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Research Article

A Survey of Ant Species in Three Habitats at Mount St. Helens National Volcanic Monument

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Ants were surveyed in three habitats at Mount St. Helens in 2008. The area most impacted by the 1980 eruption is the Pumice Plain. Less impacted is the Blowdown Zone where trees were toppled due to the blast. Two habitats were surveyed in the Pumice Plain varying in vegetation density (Pumice Plain Low-Vegetation (PPLV) and Pumice Plain High-Vegetation (PPHV)), and one habitat was surveyed in the Blowdown Zone (BDZ). Ten ant species were collected with the most species collected from the BDZ habitat and the least from the PPLV habitat. Ant abundance was higher at the BDZ and PPHV habitats than at the PPLV habitat. Ant biodiversity was highest at the BDZ habitat than at the PPHV and PPLV habitats. Significant correlations between ant community parameters and plant community parameters were also found. Few plants in the PPLV habitat may contribute to the lack of ants. High ant species richness at the BDZ habitat may be due to complex plant architecture. Results from this study suggest that ants are important focal species in tracking biotic recovery following disturbances.

1. Introduction

Mount St. Helens erupted on May 18, 1980, strongly impacting a 600 km^2 area as a result of a northern lateral blast of the volcano [1]. The volcanic eruption began with a magnitude 5.1 earthquake, which dislodged the northern slope of the mountain leading to the largest landslide in recorded history [1]. Material from the landslide covered a 60 km^2 area referred to as the Debris Avalanche [1]. Following the landslide a volcanic blast toppled forests within a 370 km^2 area referred to as the Blowdown Zone because mature trees were snapped at the base as a result of the impact [1]. Pyroclastic flows emanating from the volcano covered 15 km^2 of land immediately north of the volcano, which is now referred to as the Pumice Plain [1]. Organisms in the Pumice Plain were vaporized as a result of the volcanic blast [1].

Since 1980, numerous ecological studies have recorded the impact of the volcanic eruption on plant and animal communities and ecosystem dynamics [2]. Most impressive among the organismal responses was the discovery of pioneer arthropod colonists on the Pumice Plain within a year following the eruption [3, 4]. Even plants were quick to respond with a prairie lupine plant, *Lupinus lepidus*, being found on the Pumice Plain in 1981 [5].

Among the pioneer arthropod colonists found on the Pumice Plain were winged ants (Formicidae) [6]. Ants have been known to respond dramatically to changes in the environment and may be useful indicator species in assessing recovery of environments following disturbances [7]. A survey of ant species was performed during July 2008 in three habitat types at Mount St. Helens National Volcanic Monument to help record the trajectory of community recovery of this important subset of arthropods.

2. Materials and Methods

2.1. Study Sites. After extensive hiking throughout the Pumice Plain in July 2008, it was clear that it was not a homogeneous environment. Two distinct habitat types were apparent and consisted of areas lush with vegetation along the edge of the Pumice Plain (referred to as the Pumice Plain-High Vegetation (PPHV) habitat type) and areas devoid of almost all vegetation in the center of the Pumice Plain

Table 1: Description of 6 study sites*.

Site name**	Site location	UTM coordinates and datum
PPLV		
1a	Center of pumice plain	562988E, 5121705N, Z10
1b		562983E, 5121729N, Z10
1c		562982E, 5121754N, Z10
1d		562973E, 5121780N, Z10
2a		562953E, 5122158N, Z10
2b		562954E, 5122183N, Z10
2c		562950E, 5122203N, Z10
2d		562951E, 5122227N, Z10
PPHV		
1a	Eastern fringe of pumice plain	564847E, 5121574N, Z10
1b		564853E, 5121601N, Z10
1c		564859E, 5121624N, Z10
1d		564862E, 5121648N, Z10
2a		564342E, 5121613N, Z10
2b		564347E, 5121638N, Z10
2c		564351E, 5121660N, Z10
2d		564353E, 5121686N, Z10
BDZ		
1a	Windy ridge vicinity east of pumice plain	573269E, 5124328N, Z10
1b		573293E, 5124342N, Z10
1c		573301E, 5124363N, Z10
1d		573323E, 5124374N, Z10
2a		572996E, 5124151N, Z10
2b		572995E, 5124125N, Z10
2c		572997E, 5124102N, Z10
2d		573004E, 5124081N, Z10

*Designations of 1a–1d and 2a–2d indicate ant survey sites located 25 m apart along 75 m transects at each study site.
**PPLV: Pumice Plain-Low Vegetation habitat type, PPHV: Pumice Plain-High Vegetation habitat type, BDZ: Blowdown Zone habitat type.

(referred to as the Pumice Plain-Low Vegetation (PPLV) habitat type).

Two study sites were randomly selected within each of the Pumice Plain habitat types (Table 1 and Figures 1(a)-1(b)). The PPLV study sites were predominantly covered with sand, pumice rocks, and basalt rocks. Only two small herbaceous plants were encountered at these sites including one *Penstemon cardwellii* (Cardwell's penstemon) and one *Spraguea umbellata* (Pussypaws). The PPHV study sites were populated with a much denser plant community including the following species: *Lupinus lepidus* (Prairie lupine), *Hypochaeris radicata* (Hairy cat's ear), *Hieracium albiflorum* (White-flowered hawkweed), *Penstemon cardwellii* (Cardwell's penstemon), *Anaphalis margaritacea* (Pearly everlasting), *Castilleja miniata* (Scarlet paintbrush), *Achillea millefolium* (Yarrow), *Agrostis exarata* (Spike bentgrass), and unidentified grasses.

