Life After Burn— Herbaceous Diversity and Community Composition at Glacial Heritage Preserve

Mango Kucera[1*], Brian King[1], Sasha Dillman[1], Melissa Vanderwerf[1], Tez Stair[1], and Julian Perry[1]

[1]The Evergreen State College, Olympia, WA 98505

[*]Corresponding Author:
Mango Kucera
The Evergreen State College
2700 Evergreen Parkway NW
Olympia, WA 98505
Phone: (630) 204-1030
Email: stitchinmama36@yahoo.com

ABSTRACT

In Western Washington (USA) lowland prairie habitats, fire was once a common occurrence. In relatively recent times however, fire has been excluded from this ecosystem. We studied the differences in herbaceous plant diversity and community composition between a burned and unburned site at Glacial Heritage Preserve near Littlerock, WA. We hypothesized that an annually burned site would support greater diversity and fewer invasive species compared to an unburned site. Our results showed that species diversity was significantly different between the two sites; a higher diversity of species was found in the burned site than the unburned. In addition, community composition varied between sites with the unburned site showing a greater presence of the invasive species *Hypochaeris radicata*. Our findings show that fire may increase species diversity in a lowland prairie ecosystem.

Keywords— Lowland prairie, disturbance, fire, richness, evenness, invasive species

Introduction— Every ecosystem is subject to some level of disturbance, and the organisms within an ecosystem have adapted over time to cope with these disturbances. Some species even rely on a high level of disturbance to survive. Our study focuses specifically on fire disturbance effects on prairie lands. Disturbances such as grazing and burning were historically important and high-frequency components in the evolution of North America's grassland prairies (Collins, 1987). Native plant communities may be particularly accustomed to fire disturbance due to historically frequent exposure. Fires may reduce or eliminate aboveground biomass, which makes space, nutrients, and light available to species lower in the competitive hierarchy (Safford *et al.*, 2003). Today, due to fragmentation and increased human population, fires cannot spread as easily across the landscape as they once had, and this could place native plant communities at a competitive disadvantage.

Our study aims to determine whether or not fire has an effect on the overall diversity of plant life within a prairie. There are countless studies that focus solely on the effects of fire on a single species, but fewer studies examine the effects on the plant community as a whole. The site we chose for this study is ideal in that the burned and unburned treatments are adjacent and would be hypothetically identical if the same treatment was applied to both. The central question of this study was: does fire have an effect on herbaceous diversity and community composition in lowland prairies? In addition, a minor question of the study is whether fire is an effective means to control invasive

species. We hypothesized that the burned site would have greater diversity and fewer invasives than the site left unburned due to historical associations between native species and fire disturbance.

Study Site Description— We conducted our study on herbaceous diversity within a lowland prairie of the Pacific Northwest. The study was conducted at Glacial Heritage Preserve, a 1,000 acre burned and unburned prairie located on the western edge of Thurston County near Littlerock, Washington. The burned and unburned areas were separated by a service road. The vegetation in the area of study consisted primarily of small perennial plants less than eighteen inches tall and there were less than ten trees within the sites. The site was largely dominated by *Camassia quamash* (Common Blue Camas), *Hypochaeris radicata* (Hairy Cat's Ear), native and non-native grasses, mosses, and lichens.

Natural History— In the past, local Native American tribes frequently burned the prairie primarily to preserve open grounds for game and aid in the production of camas root (Storm *et al.,* 2006). The prairie was burned regularly until the natives were removed from their land and relocated to reservations farther out on the peninsula. It was not until recently that the practice was revived by ecologists in an attempt to determine whether or not burning had a positive or negative impact on the ecosystem, focusing on plant diversity in particular. Though the Glacial Heritage Preserve was officially created only 21 years ago in 1986, we have found no records about when the burnings occurred and have no information about when our unburned control site was last burned.

