Laying the groundwork:

post-fire complex early-seral forest community trajectories in western Cascadia

Liliana Katiana Rangel-Parra

A thesis

submitted in partial fulfillment of the

requirements for the degree of

Master of Science

University of Washington

2022

Committee:

Brian J. Harvey

Abigail L. S. Swann

Soo-Hyung Kim

Joshua S. Halofsky

Program Authorized to Offer Degree:

Environmental and Forest Sciences

University of Washington

Abstract

Laying the groundwork:

post-fire complex early-seral forest community trajectories in western Cascadia

Liliana Katiana Rangel-Parra

Chair of the Supervisory Committee:

Brian J. Harvey

School of Environmental and Forest Sciences

Climate warming and associated increases in fire activity elevate the importance of understanding post-fire complex early-seral forest (CESF) plant communities – assemblages that dominate post-fire until tree canopy closure. CESFs support high levels of biodiversity and ecosystem function, influencing successional trajectories of forest development; yet relatively little is known about CESFs compared to tree regeneration post-fire. This is especially true in forests characterized by infrequent high-severity wildfires, where opportunities to track post-fire CESFs are rare. Here, we characterize CESF plant communities after wildfire in western Cascadia (temperate maritime conifer forests in western Washington and northwestern Oregon, USA), and ask: (Q1) What is the flora of CESF communities compared to analogous unburned forests? How do community composition (Q2), and alpha diversity (species richness and evenness within stands) and beta diversity (compositional change among stands) (Q3), vary with pre-fire stand age and burn severity? We established 86 1-ha plots (stands) across four wildfires where we recorded percent cover for graminoids, bryophytes, and vascular plants to species, across strata combinations of three levels of pre-fire stand age (young, mid-seral, late-seral) and burn severity (unburned, low, high). Across strata, we compared relative abundance of species and life forms in post-fire and unburned stands (Q1), and differences in community composition (Q2) and alpha and beta diversity (Q3) across pre-fire stand age and burn severity using a range of univariate and multivariate analyses. We observed 206 species overall, with 91 species common to both burned and unburned stands. Burned stands had 83 unique species and were primarily dominated by native herbs. In contrast, unburned stands had 32 unique species and were largely shrub-dominated. Differences in CESF communities among stands were strongly and consistently driven by differences in burn severity and secondarily by differences in pre-fire stand age; composition varied widely across stands within and among strata, leading to high beta diversity. Within-stand alpha diversity was high (species richness: 22.3-31.8) across strata, with the exception of mid-seral unburned stands (species richness: 11.9); evenness did not differ among strata. Our findings have important implications for understanding and managing forests pre- and post-fire in infrequent and stand-replacing fire regimes. Specifically, our results show that an abundant, though relatively species poor, forest condition in western Cascadia (mid-seral forests) may experience the greatest increase in biodiversity and compositional heterogeneity following fire. Finally, different combinations of pre-fire conditions and fire severity on stands provide unique community assemblages, which can support a diverse array of ecosystem processes and provisions.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACKNOWLEDGMENTS

I would love to thank...

My advisor and mentor, Brian Harvey, for your unwavering support, guidance, and encouragement in believing in myself as a scientist, student, and individual.

My committee members, Joshua Halofsky, Abigail Swann, and Soo-Hyung Kim, for their thoughtful expertise, suggestions, and perspectives to help improve my scientific abilities.

Daniel Donato and Jon Bakker for allowing me to bounce questions and updates in the arduous multivariate world.

Harvey Lab members, for your constant support, friendship, and stoking the stoke in our work.

The Harvey Lab field crews of 2019 through 2022, for their hard work made this research possible, and for the stellar memories we have shared over the summers.

My undergraduate mentors, Howard Neufeld and Matt Estep, for supporting and fostering the potential you both saw in me at Appalachian State University.

My loved ones, Marley, my houseplants, Overcast Coffee, and Espresso News for keeping me grounded and energized through the storm.

The SEFS community of students, faculty, staff, and administration for making it a lot less scary to start a master's program at the start of the global pandemic.

My teachers of the beautiful world of botany in the Pacific Northwest: Madison Laughlin, Eric Burres, Ellie Aosved, Christian Rolfson, Mark Swanson, and of course, Pojar and Mackinnon.

CHAPTER 1

Laying the groundwork:

Post-fire complex early-seral forest community trajectories in western Cascadia

INTRODUCTION

As climate change and disturbance activity increase in regions worldwide, forest ecosystems are experiencing profound changes in structure, function, and composition (Stevens-Rumann et al. 2018, Halofsky et al. 2020, Case et al. 2021, Abatzoglou et al. 2021). The plant communities following a natural disturbance and prior to tree canopy closure – complex early-seral forest (CESF) communities – are foundational to forest dynamics following stand-replacing disturbances (Swanson et al. 2011, 2014). Though CESF communities are often overlooked as an intermediary phase that leads to tree dominance, the understory layer of CESFs can provide as much or more diversity in structure, function, and composition than in old-growth forests (Franklin et al. 2000, Donato et al. 2012, Swanson et al. 2014). Still, relatively little is known about post-fire regeneration of CESF communities compared to conifers. Even less is known about the important drivers of post-fire CESF communities in forests with historically rare fire rotations. The increasing probability of fire activity and associated increases in CESF abundance underline the pertinence of understanding post-fire plant community dynamics.

CESF communities are a key component of diverse ecosystems by supporting a wide array of composition, function, and structure across taxa and trophic levels. CESF communities have the highest species diversity among all lifeforms, with forest biodiversity largely being a function of the understory layer (Gilliam 2007, Swanson et al. 2014). At the ecosystem level, these diverse communities support ecosystem processes, such as increasing nutrient concentrations (Spencer et al. 2003), modifying morphology of hydrologic systems (Jones and

Daniels 2008), and cycling essential plant nutrients (e.g., N, P, K) in a way that is disproportionate to its relative biomass in forest ecosystems (Neufeld and Young 2003, Welch et al. 2007, Gilliam 2007). At the community level, CESF communities support complex food webs, equal to or exceeding levels of biodiversity seen in old-growth forests (Swanson et al. 2014), for birds (Hutto 2008, Fontaine et al. 2009, Klaus et al. 2010, Lee 2018), insects (Heyborne et al. 2003, Miller and Hammond 2007), small mammals (Crisafulli et al. 2005a), large mammals (Lewis et al. 2022, Ganz et al. 2022), riparian consumers (Malison and Baxter 2010), reptiles and amphibians (Crisafulli et al. 2005b, Rittenhouse et al. 2007). The plant communities that make up CESFs are composed of a spectrum of generalists to specialists, filling ecological niches in an array of conditions that develop after disturbances (Swanson et al. 2011), and supporting multiple paths of forest succession (Halpern and Franklin 1987, Donato et al. 2012). This high diversity in composition of post-fire CESF plant communities supports greater diversity in forest structure and function.

Until more recently, the study of the post-disturbance condition was tree and management-centric with less of a focus on the diverse ecological roles played by CESFs, particularly in western Cascadia, USA (Swanson et al. 2011, 2014, Donato et al. 2012). CESFs are often seen as a hindrance to tree establishment and growth, and therefore have received less study compared to conifer trees given their importance. As well, ecological insights on post-fire conifer tree dynamics are greater due to longer life longevity (e.g., centuries) relative to early-seral plants (e.g., years to decades) and can be inferred retrospectively from tree-rings (Winter et al. 2002, Tepley et al. 2014) and lumber inventory (Poage and Tappeiner 2005). With this lack of field-based evidence, CESF plant responses to disturbance are more difficult to predict than tree responses to disturbance, due to a greater number of species and life-history strategies. As a result, there are fewer conceptual models of CESF plant based disturbance responses compared to tree-based disturbance response models (Oliver and Larson 1996, Roberts 2004, Stephan et al. 2010). It is therefore crucial to understand CESF community responses to disturbance in the field to support empirical and simulation modelling endeavors, particularly in light of climate change.

To add to the ephemeral and elusive nature of CESFs, they can be an incredibly rare habitat condition where the probability of fire occurrence is low. For example, in western Cascadia, which historically experiences infrequent, large, stand-replacing fires, CESF conditions historically composed only ~1-30% (median 6%) of forest cover, compared to late-seral conditions dominating ~47-90% (median 70%) of the region (Donato et al. 2020). As fire activity increases with climate warming, it is unclear if post-fire CESF communities may increase in relative abundance. Therefore, it is important to document a baseline of CESF communities that historically experience rare fire, such as western Cascadia, especially as it pertains to management of biodiversity and habitat provisioning.

Uncertainty continues when considering how pre-fire stand age – the condition of forest at the time of burning – influences CESF community response in western Cascadia. Recent wildfires burned through late-seral (i.e., unmanaged old-growth) and a mosaic of mid-seral and young stands rotations from anthropogenic disturbances (e.g., logging, prescribed burns, herbicide treatments, etc.) (Abatzoglou et al. 2021, Halpern and Antos 2022). The relative abundance of plant traits and strategies at different pre-fire stand ages may drive CESF community assemblages (Rowe et al. 1983, Halpern 1988, Pyke et al. 2010). For example, mechanisms of persistence through fire include seed soil banks and buried meristematic tissue, while opportunistic mechanisms after fire include recolonization by seed dispersal (Agee 1993, 1996, Baskin and Baskin 1998, Cain et al. 2000, Auld and Denham 2006, Stephan et al. 2010).

Additionally, life-history strategies that facilitate new growth will fare better in the post-fire environment, such vegetative resprouting and clonal expansion via root systems, rhizomes, or stolons (Clarke et al. 2013, Bendall et al. 2022). Therefore, the pool of species' traits available to fire based on pre-fire stand age may be an important predictor of CESF community assemblages.

Fire is a strong filter from pre-fire to post-fire communities, determining what community assemblages persist (or succumb to) the effects of burn severity – measured by organic matter loss (Keeley 2009). In many geographies with infrequent and high-severity stand-replacing fire, burn severity is a fundamental driver of CESF plant biodiversity (Wang and Kemball 2005, Donato et al. 2009, Brodie et al. 2021). For example, low-severity fire (<30% tree mortality) often results in minor charring of tree boles, greater soil burn depths, and subtle changes in understory abundance (Pausas 2015, Johnston et al. 2019). On the other hand, high-severity fire (>90% tree mortality) tends to completely consume the overstory canopy and understory biomass but can also move at greater speeds and burn an area over a shorter time frame (Pausas 2015, Johnston et al. 2019). Burn severity can also be spatially and temporally variable within and among stands driven by heterogeneity in forest structure, topography, and weather patterns (Estes et al. 2017, Saberi et al. 2022), potentially introducing heterogeneity in responses of CESF communities. Therefore, burn severity may play an important role in shaping CESF communities in western Cascadia by acting as a stochastic filter on assemblages.

More recently, there is evidence to suggest that in naturally-regenerated post-fire CESF communities in western Cascadia, these two key factors (burn severity and pre-fire stand age) interact to shape plant community responses of diversity and composition (Halpern and Antos 2022). However, Halpern and Antos (2022) only examined responses in young forests, so their observed relationship may differ in mid-seral and late-seral forests. In this study, we characterized and tested differences among CESF plant communities in western Cascadia across strata combination of pre-fire stand age (young, mid-seral, and late-seral) and burn severity (unburned, low-severity, and high-severity), and asked the following questions: (Q1) What is the flora of CESF communities compared to analogous unburned forests? How does community composition (Q2) and alpha diversity (species richness and evenness within stands) and beta diversity (compositional change among stands) (Q3) vary with pre-fire stand age and burn severity? For Q1, we expected post-fire flora to maintain similar species that are in unburned stands of the same pre-fire stand age and support new species that are not found in unburned stands of the same pre-fire stand age, due to the differences in forest structure (e.g., tree canopy loss), function (e.g., changes in nutrient and light availability) (Franklin et al. 2002), and niche resource partitioning (Finke and Snyder 2008). For Q2, we expected differences in composition to increase as burn severity increased and for burn severity to override pre-fire stand age (Halpern and Antos 2022). For Q3, we expected species diversity (richness and evenness) to be a function of pre-fire stand age (Franklin et al. 2002) and increase across burn severity (Fornwalt and Kaufmann 2014, Romme et al. 2016). These questions will help elucidate the responses of CESF plant community responses and drivers to wildfire in western Cascadia.

METHODS

Study Area

The "western Cascadia" region is defined as the temperate montane forest lands in western Washington and northwestern Oregon, west of the Cascade Mountain Crest, and includes four physiographic provinces in this study: the Northern Cascade Range, the Southern Washington Cascade Range, the Western Cascade Range in Oregon, and the Olympic Peninsula Range (Franklin and Dyrness 1973). Outside of the Puget lowlands and Olympic rain shadow, fire activity in western Cascadia is generally climate-limited, where the occurrence of large and infrequent fires that shape the landscape are limited to the rare alignment of warm and dry conditions in late summer and periods of strong east winds coinciding with ignitions present (Reilly et al. 2022). These constraints support a fire regime that is characterized by infrequent (200+ year rotations), large fires with a substantial stand-replacing component, though many forest stands can experience even longer fire rotations (Agee 1993, Halofsky et al. 2018, Donato et al. 2020). Recent fire activity in western Cascadia over the past four decades is consistent with the current understanding of historical fire regimes in the region (Reilly et al. 2017, 2022).

Our study area covered a broad elevational gradient (171 to 1624-m), extending across the *Tsuga heterophylla* (western hemlock) forest zone and the *Abies amabilis* (Pacific silver fir) forest zone (Franklin and Dyrness 1973). The *T. heterophylla* forest zone is the most extensive vegetation zone in western Cascadia, occurring in low elevations (sea level to 1000-m) from the Puget and Willamette lowlands to mid slopes of the Cascades. Precipitation averages 1500 to 3000 mm, with most precipitation falling in the winter as rain with intermittent snow cover (Franklin and Dyrness 1973). The *A. amabilis* forest zone occurs at cool, higher elevations ranging from 900 to 1500-m. Precipitation averages 2200 to 2650-mm, with most precipitation falling in the winter, and generally retains persistent snow cover during the winter season. Across both zones, variability in temperature and variability in precipitation occurs in association with variation in latitude, elevation, and topography. As such, both zones have differing abundances of *Psuedotsuga menziesii* (Douglas-fir), *T. heterophylla*, *Thuja plicata* (western red-cedar), *A. amabilis*, and *Abies procera* (noble fir) (Franklin and Dyrness 1973). For analyses, we will not be incorporating forest zone, to focus on the effects of pre-fire stand age and burn severity.

Study design

We established 86 1-ha plots (stands) in four wildfires that burned in western Cascadia between 2015 and 2018: the Goodell Creek (2015, n = 14 plots), Eagle Creek (2017, n = 13 plots), Norse Peak (2017, n = 55 plots), and Maple (2018, n = 4 plots) Fires (**Figure 1**). All plots were sampled in the summers of 2020 and 2021, starting in mid-June and ending in mid-September.

For each plot, we assigned the pre-fire developmental stage and forest zone using established protocols and field keys (Van Pelt 2007). Pre-fire forest developmental stages were aggregated into three classes for pre-fire stand age: young, mid-seral, or late-seral. Young stands (~0-50 years old pre-fire) are characterized by the initiation of tree canopy closure, where understory light availability transitions from nearly-full sun to nearly-full shade, and dominance in plant functional groups transitions from herbs and shrubs to conifer trees. Often, understory vegetation is dominated by shade-intolerant herb and shrub species, which capitalize on the availability of light prior to tree canopy closure (Franklin et al. 2002). Mid-seral stands (~50-150 years old pre-fire) are characterized by a combination of competitive exclusion and early maturity trees. In this pre-fire stand age, the tree canopy can be so dense that nearly any light reaches the understory, but eventually, tree height differentiation and crown breakage lead to small increases in light availability. The mid-seral stands often support shade-tolerant understory species, due to the high competition in light and nutrient resources between trees (Franklin et al. 2002). Late-seral stands (~200+ years old pre-fire) are characterized by trees of all height classes with vertical and horizontal structural diversification. This heterogeneity in tree heights and diameters supports heterogeneity of light and nutrient availability, which is furthered as old trees die and form canopy gaps. Late-seral stands can often support an array of shade intolerant species growing in large canopy gap formation, and shade tolerant species growing under shaded tree canopies (Franklin et al. 2002).

Burn severity was categorized at the plot scale as unburned (no evidence of recent fire), low-severity (< 30% tree basal area mortality and ≥ 50% burned surface area) or high-severity (≥ 90% tree basal area mortality). Strata combination was defined as the combination of pre-fire stand age and burn severity classification (e.g., late-seral high-severity). Unburned plots were used as a proxy for pre-fire conditions since it was not possible to gather information about burned plots prior to fire occurrence. Across all fires, we sampled young unburned (n = 4), young high-severity (n = 3), mid-seral unburned (n = 8), mid-seral low-severity (n = 4), mid-seral high-severity (n = 11), late-seral unburned (n = 18), late-seral low-severity (n =13), and late-seral high-severity (n = 25) plots. We did not encounter young low-severity plots in these fires, and therefore this stratum was not included.

Field data collection

In each plot, we measured ground cover in twelve subplots arranged along four 24.5-m transects radiating out from plot center in sub-cardinal directions: northeast (NE – 45°), southeast (SE – 135°), southwest (SW – 225°), and northwest (NW – 315°). Along each of the four transects, we monumented three 2-m radius (12.6-m^2) subplots at 7, 14, and 21-m (n = 12 subplots per plot) (**Appendix 1**). To characterize the responses of post-fire CESF plants, we recorded percent cover of all vascular plant species within each subplot. Bryophytes (mosses, liverworts, and hornworts) and graminoids (grasses, sedges, rushes) were recorded as percent cover of each group. Bryophytes were separated from the vascular plants in the analyses, due to their large difference in ground cover and ecological functioning from vascular plants. All cover values were averaged across all twelve subplots and analyzed at the plot level.

Some plant individuals could not be identified to the species level in field and were classified as the first three letters of the genus followed by spp. (i.e., "vacspp" as *Vaccinium* species, hereafter these identifications are also referred to as species). Out of the 9057 observations of species percent cover across subplots, we were able to confidently identify 99.4% observations. With a relatively small proportion (*n* = 53 observations, 0.5% of total observations) unidentified, we excluded these unknown observations from analyses. To evaluate our sampling method efforts (i.e., if we captured a majority of species in western Cascadia, or if we may be underrepresenting species richness in this region), we examined plot-level differences in beta diversity using species accumulation curves with the *vegan* package in R to explore the number of species as a function of sampling effort across subplots (Ugland et al. 2003, Legendre and De Cáceres 2013, Deng et al. 2015, Oksanen et al. 2022).

We standardized attributes of each species for scientific name, common name, functional group, and whether the species is native, introduced, or mixed (a combination of native or introduced, more often classified for genera) using the USDA Plants Database (USDA, 2022). Functional groups were organized by plant life form listed in the database as follows: "forb/herb" classified as herb; "shrub" classified as any woody non-tree plant; "subshrub" classified as woody non-tree plants which are smaller stature and contribute less woody biomass than shrubs, proportionally (for simplicity, we bundled subshrubs and shrubs as "shrubs" in the results and discussion); "tree" classified as any deciduous tree species. Conifer tree species were not included in these analyses, as we are interested in CESF community responses (e.g., diversity, composition) prior to conifer tree dominance.

