ARTHROPOD DIVERSITY IN AN ARRAY OF NATURAL AND DISTURBED ECOSYSTEMS

Jenny Lesko

Department of Biology, University of Notre Dame, South Bend, IN

Jlesko1@alumni.nd.edu

ABSTRACT

Human disturbance affects habitats in a variety of ways. In this study, I focused on disturbance due to agriculture and cattle grazing by measuring arthropod community composition between two disturbed and two less-disturbed sites in northwestern Montana, USA. The disturbed sites included cattle plots and a wheat field, while the less-disturbed sites included a montane forest and a mixed-grass prairie. At each of these sites, I sampled four subsites using a combination of pitfall and light traps, two nights for each subsite, for a total of 32 light trap jars and 128 pitfall traps collected. For each sample, I identified all arthropods to family using a dissecting microscope. I conducted multi-way ANOVAs to test for differences between sites in terms of arthropod abundance, family richness, Shannon's diversity, and family evenness for pitfall and light traps. I also chose several more common groups of arthropods to compare between sites, using ANOVAs as well. For pitfall traps, I found arthropod abundance, family richness, and diversity to be significantly different among sites, with sites showing a variety of contrasts. For light traps, I found diversity and family evenness to be different among sites, again with an array of contrasts. The Formicidae and Araneae families were shown to have significantly different abundances between site as well; many Formicidae were found in a more disturbed ecosystem, and greater Araneae abundance was noted in less disturbed ecosystems. As predicted, arthropod family diversity was greater in the forest site. However, diversity was low at the bison range, likely due to less soil moisture. The farm field demonstrated surprisingly high family richness and diversity, and this was likely due to soil moisture as well, as the field received high levels of irrigation. The cattle plots were not very diverse,

but had high overall abundance which may have been linked to lack of predators or low plant diversity.

INTRODUCTION

Human-mediated disturbance is any modification to an ecosystem by a person or group of people. Human disturbance manifests in a variety of ways, from fire to agriculture to creating fields for cattle grazing. It has also been known to cause a number of negative effects in ecosystems, including a decrease in biodiversity. Disturbance strongly affects aspects of species diversity, as found in a large number of studies (Mackey and Currie 2001). In this study I focused on monoculture agriculture and cattle grazing as forms of disturbance.

Arthropods provide a multitude of ecosystem services such as aiding in decomposition, pest control, and pollination (Isaacs et al. 2008). Therefore, greater arthropod diversity generally positively affects ecosystems. Arthropod community composition is used as an indicator of the level of disturbance in a landscape. Arthropods are also ideal study organisms, as they are numerous and easy to capture. In a meta-study of many papers investigating disturbance, arthropod richness was found to be significantly higher in areas of less intensive land use (Attwood et al. 2008). Arthropods can also be used as indicators of biodiversity and to pinpoint the relative quality of an ecosystem. Some arthropods are generalists found in many habitats in an area, and these are commonly called cosmopolitan or urban taxa. Others are specialists found in only a few less disturbed places or near a specific plant species, and they are called indicator taxa.

For this study, I hypothesized that greater arthropod family richness and diversity would be found in the less disturbed habitats that I sampled, the bison range and the forest, for both pitfall and light traps. Conversely, I predicted that less richness and diversity would exist in the cattle plots and farm field, the two more disturbed sites. I was also measuring abundance, but did not think that it would be related to disturbance, because species can maintain the same relative abundance in a range of conditions (Gaston and Warren 1997). Finally, I expected that the presence of some families or groups of families would be correlated with a more or less disturbed habitat type, as this is commonly found in studies similar to mine.

METHODS

Location. This study was conducted in July and August 2013 in a broad array of four sites including two disturbed and two largely non-disturbed habitat types in northwestern Montana (N 47˚25', W 114˚18'). The less-disturbed sites included a montane Douglas fir forest and a small section of mixed-grass prairie within the National Bison Range. The disturbed sites included a grazed cattle plot area and a monoculture wheat field (Figure 1).

