is 6.0 cm (Slaughter and Viereck 1986).

Upland Forest Type

The upland site prior to disturbance was a 165-year-old mature white spruce stand on a south slope at an elevation of 300 to 400 m (table 1). This stand was comprised primarily of white spruce (875 trees/ha), but paper birch (22 trees/ha) and quaking aspen (15 trees/ha) were also present (Viereck and others 1986). Shrub cover included *Alnus* spp., *R. acicularis, Salix* spp., *Viburnum edule, L. borealis,* and *Vaccinium vitis-idaea* along with *Calamagrostis canadensis.* Mean daily temperature from June 1 to August 31 is 16.3 °C; mean weekly rainfall is 5.2 cm (Slaughter and Viereck 1986).

Experimental Design

Two plots, each consisting of two 168-m transects, were established in each of the disturbed and undisturbed control stands (replicated twice) in the two study areas the same year the stands were either logged or burned, and the plots were monitored 1, 5, and 10 years following disturbance. Plots were spaced 300 m apart within each site and were located a minimum of 100 m from the edge of the site. Transects were aligned in a north-south and an east-west direction and crossed at midpoint. Four permanent vegetation plots were established in each of the two plots per site except for the burned fringe site. Vegetation plots were 1 m^2 and were located 42 m from the midpoint of the transects.

Table 1—Plant species composition of upland and flood-plain white spruce plots at 1, 5, and 10 years post-disturbance, Fairbanks, Alaska

	Plot											
	Control			Clearcut			Shelterwood			Burned		
	Year			Year			Year			Year		
Species composition	**1**	**5**	**10**	**1**	**5**	**10**	**1**	**5**	**10**	**1**	**5**	**10**
	Percent cover											
Upland:												
Overstory—												
Betula papyrifera Marsh.	10	10	10	5	10	15	0	5	5	0	25	35
Picea glauca (Moench) Voss	85	85	85	0	5	5	50	50	50	0	0	5
Populus tremuloides Michx.	5	5	5	25	55	55	10	15	15	0	60	30
Tall shrubs—												
Alnus spp.	5	5	5	5	15	15	5	10	10	0	5	15
Rosa acicularis Lindl.	20	20	20	10	10	5	15	20	20	50	40	20
Salix spp.	5	5	5	5	10	10	5	10	10	15	30	30
Viburnum edule (Michx.) Raf.	20	20	20	10	15	15	15	20	20	20	20	15
Low shrubs—												
Linnaea borealis L.	15	15	15	5	5	5	10	10	5	25	15	15
Vaccinium vitis-idaea L.	15	15	15	5	10	10	10	15	15	5	15	15
Grasses—												
Calamagrostis canadensis (Michx.) Beauv.	0	0	0	20	65	45	10	15	5	20	40	55
Flood plain:												
Overstory—												
Betula papyrifera Marsh	5	5	5	50	50	50	0	5	5	0	30	35
Larix laricina (Du Roi) K. Koch)	5	5	5	0	5	5	0	0	0	0	5	5
Picea glauca (Moench) Voss	80	80	80	40	40	40	100	95	95	0	5	25
Populus balsamifera L.	10	10	10	0	5	5	0	0	0	0	5	15
Tall shrubs—												
Alnus spp.	75	75	75	40	40	35	45	50	50	0	15	15
Rosa acicularis Lindl.	90	90	90	85	90	80	85	95	50	7	75	65
Salix spp.	5	5	5	5	5	5	20	5	5	5	55	55
Viburnum edule (Michx.) Raf.	10	10	10	25	25	15	40	55	5	20	20	15
Low shrubs—												
Arctostaphylos rubra (Rehd.& Wilson)	5	5	5	5	5	5	5	5	5	0	5	5
Linnaea borealis L.	70	70	65	45	45	40	60	60	45	0	10	10
Potentilla fruticosa L.	0	0	0	0	0	0	5	5	5	0	5	9
Vaccinium vitis-idaea L.	10	10	10	10	10	10	0	0	5	5	5	5
Grasses:												
Calamagrostis canadensis (Michx.) Beauv.	5	5	5	10	15	20	10	15	20	0	5	5

Vegetation on the flood-plain plots was inventoried in 1984, 1 year after logging and prescribed fire, by using techniques developed by Ohmann and Ream (1971). Upland vegetation plots were established in 1977 in clearcut, shelterwood, and unmanaged control areas, and in 1983 in burned areas. Vegetation on these plots was measured at 1, 5, and 10 years after treatment.