Statistical analysis

We used a range of univariate and multivariate approaches to examine post-fire relative cover and frequency, composition, and species diversity, and to test for differences across factors of pre-fire stand age and burn severity. All analyses were conducted in R statistical software (R Core Team, 2021). For analyses where the focus was community composition rather than raw species cover, we relativized cover for species or functional group within plots or strata to decrease the influence of dominant species (McCune and Grace 2002). To assess ecologically meaningful differences, we used a cut-off of $p < 0.05$ ($\alpha = 0.05$) for all comparisons in all tests.

To characterize the range of flora (Q1) across strata of interest, we compared relative mean cover and frequency of the top fifteen most dominant species within a strata combination. We constructed summary tables to present cover and frequency values and horizontal bars scaled to values, using the *formattable* package in R (Ren and Russell 2021). We calculated raw and relative mean cover of bryophytes separately. We generated heat maps in R with the *ggplot2* package (Wickham 2016) to visualize species cover and frequency within and across strata.

To test for differences in understory plant community composition (Q2), we used cover of each species for each plot to compute Bray-Curtis distances between each set of plots (Bray and Curtis 1957, Legendre and De Cáceres 2013). Based on the Bray-Curtis distance matrix, we conducted an analysis of similarity (ANOSIM) with 999 permutations to test if plant community composition differed among strata combinations. ANOSIM analyses were conducted in R with the *vegan* package (Oksanen et al. 2022). To examine community composition among strata combinations, we used non-metric multidimensional scaling (NMDS) with 2 dimensions, using 100 random starting configurations, and accepted stress levels as a measure of goodness of fit close to or <0.2 to determine the dimensions of ordination (Clarke 1993). We plotted NMDS ordinations with sample units (plots) ordinated in species space, overlaying groups of strata combinations to identify differences in community composition. All NMDS analyses were conducted in R with the *vegan* package (Oksanen et al. 2022).

To test for differences in alpha diversity (within-stand richness and evenness) across levels of pre-fire stand stage and burn severity (Q3), we first used two-way analysis of variance (ANOVA) test to test for differences in diversity across levels of pre-fire stand age, burn severity, and interactions among factors. We calculated alpha diversity using two indices, as these two indices can provide complementary dimensions of diversity (McCune and Grace 2002): species richness as the total number of species present per plot and Shannon Diversity Index as a measurement of species evenness per plot. We tested for differences among strata combinations using Tukey's honestly significant difference (HSD). ANOVA and Tukey's HSD analyses were conducted in R with the *stats* package (R Core Team 2021). To test for differences in beta (among-stand) diversity, we plotted the number of species as a function of number of plots using species accumulation curves in R with the *vegan* package (Ugland et al. 2003, Deng et al. 2015, Oksanen et al. 2022).

RESULTS

Q1: Flora in unburned and post-fire stands

Overall, there were 206 species present across all conditions sampled (**Appendix 2**), with 83 unique species in burned conditions only, 32 unique species in unburned conditions only, and 91 common species across both conditions. Within stands, species accumulation curves across all subplots illustrate that we sufficiently captured plot level community diversity (**Appendix 3**).

Total vegetation cover was 10.5-22.4%, 5.6-8.8%, and 34.1-54.2% across unburned, low-severity, and high-severity fire plots, respectively. Mean cover of total vegetation in unburned plots increased with pre-fire stand age, from 10.5% in young, to 12.9% in mid-seral, and 22.4% in late-seral stands. Relative to unburned plots, mean cover in low severity was less, which was 5.6% in mid-seral and 8.8% in late-seral stands. Overall, the highest mean percent cover values were observed in high severity plots although there were differences by pre-fire stand age; mean cover of total vegetation was greatest in pre-fire young stands at 54.2%, with 34.1% in mid-seral, and 36.5% in late-seral stands.

Unburned stands were in general dominated by shrubs and herbs (**Figure 2, Table 1**). 52.4% of total vegetation was dominated by the shrubs *Gaultheria shallon* (salal), *Mahonia nervosa* (Cascade barberry), *Acer circinatum* (vine maple), and *Linnea borealis* (twinflower), and 21.4% of total vegetation dominated by the herbs *Xerophyllum tenax* (common beargrass), *Achlys triphylla* (sweet after death), *Polystitchum munitum*, (western swordfern), and *Viola sempervirens* (evergreen violet).

Herbs and shrubs also dominated stands burned at low severity (**Figure 2, Table 1**). 57.3% of total vegetation was dominated by the herbs *Chamerion angustifolium* (fireweed), *Achlys triphylla* (sweet after death), *Xerophyllum tenax* (common beargrass), and *Cornus canadensis* (bunchberry dogwood), and 23.5% of total vegetation dominated by the shrubs *Linnea borealis* (twinflower), *Mahonia nervosa* (Cascade barberry), *Vaccinium membranaceum* (thinleaf huckleberry), and *Rubus lasiococcus* (roughfruit berry).

In stands burned at high-severity, herbs and shrubs also dominated (**Figure 2, Table 1**). 30.8% of total vegetation was dominated by the herbs *Chamerion angustifolium* (fireweed), *Pteridium aquilinum* (western brackenfern), *Trientalis borealis* (broadleaf starflower), and *Mycelis muralis* (wall-lettuce), and 25.8% of total vegetation dominated by the shrubs *Mahonia nervosa* (Cascade barberry), *Lupinus* (lupine) spp., *Rubus parviflorus* (thimbleberry), and *Ceanothus sanguineus* (redstem ceanothus). Relative cover of bryophytes generally decreased with pre-fire stand age and had the greatest cover in low-severity plots (**Figure 3**).

Q2: Community composition in unburned and post-fire stands

Community composition among-stands differed by pre-fire stand age and burn severity; however, the range of composition was much greater across burn severities than across pre-fire stand ages, highlighting the consistent importance of burn severity (**Figure 4**). Six of the seven (86%) pairwise comparisons showed evidence of differences in community composition across different levels of burn severity, when pre-fire stand age was held constant (**Figure 4**, **Table 2**). The one exception was for mid-seral stands that burned at low-severity versus high-severity, where composition did not differ (**Figure 4**, **Table 2**). In contrast, only three of the seven (43%) pairwise comparisons showed evidence of differences in community composition across different levels of pre-fire stand age, when burn severity was held constant (**Figure 4**, **Table 2**). Of pairwise comparisons that did not differ, two were in high-severity fire (young versus late-seral, and mid-seral versus late-seral), and one was in unburned (mid-seral versus late-seral). The remaining 14 pairwise tests crossed levels of burn severity and pre-fire stand age, and 11 of the 14 (79%) comparisons showed evidence for differences in community composition (**Table 2**), indicating potential interactions between pre-fire stand age and burn severity. The NMDS ordination produced a two-dimensional solution (stress = 0.24), with the non-metric fit (R^2) at 0.95 for both raw and relative cover (**Appendix 4**).

Q3: Species diversity in unburned and post-fire stands

Within-stand (alpha) diversity. Overall mean species richness was 24.5 ± 1.1 species (range = 3-50), and mostly did not differ across combinations of pre-fire stand age and burn severity level, despite burn severity and the interaction between burn severity and pre-fire stand age being significant predictors of species richness (**Figure 5, Tables 3, 4**). The one exception was in mid-seral unburned stands, which had the lowest species richness (11.9 ± 3.1 species) and significantly differed from young, unburned stands (31.8 ± 4.5 species) and mid-seral and late-seral high severity stands (28.7 ± 3.9 and 26.8 ± 1.6 species, respectively) (**Figure 5, Tables 3, 4**). Species evenness (Shannon Diversity Index) was similar across all combinations of pre-fire stand age and burn severity level, with no difference in species evenness among strata (**Figure 5, Tables 3, 4**).

Among-stand (beta) diversity. Species accumulation curves (**Figure 6**) suggest no differences in beta diversity among stands within a strata. Within the first three plots, the increase in number of species from the 2nd to the 3rd plot ranged from 12-17%. As the maximum sample size in the strata with the smallest sample size was three plots (n = 3 in pre-fire young high-severity stands) quantitative comparisons of species accumulation curves across all strata are not possible beyond three plots. For strata with a greater number of plots, species accumulation curves suggest greater beta diversity in late-seral high-severity stands as the rate in species richness increases the fastest over the increased number of plots, while curves suggest less beta diversity in young, unburned stands and mid-seral high-severity stands as the rate in species richness slows down over the increased number of plots (**Figure 6**).

DISCUSSION

Our study underlines how burn severity and pre-fire stand age individually and interactively shape post-fire plant community assemblages in forest ecosystems that experience infrequent, stand-replacing fire regimes. First, important drivers of post-fire CESF plant community composition were burn severity and pre-fire stand age, though each to differing degrees of influence. Next, within-stand (alpha) species diversity was similarly high across most strata combinations of pre-fire stand age and burn severity, aside from unburned mid-seral stands. Among-stand (beta) species diversity was high across most strata combinations, demonstrating increased heterogeneity and diversity across different conditions within post-fire landscapes. Finally, our dataset is a valuable contribution to describing the flora of post-fire plant communities in western Cascadia (which have not been fully characterized), particularly in light of climate change and potential increases in fire activity.

Burn severity was a consistent driver of differences in post-fire community composition, highlighting the important role of fire in increasing heterogeneity in plant communities. As in other studies in infrequent fire systems, disturbance overrides pre-fire conditions in driving compositional change with increasing burn severity (Wang and Kemball 2005, Hollingsworth et al. 2013, Halpern and Antos 2022). Although previous studies also suggest strong persistence of understory species through disturbance (Halpern 1988, Anderson and Romme 1991, Turner et al. 1997, Halpern and Antos 2022), with even 79% of the pre-fire community being present in the post-fire community in dry forests (Abella and Fornwalt 2015), our data support a greater heterogeneity of new species in burned stands: of 173 species we recorded in the post-fire communities, 52% had been part of the unburned community while 48% were unique species to post-fire communities. This increase in diversity of species richness suggests that fire is an important ecological process for maintaining species diversity both locally and regionally in western Cascadia. As fire severity effects have a direct impact on greater range in species composition, maps of fire severity may be able to help guide conservation or management efforts towards protecting more diverse community assemblages.

Pre-fire stand age still had important effects on post-fire community composition, but to a lesser degree than burn severity. Despite burn severity having a greater influence over post-fire communities than pre-fire stand age, pre-fire stand age may still act as an initial template for a community as to what species could potentially persist through disturbance (Franklin et al. 2002). Potentially, the stochastic (or random) effects of fire severity may be more important in the short-term, but pre-fire stand condition and disturbance history as a deterministic (non-random) effect may become more important over time (Romme et al. 2016, Maren et al. 2018). Another possibility is that in low-severity fire, the effects may not be enough to overwhelm the deterministic effects of pre-fire stand age. As pre-fire condition is still an influential driver for maintaining post-fire species composition in western Cascadia, we can make predictions of community assemblages based on the age of forests at time of fire, and in conjunction with burn severity, can provide more specific insights of post-fire community assemblages. A limitation in this study on examining the interaction of pre-fire stand age and burn severity is the lack of young low-severity stands in the dataset. The lack of this forest condition type may suggest that this condition (young forests burned at low-severity) is rare due to young stands being more susceptible to fire at high-severity. Although we do not have the insight in this study, we hope to address the young low-severity plots with the sampling of the 2020 fires in western Cascadia.

Alpha (within-stand) diversity was similar across most strata combinations, suggesting there is consistently high species richness and evenness across the western Cascadia region, regardless of the pre-fire conditions or fire effects. Despite our study area covering a similar geography and forest types to Halpern and Spies (1995), species richness (140 species) peaked twenty-five years following forest management of logging, burning, salvage-logging, and planting. In a range of three to five years in forests with minimal anthropogenic disturbance, we have identified 174 post-fire species, possibly supporting two lines of evidence. First, fire as an ecological process is a key driver of biodiversity on Earth (He et al. 2019), and second, post-fire plant species richness may be greatest where current disturbance severities match historical disturbance regimes (Miller and Safford 2020).

For example, relative abundance of forest conditions (young, mid-seral, and late-seral) are outside of the natural range in variation in western Cascadia, with this region currently dominated by dense, uniform, mid-seral stands (i.e., at high levels with no historical analog) (Donato et al. 2020). Interestingly, species richness was lowest in the unburned mid-seral stands, suggesting that this condition (uniform, homogenous, low-diversity tree stands for harvest rotations) does not match the historical disturbance regime in western Cascadia (Miller and Safford 2020). On the other hand, species richness was greatest in unburned young stands and in all high-severity stands, potentially suggesting that current disturbance severities that impact specific pre-fire stand ages (young stands, recently disturbed) and burn severities (high-severity) are a closer analog to historical disturbance regimes (Miller and Safford 2020). This has important implications for the western Cascadia region, which historically has experienced infrequent, large, stand-replacing fire but currently is dominated by short-rotation forest harvest practices that do not naturally replicate regional ecosystem processes. Through evaluation of existing disturbance regimes and how they limit or aid species diversity, scientists and land managers can help maintain or restore biodiversity in an ecosystem (Odion and Sarr 2007).

The post-fire CESF communities were very dissimilar in their community composition, reflecting the mosaic in pre-fire stand age and burn severity across western Cascadia. Beta (among-stand) diversity, based on NMDS ordinations and species accumulation curves, was high across strata, demonstrating the important effects of a mosaic of different conditions across post-fire landscapes adding complexity and diversity to community assemblages. Potentially multiple stable equilibria exist in post-fire CESFs in this region, as this is a regional system with large regional species pools, low rates of connectivity (mountainous terrain), high productivity, and low rates of disturbance (Chase 2003). Differences in composition among strata suggests an array of forest successional pathways, as the heterogeneity in early-seral assemblages will potentially affect the variability of forest development trajectories, particularly in forests with infrequent high-severity-fire (Donato et al. 2012, Harvey and Holzman 2014). As a result, a diverse array of post-fire CESF community assemblages will result in western Cascadia following fire, and may lead to a wide range of forest trajectories in later successional periods, having implications for pre- and post-fire management to foster, manage, and protect CESFs.

Finally, our dataset is a valuable contribution to describing the flora of post-fire plant communities in western Cascadia, which have not yet been fully characterized. Although there has been more documentation on mid- and late-seral understory communities (Franklin and Dyrness 1973, Gilliam 2007), young understory communities following anthropogenic management treatments (Halpern 1988, Halpern and Spies 1995), and more recently young understory communities following wildfire (Halpern and Antos 2022), there has been few opportunities to document post-fire CESF flora following natural wildfire in western Cascadia across multiple pre-fire stand ages and burn severities. Although, this region is typified historically and predominantly by high-severity fire, it is helpful to gain the range of species pool in low-severity stands as well, for low-severity stands can act as important fire refugia for high-severity stands, continuing the threads of continuity in species pre- to post-fire (Franklin et al. 2000). This study serves as an important foundational list of species pre- and post-fire in a region where historically little is known about post-fire species, and potentially pre-fire forests where management is not as intense as in previous studies in western Cascadia. This will help provide an important baseline against which future post-fire plant communities can be compared to identify potential alternative stable states under a changing climate.

CONCLUSION

Impacts of climate warming and associated increases in fire activity are poorly understood in infrequent, high-severity regimes, where information about post-fire recovery often overlooks complex early-seral forest (CESF) plant communities for conifer trees. Our findings present critical information on post-fire CESF plant communities in western Cascadia, providing important implications for forest trajectories following infrequent, high-severity wildfire. We found that post-fire CESF plant communities (1) were inversely herb-dominated over shrubs compared to unburned forests, (2) composition was strongly driven by burn severity, and to a lesser degree influenced by pre-fire stand age, (3) alpha diversity was not significantly different across strata, except significantly lower species richness in mid-seral unburned stands, and (4) beta diversity (compositional differences) provide a unique array of post-fire community assemblages. Specifically, our results show that an abundant, though relatively species poor, forest condition in western Cascadia (mid-seral forests) may experience the greatest increase in biodiversity and compositional heterogeneity following fire. Further, different combinations of pre-fire stand age and burn severity can provide unique post-fire CESF community assemblages.

ACKNOWLEDGEMENTS

This research is a part of a broad, collaborative effort across agencies and partners to better understand the drivers, characteristics, and indicators of post-fire recovery in western Cascadia. We thank the Climate Adaptation and Science Center (CASC), PNW West Side Fire Initiative, and private donors for funding this research. We thank the field crew technicians from 2019 (S. Burrington, H. Jayasekera, N. Lau, M. McNorvell, H. Wilson), 2020 (B. Hagedorn, M. Mahmoud, M. McNorvell, S. Patton, M. Stone, M. Todd, S. Vieira), 2021 (A. Brown, E. Burres, F. Dezza-Parada, D. Graham, S. Kruzka, A. MacKinnon, M. Shetreat-Klein, C. Zinke), and 2022 (E. Aosved, M. Elbrecht, N. Katz, C. Rolfson, L. Taylor-Manning) whose hard work made this research possible. We thank J. Bakker for analyses consulting and suggestions, and we thank M. Swanson for insightful discussions on early-seral forests.

REFERENCES

Abatzoglou, J. T., D. S. Battisti, A. P. Williams, W. D. Hansen, B. J. Harvey, and C. A. Kolden. 2021. Projected increases in western US forest fire despite growing fuel constraints. Communications Earth & Environment 2:227.

Abella, S. R., and P. J. Fornwalt. 2015. Ten years of vegetation assembly after a North American mega fire. Global Change Biology 21:789–802.

Agee, J. K. 1993. Fire Ecology of Pacific Northwest Forests. Island Press.

Agee, J. K. 1996. Achieving conservation biology objectives with fire in the Pacific Northwest. Weed Technology 10:417–421.

Anderson, J., and W. Romme. 1991. Initial Floristics in Lodgepole Pine (Pinus contorta) Forests Following the 1988 Yellowstone Fires. International Journal of Wildland Fire 1:119.

Auld, T. D., and A. J. Denham. 2006. How much seed remains in the soil after a fire? Plant Ecology 187:15–24.

Baskin, C. C., and J. M. Baskin. 1998. Seeds: Ecology, biogeography, and evolution of dormacy and germination. Elsevier, San Diego, CA.

Bendall, E. R., M. Bedward, M. Boer, H. Clarke, L. Collins, A. Leigh, and R. A. Bradstock. 2022. Mortality and resprouting responses in forest trees driven more by tree and ecosystem characteristics than drought severity and fire frequency. Forest Ecology and Management 509:120070.

Bray, J. R., and J. T. Curtis. 1957. An Ordination of the Upland Forest Communities of Southern Wisconsin. Ecological Monographs 27:325–349.

Brodie, E. G., J. E. D. Miller, and H. D. Safford. 2021. Productivity modifies the effects of fire severity on understory diversity. Ecology 102.

Cain, M. L., B. G. Milligan, and A. E. Strand. 2000. Long-distance seed dispersal in plant populations. American Journal of Botany 87:1217–1227.