Collection. For each of the four habitat types, four subsites within 100 yards of each other were chosen. In each of these sites, four pitfall traps and one light trap were installed. The light traps were constructed of a lantern attached to a tripod above a large funnel connected to a jar filled with an alcohol and water mixture. The light trap was suspended a few feet above the ground to attract flying arthropods. At each subsite, pitfall traps and light traps were installed in the afternoon or evening and left overnight. All arthropods were collected the next morning and stored in a freezer until they could be identified (see below). Each of the subsites was assayed for two nights of trapping total, and eight pitfalls traps and two light trap jars were collected per subsite. Overall, 32 light trap jars and 128 pitfall traps were collected over twelve nights of survey.

Identification. For each of the light trap jars and pitfall traps, all arthropods were counted and identified to family under a dissecting microscope. 55 families from the light traps and 54 families from the pitfall traps were separated and counted. Because many Collembola were found in most samples, I chose to record them as 100+ individuals, rather than count them all, because their abundances were not very important due to being so high in nearly every pitfall trap.

Analysis. To analyze the data after identification, I used a variety of indices coupled with multi-way ANOVA's and post-hoc Tukey tests to determine differences between sites for pitfall traps and light traps. These included counts and calculations of total arthropod abundance per trap, family richness per site, Shannon's diversity, and family evenness. I also chose some families and groups of families found throughout all the sites and that are commonly surveyed in similar studies, including the families Cicadellidae and Formicidae, and the orders Lepidoptera and Araneae.

RESULTS

Pitfall traps. For pitfall traps, abundance of arthropods between sites was significantly different (Figure 2; $F_{3,12}$=4.707, p=0.021). Collembola counts were removed because their numbers had been great in all sites, so they played almost no part in creating differences between the four ecosystems. In a Tukey's HSD test, significantly more individual arthropods were caught at the cattle plot site than the bison range (p=0.018) and forest (p=0.076) sites. Family richness was significantly different among habitat types (Figure 3; $F_{3,12}$=2.8795, p=0.080). However, none of the sites were significantly different from one another when tested side by side. Shannon's diversity index was also significantly different among sites (Figure 4; $F_{3,12}$=4.38889, p=0.026). In comparison of means, forest had a significantly higher diversity index than cattle plots ($p=0.018$). From the Shannon index, family evenness was calculated, but was not significant for pitfall traps between any sites ($F_{3,11}=1.183$, $p=0.361$).

Light traps. For light traps, abundance of arthropods and family richness was did not differ significantly among sites ($F_{3,12}=0.578$, $p=0.641$, and $F_{3,12}=2.300$, $p=0.130$, respectively). The Shannon's diversity index was also calculated for light traps. Significant differences existed between sites (Figure 5; $F_{3,12}=3.9034$, $p=0.037$). Specifically, the forest was more diverse than the bison range ($p=0.051$) and the farm field ($p=0.062$). Though the sites did not have significantly different family evenness for pitfall traps, they did for light traps (Figure 6; $F_{3,12}=4.03$, $p=0.034$); the cattle plot sites had much lower family evenness than forest and bison range sites.

Taxa comparisons. After basic indices of overall community composition were analyzed, a few families and groups of families that were determined to be important were chosen for comparison between the four major sites. Cicadellidae and Formicidae were two of the largest families found in pitfall traps at all sites, and their abundances were considered in evaluating the differences between sites. For Cicadellidae, differences between sites were not significant ($F_{3,12}=2.580$, $p=0.102$). But for Formicidae, abundances were significantly different in the four ecosystems (Figure 7, $F_{3,12}=8.1686$, $p=0.003$). The cattle plots had a significantly higher number of Formicidae than the bison range ($p=0.004$), the farm field ($p=0.011$), and the forest ($p=0.012$).

Finally, a few larger groups of families and orders were analyzed. Though Lepidoptera catch rates were larger in light traps, they did not indicate a significant different between sites. Araneae abundances, on the other hand, were different between the four ecosystems in pitfall traps (Figure 8, $F_{3,12}$=4.7724, p=0.021). While quite a few Araneae were found in the forest, none were found in farm field pitfall traps. The specific differences found in Araneae communities were between the farm field and bison range (p=0.059) and the farm field and forest (p=0.019).

DISCUSSION

Results showed that in general, a complex mixture of contrasts existed between the four habitat types when abundance, family richness, Shannon's diversity, and family evenness were measured for pitfall and light traps.

