

1 Running head: Leave Islands as Habitat

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3 **Biodiversity in Western Oregon Managed Forests:**
4 **Leave Islands as Habitat for Species Assemblages**

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1 *Abstract.* Both leave islands, or green tree retention clusters, and thinning prescriptions have
2 been proposed as alternative silvicultural strategies designed to sustain the structural and
3 biological diversity of managed forests. However, the relationship of the physical structure of
4 leave islands and thinned forests to their associated microclimates, flora, and fauna remains
5 largely unknown. We evaluated habitat and biota after forest thinning from 600 to 200 trees per
6 hectare with three sizes of leave islands. Specifically, we used analysis of variance, species
7 occupancy pattern assessments, and community analysis methods to examine differences in
8 habitat and vascular plant, arthropod, amphibian, and mollusk abundance and diversity with
9 respect to thinning and leave island size in four, 50-70 year-old managed forest stands in western
10 Oregon, USA. We found multiple treatment effects of thinning and leave island size relative to
11 microclimate and vascular plant diversity and ground cover. The microclimate and vascular plant
12 species composition differed between thinned and unthinned forest while conditions within leave
13 islands approximated conditions in unthinned forest. For vascular plants, proportions of exotic
14 and early-successional species and species ground cover were higher in thinned forest than
15 unthinned forest and higher in small leave islands than larger leave islands. Treatment effects on
16 arthropod, amphibian, and mollusk density were mixed. Indicator species analyses identified
17 seven vascular plant and two arthropod species indicative of thinned forest, 0.2 ha and 0.4 ha
18 leave islands. Species occupancy pattern assessments highlighted the potential utility of
19 managing the forest matrix for habitat heterogeneity with 71 (19%) taxa occurring only in leave
20 islands and 139 (37%) taxa occurring only in leave islands and unthinned forest. Finally,
21 community analyses results highlighted the importance of addressing multiple spatial scales in
22 forest management prescriptions by identifying distinct biotic assemblages occurring at forest
23 type, study site, and mountain range scales. Our results suggest that leave islands may provide

1 refugia for some low-mobility, ecologically sensitive species in managed forests of the Pacific
2 Northwest, USA.

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4 ***Key words:* amphibians; arthropods; biodiversity; ecosystem management; green tree**
5 **retention; leave islands; managed forests; microclimate; mollusks; Pacific Northwest, USA;**
6 **variable retention; vascular plants**

INTRODUCTION

1
2 Forest management in the 21st century has undergone a paradigm shift away from a focus on
3 resource extraction towards the broader, all-inclusive approach of ecosystem management and
4 environmental sustainability (Kessler et al. 1992; Swanson and Franklin 1992; Grumbine 1994;
5 Christensen et al. 1996). Conceptually, ecosystem management recognizes the complexity and
6 interconnectedness of natural systems while acknowledging the social value of the intrinsic
7 commodity resources. Thus, forest ecosystem management and sustainability involve a
8 precarious balance between maintaining ecosystem functions, processes, and biota and providing
9 a constant source of wood production (Lélé and Norgaard 1996; Tappeiner et al. 1997a; Carey
10 1998).

11 Forest managers have a myriad of silvicultural methods for integrating and sustaining these
12 diverse forest resource objectives during timber harvest, including uneven-aged strategies such
13 as partial cutting and structural retention (e.g., Lindenmayer and Franklin 2002). These
14 management strategies represent a significant departure from traditional even-aged management
15 and its intensive timber harvesting methods such as clearcutting which removed entire stands
16 during harvest (Tappeiner et al. 1997a). New forest management strategies are notable in that
17 their focus is not only on what is removed during timber harvest but also on what is left behind
18 in the managed forest matrix (Lindenmayer and Franklin 2002).

19 Sustainable “matrix management” involves careful silvicultural prescriptions designed to
20 balance an array of management objectives, including maintaining habitat for biodiversity.
21 Crucial forest structures, conditions, and processes can be retained by uneven-aged management
22 techniques, variable retention harvest systems, extended rotations or cutting cycles, and
23 structural retention (USDA and USDI 1994; Franklin et al. 1997; Smith et al. 1997; Lindenmayer

1 and Franklin 2002) to benefit multiple species groups (e.g., Carey et al. 1999a, b). Green tree
2 retention within harvested forest stands is one such structural retention strategy designed to
3 maintain both floral and faunal components of native forests (Franklin and Spies 1991; Franklin
4 1993). Retained trees can be either spatially dispersed or aggregated (i.e., leave islands or patch
5 reserves).

6 Thinning to result in spatially dispersed structures can have both positive and negative
7 effects on resident plant and animal species. Thinning can alter the abundance and composition
8 of multiple taxonomic groups, including amphibians (Dupuis 1995, 1997; Aubry 2000; Grialou
9 et al. 2000), arthropods (Spence et al. 1997; Lindo and Visser 2004), birds (Chambers et al.
10 1999), small mammals (Carey 2000), fungi (Amaranthus et al. 1990; O'Dell et al. 1992;
11 Amaranthus et al. 1994), lichens (Peterson and McCune 2001), and vascular plants (Bailey and
12 Tappeiner 1998; Bailey et al. 1998; Thysell and Carey 2001). Species associated with early-
13 successional or disturbed habitats may benefit from the structural changes and habitat conditions
14 produced by forest thinning, while adverse effects may be detected for taxa associated with late-
15 successional or undisturbed habitats. Maintaining the persistence of species adversely affected by
16 forest thinning may require special consideration during timber harvest.

17 Leave islands may be one such consideration to mitigate adverse effects of thinning because
18 such aggregated tree retention can perform multiple roles relative to species' habitat in managed
19 forests. First, legacy structural habitat features characteristic of mature forests can be preserved
20 within leave islands in harvested stands (Lindenmayer and Franklin 2002). Such features include
21 large dead wood, wolf trees, minority tree species, and complex forest structure (Franklin et al.
22 1981). Plant and animal species from multiple taxonomic groups are strongly associated with
23 these mature forest structures (Marcot 1997), including arthropods (Parsons et al. 1991;

1 Heyborne et al. 2003), amphibians (Pough et al. 1987; Carey 1989; Petranka et al. 1993;
2 Blaustein et al. 1995; Petranka 1998), mollusks (Schumacher 1999; USDI 1999a), mammals
3 (Carey 1989), birds (Carey 1989), fungi (Luoma 1988; Colgan et al. 1999), bryophytes (Lesica et
4 al. 1991), lichens (Lesica et al. 1991; Neitlich and McCune 1997; Peck and McCune 1997), and
5 vascular plants (Halpern 1988, 1989; Halpern and Spies 1995; Jules 1998; Halpern and
6 McKenzie 2001). Second, leave islands also may ameliorate microclimate changes resulting
7 from timber harvest and maintain forest interior conditions, including light, moisture,
8 temperature, and humidity regimes (Barnes et al. 1998). Maintaining pockets of forest interior
9 conditions within a managed forest matrix might prevent extirpation of forest-associated species,
10 including those with ties to mature and old-growth forests. Leave islands may function as species
11 lifeboats in remnant habitats or as stepping stones for dispersal by providing connectivity
12 (Franklin et al. 1997; Lindenmayer and Franklin 2002). The lifeboat role of reserved habitat
13 patches may apply particularly to low mobility taxa or taxa sensitive to fine-grained habitat
14 gradients. Species with limited capacity for movement or with extreme physiological limitations
15 might be incapable of dispersing across an inhospitable harvested forest matrix (Gibbs 1998a and
16 1998b; Lindenmayer and Franklin 2002).

17 The value of retaining both spatially dispersed and aggregated green trees has come to the
18 forefront of forest management in the U.S. Pacific Northwest's Douglas-fir region as persistence
19 of rare species has been integrated into forest management plans. Many of these species are
20 sensitive to the physical disturbance and resulting habitat alterations associated with timber
21 harvest. While traditional management approaches centered on intensive forestry practices
22 designed to maximize wood production and timber harvest, the 1994 Northwest Forest Plan
23 introduced an ecosystem management approach on nearly 10 million hectares of federal forest

1 lands (USDA 1993; USDA and USDI 1994). Central to the Northwest Forest Plan was the
2 allocation of 80% of the federal land base to forest reserves. This management approach
3 represented a major paradigm shift from one dominated by timber production to one
4 emphasizing long-term forest sustainability. However, fine-scale strategies to retain multiple
5 forest resources including a diverse biota were applied to federal lands designated for
6 regeneration timber harvests. Biota with limited distributions and dispersal capabilities were a
7 particular concern. Rare old-forest dependent taxa such as fungi, lichens, bryophytes, vascular
8 plants, terrestrial mollusks, amphibians, and arthropods were not well-protected by large reserves
9 that were not coincident with the species' patchy occurrences (USDA and USDI 1994, 2001). In
10 2003, 304 of these species remained of concern, 179 of which were known from less than 20
11 sites, and most of which could be characterized as relatively low mobility organisms (USDA and
12 USDI 2003). Strategies to maintain these rare species generally entailed the creation of protected
13 areas at species localities (e.g., protection buffer provisions [USDA and USDI 1994] or species
14 management recommendations [USDA and USDI 2003], often implemented by the creation of
15 leave islands 0.1 ha or greater in size. The role of small-scale leave islands for such taxa and
16 their habitats warrants investigation. Due to extensive forest thinning practices planned for the
17 young managed stands in this landscape over the next several decades, the value of leave islands
18 in thinned stands is a salient information need.

19 In a retrospective study, we examined the efficiency of combined dispersed and aggregated
20 green tree retention for species persistence in managed forests. Specifically, we investigated the
21 response of habitat conditions and multiple taxa to moderate thinning and to leave islands of
22 three sizes embedded in the thinned forest stands, ages 50-70 years. Habitat responses we
23 examined included measures of microclimate (relative humidity, ambient temperature, and soil

1 temperature) and forest structure (downed wood volume, canopy closure, trees per hectare, basal
2 area, and diameter at breast height). Taxa we examined included dispersal-limited species
3 potentially sensitive to changes in these habitat conditions: vascular plants, arthropods, terrestrial
4 amphibians, and terrestrial mollusks. We characterized the microclimate, forest stand structure,
5 and biota in five types of forest: unthinned forest, thinned forest and three sizes of circular leave
6 islands (0.1 ha, 0.2 ha, and 0.4 ha).

7 Our approach to examining treatment effects of thinning and leave island size was multi-
8 tiered. Using analysis of variance, we compared habitat and biota: 1) between thinned and
9 unthinned forest; 2) among all five forest types; and 3) among three sizes of leave islands. Due to
10 the species richness of vascular plants and arthropods, we also examined treatment effects on
11 functional groups in these two taxonomic groups (i.e., association with forest seral stage or
12 feeding groups). Using indicator species analysis and blocked multi-response permutation
13 procedure analyses, we examined whether species assemblages were associated with each of the
14 forest types. To incorporate rare species into our assessment, we examined species occurrences
15 in the five forest types, tallying species richness of those only occurring in either thinned or
16 unthinned forest types.

17 In addition, we examined vascular plant, arthropod, amphibian, and mollusk assemblages
18 using multivariate community analysis methods to identify the primary environmental variables
19 structuring these communities. We expected many plants and arthropods associated with early
20 seral conditions to respond positively to the predicted increase in light and temperature in the
21 thinned forest. Conversely, we expected many arthropod, amphibian, and mollusk species
22 associated with late-seral or interior forest conditions to respond negatively to thinning and
23 positively to areas of contiguous forest.

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METHODS

Study Sites

We conducted our study in the Coast and Cascade Ranges of northwestern Oregon within the *Tsuga heterophylla* (western hemlock) vegetation zone (Franklin and Dyrness 1988). The maritime climate is relatively wet and mild with widely variable conditions depending on latitude, elevation, and location relative to mountain ranges (Franklin and Dyrness 1988). Annual precipitation occurs primarily during winter and averages 150-300 cm.

Four study sites were chosen from among the seven sites implemented for the U.S. Department of Interior Bureau of Land Management Density Management Study (Tappeiner et al. 1997b; Olson et al. 2002; Cissel et al. 2004). The Density Management Study was designed to examine alternative forest thinning treatments to accelerate late-successional habitat development while simultaneously generating timber for income. These four naturally-regenerated, 50-70 year-old stands were thinned between 1997 and 2000 according to silvicultural prescriptions that controlled for size, density, and configuration of forest treatments (Cissel et al. 2004). Each of these sites included unthinned controls (approximately 600 trees per hectare [tph]) and areas thinned to a moderate density, 200 tph. This density has been considered as an operational thinning prescription for these sites. Leave islands of three sizes (0.1, 0.2, and 0.4 hectare [ha]) were created within the 200 tph thinned area. Leave islands were not located randomly but were instead fit into available openings and were often placed over legacy forest elements (e.g., wolf trees, hardwood trees) or over known locations of species diversity (i.e., lichen species).

1 Site selection was not random but was based on two main criteria: 1) accurate
2 implementation of 200 tph thinning treatments (i.e. thinned to less than or more than 200 tph)
3 and 2) availability of all three leave island sizes in the 200 tph thinning treatment. The four study
4 sites were managed by the Salem and Eugene BLM Districts and included Bottomline
5 (43°46'20" N, 123°14'11"W) and Green Peak (44°22'00"N, 123°27'30" W) in the Coast Range,
6 and Delph Creek (45°15'56"N, 122°9'33" W) and Keel Mountain (44°31'41" N, 122°37'55" W)
7 in the Cascade Range (Figure 1). We examined five types of forest: unthinned forest (600 tph),
8 moderately-thinned forest (200 tph), and three sizes of circular leave islands (0.1, 0.2, and 0.4
9 ha) embedded within the moderately-thinned forest. Three replicates (study units) of each type of
10 forest were randomly selected at each of the four study sites (n = 60 study units).

11

12 **Data Collection**

13 Data for habitat and biota were collected within a 20 x 20 m sampling area established at the
14 center of each study unit (Figure 2). Each sampling area was comprised of four 100 m² (5 x 20
15 m) parallel transects, with transects aligned upslope. Habitat data corresponding to each study
16 unit included geographic position (elevation, latitude, mountain range), topography (slope,
17 aspect), forest stand structure, microclimate, heat load index (McCune and Keon 2002), soil
18 moisture, substrate, and downed wood volume. Biotic data included abundance and diversity
19 measures for vascular plants, arthropods, terrestrial amphibians, and terrestrial mollusks.

20 Forest stand structure data for each sampling unit included canopy closure (percentage of 20
21 sampling points, five sampling points per transect using a vertical densitometer) and tree
22 diameter at breast height (dbh; cm) for all trees in each sampling unit. We used these data to
23 compute tree density (trees per hectare; tph) and basal area per ha (conifers and hardwoods;

1 m²/ha) per sampling unit. Microclimate data were collected during both spring and summer
2 sampling seasons using automated data loggers (A.R. Harris GPSE Ltd. brand) to record ambient
3 temperature, soil temperature, and relative humidity. One data logger was placed at the center of
4 each study unit for a 10-day period in the spring during amphibian and mollusk sampling and in
5 the summer during arthropod sampling. Data were collected simultaneously at all study units at a
6 study site. We used input variables of slope, aspect, and latitude to derive an index of heat load
7 for each study unit with the following equation: $heat\ load\ index = \frac{1 - \cos(\Theta - 45)}{2}$ where $\Theta =$
8 aspect in degrees east of north (McCune and Keon 2002). This index ranges from 0 (coolest,
9 northeast slope) to 1 (warmest, southwest slope). We measured soil moisture during both spring
10 and summer sampling seasons by taking four samples of mineral soil from each study unit. Soil
11 samples weighing approximately 60 g were taken at 10 cm depth and 2 m from the center of each
12 sampling area in the direction of each sampling area corner. Soil moisture was determined using
13 gravimetry with oven-drying in which each wet soil sample was weighed, dried in a 105°C oven,
14 then re-weighed (Reynolds 1970a and 1970b). The gravimetric moisture content, or wetness (w),
15 was then calculated using the equation: $w = \frac{(soil\ mass_{wet} - soil\ mass_{dry})}{soil\ mass_{dry}}$. We used these four
16 calculated w values to derive an average soil moisture value for each sampling unit.

17 Forest floor substrate was assessed in four 5 x 5 m sampling plots within two nonadjacent
18 transects that were randomly chosen (n = eight per study site per study unit). We recorded the
19 percent cover class (1-5%, 6-33%, 34-66%, and 67-100%) for each of 14 ground substrate
20 categories, including total herbaceous cover (less than 10 cm in height), total shrub cover
21 (greater than 10 cm in height), total moss cover, fallen epiphyte, intact stump or snag, decayed
22 stump or snag, live tree bole, small (less than 5 cm diameter) or decomposed litter (including

1 bark chip piles), intact coarse downed wood (greater than 5 cm diameter), decayed coarse
2 downed wood (greater than 5 cm diameter), riparian or aquatic influence, exposed rock (rock
3 greater than 7 cm diameter), exposed mineral soil, and other atypical substrates (e.g. deep
4 concavity in ground, locally steep slope, root wad clump). Downed wood was classified by
5 increasing degree of decay; decay classes 1 and 2 were defined as intact while decay classes 3, 4,
6 and 5 were defined as decayed (after Maser et al. 1979; Maser et al. 1988). We computed the
7 average ground cover for each of the 14 substrate categories using the assessments from the four
8 sampling plots within each study unit.

9 Down wood surveys recorded pieces of dead and down wood within each of two
10 nonadjacent transects per sampling area. Tallies of wood pieces measuring at least 1 m in length
11 and 10 cm in diameter were recorded by type of piece (log, stump, snag, or rootwad), midpoint
12 diameter, length (logs and rootwads) or height (stumps and snags), species, and decay class
13 (Maser et al. 1979; Maser et al. 1988). Pieces of wood were recorded only if at least one-half (at
14 least 0.5 m of length for logs and rootwads, at least 5 cm of diameter for stumps and snags) was
15 contained within the sampled transect. Surveyors made visual estimates of the diameter and
16 length or height of four pieces of downed wood then measured the diameter and length or height
17 of every fifth piece of downed wood. These validation measurements were then used to compute
18 a correction factor for each surveyor by comparing the surveyor's estimated dimensions with the
19 measured dimensions for each fifth piece of wood (Hankin and Reeves 1988). This correction
20 factor was used to adjust the dimensions of the visually estimated downed wood. These
21 dimensions were then used to compute the estimated volume (m^3) of downed wood within each
22 transect. We used this computed volume to calculate the estimated density (m^3/m^2) of downed
23 wood per transect. These estimates were used in subsequent statistical analyses.

1 We conducted vascular plant sampling in two randomly assigned, nonadjacent transects,
2 using a modified Daubenmire cover class method during summer 2001 (Daubenmire 1959;
3 USDI 1998). Along each vascular plant transect, eight rectangular quadrats were established
4 using 2.5 x 5 m sampling frames. All vascular plants observed within each quadrat were
5 identified to species (Hitchcock and Cronquist 1973; Halse, pers. comm.). For each species, we
6 recorded percent ground cover class (1-5%, 6-33%, 34-66%, or 67-100%). Each plant species
7 was then categorized within three sets of functional groups, including plant origin (native or
8 exotic), seral class (early- or late-successional), and vertical stratum (herb, shrub, or tree; USDA
9 NRCS 2004; Pabst, pers. comm.; Vance, pers. comm.).

10 Arthropods were sampled by collecting five, circular, 1m² samples of all forest floor litter
11 and the top 1 cm of forest soil from each sampling area during summer 2002. One sample was
12 taken from the center of each study unit and additional samples were taken 5 m from the center
13 in the direction of each sampling area corner. Arthropods were extracted from litter samples
14 using Berlese-Tullgren funnels (Brydon and Fuller 1966), then identified to the finest possible
15 taxonomic level (Parsons et al. 1991; Arnett 2000; Moldenke, pers. comm.). Each arthropod
16 taxon was then categorized within three sets of functional groups, including mobility classes
17 (low, medium, or high), associations with forest seral stage (early- or late-successional), and
18 feeding groups (plant sucker, plant chewer, shredder, fungivore, detritivore, xylovore,
19 micropredator, macropredator, parasitoid, cadaver feeder, dung feeder, and unknown; Parsons et
20 al. 1991; Moldenke, pers. comm.).

21 Amphibian and mollusk sampling was conducted on the remaining two nonadjacent
22 transects in each sampling area. We used garden claws to search all substrate and cover objects
23 within two 5 x 20 m belt transects per sampling area during spring 2002. Substrate was searched

1 to a depth of 3-5 cm. Captures were identified to species (amphibians: Leonard et al. 1993,
2 Heyer et al. 1994, Corkran and Thoms 1996, USDI 1999b; mollusks: Schumacher 1999, USDI
3 1999a, Hohenlohe, pers. comm.).

4

5 **Data Analyses**

6 *Treatment Effects of Thinning and Leave Islands-*

7 We used analysis of variance to test whether mean habitat or biotic measures differed
8 between and among forest types ($\alpha < 0.10$; SAS version 9.1, SAS Institute 2004). We applied the
9 Shapiro-Wilk statistic to test all data for normality. Data with unequal variances or non-normal
10 distributions were transformed using a natural log ($x + 1$) transformation (Ramsey and Schafer
11 2002). Measures that could not be adequately transformed were not analyzed. The statistical
12 design involved two treatments applied at each of the four study sites. The first, a forest density
13 treatment (hereafter, whole plot) had two levels: thinned and unthinned. These two levels were
14 the statistical “whole plots”. The second, a leave island treatment, was applied only within the
15 thinned whole plot and had three levels: 0.1 ha, 0.2 ha, and 0.4 ha leave islands. We used site as
16 a blocking factor for all analyses.

17 Our first research question examining treatment effects of thinning on habitat and biota was
18 analyzed as a randomized complete block design (PROC GLM procedure, SAS Institute 2004).
19 Treatment means were calculated using the three replicate sampling units of the thinned and
20 unthinned whole plots at each site with the comparison occurring at the whole plot level ($n = 8$).
21 We refer to the analysis of the second research question comparing habitat and biotic responses
22 among all five types of forest using a modified split-plot as an integrated analysis. Since this
23 study design involved a leave island treatment nested only within the thinned whole plot

1 treatment, the comparison among the three leave island sizes, thinned, and unthinned sampling
2 units occurred at the split-plot level ($n = 20$; PROC MIXED procedure, SAS Institute 2004).
3 Means were calculated using the three sampling units of each forest type. Finally, we conducted
4 a focused analysis of the treatment effect of leave island size analyzed as a generalized
5 randomized block design (PROC GLM procedure, SAS Institute 2004). This analysis compared
6 treatment means of the three sizes of leave islands nested within the thinned whole plot (3
7 replicates \times 3 leave islands sizes \times 4 sites; $n = 36$). For integrated and leave island analyses
8 indicating differences in at least two of the treatment means, pairwise comparisons were then
9 conducted to determine which pairs of treatment means were different ($\alpha = 0.10$). We used
10 Bonferroni adjusted p-values to account for multiple comparisons and to control experiment-
11 wise error.

12 These three statistical approaches differed in several ways. Each analysis used different
13 sample sizes, calculations of treatment means, and different subsets of the data as a result of tests
14 of normality. Further, the integrated analyses utilized a user-specified covariance matrix which
15 assigned a common correlation to all sampling units within the thinning treatment at each site.
16 Thus, neither the thinned-unthinned analysis nor the focused leave island analysis was redundant
17 to the integrated analysis because the underlying data differed. We compared concurrence of
18 results across analysis approaches to highlight differences in findings.

19 Microclimate analyses included comparing treatment means for average, minimum,
20 maximum, average daily minimum, average daily maximum, and range of relative humidity,
21 ambient temperature, and soil temperature (Chen et al. 1993). Additional habitat analyses
22 examined measures of soil moisture and measures of forest stand structure, including canopy
23 closure, trees per hectare, average diameter at breast height, and basal area per hectare.

1 Vascular plant analyses included measures of species richness, species diversity, and percent
2 ground cover for individual species and for the three sets of functional groups, including plant
3 origin, seral class, and stratum. Analyses for arthropods, amphibians, and mollusks compared
4 overall density, density of individual species and some species groups, and measures of species
5 richness and species diversity. For arthropods, we also compared treatment means for densities
6 of the three sets of functional groups, including mobility classes, associations with forest type,
7 and feeding groups.

8 Analyses of individual species were constrained by species abundances since most species
9 we censused were extremely rare (Appendices A and B). Occupancy varied across forest types
10 and study sites, restricting the analyses to the more common taxa. Individual arthropod,
11 amphibian, and mollusk species were selected for analysis by their abundance. Species with
12 more than 30 overall captures for fauna and more than 0.5% average ground cover for vascular
13 plant species were analyzed.

14

15 *Indicator Species Analyses-*

16 We used indicator species analysis (ISA) to characterize species assemblages characteristic
17 of each of the five types of forest. ISA describes how well each species differentiates among
18 groups (Dufrene and Legendre 1997). Indicator values (IV) are calculated for each species within
19 each group by combining information about the concentration of species abundance and
20 faithfulness of occurrence in a particular group. Indicator values range from zero (no indication)
21 to 100 (perfect indicator). A perfect indicator for a particular group is present in all sampling
22 units for the group and occurs exclusively in that group. ISA produces indicator values for all
23 species in a group based on the standards of a perfect indicator. The statistical significance of

1 indicator values was tested using a Monte Carlo randomization with 1000 permutations. All
2 species data (including common and rare species) was used in ISA analyses for each taxon. Taxa
3 not identified to the species level were collapsed to the genus or family level (hereafter, species
4 group), summed, then analyzed (Appendices A and B). All community analyses were conducted
5 using PC-ORD version 4.27 (McCune and Mefford 1999).

6 *Blocked Multi-Response Permutation Procedure Analyses-*

7 Blocked multi-response permutation procedure (MRBP) is a non-parametric technique
8 providing a multivariate test of differences between *a priori* groups (Mielke 1984; Mielke and
9 Berry 2001). After blocking by site, we used MRBP with a Euclidean distance measure to test
10 the null hypothesis of no community differences among the five groups of interest: unthinned
11 forest, thinned forest, and 0.1 ha, 0.2 ha, and 0.4 ha leave islands. All species data was used in
12 MRBP analyses for each taxon; thus, both common and rare taxa were incorporated in analyses.
13 Taxa not identified to the species level were collapsed to the genus or family level (hereafter,
14 species group), summed, then analyzed (Appendices A and B).

15

16 *Occupancy Patterns-*

17 Species occupancy within the five forest types also was assessed in order to gauge patterns
18 among all species sampled, including rare species not analyzed statistically. We tallied species
19 richness per taxon per forest type (Appendices A and B) and qualitatively compared: 1) species
20 occurring only in thinned forest; 2) species occurring only in thinned forest and leave islands; 3)
21 species occurring only in unthinned forest; 4) species occurring only in unthinned forest and
22 leave islands; 5) species occurring only in leave islands; and 6) species occurring in thinned,

1 unthinned, and leave island forest types. Insights into the value of habitat heterogeneity for rare
2 species might be gained if they were to occur in categories 2, 3, 4, 5, or 6.

3

4 *Community Analyses-*

5 We used non-metric multi-dimensional scaling (NMS) to ordinate sample units in species
6 space to provide a graphical representation of vascular plant, arthropod, amphibian, and mollusk
7 community relationships with environmental variables (Kruskal 1964; Mather 1976).
8 Correlations between ordination axes and environmental variables also were examined to
9 determine the important drivers of community structure and composition for each taxonomic
10 group (McCune and Grace 2002). We used the “slow-and-thorough” autopilot mode of NMS
11 with the Sørensen distance measure and random starting configurations. Final stress for the best
12 of 40 runs with real data was evaluated with a Monte Carlo test of significance using 50 runs
13 with randomized data to assess whether NMS was extracting stronger axes than expected by
14 chance alone. Final instability was assessed by examining scree plots showing stress versus
15 iteration number. Joint plot overlays were used to display environmental variables on the
16 ordination based on linear correlations (Pearson’s r) and rank correlations (Kendall’s tau) of the
17 variables with the ordination axes. The coefficient of determination between distances in the
18 ordination space and distances in the original n -dimensional space using Sørensen distances
19 represented the variance (r^2) accounted for by each ordination axis. Ordinations were then rigidly
20 rotated to maximize the loading of the strongest gradients in community variation on a single
21 axis.