Case, M. J., B. G. Johnson, K. J. Bartowitz, and T. W. Hudiburg. 2021. Forests of the future: Climate change impacts and implications for carbon storage in the Pacific Northwest, USA. Forest Ecology and Management 482:118886.

Chase, J. M. 2003. Community assembly: when should history matter? Oecologia 136:489–498.

Clarke, K. R. 1993. Non-parametric multivariate analyses of changes in community structure. Austral Ecology 18:117–143.

Clarke, P. J., M. J. Lawes, J. J. Midgley, B. B. Lamont, F. Ojeda, G. E. Burrows, N. J. Enright, and K. J. E. Knox. 2013. Resprouting as a key functional trait: how buds, protection and resources drive persistence after fire. New Phytologist 197:19–35.

Crisafulli, C. M., J. A. MacMahon, and R. R. Parmenter. 2005a. Small-Mammal Survival and Colonization on the Mount St. Helens Volcano: 1980–2002. Pages 199–218 *in* V. H. Dale, F. J. Swanson, and C. M. Crisafulli, editors. Ecological Responses to the 1980 Eruption of Mount St. Helens. Springer New York, New York, NY.

Crisafulli, C. M., L. S. Trippe, C. P. Hawkins, and J. A. MacMahon. 2005b. Amphibian Responses to the 1980 Eruption of Mount St. Helens. Pages 183–197 *in* V. H. Dale, F. J. Swanson, and C. M. Crisafulli, editors. Ecological Responses to the 1980 Eruption of Mount St. Helens. Springer New York, New York, NY.

Deng, C., T. Daley, and A. Smith. 2015. Applications of species accumulation curves in large-scale biological data analysis. Quantitative Biology 3:135–144.

Donato, D. C., J. L. Campbell, and J. F. Franklin. 2012. Multiple successional pathways and precocity in forest development: can some forests be born complex? Journal of Vegetation Science 23:576–584.

Donato, D. C., J. B. Fontaine, W. D. Robinson, J. B. Kauffman, and B. E. Law. 2009. Vegetation response to a short interval between high-severity wildfires in a mixed-evergreen forest. Journal of Ecology 97:142–154.

Donato, D. C., J. S. Halofsky, and M. J. Reilly. 2020. Corralling a black swan: natural range of variation in a forest landscape driven by rare, extreme events. Ecological Applications 30.

Estes, B. L., E. E. Knapp, C. N. Skinner, J. D. Miller, and H. K. Preisler. 2017. Factors influencing fire severity under moderate burning conditions in the Klamath Mountains, northern California, USA. Ecosphere 8:e01794.

Finke, D. L., and W. E. Snyder. 2008. Niche Partitioning Increases Resource Exploitation by Diverse Communities. Science 321:1488–1490.

Fontaine, J. B., D. C. Donato, W. D. Robinson, B. E. Law, and J. B. Kauffman. 2009. Bird communities following high-severity fire: Response to single and repeat fires in a mixed-evergreen forest, Oregon, USA. Forest Ecology and Management 257:1496–1504.

Fornwalt, P. J., and M. R. Kaufmann. 2014. Understorey plant community dynamics following a large, mixed severity wildfire in a *Pinus ponderosa* - *Pseudotsuga menziesii* forest, Colorado, USA. Journal of Vegetation Science 25:805–818.

Franklin, J. F., and C. T. Dyrness. 1973. Natural Vegetation of Oregon and Washington. Pacific Northwest Forest and Range Experimental Station Forest Service, U.S. Department of Agriculture, Portland, Oregon USDA Forest Service General Technical Report PNW-8.

Franklin, J. F., D. Lindenmayer, J. A. MacMahon, A. McKee, J. Magnuson, D. A. Perry, R. Waide, and D. Foster. 2000. Threads of Continuity. There are immense differences between even-aged silvicultural disturbances (especially clearcutting) and natural disturbances, such as windthrow, wildfire, and even volcanic eruptions. Conservation in Practice 1:8–17.

Franklin, J. F., T. A. Spies, R. V. Pelt, A. B. Carey, D. A. Thornburgh, D. R. Berg, D. B. Lindenmayer, M. E. Harmon, W. S. Keeton, D. C. Shaw, K. Bible, and J. Chen. 2002. Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. Forest Ecology and Management 155:399–423.

Ganz, T. R., M. T. DeVivo, B. N. Kertson, T. Roussin, L. Satterfield, A. J. Wirsing, and L. R. Prugh. 2022. Interactive effects of wildfires, season and predator activity shape mule deer movements. Journal of Animal Ecology 91:2273–2288.

Gilliam, F. S. 2007. The Ecological Significance of the Herbaceous Layer in Temperate Forest Ecosystems. BioScience 57:845–858.

Halofsky, J. E., D. L. Peterson, and B. J. Harvey. 2020. Changing wildfire, changing forests: the effects of climate change on fire regimes and vegetation in the Pacific Northwest, USA. Fire Ecology 16:4.

Halofsky, J. S., D. C. Donato, J. F. Franklin, J. E. Halofsky, D. L. Peterson, and B. J. Harvey. 2018. The nature of the beast: examining climate adaptation options in forests with stand-replacing fire regimes. Ecosphere 9:e02140.

Halpern, C. B. 1988. Early Successional Pathways and the Resistance and Resilience of Forest Communities. Ecology 69:1703–1715.

Halpern, C. B., and J. A. Antos. 2022. Burn severity and pre-fire seral state interact to shape vegetation responses to fire in a young, western Cascade Range forest. Forest Ecology and Management 507:120028.

Halpern, C. B., and J. F. Franklin. 1987. Understory development in Psuedotsuga forests: multiple paths of succession. Symposium on Land Classifications Based on Vegetation: Applications for Resource Management.:6.

Halpern, C. B., and T. A. Spies. 1995. Plant Species Diversity in Natural and Managed Forests of the Pacific Northwest. Ecological Applications 5:913–934.

Harvey, B. J., and B. A. Holzman. 2014. Divergent successional pathways of stand development following fire in a California closed-cone pine forest. Journal of Vegetation Science 25:88–99.

He, T., B. B. Lamont, and J. G. Pausas. 2019. Fire as a key driver of Earth's biodiversity. Biological Reviews 94:1983–2010.

Heyborne, W. H., J. C. Miller, and G. L. Parsons. 2003. Ground dwelling beetles and forest vegetation change over a 17-year-period, in western Oregon, USA. Forest Ecology and Management 179:123–134.

Hollingsworth, T. N., J. F. Johnstone, E. L. Bernhardt, and F. S. Chapin. 2013. Fire Severity Filters Regeneration Traits to Shape Community Assembly in Alaska's Boreal Forest. PLoS ONE 8:e56033.

Hutto, R. L. 2008. The ecological importance of severe wildfire: Some like it hot. Ecological Applications 18:1827–1834.

Johnston, J. D., C. J. Dunn, and M. J. Vernon. 2019. Tree traits influence response to fire severity in the western Oregon Cascades, USA. Forest Ecology and Management 433:690–698.

Jones, T. A., and L. D. Daniels. 2008. Dynamics of large woody debris in small streams disturbed by the 2001 Dogrib fire in the Alberta foothills. Forest Ecology and Management 256:1751–1759.

Klaus, N. A., S. A. Rush, T. S. Keyes, J. Petrick, and R. J. Cooper. 2010. Short-Term Effects of Fire on Breeding Birds in Southern Appalachian Upland Forests. The Wilson Journal of Ornithology 122:518–531.

Lee, D. E. 2018. Spotted Owls and forest fire: a systematic review and meta-analysis of the evidence. Ecosphere 9:e02354.

Legendre, P., and M. De Cáceres. 2013. Beta diversity as the variance of community data: dissimilarity coefficients and partitioning. Ecology Letters 16:951–963.

Lewis, J. S., L. LeSueur, J. Oakleaf, and E. S. Rubin. 2022. Mixed-severity wildfire shapes habitat use of large herbivores and carnivores. Forest Ecology and Management 506:119933.

Malison, R. L., and C. V. Baxter. 2010. The fire pulse: wildfire stimulates flux of aquatic prey to terrestrial habitats driving increases in riparian consumers. Canadian Journal of Fisheries and Aquatic Sciences 67:570–579.

McCune, B., and J. B. Grace. 2002. Analysis of Ecological Communities. mjm Software, Gleneden Beach, Oregon, USA.

Miller, J. C., and P. C. Hammond. 2007. Butterflies and Moths of Pacific Northwest Forests and Woodlands: Rare, Endangered, and Management-Sensitive Species. Forest Health Technology Enterprise Team, U.S. Dept. of Agriculture, Forest Service.

Miller, J. E. D., and H. D. Safford. 2020. Are plant community responses to wildfire contingent upon historical disturbance regimes? Global Ecology and Biogeography 29:1621–1633.

Neufeld, H. S., and D. R. Young. 2003. The Herbaceous Layer in Forests of Eastern North America. Oxford University Press.

Oksanen J., G. L. Simpson, F. Guillaume Blanchet, R. Kindt, P. Legendre, P. R. Minchin, R.B. O'Hara, P. Solymos, M. H. H. Stevens, E. Szoecs, H. Wagner, M. Barbour, M. Bedward, B. Bolker, D. Borcard, G. Carvalho, M. Chirico, M. De Caceres, S. Durand, H. Beatriz, A. Evangelista, R. FitzJohn, M. Friendly, B. Furneaux, G. Hannigan, M. O. Hill, L. Lahti, D. McGlinn, M.-H. Ouellette, E. Ribeiro Cunha, T. Smith, A. Stier, C. J. F. Ter Braak, and J. Weedon. 2022. vegan: Community Ecology Package. R package version 2.6-2. https://CRAN.R-project.org/package=vegan

Odion, D. C., and D. A. Sarr. 2007. Managing disturbance regimes to maintain biological diversity in forested ecosystems of the Pacific Northwest. Forest Ecology and Management 246:57–65.

Oliver, C. D., and B. C. Larson. 1996. Forest stand dynamics: updated edition. John Wiley and Sons, New York, USA.

Pausas, J. G. 2015. Bark thickness and fire regime. Functional Ecology 29:315–327.

Poage, N. J., and J. C. Tappeiner. 2005. Tree species and size structure of old-growth Douglas-fir forests in central western Oregon, USA. Forest Ecology and Management 204:329–343.

Pyke, D. A., M. L. Brooks, and C. D'Antonio. 2010. Fire as a Restoration Tool: A Decision Framework for Predicting the Control or Enhancement of Plants Using Fire. Restoration Ecology 18:274–284.

R Core Team. 2021. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Reilly, M. J., C. J. Dunn, G. W. Meigs, T. A. Spies, R. E. Kennedy, J. D. Bailey, and K. Briggs. 2017. Contemporary patterns of fire extent and severity in forests of the Pacific Northwest, USA (1985-2010). Ecosphere 8:e01695.

Reilly, M. J., A. Zuspan, J. S. Halofsky, C. Raymond, A. McEvoy, A. W. Dye, D. C. Donato, J. B. Kim, B. E. Potter, N. Walker, R. J. Davis, C. J. Dunn, D. M. Bell, M. J. Gregory, J. D. Johnston, B. J. Harvey, J. E. Halofsky, and B. K. Kerns. 2022. Cascadia Burning: The historic, but not historically unprecedented, 2020 wildfires in the Pacific Northwest, USA. Ecosphere 13.

Ren K. and K. Russell. 2021. formattable: Create 'Formattable' Data Structures. R package version 0.2.1. https://CRAN.R-project.org/package=formattabl

Rittenhouse, C. D., W. D. Dijak, F. R. I. Thompson, and J. J. Millspaugh. 2007. Development of landscape-level habitat suitability models for ten wildlife species in the central hardwoods region. Page NRS-GTR-4. U.S. Department of Agriculture, Forest Service, Northern Research Station, Newtown Square, PA.

Roberts, M. R. 2004. Response of the herbaceous layer to natural disturbance in North American forests. Canadian Journal of Botany 82:1273–1283.

Romme, W. H., T. G. Whitby, D. B. Tinker, and M. G. Turner. 2016. Deterministic and stochastic processes lead to divergence in plant communities 25 years after the 1988 Yellowstone fires. Ecological Monographs 86:327–351.

Rowe, R. Wein, and D. MacLean. 1983. The role of fire in northern circumpolar ecosystems. Published on behalf of the Scientific Committee on Problems of the Environment (SCOPE) of the International Council of Scientific Unions (ICSU) by Wiley.

Saberi, S. J., M. C. Agne, and B. J. Harvey. 2022. Do you CBI what I see? The relationship between the Composite Burn Index and quantitative field measures of burn severity varies across gradients of forest structure. International Journal of Wildland Fire 31:112–123.

Spencer, C. N., K. O. Gabel, and F. R. Hauer. 2003. Wildfire effects on stream food webs and nutrient dynamics in Glacier National Park, USA. Forest Ecology and Management 178:141–153.

Stephan, K., M. Miller, and M. B. Dickinson. 2010. First-Order Fire Effects on Herbs and Shrubs: Present Knowledge and Process Modeling Needs. Fire Ecology 6:95–114.

Stevens-Rumann, C. S., K. B. Kemp, P. E. Higuera, B. J. Harvey, M. T. Rother, D. C. Donato, P. Morgan, and T. T. Veblen. 2018. Evidence for declining forest resilience to wildfires under climate change. Ecology Letters 21:243–252.

Swanson, M. E., J. F. Franklin, R. L. Beschta, C. M. Crisafulli, D. A. DellaSala, R. L. Hutto, D. B. Lindenmayer, and F. J. Swanson. 2011. The forgotten stage of forest succession: early-successional ecosystems on forest sites. Frontiers in Ecology and the Environment 9:117–125.

Swanson, M. E., N. M. Studevant, J. L. Campbell, and D. C. Donato. 2014. Biological associates of early-seral pre-forest in the Pacific Northwest. Forest Ecology and Management 324:160–171.

Tepley, A. J., F. J. Swanson, and T. A. Spies. 2014. Post-fire tree establishment and early cohort development in conifer forests of the western Cascades of Oregon, USA. Ecosphere 5:art80.

Turner, M. G., W. H. Romme, R. H. Gardner, and W. W. Hargrove. 1997. Effects of fire size and pattern on early succession in Yellowstone National Park. Ecological Monographs 67:411–433.

Ugland, K. I., J. S. Gray, and K. E. Ellingsen. 2003. The species-accumulation curve and estimation of species richness. Journal of Animal Ecology 72:888–897.

Wang, G. G., and K. J. Kemball. 2005. Effects of fire severity on early development of understory vegetation 35:9.

Welch, N. T., J. M. Belmont, and J. C. Randolph. 2007. Summer Ground Layer Biomass and Nutrient Contribution to Above-Ground Litter in an Indiana Temperate Deciduous Forest. The American Midland Naturalist 157:17.

Wickham, H. 2016. ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York, 2016.

Winter, L. E., L. B. Brubaker, J. F. Franklin, E. A. Miller, and D. Q. DeWitt. 2002. Initiation of an old-growth Douglas-fir stand in the Pacific Northwest: a reconstruction from tree-ring records 32:18.

Table 1. Dominant species across each strata combination. The six-letter species code is the first three letters of the genus and the first three letters of the species (e.g., *Vaccinium membranaceum* = vacmem). Relative mean cover percent and frequency are relative to all species within a stratum.

Young Unburned (n = 4) dominant species. Mean cover % for total vegetation across plots = 10.5%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
linbor	*Linnaea borealis*	twinflower	subshrub	native	24.0	60
vacmem	*Vaccinium membranaceum*	thinleaf huckleberry	shrub	native	23.6	94
achtri	*Achlys triphylla*	sweet after death	herb	native	9.7	48
rosgym	*Rosa gymnocarpa*	dwarf rose	shrub	native	5.4	4
corcan	*Cornus canadensis*	bunchberry dogwood	herb	native	4.7	81
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	3.3	48
camsco	*Campanula scouleri*	pale bellflower	herb	native	3.0	83
maiste	*Maianthemum stellatum*	starry false lily of the valley	herb	native	2.8	35
rublas	*Rubus lasiococcus*	roughfruit berry	subshrub	native	2.7	83
symalb	*Symphoricarpos albus*	common snowberry	shrub	native	2.2	4
ruburs	*Rubus ursinus*	California blackberry	subshrub	native	1.8	8
xerten	*Xerophyllum tenax*	common beargrass	herb	native	1.8	8
lupin	*Lupin spp*	lupine	shrub	mixed	1.6	31
cliuni	*Clintonia uniflora*	bride's bonnet	herb	native	1.3	81
paxmyr	*Paxistima myrsinites*	Oregon boxleaf	shrub	native	1.3	75

Young High-severity (n = 3) dominant species. Mean cover % for total vegetation across plots = 54.2%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
gram	*graminoids spp*	grasses, sedges, rushes	graminoids	mixed	28.1	97
lupin	*Lupin spp*	lupine	shrub	mixed	23.1	89
rublas	*Rubus lasiococcus*	roughfruit berry	subshrub	native	11.5	81
xerten	*Xerophyllum tenax*	common beargrass	herb	native	7.7	25
vacmem	*Vaccinium membranaceum*	thinleaf huckleberry	shrub	native	5.5	78
camsco	*Campanula scouleri*	pale bellflower	herb	native	3.7	50
linbor	*Linnaea borealis*	twinflower	subshrub	native	2.9	19
vioorb	*Viola orbiculata*	darkwoods violet	herb	native	2.9	72
anamar	*Anaphalis margaritacea*	western pearly everlasting	herb	native	2.1	78
fravir	*Fragaria virginiana*	Virginia strawberry	herb	native	1.5	14
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	1.5	31
rubpar	*Rubus parviflorus*	thimbleberry	subshrub	native	1.3	11
chaang	*Chamaenerion angustifolium*	fireweed	herb	native	1.2	61
phahas	*Phacelia hastata*	silverleaf phacelia	herb	native	1.1	28
corcan	*Cornus canadensis*	bunchberry dogwood	herb	native	0.9	22

Mid-seral Unburned (n = 8) dominant species. Mean cover % for total vegetation across plots = 12.9%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
xerten	*Xerophyllum tenax*	common beargrass	herb	native	73.9	36
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	8.4	72
arnlat	*Arnica latifolia*	broadleaf arnica	herb	native	3.2	11
achtri	*Achlys triphylla*	sweet after death	herb	native	2.2	3
rublas	*Rubus lasiococcus*	roughfruit berry	subshrub	native	1.8	16
vacmem	*Vaccinium membranaceum*	thinleaf huckleberry	shrub	native	1.6	45
caschr	*Castanopsis chrysophylla*	giant chinquapin	tree	native	1.1	8
symalb	*Symphoricarpos albus*	common snowberry	shrub	native	1.1	10
chiumb	*Chimaphila umbellata*	pipsissewa	subshrub	native	1.0	6
moemac	*Moehringia macrophylla*	large sandwort	herb	native	0.9	11
vanhex	*Vancouveria hexandra*	white insideout flower	herb	native	0.9	4
rosgym	*Rosa gymnocarpa*	dwarf rose	shrub	native	0.8	8
chimen	*Chimaphila menziesii*	little prince's pine	subshrub	native	0.5	9
gooobl	*Goodyera oblongifolia*	western rattlesnake plantain	herb	native	0.3	12
ortsec	*Orthilia secunda*	sidebells wintergreen	subshrub	native	0.3	15