Pitfall traps. For pitfall traps, overall abundance was significantly higher in the cattle plots than in the bison range and forest. It was also interesting to find that the cattle plots and farm field, the two most disturbed sites, held the highest arthropod abundances per trap. This could be attributed to a number of things. First, I trapped fewer predators such as Araneae in these areas. Less pressure from predators can lead to population explosions of one or a few species. As a result, some normally susceptible taxa are able to thrive. Alternatively, cattle grazing can be linked to less plant diversity and more invasive plant species (Loeser et al. 2007). Less arthropod species tend to prefer invasive plants, which can result in high abundances of a few species.

Family richness and Shannon's diversity indices held similar results. I had expected the forest to have a high richness and diversity. Forested areas generally have higher and less variable soil moisture content than grasslands (Partel and Helm 2007). However, I was surprised to find that the farm field demonstrated a high family richness and diversity as well; I had expected this area to have the least richness and diversity because non-organic monoculture fields are not often as speciose in arthropod taxa as other habitats

(Holdren and Ehrlich 1974). After analyzing results, I believe that this is likely due to irrigation. During this study, almost no rain had been seen for months, and the irrigated farm field may have drawn in species that would not normally prefer a wheat field environment (Kirchner 1977).

Light traps. Because of their lower sample size, light traps did not indicate as many differences between sites as the pitfall traps. No significant differences existed for overall arthropod abundance or family richness. For Shannon's diversity, forest again was the most diverse. The forest and bison range also indicated the highest family evenness, which is characteristic of less disturbed environments (Kimbro and Grosholz 2006).

Light and pitfall trap comparisons. The arthropods captured in the light and pitfall traps were quite different and represented completely unlike communities, with barely any family overlap. Therefore, it is hard to connect them in explaining certain differences in communities between sites. This is likely because the two groups are not dependent on the same environmental variables. Though it would be interesting to determine why the two communities contrasted in indices of diversity, more information is needed.

Taxa comparisons. Cicadellidae and Formicidae were two of the most common groups collected from pitfall traps, and in comparing their relative abundances, it was evident that they accounted for much of the high abundance noted in the cattle plots. They may be prevalent in this ecosystem due to a number of reasons. For example, less pressure from predators can be linked to high abundances of a few prey species. Or alternatively as mentioned before, cattle-grazed areas are known to result in a less diverse plant assemblage with more invasive species (Loeser et al. 2007). As less arthropod species feed on invasive plants, many of a few arthropod species would be likely to occur (Wilby et al.

2006). Cicadelllidae, or Formicidae especially due to its significant difference in abundance between sites, could be labeled cosmopolitan or urban families that indicate a more disturbed environment.

The high abundance of Araneae found in pitfall traps in the bison range and forest contrasts with the low abundance collected in the farm field and cattle plots. Though family richness and diversity was high in the farm field, I found no spiders there. In a similar study comparing wheat fields to semi-arid desert, spider richness and abundance were significantly greater in semi-arid desert than in intensely cultivated wheat fields (Pluess et al. 2008). Drawing from these observations, Araneae are a group sensitive to human disturbance, so they may be used as indicators to determine the nature of disturbance in an area.

Individuals of the order Lepidoptera were commonly captured in light traps. Though there was not a significant difference in Lepidopteran abundance between sites, it is possible or likely that there would have been had sample size been greater. Lepidoptera abundance and diversity is often assayed in similar studies to this one, and greater Lepidopteran abundance has been linked to less disturbance, and some families of Lepidoptera are very sensitive to human habitat alteration (Fiedler and Schulze 2004).

Conclusions. In this study, my hypotheses were in part supported by the data I collected. I predicted that for both pitfalls and light traps, the forest and bison range should have a more speciose and diverse arthropod community. This was true for the forest, but not for the bison range. This could be due to the lack of soil moisture during a very dry summer; the landscape may not have been able to support many organisms at the time. My prediction that abundance was not linked to disturbance could still be correct. However, my results do not reflect that, and abundance was greater in areas of greater human disturbance. Finally, I hypothesized that the presence and abundance of some families or groups of families would be correlated with human disturbance. This was supported, as Cicadellidae, Formicidae, Araneae, and Lepidoptera abundances all showed marked relationships to habitat type, though only Formicidae and Araneae indicated significant differences between sites.