22 We methodically and sequentially inspected all species and environmental data matrices
23 prior to conducting community analyses to determine if any data transformations were necessary.

1 Specifically, we log-transformed variables with skewness greater than one or ranging over an
2 order of magnitude, deleted rare species occurring in less than 5% of sample units, and deleted
3 outlying data points with standard deviations greater than 3.0 (McCune and Grace 2002). Such
4 data adjustments of community data matrices are often performed to improve statistical
5 assumptions of normality, linearity, or homogeneity of variance (McCune and Mefford 1999).
6 For the species data matrices, we deleted all rare species occurring in less than 5% of sample
7 units to reduce noise in the data set. Next, we log-transformed species data columns with a
8 skewness greater than 2.0 and/or order of magnitude difference between the minimum and
9 maximum values.

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RESULTS

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Forest stand structure and microclimate data showed a range of values across all sampling units. Elevation ranged between 290 and 756 m. Ground slope ranged from 0 to 54%. Canopy closure ranged from 20 to 100%. Average dbh ranged from 32.5 to 70.4 cm. Trees per hectare ranged from 74 to 744. Total basal area ranged from 12 to 84 m²/ha with conifer basal area ranging from 12 to 84 m²/ha and hardwood basal area ranging from 0 to 12 m²/ha. Downed wood density ranged from 0.0015 to 0.2573 m³/m². Microclimate data values ranged from 10.1 to 35.9°C for ambient temperature, from 14.5 to 21.5°C for soil temperature, and from 63 to 100% for relative humidity. Soil moisture data values ranged from 9.3 to 27.1%.

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23

We identified a total of 120 vascular plant species: 83 herbaceous species, eight subshrubs, 20 shrubs, and nine trees (Appendix A). Of these, 104 were native species, 12 were exotic, and four were of unknown origin. Finally, 62 were late-successional species, 57 were early-successional species, and one was unknown. *Polystichum munitum* (Western swordfern) was the

1 most abundant species and comprised 15.7% of all ground cover. Treatment effects were
2 examined for 26 vascular plant species (Figure 3a), two diversity measures, and measures of
3 percent ground cover within three functional groups (three stratum classes, two origin classes,
4 and two associations with forest successional stages; Table 1).

5 In soil litter samples, we captured 30,447 arthropods within 289 taxa (Appendix B).
6 *Geophilomorpha* (soil centipede) was the most abundant species group with 2,982 captures
7 (9.8% of captures). Treatment effects were examined for 80 arthropod species (Figure 3b), two
8 diversity measures, total arthropod density, and density within three functional groups (three
9 mobility classes, eleven feeding groups and two associations with forest condition; Table 1).

10 We captured 218 amphibians of seven species (Appendix B). *Ensatina eschscholtzii*
11 (*Ensatina*) was the most abundant species with 129 captures across all treatments (59.2% of
12 captures). Treatment effects were examined for three species (Figure 3c), the family
13 Plethodontidae, total amphibian density, and two diversity measures (Table 1).

14 We captured a total of 3,608 mollusks of 12 taxa (10 species and 2 species groups;
15 Appendix B). *Haplotrema vancouverense* (robust lancetooth) was the most abundant species
16 with 1,581 captures (43.8% of all captures). Treatment effects were examined for six species
17 (Figure 3d), snail, slug, and total mollusk density, and two diversity measures (Table 1).

18

19 *Treatment effects of thinning-*

20 Thinning effects were detected for 24 of 45 (53.3%) habitat measures analyzed when
21 comparing only thinned and unthinned forest ($p < 0.10$; Table 1). Specifically, seven of eleven
22 relative humidity, six of twelve ambient temperature, seven of twelve soil temperature, and four
23 of five forest structure analyses were significant (Table 1). These measures of microclimate and

1 habitat followed logical sequences of effects, with thinned forest consistently having higher
2 temperatures, lower relative humidity, and greater ranges of microclimate conditions than
3 unthinned forest. Treatment effects were not detected for any measures of soil moisture or
4 downed wood density.

5 Thinning effects were shown for 30 of 155 (19.4%) biotic measures analyzed (Table 1).
6 Almost half (21 of 43) of the plant analyses were significant, including two measures of
7 diversity, one measure of ground cover, six measures of successional status, three measures of
8 stratum, six measures of plant origin, and three species. Species richness, species diversity, and
9 overall ground cover tended to be greater in thinned forest. Thinned forest had higher
10 proportions of both early-successional and exotic species compared to unthinned forest while
11 conversely, unthinned forest had higher proportions of both late-successional and native species.
12 The three plant species with thinning effects had greater ground cover in the thinned forest units.

13 Seven of 97 (7.2%) arthropod analyses showed effects of thinning, including one mobility
14 measure and six species (Table 1). Densities of *Arctorthezia occidentalis*, *Myrmica*, and
15 *Pristoceuthophilus*, and the percentage of low-mobility species captures were higher in
16 unthinned forest than in thinned forest. Densities of *Cytilus alternatus*, *Steremnius carinatus*, and
17 Lygaeidae were higher in thinned forest than in unthinned forest. *Myrmica* density was the only
18 result that was not consistent with our predictions; we expected this disturbance-associated
19 species to be more abundant in the thinned forest matrix.

20 Five amphibian analyses examined two diversity and three density measures (Table 1).
21 Treatment effects were shown only for amphibian species richness, with richness of unthinned
22 forest (mean = 1.58; s.d. = 0.167; n = 8) exceeding that of thinned forest (mean = 1.17; s.d. =
23 0.167; n = 8).

1 Ten mollusk analyses examined two diversity measures and eight density measures (Table
2 1). Treatment effects were shown only for *H. vancouverense* density. Log-transformed densities
3 of this species were higher in unthinned forest (mean = 0.137; s.d. = 0.05; n = 8) than in thinned
4 forest (mean = 0.074; s.d. = 0.05; n = 8).

5
6 *Integrated analyses comparing all forest types-*

7 We found that the forest structure and microclimate of these managed second-growth forests
8 varied with thinning and leave island size (Table 1). Forest structure differences followed our
9 predictions for measures of canopy closure, trees per hectare, and basal area. Analyses did not
10 detect statistical differences in downed wood density among the five forest types. For
11 microclimate, measures of relative humidity, ambient temperature, and soil temperature varied
12 along a gradient according to intensity of harvest from thinned forest, small through large leave
13 islands, and unthinned forest. Microclimate conditions in 0.4 ha leave islands were most similar
14 to unthinned forest while conditions in 0.1 ha leave islands were closely aligned with thinned
15 forest. The 0.4 ha leave islands did not differ ($p > 0.10$) from unthinned controls for any
16 microclimate parameter examined, supporting our prediction that they best represent interior
17 habitat in comparison to the smaller leave islands in this thinning context. Treatment effects on
18 soil moisture were not evident for either sampling season.

19 Treatment effects were detected for 20 of 47 (42.6%) habitat measures analyzed (Table 1).
20 Seven of 12 relative humidity analyses, six of 12 ambient temperature analyses, four of 12 soil
21 temperature analyses, and three of six forest structure analyses were significant (Tables 1 and 2).
22 Specifically, these included spring and summer relative humidity and ambient temperature
23 measures, summer soil temperature, canopy closure, dbh, and trees per hectare. Direction of

1 effects followed logical sequences with thinned forest having the lowest relative humidity,
2 highest ambient and soil temperatures, lowest canopy closure, largest dbh, and fewest trees per
3 hectare (Table 2). Average daily ranges of conditions (difference between minimum and
4 maximum for microclimatic variables) were consistently greatest in thinned forest, progressively
5 less in 0.1 ha, 0.2 ha, and 0.4 ha leave islands, and smallest in unthinned forest. Conditions in
6 smaller leave islands (0.1 ha and 0.2 ha) were most similar to thinned forest while conditions in
7 the largest leave islands (0.4 ha) were most similar to unthinned forest (Table 2). Treatment
8 effects were not shown for any measures of soil moisture or downed wood density.

9 Results of the integrated analyses paralleled the thinned-unthinned comparisons for habitat;
10 for example, analyses of 17 parameters resulted in concurrence of significant differences
11 between thinned and unthinned forest (Table 1). However, seven analyses detected differences in
12 the thinned and unthinned analyses that were not also found by the integrated analyses.
13 Specifically, in the previous analyses, four measures were significantly greater in thinned forest
14 than unthinned forest, including measures of summer ambient temperature and spring and
15 summer soil temperature. Conversely, three measures were significantly greater in unthinned
16 forest than thinned forest, including summer relative humidity and measures of basal area/ha.

17 Of the 46 vascular plant measures examined (Table 1), 17 (37.0%) were significant ($p <$
18 0.10), including two diversity measures, six exotic and native species measures, six early- and
19 late-successional species measures, number of herbaceous species, and ground cover for two of
20 23 species investigated (Tables 1 and 2). As for the habitat results, these results displayed
21 consistent trends tracking the continuum of disturbance (e.g., thinned forest > 0.1 leave islands >
22 0.2 leave islands > 0.4 leave islands > unthinned forest and vice versa). The species composition
23 and types of ground cover differed greatly among forest types (Table 1). Species richness,

1 number of early-successional species, percent exotic species ground cover, and total exotic
2 species ground cover in thinned forest exceeded that of all other forest types (Table 1). Also in
3 thinned forest, Shannon diversity, number of herb species, percent early-successional species
4 ground cover, total early-successional species ground cover, percent early-successional species,
5 number of exotic species, percent exotic species, and *Poaceae* ground cover were greater than
6 that of unthinned forest and 0.2 ha and 0.4 ha leave islands but not different from 0.1 ha leave
7 islands. The percentage of late-successional species, number of late-successional species, and
8 percentage of native species were lower in thinned forest than in both 0.4 ha leave islands and in
9 unthinned forest.

10 As for habitat analyses, results of the integrated analyses of plants paralleled the thinned-
11 unthinned comparisons; for example, analyses of fifteen parameters resulted in concurrence of
12 significant differences between thinned and unthinned forest. However, six analyses detected
13 differences in the thinned and unthinned forest comparison that were not also found by the
14 integrated analyses. Specifically, the number of early-successional species and five measures of
15 ground cover were significantly greater in thinned forest than unthinned forest (Table 1). One
16 plant species, *Hypochaeris radicata* (hairy catsear), that did not meet normality assumptions
17 within the integrated analysis was found more commonly in the thinned units during the thinned-
18 unthinned comparison.

19 Treatment effects were evident for two of 77 (2.6%) arthropod analyses (Table 1), including
20 densities of immature Staphylinidae and *Geophilomorpha* (Tables 1 and 2). In particular, 0.4 ha
21 leave islands averaged higher immature Staphylinidae densities (n/m^2) than thinned forest, 0.1 ha
22 leave islands, and 0.2 ha leave islands. Similarly, 0.4 ha leave islands averaged higher

1 *Geophilomorpha* densities (n/m^2) than thinned forest and 0.1 ha leave islands while 0.2 ha leave
2 islands averaged higher *Geophilomorpha* densities (n/m^2) than 0.1 ha leave islands.

3 Twenty additional arthropod analyses were conducted with the thinned-unthinned
4 comparison than in the integrated analyses, thus allowing examination of additional species that
5 did not meet the normality assumptions within the integrated analysis approach. Seven of these
6 analyses detected differences between thinned and unthinned forest. Treatment means were
7 greater in thinned forest for three of these analyses and greater in unthinned forest for four of
8 these analyses (Tables 1 and 2). One arthropod species, *A. occidentalis*, did not meet normality
9 assumptions in the integrated analysis but was found to be less abundant in thinned units than
10 unthinned units in the thinned-unthinned analysis approach.

11 Six amphibian analyses examined two diversity measures and four density measures (Table
12 1). Treatment effects were shown for four of these analyses (66.7%), including amphibian
13 species richness and overall amphibian density, plethodontid salamander density, and *E.*
14 *eschsoltzii* density (Tables 1 and 2). Interestingly, the paucity of captures in 0.4 ha leave
15 islands and unthinned forest appeared to disrupt sequential patterns in amphibian densities
16 among forest types (Table 2). Specifically, pairwise comparisons indicated that 0.1 ha and 0.2 ha
17 leave islands averaged more amphibian species than 0.4 ha leave islands but the largest leave
18 islands averaged more amphibian species than unthinned forest. For total amphibian density, 0.1
19 ha leave islands averaged more amphibians/ m^2 than thinned forest and 0.4 ha leave islands while
20 0.2 ha leave islands averaged more amphibians/ m^2 than thinned forest and 0.4 ha leave islands.
21 Small leave islands averaged more plethodontids/ m^2 than thinned forest and 0.4 ha leave islands
22 while 0.2 ha leave islands averaged more plethodontids/ m^2 than thinned forest. Finally, for *E.*

1 *eschscholtzii* density, 0.1 ha leave islands averaged more *E. eschscholtzii* /m² than thinned forest.
2 These results supplemented previous findings comparing thinned and unthinned forest types.

3 Ten mollusk analyses examined two diversity measures and eight density measures (Table
4 1). No treatment effects were shown (Table 1). In contrast, treatment effects on *H.*
5 *vancouverense* density were shown in the previous thinned-unthinned analysis.

6

7 *Treatment effects of leave island sizes-*

8 Treatment effects were detected for 12 of 38 (31.6%) habitat measures analyzed (Table 1).
9 All six relative humidity analyses and six of 11 ambient temperature analyses were significant
10 (Table 1). Specifically, these included spring and summer relative humidity and ambient
11 temperature measures. Direction of effects followed expected sequences with relative humidity
12 increasing with increasing leave island size and ambient temperature increasing with decreasing
13 leave island size. Similarly, average daily ranges of conditions tended to be greatest in 0.1 ha
14 leave islands and progressively smaller in 0.2 ha and 0.4 ha leave islands. Treatment effects were
15 not evident for any measures of soil temperature, soil moisture, downed wood, or forest
16 structure.

17 Nine fewer habitat measures were examined using the leave island approach than the
18 integrated approach. Similar patterns emerged yet there was not complete concurrence between
19 the analyses for any parameter. Three measures not meeting normality assumptions within the
20 leave island approach were found to have treatment effects within the integrated analyses
21 (summer average daily minimum relative humidity, summer average daily maximum ambient
22 temperatures, and canopy closure).

1 Overall, leave island size showed an effect for 15 of 44 (34.1%) vascular plant analyses
2 (Table 1). Treatment effects were shown for one diversity measure, five successional status
3 measures, three measures of plant origin, and six species. Measures of diversity, exotic species,
4 and early-successional species were consistently greater in 0.1 ha leave islands and progressively
5 less in 0.2 ha and 0.4 ha leave islands. Results differed considerably between this analysis
6 approach and the integrated approach with no complete concurrence in results. This analysis
7 approach detected numerous differences among leave island sizes while the differences detected
8 by the integrated approach were primarily between thinned forest and other forest types.

9 Overall, 16 of 60 (26.7%) arthropod analyses showed effects of leave island size (Table 1).
10 Treatment effects were shown for overall arthropod density, two diversity measures, two forest
11 association measures, five mobility class measures, and six species. These measures tended to be
12 lowest in 0.1 ha leave islands and highest in 0.4 ha leave islands. In contrast, leave island size
13 mattered for only two arthropod parameters in the integrated analyses. Concurrence with the
14 integrated results occurred for these two results, which compared the densities of two individual
15 species.

16 Five amphibian analyses examined one diversity measure and four density measures (Table
17 1). Treatment effects were shown for amphibian species richness and *Batrachoseps wrighti*
18 (Oregon slender salamander) density (Table 1). Contrary to expectations, responses for both
19 measures were higher in 0.1 ha and 0.2 ha leave islands than 0.4 ha leave islands. This is the only
20 analysis approach where treatment effects were shown for *B. wrighti* (Table 1). Concurrence
21 with the integrated approach was found only for species richness.

22 Nine mollusk analyses examined two diversity measures and seven density measures (Table
23 1). Treatment effects were shown for five of these analyses (55.6%), including densities of all

1 mollusks, snails, and three species (Table 1). Densities were lowest in 0.1 ha leave islands for all
2 measures. Further, densities of two species were also lower in 0.1 ha leave islands than 0.2 ha
3 leave islands. Results from this analysis approach contrasted sharply with the integrated analysis
4 approach in which no treatment effects were found.

6 *Indicator Species Analyses-*

7 Vascular Plants

8 ISA identified six indicator species for thinned forest and one indicator species for 0.2 ha
9 leave islands when forest type was used as a grouping variable. Species indicative of thinned
10 forest included *H. radicata* (IV = 80.4, randomized groups IV mean = 39.5 and s.d. = 12.31, p =
11 0.005), *Chamerion angustifolium* (fireweed; IV = 75.0, randomized groups IV mean = 25.7 and
12 s.d. = 13.57, p = 0.024), *Epilobium ciliatum* (fringed willowherb; IV = 70.4, randomized groups
13 IV mean = 27.7 and s.d. = 14.07, p = 0.027), *Cirsium vulgare* (bull thistle; IV = 68.0,
14 randomized groups IV mean = 33.1 and s.d. = 15.99, p = 0.046), Asteraceae species (aster
15 species; IV = 65.7, randomized groups IV mean = 26.7 and s.d. = 14.48, p = 0.056), and *Luzula*
16 species (woodrush species; IV = 61.0, randomized groups IV mean = 34.2 and s.d. = 13.39, p =
17 0.060). All six of these species were herbaceous and five of six (83.3%) were associated with
18 early-successional forest. The sole indicator of 0.2 ha leave islands was the native, late-
19 successional shrub, *Acer circinatum* (vine maple; IV = 70.3, randomized groups IV mean = 48.5
20 and s.d. = 14.50, p = 0.078).

21 In addition, ISA identified vascular plant indicator species for study sites and for mountain
22 ranges. Specifically, ISA of study sites identified indicator species for Bottomline (n = 26),
23 Delph Creek (n = 8), Green Peak (n = 8), and Keel Mountain (n = 3; Appendix C). Finally, ISA

1 of mountain ranges identified eight vascular plant indicator species for the Cascade Range and
2 41 indicator species for the Coast Range (Appendix D).

3 Arthropods

4 When forest type was used as a grouping variable, ISA identified mid-mobility, late-
5 successional forest associate trap-door spider, *Hexura*, as an indicator species for 0.2 ha leave
6 islands (IV = 30.3; randomized groups IV mean = 25.6 and s.d. = 2.29, $p = 0.026$) while high-
7 mobility coleopteran Staphylinidae species were identified as indicators of 0.4 ha leave islands
8 (IV = 28.6; randomized groups IV mean = 25.0 and s.d. = 2.11, $p = 0.057$). These results were
9 consistent with the integrated analysis results which indicated that Staphylinidae species density
10 in large leave islands exceeded that of small and medium leave islands as well as thinned forest
11 (Table 2). Finally, the mid-mobility coleopteran, *S. carinatus*, was the sole indicator of thinned
12 forest (IV = 28.9; randomized groups IV mean = 25.7 and s.d. = 2.34, $p = 0.080$).

13 In addition, ISA identified arthropod indicator species for study sites and for mountain
14 ranges. Specifically, ISA of study sites identified indicator species for Bottomline ($n = 20$),
15 Delph Creek ($n = 17$), Green Peak ($n = 11$), and Keel Mountain ($n = 14$; Appendix C). Finally,
16 ISA of mountain ranges identified 23 arthropod indicator species for the Cascade Range and 21
17 indicator species for the Coast Range (Appendix D).

18 Amphibians

19 Indicator species analysis did not identify any amphibian indicator species for any treatment
20 when forest type was used as a grouping variable. However, ISA identified amphibian indicator
21 species for three study sites and for both mountain ranges. Specifically, ISA of study sites
22 identified indicator species for Delph Creek ($n = 1$), Green Peak ($n = 1$), and Keel Mountain ($n =$
23 1; Appendix C). No indicator species were identified for Bottomline. Finally, ISA of mountain

1 ranges identified two amphibian indicator species for the Cascade Range and one indicator
2 species for the Coast Range (Appendix D).

3 Mollusks

4 Indicator species analysis did not identify any indicator species for any treatment when
5 forest type was used as a grouping variable. However, as with amphibian data, ISA identified
6 mollusk indicator species for study sites and for mountain ranges (Appendix D). Specifically,
7 ISA of study sites identified indicator species for Bottomline (n = 4), Delph Creek (n = 1), Green
8 Peak (n = 1), and Keel Mountain (n = 1; Appendix C). Finally, ISA of mountain ranges
9 identified two mollusk indicator species for the Cascade Range and three indicator species for
10 the Coast Range (Appendix D).

11

12 *Blocked Multi-Response Permutation Procedure Analyses-*

13 Vascular Plants

14 MRBP revealed no differences in vascular plant communities among the five groups (forest
15 types) of interest. This comparison of unthinned forest, thinned forest, 0.1 ha, 0.2 ha, and 0.4 ha
16 leave islands resulted in a chance-corrected group agreement (A) of 0.0186 and $p = 0.752$,
17 indicating more heterogeneity within groups than expected by chance alone.

18 Arthropods

19 MRBP revealed no significant differences in arthropod communities among the five groups
20 of interest. Specifically, this analysis resulted in a chance-corrected within-group agreement (A)
21 of 0.00126 and $p = 0.477$. This indicates that arthropod communities appear to be relatively
22 homogeneous among the five groups examined in this study and more heterogeneous than
23 expected by chance alone.

1 Amphibians

2 MRBP did not reveal significant differences in amphibian communities among the five
3 groups of interest. Specifically, this analysis resulted in a chance-corrected group agreement (A)
4 of 0.0206 and $p = 0.289$, indicating more heterogeneity in groups than expected by chance.

5 Mollusks

6 MRBP did not reveal significant differences in mollusk communities among the five groups
7 of interest. Specifically, this analysis resulted in a chance-corrected group agreement (A) of
8 0.0255 and $p = 0.253$, indicating more heterogeneity in groups than expected by chance.

10 *Occupancy Patterns-*

11 Thinning and leave island effects on vascular plant species composition were apparent in
12 qualitative comparisons of occupancy patterns. Vascular plant occupancy patterns represented all
13 possible forest type combinations (Table 3; Appendix A). Of the 120 vascular plant species
14 identified, there were 49 (40.8%) ubiquitous species found in all five forest types (Appendix A).
15 Eight species were found only in thinned forest. Seven (87.5%) of these were early-successional
16 herb species, including *Senecio sylvaticus* (woodland ragwort), *Anaphalis margaritacea* (western
17 pearly everlasting), *C. angustifolium*, *Ligusticum apiifolium* (celeryleaf licorice-root),
18 *Pedicularis racemosa* (sickle-top lousewort), *Urtica dioica* (stinging nettle), and cudweed species
19 (*Gnaphalium* species). Twenty-five species were not found in unthinned forest but were found
20 only in thinned forest and leave islands. Seventeen of these species (68.0%) were associated with
21 early-successional habitat while six (24.0%) were exotic species. One species, the native, late-
22 successional forest associated species, *Pityopus californica* (California pinefoot), was found only
23 in unthinned forest. Four species found only in unthinned forest and leave islands but not thinned

1 forest were all late-successional, native species, including *Boschniakia hookeri* (Vancouver
2 ground cone), *Listera caurina* (Northwestern twayblade), *Maianthemum dilatatum* (false lily of
3 the valley), and an unidentified *Lilium* species (unidentified lily species). Seventeen species
4 (14.2%) were found only in leave islands.

5 Twelve (70.6%) of these seventeen species were associated with late-successional forest
6 habitat while fifteen (88.2%) were native species. Due to their rarity, none of these seventeen
7 species were incorporated into previous analyses (ANOVA) of treatment effects. These species
8 included three saprophytes (*Monotropa hypopithys* [pinesap], *Corallorrhiza mertensiana* [Pacific
9 coralroot], and the rare *Cephalanthera austiniiae* [phantom orchid]), subshrubs (*Menziesia*
10 *ferruginea* [rusty menziesia] and *Pyrola picta* [whiteveined wintergreen]), and lily species
11 (*Lilium columbianum* [Columbian lily] and *Maianthemum racemosum* [feathery false lily of the
12 valley]). If plant occupancy patterns of species in single forest types (unthinned, thinned, leave
13 islands) were randomly distributed, one might expect numbers of species to reflect sampling
14 effort (i.e., area sampled). Three times as much leave island area was sampled, so leave island
15 species richness would be three times higher. Observed richness was not different from this
16 expectation for plants ($\chi^2 = 4$, d.f. = 2, $p > 0.10$).

17 Arthropod occupancy patterns were a mix among forest types, similar to those of vascular
18 plants. Of the 289 arthropod species identified, 104 species (36.0%) were found in all five forest
19 types (Appendix B). Seventeen species (5.9%) were found only in thinned forest, fourteen
20 (82.4%) of which were high-mobility species, two (11.8%) were low-mobility species, and one
21 (5.9%) was mid-mobility (Table 3). Twenty species (6.9%) were found only in thinned forest
22 and leave islands but not unthinned forest. Conversely, twenty-one species (7.3%) were found
23 only in unthinned forest, twelve (57.1%) of which were high-mobility species, seven (33.3%)

1 were mid-mobility, and two (9.5%) were low-mobility. Thirty-nine species (13.5%) were not
2 found in thinned forest but were found only in unthinned forest and leave islands. Fifty-two
3 species (18.0%) were found only in leave islands, thirty-four (65.4%) of which were high-
4 mobility species, ten (19.2%) were low-mobility species, and eight (15.4%) were mid-mobility.
5 Eleven of these 52 species had known habitat associations. Six (54.6%) were associated with
6 late-successional or old-growth forest habitat while five (45.4%) were associated with disturbed
7 forest habitat. As in vascular plants, due to their rarity, none of these 52 species were
8 incorporated into previous analyses (ANOVA) of treatment effects. As for plants, observed
9 species richness in leave islands was not different from expected given random assortment of
10 species among the five forest types ($\chi^2 = 0.6$, d.f. = 2, $p > 0.05$).

11 The three most common amphibian species, *B. wrighti*, *E. eschscholtzii*, and *Plethodon*
12 *vehiculum* (western redback salamander), were ubiquitous and occurred in all five forest types
13 (Table 3; Appendix B). The remaining four species occurred only incidentally. Specifically, we
14 captured *Ambystoma gracile* (northwestern salamander; $n = 4$) only in thinned forest and
15 unthinned forest, *Ascaphus truei* (tailed frog; $n = 1$) and *Rhyacotriton variegatus* (southern
16 torrent salamander; $n = 1$) only in unthinned forest, and *Taricha granulosa* (rough-skinned newt;
17 $n = 2$) only in 0.2 ha leave islands and unthinned forest.

18 Seven mollusk species and the *Prophyaon* (tail-dropper) species group were ubiquitous
19 across all forest types (Table 3; Appendix B). Interestingly, the rare *Hemphillia malonei*
20 (Malone's jumping slug) occurred across all types of forest and most commonly in thinned
21 forest.