Trapping Method and Semiochemical Descriptions

Cylindrical sticky traps (Kline and others 1974) baited with synthetic semiochemicals and 38 by 38 cm glass window traps were alternated at 15-m intervals along each transect. Cylindrical traps measured 45 cm in length and 25 cm in diameter and were constructed from 6.35-mm mesh wire screen. Traps were placed in clusters of five at each 15-m interval. Traps within clusters were spaced at 2-m intervals to form a circle. One cylindrical trap was baited with α-pinene and frontalin to capture *Dendroctonus rufipennis* and species of *Polygraphus, Dryocoetes, Carphoborus, Cryphalus, Crypturgus, Orthotomicus, Phloeosinus, Phloeotribus, Pityophthorus, Scierus, Scolytus, and Trypodendrum* (Werner 1994b, Werner and Holsten 1995). Another trap was baited with α-pinene and seudenol to catch *Dendroctonus simplex* (Werner 1994b). The third cylindrical trap was baited with α-pinene and ipsdienol to catch species of *Ips* (Werner 1993). The fourth trap was baited with α-pinene and turpentine to catch buprestids and cerambycids based on previous field tests and the fifth trap with α-pinene and sulcatol to catch species of *Trypodendrum*.

Semiochemicals were purchased commercially from Aldrich Chemical Company, and releasers were prepared in the laboratory for the study before 1984. Chemical chirality, purity, release rates, and releaser devices were as follows: α-pinene, (-)-emantiomer, >99-percent pure, 0.7 mg/day, in closed polyethylene microcentrifuge tubes; frontalin, (R)-(-)- emantiomer, >99-percent pure, 0.1 mg/day, in eppendorf vials; racemic ipsdienol, 99-percent pure, 0.2 mg/day, in eppendorf vials; and sulcatol, 98.5 percent, polyethylene microcentrifuge tubes.

Cylindrical sticky traps and window traps were attached to iron posts and placed 1.5 m above ground level. Twelve-unit funnel traps (Lindgren 1983) replaced cylindrical sticky traps in 1984, and semiochemicals were purchased from Phero Tech Inc., Delta, British Columbia.[1] Funnel traps were hung from L-shaped iron posts with the bottom of the trap 0.5 m from the ground. Beetles were removed from traps and counted weekly between late May and mid-August. Scolytids were identified according to Wood (1963, 1982) and Bright (1976); buprestids according to Bright (1987); and cerambycids according to Linsley (1962).

Statistical Analysis

Weekly mean numbers of buprestids and cerambycids were compared between plots in a site and between sites by trapping method; i.e., funnel traps versus window traps. Non-normality was corrected for all trap counts and window trap data that were transformed by $\log_{10}(x+1)$ before analysis of variance (ANOVA), and if $P < 0.05$, comparison of means was calculated by the least significant difference (LSD) test (Zar 1984) by using SAS (SAS Institute 1990).

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[1] The use of tade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Results and Discussion

Wood borers and bark beetles were found inhabiting both disturbed and undisturbed sites of the white spruce ecosystem. Upland stands contained higher populations of cerambycids and buprestids 1 year after disturbance than flood-plain sites; however, there was no difference in beetle density between these sites 10 years after disturbance (table 2) even though the percentage of cover of white spruce decreased by 80 percent in clearcut sites and 35 percent in shelterwood sites (table 1). Flood-plain stands contained higher populations of scolytids than upland sites at 1, 5, and 10 years after disturbance. This difference can probably be attributed to a higher residual population of white spruce in the clearcut and shelterwood areas within the flood-plain sites compared to the upland sites (table 1). Logged spruce stands attract bark beetles and provide breeding sites in trees injured during logging and in recently cut stumps (Beckwith 1972, Beckwith and others 1977, Safranyik 1978).

