Effects of Increased Seasonal Rainfall on Soil- and Leaf Litter- Microarthropods in a Northern California Grassland

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Abstract Climate change models have predicted that due to anthropogenic global warming precipitation is expected to noticeably increase. This change in precipitation could have a plethora of effects on many organisms and through food web interactions alter entire ecosystems. Because soil- and leaf litter- microarthropod presence is reliant on soil moisture and because entire ecosystems are dependent on their ability to make nutrients available, it is important to understand how these organisms may be affected by an increase in precipitation and how this change may impact the ecosystem. It has yet to be determined during what seasons we should expect this precipitation increase to take place so three treatment plots of control, increased winter water addition, and increased spring water addition were created in a Northern California Meadow. After treating the plots for six years soil cores were taken on May 20, 2006 and the microarthropods contained within these soil cores were extracted with Berlese funnels and sorted based on their morphospecies. To determine if water addition could alter microarthropod communities of the meadow environment this study measured microarthropod abundance, morphospecies richness, number of unique morphospecies, and morphospecies biodiversity as indicators in determining if any relationships were different among the three treatment types. This study found there to be no statistical differences among any of these indicators and concludes that precipitation at the increased rates we expect from global warming may have no affect on microarthropod communities.

Introduction

Climate Change As predicted by the United Kingdom's health informatics (U.K.H.I.) model, a doubling of carbon dioxide will cause the average global precipitation to increase by an expected 10% and, with enhanced greenhouse gases, precipitation in many locations is expected to increase by more than 50% (Hennessey et al. 1997). The high latitudes are expected to receive more wet days and middle latitudes are expected to receive fewer wet days. Additionally, middle and low latitudes are expected to receive more intense weather events (Hennessey et al. 1997). UKHI climate change models can adequately predict only global precipitation so the National Center for Atmospheric Research uses Community Climate Models for local scale predictions, however, the Community Models have been contested because claims have been made that the newer Mesoscale Models provide more precision (Dickinson et al. 1989). The Hadley Center for Climate Prediction and Research as well as the Canadian Centre for Climate Modeling and Analysis have both predicted a future increase in precipitation for California, but they differ in when they expect this extra precipitation to fall. The Hadley model predicts this extra precipitation to fall in the current rainy season while the Canadian model predicts it to extend into the current summer drought. Habitat responses to this change could prove crucial to ecosystems (National Assessment Synthesis Team 2000).