Future studies. In future studies, I would measure more abiotic and biotic factors, such as ground cover and soil moisture. I would also classify arthropods to genus or species, as one arthropod family can contain both generalist and specialist species (Evans 1982). Finally, I might concentrate on just one family or order such as Lepidoptera or Araneae rather than the entire arthropod community in order to better ascertain species or genera that are linked to human disturbance or lack thereof.

ACKNOWLEDGMENTS

Many thanks to Gary Belovsky and Angela Laws for their excellent leadership in the program, as well as Diana Saintignon for her proficiency in being a teaching assistant and help digging holes. Thanks to Nora Nickels, Jack McLaren, Nick Kalejs, Nick Anderson, Shawn Szabo, and Stephen Elser for climbing the hill, putting up traps,, and brainstorming with me. Finally, thanks to the NSF grant and University of Notre Dame for allowing me to be a part of this program.

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FIGURES

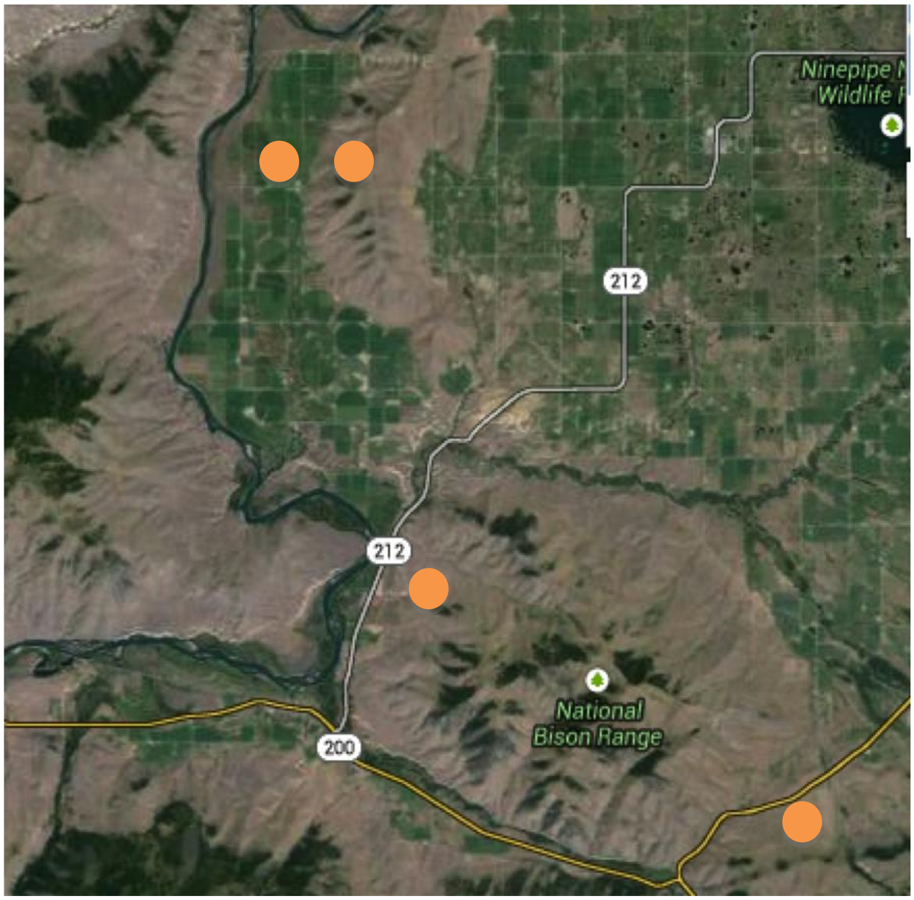

Figure 1. Wheat field left top, montane forest second to left, bison range second left, and cattle plots farthest left.