22

23 *Community Analyses-*

1 Vascular Plants

2 Using NMS, we found a 2-dimensional solution that explained 92.5% of the variation in the
3 original data of vascular plants (Figure 4a). This ordination was then rotated to align the
4 strongest variable from the environmental matrix (average annual precipitation) with axis 1.
5 After rotation, this axis explained 79.2% of the variation in vascular plant communities. This
6 axis was strongly related to mountain range with Coast Range and Cascade Range sites being
7 clearly separated on opposite ends of axis 1. This axis represented geographic gradients in annual
8 precipitation, spring ambient temperature, and soil moisture. Specifically, axis 1 was strongly
9 positively correlated ($r > 0.500$) with average annual precipitation, spring relative humidity,
10 spring and summer soil moisture, trees per hectare, downed wood density, basal area, canopy
11 closure, and heatload (Table 4). This axis was strongly negatively correlated ($r < -0.500$) with
12 spring ambient temperature and spring soil temperature. Axis 2 explained 13.3% of the variation
13 in the original data and represented gradients in stand age and daily surface heatload.
14 Specifically, this axis was positively correlated with heatload, months after timber harvest,
15 spring relative humidity, and summer ambient temperature and negatively correlated with stand
16 age. Study sites within each mountain range displayed clear separation along axis 2.

17 Vascular plant species positively correlated with axis 1 included *T.heterophylla*, *Oxalis*
18 *oregana* (redwood-sorrel), *Chimaphila menziesii* (little prince's pine), *Thuja plicata* (western red
19 cedar), and *Blechnum spicant* (deer fern; Table 5). Species negatively correlated with this axis
20 included *Campanula scouleri* (pale bellflower), *Anemone deltoidea* (Columbian windflower),
21 *Osmorhiza berteroi* (sweet cicely), *Symphoricarpos albus* (common snowberry), and *Rosa*
22 species (rose species). Species positively correlated with axis 2 included *Boykinia occidentalis*
23 (coastal brookfoam), *C. menziesii*, *Veronica officinalis* (common gypsyweed), and *T.*

1 *heterophylla*. Species negatively correlated with this axis included *Trillium ovatum* (Pacific
2 trillium), *Luzula* species (woodrush species), and *Dicentra formosa* (Pacific bleeding heart).

3 Arthropods

4 NMS selected a 3-dimensional solution that provided a substantial reduction in stress
5 compared to randomized data and represented 94.3% of the variation in the original data (Figure
6 4b). After rotating to align the strongest variable from the environmental matrix (average annual
7 precipitation) with axis 1, 42.9% of the variation in the original data was represented by axis 2,
8 30.2% by axis 1, and the remaining 21.2% by axis 3. Axis 2 was strongly related to mountain
9 range with Coast Range and Cascade Range sites being clearly separated on opposite ends of the
10 axis. This axis was strongly positively ($r > 0.500$) correlated with summer ambient and soil
11 temperatures and strongly negatively correlated ($r < -0.500$) with spring soil temperature,
12 summer relative humidity, and total vascular plant ground cover (Table 6). Axis 1 was positively
13 correlated with average annual precipitation, summer soil moisture, percent rock ground cover,
14 and density of all downed wood and negatively correlated with spring ambient temperature,
15 spring soil temperature, percent shrub ground cover, and percent vascular plant ground cover.
16 Study sites within each mountain range displayed clear separation along this axis. Finally, axis 3
17 was positively correlated with summer soil temperature, stand age, and summer ambient
18 temperature. This axis was negatively correlated with summer relative humidity, months after
19 timber harvest, and spring relative humidity.

20 Arthropod species positively correlated with axis 2 included *Julid* species, *Notiophilus*
21 *sylvaticus*, *Listemus formosus*, *Tenebrionid*, and *Micryphantid* species (Table 7). Species
22 negatively correlated with this axis included *Chordeumid*, *Agulla*, *Nemocestes puncticollis*,
23 *Pristoceuthophilus*, and *Scytonotus*. Arthropod species positively correlated with axis 1 included

1 *Cicadellid* species, *Bracon* X, *Anatis*, parasitic wasp species, and *Geodercodes latipennis*.
2 Species negatively correlated with this axis included *Geophilomorpha* species, Staphylinidae
3 species, *Lysiopetalid*, *Lithobid*, and *Carabid* species. Finally, arthropod species positively
4 correlated with axis 3 included *Bollmannella*, *Usofila*, *N. sylvaticus*, *Mycetophilid*, and *Chionea*.
5 Species negatively correlated with this axis included *Fenderia capizii*, *Acrotrichus* species,
6 *Lophoderus*, *Scytonotus*, and *Microcybaeus*.

7 Amphibians

8 NMS selected a 2-dimensional solution that represented 91.3% of the variation in the
9 original data (Figure 4c). This ordination was then rotated to align the strongest variable from the
10 environmental matrix (average annual precipitation) with axis 1. After rotation, this axis
11 explained 54.0% of the variation in amphibian communities. This axis was strongly related to
12 mountain range with all Coast Range and Cascade Range sites being segregated on opposite ends
13 of axis 1. This axis was positively correlated with average annual precipitation, density of all
14 downed wood, percent litter ground cover, spring relative humidity, and spring soil moisture and
15 negatively correlated with spring ambient temperature, spring soil temperature, and percent
16 shrub ground cover (Table 8). The second axis represented 37.3% of the variation in the original
17 data. This axis was positively correlated with slope, trees per hectare, summer soil temperature,
18 and summer ambient temperature. This axis was negatively correlated with summer relative
19 humidity, heat load, total and vascular plant ground cover. Amphibian assemblages at Coast
20 Range study sites were distinctly separated along this axis while Cascade Range study sites
21 displayed a less clear separation along this axis.

22 Amphibian species positively correlated with axis 1 included *B. wrighti* and *E. eschscholtzii*
23 while *T. granulosa* and *P. vehiculum* were negatively correlated with this axis (Table 9). *P.*

1 *vehiculum* and *E. eschscholtzii* were positively correlated with axis 2 while *B. wrighti* was
2 negatively correlated with this axis.

3 Mollusks

4 NMS found a 3-dimensional solution that explained 96.2% of the variation in the original
5 data (Figure 4d). This ordination was then rotated to align the strongest variable from the
6 environmental data matrix (average daily minimum spring soil temperature) with axis 1. After
7 rotation, this axis represented 61.0% of the variation in mollusk communities. This axis was
8 related to mountain range with Cascade Range and Coast Range sites being largely segregated
9 along axis 1. This axis was positively correlated with spring soil temperature, spring ambient
10 temperature, and percent shrub ground cover and negatively correlated with average annual
11 precipitation, percent rock ground cover, spring soil moisture, average daily minimum spring
12 relative humidity, and density of all downed wood (Table 10).

13 Axis 3 represented 20.2% of the variation in the data. This axis was positively correlated
14 with summer soil moisture, summer relative humidity, spring relative humidity, and average
15 annual precipitation. This axis was negatively correlated with summer ambient temperature and
16 summer soil temperature. Delph Creek study site sampling units were distinctly clustered at the
17 top of this axis while sampling units from other sites were only moderately separated. Finally,
18 axis 2 explained 15.0% of the variation in the data. This axis was positively correlated with
19 summer soil temperature, slope, and summer ambient temperature and negatively correlated with
20 summer relative humidity, basal area of hardwood trees, and percent exposed soil ground cover.

21 Mollusk species positively correlated with axis 1 included *Ancotrema sportella* (beaded
22 lancetooth snail), *Vespericola columbianus* (northwest hesperian snail), and *H. vancouverense*
23 (Table 11). Species negatively correlated with this axis included *Prophysaon* species (tail-

1 dropper species) and *H. malonei*. Species positively correlated with axis 3 included *H. malonei*
2 and *A. sportella/H. vancouverense* juveniles (beaded lancetooth/robust lancetooth juvenile
3 snails) while species negatively correlated with this axis included *Ariolimax columbianus*
4 (Pacific banana slugs) and *A. sportella*. Finally, *A. columbianus* was the only species positively
5 correlated with axis 2 while *H. vancouverense*, *V. columbianus*, and *Prophysaon* species were
6 negatively correlated with the axis.

7

8

DISCUSSION

9 Forest management activities can dramatically alter forest structure and habitat conditions
10 for resident biota. Sustaining species adversely affected by silvicultural activities may require the
11 implementation of innovative mitigation strategies such as aggregated and dispersed green tree
12 retention. Our retrospective study showed treatment effects on habitat and some biota resulting
13 from thinning, and leave islands represented a potentially effective strategy to mitigate some
14 treatment effects (Table 12). The larger leave islands (0.2 ha and 0.4 ha) appeared effective in
15 maintaining a semblance of interior forest conditions and several taxa within thinned forests. The
16 smallest leave islands (0.1 ha) appeared analogous to thinned forests as shown by several
17 measures of microclimate and the presence of taxa associated with thinned forests. Leave islands
18 may provide incidental benefits to a host of forest taxa.

19 Thinning most consistently affected microclimate, forest stand structure, and the
20 composition and abundance of vascular plants. About half (45 of 88) of these measures showed
21 an effect of thinning. Microclimate differences followed intuitive predictions, with measures of
22 ambient temperature and soil temperature consistently higher in thinned forest than unthinned
23 forest and measures of relative humidity consistently higher in unthinned forest than thinned

1 forest. Similarly, differences in forest stand structure followed logical patterns with measures of
2 canopy closure, trees per hectare, and basal area consistently higher in unthinned forest than
3 thinned forest.

4 Thinning effects on resident biota were most pronounced for vascular plant species
5 composition, with species assemblages in thinned forest including more early- successional and
6 exotic plant species while unthinned forest assemblages were comprised of late-successional and
7 native species. Differences in plant species composition resulting from forest thinning may have
8 cascading effects on other biota associated with or dependent upon particular vascular plant
9 species. For example, the federally endangered *Icaricia icarioides fenderi* (Fender's blue
10 butterfly) has a strong habitat association with the federally threatened *Lupinus sulphureus* ssp.
11 *kincaidii* (Kincaid's lupine; Kaye 1999), although these species were not examined here.

12 Thinning resulted in a less distinct pattern of effects on arthropods, amphibians, and
13 mollusks. Only six of the 112 (5.4%) measures analyzed for these taxa decreased with thinning
14 (amphibian species richness, percentage of low-mobility arthropod species captures, density of
15 the arthropods *A. occidentalis*, *Myrmica*, and *Pristoceuthophilus*, and density of the mollusk
16 *Haplotrema vancouverense*) while three of 112 (2.7%) measures increased with thinning (density
17 of the plant-feeding arthropods *C. alternatus*, *S. carinatus*, and Lygaeidae; Table 1; Appendix
18 B). While these effects should not be discounted, with a significance level (α) of 0.10 one might
19 expect to see this number of significant results by chance alone.

20 Several explanations might be offered for this difference in thinning effects between plants
21 and animals. Habitat conditions resulting from the moderate intensity of the 200 tph thinning
22 treatment may have remained relatively hospitable for most animal taxa. That is, although habitat
23 analyses revealed multiple treatment effects of thinning on microclimate and forest structure,

1 they may not have been biologically relevant for animals; the resulting range of ecological
2 conditions may have allowed the persistence of most of the resident animal taxa. Organisms may
3 respond more dramatically to fine-scale structural habitat changes rather than to coarse-scale
4 changes associated with this thinning treatment. Also, the scale of sampling might not be
5 appropriate for detecting treatment effects on these low-mobility organisms associated with or
6 dependent upon discrete microhabitat features. Further, the limited area of each study site
7 (approximately 2.59 km² or 259 ha) resulted in a rather tightly packed mosaic of forest types.
8 The moderate thinning treatment wholeplot abutted the unthinned forest wholeplot at three of our
9 four study sites, and unthinned riparian reserves occurred within the moderate thinning
10 treatment. The close proximity of the two forest types may have aided dispersal of organisms,
11 even those with general low mobility, thereby obscuring treatment effects.

12 The integrated and leave island analyses also showed more effects on habitats and plants (64
13 of 175 [36.6%]) than fauna (29 of 167 [17.4%]). Interestingly, more fauna could be analyzed by
14 these approaches (167 vs. 112 in thinned vs. unthinned analyses) and the number of faunal
15 treatment effects doubled (17% vs. 8%) once leave islands were incorporated into analyses.

16 In the integrated analyses comparing the five forest types, microclimate within leave islands
17 was often intermediate to thinned and unthinned forest and differed sharply from thinned forest.
18 Relative humidity, ambient temperature, soil temperature, and attributes of forest structure
19 differed among our five forest types, resulting in a heterogeneous mosaic of conditions within
20 sites. Measures of soil moisture and downed wood density (m³/m²) did not differ among forest
21 types. An apparent threshold in microclimate conditions was evident at the 0.2 ha leave island
22 size: microclimate conditions in 0.4 ha leave islands were most similar to the unthinned forest
23 while conditions in 0.1 ha leave islands were similar to the thinned forest.

1 In Pacific Northwest Douglas-fir forests, Chen et al. (1995) found that microclimatic edge
2 effects from a clearcut boundary typically extend from 30 to more than 240 m into the interior of
3 adjacent old-growth forest patches, depending upon the measure. Although we do not directly
4 address edge effects in this study, the restricted size of these leave islands (radii of approximately
5 18m, 25m, and 36m for 0.1, 0.2, and 0.4 ha leave islands, respectively) suggests that the interior
6 of these leave islands likely show strong edge effects along the boundary between thinned forest
7 and the embedded leave islands. However, the circular configuration of these leave islands
8 maximizes the interior-to-edge ratio (Forman and Godron 1986) and thereby minimizes the
9 proportion of the leave island interior influenced by the surrounding thinned forest. In this study,
10 within stand variability in measures of microclimate appeared to be ameliorated between 18 and
11 36 m (radii of 0.1 ha and 0.4 ha leave islands, respectively) from a stand edge for some measures
12 of relative humidity, ambient temperature, and soil temperature (Tables 1 and 2). This size
13 threshold is consistent with past research suggesting that leave islands smaller than 0.12 ha in
14 size are functionally ineffective for timber production due to edge effects causing poor growth
15 form and slow regeneration growth (Oliver and Larson 1996). Also, minimum size
16 recommendations greater than 0.12 ha have been made for forest “clumps” based on the poor
17 growth form and slow regeneration growth resulting from edge effects permeating forest islands
18 below this size threshold (Oliver and Larson 1996).

19 Plant species diversity and species composition were vastly different among the five forest
20 types. While plant diversity was greatest in the thinned forest and lowest in the unthinned forest,
21 the calculation of diversity was influenced by early-successional and exotic species. We found
22 over two times more early-successional species (52 and 25 species in thinned and unthinned
23 forest, respectively) and over three times more exotic species in thinned forest than unthinned

1 forest (10 and 3 species in thinned and unthinned forest, respectively). Conversely, late-
2 successional species (n = 62 species) and native species (n = 104) dominated the species
3 composition of larger leave islands and unthinned forest. We found a distinct gradient in species
4 diversity and composition from thinned forest, small through large leave islands, and unthinned
5 forest. Specifically, the percentage of exotic and the percentage of early-successional species was
6 greatest in thinned forest, incrementally less in 0.1 ha, 0.2 ha, and 0.4 ha leave islands, and
7 smallest in unthinned forest. Further, four native species associated with late-successional forest
8 habitat that occurred in leave islands and unthinned forest were absent in thinned forest.

9 Arthropods dominated the biodiversity in our study with more than 30,000 individual
10 captures within 23 orders. However, only 77 and 60 measures were incorporated into the
11 integrated and leave island analyses, respectively. Of these 137, 18 showed treatment effects at
12 the 0.10 significance level. This number is likely to be expected by chance alone (Ramsey and
13 Schafer 2002). However, interesting patterns are apparent. The percentage of low-mobility
14 captures and the density of *A. occidentalis*, *Myrmica*, and *Pristoceuthophilus* decreased with
15 thinning while the density of *C. alternatus*, Lygaeidae, and *S. carinatus* increased. This bi-
16 directional pattern was anticipated, given that some arthropods likely track plant responses. Both
17 early and late successional associates are expected in the group. Results from the integrated
18 analyses across all five forest types indicated that leave islands might provide some refugia from
19 forest thinning for two arthropod taxa, *Geophilomorpha* (the largest of the predaceous
20 arthropods; Moldenke, pers. comm.) and immature Staphylinidae (the most common and most
21 diverse of the predaceous arthropods; Moldenke, pers. comm.). Further, the focused leave island
22 size analyses revealed a tendency for increasing densities of these species with increasing leave
23 island size. Forest management strategies incorporating leave islands might help maintain the

1 persistence of these and potentially other arthropod species in managed forests. Fifteen arthropod
2 species occurred in all forest types except for thinned forest (Appendix B).

3 Across all ANOVA analyses, seven of 16 (43.8%) amphibian analyses were significant.
4 Species richness and densities of individual species were consistently greater in unthinned forest
5 than thinned forest. Similarly, these responses were consistently greater in small and medium
6 leave islands than thinned forest. However, contrary to our predictions, these responses were
7 consistently higher in small and medium leave islands than large leave islands. Several
8 explanations for this apparent anomaly can be offered. First, treatment effects may have been
9 obscured because of the optimal ecological conditions during springtime amphibian sampling.
10 Surface activities of terrestrial amphibians are confined to relatively narrow environmental
11 conditions due to thermal and moisture requirements (Sinsch 1990; Frisbie and Wyman 1991;
12 Blaustein et al. 1995). Above ground activity is generally restricted to cool, moist microhabitats
13 and conditions of high relative humidity (Petranka 1998). Habitat conditions in thinned forests at
14 the time of sampling (wet spring conditions) were designed to be within the ecological range
15 required for amphibian surface activity. Thus, overland dispersal among the various forest types
16 may have been occurring.

17 Treatment effects also may have been obscured due to the restricted nature of our sampling.
18 Terrestrial amphibians occupy three-dimensional microhabitats but our surveys of the forest
19 floor sampled only a limited two-dimensional area. Also, amphibians are well-known to have
20 patchy occurrences, often corresponding to unique habitat components such as decadent downed
21 wood or moist, rocky substrate. Treatment effects for such organisms can be obscured by these
22 patchy occurrences. In some cases, amphibians may be responding to fine-scale habitat
23 conditions rather than to habitat at a larger, leave island scale. That is, microsite components

1 such as sufficient soil moisture and abundant, decayed downed wood might be functioning as the
2 key drivers of amphibian abundance. However, these did not vary among forest types in our
3 study. Similarly, arthropods and mollusks may be tied to such microhabitats (Schumacher 1999).
4 However, information on the ecology of arthropods and terrestrial mollusks in the Pacific
5 Northwest is sparse (Dunk 2004) and habitat associations are poorly understood. Our results did
6 not indicate that any mollusk species were locally extirpated by the moderate thinning treatment.

7 While our study was designed to provide insights into the role of leave islands for
8 maintaining potentially sensitive forest-dependent species, rare species in particular, our analyses
9 were constrained by species abundances. Abundances varied across forest types and study sites,
10 restricting analyses to the more common taxa. The role of leave islands as potential species
11 lifeboats for the very rare taxa could not be addressed statistically; 311 of the 428 species
12 (72.7%) we censused were extremely rare and could not be addressed statistically while some
13 vascular plants and many arthropods could not be identified to species (Figure 3; Appendices A
14 and B). However, our multi-pronged analysis approach was designed to address this issue of
15 species rarity. Specifically, analyses of selected genera, families, or functional groups (i.e., for
16 arthropods and vascular plants) were designed to incorporate rare species into analyses while
17 ISA and MRBP analyses and occupancy pattern assessments included all taxa (Tables 3 and 12).

18 Leave islands placed over forest legacy elements or biodiversity hotspots may provide
19 habitat for rare species with patchy occurrences or strong habitat associations. This may account
20 for some occurrences in leave islands while not elsewhere, supporting their role as a lifeboat for
21 some species (Table 3). Seventy-one species occupied only leave islands. These occurrences may
22 reflect random distributions in the area rather than leave island associations. However, intact
23 forest patches may offer refugia for incidental species occurrences. The refugia role of intact

1 forest also would apply to the large number of species found only in unthinned forest and leave
2 islands ($n = 139$, 32.5%; Table 3). Species occurring in any unthinned study unit comprised 349
3 (81.5%) taxa while leave islands harbored 325 (75.9%) taxa overall. The importance of intact
4 forest for one of these species was reinforced by concurrent results with the integrated and ISA
5 analysis approaches. Specifically, the integrated analysis approach revealed that Staphylinidae
6 species density was highest in 0.4 ha leave islands while ISA identified Staphylinidae species as
7 indicators of 0.4 ha leave islands (Tables 1 and 3).

8 Habitat-based management approaches have been proposed to maintain species diversity in
9 managed forest systems (Noss et al. 1997). Concerns about biodiversity due to forest
10 fragmentation may be mitigated by intentionally introducing spatial complexity and
11 heterogeneity at the forest stand scale. Incorporating leave islands at the time of timber harvest
12 can enhance the complexity of an otherwise relatively homogenous thinned forest matrix. In this
13 study, leave islands effectively enhanced stand heterogeneity by providing microclimatic
14 conditions and forest structures intermediate between thinned forest and unthinned forest.
15 Further, leave islands appeared to help maintain vascular plant assemblages characteristic of
16 interior forest by harboring late-successional and native species within a thinned forest matrix
17 with more early-successional and exotic species. Medium and large (0.2 ha and 0.4 ha) leave
18 islands harbored consistently different vascular plant assemblages from thinned forest while
19 plant assemblages in small (0.1 ha) leave islands were often similar to thinned forest (Table 1).
20 Additionally, two arthropod and one amphibian species exhibited higher densities in leave
21 islands than thinned forests. Thus, leave islands appeared to be an effective habitat-based
22 management strategy for maintaining multiple species within managed forests.

1 In addition to habitat management approaches, forest managers also can use silvicultural
2 techniques designed to moderate the contrast between the managed forest matrix and patches of
3 the formerly contiguous forest. Prescribing moderate thinning densities (Hunter 1990) and
4 retaining legacy structures such as downed wood and large trees can “soften” the matrix
5 (Franklin 1993) to ameliorate contrasts of habitat conditions. In our study, thinning to 200 tph
6 appeared a relatively benign disturbance to our faunal groups. Negative effects of thinning were
7 shown for only three arthropod species, one arthropod functional group, overall amphibian
8 species richness, and one mollusk of 167 total measures analyzed. Some legacy elements (such
9 as wolf trees, hardwood trees, and biodiversity hotspots for lichens, fungi, and bryophytes) were
10 preserved within leave islands at each of our study sites during study implementation and may
11 explain occurrences of some rare old-forest associated species within them. For example, ISA
12 identified the minority hardwood species, *A. circinatum* as an indicator of 0.2 ha leave islands
13 (Table 12). Species occurrence and persistence may have been particularly enhanced in leave
14 islands located over identified forest legacy elements such as hardwood or wolf trees (Neitlich
15 and McCune 1997). That is, leave islands that were created to preserve a forest legacy element
16 might provide a uniquely valuable habitat patch for resident species with strong habitat
17 associations (e.g., some amphibian, mollusk, lichen, and vascular plant species). The patchy
18 occurrence of some species might be coincident with these legacy elements. This “matrix
19 management” (Lindenmayer and Franklin 2002) may maintain a relatively permeable matrix for
20 forest interior-associated species. The value of multiple-entry thinning to maintain moderate
21 changes at each entry warrants further evaluation relative to forest dependent species. Multiple,
22 low-intensity thinning entries resulting in incremental changes to stand density might allow the

1 persistence of such species more effectively than fewer, higher-intensity timber harvest entries
2 creating sudden, dramatic changes in stand density.

3 In contrast, past research examining heavier thinning treatments and clearcuts has shown
4 treatment effects on the resident forest biota. Specifically, these studies revealed decreased
5 abundances of some arthropods (Spence et al. 1997) and amphibians (Dupuis 1997). Conversely,
6 vascular plant species richness often increases following timber harvest, with this increased
7 species richness often driven by the influx of early-successional and exotic species. Biotic
8 response to timber harvest seems to vary along a gradient according to the intensity of harvest
9 and seems to be taxa-specific.

10 Biotic response to thinning is also likely influenced by temporal dynamics. That is,
11 treatment effects on forest biota likely emerge during the lag time following timber harvest as
12 forest succession proceeds. Resident wildlife may respond not to stand density but to the
13 ecological characteristics of the harvested stand (Hayes et al. 1997). The biota may require
14 several years to differentiate among forest types. The duration of this lag time and the nature of
15 the biotic response is likely taxa-specific. Thus, the timing of biotic sampling seems crucial for
16 detecting treatment effects on biota with differential temporal responses to thinning. Sampling
17 too soon or too late after forest thinning might not fully capture responses of resident species.
18 Thinning and leave island treatments were administered at our four study sites between October
19 1997 and March 2000. Vascular plant, arthropod, and amphibian and mollusk sampling was
20 conducted 17 to 45 months, 28 to 56 months, and 26 to 54 months after timber harvest,
21 respectively. Our results suggest that vascular plant assemblages responded relatively quickly
22 and dramatically to the thinning and the leave island treatments. Results for other taxa were less
23 pronounced. However, intriguing results emerged from an initial ordination analysis comparing

1 arthropod assemblages in thinned and unthinned forest at our Bottomline and Delph Creek study
2 sites (oldest and newest harvest dates, respectively). After 56 months, arthropod assemblages in
3 thinned forest and unthinned forest at Bottomline displayed a clear separation into two data
4 clouds. In contrast, arthropod assemblages in thinned and unthinned forest at Delph Creek had
5 not differentiated 28 months after thinning and were relatively homogeneous. This exploratory
6 analysis supports our hypothesis regarding the taxa-specific, temporal dimension of resident
7 biota response to forest thinning.

8 Our community and ISA analysis results also highlighted the importance of addressing
9 multiple spatial scales in forest management prescriptions. Specifically, NMS ordinations clearly
10 illustrated the distinct vascular plant, arthropod, amphibian, and mollusk species assemblages
11 occurring at both the site scale and the mountain range scale (Figure 4a-d). Further, ISA
12 identified indicator species for forest types (vascular plant and arthropod species), study sites (all
13 taxa) and mountain ranges (all taxa; Appendices C and D). While some of these indicator species
14 might truly be indicative of unique habitat conditions, some of the identified indicator species
15 might also be artifacts of the leave island placement strategy. Leave islands were often placed
16 over special habitat features such as legacy forest elements (e.g., wolf trees or minority species,
17 such as *A. circinatum*) or over known locations of species diversity (i.e., lichen species).
18 Maintaining the biodiversity of these unique biotic communities at the nested microsite, forest
19 stand, and landscape scales will likely require both fine-scale and coarse-scale management
20 strategies instead of generic or standardized approaches. Results from this study can guide forest
21 managers in developing tiered or nested silvicultural prescriptions addressing the complexity of
22 species distributions and assemblages. Forest biodiversity might be sustained at multiple spatial

1 scales by incorporating alternative strategies such as leave islands and moderate thinning
2 treatments in silvicultural prescriptions.

3 In our study, the close proximity of leave islands and riparian reserves within the moderate
4 200 tph thinning context may have minimized the scale of forest fragmentation. This particular
5 combination of silvicultural treatments may have ameliorated disturbances to habitat conditions,
6 making the thinned forest “functionally contiguous” for many of the resident species (Andrén
7 and Delin 1994). As noted earlier, surface cover and soil conditions were similar among
8 treatments and are the likely haunts of ground-dwelling species examined here. Treatment effects
9 would likely have been muted if conducive habitat conditions did not preclude dispersal of
10 organisms among the five types of forest. Silvicultural strategies that effectively maintain
11 connectivity within these study sites seems especially important in the intensively managed
12 forest landscape of western Oregon.

13 Although not addressed in our study, the landscape surrounding our study sites was a
14 heterogenous mosaic of forest conditions resulting from multiple ownerships and diverse
15 management objectives. Adjacent stands were comprised of a range of forest conditions and
16 successional stages, including recent regeneration harvests, young managed stands, and riparian
17 reserves but no late-successional stands. Effects on species by management at larger spatial
18 scales is not known for most taxa, however, emerging results from stream and riparian studies in
19 PNW western forests suggests some amphibians are strongly affected by landscape management
20 patterns (Bisson et al. 2002; Stoddard and Hayes 2005).