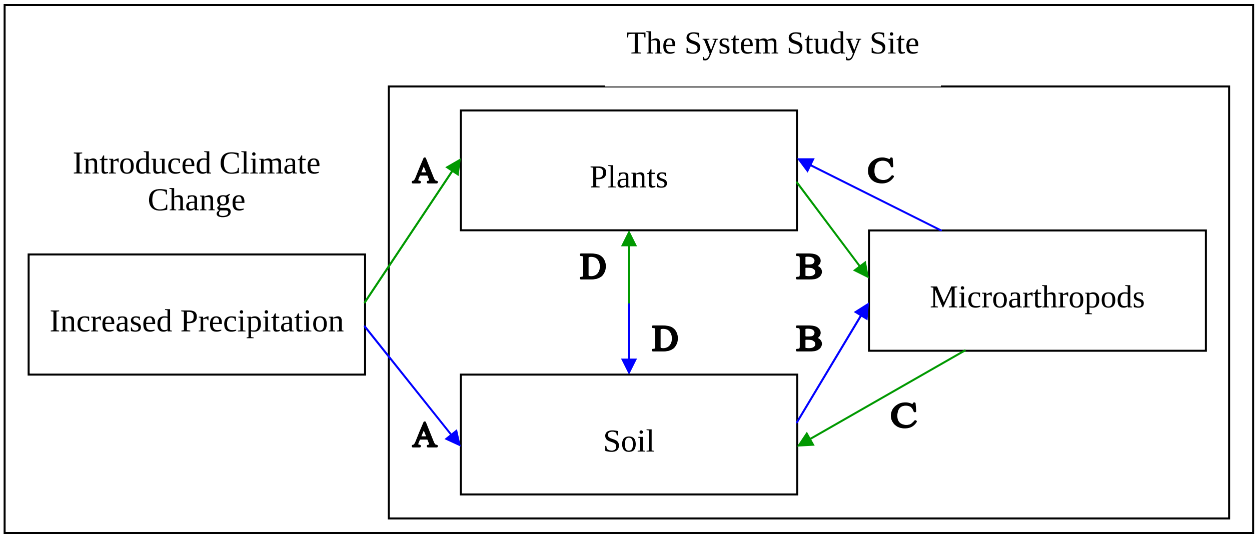

Figure 1: In the diagram above the system contains the more crucial elements that impact the immediate environment of microarthropods in this experiment. The green arrows show the pathway of influence that increased precipitation has on microarthropods through plant life and the blue arrows show the pathway of influence that increased precipitation has on microarthropods through soil. At step D the pathways intersect and become

cyclical within the system.

Study Site The Heath and Marjorie Angelo Coast Range Reserve was established as a University of California Natural Reserve in 1994 and is solely administered by the University of California, Berkeley's office of the Natural Reserve System (Herring 2006). The reserve is located in Mendocino County, California. It contains 1,642 hectares of land and diverse habitats (Herring 2006). It includes elevation from 378 to 1,290 meters and is thirteen miles east of the Pacific Ocean. It is also east of Elkhorn Ridge, which prevents it from receiving any maritime fog (Herring 2006). From 1961 to 1990 the central coast of Mendocino County's maximum daily temperatures ranged from 14°C between December and January and 19°C between July and September. The rainfall for this area is greater than 2,000 millimeters per year (Eisen et al. 2003). The Elder Creek watershed, which contains the reserve, covers 16.8 kilometers and runs into Eel Creek, which is free from dams and logging (Herring 2006).

The Heath and Marjorie Angelo Coast Range Reserve (A.C.R.R.) has a Mediterranean-type climate of warm, dry summers and cool, wet winters (Herring 2006). The A.C.R.R.'s soils consist of Franciscan Complex greywacke sandstones and mudstones as well as soils derived from the Josephine and Hugo series (Herring 2006). The A.C.R.R. contains nine meadows on upland river terraces, and chaparral at higher elevations. The reserve has many animal inhabitants and is home to a variety of families of arthropods (Herring 2006). It is used as a University of California, Berkeley Field Station to promote research and create teaching opportunities within a remnant natural area (Ford and Norris 1988).

Plants Although abiotic stress has larger effects on higher trophic levels, these higher trophic level effects can have influential impacts on lower trophic levels (Preisser and Strong 2004). Anthropogenic global change will result in altered climatic mean and variance. These conditions constrain plant communities, so they are also forecasted to shift (Tilman et al. 2001). It has already been determined that plant species diversity can influence the abundance and species richness of higher trophic level organisms (Salamon et al. 2004). Due to anthropogenic changes of our environment's limiting factors, plant diversity will be on a significant decline. This will result in many empty niches within the plant community, which will ultimately lead to plant domination by species which might be less successful competitors, but are more successful dispersers. This type of plant, which will competitively displace most plant species, is considered to be a weedier species (Tilman et al. 2001).

Soils Soils play an important role in an ecosystem as most organisms (plants, animals, fungi, bacteria, and viruses) spend part or all of their lives as residents of the soil. Leaf fall and fine roots of plants, which reach into the ground in search of water and minerals, provide accessible organic compounds to soil microorganisms. Though plant life is the leading ecological force behind terrestrial soil ecosystems, soil organisms or soil fauna are critical in the development of these ecosystems (Fuhrmann et al. 2005). Soil fauna have influence on other organisms through both positive interactions (commensalisms, synergism, and mutualism) and negative interactions (predation, competition, and amensalism) within the food web. They also have influence on the soil through both direct (mineralizing nutrients, controlling microbial pathogens, and changing microbial community composition) and indirect (engineering habitats, changing primary production, and transporting microorganisms) interactions with the soil (Fuhrmann et al. 2005).