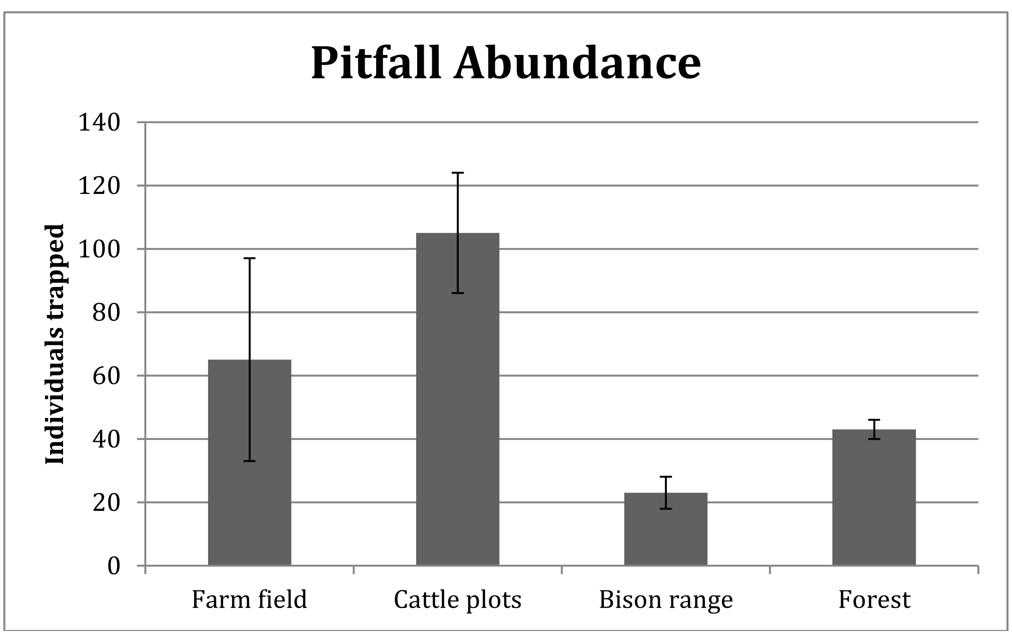

Figure 2. Sites were significantly different in overall abundance for pitfall traps (F=4.707, p=0.021). Cattle plots have significantly greater arthropod abundance than bison range and forest.

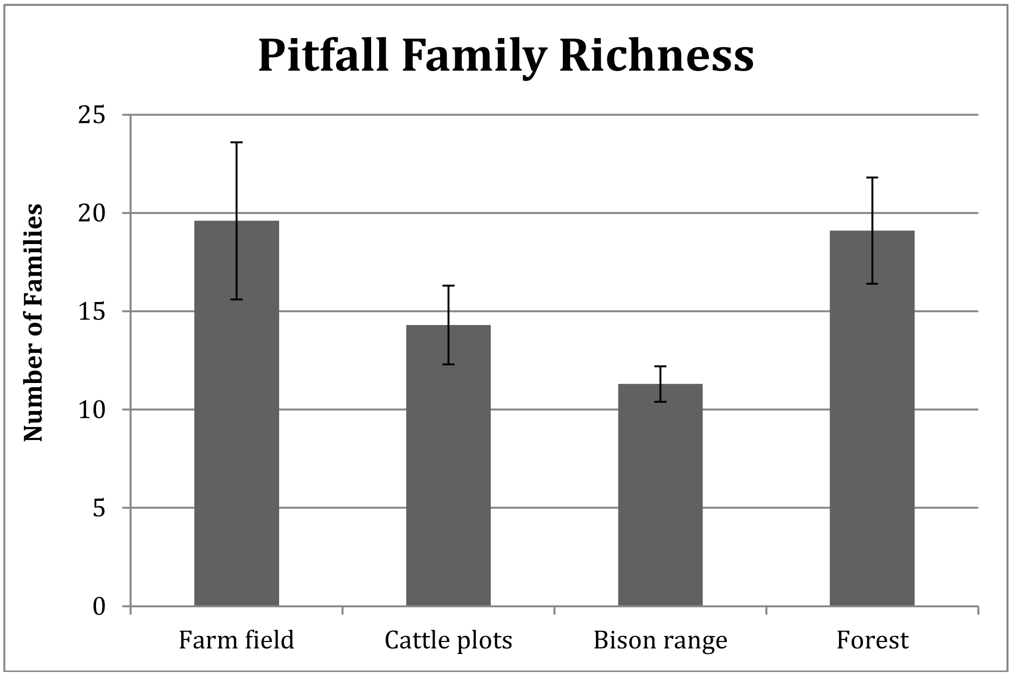

Figure 3. Sites were significantly different overall in family richness for pitfall traps (F=2.295, p=0.080), but not between any specific sites (Alpha of 0.10 was accepted as significant).