To provide a comparison to the habitat types within the Pumice Plain, an additional habitat type was surveyed outside of the Pumice Plain to the east in the Blowdown Zone in the Windy Ridge vicinity (referred to as the Blowdown Zone (BDZ) habitat type). Two study sites were randomly selected within this third habitat type (Table 1 and Figure 1(c)). These study sites were impacted to a lesser extent by the 1980 volcanic explosion when compared to the Pumice Plain study sites and are located within pine forests dominated by *Abies procera* (Noble fir). Among the other plants found at the BDZ study sites were *Vaccinium membranaceum* (Mountain huckleberry), *Anaphalis margaritacea* (Pearly everlasting), *Hypochaeris radicata* (Hairy cat's ear), *Penstemon cardwellii* (Cardwell's penstemon), *Hieracium albiflorum* (White-flowered hawkweed), *Epilobium angustifolium* (Fireweed), *Fragaria virginiana* (Wild strawberry), *Salix* spp. (Willow), *Carex* spp. (Sedge), *Juncus* spp. (Rush), and unidentified ferns and grasses.

2.2. Survey. A survey of ant species at each of the study sites was conducted between 22 and 25 July, 2008. During this time period air temperature maximums ranged from 15.6 to 25.9°C, and air temperature minimums ranged from 5.1 to 9.1°C; there was no precipitation, some low lying fog early in the mornings, clouds and sun the rest of the day, and at times breezy conditions [8]. At each study site a 75 m transect was laid out and markers were placed every 25 m for a total of 4 survey sites along each transect (at 0 m, 25 m, 50 m, and 75 m). At each marker a 4 m diameter circle was delineated with the marker located at the center of the circle. Over a 10-minute period during the day, as many ants as possible were aspirated from within the circle. In order to cover the entire area in 10 minutes, the circle was broken down into quarters and 2.5 minutes were spent aspirating ants in each quarter. Ants collected in the aspirator were preserved in 70% isopropyl alcohol for future identification. Once ant aspiration was complete, a 0.5 m^2 quadrat was laid down in the center of the circle, and all plant species inside the quadrat were identified, and percent cover of the quadrat by plants was determined. A pitfall trap was then situated at the center of the circle, which consisted of sinking a 16 oz plastic drinking cup into the ground so that that lip was flush with the terrain. Spring water was poured into the cup until it reached a level of 2.5 cm from the bottom. Then two drops of Dr. Bronner's Unscented Baby-Mild Pure Castile soap were added to break the water's surface tension. Contents of the pitfall traps were collected 24 hours later and preserved in 70% isopropyl alcohol for identification in the laboratory.

2.3. Data Analysis. Statistical analyses were performed to evaluate differences in the ant communities between habitat types at Mount St. Helens National Volcanic Monument. Richness and abundance of the ant communities were compared among habitat types using a nested ANOVA with study site nested within habitat type. Statistical analyses of richness and abundance of ant communities were performed on untransformed data because all ANOVA assumptions were met. Following ANOVA analyses, Tukey's pairwise

(a) (b) (c)

Figure 1: Representative photographs of (a) Pumice Plain-Low Vegetation (PPLV) habitat type, (b) Pumice Plain-High Vegetation (PPHV) habitat type, and (c) Blowdown Zone (BDZ) habitat type, where ants were collected at Mount St. Helens National Volcanic Monument. Images were taken between 22 and 25 of July 2008.

comparison tests were used to elucidate differences in richness and abundance of the ant communities collected at the different habitat types.

The data for the Shannon-Wiener Biodiversity Indices of ant communities, plant richness, and percent ground cover by plants were not normally distributed. No transformations normalized the data, so nonparametric statistical tests were performed. Specifically, Kruskal-Wallis tests were conducted to look for differences in the Shannon-Wiener Biodiversity Indices of ant communities, plant richness, and percent ground cover by plants among habitat types (an equivalent nonparametric test does not exist for a nested ANOVA [9], so survey sites along transects at each study site were treated as independent samples). When Kruskal-Wallis tests gave significant results, Mann-Whitney *U* Tests (with a Bonferroni correction) were performed to determine which habitat types were different from each other.

The relationships between plant communities (richness and percent ground cover by plants) and ant communities (richness, abundance, and Shannon-Wiener Biodiversity Indices) were explored by performing Spearman rank-order correlations. Nonparametric correlations were used instead of Pearson product-moment correlations because the data for both plant richness and percent ground cover by plants were not normally distributed.