Mid-seral Low-severity (n = 4) dominant species. Mean cover % for total vegetation across plots = 5.61%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
chaang	*Chamaenerion angustifolium*	fireweed	herb	native	48.7	81
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	14.5	42
gram	*graminoids spp*	grasses, sedges, rushes	graminoids	mixed	8.4	27
linbor	*Linnaea borealis*	twinflower	subshrub	native	3.1	6
fraves	*Fragaria vesca*	woodland strawberry	herb	native	2.8	12
mycmur	*Mycelis muralis*	wall-lettuce	herb	introduced	2.8	42
gausha	*Gaultheria shallon*	salal	subshrub	native	1.6	8
rosgym	*Rosa gymnocarpa*	dwarf rose	shrub	native	1.6	12
vacpar	*Vaccinium parvifolium*	red huckleberry	shrub	native	1.5	23
ruburs	*Rubus ursinus*	California blackberry	subshrub	native	1.4	19
vioorb	*Viola orbiculata*	darkwoods violet	herb	native	1.4	40
tribor	*Trientalis borealis*	broadleaf starflower	herb	native	1.3	31
camsco	*Campanula scouleri*	pale bellflower	herb	native	1.2	8
hiealb	*Hieracium albiflorum*	white hawkweed	herb	native	1.1	25
aspvir	*Asplenium viride*	brightgreen spleenwort	herb	native	0.9	31

Mid-seral High-severity (n = 11) dominant species. Mean cover % for total vegetation across plots = 34.1%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
chaang	*Chamaenerion angustifolium*	fireweed	herb	native	16.1	76
lupin	*Lupin spp*	lupine	shrub	mixed	13.4	59
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	10.7	48
phahas	*Phacelia hastata*	silverleaf phacelia	herb	native	10.7	47
rubpar	*Rubus parviflorus*	thimbleberry	subshrub	native	8.4	45
symmol	*Symphoricarpos mollis*	creeping snowberry	subshrub	native	6.1	32
gram	*graminoids spp*	grasses, sedges, rushes	graminoids	mixed	3.5	70
arnlat	*Arnica latifolia*	broadleaf arnica	herb	native	3.4	20
tribor	*Trientalis borealis*	broadleaf starflower	herb	native	2.9	33
rosgym	*Rosa gymnocarpa*	dwarf rose	shrub	native	2.6	33
camsco	*Campanula scouleri*	pale bellflower	herb	native	2.0	43
ribvis	*Ribes viscosissimum*	sticky currant	shrub	native	1.9	30
acecir	*Acer circinatum*	vine maple	tree	native	1.4	3
viosem	*Viola sempervirens*	evergreen violet	herb	native	1.4	26
ceavel	*Ceanothus velutinus*	snowbrush ceanothus	shrub	native	1.2	23

Late-seral Unburned (n = 18) dominant species. Mean cover % for total vegetation across plots = 22.4%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
gausha	*Gaultheria shallon*	salal	subshrub	native	32.1	35
acecir	*Acer circinatum*	vine maple	tree	native	15.4	19
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	14.8	46
vacala	*Vaccinium alaskaense*	Alaska blueberry	shrub	native	4.2	15
linbor	*Linnaea borealis*	twinflower	subshrub	native	4.0	39
acegla	*Acer glabrum*	Rocky Mountain maple	tree	native	3.6	3
vacspp	*Vaccinium spp*	blueberry	shrub	native	3.3	33
xerten	*Xerophyllum tenax*	common beargrass	herb	native	3.1	9
achtri	*Achlys triphylla*	sweet after death	herb	native	1.8	19
polmun	*Polystichum munitum*	western swordfern	herb	native	1.7	8
viosem	*Viola sempervirens*	evergreen violet	herb	native	1.7	9
pteaqu	*Pteridium aquilinum*	western brackenfern	herb	native	1.5	8
vacoval	*Vaccinium ovalifolium*	oval-leaf blueberry	shrub	native	1.4	17
menfer	*Menziesia ferruginea*	rusty menziesia	shrub	native	1.3	10
vacpar	*Vaccinium parvifolium*	red huckleberry	shrub	native	1.1	31

Late-seral Low-severity (n = 13) dominant species. Mean cover % for total vegetation across plots = 8.81%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
chaang	*Chamaenerion angustifolium*	fireweed	herb	native	42.7	70
linbor	*Linnaea borealis*	twinflower	subshrub	native	13.4	23
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	9.3	42
achtri	*Achlys triphylla*	sweet after death	herb	native	8.7	22
xerten	*Xerophyllum tenax*	common beargrass	herb	native	4.4	11
corcan	*Cornus canadensis*	bunchberry dogwood	herb	native	3.0	24
tiatri	*Tiarella trifoliata*	oneleaf foamflower	herb	native	2.0	16
aspvir	*Asplenium viride*	brightgreen spleenwort	herb	native	1.6	29
fraves	*Fragaria vesca*	woodland strawberry	herb	native	1.3	3
vacmem	*Vaccinium membranaceum*	thinleaf huckleberry	shrub	native	1.2	35
ortsec	*Orthilia secunda*	sidebells wintergreen	subshrub	native	0.9	21
rublas	*Rubus lasiococcus*	roughfruit berry	subshrub	native	0.9	21
vacpar	*Vaccinium parvifolium*	red huckleberry	shrub	native	0.7	22
epicil	*Epilobium ciliatum*	fringed willowherb	herb	native	0.6	18
maitri	*Maianthemum trifolium*	threeleaf false lily of the valley	herb	native	0.6	13

Late-seral High-severity (n = 25) dominant species. Mean cover % for total vegetation across plots = 36.5%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
chaang	*Chamaenerion angustifolium*	fireweed	herb	native	26.0	91
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	9.1	47
pteaqu	*Pteridium aquilinum*	western brackenfern	herb	native	8.8	20
ceasan	*Ceanothus sanguineus*	redstem ceanothus	shrub	native	6.9	23
rubpar	*Rubus parviflorus*	thimbleberry	subshrub	native	5.9	18
ruburs	*Rubus ursinus*	California blackberry	subshrub	native	5.5	25
gausha	*Gaultheria shallon*	salal	subshrub	native	4.8	21
salix	*Salix spp*	willow	shrub	mixed	4.6	38
tribor	*Trientalis borealis*	broadleaf starflower	herb	native	3.0	50
mycmur	*Mycelis muralis*	wall-lettuce	herb	introduced	2.9	56
rubleu	*Rubus leucodermis*	whitebark raspberry	subshrub	native	2.3	20
acemac	*Acer macrophyllum*	bigleaf maple	tree	native	2.1	17
gram	*graminoids spp*	grasses, sedges, rushes	graminoids	mixed	2.1	42
sensyl	*Senecio sylvaticus*	woodland ragwort	herb	introduced	1.4	37
acecir	*Acer circinatum*	vine maple	tree	native	1.3	4

Table 2. Results of analysis of similarity (ANOSIM) for raw and relative (Rel.) mean percent cover between strata combinations. Significance values are denoted as: * p < 0.05, ** p < 0.01, *** p < 0.001, **** p < 0.0001.

Pairwise strata	Raw R-statistic	Raw significance	Rel. R-statistic	Rel. significance
young:unburned V young:high	0.759	0.031 *	0.667	0.030 *
young:unburned V mid-seral:unburned	0.167	0.112	0.259	0.076
young:unburned V mid-seral:low	0.979	0.033 *	0.999	0.030 *
young:unburned V mid-seral:high	0.411	0.007 **	0.481	0.004 **
young:unburned V late-seral:unburned	-0.034	0.578	-0.051	0.631
young:unburned V late-seral:low	0.085	0.229	0.346	0.005
young:unburned V late-seral:high	0.865	0.001 ***	0.821	0.001 ***
young:high V mid-seral:unburned	0.356	0.017 *	0.362	0.036 *
young:high V mid-seral:low	0.833	0.022 *	0.907	0.019 *
young:high V mid-seral:high	-0.020	0.464	0.134	0.134
young:high V late-seral:unburned	0.433	0.009 **	0.327	0.013 *
young:high V late-seral:low	0.539	0.001 ***	0.680	0.002 **
young:high V late-seral:high	0.677	0.002 **	0.651	0.001 ***
mid-seral:unburned V mid-seral:low	0.446	0.022 *	0.478	0.014 *
mid-seral:unburned V mid-seral:high	0.617	0.002 **	0.536	0.001 ***
mid-seral:unburned V late-seral:unburned	0.304	0.002 **	0.054	0.232
mid-seral:unburned V late-seral:low	0.472	0.001 ***	0.463	0.001 ***
mid-seral:unburned V late-seral:high	0.899	0.001 ***	0.713	0.001 ***
mid-seral:low V mid-seral:high	0.005	0.456	0.045	0.251
mid-seral:low V late-seral:unburned	0.331	0.331	0.347	0.012 *
mid-seral:low V late-seral:low	-0.122	0.836	-0.065	0.688
mid-seral:low V late-seral:high	0.210	0.086	-0.104	0.740
mid-seral:high V late-seral:unburned	0.529	0.001 ***	0.501	0.001 ***
mid-seral:high V late-seral:low	0.310	0.002 **	0.295	0.002 **
mid-seral:high V late-seral:high	0.326	0.002 **	0.190	0.026 *
late-seral:unburned V late-seral:low	0.296	0.002 **	0.307	0.001 ***
late-seral:unburned V late-seral:high	0.607	0.001 ***	0.608	0.001 ***
late-seral:low V late-seral:high	0.386	0.001 ***	0.174	0.012 *

Table 3. Results of analysis of variance (ANOVA) within species richness (number of species) and species evenness (as the Shannon Diversity Index, SDI) across pre-fire stand age, burn severity, and the interaction effect. Significance values are denoted as: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$.

Response	Strata	F-val	p-val
Richness	Pre-fire stand age	1.920	0.153
	Burn severity	4.560	0.013*
	Pre-fire stand age:Burn severity	3.310	0.024*
Evenness (SDI)	Pre-fire stand age	2.270	0.111
	Burn severity	0.128	0.88
	Pre-fire stand age:Burn severity	0.158	0.924

Table 4. Results of Tukey's Honestly Significantly Different (HSD) test across strata combination (pre-fire stand age: burn severity) pairwise combinations. Significance values are denoted as: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$.

Pairwise strata	richness p-val	diversity p-val
young:unburned V young:high	0.999	0.999
young:unburned V mid-seral:unburned	0.024 *	0.740
young:unburned V mid-seral:low	0.999	0.966
young:unburned V mid-seral:high	0.999	0.943
young:unburned V late-seral:unburned	0.729	0.658
young:unburned V late-seral:low	0.710	0.707
young:unburned V late-seral:high	0.988	0.774
young:high V mid-seral:unburned	0.169	0.966
young:high V mid-seral:low	0.999	0.999
young:high V mid-seral:high	1.000	0.999
young:high V late-seral:unburned	0.978	0.956
young:high V late-seral:low	0.971	0.965
young:high V late-seral:high	0.999	0.979
mid-seral:unburned V mid-seral:low	0.176	0.999
mid-seral:unburned V mid-seral:high	0.007 **	0.999
mid-seral:unburned V late-seral:unburned	0.155	1.000
mid-seral:unburned V late-seral:low	0.263	1.000
mid-seral:unburned V late-seral:high	0.006 **	0.999
mid-seral:low V mid-seral:high	0.999	1.000
mid-seral:low V late-seral:unburned	0.994	0.999
mid-seral:low V late-seral:low	0.991	0.999
mid-seral:low V late-seral:high	1.000	0.999
mid-seral:high V late-seral:unburned	0.772	0.998
mid-seral:high V late-seral:low	0.765	0.999
mid-seral:high V late-seral:high	0.999	0.999
late-seral:unburned V late-seral:low	1.000	1.000
late-seral:unburned V late-seral:high	0.896	0.999
late-seral:low V late-seral:high	0.891	0.999

Figure 1. A map of the western Cascadia region (green), with the four sampled fire perimeters (red), and inset from the Pacific Northwest, USA (black outline).

Figure 2. Heatmaps of relativized a) mean raw cover and b) frequency of life forms across strata combination (Pre-fire stand age + Burn severity). Mid-seral and late-seral were shortened to mid and late, respectively.

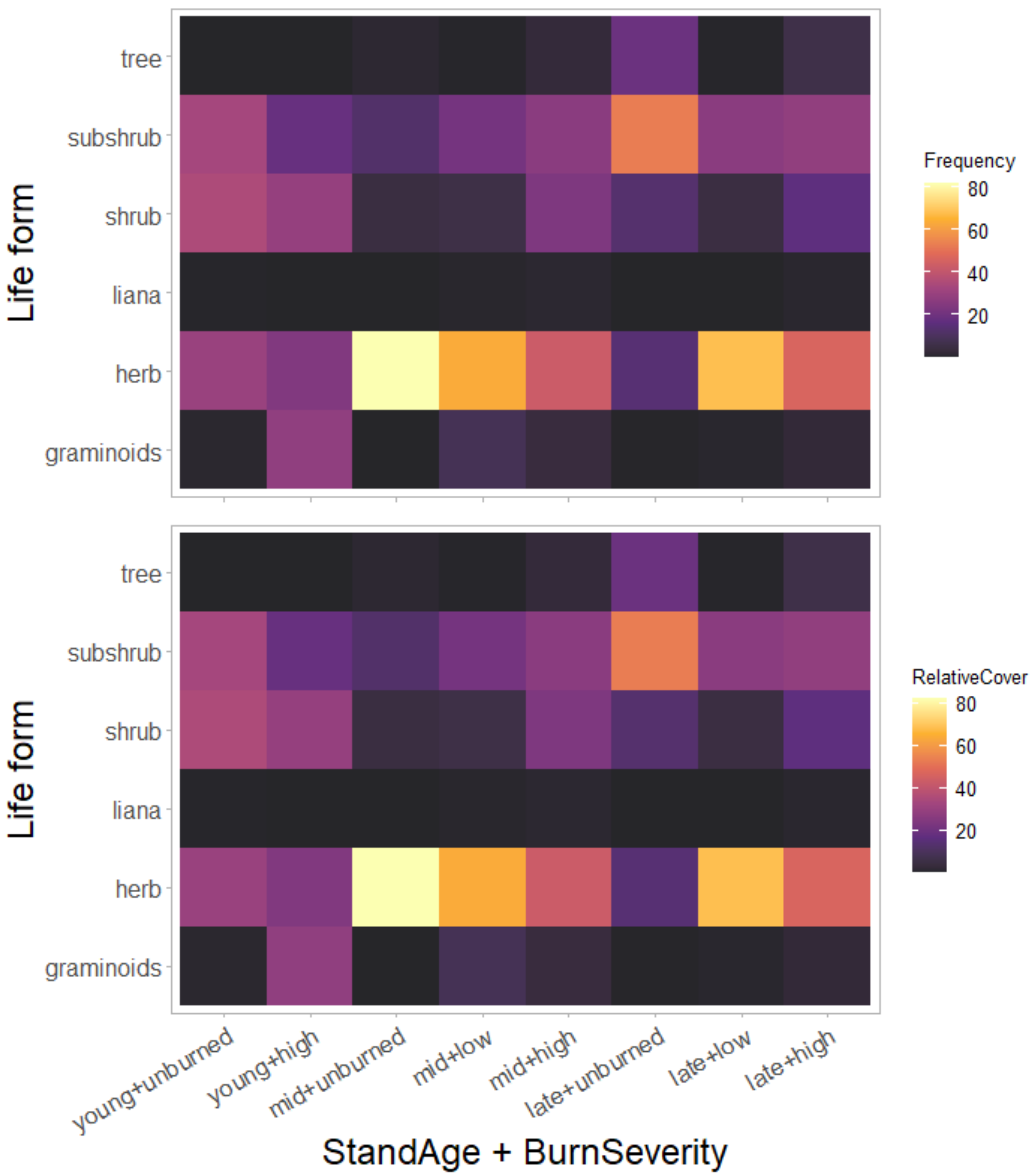


Figure 3. Raw mean cover (top) and relative mean cover (bottom) percent of bryophytes (mosses, liverworts, hornworts) across pre-fire stand age and burn severity.

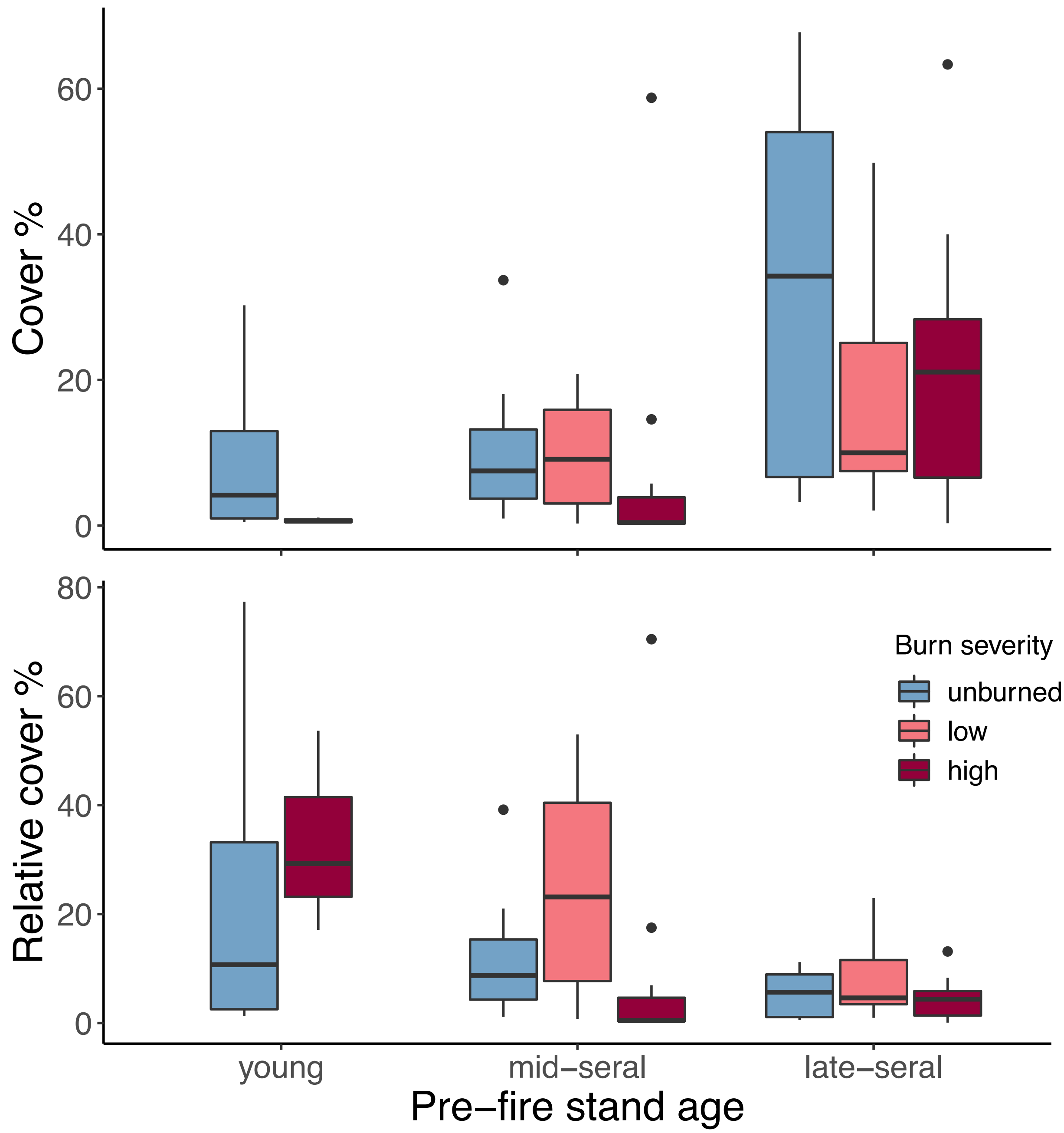


Figure 4. Species composition (raw and relative mean cover %) within species space using non-metric multidimensional scaling (NMDS) ordination. Shapes designate pre-fire stand age (circle = young, triangle = mid-seral, square = late-seral), and colors designate burn severity (blue = unburned, pink = low, red = high). Arrows indicate movement within pre-fire stand age due to burn severity effects.