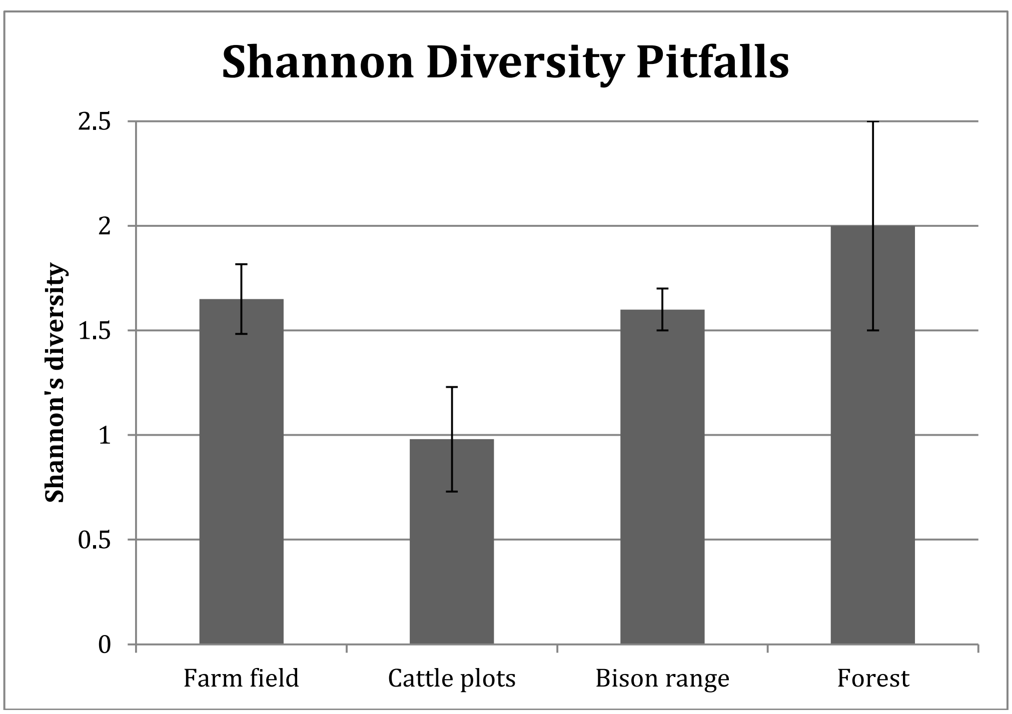

Figure 4. Sites were significantly different in diversity for pitfall traps (F=4.390, p=0.023). Forest had greater diversity than cattle plots.