One year after disturbance, significantly more cerambycids were caught in the fringe sites of upland stands than in other study sites in both upland and flood-plain stands (table 3). Shelterwood sites also contained high populations of cerambycids 1 year after disturbance; few cerambycids were caught, however, in the burned and clearcut sites of upland and flood-plain stands 1, 5, and 10 years after disturbance. The flood-plain shelterwood site had more cerambycids both 5 and 10 years after disturbance than any other upland or flood-plain site.

Most buprestids were caught in the fringe and burned sites 1 year after disturbance; however, high densities were also present in the upland shelterwood site after 1 year. Most sites had low populations of buprestids 5 and 10 years after disturbance in both upland and flood-plain stands. This information supports previous reports of the attraction of buprestids to forest fires and recently burned areas of boreal forests (Evans 1972, 1973; Parmelee 1941; Werner and Post 1985).

The number of scolytids trapped was highest in the undisturbed control site of the flood-plain stands 1 year after the other sites were disturbed (table 3). High numbers of scolytids also were caught in the upland and flood-plain fringe and clearcut sites 1 year after disturbance. Werner and Post (1985) also report high populations of wood borers and bark beetles in the fringe areas surrounding recently burned stands of white spruce in interior Alaska. Burned sites had the lowest populations of scolytids throughout the study.

Semiochemical-baited traps caught more cerambycids, buprestids, and scolytids than window traps in all study sites (table 3). Window traps could have caught some beetles that were flying to semiochemical-baited traps because beetles respond directly to specific semiochemicals compared to being caught in window traps during random flight.

Twenty-eight species of cerambycids were caught in upland stands compared to 21 species in flood-plain stands (tables 4 and 5). Species of *Acmaeops, Anoplodera, Callidium, Gnathacmaeops, Neoclytus,* and *Xylotrechus* were caught only during the first year after disturbance; other species were caught at 1 year and either at 5 or 10 years after disturbance (tables 4 and 5). Nineteen species of cerambycids were caught in the undisturbed upland site compared with five species in the undisturbed flood-plain site. This difference can probably be attributed to the higher percentage of snow-damaged spruce on the undisturbed upland site. White spruce damaged by ice and snow is

Table 2—Mean (+ SEM) number of wood borers and bark beetles in upland and flood-plain stands of white spruce in interior Alaska in years 1, 5, and 10 postdisturbance

	Beetles caught[a]								
	Cerambycidae			Buprestidae			Scolytidae		
	Year			Year			Year		
Site	1	5	10	1	5	10	1	5	10
Upland	821 + 58a	274 + 25a	259 + 27a	735 + 60a	113 + 15a	125 + 17a	3,296 + 291b	1,408 + 119b	1,438 + 123b
Flood plain	414 + 33b	290 + 28b	283 + 24a	585 + 44b	137 + 16a	121 + 15a	6,208 + 442a	2,163 + 192a	1,974 + 174a

[a] Mean values within each column for each year followed by the same letter are not significantly different ($P < 0.05$) LSD test (Zar 1984).

Table 3—Mean (+ SEM) number of wood borers and bark beetles caught in semiochemical-baited traps and window traps in disturbed and undisturbed sites on upland and flood-plain stands of white spruce in interior Alaska