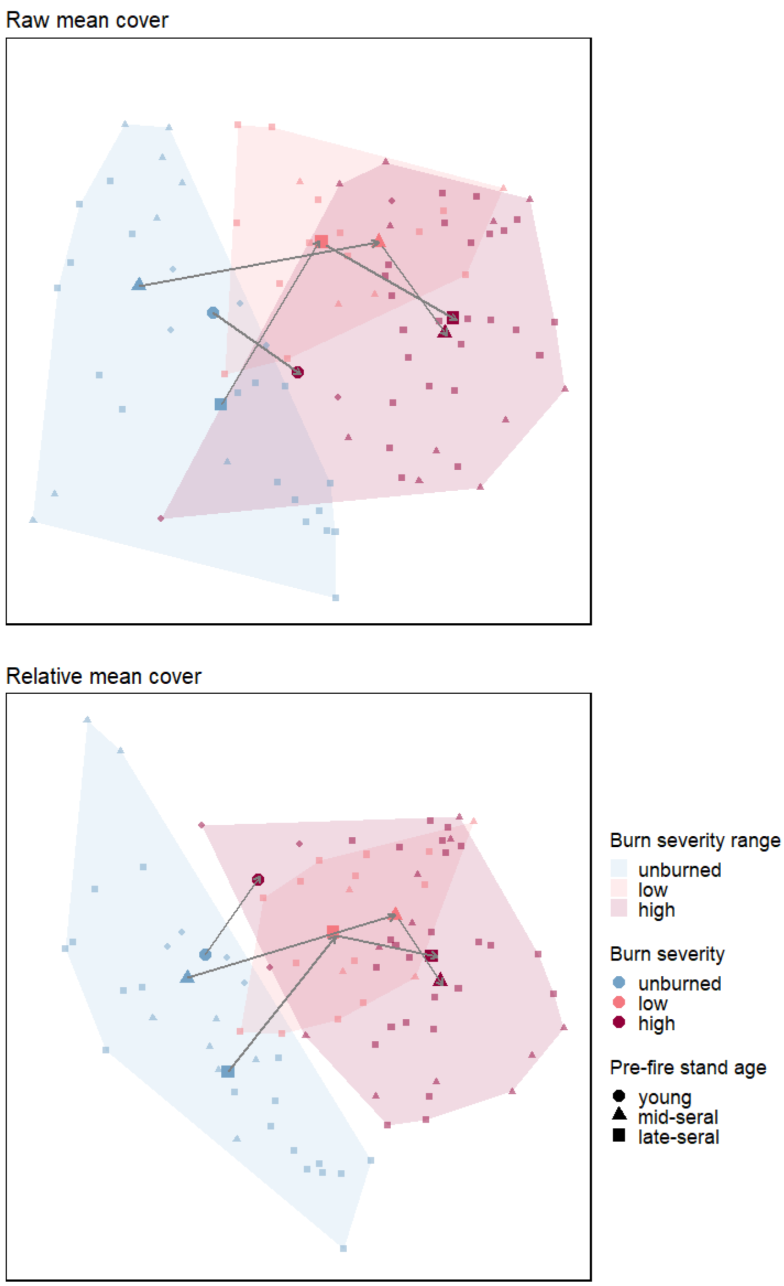


Figure 5. Species richness (top) and Shannon Diversity Index (bottom) across pre-fire stand age and burn severity. Letter pairs designate significant differences among groups. Mid-seral unburned is in every single significantly different pairwise combo (hence, the a-c). Boxes with no letters are not significantly different with any other strata combination. Median (middle line), 25th and 75th percentiles (box), 95% confidence interval (whiskers), and outliers (dots).

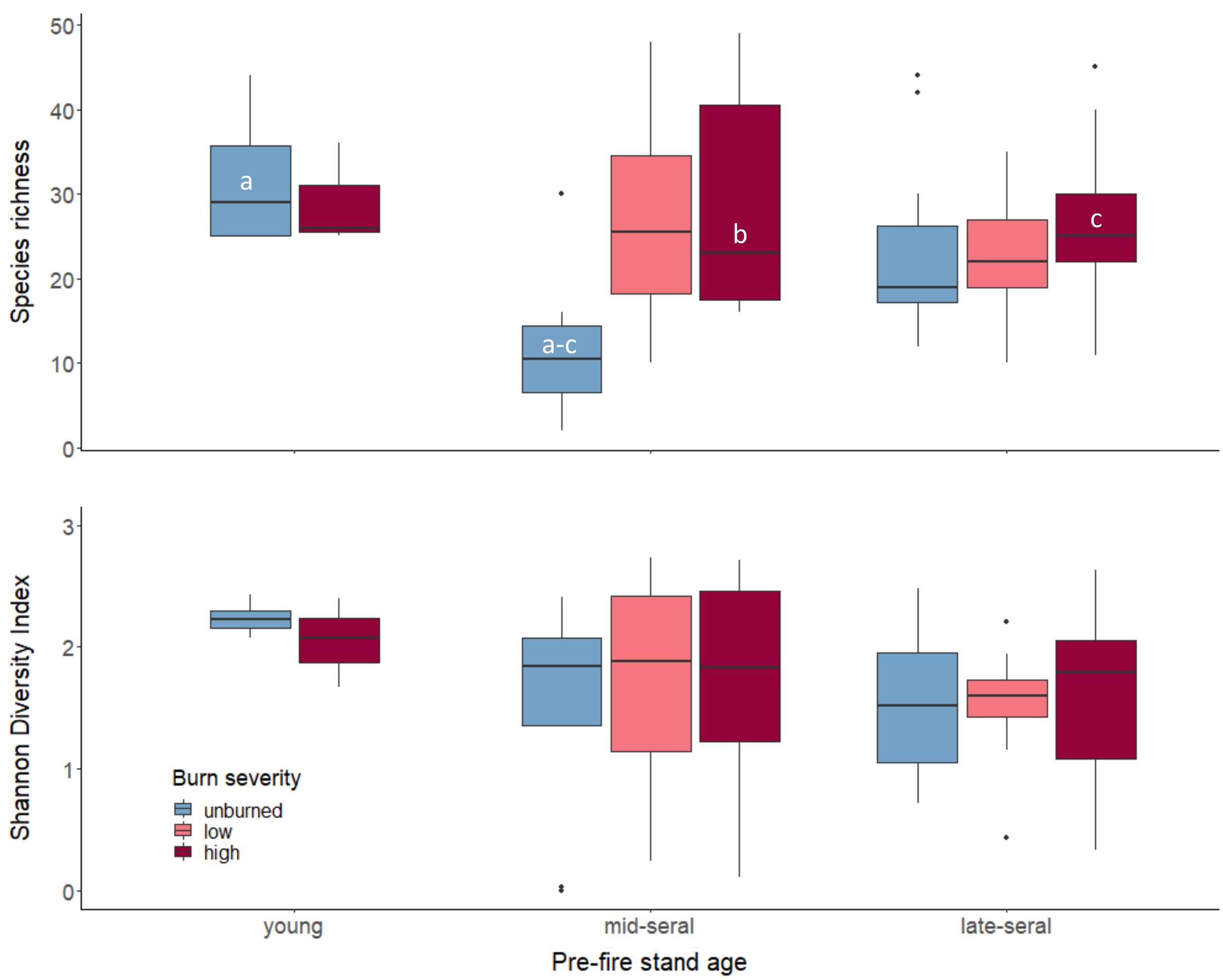
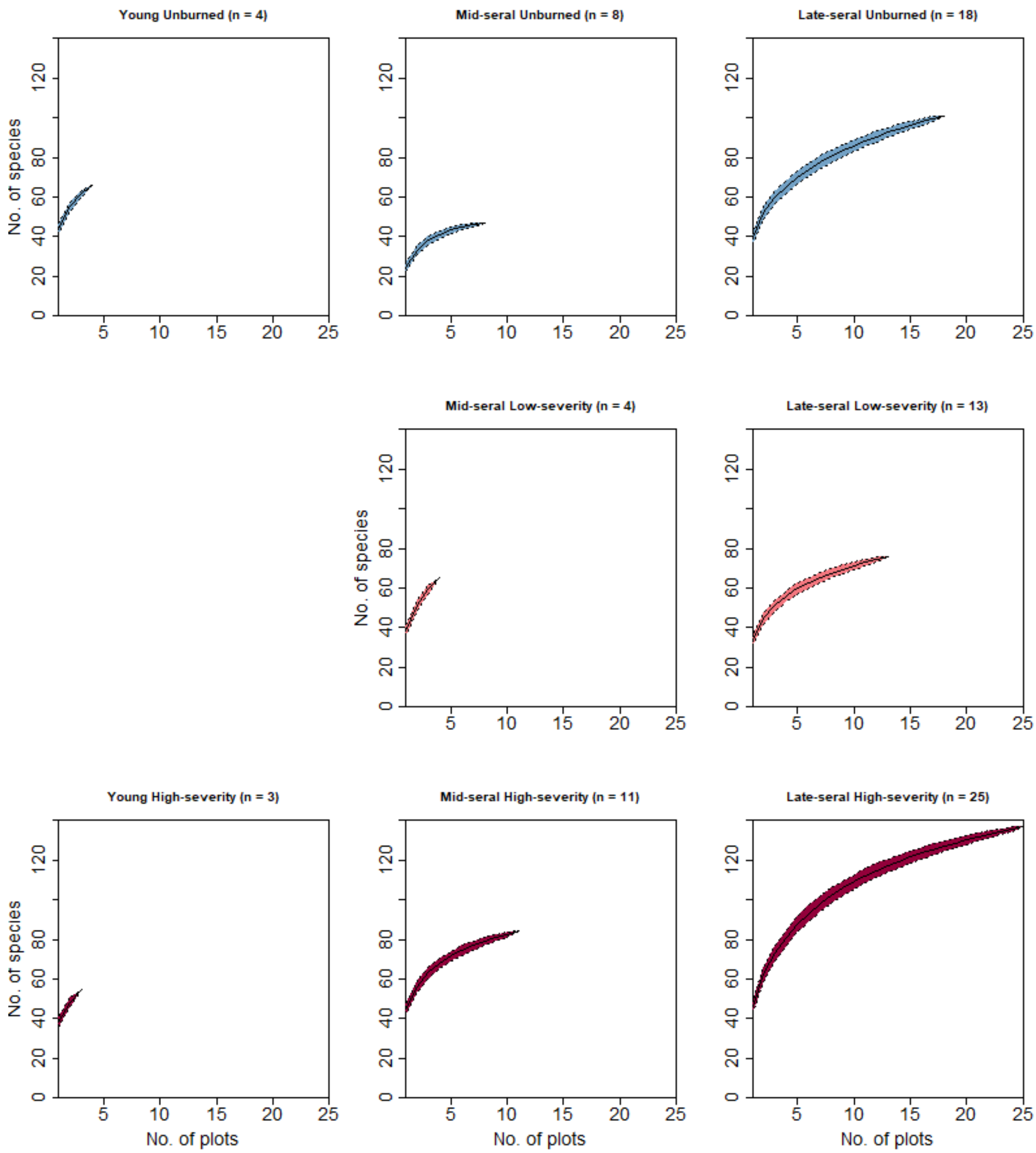
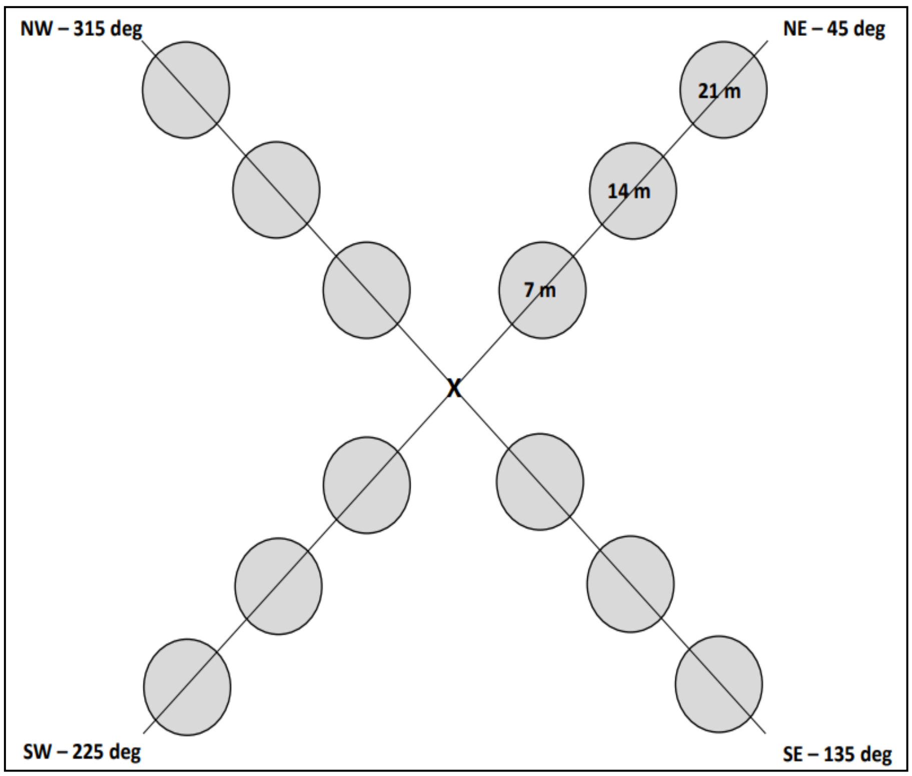


Figure 6. Mean (black line) and SE (envelope) of species accumulation curves in each strata combination (stand age + burn severity), depicting the number of species (y-axis) across the number of stands (x-axis). Colors represent burn severity (blue = unburned, pink = low-severity, red = high-severity).



Appendix 1. The plot design used to collect ground cover. Plot center is marked by the center bolded X. Four transect lines (24.5 m) run out in the sub-cardinal directions: northeast (NE – 45°), southeast (SE – 135°), southwest (SW – 225°), and northwest (NW – 315°). Along each of the four transect lines, three 2-m radius subplots are marked at 7 m, 14 m, and 21 m, where ground cover data were collected.



Appendix 2. Full species list of each strata combination (pre-fire stand age and burn severity), split into two halves for visibility of tables.

Young Unburned - part 1

Young Unburned (n = 4) species (n = 66). Mean cover % for total vegetation across plots = 10.5%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
linbor	*Linnaea borealis*	twinflower	subshrub	native	24.0	60
vacmem	*Vaccinium membranaceum*	thinleaf huckleberry	shrub	native	23.6	94
achtri	*Achlys triphylla*	sweet after death	herb	native	9.7	48
rosgym	*Rosa gymnocarpa*	dwarf rose	shrub	native	5.4	4
corcan	*Cornus canadensis*	bunchberry dogwood	herb	native	4.7	81
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	3.3	48
camsco	*Campanula scouleri*	pale bellflower	herb	native	3.0	83
maiste	*Maianthemum stellatum*	starry false lily of the valley	herb	native	2.8	35
rublas	*Rubus lasiococcus*	roughfruit berry	subshrub	native	2.7	83
symalb	*Symphoricarpos albus*	common snowberry	shrub	native	2.2	4
ruburs	*Rubus ursinus*	California blackberry	subshrub	native	1.8	8
xerten	*Xerophyllum tenax*	common beargrass	herb	native	1.8	8
lupin	*Lupin spp*	lupine	shrub	mixed	1.6	31
cliuni	*Clintonia uniflora*	bride's bonnet	herb	native	1.3	81
paxmyr	*Paxistima myrsinites*	Oregon boxleaf	shrub	native	1.3	75
anamar	*Anaphalis margaritacea*	western pearly everlasting	herb	native	1.0	27
epigla	*Epilobium glaberrimum*	glaucus willowherb	herb	native	1.0	6
gram	*graminoids spp*	grasses, sedges, rushes	graminoids	mixed	0.8	23
menfer	*Menziesia ferruginea*	rusty menziesia	shrub	native	0.8	8
chiumb	*Chimaphila umbellata*	pipsissewa	subshrub	native	0.6	19
vioorb	*Viola orbiculata*	darkwoods violet	herb	native	0.6	46
hiealb	*Hieracium albiflorum*	white hawkweed	herb	native	0.5	48
polmun	*Polystichum munitum*	western swordfern	herb	native	0.5	17
triova	*Trillium ovatum*	Pacific trillium	herb	native	0.5	50
viosem	*Viola sempervirens*	evergreen violet	herb	native	0.5	48
ortsec	*Orthilia secunda*	sidebells wintergreen	subshrub	native	0.4	40
symmol	*Symphoricarpos mollis*	creeping snowberry	subshrub	native	0.4	2
chaang	*Chamaenerion angustifolium*	fireweed	herb	native	0.3	31
tiatri	*Tiarella trifoliata*	oneleaf foamflower	herb	native	0.3	12
amealn	*Amelanchier alnifolia*	Saskatoon serviceberry	shrub	native	0.2	2
asacau	*Asarum caudatum*	British Columbia wildginger	herb	native	0.2	6
calbul	*Calypso bulbosa*	fairy slipper	herb	native	0.2	25
ciredu	*Cirsium edule*	edible thistle	herb	native	0.2	4