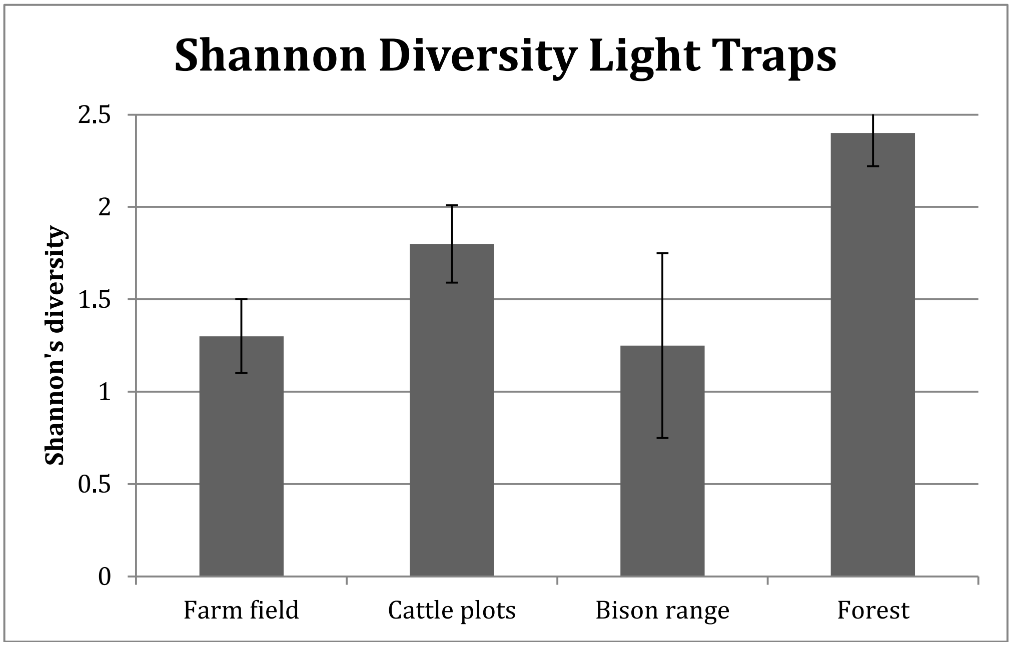

Figure 5. Sites were significantly different in diversity for light traps (F=3.903, p=0.037). Forest had greater diversity than bison range and farm field.

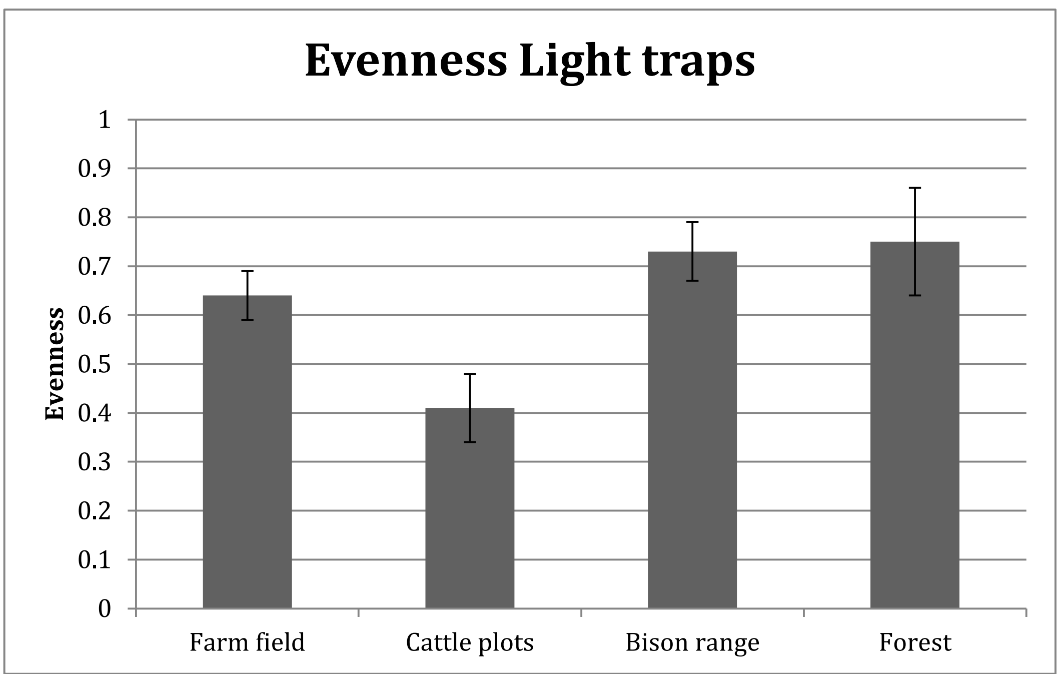

Figure 6. Sites were significantly different in family evenness for light traps (F=4.030, p=0.034). Forest and bison range had greater evenness than cattle plots.