Years after disturbance	Site	Cerambycidae: Pheromone traps	Cerambycidae: Window traps	Cerambycidae: Total	Buprestidae: Pheromone traps	Buprestidae: Window traps	Buprestidae: Total	Scolytidae: Pheromone traps	Scolytidae: Window traps	Scolytidae: Total
		Beetles caught[a]								
1	Upland:									
	Burned	56 + 5d	36 + 3c	92 + 14d	134 + 15b	46 + 4b	180 + 18b	41 + 3g	15 + 2f	56 + 5f
	Fringe	322 + 31a	129 + 16a	451 + 41a	199 + 22a	72 + 7a	271 + 27a	876 + 65c	293 + 29b	1,169 + 134b
	Clearcut	55 + 4d	28 + 1c	83 + 9d	20 + 2d	11 + 1d	31 + 2d	841 + 60c	225 + 24c	1,066 + 113b
	Shelterwood	107 + 15c	30 + 2c	137 + 15c	152 + 19b	31 + 3b	183 + 20b	594 + 43d	151 + 16d	745 + 64c
	Control	37 + 2d	21 + 2c	58 + 4d	45 + 3d	25 + 3c	70 + 8c	215 + 31e	45 + 3e	260 + 25e
	Flood plain:									
	Burned	59 + 6d	28 + 2c	87 + 12d	111 + 13c	84 + 9a	195 + 21b	67 + 7f	32 + 2e	99 + 11e
	Fringe	221 + 25b	89 + 8b	310 + 28b	152 + 17b	62 + 5a	214 + 24a	1,575 + 121b	322 + 30b	1,897 + 179b
	Clearcut	27 + 4e	42 + 4c	69 + 6d	26 + 2d	11 + 1d	37 + 3d	899 + 73c	296 + 29b	1,195 + 130b
	Shelterwood	95 + 11c	29 + 3c	124 + 14c	85 + 10d	24 + 2c	109 + 12c	294 + 28e	97 + 14d	391 + 37d
	Control	88 + 9c	16 + 1d	104 + 11c	18 + 2e	12 + 1d	30 + 3c	2,139 + 187a	487 + 44a	2,626 + 223a
5	Upland:									
	Burned	7 + 1e	11 + 2d	18 + 2e	10 + 1e	7 + 1d	17 + 2e	16 + 2g	11 + 1f	27 + 3f
	Fringe	62 + 6d	24 + 2c	86 + 10d	13 + 1e	16 + 2d	29 + 3d	369 + 35e	123 + 18c	492 + 35d
	Clearcut	15 + 2e	9 + 1d	24 + 2e	8 + 1e	4 + 1d	12 + 1e	112 + 16f	76 + 10e	188 + 24e
	Shelterwood	43 + 4d	22 + 2c	65 + 5d	20 + 2d	11 + 1d	31 + 3d	194 + 23g	93 + 12d	287 + 28e
	Control	50 + 5d	31 + 3c	81 + 9d	15 + 2e	9 + 1d	24 + 2d	269 + 26e	145 + 19d	414 + 34d
	Flood plain:									
	Burned	10 + 1e	10 + 1d	20 + 2e	3 + 1e	0 + 0d	3 + 1e	22 + 3g	8 + 1f	30 + 3f
	Fringe	54 + 4d	31 + 3c	85 + 8d	15 + 2e	10 + 1d	25 + 3d	579 + 40d	231 + 26c	810 + 54c
	Clearcut	25 + 2e	13 + 1d	38 + 4e	24 + 2d	11 + 1d	35 + 4d	132 + 17f	67 + 7e	199 + 23e
	Shelterwood	67 + 6d	44 + 4c	111 + 12c	29 + 3d	14 + 1d	43 + 4d	156 + 19f	85 + 9d	241 + 25e
	Control	33 + 3d	21 + 2c	36 + 4e	20 + 2d	11 + 1d	31 + 3d	621 + 46d	262 + 29c	883 + 72c
10	Upland:									
	Burned	17 + 2e	20 + 2c	37 + 6e	11 + 1e	8 + 1d	19 + 2e	21 + 2g	14 + 1f	35 + 4f
	Fringe	32 + 4d	23 + 3c	55 + 5d	9 + 1e	8 + 1d	17 + 2e	327 + 31e	157 + 22d	484 + 38d
	Clearcut	24 + 3e	16 + 3d	40 + 4e	15 + 2e	5 + 1d	20 + 2e	99 + 13f	52 + 5e	151 + 22e
	Shelterwood	36 + 3d	26 + 3c	62 + 5d	14 + 2e	11 + 1d	25 + 3d	216 + 23e	98 + 11d	314 + 31d
	Control	41 + 5d	24 + 2c	65 + 6d	19 + 2e	25 + 3c	44 + 4d	301 + 27e	153 + 21d	454 + 38d
	Flood plain:									
	Burned	21 + 2e	13 + 1d	34 + 3e	6 + 1e	9 + 1d	15 + 2e	17 + 2g	9 + 1f	26 + 3f
	Fringe	42 + 4d	26 + 3c	68 + 7d	13 + 1e	5 + 1d	18 + 2e	425 + 35d	269 + 31c	694 + 51d
	Clearcut	31 + 3d	21 + 3c	52 + 6d	19 + 2e	7 + 1d	26 + 3d	123 + 16f	46 + 4e	169 + 21e
	Shelterwood	44 + 5d	26 + 4c	70 + 8d	21 + 2d	11 + 1d	32 + 4d	135 + 18f	53 + 4e	188 + 24e
	Control	37 + 4d	22 + 3c	59 + 5d	18 + 2e	12 + 1d	30 + 4d	562 + 39d	335 + 34b	897 + 77c