Field Study— Our study was conducted on May 9 and 14, 2007 at two adjacent sites of prairie land within the Glacial Heritage Preserve that have the same general topography. The burned site was subject to a single controlled burn during Fall 2006, and the control site was unburned. To assess herbaceous richness between the two sites, we identified and recorded the presence of every species in 100 haphazardly located one-meter plots; we collected 50 samples in the burned and 50 samples in the unburned. To assess evenness between the sites, we estimated every species' overall abundance within the plots on a scale from 0 to 6. Zero represents absent, 1 represents 1 to 5% (trace), 2 represents 6 to 19%, 3 represents 20 to 39%, 4 represents 40 to 59%, 5 represents 60 to 79%, and 6 represents 80 to 100%. To determine the placement of the plots, we used a random number table that dictated our movement in terms of direction and number of paces.

RESULTS

A total number of 33 different species were identified throughout the study in addition to separate categories for grass and moss/lichen (Table 1). Twenty-seven different species were found in the burned site and 25 different species were found in the unburned site plus bulk categories of grass and moss/lichen; 21 species were shared between sites. A Multiple Response Permutation Procedure (MRPP) for community analysis indicated that communities are significantly different between the burned and unburned site (Fig. 1; $A=0.041$, $P<0.001$).

We used ANOVA on diversity indices Shannon's H, Simpson's D, richness, and evenness to test differences between the burned and unburned sites. All four tests showed significant differences between the sites. The Shannon's index value was 1.91 (+/- 0.042) for the burned site and 1.71 (+/- 0.042) for the unburned (Fig. 2A; P=0.001); the Simpson's index value was 0.83 (+/- 0.007) for the burned and 0.79 (+/- 0.007) for the unburned (Fig. 2B; P=0.001). The richness value was 7.74 (+/- 0.309) for the burned and 6.5 (+/- 0.309) for the unburned, not including grass and moss/lichen (Fig. 3A; P=0.006), and the evenness value was 0.96 (+/- 0.004) for burned and 0.93 (+/- 0.004) for unburned (Fig. 3B; P<0.001). In all four of these tests, the burned site had larger values than the unburned site.

The average evenness of *Hypochaeris radicata* was 2.22 in the burned site and 3.24 in the unburned site (Fig. 4; P < 0.001). *H. radicata* was absent in four plots in the burned site and absent in only one plot in the unburned site.

DISCUSSION

We hypothesized that there would be more plant diversity in the annually burned portion of Glacial Prairie than the unburned. The data clearly suggest there is indeed a difference in diversity and community composition between the burned and unburned sites. All the statistical tests used show that the burned site was significantly more diverse, and the low P values indicate that the pattern found is almost certainly not by chance ($p < 0.05$). The high A value calculated by the MRPP indicates that the two communities also differ in composition.

Our results are ecologically relevant as they support findings that fire is an important factor in maintaining prairie diversity, and potentially keeping invasive species at bay. Other studies have shown that small-scale native richness increases or remains stable in burned sites and declines or remains stable in unburned sites, whereas invasive richness increases in unburned sites and declines in burned sites (Bowles *et al.*, 2002). We found similar findings when comparing the very abundant invasive species *H. radicata* in burned versus unburned; *H. radicata* was less abundant in the burned site. Therefore, annual burning may aid in lowering the numbers of this invasive species.

Fire introductions may aid in maintenance of diversity in Western Washington prairie ecosystems. Our work adds to a growing body of literature suggesting that fire effects may increase species diversity in prairie ecosystems in general, and in Western Washington prairies in specific. Positive responses to fire by native herbaceous species may indicate adaptation to fire disturbance, while invasive species not accustomed to fire may suffer. This study and others like it help inform the public that not all land disturbances are unhealthy for ecosystems, and in fact fire may play a critical role in maintaining diversity on the landscape.

ACKNOWLEDGEMENTS

We would like to sincerely thank Dylan Fischer, Bill Ransom, and Jill Wilks for their support, advice and facilitation of this research project. We would also like to thank The Nature Conservancy for allowing us to use the Glacial Heritage Preserve as the site

for our study and to The Evergreen State College for providing facilities, materials, and resources that made our study possible. Finally, we would like to acknowledge Zach Miller, Pat Babbin, and Brett Ivey for their assistance in plant identification in the field and providing information about the Glacial Heritage Preserve.