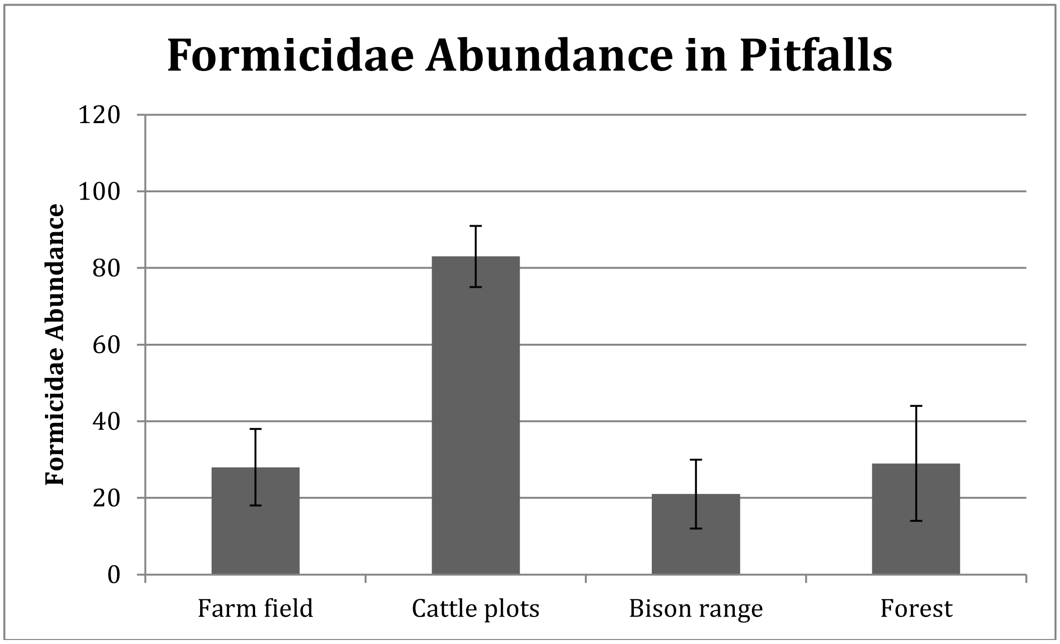

Figure 7. Sites were significantly different in Formicidae abundance for pitfall traps (F=8.169, p=0.003). Cattle plots had greater Formicidae abundance than farm field, bison range, and forest.

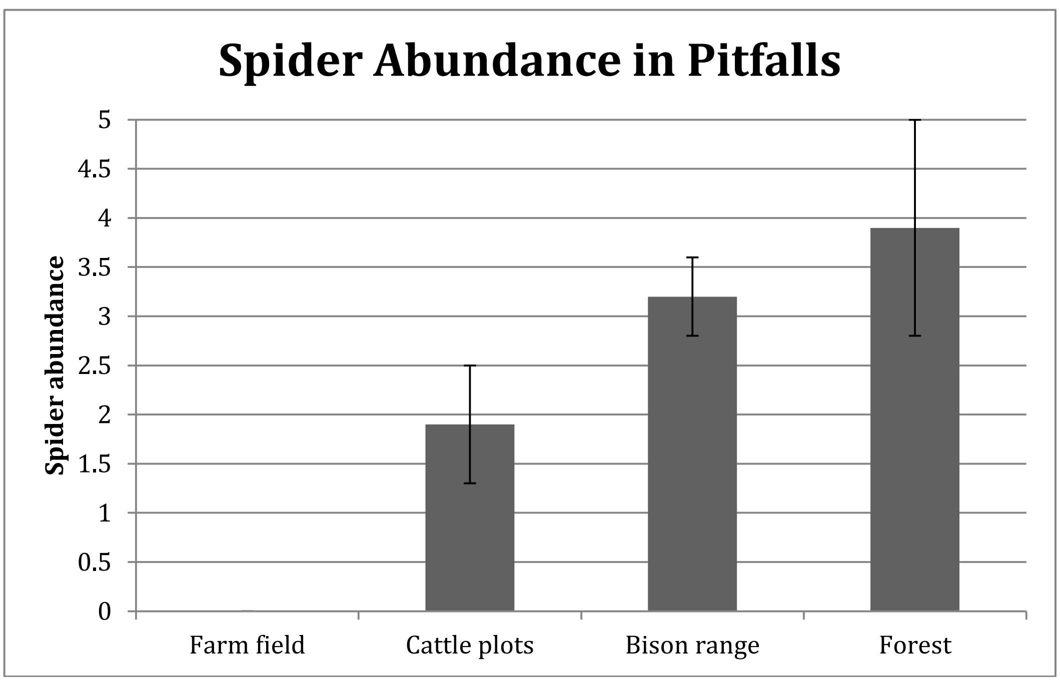

Figure 8. Sites were significantly different in Araneae abundance for pitfall traps (F=4.772, p=0.021). Forest and bison range had greater spider abundance than the farm field.