[a] Mean values within each column for each year followed by the same letter are not significantly different ($P < 0.05$) LSD test (Zar 1984).

highly attractive to wood borer and bark beetle attack 1 to 2 years after damage has occurred (Werner 1993). Werner and Post (1985) report the capture of *Monochamus scutellatus* and *Tetropium* spp. in the burned and fringe areas associated with a wildfire in interior Alaska. They also note that these species primarily attacked partially burned white spruce in these areas.

Twelve species of buprestids were caught in the upland sites and eight species in the flood-plain sites (tables 4 and 5). Fewer than 50 percent of these buprestids were caught in undisturbed upland and flood-plain sites (table 3), indicating that buprestids are attracted primarily to disturbed sites. All species of buprestids were caught either 1 or 5 years after disturbance in burned, fringe, clearcut, and shelterwood sites of both upland and flood-plain stands. Werner and Post (1985) found *Oxypteris acuminata* and *Melanophila drummondi* feeding in the roots and lower portions of the trunk of partially burned white spruce in upland stands.

Twenty species of scolytids were found in upland sites and 21 species in flood-plain sites (tables 6 and 7). Nineteen species were found in undisturbed control sites of both upland and flood-plain stands. This is fewer than the 27 species caught in semiochemical-baited traps and trap trees in undisturbed sites in the Fairbanks area (Werner and Holsten 1984). Fewer species were caught in burned sites than in fringe, clearcut, shelterwood, and control sites. Species of *Dendroctonus, Dryocoetes, Ips, Orthotomicus, Scierus, Scolytus,* and *Trypodendrum* were caught in burned sites 1 year after disturbance. Werner and Post (1985) report *Dendroctonus rufipennis, Ips* spp*.,* and *T. lineatum* as the major scolytids in burned and fringe sites following disturbance. Beckwith (1972) reports that *Dryocoetes affaber* and *Ips* spp. accounted for 80 percent of the scolytids collected in window traps in thinned stands of upland white spruce in the Fairbanks area. He also found *Scolytus piceae* only in thinned stands, whereas it was found in all sites in this study. In this study, *Ips perturbatus* was caught in greater numbers than other species in all study sites.

Fire removes most host trees that normally would be inhabited by scolytid and cerambycid beetles, but the scorched trees provide excellent habitat for buprestid species the first year after burning. The effects of fire are long-lasting, and few bark and wood-boring beetles are found inhabiting burned areas 5 and 10 years after the initial disturbance because burned spruce ecosystems usually are replaced by hardwood species. The effects of fire, however, are beneficial in providing habitat for populations of cerambycids and scolytids in the fringe areas surrounding the severely burned areas. Partially burned trunks and roots of spruce are intensively infested with these beetles during the first year of burning and, up to 15 years after burning, continue to maintain high populations of scolytids, but not buprestids or cerambycids. The effects of timber harvest are notable in clearcut areas where populations of wood borers are significantly reduced but where populations of scolytids increase the first year after logging. Shelterwood areas provide increased habitat for wood borers and scolytids for 1 year after logging, but populations decline thereafter. Both types of disturbance provide habitats that attract wood borers and bark beetles the first year after the disturbance, but populations then decrease to levels below those in undisturbed sites.