Young Unburned - part 2

Young Unburned (n = 4) species (n = 66). Mean cover % for total vegetation across plots = 10.5%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
notnem	*Nothochelone nemorosa*	woodland beardtongue	herb	native	0.2	21
anedel	*Anemone deltoidea*	Columbian windflower	herb	native	0.1	6
epilat	*Epilobium latifolium*	dwarf willowherb	herb	native	0.1	8
liscor	*Listera cordata*	heartleaf twayblade	herb	native	0.1	10
lotmic	*Lotus micranthus*	desert deervetch	herb	native	0.1	6
mairac	*Maianthemum racemosum*	feathery false lily of the valley	herb	native	0.1	6
moemac	*Moehringia macrophylla*	large sandwort	herb	native	0.1	6
pyrasa	*Pyrola asarifolia*	liverleaf wintergreen	subshrub	native	0.1	10
pyrpic	*Pyrola picta*	whiteveined wintergreen	subshrub	native	0.1	6
rubpar	*Rubus parviflorus*	thimbleberry	subshrub	native	0.1	8
selore	*Selaginella oregana*	Oregon spikemoss	herb	native	0.1	6
tribor	*Trientalis borealis*	broadleaf starflower	herb	native	0.1	10
vacpar	*Vaccinium parvifolium*	red huckleberry	shrub	native	0.1	8
vacspp	*Vaccinium spp*	blueberry	shrub	native	0.1	15
verwor	*Veronica wormskjoldii*	American alpine speedwell	herb	native	0.1	12
vicame	*Vicia americana*	American vetch	liana	native	0.1	8
adebic	*Adenocaulon bicolor*	American trailplant	herb	native	0.1	2
aqufor	*Aquilegia formosa*	western columbine	herb	native	0.1	2
fravir	*Fragaria virginiana*	Virginia strawberry	herb	native	0.1	2
galtrifi	*Galium trifidum*	threepetal bedstraw	liana	native	0.1	2
galtrifl	*Galium triflorum*	fragrant bedstraw	liana	native	0.1	4
gauova	*Gaultheria ovatifolia*	western teaberry	subshrub	native	0.1	2
gooobl	*Goodyera oblongifolia*	western rattlesnake plantain	herb	native	0.1	2
hupsel	*Huperzia selago*	fir clubmoss	herb	native	0.1	2
latnev	*Lathyrus nevadensis*	Sierra pea	liana	native	0.1	2
osmchi	*Osmorhiza chilensis*	Mountain sweet cicely	herb	native	0.1	2
ranunc	*Ranunculus uncinatus*	woodland buttercup	herb	native	0.1	2
ribvis	*Ribes viscosissimum*	sticky currant	shrub	native	0.1	4
rubped	*Rubus pedatus*	strawberryleaf raspberry	subshrub	native	0.1	4
trirep	*Trifolium repens*	white clover	herb	introduced	0.1	2
vacsco	*Vaccinium scoparium*	grouse whortleberry	shrub	native	0.1	2
valsit	*Valeriana sitchensis*	Sitka valerian	herb	native	0.1	4
viocan	*Viola canadensis*	Canada white violet	herb	native	0.1	2

Young High-severity - part 1

Young High-severity (n = 3) species (n = 55). Mean cover % for total vegetation across plots = 54.2%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
gram	*graminoids spp*	grasses, sedges, rushes	graminoids	mixed	28.1	97
lupin	*Lupin spp*	lupine	shrub	mixed	23.1	89
rublas	*Rubus lasiococcus*	roughfruit berry	subshrub	native	11.5	81
xerten	*Xerophyllum tenax*	common beargrass	herb	native	7.7	25
vacmem	*Vaccinium membranaceum*	thinleaf huckleberry	shrub	native	5.5	78
camsco	*Campanula scouleri*	pale bellflower	herb	native	3.7	50
linbor	*Linnaea borealis*	twinflower	subshrub	native	2.9	19
vioorb	*Viola orbiculata*	darkwoods violet	herb	native	2.9	72
anamar	*Anaphalis margaritacea*	western pearly everlasting	herb	native	2.1	78
fravir	*Fragaria virginiana*	Virginia strawberry	herb	native	1.5	14
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	1.5	31
rubpar	*Rubus parviflorus*	thimbleberry	subshrub	native	1.3	11
chaang	*Chamaenerion angustifolium*	fireweed	herb	native	1.2	61
phahas	*Phacelia hastata*	silverleaf phacelia	herb	native	1.1	28
corcan	*Cornus canadensis*	bunchberry dogwood	herb	native	0.9	22
achtri	*Achlys triphylla*	sweet after death	herb	native	0.8	22
gauova	*Gaultheria ovatifolia*	western teaberry	subshrub	native	0.8	19
mimbre	*Mimulus breweri*	Brewer's monkeyflower	herb	native	0.8	19
riblac	*Ribes lacustre*	prickly currant	shrub	native	0.4	6
tribor	*Trientalis borealis*	broadleaf starflower	herb	native	0.4	22
moemac	*Moehringia macrophylla*	large sandwort	herb	native	0.2	11
rubspp	*Rubus spp*	blackberry	subshrub	mixed	0.2	3
achmil	*Achillea millefolium*	common yarrow	herb	mixed	0.1	6
chiumb	*Chimaphila umbellata*	pipsissewa	subshrub	native	0.1	11
cliuni	*Clintonia uniflora*	bride's bonnet	herb	native	0.1	19
epicil	*Epilobium ciliatum*	fringed willowherb	herb	native	0.1	53
epimin	*Epilobium minutum*	chaparral willowherb	herb	native	0.1	25
hiealb	*Hieracium albiflorum*	white hawkweed	herb	native	0.1	36

Young High-severity - part 2

Young High-severity (n = 3) species (n = 55). Mean cover % for total vegetation across plots = 54.2%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
lapcom	*Lapsana communis*	common nipplewort	herb	introduced	0.1	3
notnem	*Nothochelone nemorosa*	woodland beardtongue	herb	native	0.1	6
paxmyr	*Paxistima myrsinites*	Oregon boxleaf	shrub	native	0.1	28
ribsan	*Ribes sanguineum*	redflower currant	shrub	native	0.1	3
rosgym	*Rosa gymnocarpa*	dwarf rose	shrub	native	0.1	3
rumace	*Rumex acetosella*	common sheep sorrel	herb	native	0.1	6
sagdec	*Sagina decumbens*	trailing pearlwort	herb	native	0.1	3
sensyl	*Senecio sylvaticus*	woodland ragwort	herb	introduced	0.1	28
triova	*Trillium ovatum*	Pacific trillium	herb	native	0.1	6
vacpar	*Vaccinium parvifolium*	red huckleberry	shrub	native	0.1	6
agoaur	*Agoseris aurantiaca*	orange agoseris	herb	native	0.1	8
carocc	*Cardamine occidentalis*	big western bittercress	herb	native	0.1	3
cirvul	*Cirsium vulgare*	bull thistle	herb	introduced	0.1	3
hieumb	*Hieracium umbellatum*	narrowleaf hawkweed	herb	native	0.1	8
maiste	*Maianthemum stellatum*	starry false lily of the valley	herb	native	0.1	6
menfer	*Menziesia ferruginea*	rusty menziesia	shrub	native	0.1	3
mycmur	*Mycelis muralis*	wall-lettuce	herb	introduced	0.1	3
ortsec	*Orthilia secunda*	sidebells wintergreen	subshrub	native	0.1	6
plasco	*Plagiobothrys scouleri*	Scouler's popcornflower	herb	native	0.1	3
poldou	*Polygonum douglasii*	Douglas' knotweed	herb	native	0.1	3
pyrasa	*Pyrola asarifolia*	liverleaf wintergreen	subshrub	native	0.1	17
ranunc	*Ranunculus uncinatus*	woodland buttercup	herb	native	0.1	3
samrac	*Sambucus racemosa*	red elderberry	shrub	native	0.1	3
saxfer	*Saxifraga ferruginea*	russethair saxifrage	herb	native	0.1	3
sorsit	*Sorbus sitchensis*	western mountain ash	shrub	native	0.1	3
telgra	*Tellima grandiflora*	bigflower tellima	herb	native	0.1	3
tiatri	*Tiarella trifoliata*	oneleaf foamflower	herb	native	0.1	3

Mid-seral Unburned - part 1

Mid-seral Unburned (n = 8) species (n = 47). Mean cover % for total vegetation across plots = 12.9%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
xerten	*Xerophyllum tenax*	common beargrass	herb	native	73.9	36
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	8.4	72
arnlat	*Arnica latifolia*	broadleaf arnica	herb	native	3.2	11
achtri	*Achlys triphylla*	sweet after death	herb	native	2.2	3
rublas	*Rubus lasiococcus*	roughfruit berry	subshrub	native	1.8	16
vacmem	*Vaccinium membranaceum*	thinleaf huckleberry	shrub	native	1.6	45
caschr	*Castanopsis chrysophylla*	giant chinquapin	tree	native	1.1	8
symalb	*Symphoricarpos albus*	common snowberry	shrub	native	1.1	10
chiumb	*Chimaphila umbellata*	pipsissewa	subshrub	native	1.0	6
moemac	*Moehringia macrophylla*	large sandwort	herb	native	0.9	11
vanhex	*Vancouveria hexandra*	white insideout flower	herb	native	0.9	4
rosgym	*Rosa gymnocarpa*	dwarf rose	shrub	native	0.8	8
chimen	*Chimaphila menziesii*	little prince's pine	subshrub	native	0.5	9
gooobl	*Goodyera oblongifolia*	western rattlesnake plantain	herb	native	0.3	12
ortsec	*Orthilia secunda*	sidebells wintergreen	subshrub	native	0.3	15
pyrpic	*Pyrola picta*	whiteveined wintergreen	subshrub	native	0.3	17
hemcon	*Hemitomes congestum*	coneplant	herb	native	0.2	2
triova	*Trillium ovatum*	Pacific trillium	herb	native	0.2	20
vacpar	*Vaccinium parvifolium*	red huckleberry	shrub	native	0.2	22
vacspp	*Vaccinium spp*	blueberry	shrub	native	0.2	29
amealn	*Amelanchier alnifolia*	Saskatoon serviceberry	shrub	native	0.1	3
calbul	*Calypso bulbosa*	fairy slipper	herb	native	0.1	10
cormer	*Corallorhiza mertensiana*	Pacific coralroot	herb	native	0.1	10
notnem	*Nothochelone nemorosa*	woodland beardtongue	herb	native	0.1	5

Mid-seral Unburned - part 2

Mid-seral Unburned (n = 8) species (n = 47). Mean cover % for total vegetation across plots = 12.9%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
pyrasa	*Pyrola asarifolia*	liverleaf wintergreen	subshrub	native	0.1	8
viosem	*Viola sempervirens*	evergreen violet	herb	native	0.1	7
anedel	*Anemone deltoidea*	Columbian windflower	herb	native	0.1	4
camsco	*Campanula scouleri*	pale bellflower	herb	native	0.1	1
cliuni	*Clintonia uniflora*	bride's bonnet	herb	native	0.1	4
coralspp	*Corallorhiza spp*	coralroot	herb	native	0.1	1
corcan	*Cornus canadensis*	bunchberry dogwood	herb	native	0.1	2
gausha	*Gaultheria shallon*	salal	subshrub	native	0.1	6
gram	*graminoids spp*	grasses, sedges, rushes	graminoids	mixed	0.1	1
hiealb	*Hieracium albiflorum*	white hawkweed	herb	native	0.1	4
linbor	*Linnaea borealis*	twinflower	subshrub	native	0.1	6
liscor	*Listera cordata*	heartleaf twayblade	herb	native	0.1	2
maiste	*Maianthemum stellatum*	starry false lily of the valley	herb	native	0.1	1
menfer	*Menziesia ferruginea*	rusty menziesia	shrub	native	0.1	1
paxmyr	*Paxistima myrsinites*	Oregon boxleaf	shrub	native	0.1	4
pteand	*Pteridium aquilinum*	western brackenfern	herb	native	0.1	2
pteaqu	*Pteridium aquilinum*	western brackenfern	herb	native	0.1	2
rubped	*Rubus pedatus*	strawberryleaf raspberry	subshrub	native	0.1	2
ruburs	*Rubus ursinus*	California blackberry	subshrub	native	0.1	1
spidou	*Spiraea douglasii*	rose spirea	shrub	native	0.1	3
tiatri	*Tiarella trifoliata*	oneleaf foamflower	herb	native	0.1	3
tribor	*Trientalis borealis*	broadleaf starflower	herb	native	0.1	4
vioorb	*Viola orbiculata*	darkwoods violet	herb	native	0.1	1

Mid-seral Low-severity - part 1

Mid-seral Low-severity (n = 4) species (n = 65). Mean cover % for total vegetation across plots = 5.61%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
chaang	*Chamaenerion angustifolium*	fireweed	herb	native	48.7	81
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	14.5	42
gram	*graminoids spp*	grasses, sedges, rushes	graminoids	mixed	8.4	27
linbor	*Linnaea borealis*	twinflower	subshrub	native	3.1	6
fraves	*Fragaria vesca*	woodland strawberry	herb	native	2.8	12
mycmur	*Mycelis muralis*	wall-lettuce	herb	introduced	2.8	42
gausha	*Gaultheria shallon*	salal	subshrub	native	1.6	8
rosgym	*Rosa gymnocarpa*	dwarf rose	shrub	native	1.6	12
vacpar	*Vaccinium parvifolium*	red huckleberry	shrub	native	1.5	23
ruburs	*Rubus ursinus*	California blackberry	subshrub	native	1.4	19
vioorb	*Viola orbiculata*	darkwoods violet	herb	native	1.4	40
tribor	*Trientalis borealis*	broadleaf starflower	herb	native	1.3	31
camsco	*Campanula scouleri*	pale bellflower	herb	native	1.2	8
hiealb	*Hieracium albiflorum*	white hawkweed	herb	native	1.1	25
aspvir	*Asplenium viride*	brightgreen spleenwort	herb	native	0.9	31
sensyl	*Senecio sylvaticus*	woodland ragwort	herb	introduced	0.7	40
achtri	*Achlys triphylla*	sweet after death	herb	native	0.6	12
epicil	*Epilobium ciliatum*	fringed willowherb	herb	native	0.6	31
amealn	*Amelanchier alnifolia*	Saskatoon serviceberry	shrub	native	0.4	2
ceasan	*Ceanothus sanguineus*	redstem ceanothus	shrub	native	0.4	21
galtrifl	*Galium triflorum*	fragrant bedstraw	liana	native	0.4	4
moemac	*Moehringia macrophylla*	large sandwort	herb	native	0.4	6
ribsan	*Ribes sanguineum*	redflower currant	shrub	native	0.4	21
rubspp	*Rubus spp*	blackberry	subshrub	mixed	0.4	2
vacmem	*Vaccinium membranaceum*	thinleaf huckleberry	shrub	native	0.4	21
paxmyr	*Paxistima myrsinites*	Oregon boxleaf	shrub	native	0.3	15
adebic	*Adenocaulon bicolor*	American trailplant	herb	native	0.2	10
pyrasa	*Pyrola asarifolia*	liverleaf wintergreen	subshrub	native	0.2	12
rublas	*Rubus lasiococcus*	roughfruit berry	subshrub	native	0.2	12
salix	*Salix spp*	willow	shrub	mixed	0.2	10
acecir	*Acer circinatum*	vine maple	tree	native	0.1	6
agoaur	*Agoseris aurantiaca*	orange agoseris	herb	native	0.1	6
anamar	*Anaphalis margaritacea*	western pearly everlasting	herb	native	0.1	8

Mid-seral Low-severity - part 2

Mid-seral Low-severity (n = 4) species (n = 65). Mean cover % for total vegetation across plots = 5.61%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
chiumb	*Chimaphila umbellata*	pipsissewa	subshrub	native	0.1	8
cliuni	*Clintonia uniflora*	bride's bonnet	herb	native	0.1	4
cysfra	*Cystopteris fragilis*	brittle bladderfern	herb	native	0.1	6
galspp	*Galium spp*	bedstraw	herb	mixed	0.1	4
gooobl	*Goodyera oblongifolia*	western rattlesnake plantain	herb	native	0.1	8
maiste	*Maianthemum stellatum*	starry false lily of the valley	herb	native	0.1	4
riblac	*Ribes lacustre*	prickly currant	shrub	native	0.1	8
rosspp	*Rosa spp*	rose	shrub	mixed	0.1	6
rubpar	*Rubus parviflorus*	thimbleberry	subshrub	native	0.1	4
symalb	*Symphoricarpos albus*	common snowberry	shrub	native	0.1	8
triova	*Trillium ovatum*	Pacific trillium	herb	native	0.1	4
viosem	*Viola sempervirens*	evergreen violet	herb	native	0.1	8
acegla	*Acer glabrum*	Rocky Mountain maple	tree	native	0.1	2
acespp	*Acer spp*	maple	tree	native	0.1	2
achmil	*Achillea millefolium*	common yarrow	herb	mixed	0.1	2
astspp	*Aster spp*	aster	herb	mixed	0.1	2
chimen	*Chimaphila menziesii*	little prince's pine	subshrub	native	0.1	2
epimin	*Epilobium minutum*	chaparral willowherb	herb	native	0.1	2
fraspp	*Fragaria spp*	strawberry	herb	native	0.1	2
fravir	*Fragaria virginiana*	Virginia strawberry	herb	native	0.1	2
heumic	*Heuchera micrantha*	crevice alumnroot	herb	native	0.1	2
hiegra	*Hieracium gracile*	slender hawkweed	herb	native	0.1	2
lilcol	*Lilium columbianum*	Columbia lily	herb	native	0.1	2
osmchi	*Osmorhiza chilensis*	Mountain sweet cicely	herb	native	0.1	2
polmun	*Polystichum munitum*	western swordfern	herb	native	0.1	2
polspp	*Polypodium spp*	polypody	herb	native	0.1	2
pteaqu	*Pteridium aquilinum*	western brackenfern	herb	native	0.1	2
rublac	*Rubus laciniatus*	cutleaf blackberry	liana	introduced	0.1	2
samrac	*Sambucus racemosa*	red elderberry	shrub	native	0.1	2
scrore	*Scrophularia oregana*	Oregon figwort	herb	native	0.1	2
spidou	*Spiraea douglasii*	rose spirea	shrub	native	0.1	2
stespp	*Stellaria spp*	starwort	herb	native	0.1	2