21 In our study, we found somewhat of a gradient of response to treatment among taxa.
22 Multiple treatment effects were evident for vascular plants, fewer for amphibians and arthropods,
23 and fewer still for mollusks. Thus, the taxa examined in the current study displayed different

1 responses to the scale of forest treatment. The taxa examined in this study are thought to be
2 sensitive to habitat changes created by silvicultural activities at the forest stand scale (Wiens
3 1989). However, the forest stand scale might not be the appropriate scale at which these patterns
4 become evident for faunal taxa. Species are thought to respond to ecological processes and
5 disturbance at different domains of scale (Wiens 1989). Vascular plants seemed to be more
6 responsive than other taxa to forest treatments at the treatment scale; while vascular plants may
7 have small domain of scale, arthropods, amphibians, and mollusks may display different
8 domains of scale. At this study's spatial scale, fragmentation might be too limited to be
9 detectable; the forest matrix might not be inhospitable enough to be associated with differences
10 in mollusks, less so in arthropods and amphibians. Ecological processes shaping forest
11 biodiversity operate over wide ranges of spatial and temporal scales (Christensen et al. 1996;
12 Davies et al. 2001). Patterns detected in research are inextricably tied to the chosen scale of
13 investigation. The effects of managing for complexity at the stand scale might not have
14 detectable cascading effects at larger (or smaller) spatial scales. The relative influence of stand-
15 scale habitat features might be less important than that of landscape-scale or finer-scale habitat.

16 In summary, our results indicate that treatment effects of thinning and leave islands included
17 substantial differences in microclimate, forest stand structure, and vascular plant assemblages
18 (Table 12). Less dramatic and consistent treatment effects were evident for arthropods,
19 amphibians, and mollusks, but some examples were apparent in each group, nonetheless. While
20 the taxa in this study responded to the moderate thinning treatment to varying degrees, they still
21 occurred in these managed forests. If a primary management goal for these forests is to maintain
22 species persistence at the stand scale, this silvicultural approach of combined dispersed and
23 aggregated green tree retention involving a moderate thinning treatment and embedded leave

1 islands holds promise. This design may have provided for species persistence across these study
2 sites by creating a functionally contiguous matrix for many species.

3

4

ACKNOWLEDGEMENTS

5 We would like to thank J. Cissel, J. Hayes, B. Marcot, and A. Moldenke for reviewing
6 preliminary drafts of this manuscript. We thank N. Duncan, R. Halse, P. Hohenlohe, R. Pabst, C.
7 Sheridan, N. Vance, and H. Yi for graciously lending their taxonomic expertise and P.
8 Cunningham, L. Ganio, M. Huso, and B. McCune for providing sage statistical advice. Our
9 appreciation goes to B. Marcot for his assistance with study protocol design and J. Cissel, F.
10 Freeman, P. O'Toole, H. Snook, and C. Thompson for logistical support. We are especially
11 grateful for the tireless field assistance of L. Campbell, K. Christiansen, L. Ellenburg, K. Fausti,
12 M. Hatfield, C. Jacobsen, C. McKeone, W. Wessell, and H. Wick and the graphic artistry of K.
13 Ronnenberg. Financial and logistical support was generously provided by the federal Survey and
14 Manage Program, Northwest Forest Plan, USDA Forest Service and USDI Bureau of Land
15 Management, the USDA Forest Service Pacific Northwest Research Station, Oregon Bureau of
16 Land Management, and Oregon State University.

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- 8 APPENDICES

Appendix A: Flora species list. Site names are abbreviated as follows: BL = Bottomline, DC = Delph Creek, GP = Green Peak, and KM = Keel Mountain. Forest types are abbreviated as follows: T = thinned forest, S = small (0.1 ha) leave islands, M = medium (0.2 ha) leave islands, L = large (0.4 ha) leave islands, and U = unthinned forest.

Scientific Name	Rank	Family	Stratum	Origin	Serai Class	Sites				Forest Types				
						BL	DC	GP	KM	T	S	M	L	U
<i>Abies grandis</i>	101	Pinaceae	Tree	Native	Late-successional			X		X	X			
<i>Abies procera</i>	113	Pinaceae	Tree	Native	Late-successional		X					X		
<i>Acer circinatum</i>	13	Aceraceae	Shrub	Native	Late-successional	X	X	X	X	X	X	X	X	X
<i>Acer macrophyllum</i>	67	Aceraceae	Tree	Native	Late-successional	X		X		X	X	X	X	
<i>Achlys triphylla</i>	68	Berberidaceae	Herb	Native	Late-successional	X		X		X	X	X	X	X
<i>Actaea rubra</i>	75	Ranunculaceae	Herb	Native	Late-successional	X	X	X		X	X	X		
<i>Adenocaulon bicolor</i>	22	Asteraceae	Herb	Native	Late-successional	X	X	X	X	X	X	X	X	X
<i>Alnus rubra</i>	81	Betulaceae	Tree	Native	Early-successional			X	X			X	X	
<i>Anaphalis margaritacea</i>	114	Asteraceae	Herb	Native	Early-successional	X				X				
<i>Anemone deltoidea</i>	30	Ranunculaceae	Herb	Native	Late-successional	X	X	X	X	X	X	X	X	X
<i>Anemone lyallii</i>	84	Ranunculaceae	Herb	Native	Late-successional			X			X	X		
<i>Anemone oregana</i>	85	Ranunculaceae	Herb	Native	Early-successional	X			X	X	X	X	X	
<i>Asarum caudatum</i>	35	Aristolochiaceae	Herb	Native	Late-successional	X		X		X	X	X	X	X
<i>Asteraceae</i> species	60	Asteraceae	Herb	Unknown	Unknown	X		X	X	X	X			
<i>Blechnum spicant</i>	32	Blechnaceae	Herb	Native	Late-successional		X		X	X	X	X	X	X
<i>Boschniakia hookeri</i>	102	Orobanchaceae	Herb	Native	Late-successional			X					X	X
<i>Boykinia occidentalis</i>	96	Saxifragaceae	Herb	Native	Late-successional				X	X				X
<i>Calocedrus decurrens</i>	107	Cupressaceae	Tree	Native	Late-successional	X				X				
<i>Campanula scouleri</i>	14	Campanulaceae	Herb	Native	Early-successional	X		X	X	X	X	X	X	X
<i>Cardamine angulata</i>	42	Brassicaceae	Herb	Native	Early-successional	X		X		X	X	X	X	X
<i>Cardamine</i> species	61	Brassicaceae	Herb	Native	Early-successional	X		X		X	X	X	X	X

Scientific Name	Rank	Family	Stratum	Origin	Serai Class	Sites				Forest Types				
						BL	DC	GP	KM	T	S	M	L	U
<i>Gnaphalium</i> species	106	Asteraceae	Herb	Native	Early-successional		X			X				
<i>Goodyera oblongifolia</i>	57	Orchidaceae	Herb	Native	Late-successional	X	X	X	X	X	X	X	X	X
<i>Hieracium albiflorum</i>	54	Asteraceae	Herb	Native	Early-successional	X	X	X		X	X	X	X	
<i>Holodiscus discolor</i>	27	Rosaceae	Shrub	Native	Early-successional	X		X		X	X	X	X	X
<i>Hypericum perforatum</i>	51	Clusiaceae	Herb	Exotic	Early-successional	X		X		X	X	X	X	
<i>Hypochaeris radicata</i>	19	Asteraceae	Herb	Exotic	Early-successional	X	X	X	X	X	X	X	X	X
<i>Ilex aquifolium</i>	118	Aquifoliaceae	Shrub	Exotic	Early-successional		X						X	
<i>Ligusticum apiifolium</i>	94	Apiaceae	Herb	Native	Early-successional	X				X				
<i>Lilium columbianum</i>	90	Liliaceae	Herb	Native	Late-successional			X				X		
Lily species	63	Liliaceae	Herb	Native	Late-successional	X	X	X	X		X	X	X	X
<i>Linnaea borealis</i>	44	Caprifoliaceae	Subshrub	Native	Late-successional	X	X		X	X	X	X		X
<i>Listera caurina</i>	80	Orchidaceae	Herb	Native	Late-successional	X		X			X	X	X	X
<i>Listera cordata</i>	55	Orchidaceae	Herb	Native	Late-successional		X	X		X	X	X	X	X
<i>Lonicera hispidula</i>	69	Caprifoliaceae	Subshrub	Native	Early-successional	X		X		X	X	X	X	X
<i>Lupinus polyphyllus</i>	98	Fabaceae	Herb	Native	Early-successional	X				X			X	
<i>Luzula</i> species	34	Juncaceae	Herb	Native	Early-successional	X	X	X	X	X	X	X	X	X
<i>Mahonia nervosa</i>	4	Berberidaceae	Subshrub	Native	Late-successional	X	X	X	X	X	X	X	X	X
<i>Maianthemum dilatatum</i>	82	Liliaceae	Herb	Native	Late-successional		X		X			X	X	X
<i>Maianthemum racemosum</i>	93	Liliaceae	Herb	Native	Late-successional	X		X			X	X		
<i>Maianthemum stellatum</i>	39	Liliaceae	Herb	Native	Late-successional	X	X	X	X	X	X	X	X	X
<i>Menziesia ferruginea</i>	119	Ericaceae	Shrub	Native	Late-successional		X					X		
<i>Moehringia macrophylla</i>	36	Caryophyllaceae	Herb	Native	Early-successional	X		X	X	X	X	X	X	X
<i>Monotropa hypopithys</i>	117	Monotropaceae	Herb	Native	Late-successional		X						X	
<i>Mycelis muralis</i>	33	Asteraceae	Herb	Exotic	Early-successional	X	X	X	X	X	X	X	X	X
<i>Nemophila parviflora</i>	48	Hydrophyllaceae	Herb	Native	Early-successional	X		X		X	X	X	X	X

Scientific Name	Rank	Family	Stratum	Origin	Seral Class	Sites				Forest Types				
						BL	DC	GP	KM	T	S	M	L	U
<i>Osmorhiza berteroi</i>	31	Apiaceae	Herb	Native	Early-successional	X		X	X	X	X	X	X	X
<i>Oxalis oregana</i>	3	Oxalidaceae	Herb	Native	Late-successional		X	X	X	X	X	X	X	X
<i>Oxalis suksdorfii</i>	53	Oxalidaceae	Herb	Native	Early-successional	X	X			X	X	X	X	
<i>Pedicularis racemosa</i>	45	Scrophulariaceae	Herb	Native	Early-successional				X	X				
<i>Penstemon</i> species	108	Scrophulariaceae	Herb	Native	Early-successional				X	X	X			
<i>Phacelia nemoralis</i>	66	Hydrophyllaceae	Herb	Native	Late-successional			X		X	X	X	X	
<i>Pityopus californica</i>	120	Monotropaceae	Herb	Native	Late-successional				X					X
<i>Poa</i> species	12	Poaceae	Herb	Unknown	Early-successional	X	X	X	X	X	X	X	X	X
<i>Polypodium glycyrrhiza</i>	109	Polypodiaceae	Herb	Native	Late-successional	X					X	X		
<i>Polystichum munitum</i>	1	Dryopteridaceae	Herb	Native	Late-successional	X	X	X	X	X	X	X	X	X
<i>Pseudotsuga menziesii</i>	18	Pinaceae	Tree	Native	Late-successional	X	X	X	X	X	X	X	X	X
<i>Pteridium aquilinum</i>	8	Dennstaedtiaceae	Herb	Native	Early-successional	X	X	X	X	X	X	X	X	X
<i>Pyrola picta</i>	91	Pyrolaceae	Subshrub	Native	Late-successional			X	X		X	X	X	
<i>Ranunculus uncinatus</i>	110	Ranunculaceae	Herb	Native	Late-successional			X		X	X			
<i>Rhododendron macrophyllum</i>	95	Ericaceae	Shrub	Native	Late-successional		X					X		X
<i>Ribes</i> species	92	Grossulariaceae	Shrub	Native	Late-successional	X			X		X	X	X	
<i>Rosa</i> species	21	Rosaceae	Shrub	Native	Early-successional	X	X	X		X	X	X	X	X
<i>Rubus laciniatus</i>	83	Rosaceae	Shrub	Exotic	Early-successional	X	X		X	X		X		X
<i>Rubus nivalis</i>	64	Rosaceae	Subshrub	Native	Late-successional		X		X		X	X		X
<i>Rubus parviflorus</i>	56	Rosaceae	Shrub	Native	Early-successional	X	X	X		X	X	X	X	
<i>Rubus spectabilis</i>	78	Rosaceae	Shrub	Native	Early-successional		X		X	X	X		X	
<i>Rubus ursinus</i>	6	Rosaceae	Shrub	Native	Early-successional	X	X	X	X	X	X	X	X	X
<i>Rumex acetosella</i>	88	Polygonaceae	Herb	Exotic	Early-successional	X		X		X	X			
<i>Sanicula crassicaulis</i>	99	Apiaceae	Herb	Native	Early-successional	X								X
<i>Senecio sylvaticus</i>	62	Asteraceae	Herb	Exotic	Early-successional		X	X		X				

Scientific Name	Rank	Family	Stratum	Origin	Seral Class	Sites				Forest Types				
						BL	DC	GP	KM	T	S	M	L	U
<i>Sonchus species</i>	73	Asteraceae	Herb	Exotic	Early-successional	X	X	X		X	X			
<i>Stachys mexicana</i>	49	Lamiaceae	Herb	Native	Early-successional	X		X		X	X	X	X	X
<i>Symphoricarpos albus</i>	5	Caprifoliaceae	Shrub	Native	Early-successional	X		X		X	X	X	X	X
<i>Symphoricarpos mollis</i>	10	Caprifoliaceae	Subshrub	Native	Early-successional	X		X		X	X	X	X	X
<i>Synthyris reniformis</i>	47	Scrophulariaceae	Herb	Native	Early-successional	X	X	X	X	X	X	X	X	
<i>Tellima grandiflora</i>	70	Saxifragaceae	Herb	Native	Early-successional			X		X	X	X		
<i>Thermopsis gracilis</i>	87	Fabaceae	Herb	Native	Early-successional	X				X	X		X	X
<i>Thuja plicata</i>	41	Cupressaceae	Tree	Native	Late-successional		X	X	X	X	X	X	X	X
<i>Tiarella trifoliata</i>	65	Saxifragaceae	Herb	Native	Late-successional		X		X	X	X	X	X	
<i>Toxicodendron diversilobum</i>	111	Anacardiaceae	Shrub	Native	Early-successional	X		X		X				X
<i>Trientalis borealis</i>	28	Primulaceae	Herb	Native	Late-successional	X	X	X	X	X	X	X	X	X
<i>Trifolium species</i>	77	Fabaceae	Herb	Unknown	Early-successional			X		X	X	X		
<i>Trillium ovatum</i>	26	Liliaceae	Herb	Native	Late-successional	X	X	X	X	X	X	X	X	X
<i>Tsuga heterophylla</i>	16	Pinaceae	Tree	Native	Late-successional	X	X	X	X	X	X	X	X	X
<i>Urtica dioica</i>	100	Urticaceae	Herb	Unknown	Early-successional		X			X				
<i>Vaccinium ovalifolium</i>	25	Ericaceae	Shrub	Native	Late-successional		X		X	X	X	X	X	
<i>Vaccinium parvifolium</i>	9	Ericaceae	Shrub	Native	Late-successional	X	X	X	X	X	X	X	X	X
<i>Vancouveria hexandra</i>	17	Berberidaceae	Herb	Native	Late-successional	X	X	X	X	X	X	X	X	X
<i>Veronica officinalis</i>	59	Scrophulariaceae	Herb	Native	Early-successional				X	X	X	X		
<i>Vicia americana</i>	86	Fabaceae	Herb	Native	Early-successional	X		X		X	X			
<i>Vicia sativa</i>	43	Fabaceae	Herb	Exotic	Early-successional	X		X		X	X	X	X	
<i>Viola species</i>	11	Violaceae	Herb	Native	Early-successional	X	X	X	X	X	X	X	X	X
<i>Whipplea modesta</i>	40	Hydrangaceae	Subshrub	Native	Early-successional	X				X	X	X	X	X
<i>Xerophyllum tenax</i>	112	Liliaceae	Herb	Native	Late-successional			X	X	X				X

Appendix B: Fauna species list. Site names are abbreviated as follows: BL = Bottomline, DC = Delph Creek, GP = Green Peak, and KM = Keel Mountain. Forest types are abbreviated as follows: T = thinned forest, S = small (0.1 ha) leave islands, M = medium (0.2 ha) leave islands, L = large (0.4 ha) leave islands, and U = unthinned forest. Forest association assignments are as follows: LSOG = late-successional/old-growth, DIST = disturbed forest, BIPH = bi-phasic, associated with both LSOG and disturbed forest during different life stages.

ARTHROPODS				FUNCTIONAL GROUPS			SITES				FOREST TYPES				
Scientific Name	Rank	Family	Order	Feeding Group	Mobility	Forest Assoc.	BL	D C	G P	K M	T	S	M	L	U
<i>Acalypta</i>	92	Tingidae	Hemiptera	Plant sucker	Mid	BIPH	X		X		X	X		X	X
<i>Acrotrichus</i> sp	15	Ptiliidae	Coleoptera	Fungivore	Mid		X	X	X	X	X	X	X	X	X
<i>Actium</i>	77	Pselaphidae	Coleoptera	Micropredator	Mid	LSOG	X	X	X	X	X	X	X	X	X
<i>Agathidium</i> sp A	154	Leiodidae	Coleoptera	Slime-mold feeder	High	LSOG		X	X					X	X
<i>Agathidium</i> sp B	174	Leiodidae	Coleoptera	Slime-mold feeder	High	LSOG	X		X	X	X			X	
<i>Agathidium</i> sp C	161	Leiodidae	Coleoptera	Slime-mold feeder	High	LSOG	X		X					X	X
<i>Agathidium</i> sp D	227	Leiodidae	Coleoptera	Slime-mold feeder	High	LSOG	X							X	
<i>Agathidium</i> sp E	227	Leiodidae	Coleoptera	Slime-mold feeder	High	LSOG		X			X				
<i>Agathidium</i> sp F	203	Leiodidae	Coleoptera	Slime-mold feeder	High	LSOG	X			X	X			X	
<i>Agulla</i>	73	Raphidiidae	Neuroptera	Micropredator	High		X		X		X	X	X	X	X
Aleocharine black	55	Staphylinidae	Coleoptera	Parasitoid	Mid		X	X	X	X	X	X	X	X	X
Aleocharine red sp AR	64	Staphylinidae	Coleoptera	Parasitoid	Mid		X	X	X	X	X	X	X	X	X
Aleocharine red sp BR	118	Staphylinidae	Coleoptera	Parasitoid	Mid		X	X	X	X		X	X	X	X
<i>Anaspis</i>	227	Melandryiidae	Coleoptera	Plant chewer	High	DIST	X				X				

ARTHROPODS				FUNCTIONAL GROUPS			SITES				FOREST TYPES				
Scientific Name	Rank	Family	Order	Feeding Group	Mobility	Forest Assoc.	BL	D C	G P	K M	T	S	M	L	U
<i>Brachyrhinus rugostriatus</i>	35	Curculionidae	Coleoptera	Plant chewer	Mid		X	X	X	X	X	X	X	X	X
Bracon X	141	Braconidae	Hymenoptera	Parasitoid	High			X	X	X	X	X	X		X
<i>Bradysia</i>	2	Sciaridae	Diptera	Shredder	High		X	X	X	X	X	X	X	X	X
Buprestid	161	Buprestidae	Coleoptera	Xylivore	High	DIST	X			X	X				X
Byrrhid (immature)	26	Byrrhidae	Coleoptera	Plant chewer	High	LSOG	X	X	X	X	X	X	X	X	X
<i>Campodea</i>	11	Campodeidae	Diplura	Fungivore	Low		X	X	X	X	X	X	X	X	X
<i>Camponotus modoc</i>	203	Formicidae	Hymenoptera	Macropredator	High				X	X	X				
Cantharid (immature)	32	Cantharidae	Coleoptera	Micropredator	High		X	X	X	X	X	X	X	X	X
Cantharis (adult)	227	Cantharidae	Coleoptera	Micropredator	High					X			X		
Carabid (immature)	24	Carabidae	Coleoptera	Macropredator	High		X	X	X	X	X	X	X	X	X
Carabid sp A	227	Carabidae	Coleoptera	Macropredator	High				X						X
Carabid sp B	227	Carabidae	Coleoptera	Macropredator	High			X				X			
Carabid sp D	227	Carabidae	Coleoptera	Macropredator	High					X				X	
<i>Caseya</i>	10	Caseyidae	Diplopoda	Shredder	Mid		X	X	X	X	X	X	X	X	X
<i>Catopocerus</i> sp A	43	Leiodidae	Coleoptera	Fungivore	Low	LSOG	X	X	X	X	X	X	X	X	X
<i>Catopocerus</i> sp T	81	Leiodidae	Coleoptera	Fungivore	Low	LSOG	X	X	X	X	X	X	X	X	X
Cecidomyid	108	Cecidomyiidae	Diptera	Fungivore	High		X		X	X		X	X	X	X
Cecidomyid wingless	154	Cecidomyiidae	Diptera	Fungivore	Low	LSOG		X	X	X	X			X	X
<i>Ceraphron</i> sp A	108	Ceraphonidae	Hymenoptera	Parasitoid	Low		X		X	X		X	X	X	X
<i>Ceraphron</i> sp B	87	Ceraphonidae	Hymenoptera	Parasitoid	Low		X	X	X	X	X	X	X	X	X
<i>Ceraphron</i> sp C	227	Ceraphonidae	Hymenoptera	Parasitoid	Low		X					X			

ARTHROPODS				FUNCTIONAL GROUPS			SITES				FOREST TYPES				
Scientific Name	Rank	Family	Order	Feeding Group	Mobility	Forest Assoc.	BL	D C	G P	K M	T	S	M	L	U
<i>Ceraphron</i> sp D	174	Ceraphonidae	Hymenoptera	Parasitoid	Low				X	X	X				X
<i>Ceraphron</i> sp E	187	Ceraphonidae	Hymenoptera	Parasitoid	Low				X					X	
<i>Ceraphron</i> sp F	203	Ceraphonidae	Hymenoptera	Parasitoid	Low				X					X	
<i>Ceraphron</i> sp G	203	Ceraphonidae	Hymenoptera	Parasitoid	Low		X		X			X		X	
<i>Ceraphron</i> sp H	147	Ceraphonidae	Hymenoptera	Parasitoid	Low			X		X	X		X	X	X
<i>Ceraphron</i> sp I	174	Ceraphonidae	Hymenoptera	Parasitoid	Low					X	X	X	X	X	
<i>Ceraphron</i> sp J	227	Ceraphonidae	Hymenoptera	Parasitoid	Low					X			X		
<i>Ceraphron</i> sp R	161	Ceraphonidae	Hymenoptera	Parasitoid	Low		X	X	X	X	X		X	X	X
<i>Ceratolasma</i>	123	Nemastomatidae	Opiliona	Macropredator	Mid	LSOG	X		X		X	X	X	X	X
Ceratopogonid	79	Ceratopogonidae	Diptera	Unknown	High		X	X		X		X	X	X	X
Cercopid	203	Cercopidae	Hemiptera	Plant sucker	High			X	X		X			X	
<i>Chionea</i>	161	Tipulidae	Diptera	Unknown	Low	LSOG		X			X			X	X
Chironomid	41	Chironomidae	Diptera	Unknown	High		X	X	X	X	X	X	X	X	X
Chordeumid	22	Chordeumid s.n.	Diplopoda	Shredder	Mid		X	X	X	X	X	X	X	X	X
<i>Chrysopa</i>	174	Chrysopidae	Neuroptera	Micropredator	High				X	X			X	X	X
Cicadellid	94	Cicadellidae	Neuroptera	Plant sucker	High	DIST			X	X	X	X	X	X	X
Cicadellid PW	227	Cicadellidae	Neuroptera	Plant sucker	High	DIST			X					X	
<i>Coccinella</i>	187	Coccinellidae	Coleoptera	Micropredator	High	DIST		X			X			X	
<i>Colon</i>	187	Leiodidae	Coleoptera	Cadaver feeder	High			X					X	X	X
<i>Cupila</i>	118	Pselaphidae	Coleoptera	Micropredator	High	LSOG	X			X	X				X
Curculionid (immature)	77	Curculionidae	Coleoptera	Plant chewer	Mid			X	X	X	X	X	X	X	X
Curculionid sp AA	227	Curculionidae	Coleoptera	Plant chewer	Mid			X					X		

ARTHROPODS				FUNCTIONAL GROUPS			SITES				FOREST TYPES				
Scientific Name	Rank	Family	Order	Feeding Group	Mobility	Forest Assoc.	BL	D C	G P	K M	T	S	M	L	U
Curculionid sp BB	227	Curculionidae	Coleoptera	Plant chewer	Mid			X							X
Curculionid sp CC	203	Curculionidae	Coleoptera	Plant chewer	Mid		X					X		X	
Curculionid sp DD	161	Curculionidae	Coleoptera	Plant chewer	Mid			X	X		X	X	X	X	X
Curculionid sp XX	174	Curculionidae	Coleoptera	Plant chewer	Mid			X		X	X		X		
Curculionid sp YY	118	Curculionidae	Coleoptera	Plant chewer	Mid		X	X	X	X		X	X	X	X
Curculionid sp ZZ	135	Curculionidae	Coleoptera	Plant chewer	Mid			X	X	X	X	X	X	X	X
<i>Cybaeus</i>	27	Agelenidae	Araneae	Macropredator	High		X	X	X	X	X	X	X	X	X
<i>Cybaeus</i> blacklegs	135	Agelenidae	Araneae	Macropredator	High		X		X		X	X	X	X	X
<i>Cybaeus</i> giant	129	Agelenidae	Araneae	Macropredator	High			X		X	X	X	X	X	
<i>Cybaeus</i> leg-striped	102	Agelenidae	Araneae	Macropredator	High		X	X	X	X	X	X	X	X	X
Cynipid X	113	Cynipidae	Hymenoptera	Parasitoid	Mid		X	X	X	X	X	X	X	X	X
<i>Cytilus alternatus</i>	47	Byrrhidae	Coleoptera	Plant chewer	High	LSOG	X	X	X	X	X	X	X	X	X
<i>Dendrolasma</i>	100	Nemastomatidae	Opiliona	Micropredator	Mid		X		X	X	X	X	X	X	X
Diapriid sp A	112	Diapriidae	Hymenoptera	Parasitoid	Low		X		X	X		X	X	X	X
Diapriid sp B	187	Diapriidae	Hymenoptera	Parasitoid	Low		X		X	X	X	X		X	
Diapriid sp C	227	Diapriidae	Hymenoptera	Parasitoid	Low		X					X			
Diapriid sp D	227	Diapriidae	Hymenoptera	Parasitoid	Low				X				X		
Diapriid sp T	187	Diapriidae	Hymenoptera	Parasitoid	Low				X	X			X	X	
<i>Dyslobus productus</i>	118	Curculionidae	Coleoptera	Plant chewer	Low		X	X	X	X	X	X	X	X	X
<i>Elater</i> 2HK	65	Elateridae	Coleoptera	Plant chewer	High		X	X	X	X	X	X	X	X	X
<i>Elater</i> sp 1	69	Elateridae	Coleoptera	Plant chewer	High		X	X	X	X	X	X	X	X	X
<i>Elater</i> sp 2	227	Elateridae	Coleoptera	Plant chewer	High				X		X				