Table 4—List of wood borers caught in upland white spruce sites by years after disturbance

Families and species	Host	Years after disturbance				
		Burned	Fringe	Clearcut	Shelterwood	Control
Cerambycidae:						
Acmaeops pratensis Laichartig	*Picea*		1	1	1	
Acmaeops proteus proteus (Kirby)	*Picea*		1	1	1	
Anoplodera canadensis (Olivier)	*Picea*		1	1	1	
Arhopalus productus (LeConte)	*Picea*	1	1		1, 5	1, 5
Callidium cicatricosum Mannerheim	*Picea*		1, 5	1, 5	1, 5	1, 5, 10
Dorcasta sp.	*Picea*			1, 5	1, 5	1, 5, 10
Evodinus monticola vancouveri Casey	*Populus*					1, 5, 10
Gnathacmaeops pratensis (Laichartig)	*Picea*		1, 5	1, 5		1, 5, 10
Grammoptera subargentata (Kirby)	*Populus*				1, 5	1, 5, 10
Judolia montivagans montivagans (Couper)	*Picea*				1, 5	1, 5, 10
Leptura propinqua Bland	*Picea*					1, 5, 10
Meacanthocinus pusillus (Kirby)	*Picea*					1
Meriellum proteus (Kirby)	*Picea*	1	1		1, 5	
Monochamus scutellus (Say)	*Picea*	1	1, 5	1, 5	1, 5	1, 5, 10
Monochamus oregonensis LeConte	*Picea*			1	1, 5	1, 5, 10
Neoclytus muricatulus muricatulus (Kirby)	*Picea*			1	1, 5	1, 5, 10
Neacanthocinus pusillus Kirby	*Picea*					1, 5
Pachyta lamed (L.)	*Picea*	1	1, 5			
Pachyta lamed liturata Kirby	*Picea*	1	1, 5			
Pogonocherus mixtus Haldeman	*Picea*				1, 5	1, 5, 10
Pogonocherus penicillatus LeConte	*Picea*			1	1, 5	1, 5, 10
Pronocera collaris (Kirby)	*Picea*			1	1, 5	1, 5, 10
Pronocera collaris collaris (Kirby)	*Picea*			1	1, 5	1, 5, 10
Phymatodes dimidiatus (Kirby)	*Picea*	1	1, 5	1	1, 5	
Semanotus litigious (Casey)	*Picea*	1	1	1	1	
Tetropium cinnamopterum parvulum Casey	*Picea*		1, 5	1	1, 5	
Trachysida asperda asperda (LeConte)	*Picea*				1, 5	1, 5, 10
Xylotrechus undulatus (Say)	*Picea*		1, 5	1, 5	1, 5	1, 5, 10
Buprestidae:						
Agrilus anxius Gory	*Betula*				1, 5	1, 5, 10
Agrilus politus (Say)	*Salix*				1, 5	1, 5, 10
Anthaxia inornata (Randall)	*Picea*			1	1	
Anthaxia retifer LeConte	*Picea*		1	1	1	
Buprestis nuttalli Kirby	*Picea*			1, 5	1, 5	
Chrysobothris trinervia (Kirby)	*Picea*			1	1, 5	1, 5, 10
Dicera callosa callosa Casey	*Populus*			1, 5	1, 5	1, 5, 10
Dicera tenebrica Kirby	*Populus*				1, 5	1, 5, 10
Dicera tenebrosa Kirby	*Picea*		1, 5	1, 5	1, 5	1, 5, 10
Melanophila drummondi (Kirby)	*Picea*		1, 5	1, 5	1, 5	
Melanophila fulvoguttata (Harris)	*Picea*			1, 5	1, 5	
Oxypteris acuminata (De Geer)	*Picea*	1	1, 5	1		

Table 5—List of wood borers caught in flood-plain white spruce sites by years after disturbance