Microarthropods Though the comparative biomass of below ground soil fauna would suggest that its organisms' activities have less influence than above ground heterotrophic soil organisms, their soil food web ecological interactions with microbes give them great importance within soil ecology (Fuhrmann et al. 2005). Dead organic material would accumulate endlessly if it were not for the assistance of decomposers which transform complex organic material into inorganic forms and immobilize the nutrients for use by producers (Milcu et al. 2006). Within the soil these organisms are able to transfer nutrients and carbon to different trophic groups and allow for nutrients to be released through mineralization. For soil ecosystems, where the major nutrient inputs are from plant residues, mineralization becomes a crucial key to maintaining them. When the soil fauna mineralizes the bacterial biomass, the surface and soil plant litter is increased, resulting in an increase in production of plant biomass (Fuhrmann et al. 2005).

Microarthropods are generally found in the above ground plant litter and surface soils. Their populations range form forest populations of 10^6 per square meter soil to agricultural populations of 10^3 per square meter soil. Microarthropods are members of the mesofauna (0.1 to 2 millimeters) habitat and food resource (Fuhrmann et al. 2005). They are aerial organisms and fit within macrospores of less than 100 micrometers and they prefer moist inagrigated spaces within the soil (Fuhrmann et al. 2005). The variables that most influence their survival are temperature, soil water content, soil pH, total length of fungal hyphae in proximity, and the diversity of darkly-pigmented fungi in proximity (Kendrick and Klironomos 1995). The most abundantly found Microarthropods are collembola, also known as springtails, and mites (Fuhrmann et al. 2005).

Mites and Collembola Mites species predominately found in soil ecosystems are the oribatid, prostigmatid, and mesostigatid mites. The oribatid mites feed on fungi and decomposing plant detritus, the prostigmatid mites feed on fungus, but mostly small arthropods and nematodes, and the mesostigatid mites feed on small arthropods and nematodes (Fuhrmann et al. 2005).

Collembola are generally a width of 0.2 to 2 millimeters and a few millimeters in length. They are omnivorous and feed off of bacteria, fungi, nematodes, algae, decaying plant matter, and other collembola (Fuhrmann et al. 2005). Collembolan densities are higher in temperate grassland areas and higher abundance of grasses increases the density of collembolan species (Milcu et al. 2006). For temperate grasslands collembolan biomass is estimated to be 90 milligrams (Rusek 1998). A few collembolan species' survival and reproduction are increased by the presence of certain combinations of grass species, but these collembolan species densities are less pronounced when legumes are present. Overall collembolan grassland densities seem unaffected by plant species diversity and legume presence. It appears that collembolan functional groups do respond to plant community compositions differentially. The identity of a functional group, such as grasses and the identity of the plant species, plays a greater role in influencing the abundance of collembola than do plant species diversity (Milcu et al. 2006).

Related Research Collembola seem unresponsive to any alteration of the plant diversity other than the removal of all plants. Only the removal of all plants decreased the collembolan populations of a New Zealand perennial grassland ecosystem as collembola are highly unresponsive to plant variables. However, when all plant species are removed collembolan populations are drastically reduced (Wardle et al. 1999). Plant net primary productivity, plant biomass, and plant species composition all seem to have little significance on the diversity and abundance of these organisms. Other soil organisms do seem dependent on plant diversity and benefit from the removal of C_4 plant species. Soil organisms seem to be influenced by which plant species are lost from the ecosystem and on the specific traits of these species (Wardle et al. 1999).

Another experiment in Switzerland found no correlation between plant species richness and number of plant functional groups on collembolan diversity, but did find the presence of collembolan species increased the amount of legumes and grass (Salamon 2004). Though the relation between the numbers of plant functional groups present and collembolan diversity and densities is insignificant, this relation was still stronger than that of the relation between collembolan diversity and densities and the plant species richness. It could be that the relation between numbers of plant functional groups and collembolan diversity and density has a stronger relation because there is increased fine root biomass in treatments that have increased numbers of plant functional groups (Salamon 2004).

Arthropod populations have also been shown to be significantly altered by water treatments. In prairie grasses the addition of nutrient rich water increases both diversity and biomass of arthropod communities, but decreases the diversity and increases the biomass of the prairie's primary producers. However, the addition of water alone on prairie grasses increases the diversity and biomass of both arthropods and primary producers (Kirchner 1977). This study was only conducted over a period of three years so it is possible that the nutrient rich water had a stronger immediate effect on the primary producers, but that the addition of water without nutrients would have eventually impacted the primary producers in the same way. If an increase in temperature and in precipitation both are capable of increasing abundance or biomass of microarthropods then combined together they could have highly detrimental impacts on the communities which rely upon them and influence the entire food web.