ARTHROPODS				FUNCTIONAL GROUPS		SITES				FOREST TYPES					
Scientific Name	Rank	Family	Order	Feeding Group	Mobility	Forest Assoc.	BL	D C	G P	K M	T	S	M	L	U
<i>Microcybaeus</i>	66	Agelenidae	Araneae	Macropredator	Mid		X		X			X	X	X	X
<i>Microhexura</i>	18	Dipluridae	Araneae	Micropredator	Low		X	X	X	X	X	X	X	X	X
<i>Micropeplus</i>	91	Staphylinidae	Coleoptera	Micropredator	High		X		X	X		X	X	X	X
Micryphantid (immature)	16	Micryphantidae	Araneae	Micropredator	High		X	X	X	X	X	X	X	X	X
Micryphantid sp A	96	Micryphantidae	Araneae	Micropredator	High		X	X		X	X	X	X	X	X
Micryphantid sp B	227	Micryphantidae	Araneae	Micropredator	High					X					X
Micryphantid sp C	69	Micryphantidae	Araneae	Micropredator	High			X	X	X	X	X	X	X	X
Micryphantid sp D	83	Micryphantidae	Araneae	Micropredator	High		X	X	X	X	X	X	X	X	X
Micryphantid sp E	187	Micryphantidae	Araneae	Micropredator	High		X				X		X		
Micryphantid sp F	129	Micryphantidae	Araneae	Micropredator	High		X	X	X	X		X		X	X
Micryphantid sp G	227	Micryphantidae	Araneae	Micropredator	High		X					X			
Micryphantid sp H	227	Micryphantidae	Araneae	Micropredator	High				X		X				
Micryphantid sp I	227	Micryphantidae	Araneae	Micropredator	High				X						X
Micryphantid sp J	154	Micryphantidae	Araneae	Micropredator	High			X			X	X	X	X	
Micryphantid sp K	227	Micryphantidae	Araneae	Micropredator	High			X				X			
Micryphantid sp L	227	Micryphantidae	Araneae	Micropredator	High			X			X				
Micryphantid sp M	227	Micryphantidae	Araneae	Micropredator	High		X								X
Micryphantid sp N	227	Micryphantidae	Araneae	Micropredator	High			X			X				
Mirid	129	Miridae	Hemiptera	Plant sucker	High		X		X	X			X	X	X
<i>Molorchus</i>	227	Cerambycidae	Coleoptera	Micropredator	High				X					X	
Moth s.n.	98	Incurvariidae	Lepidoptera	Plant chewer	High		X		X	X	X		X	X	X
Mycetophilid	187	Mycetophilidae	Diptera	Fungivore	High			X			X			X	X

ARTHROPODS				FUNCTIONAL GROUPS			SITES				FOREST TYPES				
Scientific Name	Rank	Family	Order	Feeding Group	Mobility	Forest Assoc.	BL	D C	G P	K M	T	S	M	L	U
Mymarid	227	Mymaridae	Hymenoptera	Parasitoid	Mid					X	X				
<i>Myrmica</i>	4	Formicidae	Hymenoptera	Macropredator	High	DIST	X	X	X	X	X	X	X	X	X
<i>Nearctodesmus</i>	66	Nearctodesmidae	Diplopoda	Shredder	Mid		X	X	X	X		X	X	X	X
<i>Nemocestes puncticollis</i>	98	Curculionidae	Coleoptera	Plant chewer	Low		X	X	X	X	X	X	X	X	X
<i>Neon</i>	104	Salticidae	Araneae	Micropredator	High		X	X	X		X	X	X	X	X
Nitidulid sp A	227	Nitidulidae	Coleoptera	Fungivore	High					X					X
Nitidulid sp B	161	Nitidulidae	Coleoptera	Fungivore	High			X		X	X				X
Noctuid	46	Noctuidae	Lepidoptera	Plant chewer	High		X	X	X	X	X	X	X	X	X
<i>Notiophilus sylvaticus</i>	59	Carabidae	Coleoptera	Micropredator	High			X		X	X	X	X	X	X
<i>Nuctenea patagiata</i>	174	Araneidae	Araneae	Macropredator	High		X	X		X				X	X
<i>Omaline</i>	227	Staphylinidae	Coleoptera	Micropredator	High					X					X
<i>Omus californicus</i>	227	Carabidae	Coleoptera	Macropredator	Mid		X								X
<i>Ostoma</i>	203	Trogositidae	Coleoptera	Micropredator	High				X			X			
<i>Panorpa</i>	203	Panorpoidea	Neuroptera	Macropredator	High	LSOG			X			X			
<i>Pardosa</i>	227	Lycosidae	Araneae	Macropredator	High	DIST			X					X	
Pentatomid	147	Pentatomidae	Hemiptera	Plant sucker	High	DIST	X		X	X	X		X	X	
<i>Philonthus</i> sp A	129	Staphylinidae	Coleoptera	Macropredator	High				X	X	X	X	X	X	X
<i>Philonthus</i> sp B	203	Staphylinidae	Coleoptera	Macropredator	High			X						X	X
<i>Philonthus</i> sp C	227	Staphylinidae	Coleoptera	Macropredator	High			X			X				
<i>Phora</i>	174	Phoridae	Diptera	Fungivore	High				X	X		X			X
<i>Phrurotimpus</i>	227	Clubionidae	Araneae	Micropredator	Mid					X					X
<i>Piestus</i>	135	Staphylinidae	Coleoptera	Micropredator	High		X	X	X			X		X	X

ARTHROPODS				FUNCTIONAL GROUPS		SITES				FOREST TYPES					
Scientific Name	Rank	Family	Order	Feeding Group	Mobility	Forest Assoc.	BL	D C	G P	K M	T	S	M	L	U
<i>Pimoa</i>	203	Linyphiidae	Araneae	Macropredator	High				X	X				X	X
<i>Pityohyphantes</i>	227	Linyphiidae	Araneae	Macropredator	High				X						X
<i>Polyxenes</i>	47	Polyxenidae	Diplopoda	Shredder	Low		X	X	X	X	X	X	X	X	X
<i>Pristoceuthophilus</i>	88	Gryllacrididae	Orthoptera	Unknown	Mid		X	X	X	X	X	X	X	X	X
Proctotrupid sp A	108	Proctotrupidae	Hymenoptera	Parasitoid	Mid		X	X	X	X	X	X	X	X	X
Proctotrupid sp B	227	Proctotrupidae	Hymenoptera	Parasitoid	Mid				X				X		
<i>Promecognathus laevissimus</i>	161	Carabidae	Coleoptera	Macropredator	Low	LSOG	X	X			X			X	
<i>Protura</i>	51	Protura s.n.	Protura	Fungivore	Low		X	X	X	X	X	X	X	X	X
Pselaphid (immature)	88	Pselaphidae	Coleoptera	Micropredator	Mid		X	X	X	X	X	X	X	X	X
<i>Pselaptrichus rothi</i>	44	Pselaphidae	Coleoptera	Micropredator	Mid	LSOG	X	X	X	X	X	X	X	X	X
<i>Pseudotyrranochthonius</i>	116	Chthoniidae	Pseudoscorpiones	Micropredator	Low	LSOG	X	X	X	X			X	X	X
Psychodid	118	Psychodidae	Diptera	Fungivore	High		X	X	X	X	X			X	
<i>Pterostichus herculaneus</i>	187	Carabidae	Coleoptera	Macropredator	High		X	X			X	X			
<i>Pterostichus inopinus</i>	227	Carabidae	Coleoptera	Macropredator	Mid			X							X
<i>Pterostichus lanei</i>	37	Carabidae	Coleoptera	Macropredator	Mid		X	X	X	X	X	X	X	X	X
<i>Pterostichus</i> sp X	227	Carabidae	Coleoptera	Macropredator	Mid			X				X			
<i>Pterostichus</i> sp Y	126	Carabidae	Coleoptera	Macropredator	Mid		X				X				X
Ptiliid (adult)	62	Ptiliidae	Coleoptera	Fungivore	Mid		X	X	X	X	X	X	X	X	X
Ptiliid black	108	Ptiliidae	Coleoptera	Fungivore	Mid		X	X			X	X	X	X	X
PW FB	104	Braconidae	Hymenoptera	Parasitoid	Mid			X	X	X	X	X	X	X	X
PW RE	227	Braconidae	Hymenoptera	Parasitoid	Mid				X					X	

ARTHROPODS				FUNCTIONAL GROUPS			SITES				FOREST TYPES				
Scientific Name	Rank	Family	Order	Feeding Group	Mobility	Forest Assoc.	BL	D C	G P	K M	T	S	M	L	U
PW W	45	Braconidae	Hymenoptera	Parasitoid	Mid		X	X	X	X	X	X	X	X	X
<i>Rhyncolus brunneus</i>	161	Curculionidae	Coleoptera	Plant chewer	Low		X	X		X		X	X	X	X
<i>Sabacon</i>	187	Ischyropsalididae	Opilionida	Micropredator	Low	LSOG	X	X			X	X			X
<i>Scaphinotus</i> (immature)	154	Carabidae	Coleoptera	Macropredator	High		X		X			X	X	X	
<i>Scaphinotus marginatus</i>	174	Carabidae	Coleoptera	Macropredator	High		X		X		X	X			X
Scarab (immature)	187	Scarabaeidae	Coleoptera	Plant chewer	High		X	X			X				
Sciarid (immature)	227	Sciaridae	Diptera	Shredder	High			X							X
<i>Sclerobunus</i>	154	Triaenonychidae	Opilionida	Macropredator	Mid	LSOG	X	X		X		X		X	X
<i>Scolopocryptos</i>	23	Scolopocryptopidae	Chilopoda	Macropredator	Mid		X	X	X	X	X	X	X	X	X
<i>Scutigereilla</i>	50	Scutigereillidae	Symphyla	Plant chewer	Low		X	X	X	X	X	X	X	X	X
Scydmaenid (immature)	135	Scydmaenidae	Coleoptera	Micropredator	Low		X	X	X			X	X		X
<i>Scydmaenus</i>	80	Scydmaenidae	Coleoptera	Micropredator	Low	LSOG	X	X	X	X	X	X		X	X
<i>Scytonotus</i>	17	Polydesmidae	Diplopoda	Shredder	Mid	DIST	X	X	X	X	X	X	X	X	X
<i>Silis</i>	203	Cantharidae	Coleoptera	Micropredator	High			X							X
<i>Siro acaroides</i>	7	Sironidae	Opilionida	Micropredator	Low		X	X	X	X	X	X	X	X	X
<i>Smittia</i>	93	Chironomidae	Diptera	Unknown	High			X		X	X	X	X	X	X
<i>Sonoma</i>	123	Pselaphidae	Coleoptera	Micropredator	High	LSOG	X		X	X	X	X		X	X
Sphaerocerid	203	Sphaeroceridae	Diptera	Fungivore	High			X		X		X	X		
Staphylinid (immature)	12	Staphylinidae	Coleoptera	Micropredator	High		X	X	X	X	X	X	X	X	X
Staphylinid sp AR	72	Staphylinidae	Coleoptera	Micropredator	High		X	X	X	X	X	X	X	X	X
Staphylinid sp AZ	126	Staphylinidae	Coleoptera	Micropredator	High		X	X	X	X	X	X	X	X	X
Staphylinid sp B	227	Staphylinidae	Coleoptera	Micropredator	High				X			X			

ARTHROPODS				FUNCTIONAL GROUPS			SITES				FOREST TYPES				
Scientific Name	Rank	Family	Order	Feeding Group	Mobility	Forest Assoc.	BL	D C	G P	K M	T	S	M	L	U
Staphylinid sp BX	227	Staphylinidae	Coleoptera	Micropredator	High				X						X
Staphylinid sp EE	227	Staphylinidae	Coleoptera	Micropredator	High			X							X
Staphylinid sp GEO	227	Staphylinidae	Coleoptera	Micropredator	High			X					X		
Staphylinid sp PH	174	Staphylinidae	Coleoptera	Micropredator	High		X	X	X	X				X	X
Staphylinid sp RA	147	Staphylinidae	Coleoptera	Micropredator	High			X	X	X		X		X	X
Staphylinid sp TB	227	Staphylinidae	Coleoptera	Micropredator	High					X				X	
Staphylinid sp TY	203	Staphylinidae	Coleoptera	Micropredator	High			X				X			X
<i>Stenus</i> sp B	141	Staphylinidae	Coleoptera	Micropredator	High			X	X	X	X	X			X
<i>Stenus</i> sp R	113	Staphylinidae	Coleoptera	Micropredator	High		X	X		X	X		X	X	X
<i>Steremnius carinatus</i>	58	Curculionidae	Coleoptera	Plant chewer	Mid		X	X	X	X	X	X	X	X	X
Syrphid	154	Syrphidae	Diptera	Micropredator	High	DIST	X	X	X			X			X
<i>Tachinus</i> sp A	141	Staphylinidae	Coleoptera	Micropredator	High		X			X				X	X
<i>Tachinus</i> sp B	86	Staphylinidae	Coleoptera	Micropredator	High		X	X	X	X	X	X	X	X	X
<i>Tachyporus</i> sp A	60	Staphylinidae	Coleoptera	Micropredator	High		X	X	X	X	X	X	X	X	X
<i>Tachyporus</i> sp B	141	Staphylinidae	Coleoptera	Micropredator	High		X								X
<i>Tachyporus</i> sp C	187	Staphylinidae	Coleoptera	Micropredator	High					X		X	X		
<i>Taracus</i>	102	Ischyropsalididae	Opilionida	Micropredator	Low	LSOG	X	X		X	X	X	X	X	X
Tenebrionid (immature)	13	Tenebrionidae	Coleoptera	Plant chewer	High		X	X	X	X	X	X	X	X	X
Tenthredenid	84	Tenthredinidae	Lepidoptera	Plant chewer	High		X	X	X	X	X	X	X	X	X
<i>Theridion</i>	135	Theridiidae	Araneae	Micropredator	High		X	X	X	X		X	X	X	X
Thrips	203	Phloeothripidae	Thysanoptera	Fungivore	Mid			X							X
Thrips (banded wings)	203	Phloeothripidae	Thysanoptera	Fungivore	Mid				X						X

ARTHROPODS				FUNCTIONAL GROUPS		SITES				FOREST TYPES					
Scientific Name	Rank	Family	Order	Feeding Group	Mobility	Forest Assoc.	BL	D C	G P	K M	T	S	M	L	U
Throscid	227	Throscidae	Coleoptera	Micropredator	High		X							X	
<i>Timarcha</i>	147	Chrysomelidae	Coleoptera	Plant chewer	Mid		X	X	X	X	X	X			X
Tipulid	32	Tipulidae	Diptera	Plant chewer	High		X	X	X	X	X	X	X	X	X
<i>Tribolium</i>	187	Tenebrionidae	Coleoptera	Fungivore	High		X	X			X		X		X
Trombidiid	41	Trombidiidae	Acari	Micropredator	Low		X	X	X	X	X	X	X	X	X
<i>Tylobolus</i>	161	Spirobolidae	Diplopoda	Shredder	Mid		X	X	X		X	X		X	X
<i>Usechomorpha</i>	203	Tenebrionidae	Coleoptera	Fungivore	High	LSOG	X		X					X	
<i>Usofila</i>	104	Telemidae	Araneae	Micropredator	High			X			X	X	X	X	X
<i>Veraphis</i>	203	Scydmaenidae	Coleoptera	Micropredator	Mid	LSOG				X				X	
<i>Wubana</i>	227	Linyphiidae	Araneae	Micropredator	High					X		X			
Xylophagid	227	Xylophagidae	Diptera	Xylivore	High		X					X			
<i>Xysticus</i>	34	Thomisidae	Araneae	Macropredator	High	DIST	X	X	X	X	X	X	X	X	X
<i>Zacotus matthewsi</i>	187	Carabidae	Coleoptera	Macropredator	Mid			X		X		X	X	X	
<i>Zelotes</i>	227	Gnaphosidae	Araneae	Micropredator	Mid					X					X
<i>Zygiella</i>	203	Araneidae	Araneae	Macropredator	High			X				X			

Appendix C: Study site indicator species analysis results. Vascular plant, arthropod, amphibian, and mollusk indicator species listed for all study sites ($p < 0.10$). Site names are abbreviated as follows: BL = Bottomline, DC = Delph Creek, GP = Green Peak, and KM = Keel Mountain.

Species	Max Group	Observed	IV from Randomized Groups		
		Indicator Value (IV)	Mean	s.d.	p *
Vascular Plants:					
<i>Corylus cornuta</i>	BL	92.4	30.0	11.46	0.001
<i>Galium trifidum</i>	BL	86.3	29.1	10.60	0.001
<i>Moehringia macrophylla</i>	BL	91.5	33.6	12.88	0.001
<i>Rubus ursinus</i>	BL	53.0	36.0	5.01	0.001
<i>Whipplea modesta</i>	BL	100.0	25.3	12.48	0.001
<i>Rosa</i> species	BL	76.9	32.0	10.82	0.002
<i>Symphoricarpos albus</i>	BL	84.8	34.7	13.14	0.002
<i>Pteridium aquilinum</i>	BL	49.3	34.0	4.26	0.003
<i>Symphoricarpos mollis</i>	BL	87.3	33.4	12.50	0.003
<i>Adenocaulon bicolor</i>	BL	78.5	35.8	11.25	0.005
<i>Oxalis suksdorfii</i>	BL	74.0	27.3	12.52	0.006
<i>Poa</i> species	BL	65.7	41.2	9.10	0.006
<i>Maianthemum stellatum</i>	BL	76.5	36.0	11.62	0.007
<i>Clinopodium douglasii</i>	BL	80.0	26.3	13.34	0.008
<i>Fragaria virginiana</i>	BL	80.0	24.6	13.18	0.008
<i>Thermopsis gracilis</i>	BL	80.0	23.4	12.31	0.008
<i>Vancouveria hexandra</i>	BL	78.5	47.9	13.36	0.009
<i>Achlys triphylla</i>	BL	61.5	27.0	10.52	0.015
<i>Osmorhiza berteroi</i>	BL	61.8	32.4	10.83	0.020
<i>Vicia sativa</i>	BL	68.4	28.1	13.21	0.021
<i>Nemophila parviflora</i>	BL	63.8	32.6	12.86	0.029
<i>Rubus parviflorus</i>	BL	56.2	26.9	12.05	0.035
<i>Holodiscus discolor</i>	BL	53.1	30.6	10.52	0.036
<i>Anemone deltoidea</i>	BL	51.7	33.6	8.66	0.041
<i>Lonicera hispidula</i>	BL	46.5	26.3	10.83	0.061
<i>Viola</i> species	BL	37.8	32.4	3.61	0.084
<i>Blechnum spicant</i>	DC	85.8	32.1	11.94	0.001

Species	Max Group	Observed	IV from Randomized Groups		
		Indicator Value (IV)	Mean	s.d.	p *
<i>Trillium ovatum</i>	DC	43.5	32.5	4.37	0.009
<i>Frangula purshiana</i>	DC	54.8	31.2	9.41	0.024
<i>Luzula</i> species	DC	63.6	35.3	12.45	0.040
<i>Dryopteris expansa</i>	DC	60.0	21.7	12.36	0.048
<i>Oxalis oregana</i>	DC	51.5	33.5	9.59	0.051
<i>Tiarella trifoliata</i>	DC	45.2	22.1	11.93	0.060
<i>Thuja plicata</i>	DC	48.3	33.0	9.02	0.068
<i>Cardamine angulata</i>	GP	96.4	25.3	11.64	0.002
<i>Cardamine</i> species	GP	94.7	25.4	11.75	0.002
<i>Listera cordata</i>	GP	97.9	25.8	12.19	0.002
<i>Asarum caudatum</i>	GP	79.7	26.1	10.80	0.003
<i>Pseudotsuga menziesii</i>	GP	44.2	32.6	3.67	0.003
<i>Trientalis borealis</i>	GP	56.0	32.7	8.00	0.006
<i>Phacelia nemoralis</i>	GP	80.0	29.5	13.54	0.009
<i>Goodyera oblongifolia</i>	GP	65.1	34.1	10.81	0.022
<i>Campanula scouleri</i>	GP	54.7	30.9	9.57	0.025
<i>Chrysolepis chrysophylla</i>	GP	60.0	28.4	11.93	0.025
<i>Collomia heterophylla</i>	GP	53.7	23.7	12.78	0.039
<i>Claytonia sibirica</i>	GP	67.0	42.6	12.80	0.040
<i>Acer circinatum</i>	GP	75.4	49.7	13.55	0.041
<i>Tellima grandiflora</i>	GP	60.0	24.8	12.23	0.042
<i>Trifolium</i> species	GP	60.0	25.3	11.99	0.042
<i>Dicentra formosa</i>	GP	59.3	33.8	13.62	0.061
<i>Tsuga heterophylla</i>	KM	59.9	33.5	7.50	0.001
<i>Chimaphila menziesii</i>	KM	49.4	31.3	7.77	0.028
<i>Veronica officinalis</i>	KM	60.0	23.6	11.71	0.034
Arthropods:					
<i>Atrechus</i>	BL	72.3	34.6	7.96	0.001
<i>Caseya</i>	BL	41.3	30.8	2.78	0.001
<i>Sciaria</i> species	BL	72.1	32.3	8.74	0.001

Species	Max Group	Observed	IV from Randomized Groups		
		Indicator Value (IV)	Mean	s.d.	p *
<i>Scolopocryptops</i>	BL	44.9	31.7	3.12	0.001
Chordeumid	BL	47.2	32.0	5.61	0.003
<i>Fenderia capizii</i>	BL	57.6	32.0	8.37	0.003
<i>Acalypta</i>	BL	74.3	25.1	12.01	0.006
<i>Taracus</i>	BL	75.0	25.6	10.25	0.007
Lygaeidae	BL	56.8	30.4	8.71	0.010
<i>Myrmica</i>	BL	33.8	28.7	1.99	0.010
<i>Lasius</i>	BL	63.8	31.4	10.42	0.011
<i>Ceratolasma</i>	BL	65.7	23.3	10.84	0.012
<i>Bdellozonium</i>	BL	55.1	29.8	10.26	0.027
<i>Hesperonemastoma</i>	BL	51.5	30.9	8.84	0.034
<i>Geophilomorpha</i> species	BL	28.6	26.9	1.20	0.037
<i>Colon</i>	BL	60.0	19.4	12.88	0.042
<i>Gelis</i>	BL	60.0	20.0	12.59	0.042
<i>Dendrolasma</i>	BL	48.5	29.1	8.57	0.043
<i>Pterostichus</i> species	BL	36.2	30.9	3.21	0.047
<i>Scytonotus</i>	BL	47.3	31.3	7.94	0.048
<i>Bollmannella</i>	DC	80.5	30.0	10.36	0.001
<i>Arctothezia occidentalis</i>	DC	55.8	32.9	5.65	0.001
<i>Usofila</i>	DC	100.0	23.1	10.73	0.001
Tenebrionid (immature)	DC	39.3	30.9	2.78	0.003
<i>Smittia</i>	DC	65.3	26.4	10.97	0.005
Chironomid	DC	60.9	32.4	9.16	0.007
<i>Notiophilus sylvaticus</i>	DC	54.3	28.4	9.04	0.010
Carabid species	DC	40.9	31.3	4.22	0.011
<i>Lucifotychus</i> species	DC	36.2	30.3	2.56	0.012
<i>Siro acaroides</i>	DC	51.4	32.7	8.00	0.025
<i>Cybaeus</i> species	DC	30.4	27.7	1.48	0.027
<i>Chionea</i>	DC	60.0	19.4	11.81	0.029
Lithobid	DC	29.9	27.5	1.40	0.029
Mycetophilid	DC	60.0	18.9	12.04	0.029

Species	Max Group	Observed	IV from Randomized Groups		
		Indicator Value (IV)	Mean	s.d.	p *
<i>Tachyporus</i> species	DC	50.8	32.5	8.04	0.033
<i>Metanonychus</i>	DC	41.4	32.6	4.53	0.035
Staphylinidae species	DC	33.4	29.8	2.38	0.078
<i>Agulla</i>	GP	67.1	28.1	9.86	0.002
Tenthredenid	GP	64.9	32.2	9.60	0.002
Cicadellid species	GP	73.2	29.5	11.08	0.003
Braconid species	GP	37.0	30.2	2.71	0.004
<i>Polyxenes</i>	GP	70.1	28.3	11.40	0.005
<i>Pristoceuthophilus</i>	GP	62.5	28.8	9.78	0.007
Machilid	GP	66.5	28.1	10.10	0.008
<i>Nemocestes puncticollis</i>	GP	58.4	29.8	8.82	0.013
<i>Bracon</i> X	GP	49.1	25.1	9.88	0.036
<i>Scaphinotus</i> species	GP	47.1	25.6	10.56	0.081
<i>Ceraphron</i> species	GP	35.4	30.9	3.35	0.095
<i>Campodea</i>	KM	41.6	31.1	3.04	0.001
<i>Scutigereella</i>	KM	56.1	33.3	6.04	0.001
<i>Listemus formosus</i>	KM	63.8	30.3	9.21	0.002
<i>Megaselia</i>	KM	80.0	23.5	12.80	0.004
<i>Bradysia</i>	KM	47.0	33.3	4.03	0.005
<i>Elater</i> species	KM	32.0	27.8	1.59	0.009
<i>Protura</i>	KM	67.5	30.8	10.99	0.013
Cecidomyid species	KM	58.5	27.1	10.56	0.014
<i>Lasioglossum</i>	KM	53.0	27.4	10.78	0.028
<i>Julid</i> species	KM	40.6	31.4	5.09	0.031
Curculionid species	KM	44.8	32.6	6.14	0.035
<i>Garypus</i>	KM	43.8	31.5	7.13	0.060
<i>Sonoma</i>	KM	46.5	25.0	10.26	0.083
<i>Cytilus alternatus</i>	KM	35.2	31.1	3.08	0.090

Species	Max Group	Observed	IV from Randomized Groups		
		Indicator Value (IV)	Mean	s.d.	p *
Amphibians:					
<i>Plethodon vehiculum</i>	GP	100.0	25.6	12.11	0.001
<i>Batrachoseps wrighti</i>	DC	57.9	30.1	9.42	0.010
<i>Ensatina eschscholtzii</i>	KM	30.5	28.4	1.68	0.098
Mollusks:					
<i>Ancotrema sportella</i>	BL	52.5	32.1	6.73	0.001
<i>Monadenia fidelis</i>	BL	77.0	28.4	11.25	0.003
<i>Haplotrema vancouverense</i>	BL	29.9	27.5	1.30	0.013
<i>Vespericola columbianus</i>	BL	33.4	29.5	2.18	0.038
<i>Hemphillia malonei</i>	DC	100.0	22.6	9.90	0.001
<i>Ariolimax columbianus</i>	GP	41.3	32.3	4.96	0.038
<i>Prophysaon</i> species	KM	50.4	33.7	6.60	0.011

Appendix D: Mountain range indicator species analysis results. Vascular plant, arthropod, amphibian, and mollusk indicator species listed for Cascade and Coast mountain ranges ($p < 0.10$).