3. Results

A total of 987 ants belonging to ten different species were collected during the course of the survey (Table 2). Of the ten ant species collected, the least commonly collected were *Manica hunteri* (represented by a singleton) and *Lasius alienus* (represented by a doubleton), which were found only at the BDZ habitat type. The most commonly collected ant species included *Formica lasioides* and *Formica montana*, which were collected at all habitat types. Interestingly, five ant species were unique to the BDZ habitat type (*Camponotus modoc*, *Tapinoma sessile*, *Formica argentea*, *L. alienus*, and *M. hunteri*), whereas only one ant species was unique to the PPHV habitat type (*Formica obscuripes*). Only the two most commonly collected ant species were found at the PPLV habitat type. All ant species were collected through both aspiration and pitfall trapping techniques except for the least commonly collected species, *L. alienus* and *M. hunteri*, which were collected solely through pitfall trapping.

The richness (Table 3, Figure 2), abundance (Table 4, Figure 3), and Shannon-Wiener Biodiversity Indices (Figure 4) of ant communities varied between habitat types at Mount St. Helens National Volcanic Monument. Specifically, ant species richness was significantly different between all habitat types with the greatest richness found at the BDZ habitat type and the lowest richness found at the PPLV habitat type (ANOVA followed by Tukey's pairwise comparison tests, richness: BDZ > PPHV > PPLV, $P < 0.01$). Ant abundance was the lowest at the PPLV habitat type when compared to the BDZ and PPHV habitat types (ANOVA followed by Tukey's pairwise comparison tests, abundance: BDZ, PPHV > PPLV, $P < 0.0001$). In fact, only a total of 11 ants were collected from the PPLV habitat type. There was a significant difference in the Shannon-Wiener Biodiversity Indices among the habitat types (Kruskal-Wallis Test Statistic = 15.2, $P = 0.001$) with significantly higher biodiversity at the BDZ habitat type when compared to the PPHV and PPLV habitat types (Table 5). However, even

Table 2: List of ant species and numbers collected in each habitat type at Mount St. Helens National Volcanic Monument between 22 and 25 July 2008.

Genus	Species	Habitat type*			Total number
		PPLV	PPHV	BDZ	
Formica	*lasioides* Emery	1	479	49	529
Formica	*montana* Wheeler	10	11	314	335
Formica	*obscuripes* Forel	0	40	0	40
Camponotus	*modoc* Wheeler	0	0	39	39
Leptothorax	*muscorum* (Nylander)	0	3	12	15
Tapinoma	*sessile* (Say)	0	0	13	13
Myrmica	*fracticornis* Forel	0	3	4	7
Formica	*argentea* Wheeler	0	0	6	6
Lasius	*alienus* (Foerster)	0	0	2	2
Manica	*hunteri* (Wheeler)	0	0	1	1

*PPLV: Pumice Plain-Low Vegetation, PPHV: Pumice Plain-High Vegetation, BDZ: Blowdown Zone.

Table 3: Overall nested ANOVA of the effect of habitat type and study site on richness of ant communities ($n = 24$).

Source	SS	df	F	P
Habitat type	68.250	2	30.560	<0.001
Study site (habitat type)	1.042	1	0.930	0.346
Error	22.333	20		

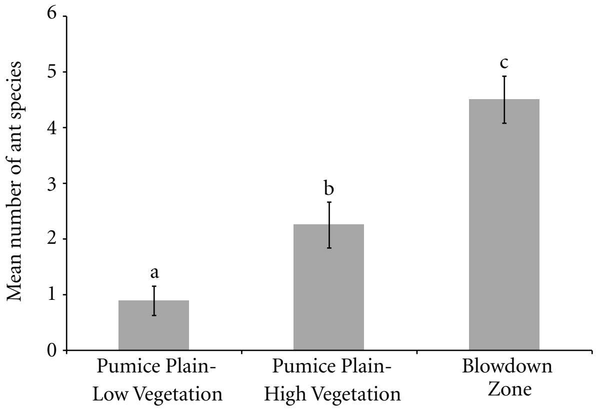

Figure 2: Richness (mean number of ant species ±1 SE) of ant communities in three habitat types at Mount St. Helens National Volcanic Monument sampled between 22 and 25 July 2008. Different letters above the bars indicate significant differences ($P < 0.01$) between habitat types.

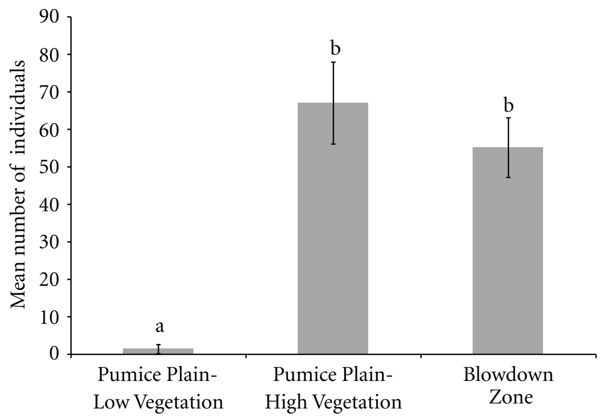

Figure 3: Abundance (mean number of individuals ±1 SE) of ants in three habitat types at Mount St. Helens National Volcanic Monument sampled between 22 and 25 July 2008. Different letters above the bars indicate significant differences ($P < 0.0001$) between habitat types.

Table 4: Overall nested ANOVA of the effect of habitat type and study site on abundance of ants ($n = 24$).