LITERATURE CITED

Bowles, M.L., M.D. Jones, and J.L. McBride. 2003. Twenty-year Changes in Burned and Unburned Sand Prairie Remnants in Northwestern Illinois and Implications for Management. Am. Midl. Nat. **149**:35-45.

Collins, S.L. 1987. Interaction of Disturbance in Tallgrass Prairie: A Field Experiment. Ecology, **68**: 1243-1250.

Safford, H.D. and S. Harrison. 2003. Fire Effects on Plant Diversity in Serpentine vs. Sandstone Chaparral. Ecology, **85**: 539-548.

Storm, L. and D. Shebitz. 2006. Evaluating the Purpose, Extent and Ecological Restoration Applications of Indigenous Burning Practices in Southwestern Washington. Ecological Restoration, **24**: 256-266.

Table 1—Total species found in the burned and unburned sites

Species List	
BURNED	UNBURNED
1. *Camas quamash*	1. *Camas quamash*
2. *Hypochaeris radicata*	2. *Hypochaeris radicata*
3. *Rumex acetocella*	3. *Rumex acetocella*
4. *Lomatuim utriculatum*	4. *Lomatium utriculatum*
5. *Achillea millifolium*	5. *Achillea millifolium*
6. *Teesdalia nudicaulis*	6. *Teesdalia nudicaulis*
7. *Cytisus scoparius*	7. *Cytisus scoparius*
8. *Vitica sativa*	8. *Vitica sativa*
9. *Lotus micranthus*	9. *Lotus micranthus*
10. *Viola adunca*	10. *Viola adunca*
11. *Campanula rotundifolia*	11. *Campanula rotundifolia*
12. *Prunella vulgaris*	12. *Prunella vulgaris*
13. *Microseris lacinata*	13. *Microseris lacinata*
14. *Hypericum perforatum*	14. *Hypericum perforatum*
15. *Chrysanthemum leucanthemum*	15. *Chrysanthemum leucanthemum*
16. *Eriophyllum lanatum*	16. *Eriophyllum lanatum*
17. *Ranunculus occidentalis*	17. *Ranunculus occidentalis*
18. *Plantago lanceolata*	18. *Plantago lanceolata*
19. *Trifolium dubium*	19. *Trifolium dubium*
20. *Viola sempervirens*	20. *Viola sempervirens*
21. *Hieracium albiflorum*	21. *Hieracium albiflorum*
22. *Solidago Canadensis*	22. *Lupinus lepidus*
23. *Solidago spathulata*	23. *Pteridum aquilinum*
24. *Arctostaphylos uva-ursi*	24. *Senecio vulgaris*
25 *Crepis capillaris*.	25. *Unidentified sp. b*
26. *Campanula scouleri*	
27. *Unidentified sp. a*	

Figure Legend—

Figure 1, A NMS ordination representing the differences in community composition and abundance of species generated by a MRPP analysis. Each point represents a plot; black points represent plots sampled in the unburned site and white points represent plots sampled in the burned site

Figure 2. Shannon's (**A**) and Simpson's (**B**) values for the burned and unburned sites. Error bars represent ± one standard error from the mean. The greater values represent the more diverse site.

Figure 3 compares species richness (**A**) and evenness (**B**) between the burned and unburned sites. Error bars represent ± one standard error from the mean. The greater values represent the more diverse site.

Figure 4 shows the average abundance of *Hypochaeris radicata* in burned vs. unburned.