Species	Max Group	Observed Indicator Value (IV)	IV from Randomized Groups		
			Mean	s.d.	p *
Vascular Plants:					
<i>Anemone deltoidea</i>	Coast	94.7	46.1	9.15	0.001
<i>Campanula scouleri</i>	Coast	99.8	39.0	9.43	0.001
<i>Claytonia sibirica</i>	Coast	94.2	49.2	11.48	0.001
<i>Corylus cornuta</i>	Coast	90.0	34.4	10.15	0.001
<i>Galium triflorum</i>	Coast	81.8	58.3	7.00	0.001
<i>Holodiscus discolor</i>	Coast	100.0	36.7	9.88	0.001
<i>Nemophila parviflora</i>	Coast	90.0	35.3	10.74	0.001
<i>Osmorhiza berteroi</i>	Coast	99.3	39.7	9.96	0.001
<i>Pteridium aquilinum</i>	Coast	75.9	56.5	5.21	0.001
<i>Rosa</i> species	Coast	99.2	39.6	10.24	0.001
<i>Symphoricarpos albus</i>	Coast	100.0	38.7	11.01	0.001
<i>Symphoricarpos mollis</i>	Coast	100.0	37.6	11.13	0.001
<i>Trientalis borealis</i>	Coast	84.6	45.6	8.84	0.001
<i>Vancouveria hexandra</i>	Coast	97.2	54.1	11.37	0.001
<i>Viola</i> species	Coast	71.0	55.3	4.39	0.001
<i>Achlys triphylla</i>	Coast	80.0	30.8	9.09	0.002
<i>Adenocaulon bicolor</i>	Coast	93.5	45.3	10.71	0.002
<i>Poa</i> species	Coast	85.8	57.5	9.81	0.003
<i>Stachys mexicana</i>	Coast	80.0	32.3	10.77	0.003
<i>Moehringia macrophylla</i>	Coast	78.6	38.1	11.36	0.004
<i>Lonicera hispidula</i>	Coast	70.0	28.4	9.22	0.005
<i>Maianthemum stellatum</i>	Coast	84.2	43.3	11.19	0.005
<i>Asarum caudatum</i>	Coast	70.0	28.6	9.54	0.006
<i>Chrysolepis chrysophylla</i>	Coast	66.5	32.1	9.88	0.008
<i>Vicia sativa</i>	Coast	60.0	26.3	10.04	0.010
<i>Cardamine angulata</i>	Coast	60.0	26.0	9.27	0.016
<i>Cardamine</i> species	Coast	60.0	26.0	9.39	0.016
<i>Pseudotsuga menziesii</i>	Coast	64.9	55.3	4.21	0.017
<i>Gaultheria shallon</i>	Coast	78.7	60.8	7.90	0.022
<i>Acer macrophyllum</i>	Coast	50.0	23.4	8.92	0.027
<i>Hypericum perforatum</i>	Coast	50.0	26.4	9.46	0.033
<i>Whipplea modesta</i>	Coast	50.0	23.1	8.87	0.033
<i>Listera cordata</i>	Coast	48.9	25.9	9.46	0.036
<i>Disporum hookeri</i>	Coast	65.3	52.0	7.81	0.070
<i>Collomia heterophylla</i>	Coast	40.0	20.3	8.02	0.078
<i>Listera caurina</i>	Coast	40.0	21.0	8.30	0.080

Species	Max Group	Observed	IV from Randomized Groups		
		Indicator Value (IV)	Mean	s.d.	p *
<i>Asteraceae</i> species	Coast	39.0	23.6	9.23	0.081
<i>Phacelia nemoralis</i>	Coast	40.0	22.2	8.76	0.088
<i>Clinopodium douglasii</i>	Coast	40.0	20.8	8.75	0.093
<i>Fragaria virginiana</i>	Coast	40.0	20.3	8.50	0.093
<i>Thermopsis gracilis</i>	Coast	40.0	20.2	8.35	0.093
<i>Blechnum spicant</i>	Cascade	100.0	38.0	10.79	0.001
<i>Oxalis oregana</i>	Cascade	94.6	44.2	9.77	0.001
<i>Tsuga heterophylla</i>	Cascade	98.1	48.0	8.67	0.001
<i>Thuja plicata</i>	Cascade	88.5	44.4	9.79	0.003
<i>Chimaphila menziesii</i>	Cascade	71.5	42.8	8.47	0.005
<i>Maianthemum dilatatum</i>	Cascade	50.0	23.6	8.77	0.024
<i>Vaccinium ovalifolium</i>	Cascade	50.0	22.8	8.65	0.038
<i>Tiarella trifoliata</i>	Cascade	40.0	20.0	8.22	0.086
Arthropods:					
<i>Agulla</i>	Coast	90.0	33.2	9.16	0.001
<i>Chordeumid</i>	Coast	78.9	48.9	7.29	0.001
<i>Nemocestes puncticollis</i>	Coast	81.0	38.2	8.95	0.001
<i>Pristoceuthophilus</i>	Coast	86.3	36.3	8.97	0.001
<i>Scytonotus</i>	Coast	87.2	43.0	8.75	0.001
Machilid	Coast	76.9	33.8	9.49	0.002
<i>Scaphinotus</i> species	Coast	70.0	28.1	8.81	0.002
<i>Lasius</i>	Coast	74.3	39.0	9.70	0.005
<i>Polyxenes</i>	Coast	64.6	31.6	9.80	0.011
Tenthredenid	Coast	66.9	41.9	9.47	0.017
<i>Ceratolasma</i>	Coast	50.0	22.3	7.77	0.023
<i>Atrechus</i>	Coast	68.0	48.3	8.96	0.031
<i>Acalypta</i>	Coast	50.0	22.9	9.14	0.036
<i>Caseya</i>	Coast	60.6	54.3	3.56	0.044
<i>Neon</i>	Coast	49.4	30.5	9.31	0.049
<i>Xysticus</i>	Coast	59.2	54.0	3.36	0.054
<i>Myrmica</i>	Coast	56.4	52.8	2.64	0.060
<i>Dendrolasma</i>	Coast	53.8	38.3	8.78	0.067
<i>Pterostichus</i> species	Coast	60.3	51.6	5.48	0.072
<i>Acrotrichus</i>	Coast	63.5	49.1	9.80	0.085
<i>Microcybaeus</i>	Coast	40.0	20.2	8.21	0.087
<i>Julid</i> species	Cascade	79.1	48.4	6.99	0.001
<i>Listemus formosus</i>	Cascade	97.4	38.4	9.12	0.001
<i>Notiophilus sylvaticus</i>	Cascade	100.0	35.7	8.86	0.001
Tipulid	Cascade	73.4	54.7	5.50	0.001

Species	Max Group	Observed	IV from Randomized Groups		
		Indicator Value (IV)	Mean	s.d.	p *
<i>Siro acaroides</i>	Cascade	85.2	45.4	8.69	0.002
Tenebrionid (immature)	Cascade	69.2	54.6	3.83	0.002
Byrrhid (immature)	Cascade	64.9	53.3	4.28	0.003
Micryphantid species	Cascade	56.6	51.8	2.16	0.003
<i>Cytilus alternatus</i>	Cascade	66.3	53.5	4.66	0.004
<i>Bollmannella</i>	Cascade	74.6	36.7	9.91	0.005
<i>Smittia</i>	Cascade	70.0	28.2	9.60	0.006
Chironomid	Cascade	71.1	43.7	9.08	0.007
<i>Brachyrhinus rugostriatus</i>	Cascade	61.5	53.5	3.19	0.012
<i>Antrodiaetus</i> species	Cascade	64.6	51.8	5.45	0.015
Carabid species	Cascade	66.5	50.4	6.28	0.015
<i>Lucifotychus</i> species	Cascade	62.0	54.2	3.58	0.022
<i>Usofila</i>	Cascade	50.0	23.4	8.72	0.034
<i>Apochthonius</i>	Cascade	55.8	52.3	2.38	0.038
<i>Arctorthezia occidentalis</i>	Cascade	67.0	51.2	7.27	0.040
<i>Batrissodes</i> species	Cascade	63.4	52.5	5.88	0.047
Trombidiid	Cascade	64.2	49.2	7.50	0.048
<i>Megaselia</i>	Cascade	40.0	20.3	8.11	0.083
<i>Protura</i>	Cascade	52.7	37.3	10.10	0.088
Amphibians:					
<i>Plethodon vehiculum</i>	Coast	55.6	24.3	9.67	0.016
<i>Batrachoseps wrighti</i>	Cascade	100.0	37.6	9.57	0.001
<i>Ensatina eschscholtzii</i>	Cascade	56.7	52.7	2.56	0.045
Mollusks:					
<i>Ancotrema sportella</i>	Coast	88.6	46.9	7.82	0.001
<i>Monadenia fidelis</i>	Coast	66.3	32.3	9.95	0.009
<i>Vespericola columbianus</i>	Coast	58.2	53.5	3.17	0.071
<i>Prophysaon</i> species	Cascade	84.6	49.4	7.93	0.001
<i>Hemphillia malonei</i>	Cascade	50.0	23.2	8.60	0.038

Table 1. List of all ANOVA results (p-values) for habitat and biota, including thinned vs. unthinned forest analyses, integrated analyses (simultaneous comparison of all five types of forest), and leave island analyses. Forest types are abbreviated as follows: T=thinned forest, S=small (0.1 ha) leave islands, M=medium (0.2 ha) leave islands, L=large (0.4 ha) leave islands, and U=unthinned forest. Direction of treatment effects (Dir.) indicated for all significant analyses ($p < 0.10$). Analyses not meeting ANOVA assumptions indicated with 'X'. For vascular plant analyses, * indicates percent of total vascular plant ground cover.

PARAMETER	Analysis					
	Thinned vs. Unthinned		Integrated		Leave Island	
	<i>p</i>	Dir.	<i>p</i>	Dir.	<i>p</i>	Dir.
<i>HABITAT</i>						
Relative Humidity:						
Spring average	0.0073	T<U	0.0208	T<L; T<U; S<L	0.0547	S<L; M<L
Spring minimum	0.0253	T<U	0.0072	T<U; S<U; M<U	0.0245	S<L; M<L
Spring maximum	0.3910		0.4558		X	
Spring range	0.0237	T>U	0.0026	T>U; S>L; S>U; M>U	0.0245	S>L; M>L
Spring average daily minimum	0.0186	T<U	0.0112	T<U; S<U; M<U	0.0618	S<L; M<L
Spring average daily maximum	0.4881		0.2635		X	
Summer average	0.3305		0.1039		X	
Summer minimum	0.0491	T<U	0.0042	T<L; T<U; S<L; S<U; M<U	0.0002	S<M; S<L; M<L
Summer maximum	X		0.4558		X	
Summer range	0.0757	T>U	0.0027	T>L; T>U; S>L; S>U; M>U	0.0002	S>M; S>L; M>L
Summer average daily minimum	0.0095	T<U	0.0010	T<M; T<L; S<L; S<U; M<U	X	
Summer average daily maximum	0.6050		0.5135		X	
Ambient Temperature:						
Spring average	0.0420	T>U	0.0867	T>U	0.3810	
Spring minimum	0.9666		0.5981		0.0761	S<L; M<L
Spring maximum	0.2459		0.3145		0.1220	
Spring range	0.2838		0.3053		0.0561	S<L; M<L
Spring average daily minimum	0.9345		0.9815		0.8236	
Spring average daily maximum	0.0805	T>U	0.0909	T>U	0.0504	S>L; M>L
Summer average	0.0020	T>U	0.0020	T>M; T>L; T>U; S>U	0.1253	
Summer minimum	0.7074		0.4563		0.3526	
Summer maximum	0.0090	T>U	0.0023	T>M; T>L; T>U; S>U	0.0277	S>M; S>L

PARAMETER	<i>Analysis</i>					
	Thinned vs. Unthinned		Integrated		Leave Island	
	<i>p</i>	Dir.	<i>p</i>	Dir.	<i>p</i>	Dir.
Summer range	0.0219	T>U	0.0026	T>M; T>L; T>U; S>U	0.0125	S>M; S>L
Summer average daily minimum	0.0152	T>U	0.7045		0.0524	S>M; S>L
Summer average daily maximum	0.9574		0.0028	T>M; T>L; T>U; S>U	X	
Soil Temperature:						
Spring average	0.0849	T>U	0.1785		0.8756	
Spring minimum	0.5821		0.7265		0.9735	
Spring maximum	0.1762		0.2969		0.8631	
Spring range	0.3701		0.7131		0.8388	
Spring average daily minimum	0.1764		0.5058		0.8730	
Spring average daily maximum	0.0529	T>U	0.2348		0.9684	
Summer average	0.0124	T>U	0.0302	T>S; T>M; T>L; T>U	0.6116	
Summer minimum	0.0371	T>U	0.1504		0.6824	
Summer maximum	0.0031	T>U	0.0186	T>S; T>M; T>L; T>U	0.7682	
Summer range	0.2576		0.5160		0.9504	
Summer average daily minimum	0.0201	T>U	0.0601	T>L; T>U	0.5290	
Summer average daily maximum	0.0098	T>U	0.0241	T>S; T>M; T>L; T>U	0.7271	
Soil Moisture:						
Spring soil moisture	0.4562		0.5691		0.2095	
Summer soil moisture	0.3169		0.5099		0.5822	
Downed Wood Data:						
Total density (m ³ / m ²)	0.5820		0.2677		0.6389	
Density in decay classes 1-2 (m ³ / m ²)	0.6607		0.2415		0.2125	
Density in decay classes 3-5 (m ³ / m ²)	0.3828		0.6702		0.7220	
Forest Stand Data:						
Canopy closure	0.0242	T<U	0.0027	T<S; T<M; T<L; T<U	X	
Average tree diameter at breast height (cm)	0.1651		0.0069	T>S; T>L	0.4173	
Trees per hectare	0.0454	T<U	0.0072	T<S; T<M; T<L; T<U	0.8007	

PARAMETER	<i>Analysis</i>					
	Thinned vs. Unthinned		Integrated		Leave Island	
	<i>p</i>	Dir.	<i>p</i>	Dir.	<i>p</i>	Dir.
Basal area/hectare (m ² /ha)	0.0293	T<U	0.1003		0.5628	
Conifer basal area/hectare (m ² /ha)	0.0293	T<U	0.0999		0.4682	
Hardwood basal area/hectare (m ² /ha)	X		0.2804		X	
<i>BIOTA</i>						
Vascular Plants:						
Species richness	0.001	T>U	0.001	T>S; T>M; T>L; T>U	0.098	S>L; M>L
Shannon diversity	0.009	T>U	0.022	T>M; T>L; T>U	0.732	
Total ground cover	0.054	T>U	0.528		0.266	
Herb ground cover	0.065	T>U	0.447		0.597	
Shrub ground cover	0.844		0.539		0.169	
Tree ground cover	0.063	T>U	0.347		0.898	
No. herb species	0.016	T>U	0.006	T>M; T>L; T>U	0.165	
No. shrub species	0.824		0.445		0.419	
No. tree species	0.444		0.401		0.341	
% early-successional species ground cover*	0.007	T>U	0.031	T>M; T>L; T>U	0.198	
% late-successional species ground cover*	0.007	T<U	0.028	T<M; T<L; T<U	0.019	S>M; S<L
Early-successional species ground cover	0.001	T>U	0.004	T>M; T>L; T>U	0.199	
Late-successional species ground cover	0.904		0.866		0.441	
No. early-successional species	0.014	T>U	0.002	T>S; T>M; T>L; S>U	0.041	S>M; S>L
No. late-successional species	0.492		0.135		0.093	S<M; M>L
% early-successional species*	0.018	T>U	0.005	T>M; T>L; T>U; S>U	0.049	S>M; S>L
% late-successional species*	0.013	T<U	0.003	T<M; T<L; T<U	0.028	S<M; S<L
% exotic species ground cover*	0.013	T>U	0.002	T>S; T>M; T>L; T>U	0.363	
% native species ground cover*	0.561		X		0.200	
Exotic species ground cover	0.023	T>U	0.004	T>S; T>M; T>L; T>U	0.245	
Native species ground cover	0.114		X		0.395	
No. exotic species	0.044	T>U	0.009	T>M; T>L; T>U	0.022	S>M; S>L
No. native species	0.030	T>U	0.027	T>L; T>U	0.214	
% exotic species*	0.030	T>U	0.029	T>M; T>L; T>U	0.042	S>M; S>L
% native species*	0.028	T<U	0.016	T<M; T<L; T<U	0.018	S<M; S<L

PARAMETER	<i>Analysis</i>					
	Thinned vs. Unthinned		Integrated		Leave Island	
	<i>p</i>	Dir.	<i>p</i>	Dir.	<i>p</i>	Dir.
<i>Acer circinatum</i> ground cover	0.450		0.153		X	
<i>Adenocaulon bicolor</i> ground cover	0.163		X		X	
<i>Campanula scouleri</i> ground cover	X		0.191		0.016	S>M; S>L
<i>Chimaphila menziesii</i> ground cover	0.290		X		X	
<i>Claytonia sibirica</i> ground cover	0.163		0.228		0.048	S<L
<i>Corylus cornuta</i> ground cover	X		0.140		0.282	
<i>Disporum hookeri</i> ground cover	0.861		0.519		0.421	
<i>Galium triflorum</i> ground cover	0.082	T>U	0.128		0.489	
<i>Gaultheria shallon</i> ground cover	X		0.780		0.657	
<i>Holodiscus discolor</i> ground cover	X		0.262		0.134	
<i>Hypochaeris radicata</i> ground cover	0.097	T>U	X		X	
<i>Mahonia nervosa</i> ground cover	0.451		0.717		0.121	
<i>Oxalis oregana</i> ground cover	0.184		0.627		X	
Poaceae species ground cover	0.029	T>U	0.026	T>M; T>L; T>U	0.070	S>M; S>L
<i>Polystichum munitum</i> ground cover	0.467		0.421		0.842	
<i>Pteridium aquilinum</i> ground cover	0.226		0.027	T>M; S>M	0.209	
<i>Rosa gymnocarpa</i> ground cover	X		0.492		0.040	S>M; M<L
<i>Rubus ursinus</i> ground cover	0.281		0.539		0.287	
<i>Symphoricarpos albus</i> ground cover	X		0.197		0.021	S>M; S>L
<i>Symphoricarpos mollis</i> ground cover	X		0.304		0.061	S>M; S>L
<i>Trientalis latifolia</i> ground cover	0.153		0.367		X	
<i>Trillium ovatum</i> ground cover	0.836		0.810		0.925	
<i>Vancouveria hexandra</i> ground cover	0.463		0.533		X	
<i>Vaccinium ovatum</i> ground cover	X		0.902		0.934	
<i>Vaccinium parvifolium</i> ground cover	0.988		0.394		0.101	
<i>Viola</i> species ground cover	0.431		0.492		0.617	

PARAMETER	<i>Analysis</i>					
	Thinned vs. Unthinned		Integrated		Leave Island	
	<i>p</i>	Dir.	<i>p</i>	Dir.	<i>p</i>	Dir.
Arthropods:						
No. orders	0.900		0.906		0.387	
No. functional groups	1.000		0.344		0.039	S<L; M<L
Species richness	0.627		0.749		0.080	S<L; M<L
Shannon diversity	0.424		0.725		0.608	
Low-mobility captures/m ²	0.457		0.508		0.055	M<L
Mid-mobility captures/m ²	0.694		0.421		0.156	
High-mobility captures/m ²	0.761		0.303		0.024	S<L; M<L
No. low-mobility species	0.543		0.635		0.088	S<L; M<L
No. mid-mobility species	0.354		0.675		0.593	
No. high-mobility species	0.810		0.514		0.017	S<L; M<L
% low-mobility captures	0.089	T<U	0.442		0.319	
% mid-mobility captures	0.660		0.128		0.017	S<M; M>L
% high-mobility captures	0.533		0.673		0.325	
Disturbance-associated captures/m ²	0.322		0.291		0.204	
LSOG-associated captures/m ²	0.593		0.192		0.018	S<L; M<L
% disturbance-associated captures	0.431		0.597		0.663	
% LSOG-associated captures	0.313		0.157		0.051	S>M; M<L
Arthropods/m ²	0.720		0.475		0.019	S<L; M<L
Cadaver feeders/m ²	X		X		X	
Dung feeders/m ²	X		X		X	
Fungivores/m ²	0.464		X		0.464	
Macropredators/m ²	0.145		X		0.559	
Micropredators/m ²	0.542		0.485		0.542	
Parasitoids/m ²	0.576		0.570		0.366	
Plant chewers/m ²	0.437		0.843		0.907	
Plant suckers/m ²	0.807		0.773		0.561	
Shredders/m ²	0.390		0.903		0.937	
Slime-mold feeders/m ²	X		X		X	
Xylivores/m ²	X		0.571		0.799	
<i>Acrotrichus</i> sp/m ²	0.339		X		X	
<i>Actium</i> /m ²	X		X		X	
<i>Agulla</i> /m ²	X		0.294		0.426	

PARAMETER	<i>Analysis</i>					
	Thinned vs. Unthinned		Integrated		Leave Island	
	<i>p</i>	Dir.	<i>p</i>	Dir.	<i>p</i>	Dir.
<i>Aleocharine black</i> sp/m ²	0.878		X		X	
<i>Aleocharine red</i> sp/m ²	1.000		0.827		X	
<i>Antrodiaetus</i> /m ²	0.179		0.333		0.025	S<L; M<L
<i>Apochthonius</i> /m ²	0.930		0.346		0.081	M<L
<i>Arctorthesia occidentalis</i> /m ²	0.030	T<U	X		0.399	
<i>Atrechus</i> /m ²	0.604		X		X	
<i>Batrissodes</i> sp/m ²	0.793		0.661		0.489	
<i>Bdellozonium</i> /m ²	0.368		X		X	
<i>Bollmannella</i> /m ²	0.620		X		X	
<i>Brachyrhinus rugostriatus</i> /m ²	0.642		0.801		0.754	
<i>Bradysia</i> /m ²	X		X		0.280	
Byrrhid immature/m ²	0.400		0.411		0.209	
Cantharid immature/m ²	0.506		0.351		0.167	
Carabid immature/m ²	0.814		0.363		0.010	S<L; M<L
<i>Catopocerus</i> sp A/m ²	0.632		0.554		X	
<i>Ceraphron</i> sp B/m ²	0.297		0.600		0.613	
Chironomid/m ²	0.166		0.093		X	
Chordeumid/m ²	0.311		0.503		X	
Curculionid immature/m ²	0.220		X		X	
<i>Cybaeus</i> /m ²	0.461		0.446		0.463	
<i>Cytilus alternatus</i> /m ²	0.075	T>U	0.310		0.591	
<i>Elater</i> 2HK/m ²	0.658		0.668		0.554	
<i>Elater</i> sp 1/m ²	0.468		0.564		X	
Elaterid immature/m ²	0.508		0.261		0.447	
<i>Ellychnia</i> /m ²	0.967		X		X	
<i>Fenderia capizii</i> /m ²	0.489		X		X	
<i>Garypus</i> /m ²	0.594		0.169		X	
<i>Geodercodes latipennis</i> /m ²	0.699		0.756		0.399	
<i>Geophilomorph</i> /m ²	0.648		0.024	T<L; S<M; S<L	0.098	S<M; S<L
Giant <i>Geophilomorph</i> /m ²	0.439		0.345		0.832	
<i>Harpaphe haydeniana haydeniana</i> /m ²	0.899		0.884		0.150	
<i>Hesperonemastoma</i> /m ²	0.402		0.693		X	
<i>Hexura</i> /m ²	0.298		0.210		0.018	S<M

PARAMETER	<i>Analysis</i>					
	Thinned vs. Unthinned		Integrated		Leave Island	
	<i>p</i>	Dir.	<i>p</i>	Dir.	<i>p</i>	Dir.
<i>Ichneumonid/m</i> ²	0.200		0.343		X	
<i>Julid ST/m</i> ²	0.525		0.527		0.295	
<i>Lasius/m</i> ²	0.190		0.421		X	
<i>Ligidium gracile/m</i> ²	0.575		0.436		X	
<i>Lioon simplicipes/m</i> ²	0.755		0.648		0.236	
<i>Listemus formosus/m</i> ²	0.617		X		X	
Lithobid/ <i>m</i> ²	0.897		0.789		0.610	
<i>Lophoderus/m</i> ²	0.546		X		X	
<i>Lucifotychus impellus/m</i> ²	0.326		0.707		0.327	
Lygaeid/ <i>m</i> ²	0.079	T>U	0.249		X	
Lysiopetalid/ <i>m</i> ²	0.151		X		X	
Machilid/ <i>m</i> ²	0.733		X		X	
<i>Megarofonus/m</i> ²	0.423		X		X	
<i>Metanonychus/m</i> ²	0.660		0.664		0.269	
<i>Microcreagis/m</i> ²	0.457		0.398		0.174	
<i>Microcybaeus/m</i> ²	X		X		X	
<i>Micropeplus/m</i> ²	X		X		X	
Micryphantid sp C/ <i>m</i> ²	0.790		0.204		X	
Micryphantid sp D/ <i>m</i> ²	0.670		X		X	
<i>Myrmica/m</i> ²	0.089	T<U	0.107		0.289	
<i>Nearctodesmus/m</i> ²	0.268		X		X	
Noctuid/ <i>m</i> ²	X		0.108		0.164	
<i>Notiophilus sylvaticus/m</i> ²	X		0.367		0.134	
Parasitic wasp sp W/ <i>m</i> ²	X		0.355		0.276	
<i>Polyxenes/m</i> ²	0.531		X		X	
<i>Pristoceuthophilus/m</i> ²	0.080	T<U	0.273		X	
Pselaphid immature/ <i>m</i> ²	0.504		X		X	
<i>Pselaptrichus rothi/m</i> ²	0.417		0.335		X	
<i>Pterostichus lanei/m</i> ²	0.818		0.996		X	
Ptillid adult/ <i>m</i> ²	0.856		X		X	
<i>Scolopocryptops/m</i> ²	0.950		0.580		0.681	
<i>Scutigerella/m</i> ²	0.830		X		X	
<i>Scydmaenus/m</i> ²	0.693		X		X	

PARAMETER	<i>Analysis</i>					
	Thinned vs. Unthinned		Integrated		Leave Island	
	<i>p</i>	Dir.	<i>p</i>	Dir.	<i>p</i>	Dir.
<i>Scytonotus</i> /m ²	0.569		0.613		X	
<i>Siro</i> /m ²	0.884		0.264		X	
Staphylinid immature/m ²	0.308		0.012	T<L; S<L; M<L	0.002	S<L; M<L
Staphylinid sp AR/m ²	0.228		0.403		X	
<i>Steremnius carinatus</i> /m ²	0.020	T>U	0.148		0.835	
<i>Tachinus</i> sp B/m ²	0.822		0.129		X	
<i>Tachyporus</i> sp A/m ²	0.548		X		X	
Tenthredenid/m ²	0.789		X		X	
Tipulid/m ²	0.896		0.316		X	
Trombidiid/m ²	0.558		0.204		X	
<i>Xysticus</i> /m ²	0.135		0.314		0.520	
Amphibians:						
Species richness	0.015	T<U	0.004	S>L; M>L; L<U	0.002	S>L; M>L
Shannon diversity	0.193		0.308		X	
Amphibians/m ²	0.241		0.010	T<S; T<M; S>L; M>L	0.448	
Plethodontids/m ²	0.239		0.014	T<S; T<M; S>L	0.466	
<i>Batrachoseps wrightii</i> /m ²	X		0.730		0.078	S>L; M>L
<i>Ensatina eschscholtzii</i> /m ²	0.366		0.065	T<S	0.729	
<i>Plethodon vehiculum</i> /m ²	X		X		X	
Mollusks:						
Species richness	0.940		0.997		0.787	
Shannon diversity	0.885		0.996		0.949	
Mollusks/m ²	0.122		0.311		0.050	S<L
Snails/m ²	0.114		0.275		0.057	S<L
Slugs/m ²	0.583		0.907		0.887	
<i>Ancotrema sportella</i> /m ²	0.238		0.362		0.079	S<M; S<L
<i>Ancotrema sportella-Haplotrema vancouverense</i> juveniles/m ²	0.137		0.298		0.037	S<M; S<L
<i>Ariolimax columbianus</i> /m ²	0.923		0.723		X	
<i>Haplotrema vancouverense</i> /m ²	0.090	T<U	0.303		0.019	S<L
<i>Monadenia fidelis</i> /m ²	X		X		X	
<i>Vespericola columbianus</i> /m ²	0.175		0.350		0.131	

Table 2. List of all significant ANOVA analyses ($p < 0.10$) and resulting pairwise comparisons (Bonferroni-adjusted p-values: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$) for integrated analyses comparing all five types of forest. Forest types are abbreviated as follows: T=thinned forest, S=small (0.1 ha) leave islands, M=medium (0.2 ha) leave islands, L=large (0.4 ha) leave islands, and U=unthinned forest. For vascular plant analyses, GC=ground cover and * indicates percent of total vascular plant ground cover.