Source	SS	df	F	P
Habitat type	19564.600	2	22.170	<0.001
Study site (habitat type)	748.200	1	1.700	0.208
Error	8824.600	20		

at the BDZ habitat type the Shannon-Wiener Biodiversity Indices were very low (mean biodiversity index ±1 SE: 0.71 ± 0.09) indicating that the ant communities were not diverse (Shannon-Wiener Biodiversity Index ranges from 0, low, to 4.5, high) [10].

The study sites within the PPLV habitat type were almost entirely devoid of plants leading to clear differences in plant species composition (Table 6), plant richness (Kruskal-Wallis Test Statistic = 16.41, $P < 0.001$, Figure 5), and percent ground cover by plants (Kruskal-Wallis Test Statistic = 16.61, $P < 0.001$, Figure 6) between the three habitat types. Specifically, the PPLV habitat type had significantly lower plant richness and percent ground cover by plants than the PPHV and BDZ habitat types (Table 7). However, there were no significant differences in plant richness or percent ground cover by plants between the PPHV and BDZ habitat types (Table 7).

Several positive correlations between plant community and ant community characteristics were found in this survey (Table 8). The strongest correlations were between ant

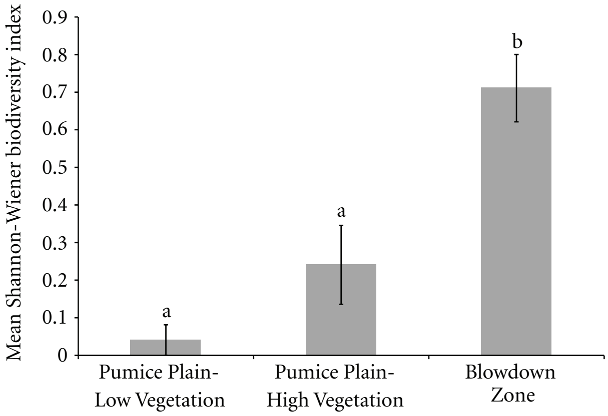

Figure 4: Shannon-Wiener Biodiversity Indices (mean biodiversity index ±1 SE) for ant communities in three habitat types at Mount St. Helens National Volcanic Monument sampled between 22 and 25 July 2008. Different letters above the bars indicate significant differences ($P < 0.05$) between habitat types.

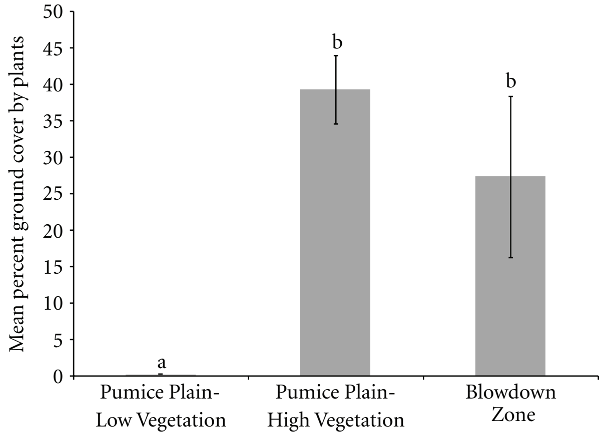

Figure 6: Percent ground cover by plants (mean percent ground cover ±1 SE) in three habitat types at Mount St. Helens National Volcanic Monument sampled between 22 and 25 July 2008. Different letters above the bars indicate significant differences ($P < 0.01$) between habitat types.

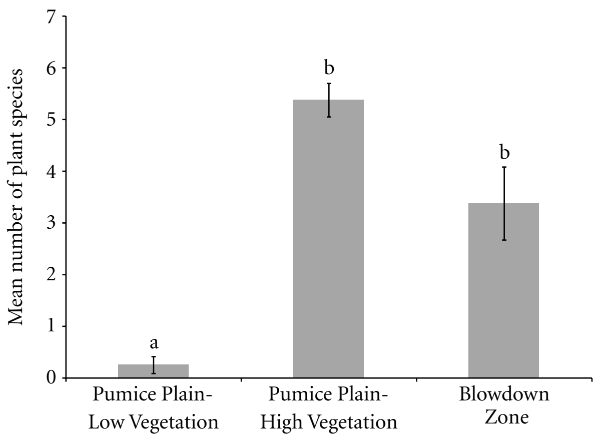

Figure 5: Richness (mean number of plant species ±1 SE) of plant communities in three habitat types at Mount St. Helens National Volcanic Monument sampled between 22 and 25 July 2008. All plant species, including unidentified ferns and grasses (which were categorized to morphospecies), found within the 0.5 m^2 sampling quadrats were used in plant richness calculations. Different letters above the bars indicate significant differences ($P < 0.01$) between habitat types.

Table 5: Mann-Whitney *U* tests comparing Shannon-Wiener Biodiversity Indices of ant communities between habitat types at Mount St. Helens National Volcanic Monument.

Habitat type* comparison	Mann-Whitney *U* test statistic	*P***
BDZ > PPLV	99	0.0014
BDZ > PPHV	36	0.0009
PPHV = PPLV	51	0.0754

*PPLV: Pumice Plain-Low Vegetation, PPHV: Pumice Plain-High Vegetation, BDZ: Blowdown Zone.
**With a Bonferroni correction, only *P* values < 0.017 were considered significant.

abundance and percent ground cover by plants (Figure 7) and between ant abundance and plant richness (Figure 8). The next strongest correlations were between ant richness and percent ground cover by plants and between ant richness and plant richness. When compared to ant biodiversity, there was a significant positive correlation with percent ground cover by plants but not with plant richness.