Figure 1

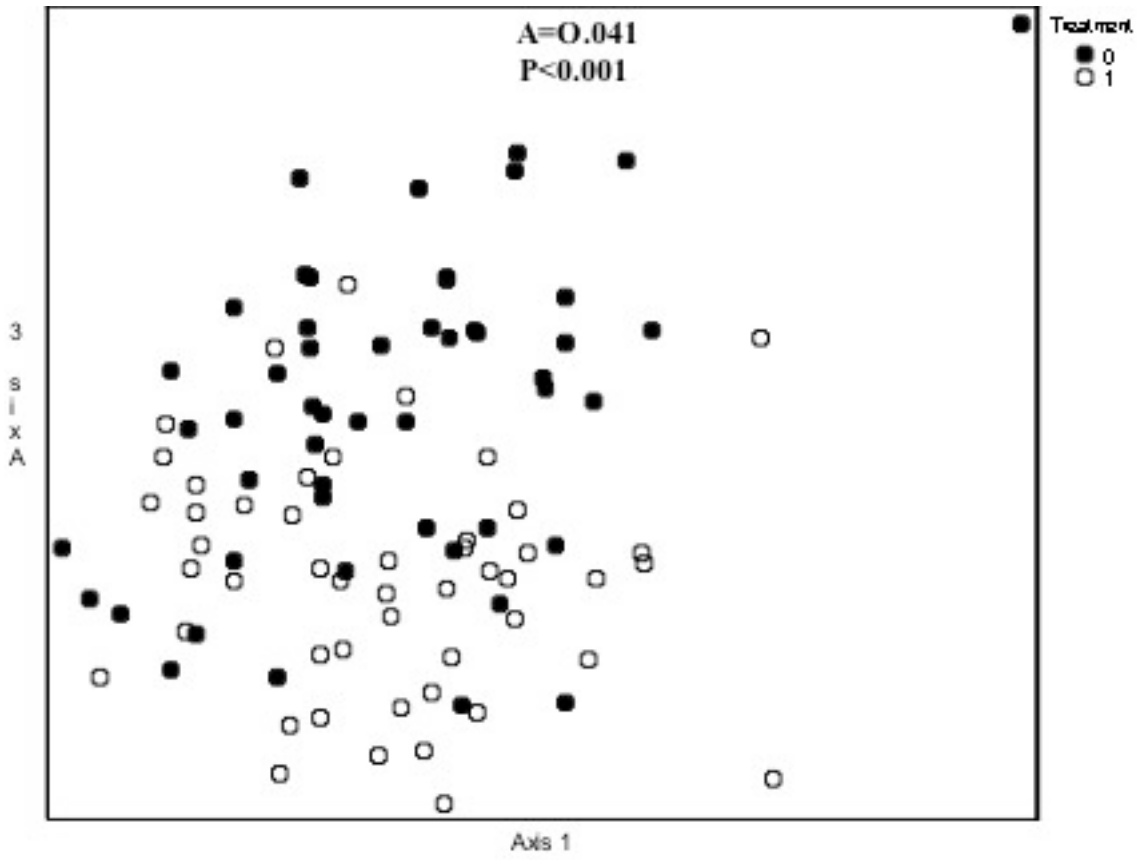


Figure 2