PARAMETER	F	p	Pairwise Comparisons														
			Treatment Means					Thinned vs.				S vs.			M vs.		L vs.
			T	S	M	L	U	S	M	L	U	M	L	U	L	U	U
HABITAT:																	
Relative Humidity:																	
Spring average	5.03	0.021	82.211	82.912	83.848	85.353	85.582			**	*		*				
Ln Spring minimum	7.11	0.007	3.585	3.525	3.588	3.695	3.817				**			***		**	
Spring range	9.69	0.003	64.125	65.917	63.750	59.917	54.917			***		*	***		***		
Spring average daily minimum	6.19	0.011	62.678	63.158	64.675	67.893	70.867			**			**		*		
Summer minimum	8.37	0.004	35.750	32.583	36.083	41.417	42.333			*	*		***	***		*	
Summer range	9.50	0.003	64.000	67.417	63.917	58.583	57.417			*	**		***	***		**	
Summer average daily minimum	12.49	0.001	53.275	52.200	56.533	61.800	62.450			***	***		***	***		*	
Ambient Temperature:																	
Spring average	2.88	0.087	7.522	7.295	7.358	7.146	6.890									*	
Spring average daily maximum	2.82	0.091	12.975	12.433	12.383	11.583	11.067									*	
Summer average	10.41	0.002	15.668	15.258	15.073	14.912	14.748			**	***	***		*			
Summer maximum	10.04	0.002	29.075	27.350	25.600	25.150	24.500			**	***	***		**			
Ln Summer range	9.60	0.003	3.103	3.019	2.942	2.904	2.858			**	***	***		**			
Summer average daily maximum	9.45	0.003	22.825	21.517	20.383	19.967	19.325			**	***	***		**			
Soil Temperature:																	
Summer average	4.40	0.030	13.543	12.932	12.929	12.767	12.778		*	*	**	**					
Summer maximum	5.23	0.019	15.025	14.367	14.367	14.200	14.225		*	*	**	**					
Summer average daily minimum	3.37	0.060	13.192	12.650	12.683	12.500	12.525				*	*					

PARAMETER	F	p	Pairwise Comparisons															
			Treatment Means					Thinned vs.				S vs.			M vs.		L vs.	
			T	S	M	L	U	S	M	L	U	M	L	U	L	U	U	
Summer average daily maximum	4.78	0.024	13.992	13.325	13.300	13.167	13.167	*	*	**	**							
Forest Stand Data:																		
Canopy closure	9.56	0.003	63.333	90.000	88.750	83.750	89.583	***	***	**	***							
Average diameter at breast height (cm)	7.21	0.007	46.708	39.267	42.617	38.525	42.492	***		***								
Trees per hectare	7.13	0.007	226.330	479.000	445.920	445.670	444.920	***	**	**	***							
BIOTA:																		
Vascular Plants (GC=ground cover):																		
Ln Species richness	12.12	0.001	3.554	3.321	3.328	3.183	3.095	**	**	***	***							*
Shannon diversity	4.90	0.022	2.840	2.481	2.460	2.384	2.196		*	**	**							
Number of herb species	7.52	0.006	24.333	18.750	17.417	15.667	13.167		*	**	***							
Percent early-successional GC (percent of total GC)	4.38	0.031	38.758	30.545	18.493	19.882	17.765		**	*	*							
Percent late-successional GC (percent of total GC)	4.55	0.028	60.758	69.356	81.505	80.125	82.245		**	*	*							
Ln Early-successional species GC	8.61	0.004	3.323	2.755	2.436	2.265	2.224		**	***	***							
Number of early-successional species	10.67	0.002	17.417	12.417	9.833	9.917	7.500	*	***	***							*	
Percent late-successional species (percent of total species)	9.41	0.003	51.806	60.734	67.718	65.388	71.382		***	**	***							
Percent early-successional species (percent of total species)	8.08	0.005	47.197	38.648	32.283	34.613	28.618		**	**	***						*	
Ln Percent exotic species GC (percent of total GC)	11.04	0.002	1.774	0.653	0.543	0.315	0.120	**	***	***	***							
Ln Exotic species GC	8.71	0.004	1.684	0.575	0.416	0.249	0.099	**	**	***	***							
Number of native species	4.59	0.027	29.417	26.083	27.083	24.167	22.500			*	**							

Table 3. Qualitative comparison of key occupancy patterns per taxon.

Occurrence by Forest Type	Plants	Arthropods	Amphibians	Mollusks
Thinned only	8	17	0	1
Thinned and any leave island, only	25	20	0	1
Unthinned only	1	21	2	0
Unthinned and any leave island, only	4	39	1	0
Leave islands only	17	52	0	2
All forest types (ubiquitous)	49	104	3	8
Other	16	36	1	0
Total Taxa	120	289	7	12

Table 4. Vascular plant environmental data correlation coefficients with axes 1 and 2 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (τ) coefficients for both axes displayed. Parameters listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Axis:	1			2		
	r	r-sq	tau	r	r-sq	tau
Spring average ambient temperature	-0.941	0.885	-0.726	-0.378	0.143	-0.284
Average annual precipitation	0.940	0.884	0.723	0.060	0.004	-0.107
Spring average daily minimum soil temperature	-0.881	0.775	-0.653	-0.459	0.211	-0.295
Spring average daily minimum RH	0.840	0.705	0.568	0.567	0.321	0.421
Spring soil moisture	0.784	0.615	0.516	0.200	0.040	0.095
Summer soil moisture	0.711	0.505	0.474	0.225	0.051	0.179
Trees per hectare	0.688	0.474	0.547	0.311	0.097	0.189
Downed wood debris density	0.672	0.451	0.432	0.200	0.040	0.095
Basal area (m ² /ha)	0.661	0.436	0.484	0.250	0.062	0.147
Canopy closure	0.600	0.360	0.594	0.360	0.130	0.256
Heatload	0.503	0.253	0.316	0.785	0.617	0.653
Stand age	-0.458	0.210	-0.166	-0.773	0.597	-0.782
Months after timber harvest	-0.307	0.094	-0.426	0.683	0.466	0.403
Summer average ambient temperature	-0.006	0.000	-0.074	0.515	0.266	0.263

Table 5. Vascular plant species data correlation coefficients with axes 1 and 2 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (tau) coefficients for both axes displayed. Species listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Axis:	1			2		
	r	r-sq	tau	r	r-sq	tau
<i>Campanula scouleri</i>	-0.929	0.862	-0.674	-0.384	0.148	-0.229
<i>Tsuga heterophylla</i>	0.922	0.850	0.634	0.426	0.182	0.230
<i>Anemone deltoidea</i>	-0.873	0.762	-0.645	-0.233	0.054	-0.089
<i>Osmorhiza berteroi</i>	-0.873	0.762	-0.760	-0.207	0.043	-0.140
<i>Symphoricarpos albus</i>	-0.869	0.756	-0.777	-0.001	0.000	-0.066
<i>Rosa</i> species	-0.855	0.730	-0.768	-0.043	0.002	-0.111
<i>Galium triflorum</i>	-0.838	0.702	-0.783	-0.500	0.250	-0.212
<i>Symphoricarpos mollis</i>	-0.826	0.681	-0.777	-0.003	0.000	-0.114
<i>Poa</i> species	-0.821	0.674	-0.713	-0.168	0.028	-0.128
<i>Holodiscus discolor</i>	-0.820	0.672	-0.669	-0.287	0.082	-0.199
<i>Pteridium aquilinum</i>	-0.813	0.661	-0.674	-0.123	0.015	-0.058
<i>Adenocaulon bicolor</i>	-0.811	0.657	-0.729	-0.103	0.011	-0.186
<i>Achlys triphylla</i>	-0.798	0.636	-0.662	-0.203	0.041	-0.106
<i>Vancouveria hexandra</i>	-0.784	0.615	-0.697	-0.121	0.015	-0.122
<i>Trientalis borealis</i>	-0.783	0.613	-0.494	-0.341	0.117	-0.216
<i>Viola</i> species	-0.768	0.590	-0.554	-0.493	0.243	-0.311
<i>Corylus cornuta</i>	-0.766	0.587	-0.702	0.119	0.014	0.025
<i>Maianthemum stellatum</i>	-0.738	0.545	-0.596	-0.003	0.000	0.017
<i>Moehringia macrophylla</i>	-0.730	0.533	-0.629	0.097	0.009	0.092
<i>Nemophila parviflora</i>	-0.722	0.521	-0.673	-0.041	0.002	-0.170
<i>Oxalis oregana</i>	0.713	0.508	0.571	-0.157	0.025	-0.078
<i>Chimaphila menziesii</i>	0.704	0.495	0.593	0.543	0.295	0.347
<i>Whipplea modesta</i>	-0.673	0.453	-0.574	0.126	0.016	0.244
<i>Claytonia sibirica</i>	-0.655	0.429	-0.560	-0.450	0.203	-0.269
<i>Vicia sativa</i>	-0.635	0.403	-0.660	-0.097	0.009	-0.117
<i>Thuja plicata</i>	0.618	0.382	0.548	0.005	0.000	0.006
<i>Stachys mexicana</i>	-0.617	0.381	-0.693	-0.332	0.110	-0.218
<i>Oxalis suksdorfii</i>	-0.608	0.370	-0.386	0.010	0.000	-0.036
<i>Blechnum spicant</i>	0.604	0.365	0.542	-0.247	0.061	0.024
<i>Fragaria virginiana</i>	-0.597	0.356	-0.538	0.103	0.011	0.208
<i>Galium trifidum</i>	-0.594	0.353	-0.311	0.091	0.008	0.108
<i>Clinopodium douglasii</i>	-0.589	0.346	-0.520	0.130	0.017	0.225
<i>Thermopsis gracilis</i>	-0.588	0.345	-0.520	0.102	0.010	0.225
<i>Lonicera hispidula</i>	-0.587	0.344	-0.475	-0.124	0.015	-0.062

Axis:	1			2		
	r	r-sq	tau	r	r-sq	tau
<i>Rumex acetosella</i>	-0.516	0.266	-0.488	-0.278	0.077	-0.149
<i>Asarum caudatum</i>	-0.512	0.262	-0.379	-0.515	0.265	-0.448
<i>Pseudotsuga menziesii</i>	-0.446	0.199	-0.315	-0.536	0.287	-0.432
<i>Cardamine species</i>	-0.422	0.178	-0.322	-0.565	0.319	-0.484
<i>Cardamine angulata</i>	-0.418	0.175	-0.293	-0.562	0.315	-0.484
<i>Listera cordata</i>	-0.358	0.128	-0.182	-0.501	0.251	-0.532
<i>Collomia heterophylla</i>	-0.341	0.116	-0.288	-0.530	0.281	-0.428
<i>Trillium ovatum</i>	0.319	0.102	0.289	-0.624	0.389	-0.428
<i>Boykinia occidentalis</i>	0.285	0.081	0.227	0.637	0.406	0.417
<i>Dicentra formosa</i>	-0.231	0.053	-0.203	-0.583	0.340	-0.464
<i>Sonchus species</i>	-0.222	0.049	-0.323	-0.509	0.259	-0.393
<i>Luzula species</i>	0.127	0.016	-0.012	-0.587	0.344	-0.435
<i>Senecio sylvaticus</i>	-0.094	0.009	-0.155	-0.540	0.291	-0.441

Table 6. Arthropod environmental data correlation coefficients with axes 1, 2, and 3 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (τ) coefficients for all axes displayed. Parameters listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Axis:	1			2			3		
	r	r-sq	tau	r	r-sq	tau	r	r-sq	tau
Average annual precipitation	0.908	0.824	0.758	-0.004	0.000	0.107	-0.004	0.000	0.012
Spring average daily minimum ambient temperature	-0.778	0.605	-0.432	-0.356	0.127	-0.358	0.075	0.006	0.095
Spring average ambient temperature	-0.770	0.593	-0.411	-0.363	0.132	-0.379	0.053	0.003	0.032
Summer soil moisture	0.718	0.515	0.495	-0.458	0.210	-0.253	-0.257	0.066	-0.137
Spring average daily minimum soil temperature	-0.698	0.487	-0.463	-0.491	0.241	-0.368	-0.010	0.000	0.021
% rock ground cover	0.677	0.459	0.500	0.386	0.149	0.272	0.135	0.018	0.087
Downed wood debris density	0.668	0.447	0.495	-0.109	0.012	0.021	-0.116	0.013	-0.179
% shrub ground cover	-0.666	0.443	-0.522	-0.430	0.185	-0.332	-0.237	0.056	0.026
Spring average daily minimum RH	0.613	0.376	0.253	0.096	0.009	0.137	-0.304	0.092	-0.211
Spring average daily maximum RH	0.612	0.375	0.434	-0.353	0.124	-0.212	-0.387	0.150	-0.265
Spring average RH	0.601	0.361	0.284	-0.127	0.016	0.042	-0.471	0.222	-0.284
Total % vascular plant ground cover	-0.600	0.360	-0.421	-0.545	0.296	-0.432	-0.025	0.001	0.021
Spring soil moisture	0.564	0.318	0.347	0.147	0.022	0.105	-0.015	0.000	-0.011
Spring average daily maximum soil temperature	-0.426	0.182	-0.253	-0.768	0.590	-0.579	-0.108	0.012	-0.084
Months after timber harvest	-0.393	0.154	-0.509	0.026	0.001	0.118	-0.502	0.252	-0.308
Summer average daily maximum ambient temperature	-0.341	0.116	-0.137	0.571	0.326	0.337	0.019	0.000	-0.032
Summer average daily maximum soil temperature	-0.271	0.073	-0.021	0.773	0.597	0.474	0.267	0.071	0.211
Stand age	-0.242	0.058	-0.083	-0.501	0.251	-0.118	0.304	0.093	0.450
Summer average daily minimum soil temperature	-0.174	0.030	-0.021	0.820	0.673	0.474	0.308	0.095	0.211
Summer average RH	0.159	0.025	0.053	-0.695	0.483	-0.316	-0.587	0.344	-0.432
Summer average daily maximum RH	0.158	0.025	-0.105	-0.630	0.397	-0.368	-0.612	0.375	-0.505

Axis:	1			2			3		
	r	r-sq	tau	r	r-sq	tau	r	r-sq	tau
% moss ground cover	0.106	0.011	0.058	-0.514	0.264	-0.343	0.071	0.005	0.100
Aspect	0.070	0.005	0.027	0.506	0.256	0.456	-0.209	0.044	-0.188
Summer average daily minimum ambient temperature	0.060	0.004	0.053	0.897	0.805	0.589	0.164	0.027	0.137

Table 7. Arthropod species data correlation coefficients with axes 1, 2, and 3 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (τ) coefficients for all axes displayed. Species listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Axis:	1			2			3		
	r	r-sq	tau	r	r-sq	tau	r	r-sq	tau
<i>Geophilomorph</i> species	-0.856	0.733	-0.660	0.103	0.011	0.047	-0.082	0.007	0.005
<i>Staphylinid</i> species	-0.783	0.613	-0.570	0.253	0.064	0.194	-0.209	0.044	-0.022
<i>Carabid</i> species	-0.760	0.578	-0.538	0.477	0.227	0.312	0.045	0.002	0.086
<i>Lysiopetalid</i>	-0.760	0.577	-0.669	-0.419	0.176	-0.200	-0.299	0.089	0.017
<i>Lithobid</i>	-0.760	0.577	-0.533	0.181	0.033	0.090	-0.189	0.036	-0.111
<i>Scolopocryptops</i>	-0.745	0.555	-0.595	-0.174	0.030	-0.080	-0.339	0.115	-0.220
<i>Tachinus</i> species	-0.733	0.537	-0.651	0.091	0.008	0.006	-0.329	0.108	-0.088
<i>Hesperonemastoma</i>	-0.706	0.499	-0.573	-0.169	0.029	-0.152	-0.307	0.094	-0.129
<i>Caseya</i>	-0.693	0.480	-0.544	-0.419	0.175	-0.227	-0.325	0.106	-0.058
<i>Bdellozonium</i>	-0.689	0.475	-0.560	-0.235	0.055	-0.110	-0.609	0.371	-0.110
<i>Cicadellid</i> species	0.686	0.471	0.665	-0.303	0.092	-0.078	-0.071	0.005	-0.169
<i>Bracon</i> X	0.681	0.464	0.552	-0.205	0.042	-0.169	0.191	0.036	0.155
<i>Batrissodes</i> species	-0.622	0.387	-0.454	0.403	0.163	0.238	-0.027	0.001	-0.054
<i>Lucifotychus</i> species	-0.601	0.361	-0.447	0.503	0.253	0.277	0.098	0.010	0.032
<i>Arctorthesia occidentalis</i>	-0.598	0.358	-0.448	0.483	0.233	0.328	0.384	0.147	0.197
<i>Antrodiaetus</i> species	-0.590	0.349	-0.439	0.615	0.379	0.428	-0.144	0.021	-0.005
<i>Myrmica</i>	-0.580	0.336	-0.459	-0.345	0.119	-0.216	-0.489	0.239	-0.237
<i>Colon</i>	-0.539	0.291	-0.498	-0.350	0.123	-0.234	-0.497	0.247	-0.376
<i>Atrechus</i>	-0.532	0.283	-0.358	-0.589	0.347	-0.336	-0.437	0.191	-0.325
<i>Taracus</i>	-0.531	0.281	-0.446	-0.315	0.099	-0.234	-0.412	0.170	-0.304
<i>Ptiliid</i> species	-0.525	0.276	-0.312	-0.055	0.003	-0.043	-0.514	0.264	-0.519
<i>Pterostichus</i> species	-0.524	0.275	-0.313	-0.431	0.186	-0.292	0.002	0.000	0.037
<i>Anatis</i>	0.517	0.268	0.381	0.023	0.001	0.073	0.133	0.018	0.073
Parasitic wasp species	0.517	0.267	0.379	-0.004	0.000	-0.048	-0.334	0.111	-0.197
<i>Geodercodes latipennis</i>	0.496	0.246	0.327	0.036	0.001	0.172	-0.601	0.362	-0.449
<i>Brachyrhinus rugostriatus</i>	0.491	0.241	0.280	0.581	0.337	0.430	0.344	0.119	0.140
<i>Microcreagis</i>	-0.489	0.239	-0.324	-0.059	0.003	0.005	-0.641	0.411	-0.355
<i>Fenderia capizii</i>	-0.482	0.232	-0.351	-0.210	0.044	0.011	-0.879	0.772	-0.612

Axis:	1			2			3		
	r	r-sq	tau	r	r-sq	tau	r	r-sq	tau
<i>Lasius</i>	-0.467	0.218	-0.242	-0.344	0.118	-0.277	-0.526	0.277	-0.313
<i>Lophoderus</i>	-0.455	0.207	-0.308	-0.115	0.013	-0.099	-0.810	0.657	-0.539
<i>Acrotrichus</i> species	-0.437	0.191	-0.229	-0.213	0.045	-0.229	-0.835	0.697	-0.486
<i>Julid</i> species	-0.425	0.181	-0.281	0.865	0.748	0.606	0.100	0.010	0.076
<i>Tipulid</i>	-0.409	0.167	-0.303	0.634	0.402	0.476	0.169	0.029	0.227
<i>Agulla</i>	0.399	0.159	0.220	-0.730	0.534	-0.610	-0.179	0.032	-0.170
<i>Machilid</i>	0.399	0.159	0.339	-0.576	0.331	-0.364	-0.327	0.107	-0.236
<i>Lucanid</i> (immature)	-0.383	0.147	-0.298	-0.132	0.018	-0.107	-0.608	0.370	-0.394
<i>Noctuid</i>	-0.383	0.146	-0.278	-0.270	0.073	-0.213	-0.605	0.366	-0.409
<i>Microcybaeus</i>	-0.382	0.146	-0.277	-0.203	0.041	-0.121	-0.716	0.513	-0.555
<i>Liposcelis</i>	-0.380	0.145	-0.274	-0.045	0.002	0.107	-0.625	0.391	-0.417
<i>Usofila</i>	-0.378	0.143	-0.291	0.426	0.182	0.260	0.500	0.250	0.449
<i>Ceratolasma</i>	-0.372	0.138	-0.301	-0.486	0.236	-0.380	-0.503	0.253	-0.396
<i>Pselaphid</i> (immature)	-0.369	0.136	-0.253	0.253	0.064	0.189	-0.553	0.306	-0.351
<i>Nearctodesmus</i>	-0.367	0.135	-0.182	-0.084	0.007	0.084	-0.606	0.367	-0.251
<i>Nemocestes puncticollis</i>	0.359	0.129	0.210	-0.712	0.507	-0.581	-0.262	0.069	-0.259
<i>Megaselia</i>	0.352	0.124	0.292	0.525	0.276	0.541	-0.087	0.008	-0.115
<i>Pristoceuthophilus</i>	0.351	0.123	0.228	-0.650	0.423	-0.425	-0.393	0.154	-0.265
<i>Smittia</i>	-0.351	0.123	-0.227	0.532	0.283	0.406	0.170	0.029	0.351
<i>Bollmannella</i>	-0.350	0.123	-0.148	0.512	0.262	0.371	0.538	0.289	0.432
<i>Ceraphron</i> species	0.348	0.121	0.199	0.090	0.008	0.133	-0.528	0.279	-0.354
<i>Catopocerus</i> species	-0.328	0.108	-0.198	0.023	0.001	0.134	-0.669	0.448	-0.424
<i>Aranaeus saevus</i>	-0.326	0.106	-0.107	-0.113	0.013	-0.060	-0.560	0.313	-0.203
<i>Enicmus</i>	-0.324	0.105	-0.110	0.033	0.001	0.269	-0.643	0.413	-0.448
<i>Siro acaroides</i>	-0.300	0.090	-0.170	0.722	0.521	0.565	0.115	0.013	0.115
<i>Micropeplus</i>	-0.297	0.088	-0.253	0.054	0.003	-0.063	-0.580	0.336	-0.586
<i>Polyxenes</i>	0.283	0.080	0.328	-0.329	0.108	-0.236	-0.571	0.327	-0.342
<i>Harpalus</i> species	-0.277	0.076	-0.070	-0.228	0.052	-0.269	-0.589	0.347	-0.329
<i>Proctotrupid</i> species	-0.274	0.075	-0.169	-0.139	0.019	-0.104	-0.636	0.404	-0.430
<i>Actium</i>	-0.260	0.067	-0.142	-0.053	0.003	-0.026	-0.559	0.312	-0.530
<i>Tenebrionid</i> (immature)	-0.246	0.060	-0.186	0.763	0.582	0.483	0.343	0.117	0.239
<i>Micromoth</i>	-0.245	0.060	0.026	-0.057	0.003	0.166	-0.680	0.462	-0.480
<i>Malachius</i>	-0.229	0.052	-0.141	0.070	0.005	0.141	-0.663	0.440	-0.423
<i>Piestus</i>	-0.222	0.049	-0.135	-0.262	0.069	-0.151	-0.628	0.394	-0.326

Axis:	1			2			3		
	r	r-sq	tau	r	r-sq	tau	r	r-sq	tau
<i>Scaphinotus</i> species	0.190	0.036	0.172	-0.595	0.353	-0.474	-0.339	0.115	-0.287
<i>Scutigerella</i>	0.161	0.026	0.175	0.525	0.275	0.328	-0.368	0.135	-0.295
<i>Byrrhid</i> (immature)	-0.150	0.023	-0.016	0.642	0.412	0.443	0.234	0.055	0.165
<i>Scytonotus</i>	-0.150	0.023	-0.061	-0.628	0.395	-0.419	-0.739	0.546	-0.530
<i>Bradysia</i>	-0.149	0.022	-0.171	0.545	0.297	0.471	-0.524	0.275	-0.342
<i>Diapriid</i> species	-0.150	0.022	-0.061	-0.146	0.021	-0.122	-0.661	0.437	-0.511
<i>Listemus formosus</i>	0.143	0.020	0.089	0.814	0.662	0.691	0.268	0.072	0.195
<i>Trombidiid</i>	-0.136	0.018	-0.098	0.682	0.465	0.522	-0.235	0.055	-0.174
<i>Elater</i> species	0.118	0.014	0.069	0.525	0.276	0.451	-0.477	0.228	-0.324
<i>Chordeumid</i>	-0.115	0.013	-0.070	-0.746	0.556	-0.456	-0.376	0.141	-0.274
<i>Micryphantid</i> species	-0.100	0.010	-0.193	0.729	0.531	0.588	-0.104	0.011	-0.032
<i>Notiophilus sylvaticus</i>	-0.082	0.007	-0.042	0.862	0.744	0.601	0.404	0.163	0.346
<i>Megarofonus</i> species	-0.084	0.007	0.029	0.151	0.023	0.179	-0.538	0.290	-0.295
<i>Apochthonius</i>	0.076	0.006	-0.021	0.586	0.344	0.434	-0.341	0.116	-0.254
<i>Cytilus alternatus</i>	0.072	0.005	0.048	0.602	0.363	0.400	0.265	0.070	0.133
<i>Geometrid</i> (immature)	-0.057	0.003	0.014	0.066	0.004	0.027	-0.576	0.332	-0.544
<i>Ichneumonid</i> (adult)	0.028	0.001	0.133	-0.130	0.017	0.000	-0.522	0.272	-0.266

Table 8. Amphibian environmental data correlation coefficients with axes 1 and 2 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (τ) coefficients for both axes displayed. Parameters listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Axis:	1			2		
	r	r-sq	tau	r	r-sq	tau
Average annual precipitation	0.875	0.765	0.757	0.004	0.000	-0.020
Spring average ambient temperature	-0.820	0.673	-0.567	-0.053	0.003	-0.088
Spring average daily maximum ambient temperature	-0.793	0.628	-0.579	-0.083	0.007	-0.076
% shrub ground cover	-0.765	0.585	-0.563	-0.445	0.198	0.000
Spring average daily minimum soil temperature	-0.727	0.529	-0.497	-0.106	0.011	-0.041
Downed wood debris density	0.690	0.476	0.532	-0.126	0.016	-0.205
% litter ground cover	0.666	0.444	0.394	0.240	0.058	-0.037
Spring average daily minimum RH	0.654	0.428	0.404	-0.229	0.053	-0.123
Total % vascular plant ground cover	-0.649	0.422	-0.380	-0.479	0.229	-0.205
Spring soil moisture	0.641	0.411	0.520	-0.140	0.020	-0.123
Spring average RH	0.626	0.392	0.298	-0.397	0.158	-0.135
Summer soil moisture	0.622	0.387	0.404	-0.399	0.159	-0.193
Average tree diameter at breast height	-0.584	0.340	-0.404	-0.308	0.095	-0.158
% rock ground cover	0.552	0.305	0.433	0.175	0.031	0.120
Trees per hectare	0.553	0.305	0.380	0.413	0.171	0.251
Basal area (m ² /ha)	0.544	0.296	0.333	0.314	0.099	0.298
Spring average daily maximum soil temperature	-0.514	0.264	-0.357	-0.289	0.084	-0.205
Heatload	0.366	0.134	0.216	-0.515	0.265	-0.263
Months after timber harvest	-0.337	0.113	-0.428	-0.565	0.319	-0.309
Summer average daily maximum RH	0.199	0.040	-0.029	-0.724	0.524	-0.556