4. Discussion

A total of 10 different ant species were collected at three habitat types in Mount St. Helens National Volcanic Monument during this study, which was conducted over a 4-day period in July 2008. The most ant species (total of 9) were collected in the BDZ habitat type, whereas the least ant species (total of 2) were collected in the PPLV habitat type. Interesting comparisons can be made between the ant communities found in this study to those found in previous studies at Mount St. Helens to better understand the trajectory of recovery of this important biotic community.

The most interesting comparison would be to compare the ant species collected from Mount St. Helens in this study to those in the area prior to the 1980 eruption to determine whether the ant communities are recovering to their original composition or to a composition that is totally different. Unfortunately, there is little documentation of the biological communities at Mount St. Helens prior to 1980 [11]. However, in the 1980s Sugg [11] sampled ant communities in clear cuts in the forest north of Mount St. Helens that were not strongly affected by the 1980 eruption. The ant communities collected from these clear cuts are useful as a proxy of what the Mount St. Helens ant communities might have been like if the eruption had not occurred. Of the sixteen ant species that were collected from clear cuts [11], 6 were also collected during this study including *C. modoc*, *F. lasioides*, *Leptothorax muscorum*, *M.*

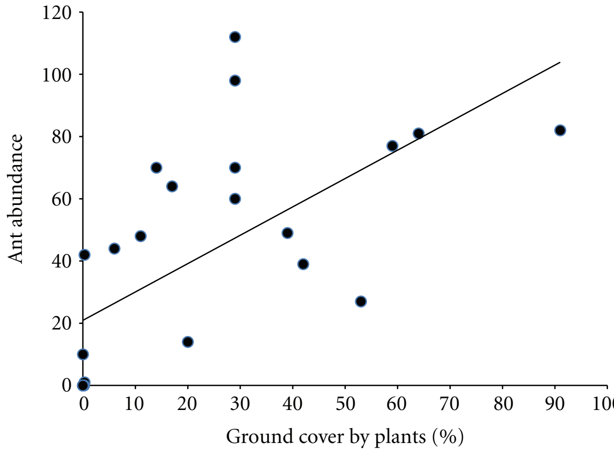

Figure 7: Relationship between percent ground cover by plants and ant abundance from samples collected at Mount St. Helens National Volcanic Monument between 22 and 25 July 2008. This relationship represents a significant positive correlation (Spearman rank correlation coefficient = 0.787, $P < 0.001$). The equation for the fitted line is $y = 0.9118x + 20.925$.

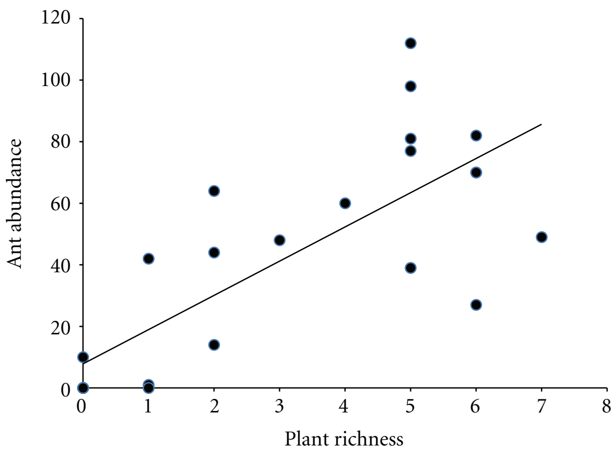

Figure 8: Relationship between plant richness and ant abundance from samples collected at Mount St. Helens National Volcanic Monument between 22 and 25 July 2008. This relationship represents a significant positive correlation (Spearman rank correlation coefficient = 0.784, $P < 0.001$). The equation for the fitted line is $y = 11.12x + 7.8075$.

hunteri, *Myrmica fracticornis* (classified as *Myrmica latifrons* in [11] which is a junior synonym of *Myrmica fracticornis* [12]), and *T. sessile*. The similarity in ant species found in the clear cuts and currently at Mount St. Helens suggests that the ant communities may be on the path to recovering to their original composition. However, there are enough differences in species composition (the current Mount St. Helens ant communities lack some species found in clear cuts and also have some species that were not found in clear cuts) to make predictions about full recovery difficult. Only time will tell how closely the trajectory of ant community recovery at Mount St. Helens will match the original composition, especially in the species poor PPLV habitat type.

The next interesting comparison to make is between the ant communities presently found at Mount St. Helens and those found immediately following the 1980 eruption. Detailed studies of ant communities at Mount St. Helens were conducted by Sugg [11], Edwards and Sugg [6], and Sugg and Edwards [4] between 1981 and 1983. Sugg and Edwards [4] collected 27 different ant species at sites on the Pumice Plain during this time through pitfall trapping. However, with the exception of four *Formica fusca* worker ants that were thought to be blown in by the wind [11], all the collected ants were alates who arrived on the Pumice Plain by flying. Sugg [11] concluded from these studies that ants (and their colonies) did not survive the 1980 eruption in the location now referred to as the Pumice Plain. Twenty-five years later, this study has found five ant species (none of them represented by alates) on the Pumice Plain suggesting that recovery of ant communities is happening, just not quickly.