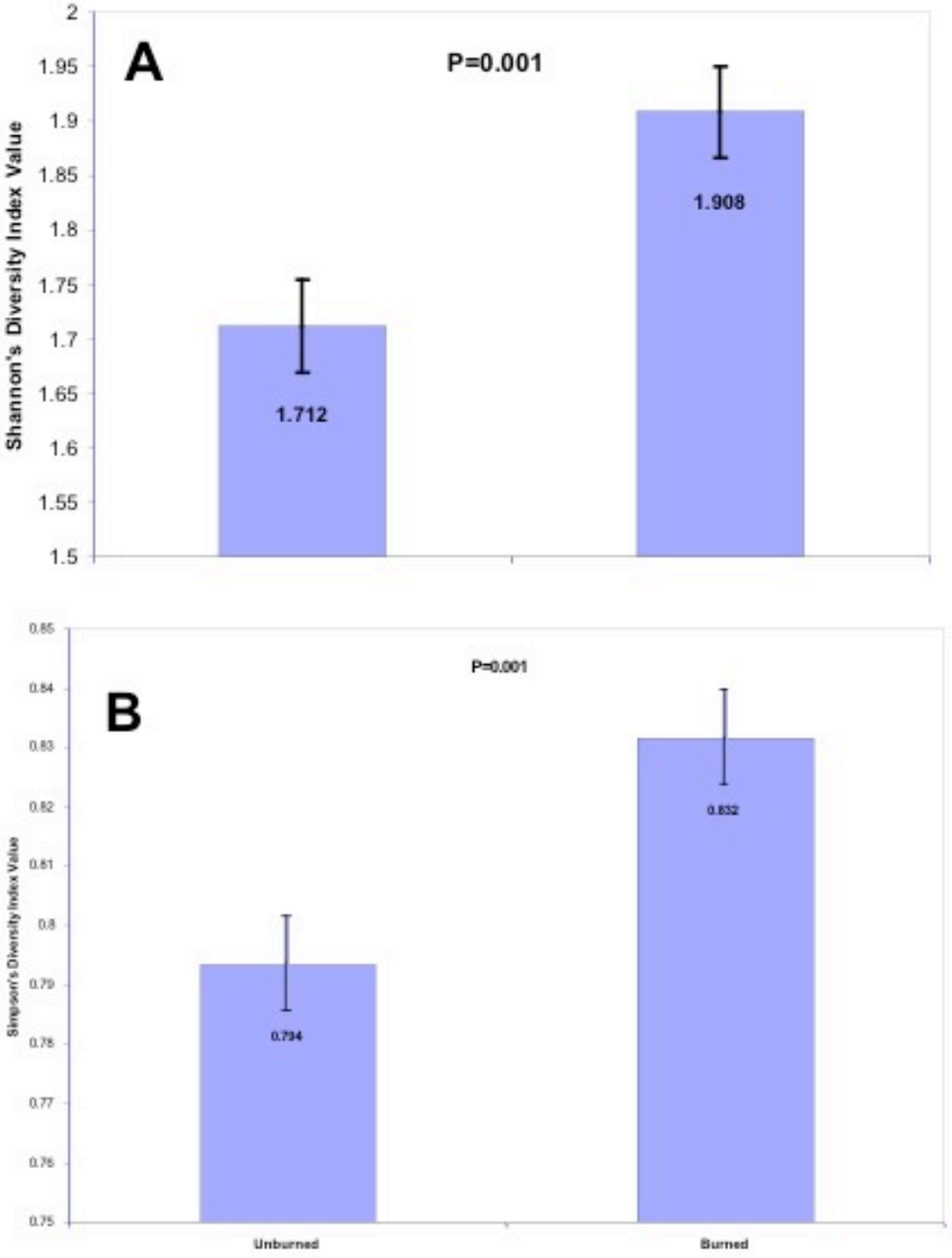
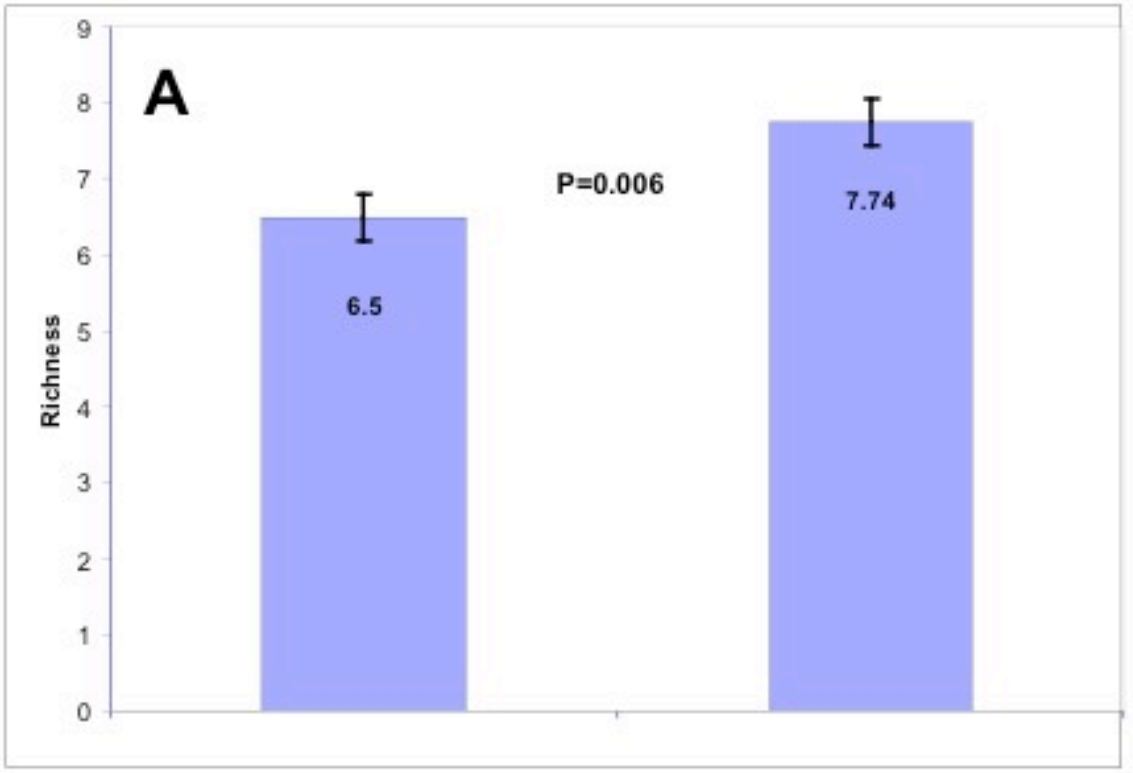