Table 9. Amphibian species data correlation coefficients with axes 1 and 2 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (τ) coefficients for both axes displayed. Species listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Axis:	1			2		
	r	r-sq	tau	r	r-sq	tau
<i>Batrachoseps wrighti</i>	0.888	0.789	0.862	-0.172	0.029	-0.265
<i>Ensatina eschscholtzii</i>	0.595	0.354	0.397	0.701	0.491	0.519
<i>Plethodon vehiculum</i>	-0.269	0.072	-0.301	0.753	0.567	0.680

Table 10. Mollusk environmental data correlation coefficients with axes 1, 2, and 3 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (τ) coefficients for all axes displayed. Parameters listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Axis:	1			2			3		
	r	r-sq	tau	r	r-sq	tau	r	r-sq	tau
Spring average daily minimum soil temperature	0.816	0.666	0.621	-0.002	0.000	0.032	0.045	0.002	0.032
Spring average daily minimum ambient temperature	0.809	0.654	0.547	0.125	0.016	0.147	-0.090	0.008	0.021
Average annual precipitation	-0.772	0.596	-0.687	-0.190	0.036	-0.142	0.488	0.239	0.284
% shrub ground cover	0.771	0.594	0.649	-0.113	0.013	0.005	-0.155	0.024	-0.090
Spring average daily maximum ambient temperature	0.750	0.562	0.484	0.179	0.032	0.147	-0.120	0.015	-0.021
% rock ground cover	-0.745	0.556	-0.489	0.199	0.039	-0.054	0.110	0.012	0.065
Total % vascular plant ground cover	0.722	0.521	0.558	-0.150	0.022	-0.032	-0.067	0.004	0.032
Spring average daily maximum soil temperature	0.685	0.469	0.432	-0.139	0.019	-0.116	0.374	0.140	0.221
Spring soil moisture	-0.603	0.363	-0.421	-0.228	0.052	-0.147	0.200	0.040	0.084
Spring average daily minimum RH	-0.588	0.345	-0.347	-0.356	0.127	-0.347	0.167	0.028	0.074
Downed wood debris density	-0.504	0.254	-0.421	-0.286	0.082	-0.232	0.432	0.187	0.295
% litter ground cover	-0.479	0.230	-0.414	-0.177	0.031	-0.303	0.451	0.203	0.370
Spring average RH	-0.477	0.228	-0.358	-0.436	0.190	-0.379	0.303	0.092	0.126
Summer soil moisture	-0.467	0.218	-0.316	-0.399	0.159	-0.400	0.676	0.457	0.421
% herbaceous ground cover	0.465	0.216	0.242	-0.134	0.018	-0.137	0.033	0.001	0.095
Stand age	0.436	0.190	0.154	0.102	0.010	0.320	0.423	0.179	0.225
Summer average daily minimum ambient temperature	-0.432	0.186	-0.189	0.256	0.065	0.211	-0.666	0.443	-0.442
Trees per hectare	-0.418	0.174	-0.347	-0.247	0.061	-0.179	0.043	0.002	0.053
Spring average daily maximum RH	-0.376	0.141	-0.339	-0.407	0.166	-0.423	0.504	0.254	0.296
Average tree diameter at breast height	0.342	0.117	0.284	0.209	0.044	0.116	0.010	0.000	-0.032
Basal area (m ² /ha)	-0.339	0.115	-0.242	-0.308	0.095	-0.263	0.145	0.021	0.074

Axis:	1			2			3		
	r	r-sq	tau	r	r-sq	tau	r	r-sq	tau
Heatload	-0.317	0.100	-0.179	-0.281	0.079	-0.284	-0.069	0.005	-0.116
Months after timber harvest	0.316	0.100	0.415	-0.166	0.027	-0.036	-0.458	0.210	-0.391
Hardwood basal area (m ² /ha)	0.266	0.071	0.270	-0.431	0.185	-0.284	-0.098	0.010	-0.036
Summer average daily minimum soil temperature	-0.236	0.056	-0.116	0.566	0.320	0.347	-0.707	0.499	-0.432
Summer average ambient temperature	-0.236	0.055	-0.211	0.281	0.079	0.189	-0.785	0.617	-0.526
% moss ground cover	0.208	0.043	0.121	-0.183	0.034	-0.016	0.133	0.018	0.005
Summer average soil temperature	-0.200	0.040	-0.105	0.571	0.326	0.358	-0.720	0.518	-0.442
Canopy closure	-0.200	0.040	-0.354	-0.354	0.125	-0.213	0.052	0.003	-0.005
Slope	0.185	0.034	0.150	0.483	0.233	0.353	-0.288	0.083	-0.128
Aspect	-0.171	0.029	-0.091	-0.062	0.004	-0.123	-0.441	0.195	-0.274
% exposed soil ground cover	0.134	0.018	0.043	-0.394	0.155	-0.333	0.296	0.088	0.312
Summer average RH	0.110	0.012	0.042	-0.603	0.364	-0.400	0.614	0.377	0.421
Summer average daily maximum RH	0.090	0.008	0.158	-0.573	0.328	-0.284	0.400	0.160	0.179
Summer average daily minimum RH	-0.033	0.001	-0.063	-0.568	0.322	-0.442	0.659	0.434	0.400
Summer average daily maximum ambient temperature	-0.030	0.001	-0.021	0.379	0.143	0.211	-0.747	0.559	-0.484

Table 11. Mollusk species data correlation coefficients with axes 1, 2, and 3 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (τ) coefficients for all axes displayed. Species listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Axis:	1			2			3		
	r	r-sq	tau	r	r-sq	tau	r	r-sq	tau
<i>Ancotrema sportella</i>	0.872	0.760	0.732	-0.066	0.004	-0.005	-0.378	0.143	-0.222
<i>Vespericola columbianus</i>	0.823	0.678	0.642	-0.700	0.490	-0.379	-0.020	0.000	0.011
<i>Haplotrema vancouverense</i>	0.762	0.581	0.501	-0.784	0.615	-0.512	0.370	0.137	0.301
<i>Monadenia fidelis</i>	0.686	0.471	0.728	-0.218	0.047	-0.146	-0.072	0.005	-0.040
<i>Prophysaon</i> species	-0.540	0.292	-0.412	-0.462	0.214	-0.345	-0.032	0.001	0.033
<i>Hemphillia malonei</i>	-0.412	0.170	-0.427	-0.181	0.033	-0.222	0.778	0.605	0.602
<i>Ancotrema sportella/Haplotrema vancouverense</i>	0.257	0.066	0.219	-0.462	0.214	-0.432	0.647	0.419	0.517
<i>Ariolimax columbianus</i>	-0.175	0.031	-0.122	0.402	0.162	0.387	-0.554	0.307	-0.498

Table 12. Summary of key findings. Bold indicates concurrence of findings among different analyses. +/- indicates direction of treatment effect (i.e., + indicates parameter increased with forest thinning/with larger leave island size). Treatment names for indicator species analysis results are abbreviated as follows: T = thinned forest, S = small (0.1 ha) leave islands, M = medium (0.2 ha) leave islands, L = large (0.4 ha) leave islands, and U = unthinned forest.

Analysis	Taxon			
	Plants	Arthropods	Amphibians	Mollusks
ANOVA—Thinning effect	% late-successional species ground cover (-)	% low-mobility captures (-)	Species richness (-)	1 species (-)
	% late-successional species (-)	1 species (-)		
	% native species (-)	4 species groups (-)		
	Species richness (+)	2 species (+)		
	Shannon diversity (+)	1 species group (+)		
	Total ground cover (+)			
	Herb and tree ground cover (+)			
	No. herb species (+)			
	% early-successional species ground cover* (+)			
	Early-successional species ground cover (+)			
	No. early-successional species (+)			
	% early-successional species* (+)			
	% exotic species ground cover* (+)			
	Exotic species ground cover (+)			
	No. exotic species (+)			
	% exotic species* (+)			
	No. native species (+)			
	2 species ground cover (+)			
	1 species group ground cover (+)			

Analysis	Taxon			
	Plants	Arthropods	Amphibians	Mollusks
ANOVA—Leave island effect	% late-successional species ground cover (+)	Species richness (+)	Species richness (-)	Mollusk density (+)
	% late-successional species (+)	Arthropods density (+)	1 species (-)	Snail density (+)
	% native species (+)	No. functional groups (+)	1 species (+)	2 species (+)
	1 species ground cover (+)	No. low-mobility species (+)		1 species group (+)
	Species richness (-)	Low-mobility captures (+)		
	Shannon diversity (-)	No. high-mobility species (+)		
	No. herb species (-)	High-mobility species density (+)		
	% early-successional species ground cover* (-)	LSOG-associated captures/m ² (+)		
	Early-successional species ground cover (-)	6 species groups (+)		
	% early-successional species* (-)			
	No. early-successional species (-)			
	% exotic species ground cover* (-)			
	Exotic species ground cover (-)			
	No. exotic species (-)			
	% exotic species* (-)			
	No. native species (-)			
	4 species ground cover (-)			
1 species group ground cover (-)				
Indicator species	<i>Hypochoeris radicata</i> (T)	<i>Steremnius carinatus</i> (T)		
	<i>Chamerion angustifolium</i> (T)	<i>Hexura</i> (M)		
	<i>Epilobium ciliatum</i> (T)	<i>Staphylinid</i> species (L)		
	<i>Cirsium vulgare</i> (T)			
	<i>Asteraceae</i> species (T)			
	<i>Luzula</i> species (T)			
	<i>Acer circinatum</i> (M)			

Figure and Table Captions

Figure 1. Location of four study sites within the study area of western Oregon. Mountain ranges, rivers, and major cities are displayed.

Figure 2. Schematic of sampling area showing four parallel transects sampled for vascular plants, amphibians, and mollusks. Five arthropod sampling plots (•) and one microclimate sampling point (+) are displayed.

Figure 3. Rank abundance curves for a) vascular plants, b) arthropods, c) amphibians, and d) mollusks. Species names, ranks, taxonomic classifications, functional group assignments, site occurrences, and forest type occurrences are listed in Appendices A and B.

Figure 4. NMS ordination diagrams for a) vascular plants, b) arthropods, c) amphibians, and d) mollusks. Site names are abbreviated as follows: BL = Bottomline, DC = Delph Creek, GP = Green Peak, and KM = Keel Mountain. Solid ellipses indicate Coast Range sites. Dashed ellipses indicate Cascade Range sites. Sampling units are plotted in species space. a) 2-dimensional NMS ordination solution for vascular plant species data. Together, these two axes represented 92.5% of the variation in the original data (79.2% and 13.3% for axis 1 and axis 2, respectively). b) Axis 2 and axis 1 of 3-dimensional NMS ordination solution for arthropod species data, representing 94.3% of the variation in the original data. Together, these two axes represented 73.1% of the variation in the original data (42.9% and 30.2% for axis 2 and axis 1, respectively). Axis 3 accounted for the remaining 21.2% of the variation in the original data. c)

2-dimensional NMS ordination solution for amphibian species data. Together, these two axes represented 91.3% of the variation in the original data (54.0% and 37.3% for axis 1 and axis 2, respectively). d) Axis 1 and axis 3 of 3-dimensional NMS ordination solution for mollusk species data, representing 96.2% of the variation in the original data. Together, these two axes represented 81.2% of the variation in the original data (61.0% and 20.2% for axis 1 and axis 3, respectively). Axis 2 accounted for the remaining 15.0% of the variation in the original data.

Table 1. List of all ANOVA results (p-values) for habitat and biota, including thinned vs. unthinned forest analyses, integrated analyses (simultaneous comparison of all five types of forest), and leave island analyses. Forest types are abbreviated as follows: T = thinned forest, S = small (0.1 ha) leave islands, M = medium (0.2 ha) leave islands, L = large (0.4 ha) leave islands, and U = unthinned forest. Direction of treatment effects (Dir.) indicated for all significant analyses ($p < 0.10$). Analyses not meeting ANOVA assumptions indicated with 'X'. For vascular plant analyses, * indicates percent of total vascular plant ground cover.

Table 2. List of all significant ANOVA analyses ($p < 0.10$) and resulting pairwise comparisons (Bonferroni-adjusted p-values: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$) for integrated analyses comparing all five types of forest. Forest types are abbreviated as follows: T = thinned forest, S = small (0.1 ha) leave islands, M = medium (0.2 ha) leave islands, L = large (0.4 ha) leave islands, and U = unthinned forest. For vascular plant analyses, GC = ground cover and * indicates percent of total vascular plant ground cover.

Table 3. Qualitative comparison of key occupancy patterns per taxon.

Table 4. Vascular plant environmental data correlation coefficients with axes 1 and 2 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (τ) coefficients for both axes displayed. Parameters listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Table 5. Vascular plant species data correlation coefficients with axes 1 and 2 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (τ) coefficients for both axes displayed. Species listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Table 6. Arthropod environmental data correlation coefficients with axes 1, 2, and 3 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (τ) coefficients for all axes displayed. Parameters listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Table 7. Arthropod species data correlation coefficients with axes 1, 2, and 3 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (τ) coefficients for all axes displayed. Species listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Table 8. Amphibian environmental data correlation coefficients with axes 1 and 2 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (τ)

coefficients for both axes displayed. Parameters listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Table 9. Amphibian species data correlation coefficients with axes 1 and 2 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (τ) coefficients for both axes displayed. Species listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Table 10. Mollusk environmental data correlation coefficients with axes 1, 2, and 3 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (τ) coefficients for all axes displayed. Parameters listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Table 11. Mollusk species data correlation coefficients with axes 1, 2, and 3 of NMS ordination solution. Pearson (r), proportion of variance (r^2), and Kendall rank correlation (τ) coefficients for all axes displayed. Species listed only if proportion of variance (r^2) explained by at least one axis was greater than or equal to 0.250.

Table 12. Summary of key findings. Bold indicates concurrence of findings among different analyses. +/- indicates direction of treatment effect (i.e., + indicates parameter increased with forest thinning/with larger leave island size). Treatment names for indicator species analysis results are abbreviated as follows: T = thinned forest, S = small (0.1 ha) leave islands, M = medium (0.2 ha) leave islands, L = large (0.4 ha) leave islands, and U = unthinned forest.

Appendix A: Flora species list. Site names are abbreviated as follows: BL = Bottomline, DC = Delph Creek, GP = Green Peak, and KM = Keel Mountain. Forest types are abbreviated as follows: T = thinned forest, S = small (0.1 ha) leave islands, M = medium (0.2 ha) leave islands, L = large (0.4 ha) leave islands, and U = unthinned forest.

Appendix B: Fauna species list. Site names are abbreviated as follows: BL = Bottomline, DC = Delph Creek, GP=Green Peak, and KM = Keel Mountain. Forest types are abbreviated as follows: T = thinned forest, S = small (0.1 ha) leave islands, M = medium (0.2 ha) leave islands, L = large (0.4 ha) leave islands, and U = unthinned forest. Forest association assignments are as follows: LSOG = late-successional/old-growth, DIST = disturbed forest, BIPH = bi-phasic, associated with both LSOG and disturbed forest during different life stages.

Appendix C: Study site indicator species analysis results. Vascular plant, arthropod, amphibian, and mollusk indicator species listed for all study sites ($p < 0.10$). Site names are abbreviated as follows: BL = Bottomline, DC = Delph Creek, GP = Green Peak, and KM = Keel Mountain.

Appendix D: Mountain range indicator species analysis results. Vascular plant, arthropod, amphibian, and mollusk indicator species listed for Cascade and Coast mountain ranges ($p < 0.10$).

Figure 1. Location of four study sites within the study area of western Oregon. Mountain ranges, rivers, and major cities are displayed.

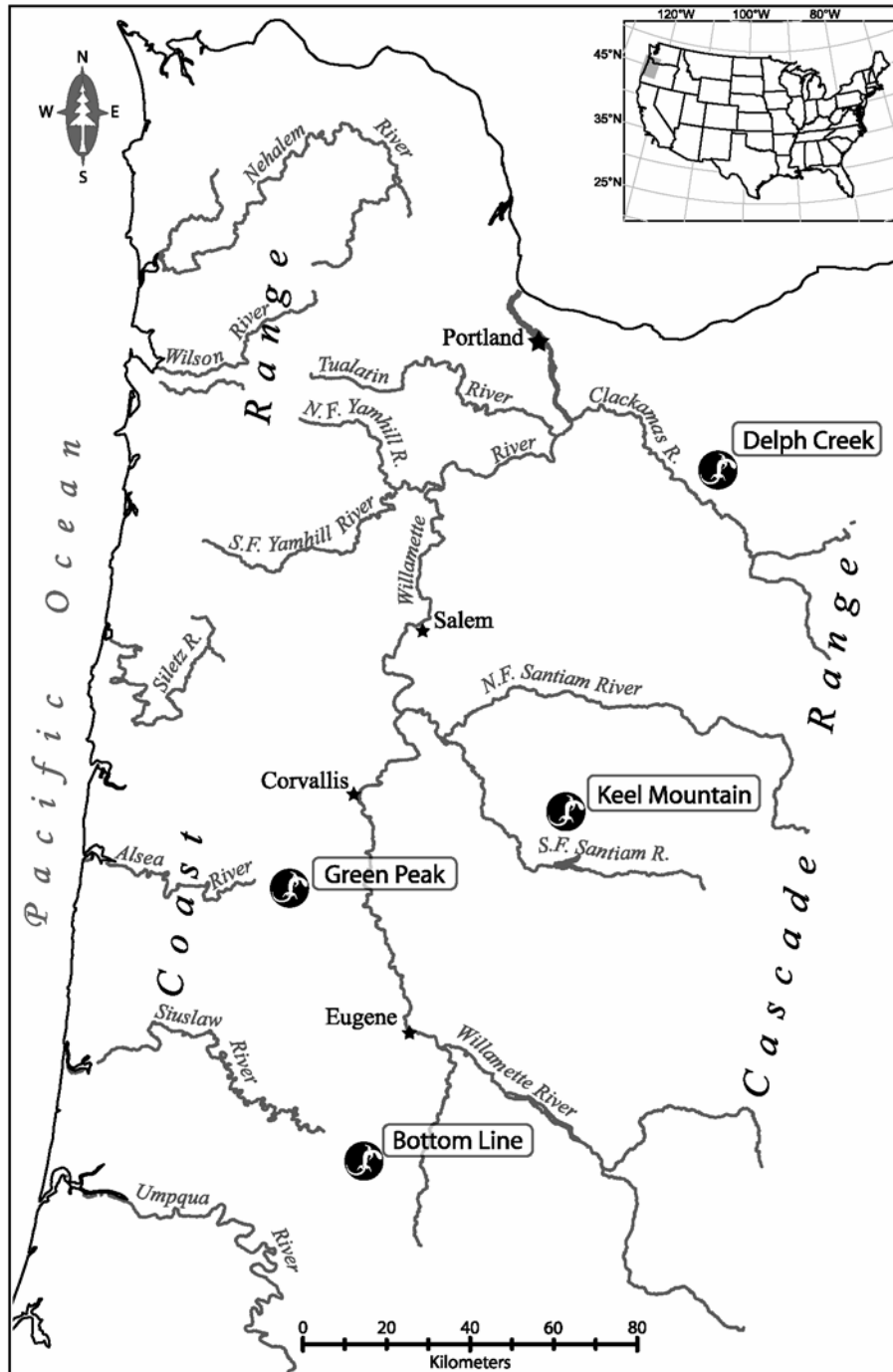


Figure 2. Schematic of sampling area showing four parallel transects sampled for vascular plants, amphibians, and mollusks. Five arthropod sampling plots (•) and one microclimate sampling point (+) are displayed.

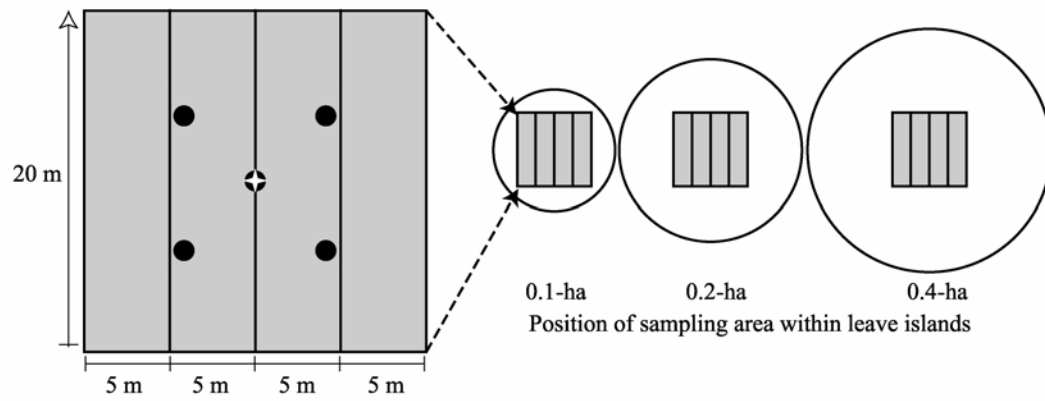


Figure 3. Rank abundance curves for a) vascular plants, b) arthropods, c) amphibians, and d) mollusks. Species names, ranks, taxonomic classifications, functional group assignments, site occurrences, and forest type occurrences are listed in Appendices A and B.

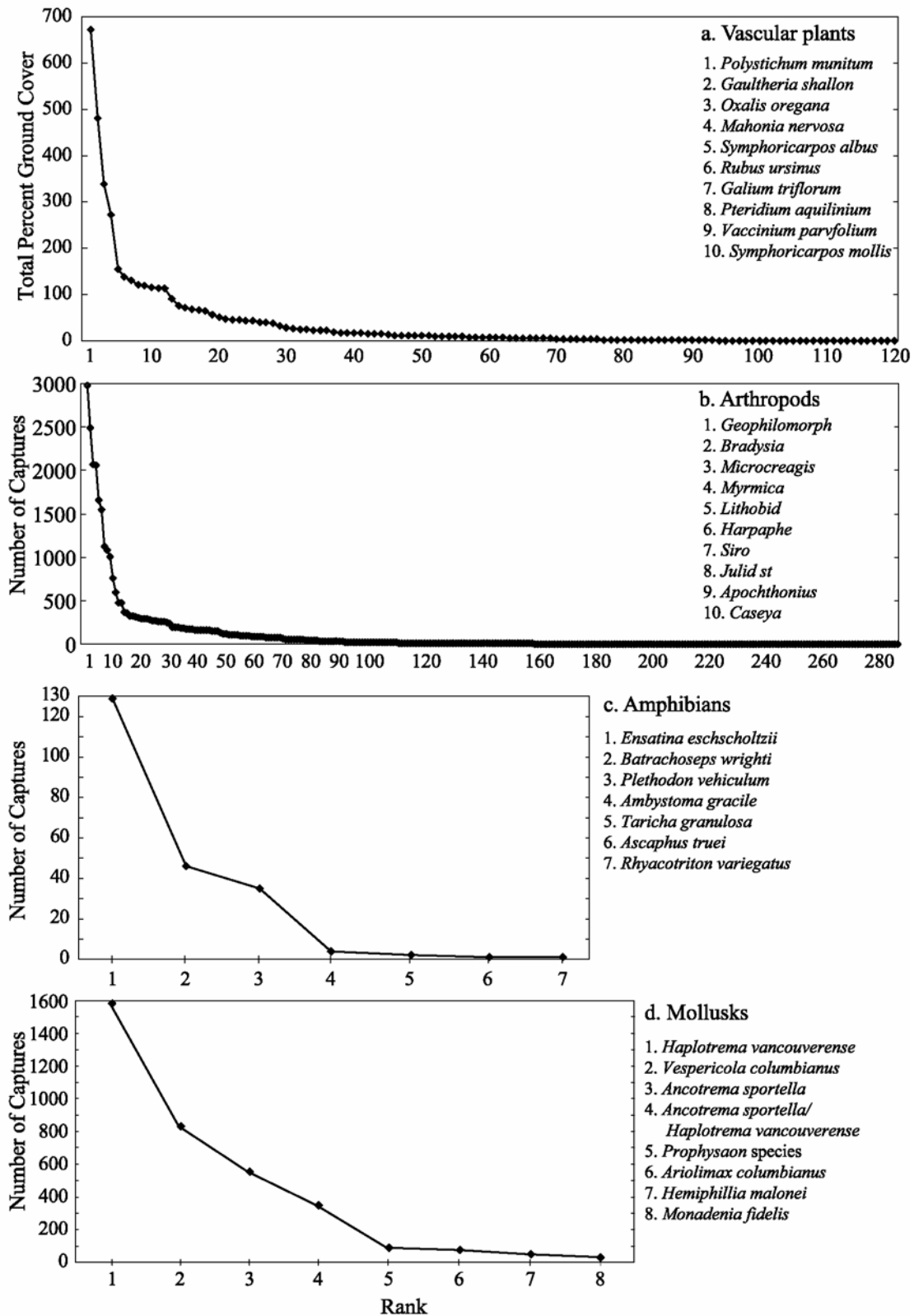
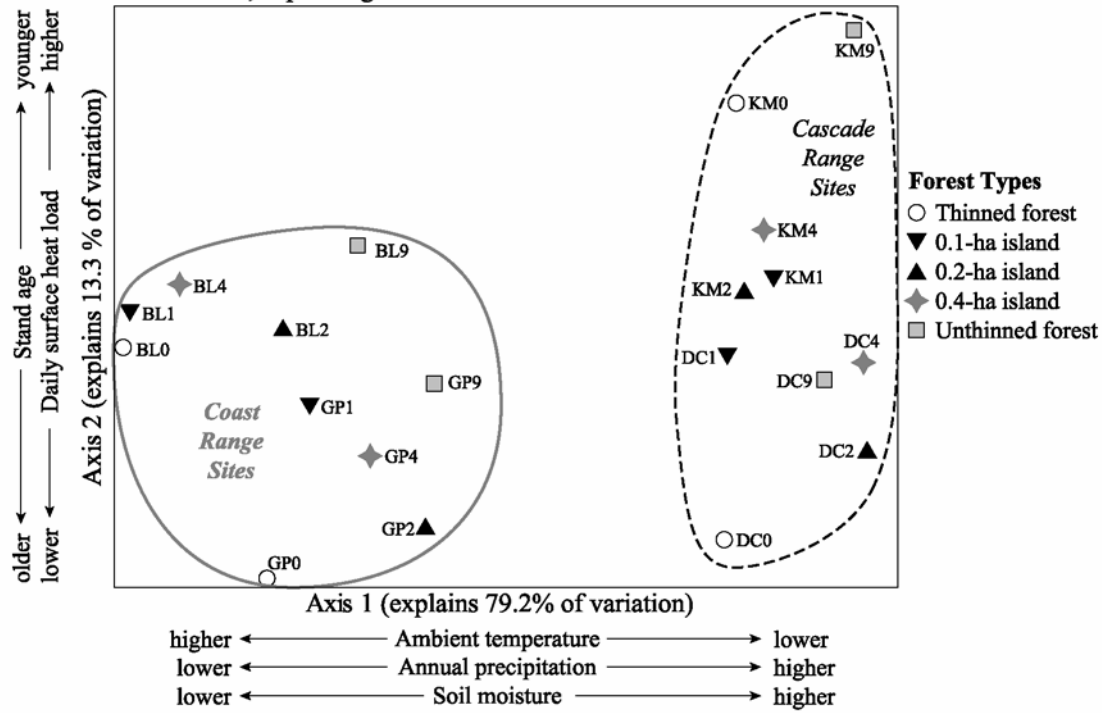


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Study sites: BL = Bottom Line; DC = Delph Creek; GP = Green Peak; KM = Keel Mountain.

a. Vascular plants

2-D solution, explaining 92.5% of variation



b. Arthropods

3-D solution, axes 1 & 2 together explain 73.1% of variation; axis 3 explains 21.2%