In addition to collecting ants on the Pumice Plain, Sugg [11] also sampled the surrounding Blowdown Zone by placing more than 200 pitfall traps in 16 different locations. Nineteen different ant species (in addition to two unidentified ant species) were collected from the sites within the Blowdown Zone between 1981 and 1983. Sugg [11] concluded that some ant species in the Blowdown Zone survived the eruption if they were able to find enough food and if there was a low degree of disturbance in the environment (i.e., less tephra fall out). Only nine ant species (7 of which are the same as those collected by Sugg [11]) were collected in the BDZ habitat type in the present study which is quite low compared to what was found in the early 1980s. The difference in the number of ant species collected between these two studies can most likely be attributed to differences in the length of the studies, the number of study sites surveyed, and the number of pitfall traps that were used.

The most commonly collected ants in this study came from the genus *Formica* (in order of dominance: *F. lasioides*, *F. montana,* and *F. obscuripes*). This is not surprising considering that *Formica* is the largest genus of ants found in North America [13]. *Formica lasioides* was not only the most dominant ant species collected in this study but it was also found at all habitat types. *Formica lasioides* is often associated with open habitats [14], like those found at Mount St. Helens National Volcanic Monument, where it forms small colonies in the soil beneath rocks or other objects [13]. As demonstrated by Sugg [11], some *F. lasioides* colonies survived in the Blowdown Zone following the 1980 eruption. These surviving colonies most likely served as sources of colonists to the Pumice Plain. Furthermore, the feeding preferences of *F. lasioides* indicate that it is omnivorous [14] and is often a generalist predator [15]. It has been suggested that heterotrophic organisms such as scavengers and predators should be the first colonizers during primary community assembly [16], explaining why *F. lasioides* would be found even in the PPLV habitat type, which is practically devoid of plants.

The least commonly collected ant species in this survey was *M. hunteri*, represented by a sole individual, which was found in the BDZ habitat type. *Manica hunteri* are generally found in coniferous forests that are not very dense and

Table 6: List of plant species and numbers found in each habitat type at Mount St. Helens National Volcanic Monument between 22 and 25 July 2008*.

Genus	Species	Habitat type**			Total number
		PPLV	PPHV	BDZ	
Unidentified grasses***		0	90	110	200
Hypochaeris	*radicata*	0	125	15	140
Lupinus	*lepidus*	0	115	0	115
Hieracium	*albiflorum*	0	40	1	41
Anaphalis	*margaritacea*	0	1	27	28
Abies	*procera*	0	0	13	13
Fragaria	*virginiana*	0	0	10	10
Penstemon	*cardwellii*	1	8	1	10
Carex	spp.	0	0	9	9
Juncus	spp.	0	0	8	8
Castilleja	*miniata*	0	7	0	7
Agrostis	*exarata*	0	6	0	6
Unidentified ferns		0	0	3	3
Achillea	*millefolium*	0	2	0	2
Epilobium	*angustifolium*	0	0	1	1
Salix	spp.	0	0	1	1
Spraguea	*umbellata*	1	0	0	1
Vaccinium	*membranaceum*	0	0	1	1

*Only plants that fell within the 0.5 m^2 quadrats placed in the center of each ant survey circle were included.
**PPLV: Pumice Plain-Low Vegetation, PPHV: Pumice Plain-High Vegetation, BDZ: Blowdown Zone.
***The number of grass plants is an estimate due to the difficulty of distinguishing one individual from another.

Table 7: Mann-Whitney *U* tests comparing plant community characteristics between habitat types at Mount St. Helens National Volcanic Monument.

Plant community characteristic	Habitat type* comparison	Mann-Whitney *U* test statistic	*P***
Plant richness	BDZ > PPLV	99	0.0014
	PPHV > PPLV	36	0.0009
	BDZ = PPHV	51	0.0754
Percent ground cover by plants	BDZ > PPLV	99.5	0.0011
	PPHV > PPLV	36	0.0006
	BDZ = PPHV	51	0.0809

*PPLV: Pumice Plain-Low Vegetation, PPHV: Pumice Plain-High Vegetation, BDZ: Blowdown Zone.
**With a Bonferroni correction, only *P* values < 0.017 were considered significant.

Table 8: Spearman rank-order correlations between ant community and plant community characteristics.

Correlations	Spearman rank correlation coefficient	*P*
Ant abundance and percent ground cover by plants	0.787	<0.001
Ant abundance and plant richness	0.784	<0.001
Ant richness and percent ground cover by plants	0.550	0.005
Ant richness and plant richness	0.508	0.011
Ant biodiversity and percent ground cover by plants	0.491	0.015
Ant biodiversity and plant richness	0.365	0.079

have lots of open areas [17], which accurately describes the Blowdown Zone located around Mount St. Helens. The natural history details of *M. hunteri* are largely a mystery; however, it is thought that the colonies are very small (<1000 individuals) and that workers go out of the colonies in small numbers for only short periods of time during the day and rarely at night [17]. Additionally, it has been suggested that *M. hunteri* eat root-mycorrhizae underground [17]. If what is known about the *M. hunteri* natural history is accurate, it is not a surprise that these reclusive ants were not well represented in this Mount St. Helens ant survey. It should be noted that Sugg [11] collected *M. hunteri* from the Blowdown Zone following the 1980 eruption, indicating that it was an ant species that survived the eruption.