Mid-seral High-severity - part 1

Mid-seral High-severity (n = 11) species (n = 84). Mean cover % for total vegetation across plots = 34.1%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
chaang	*Chamaenerion angustifolium*	fireweed	herb	native	16.1	76
lupin	*Lupin spp*	lupine	shrub	mixed	13.4	59
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	10.7	48
phahas	*Phacelia hastata*	silverleaf phacelia	herb	native	10.7	47
rubpar	*Rubus parviflorus*	thimbleberry	subshrub	native	8.4	45
symmol	*Symphoricarpos mollis*	creeping snowberry	subshrub	native	6.1	32
gram	*graminoids spp*	grasses, sedges, rushes	graminoids	mixed	3.5	70
arnlat	*Arnica latifolia*	broadleaf arnica	herb	native	3.4	20
tribor	*Trientalis borealis*	broadleaf starflower	herb	native	2.9	33
rosgym	*Rosa gymnocarpa*	dwarf rose	shrub	native	2.6	33
camsco	*Campanula scouleri*	pale bellflower	herb	native	2.0	43
ribvis	*Ribes viscosissimum*	sticky currant	shrub	native	1.9	30
acecir	*Acer circinatum*	vine maple	tree	native	1.4	3
viosem	*Viola sempervirens*	evergreen violet	herb	native	1.4	26
ceavel	*Ceanothus velutinus*	snowbrush ceanothus	shrub	native	1.2	23
vanhex	*Vancouveria hexandra*	white insideout flower	herb	native	1.2	21
xerten	*Xerophyllum tenax*	common beargrass	herb	native	1.2	9
pendav	*Penstemon davidsonii*	Davidson's penstemon	subshrub	native	1.1	14
pruema	*Prunus emarginata*	bittercherry	tree	native	0.9	17
vacmem	*Vaccinium membranaceum*	thinleaf huckleberry	shrub	native	0.9	15
achtri	*Achlys triphylla*	sweet after death	herb	native	0.8	17
moemac	*Moehringia macrophylla*	large sandwort	herb	native	0.8	23
salix	*Salix spp*	willow	shrub	mixed	0.8	14
spidou	*Spiraea douglasii*	rose spirea	shrub	native	0.8	11
vicame	*Vicia americana*	American vetch	liana	native	0.8	27
sensyl	*Senecio sylvaticus*	woodland ragwort	herb	introduced	0.6	40
ceasan	*Ceanothus sanguineus*	redstem ceanothus	shrub	native	0.5	10
holdis	*Holodiscus discolor*	oceanspray	shrub	native	0.4	9
amealn	*Amelanchier alnifolia*	Saskatoon serviceberry	shrub	native	0.3	5
anedel	*Anemone deltoidea*	Columbian windflower	herb	native	0.3	12
germol	*Geranium molle*	dovefoot geranium	herb	introduced	0.3	5
paxmyr	*Paxistima myrsinites*	Oregon boxleaf	shrub	native	0.3	28
ribsan	*Ribes sanguineum*	redflower currant	shrub	native	0.3	19
mycmur	*Mycelis muralis*	wall-lettuce	herb	introduced	0.2	36
notnem	*Nothochelone nemorosa*	woodland beardtongue	herb	native	0.2	5
rublas	*Rubus lasiococcus*	roughfruit berry	subshrub	native	0.2	9
achmil	*Achillea millefolium*	common yarrow	herb	mixed	0.1	1
anamar	*Anaphalis margaritacea*	western pearly everlasting	herb	native	0.1	23
arccol	*Arctostaphylos columbiana*	hairy manzanita	shrub	native	0.1	2
corcan	*Cornus canadensis*	bunchberry dogwood	herb	native	0.1	4
epimin	*Epilobium minutum*	chaparral willowherb	herb	native	0.1	33
galtrifl	*Galium triflorum*	fragrant bedstraw	liana	native	0.1	4

Mid-seral High-severity - part 2

Mid-seral High-severity (n = 11) species (n = 84). Mean cover % for total vegetation across plots = 34.1%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
pteaqu	*Pteridium aquilinum*	western brackenfern	herb	native	0.1	5
ruburs	*Rubus ursinus*	California blackberry	subshrub	native	0.1	5
stecri	*Stellaria crispa*	curled starwart	herb	native	0.1	2
acegla	*Acer glabrum*	Rocky Mountain maple	tree	native	0.1	1
agogra	*Agoseris grandiflora*	bigflower agoseris	herb	native	0.1	1
aqufor	*Aquilegia formosa*	western columbine	herb	native	0.1	3
arcnev	*Arctostaphylos nevadensis*	pinemat manzanita	subshrub	native	0.1	3
aspvir	*Asplenium viride*	brightgreen spleenwort	herb	native	0.1	2
chimen	*Chimaphila menziesii*	little prince's pine	subshrub	native	0.1	2
chiumb	*Chimaphila umbellata*	pipsissewa	subshrub	native	0.1	1
cirarv	*Cirsium arvense*	Canada thistle	herb	introduced	0.1	2
cirbre	*Cirsium brevistylum*	clustered thistle	herb	native	0.1	1
cliuni	*Clintonia uniflora*	bride's bonnet	herb	native	0.1	2
epibra	*Epilobium brachycarpum*	tall annual willowherb	herb	native	0.1	2
epicil	*Epilobium ciliatum*	fringed willowherb	herb	native	0.1	14
eripyr	*Eriogonum pyrolifolium*	Shasta buckwheat	herb	native	0.1	1
fraves	*Fragaria vesca*	woodland strawberry	herb	native	0.1	1
fravir	*Fragaria virginiana*	Virginia strawberry	herb	native	0.1	1
galkam	*Galium kamtschaticum*	boreal bedstraw	herb	native	0.1	3
gauova	*Gaultheria ovatifolia*	western teaberry	subshrub	native	0.1	1
gooobl	*Goodyera oblongifolia*	western rattlesnake plantain	herb	native	0.1	1
hiealb	*Hieracium albiflorum*	white hawkweed	herb	native	0.1	8
hieumb	*Hieracium umbellatum*	narrowleaf hawkweed	herb	native	0.1	2
maiste	*Maianthemum stellatum*	starry false lily of the valley	herb	native	0.1	2
ortsec	*Orthilia secunda*	sidebells wintergreen	subshrub	native	0.1	5
petfri	*Petasites frigidus*	arctic sweet coltsfoot	herb	native	0.1	1
polmun	*Polystichum munitum*	western swordfern	herb	native	0.1	2
prohoo	*Prosartes hookeri*	drops-of-gold	herb	native	0.1	2
pyrpic	*Pyrola picta*	whiteveined wintergreen	subshrub	native	0.1	8
ranspp	*Ranunculus spp*	buttercup	herb	mixed	0.1	1
riblac	*Ribes lacustre*	prickly currant	shrub	native	0.1	2
ribspp	*Ribes spp*	currant	shrub	mixed	0.1	1
rubleu	*Rubus leucodermis*	whitebark raspberry	subshrub	native	0.1	1
samrac	*Sambucus racemosa*	red elderberry	shrub	native	0.1	5
sorsit	*Sorbus sitchensis*	western mountain ash	shrub	native	0.1	1
tiatri	*Tiarella trifoliata*	oneleaf foamflower	herb	native	0.1	1
triova	*Trillium ovatum*	Pacific trillium	herb	native	0.1	8
vacpar	*Vaccinium parvifolium*	red huckleberry	shrub	native	0.1	8
vacspp	*Vaccinium spp*	blueberry	shrub	native	0.1	2
vicspp	*Vicia spp*	vetch	liana	mixed	0.1	5
viocan	*Viola canadensis*	Canada white violet	herb	native	0.1	2
vioorb	*Viola orbiculata*	darkwoods violet	herb	native	0.1	4

Late-seral Unburned - part 1

Late-seral Unburned (n = 18) species (n = 101). Mean cover % for total vegetation across plots = 22.4%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
gausha	*Gaultheria shallon*	salal	subshrub	native	32.1	35
acecir	*Acer circinatum*	vine maple	tree	native	15.4	19
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	14.8	46
vacala	*Vaccinium alaskaense*	Alaska blueberry	shrub	native	4.2	15
linbor	*Linnaea borealis*	twinflower	subshrub	native	4.0	39
acegla	*Acer glabrum*	Rocky Mountain maple	tree	native	3.6	3
vacspp	*Vaccinium spp*	blueberry	shrub	native	3.3	33
xerten	*Xerophyllum tenax*	common beargrass	herb	native	3.1	9
achtri	*Achlys triphylla*	sweet after death	herb	native	1.8	19
polmun	*Polystichum munitum*	western swordfern	herb	native	1.7	8
viosem	*Viola sempervirens*	evergreen violet	herb	native	1.7	9
pteaqu	*Pteridium aquilinum*	western brackenfern	herb	native	1.5	8
vacoval	*Vaccinium ovalifolium*	oval-leaf blueberry	shrub	native	1.4	17
menfer	*Menziesia ferruginea*	rusty menziesia	shrub	native	1.3	10
vacpar	*Vaccinium parvifolium*	red huckleberry	shrub	native	1.1	31
maiste	*Maianthemum stellatum*	starry false lily of the valley	herb	native	0.8	19
vacmem	*Vaccinium membranaceum*	thinleaf huckleberry	shrub	native	0.8	44
cliuni	*Clintonia uniflora*	bride's bonnet	herb	native	0.6	29
rubped	*Rubus pedatus*	strawberryleaf raspberry	subshrub	native	0.6	23
chiumb	*Chimaphila umbellata*	pipsissewa	subshrub	native	0.5	20
rosgym	*Rosa gymnocarpa*	dwarf rose	shrub	native	0.5	14
tiatri	*Tiarella trifoliata*	oneleaf foamflower	herb	native	0.5	12
corcan	*Cornus canadensis*	bunchberry dogwood	herb	native	0.4	15
gymdry	*Gymnocarpium dryopteris*	western oakfern	herb	native	0.4	3
amealn	*Amelanchier alnifolia*	Saskatoon serviceberry	shrub	native	0.3	9
gauova	*Gaultheria ovatifolia*	western teaberry	subshrub	native	0.3	1
holdis	*Holodiscus discolor*	oceanspray	shrub	native	0.3	2
ruburs	*Rubus ursinus*	California blackberry	subshrub	native	0.3	9
paxmyr	*Paxistima myrsinites*	Oregon boxleaf	shrub	native	0.2	12
rublas	*Rubus lasiococcus*	roughfruit berry	subshrub	native	0.2	25
tribor	*Trientalis borealis*	broadleaf starflower	herb	native	0.2	10
viogla	*Viola glabella*	pioneer violet	herb	native	0.2	1
blespi	*Blechnum spicant*	deer fern	herb	native	0.1	2
chimen	*Chimaphila menziesii*	little prince's pine	subshrub	native	0.1	25
corcor	*Corylus cornuta*	beaked hazlenut	tree	native	0.1	0
gooobl	*Goodyera oblongifolia*	western rattlesnake plantain	herb	native	0.1	31
gram	*graminoids spp*	grasses, sedges, rushes	graminoids	mixed	0.1	4
notnem	*Nothochelone nemorosa*	woodland beardtongue	herb	native	0.1	4
ortsec	*Orthilia secunda*	sidebells wintergreen	subshrub	native	0.1	20
pyrasa	*Pyrola asarifolia*	liverleaf wintergreen	subshrub	native	0.1	4
pyrpic	*Pyrola picta*	whiteveined wintergreen	subshrub	native	0.1	10
triova	*Trillium ovatum*	Pacific trillium	herb	native	0.1	13
trolax	*Trollius laxus*	American globeflower	herb	native	0.1	3
valsit	*Valeriana sitchensis*	Sitka valerian	herb	native	0.1	2
vioorb	*Viola orbiculata*	darkwoods violet	herb	native	0.1	9
acemac	*Acer macrophyllum*	bigleaf maple	tree	native	0.1	1
acespp	*Acer spp*	maple	tree	native	0.1	0
adebic	*Adenocaulon bicolor*	American trailplant	herb	native	0.1	2
alnvir	*Alnus viridis*	Sitka alder	tree	native	0.1	0
anedel	*Anemone deltoidea*	Columbian windflower	herb	native	0.1	2
arccol	*Arctostaphylos columbiana*	hairy manzanita	shrub	native	0.1	1

Late-seral Unburned - part 2

Late-seral Unburned (n = 18) species (n = 101). Mean cover % for total vegetation across plots = 22.4%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
arnlat	*Arnica latifolia*	broadleaf arnica	herb	native	0.1	1
asacau	*Asarum caudatum*	British Columbia wildginger	herb	native	0.1	1
aspden	*Aspidotis densa*	Indian's dream	herb	native	0.1	1
athfil	*Athyrium filix-femina*	common ladyfern	herb	native	0.1	0
calbul	*Calypso bulbosa*	fairy slipper	herb	native	0.1	6
camsco	*Campanula scouleri*	pale bellflower	herb	native	0.1	4
carspp	*Cardamine spp*	bittercress	herb	mixed	0.1	1
caschr	*Castanopsis chrysophylla*	giant chinquapin	tree	native	0.1	0
chaang	*Chamaenerion angustifolium*	fireweed	herb	native	0.1	0
chispp	*Chimaphilla spp*	prince's pine	subshrub	native	0.1	0
clasib	*Claytonia sibirica*	Siberian springbeauty	herb	native	0.1	1
coralspp	*Corallorhiza spp*	coralroot	herb	native	0.1	7
cormer	*Corallorhiza mertensiana*	Pacific coralroot	herb	native	0.1	5
corstr	*Corallorhiza striata*	hooded coralroot	herb	native	0.1	1
cysfra	*Cystopteris fragilis*	brittle bladderfern	herb	native	0.1	1
dicfor	*Dicentra formosa*	Pacific bleeding heart	herb	native	0.1	0
epicil	*Epilobium ciliatum*	fringed willowherb	herb	native	0.1	0
epimin	*Epilobium minutum*	chaparral willowherb	herb	native	0.1	1
frapur	*Frangula purshiana*	Cascara buckthorn	shrub	native	0.1	0
fraves	*Fragaria vesca*	woodland strawberry	herb	native	0.1	0
galkam	*Galium kamtschaticum*	boreal bedstraw	herb	native	0.1	1
heumic	*Heuchera micrantha*	crevice alumnroot	herb	native	0.1	2
hiealb	*Hieracium albiflorum*	white hawkweed	herb	native	0.1	1
juncom	*Juniperus communis*	common juniper	shrub	native	0.1	0
lilcol	*Lilium columbianum*	Columbia lily	herb	native	0.1	0
liscau	*Listera caurina*	northwestern twayblade	herb	native	0.1	5
liscor	*Listera cordata*	heartleaf twayblade	herb	native	0.1	6
mairac	*Maianthemum racemosum*	feathery false lily of the valley	herb	native	0.1	5
maispp	*Maianthemum spp*	mayflower	herb	native	0.1	1
moemac	*Moehringia macrophylla*	large sandwort	herb	native	0.1	1
monpar	*Montia parvifolia*	littleleaf minerslettuce	herb	native	0.1	1
monuni	*Monotropa uniflora*	Indianpipe	herb	native	0.1	0
mycmur	*Mycelis muralis*	wall-lettuce	herb	introduced	0.1	0
osmchi	*Osmorhiza chilensis*	Mountain sweet cicely	herb	native	0.1	0
pedrac	*Pedicularis racemosa*	sickletop lousewort	subshrub	native	0.1	0
plaorb	*Platanthera orbiculata*	lesser roundleaved orchid	herb	native	0.1	0
polgly	*Polypodium glycyrrhiza*	licorice fern	herb	native	0.1	3
pollon	*Polystichum lonchitis*	northern hollyfern	herb	native	0.1	0
pyraph	*Pyrola aphylla*	leafless wintergreen	herb	native	0.1	1
pyrmin	*Pyrola minor*	snowline wintergreen	subshrub	native	0.1	0
ranunc	*Ranunculus uncinatus*	woodland buttercup	herb	native	0.1	0
rhoalb	*Rhododendron macrophyllum*	Pacific rhododendron	shrub	native	0.1	0
riblac	*Ribes lacustre*	prickly currant	shrub	native	0.1	0
rubleu	*Rubus leucodermis*	whitebark raspberry	subshrub	native	0.1	0
rubpar	*Rubus parviflorus*	thimbleberry	subshrub	native	0.1	0
sorsit	*Sorbus sitchensis*	western mountain ash	shrub	native	0.1	1
symalb	*Symphoricarpos albus*	common snowberry	shrub	native	0.1	1
symmol	*Symphoricarpos mollis*	creeping snowberry	subshrub	native	0.1	5
vanhex	*Vancouveria hexandra*	white insideout flower	herb	native	0.1	1
verwor	*Veronica wormskjoldii*	American alpine speedwell	herb	native	0.1	0

Late-seral Low-severity - part 1

Late-seral Low-severity (n = 13) species (n = 76). Mean cover % for total vegetation across plots = 8.81%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
chaang	*Chamaenerion angustifolium*	fireweed	herb	native	42.7	70
linbor	*Linnaea borealis*	twinflower	subshrub	native	13.4	23
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	9.3	42
achtri	*Achlys triphylla*	sweet after death	herb	native	8.7	22
xerten	*Xerophyllum tenax*	common beargrass	herb	native	4.4	11
corcan	*Cornus canadensis*	bunchberry dogwood	herb	native	3.0	24
tiatri	*Tiarella trifoliata*	oneleaf foamflower	herb	native	2.0	16
aspvir	*Asplenium viride*	brightgreen spleenwort	herb	native	1.6	29
fraves	*Fragaria vesca*	woodland strawberry	herb	native	1.3	3
vacmem	*Vaccinium membranaceum*	thinleaf huckleberry	shrub	native	1.2	35
ortsec	*Orthilia secunda*	sidebells wintergreen	subshrub	native	0.9	21
rublas	*Rubus lasiococcus*	roughfruit berry	subshrub	native	0.9	21
vacpar	*Vaccinium parvifolium*	red huckleberry	shrub	native	0.7	22
epicil	*Epilobium ciliatum*	fringed willowherb	herb	native	0.6	18
maitri	*Maianthemum trifolium*	threeleaf false lily of the valley	herb	native	0.6	13
tribor	*Trientalis borealis*	broadleaf starflower	herb	native	0.6	21
cliuni	*Clintonia uniflora*	bride's bonnet	herb	native	0.5	17
gausha	*Gaultheria shallon*	salal	subshrub	native	0.5	4
gram	*graminoids spp*	grasses, sedges, rushes	graminoids	mixed	0.5	13
paxmyr	*Paxistima myrsinites*	Oregon boxleaf	shrub	native	0.5	22
ribsan	*Ribes sanguineum*	redflower currant	shrub	native	0.5	5
rubped	*Rubus pedatus*	strawberryleaf raspberry	subshrub	native	0.5	3
sensyl	*Senecio sylvaticus*	woodland ragwort	herb	introduced	0.4	19
vioorb	*Viola orbiculata*	darkwoods violet	herb	native	0.4	17
camsco	*Campanula scouleri*	pale bellflower	herb	native	0.3	6
ceasan	*Ceanothus sanguineus*	redstem ceanothus	shrub	native	0.3	6
chiumb	*Chimaphila umbellata*	pipsissewa	subshrub	native	0.3	12
gauova	*Gaultheria ovatifolia*	western teaberry	subshrub	native	0.3	5
rosgym	*Rosa gymnocarpa*	dwarf rose	shrub	native	0.3	5
ruburs	*Rubus ursinus*	California blackberry	subshrub	native	0.3	11
acecir	*Acer circinatum*	vine maple	tree	native	0.2	3
gooobl	*Goodyera oblongifolia*	western rattlesnake plantain	herb	native	0.2	8
mycmur	*Mycelis muralis*	wall-lettuce	herb	introduced	0.2	15
polmun	*Polystichum munitum*	western swordfern	herb	native	0.2	3
riblac	*Ribes lacustre*	prickly currant	shrub	native	0.2	4
salix	*Salix spp*	willow	shrub	mixed	0.2	4
spidou	*Spiraea douglasii*	rose spirea	shrub	native	0.2	2
telgra	*Tellima grandiflora*	bigflower tellima	herb	native	0.2	3