A
P=0.001
Shannon's Diversity Index Value
2
1.95
1.9
1.85
1.8
1.75
1.7
1.65
1.6
1.55
1.5
1.712
1.908
B
P=0.001
Simpson's Diversity Index Value
0.85
0.84
0.83
0.82
0.81
0.8
0.79
0.78
0.77
0.76
0.75
0.794
0.832
Unburned
Burned

Figure 3


A
P=0.006
6.5
7.74
Richness
9
8
7
6
5
4
3
2
1
0

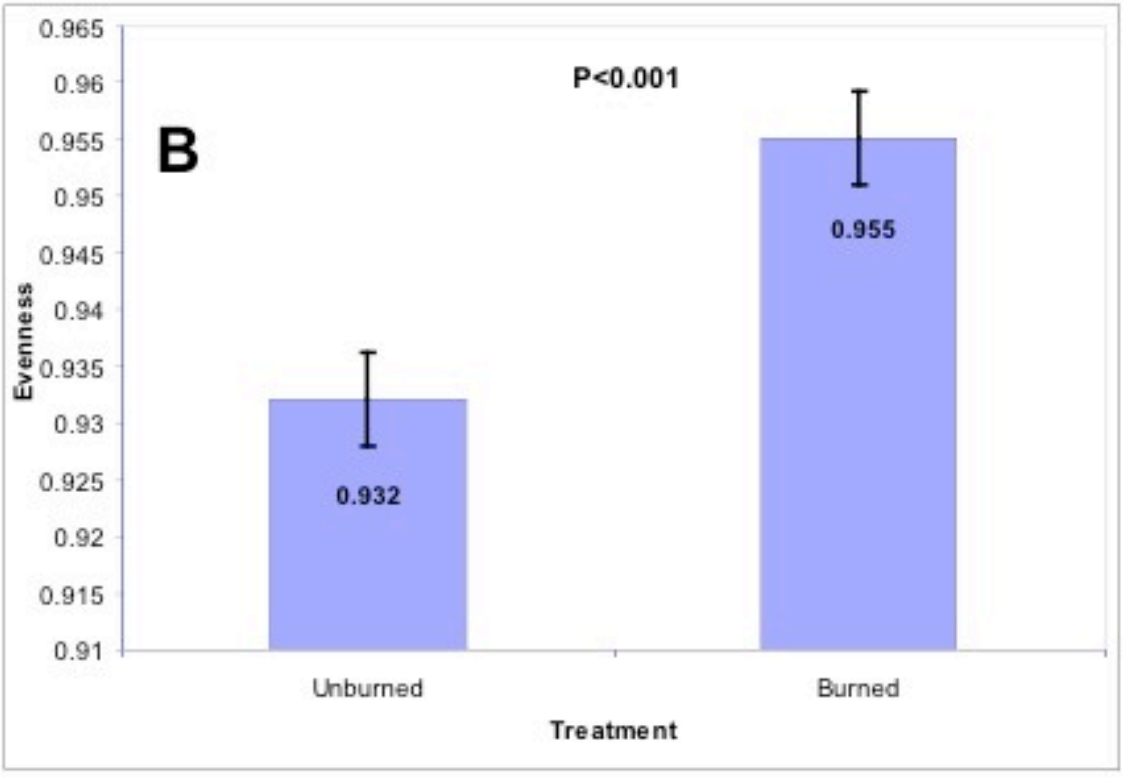
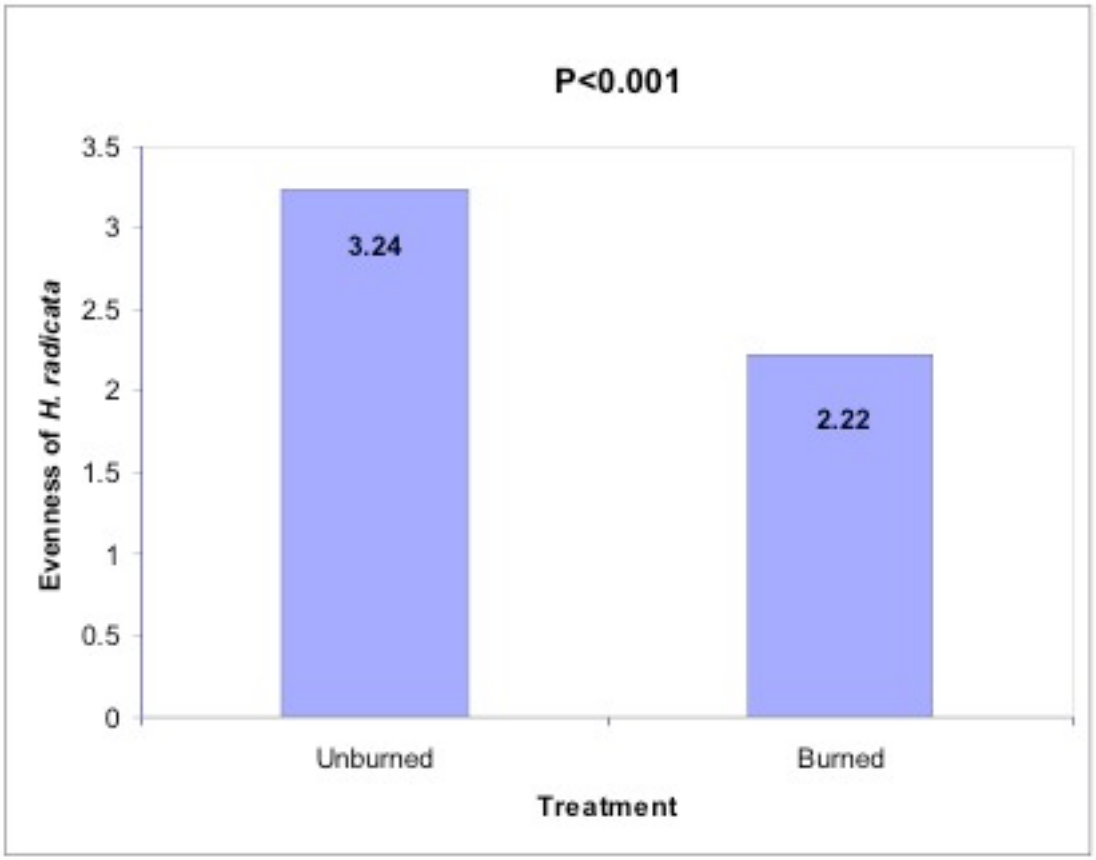

B
P<0.001
0.932
0.955
Evenness
0.965
0.96
0.955
0.95
0.945
0.94
0.935
0.93
0.925
0.92
0.915
0.91
Unburned
Burned
Treatment

Figure 4


P<0.001
Evenness of H. radicata
3.5
3
2.5
2
1.5
1
0.5
0
3.24
2.22
Unburned
Burned
Treatment