Of the 10 ant species collected during this study, only *F. obscuripes* was not collected at the BDZ habitat type and was, instead, found uniquely at the PPHV habitat type. *Formica obscuripes* are known to build large mounds made of thatch in prairie and dry forest ecosystems in the western United States [18], which could easily describe the environments found at Mount St. Helens National Volcanic Monument. However, from this habitat preference description one would expect to find *F. obscuripes* at the BDZ habitat type instead of the PPHV habitat type. Jurgensen et al. [18] mention that the distribution of *F. obscuripes* may be limited by their interaction with carpenter ants (*Camponotus* spp.). It is thought that carpenter ants influence the distribution of *F. obscuripes* by either directly competing with or predating upon the *F. obscuripes* colonies [18]. Interestingly, carpenter ants (*C. modoc*) were collected only at the BDZ habitat type but not the PPHV habitat type suggesting that *F. obscuripes* may have been able to escape predatory carpenter ants by avoiding the Blowdown Zone.

The distribution of *C. modoc* only at the BDZ habitat type and not at the PPHV habitat type is also interesting. This distribution pattern hinges on the presence or absence of dead wood where *C. modoc* like to dwell. Dead fir trees are commonly found within the Blowdown Zone around Mount St. Helens because they were toppled by the force of the 1980 eruption. Trees in the area now referred to as the Pumice Plain were vaporized by the explosion so there are few remnants of standing or fallen dead wood. Additionally, the successional stages of vegetation recovery on the Pumice Plain have not yet progressed to the point where there are many trees leading to a dearth of shelter for *C. modoc* colonies.

Both ant species richness and ant abundance were significantly higher at the BDZ and PPHV habitat types than at the PPLV habitat type. Additionally, there were overall significant correlations between ant parameters (richness and abundance) and plant parameters (richness and percent ground cover). These results seem to fall in line with the "taxonomic diversity hypothesis" put forward by Murdoch et al. [19], which hypothesized that a greater diversity of plants would go hand in hand with a greater diversity of animals who ate them. Positive relationships between plant species richness and ant species richness have been observed in many studies. For instance, Fergnani et al. [20] found that an increase in plant species richness and disturbance by cattle grazing encouraged an increase in ant species richness in a Subantarctic-Patagonian transition zone. Similarly, in a study conducted by Simao et al. [21] in experimental plots in Indiana (US) a strong correlation was found between total arthropod abundance and richness and plant species richness in areas where native plant species richness had been reduced by the invasion of the nonnative Japanese stiltgrass (*Microstegium vimineum*). The arthropods that most strongly responded to changes in plant species richness were ants, aphids (Aphididae), and shining flower beetles (Phalacridae) [21]. The positive correlation between ant species richness and abundance and plant species richness observed at Mount St. Helens in this survey may be attributed to greater food availability for ants. Specifically, all of the ant species that were collected can be characterized as omnivores that opportunistically eat a variety of food items including plant exudates, seeds, and live or dead insects [14, 22]. As a result, habitats with higher plant species richness (like BDZ and PPHV habitat types) should harbor greater ant species richness and abundance than habitats with very low plant species richness (like the PPLV habitat type) simply due to expanded food options.

Another interesting finding from this survey was the positive correlation between percent ground cover by plants and ant species richness and abundance. Two explanations for this observation involve the importance of shelter and shade for ants. Andersen [23] suggested that plant litter may create important hiding places for cryptic species of ants. During the daytime collection of ants through aspiration at Mount St. Helens, the author observed that ants would often attempt to evade collection by hiding under and within plants. This suggests that percent ground cover by plants may be important to ants at Mount St. Helens because of the shelter, or "hiding places," that is provided from predators. The importance of shade for ants was discussed by Bestelmeyer [24] in a study exploring the behavior of *Forelius nigriventris* who used plant cover to cool off in the Argentine Chaco. Plant cover may also be important to ants on the Pumice Plain by providing thermal refugia, especially during the summer.