Late-seral Low-severity - part 2

Late-seral Low-severity (n = 13) species (n = 76). Mean cover % for total vegetation across plots = 8.81%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
anamar	*Anaphalis margaritacea*	western pearly everlasting	herb	native	0.1	5
cysfra	*Cystopteris fragilis*	brittle bladderfern	herb	native	0.1	5
epimin	*Epilobium minutum*	chaparral willowherb	herb	native	0.1	3
hiealb	*Hieracium albiflorum*	white hawkweed	herb	native	0.1	6
mairac	*Maianthemum racemosum*	feathery false lily of the valley	herb	native	0.1	5
menfer	*Menziesia ferruginea*	rusty menziesia	shrub	native	0.1	1
pyrasa	*Pyrola asarifolia*	liverleaf wintergreen	subshrub	native	0.1	5
ranunc	*Ranunculus uncinatus*	woodland buttercup	herb	native	0.1	1
rubleu	*Rubus leucodermis*	whitebark raspberry	subshrub	native	0.1	1
samrac	*Sambucus racemosa*	red elderberry	shrub	native	0.1	2
sorsco	*Sorbus scopulina*	Greene's mountain ash	shrub	native	0.1	2
triova	*Trillium ovatum*	Pacific trillium	herb	native	0.1	5
adebic	*Adenocaulon bicolor*	American trailplant	herb	native	0.1	2
agoaur	*Agoseris aurantiaca*	orange agoseris	herb	native	0.1	1
amealn	*Amelanchier alnifolia*	Saskatoon serviceberry	shrub	native	0.1	1
carocc	*Cardamine occidentalis*	big western bittercress	herb	native	0.1	3
chimen	*Chimaphila menziesii*	little prince's pine	subshrub	native	0.1	1
cirvul	*Cirsium vulgare*	bull thistle	herb	introduced	0.1	1
clasib	*Claytonia sibirica*	Siberian springbeauty	herb	native	0.1	1
coralspp	*Corallorhiza spp*	coralroot	herb	native	0.1	3
galtrifl	*Galium triflorum*	fragrant bedstraw	liana	native	0.1	1
hiegra	*Hieracium gracile*	slender hawkweed	herb	native	0.1	1
hieumb	*Hieracium umbellatum*	narrowleaf hawkweed	herb	native	0.1	1
holdis	*Holodiscus discolor*	oceanspray	shrub	native	0.1	2
lilcol	*Lilium columbianum*	Columbia lily	herb	native	0.1	1
lisspp	*Listera spp*	twayblade	herb	native	0.1	1
maiste	*Maianthemum stellatum*	starry false lily of the valley	herb	native	0.1	1
phahas	*Phacelia hastata*	silverleaf phacelia	herb	native	0.1	1
pteand	*Pteridium aquilinum*	western brackenfern	herb	native	0.1	1
pyrpic	*Pyrola picta*	whiteveined wintergreen	subshrub	native	0.1	2
rublac	*Rubus laciniatus*	cutleaf blackberry	liana	introduced	0.1	1
rubpar	*Rubus parviflorus*	thimbleberry	subshrub	native	0.1	1
rubspp	*Rubus spp*	blackberry	subshrub	mixed	0.1	1
samspp	*Sambucus spp*	elderberry	shrub	mixed	0.1	1
stespp	*Stellaria spp*	starwort	herb	native	0.1	1
symalb	*Symphoricarpos albus*	common snowberry	shrub	native	0.1	1
vacspp	*Vaccinium spp*	blueberry	shrub	native	0.1	1
viosem	*Viola sempervirens*	evergreen violet	herb	native	0.1	1

Late-seral High-severity - part 1

Late-seral High-severity (n = 25) species (n = 137). Mean cover % for total vegetation across plots = 36.5%

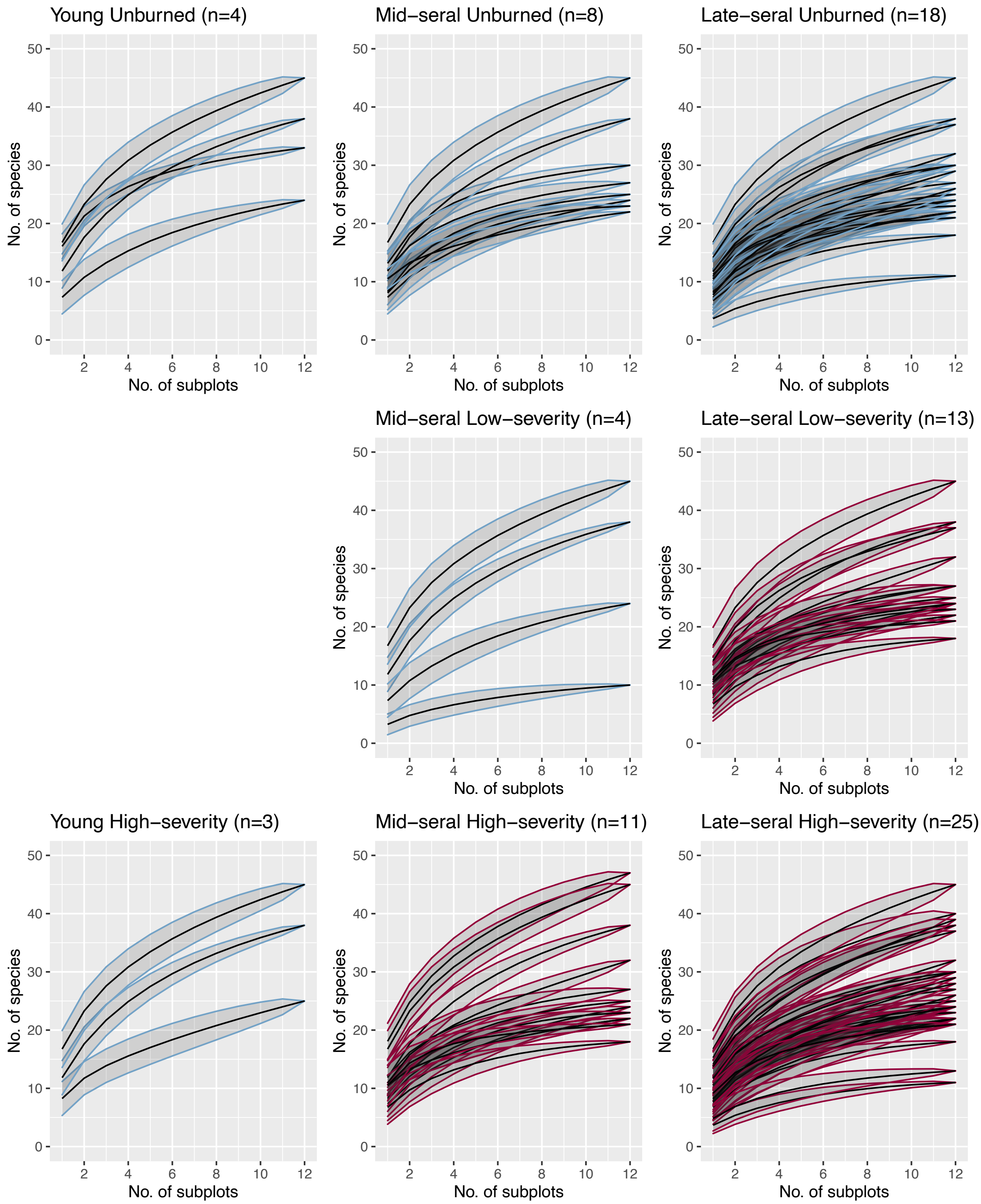
Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
chaang	*Chamaenerion angustifolium*	fireweed	herb	native	26.0	91
mahner	*Mahonia nervosa*	Cascade barberry	subshrub	native	9.1	47
pteaqu	*Pteridium aquilinum*	western brackenfern	herb	native	8.8	20
ceasan	*Ceanothus sanguineus*	redstem ceanothus	shrub	native	6.9	23
rubpar	*Rubus parviflorus*	thimbleberry	subshrub	native	5.9	18
ruburs	*Rubus ursinus*	California blackberry	subshrub	native	5.5	25
gausha	*Gaultheria shallon*	salal	subshrub	native	4.8	21
salix	*Salix spp*	willow	shrub	mixed	4.6	38
tribor	*Trientalis borealis*	broadleaf starflower	herb	native	3.0	50
mycmur	*Mycelis muralis*	wall-lettuce	herb	introduced	2.9	56
rubleu	*Rubus leucodermis*	whitebark raspberry	subshrub	native	2.3	20
acemac	*Acer macrophyllum*	bigleaf maple	tree	native	2.1	17
gram	*graminoids spp*	grasses, sedges, rushes	graminoids	mixed	2.1	42
sensyl	*Senecio sylvaticus*	woodland ragwort	herb	introduced	1.4	37
acecir	*Acer circinatum*	vine maple	tree	native	1.3	4
popbal	*Populus balsamifera*	black cottonwood	tree	native	0.9	11
betpap	*Betula papyrifera*	paper birch	tree	native	0.8	10
lupin	*Lupin spp*	lupine	shrub	mixed	0.8	14
ribsan	*Ribes sanguineum*	redflower currant	shrub	native	0.8	16
polmun	*Polystichum munitum*	western swordfern	herb	native	0.7	29
rosgym	*Rosa gymnocarpa*	dwarf rose	shrub	native	0.7	9
vacmem	*Vaccinium membranaceum*	thinleaf huckleberry	shrub	native	0.7	18
ceavel	*Ceanothus velutinus*	snowbrush ceanothus	shrub	native	0.6	14
vanhex	*Vancouveria hexandra*	white insideout flower	herb	native	0.6	9
rublas	*Rubus lasiococcus*	roughfruit berry	subshrub	native	0.5	13
viccra	*Vicia cracca*	bird vetch	liana	introduced	0.5	7
anamar	*Anaphalis margaritacea*	western pearly everlasting	herb	native	0.4	29
alnrub	*Alnus rubra*	red alder	tree	native	0.3	2
arnlat	*Arnica latifolia*	broadleaf arnica	herb	native	0.3	2
epicil	*Epilobium ciliatum*	fringed willowherb	herb	native	0.3	31
phahas	*Phacelia hastata*	silverleaf phacelia	herb	native	0.3	6
ribvis	*Ribes viscosissimum*	sticky currant	shrub	native	0.3	5
samcae	*Sambucus racemosa*	elderberry	shrub	native	0.3	1
astspp	*Aster spp*	aster	herb	mixed	0.2	3
corspp	*Cornus spp*	dogwood	tree	mixed	0.2	1
epimin	*Epilobium minutum*	chaparral willowherb	herb	native	0.2	29
pruema	*Prunus emarginata*	bittercherry	tree	native	0.2	3
vacpar	*Vaccinium parvifolium*	red huckleberry	shrub	native	0.2	8
achtri	*Achlys triphylla*	sweet after death	herb	native	0.1	9
apoand	*Apocynum androsaemifolium*	spreading dogbane	herb	native	0.1	3
athfil	*Athyrium filix-femina*	common ladyfern	herb	native	0.1	1
camsco	*Campanula scouleri*	pale bellflower	herb	native	0.1	5
cirvul	*Cirsium vulgare*	bull thistle	herb	introduced	0.1	5
corcan	*Cornus canadensis*	bunchberry dogwood	herb	native	0.1	4
corcor	*Corylus cornuta*	beaked hazlenut	tree	native	0.1	1
epibra	*Epilobium brachycarpum*	tall annual willowherb	herb	native	0.1	3
galkam	*Galium kamtschaticum*	boreal bedstraw	herb	native	0.1	1
galspp	*Galium spp*	bedstraw	herb	mixed	0.1	3
galtrifl	*Galium triflorum*	fragrant bedstraw	liana	native	0.1	6
hiealb	*Hieracium albiflorum*	white hawkweed	herb	native	0.1	15
iriset	*Iris setosa*	wild flag	herb	native	0.1	1
notnem	*Nothochelone nemorosa*	woodland beardtongue	herb	native	0.1	1
oxaore	*Oxalis oregana*	redwood-sorrel	herb	native	0.1	2
paxmyr	*Paxistima myrsinites*	Oregon boxleaf	shrub	native	0.1	23
riblac	*Ribes lacustre*	prickly currant	shrub	native	0.1	7
rubida	*Rubus idaeus*	American red raspberry	subshrub	mixed	0.1	1
samrac	*Sambucus racemosa*	red elderberry	shrub	native	0.1	2
symmol	*Symphoricarpos mollis*	creeping snowberry	subshrub	native	0.1	1
vioorb	*Viola orbiculata*	darkwoods violet	herb	native	0.1	8
viosem	*Viola sempervirens*	evergreen violet	herb	native	0.1	9
xerten	*Xerophyllum tenax*	common beargrass	herb	native	0.1	3
acegla	*Acer glabrum*	Rocky Mountain maple	tree	native	0.1	1
acespp	*Acer spp*	maple	tree	native	0.1	1
achmil	*Achillea millefolium*	common yarrow	herb	mixed	0.1	1
adebic	*Adenocaulon bicolor*	American trailplant	herb	native	0.1	0
agoaur	*Agoseris aurantiaca*	orange agoseris	herb	native	0.1	2
agogra	*Agoseris grandiflora*	bigflower agoseris	herb	native	0.1	0
alnvir	*Alnus viridis*	Sitka alder	tree	native	0.1	0

Late-seral High-severity - part 2

Late-seral High-severity (n = 25) species (n = 137). Mean cover % for total vegetation across plots = 36.5%

Code	Scientific Name	Common Name	Functional group(s)	Native/Introduced	Relative cover %	Frequency %
amealn	*Amelanchier alnifolia*	Saskatoon serviceberry	shrub	native	0.1	2
antmic	*Antennaria microphylla*	littleleaf pussytoes	herb	native	0.1	0
arccol	*Arctostaphylos columbiana*	hairy manzanita	shrub	native	0.1	1
arcuva	*Arctostaphylos uva-ursi*	kinnikinnick	subshrub	native	0.1	2
arecap	*Arenaria capillaris*	fescue sandwort	herb	native	0.1	0
arudio	*Aruncus dioicus*	bride's feathers	herb	native	0.1	1
asacau	*Asarum caudatum*	British Columbia wildginger	herb	native	0.1	2
aspvir	*Asplenium viride*	brightgreen spleenwort	herb	native	0.1	7
calbul	*Calypso bulbosa*	fairy slipper	herb	native	0.1	0
carspp	*Cardamine spp*	bittercress	herb	mixed	0.1	0
ceaspp	*Ceanothus spp*	ceanothus	shrub	native	0.1	0
chiumb	*Chimaphila umbellata*	pipsissewa	subshrub	native	0.1	4
cirarv	*Cirsium arvense*	Canada thistle	herb	introduced	0.1	1
ciredu	*Cirsium edule*	edible thistle	herb	native	0.1	2
cirspp	*Cirsium spp*	thistle	herb	mixed	0.1	1
colhet	*Collomia heterophylla*	variableleaf collomia	herb	native	0.1	0
cornut	*Cornus nuttallii*	Pacific dogwood	tree	native	0.1	0
crecap	*Crepis capillaris*	smooth hawksbeard	herb	introduced	0.1	2
cysfra	*Cystopteris fragilis*	brittle bladderfern	herb	native	0.1	1
dicfor	*Dicentra formosa*	Pacific bleeding heart	herb	native	0.1	0
equspp	*Equisetum spp*	horsetail	herb	native	0.1	0
frapur	*Frangula purshiana*	Cascara buckthorn	shrub	native	0.1	0
fraves	*Fragaria vesca*	woodland strawberry	herb	native	0.1	1
fravir	*Fragaria virginiana*	Virginia strawberry	herb	native	0.1	1
germol	*Geranium molle*	dovefoot geranium	herb	introduced	0.1	0
gerrob	*Geranium robertianum*	Robert geranium	herb	mixed	0.1	1
gnomic	*Pseudognaphalium canescens*	Wright's cudweed	herb	native	0.1	1
gooobl	*Goodyera oblongifolia*	western rattlesnake plantain	herb	native	0.1	0
gymdry	*Gymnocarpium dryopteris*	western oakfern	herb	native	0.1	2
heumic	*Heuchera micrantha*	crevice alumnroot	herb	native	0.1	1
heuspp	*Heuchera spp*	alumroot	herb	native	0.1	2
hieumb	*Hieracium umbellatum*	narrowleaf hawkweed	herb	native	0.1	3
holdis	*Holodiscus discolor*	oceanspray	shrub	native	0.1	3
hyprad	*Hypochaeris radicata*	hairy cat's ear	herb	introduced	0.1	1
latnev	*Lathyrus nevadensis*	Sierra pea	liana	native	0.1	3
lilcol	*Lilium columbianum*	Columbia lily	herb	native	0.1	1
lisspp	*Listera spp*	twayblade	herb	native	0.1	0
mairac	*Maianthemum racemosum*	feathery false lily of the valley	herb	native	0.1	0
maiste	*Maianthemum stellatum*	starry false lily of the valley	herb	native	0.1	1
micgra	*Microsteris gracilis*	slender phlox	herb	native	0.1	0
mitpen	*Mitella pentandra*	fivestamen miterwort	herb	native	0.1	0
moemac	*Moehringia macrophylla*	large sandwort	herb	native	0.1	1
monpar	*Montia parvifolia*	littleleaf minerslettuce	herb	native	0.1	0
ortsec	*Orthilia secunda*	sidebells wintergreen	subshrub	native	0.1	5
osmchi	*Osmorhiza chilensis*	Mountain sweet cicely	herb	native	0.1	0
polspp	*Polypodium spp*	polypody	herb	native	0.1	0
prohoo	*Prosartes hookeri*	drops-of-gold	herb	native	0.1	1
pyrpic	*Pyrola picta*	whiteveined wintergreen	subshrub	native	0.1	1
ranocc	*Ranunculus occidentalis*	western buttercup	herb	native	0.1	0
ranunc	*Ranunculus uncinatus*	woodland buttercup	herb	native	0.1	0
rosspp	*Rosa spp*	rose	shrub	mixed	0.1	1
rublac	*Rubus laciniatus*	cutleaf blackberry	liana	introduced	0.1	0
rubspp	*Rubus spp*	blackberry	subshrub	mixed	0.1	1
samspp	*Sambucus spp*	elderberry	shrub	mixed	0.1	1
spidou	*Spiraea douglasii*	rose spirea	shrub	native	0.1	0
symalb	*Symphoricarpos albus*	common snowberry	shrub	native	0.1	0
taroff	*Taraxacum officinale*	common dandelion	herb	mixed	0.1	1
telgra	*Tellima grandiflora*	bigflower tellima	herb	native	0.1	1
tiatri	*Tiarella trifoliata*	oneleaf foamflower	herb	native	0.1	2
tolmen	*Tomiea menziesii*	youth on age	herb	native	0.1	2
triova	*Trillium ovatum*	Pacific trillium	herb	native	0.1	1
trirep	*Trifolium repens*	white clover	herb	introduced	0.1	1
vacspp	*Vaccinium spp*	blueberry	shrub	native	0.1	1
verbec	*Veronica beccabunga*	European speedwell	herb	introduced	0.1	0
veroff	*Veronica officinalis*	common gypsyweed	herb	introduced	0.1	0
verspp	*Veronica spp*	speedwell	herb	mixed	0.1	0
vicame	*Vicia americana*	American vetch	liana	native	0.1	4
vicsat	*Vicia sativa*	garden vetch	liana	introduced	0.1	2
vicspp	*Vicia spp*	vetch	liana	mixed	0.1	3

Appendix 3. Within-stand (plot) species accumulation curve.



Appendix 4. Stress plots for the non-metric multidimensional scaling (NMDS) ordinations for raw and relative cover percent.