		Years after disturbance				
Families and species	Host	Burned	Fringe	Clearcut	Shelterwood	Control
Cerambycidae:						
Acmaeops pratensis Laichartig	*Picea*		1	1	1	
Acmaeops proteus proteus (Kirby)	*Picea*		1	1	1	
Anoplodera canadensis (Olivier)	*Picea*		1	1	1	
Arhopalus productus (LeConte)	*Picea*		1, 5		1, 5	
Callidium cicatricosum Mannerheim	*Picea*		1	1	1	
Gnathacmaeops pratensis (Laichartig)	*Picea*		1	1		
Meriellum proteus (Kirby)	*Picea*	1	1, 5		1, 5	
Monochamus scutellus (Say)	*Picea*	1	1, 5, 10	1, 5, 10	1, 5, 10	1, 5, 10
Monochamus oregonensis LeConte	*Picea*			1, 5	1, 5	
Neoclytus muricatulus muricatulus (Kirby)	*Larix*			1	1	
Pachyta lamed (L.)	*Picea*	1	1, 5			
Pachyta lamed liturata Kirby	*Picea*	1	1, 5			
Pogonocherus mixtus Haldeman	*Larix*				1, 5	1, 5, 10
Pogonocherus penicillatus LeConte	*Larix*				1, 5	1, 5, 10
Pronocera collaris (Kirby)	*Picea*					1, 5, 10
Pronocera collaris collaris (Kirby)	*Picea*				1, 5	1, 5, 10
Phymatodes dimidiatus (Kirby)	*Picea*		1, 5	1, 5	1, 5	
Semanotus litigious (Casey)	*Larix*	1	1, 5	1, 5	1, 5	
Tetropium cinnamopterum parvulum Casey	*Picea*		1, 5	1, 5	1, 5	
Tetropium velutinum LeConte	*Larix*	1	1, 5	1, 5	1, 5	
Xylotrechus undulatus (Say)	*Picea*		1	1	1	
Buprestidae:						
Agrilus politus (Say)	*Salix*			1, 5	1, 5	1, 5
Anthaxia inornata (Randall)	*Picea*		1	1	1	
Buprestis nuttalli Kirby	*Picea*	1	1	1, 5	1, 5	
Chrysobothris trinervia (Kirby)	*Picea*		1	1, 5	1, 5	
Dicera tenebrosa Kirby	*Picea*		1, 5	1, 5	1, 5	1, 5, 10
Melanophila drummondi (Kirby)	*Picea*		1, 5	1, 5	1, 5	
Melanophila fulvoguttata (Harris)	*Picea*			1, 5	1, 5	
Oxypteris accuminata (De Geer)	*Picea*	1	1, 5	1, 5		

Table 6—List of scolytid bark beetles caught in upland white spruce sites by years after disturbance

Species	Host	Years after disturbance				
		Burned	Fringe	Clearcut	Shelterwood	Control
Carphoborus andersoni Swaine	*Picea*				1, 5, 10	1, 5, 10
Carphoborus carri Swaine	*Picea*				1, 5, 10	1, 5, 10
Cryphalus ruficollis ruficollis Hopkins	*Picea*				1	1, 5, 10
Crypturgus borealis Swaine	*Picea*			1	1	1, 5, 10
Dendroctonus rufipennis (Kirby)	*Picea*	1	1, 5	1, 5	1, 5, 10	1, 5, 10
Dendroctonus simplex LeConte	*Picea*		1, 5	1	1	
Dryocoetes affaber (Mannerheim)	*Picea*	1	1, 5, 10	1, 5	1, 5, 10	1, 5, 10
Dryocoetes autographus (Ratzeburg)	*Picea*	1	1, 5, 10	1	1, 5, 10	1, 5, 10
Ips borealis borealis Swaine	*Picea*	1	1, 5	1	1, 5, 10	1, 5, 10
Ips perturbatus (Eichhoff)	*Picea*	1	1, 5	1, 5	1, 5, 10	1, 5, 10
Ips tridens tridens (Mannerheim)	*Picea*		1	1	1, 5, 10	1, 5, 10
Orthotomicus caelatus (Eichhoff)	*Picea*	1	1	1, 5	1, 5, 10	1, 5, 10
Phloeosinus pini Swaine	*Picea*					1, 5, 10
Phloeotribus picea Swaine	*Picea*					1, 5, 10
Pityophthorus spp.	*Picea*	1	1, 5	1	1, 5	1, 5, 10
Polygraphus rufipennis (Kirby)	*Picea*		1, 5	1, 5	1, 5, 10	1, 5, 10
Scierus annectans LeConte	*Picea*	1	1, 5	1, 5	1, 5	1, 5, 10
Scolytus piceae (Swaine)	*Picea*	1	1, 5, 10	1, 5, 10	1, 5, 10	1, 5, 10
Trypodendrum lineatum (Olivier)	*Picea*		1, 5, 10	1, 5, 10	1, 5, 10	1, 5, 10
Xylechinus montanus Blackman	*Picea*		1	1	1, 5	1, 5, 10