As previously discussed, ant species richness was significantly higher at the BDZ and PPHV habitat types than at the PPLV habitat type. Upon closer investigation, it turns out that the BDZ habitat had significantly higher ant species richness when compared to the PPHV habitat type. At first glance there is no clear explanation for this difference considering that both the plant species richness and percent ground cover by plants are not significantly different between the BDZ and PPHV habitat types. However, representative images of the PPHV and BDZ habitat types (Figures 1(b)-1(c)) show a clear distinction in the structure of the plant communities. Specifically, the BDZ habitat type has plants that vary greatly in height (trees, shrubs, and annual flowers) when compared to the PPHV habitat type which is dominated by low-lying plants. Murdoch et al. [19] hypothesized that greater structural heterogeneity of plants may lead to greater diversity of animals by opening up access to more diverse foraging areas and types of shelter. Along these lines, plant architecture has been found to greatly influence the richness of ant communities in different habitats. In a study exploring Amazonian forest succession, tree height was found to be the strongest predictor of ant species richness [25]. Additionally, da Costa et al. [26] found that the height of *Copaifera langsdorffii* (Fabaceae) trees was positively correlated with ant species richness. da Costa et al. [26] suggest that larger trees provide more complex plant architecture leading to a diversity of habitats for feeding, hiding, and egg laying, enabling multiple species of ants to coexist. Although plant architecture was not quantified in this study, it is probable that the more variable canopy structure at the BDZ habitat type when compared to the PPHV habitat type led to greater resource partitioning enabling more species of ants to coexist in the same environment. Further exploration into the relationships between plant communities (diversity and architecture) and ant communities at Mount St. Helens may prove fruitful in more fully testing the taxonomic diversity and structural heterogeneity hypotheses.

In conclusion, this study documents the ecological response of ants (Formicidae) to the 1980 eruption of Mount St. Helens by recording species distributions in three habitat types in 2008. Positive correlations between ant richness and abundance and plant richness and percent ground cover were found at Mount St. Helens suggesting that there is a strong connection between ant and plant community recovery. Further studies exploring ant-plant interactions may help us better understand the complex mechanisms driving the recovery of biotic communities following natural disasters such as volcanic eruptions.

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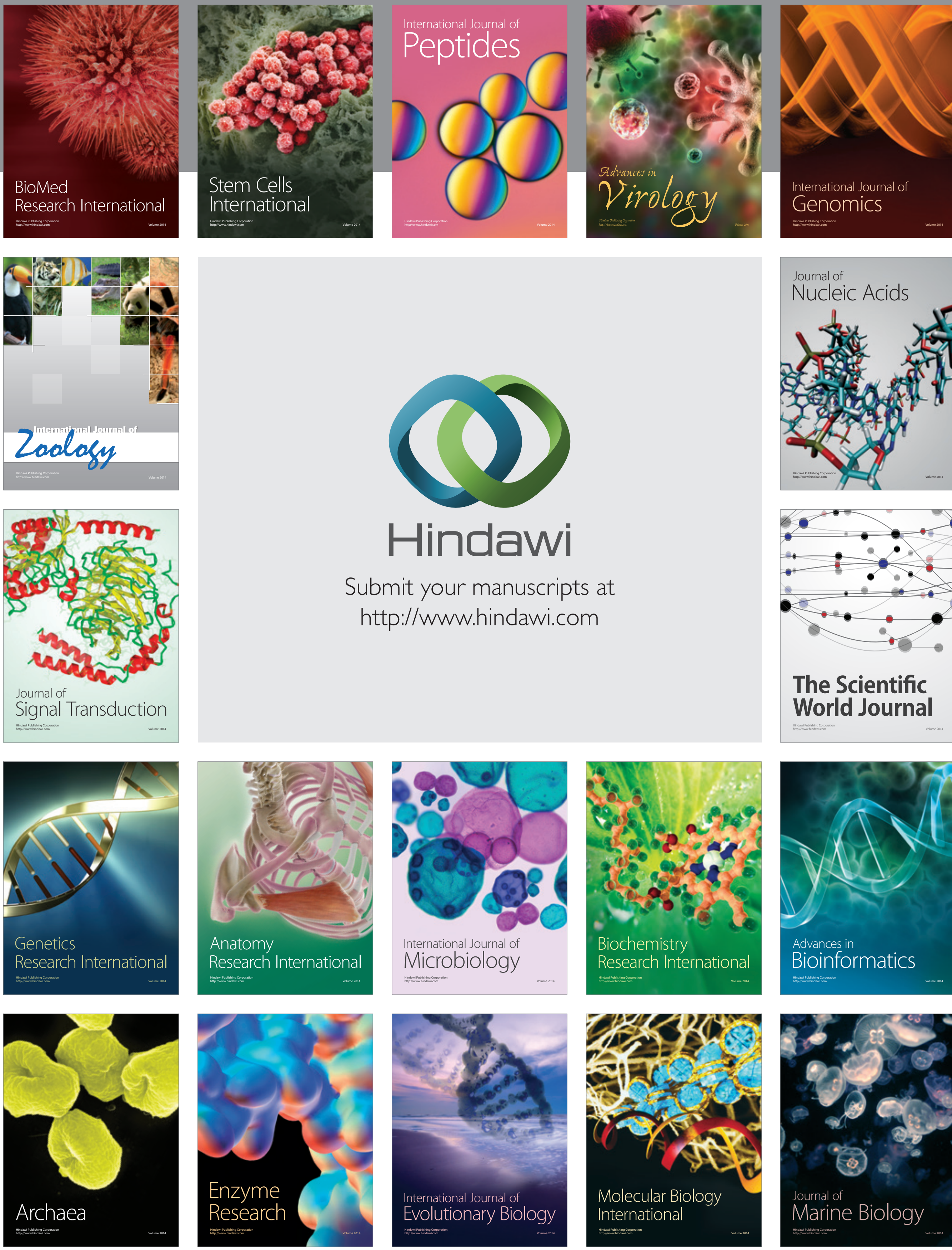
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