Table 7—List of scolytid bark beetles caught in flood-plain white spruce sites by years after disturbance

		Years after disturbance				
Species	**Host**	**Burned**	**Fringe**	**Clearcut**	**Shelterwood**	**Control**
Carphoborus carri Swaine	*Picea*		1, 5			1, 5, 10
Carphoborus intermedius Wood	*Picea*		1			1, 5
Cryphalus ruficollis ruficollis Hopkins	*Picea*		1	1		1, 5
Crypturgus borealis Swaine	*Picea*		1	1, 5		1, 5, 10
Dendroctonus rufipennis (Kirby)	*Picea*	1	1, 5	1, 5	1	1, 5, 10
Dendroctonus simplex LeConte	*Picea*	1	1, 5, 10	1, 5	1, 5, 10	1, 5, 10
Dryocoetes affaber (Mannerheim)	*Picea*	1	1, 5, 10	1, 5	1, 5, 10	1, 5, 10
Dryocoetes autographus (Ratzeburg)	*Picea*		1, 5, 10	1, 5	1, 5, 10	1, 5, 10
Ips borealis borealis Swaine	*Picea*		1, 5, 10	1	1, 5, 10	1, 5, 10
Ips perturbatus (Eichhoff)	*Picea*	1	1, 5, 10	1, 5	1, 5, 10	1, 5, 10
Ips tridens tridens (Mannerheim)	*Picea*		1	1	1, 5, 10	1, 5, 10
Orthotomicus caelatus (Eichhoff)	*Picea*	1	1	1	1	1, 5, 10
Phloeosinus pini Swaine	*Picea*			1		
Phloeotribus picea Swaine	*Picea*					1, 5, 10
Pityophthorus spp.	*Picea*		1	1, 5		1, 5, 10
Polygraphus convexifrons Wood	*Picea*			1		
Polygraphus rufipennis (Kirby)	*Picea*		1, 5, 10	1, 5	1, 5	1, 5, 10
Scierus annectans LeConte	*Picea*	1	1	1		1, 5, 10
Scolytus piceae (Swaine)	*Picea*		1, 5, 10	1, 5, 10	1, 5, 10	1, 5, 10
Trypodendrum lineatum (Olivier)	*Picea*	1	1, 5, 10	1, 5	1, 5	1, 5, 10
Trypodendrum retusum (LeConte)	*Picea*				1	1, 5, 10

Conclusions

This study indicates that various disturbances of white spruce ecosystems in interior Alaska have a direct impact on the diversity of species of wood borer and scolytid bark beetles occurring in disturbed areas. Silvicultural practices such as clearcut and shelterwood harvest provide habitat for wood borers and bark beetles that inhabit logging slash and weakened residual trees. Likewise, the fringe areas of prescribed fire or wildfire provide host trees susceptible to bark beetle and cerambycid attack because of reduced resistance of the host tree caused by damage from smoke and heat.

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English Equivalents

When you know:	Multiply by:	To find:
Celsius (°C)	1.8 and add 32	Fahrenheit
Centimeters (cm)	2.54	Inches
Hectares (ha)	2.47	Acres
Kilometers (km)	0.621	Miles
Meters (m)	3.281	Feet
Millimeters (mm)	0.254	Inches

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