Climatic change has already begun to affect these microarthropod populations and differences can already be seen within Antarctica where at higher temperatures microarthropod abundance has increased drastically while diversity has remained nearly the same (Kennedy, 1994). Also, before 1977 the alpine ecosystem of the Tatra National Park did not contain collembola, but it now serves as a host to both lowland and mountain forest collembola species. Additionally, since the last continental glaciation collembolan populations are desisting in central Boehemia (Rusek 1998).

Larger Implications Food web experimentation in relation to microarthropods is beneficial to understanding ecosystems and could possibly reveal influential patterns that can be applied beyond the scope of this particular research project. Complicated combinations of food web interactions can be seen in studies on as few as four species. Recently, researchers have come to realize the importance of indirect interactions of a food web in addition to the direct interactions. A food web is generally a complicated structure because densities are not only determined by predator-prey interactions and direct or indirect defense interactions, but also by other various direct or indirect interactions. These other interactions can be due to resource competition, intraguild predation, apparent competition, and various other forms (Janssen et al. 1998). Vital ecological importance of a food web structure is defined as the stability or persistence of a natural community and can be determined by the link between species and the trophic scaffolding (Paine 1980).

Research has not begun to address the possible impacts this precipitation change could have on the sustainability of microarthropods. A disruption of an organism's food web could have a lasting and potentially devastating impact on its ability to survive as well as those organisms dependent on it. It is difficult to account for the multitude of consequences that could arise from this increase in precipitation and experimentation is the only way to know what the most likely outcome will be.

The purpose of this research is to examine how surface soil- and leaf litter- community microarthropods will adjusted to an increase in precipitation at an A.C.R.R. meadow. The A.C.R.R. is host to many research projects including Kenwyn Blakeslee Suttle's dissertation research titled the Consequences of Changing Rainfall Patterns for a Northern California Grassland Community (K. B. Suttle personal communication). Suttle has collected enough information to properly analyze the entire above ground food web interactions of his research site, but studies of the soil fauna community were missing. This research project will be conducted at Suttle's research site and it will finally put the last piece of this food web structure together by examining how the surface soil- and leaf litter- community of all microarthropods have adjusted to an increase in precipitation.

Even at the limited interactions of microarthropods inhabiting a small grassland on the A.C.R.R., much can be learned because one will be able to view its far reaching influences. In addition, it is a step towards discovering preemptively how increased rain fall will influence a population of organisms, instead of the commonly retroactive actions of environmentalism. This knowledge gained could help establish preventative measures to protect the diversity and sustainability of our habitats before it is too late and potentially devastating consequences become lethal to even humans.

Hypothesis This study will determine how an expected increase in precipitation, due to anthropogenic global warming, will affect a microarthropod community of a Northern California grassland. The hypothesis is that there will be significant differences among the establishment of microarthropods between the control plots and the water altered plots because the water altered plots will have greater abundance of microarthropods, but less morphospecies richness, number of unique morphospecies, and morphospecies biodiversity.

Methods

Treatments The research site is located in the South Meadow of the reserve at 39° 43’ 45” North and 123° 38’ 40” West. As an overview of the meadow, the fauna consists predominately of Mediterranean annual grasses of *Aira caryophyllea*, *Bromus diandrus*, *Bromus hordeaceus*, *Bromus tectorum*, and *Cynosurus echinatus*, the dominate herbivore is the *Melanoplus devastator* grasshopper, and the dominate predators are the wolf, crab, and lynx spiders (K. B. Suttle personal communication).

K. Suttle designed the experiment to test the effects of increased rainfall on this meadow community and has been running the experiment for nearly six years. Within this meadow he constructed eighteen 70 square meter experimental plots with a distance of 6 meters between plots. Within the meadow, but outside of the specific study site, growing in clusters, there are three types of native bunchgrass species. These species of *Danthonia californica*, *Elymus elymoides*, and *Elymus glaucus* were introduced into every plot evenly by means of seed addition and transplantation within the meadow (K. B. Suttle, personal communication).

These eighteen circular plots were, through a randomized block design, sorted into three differing types of water treatment so that each water treatment would have 6 replicates (K. B. Suttle, personal communication). The average precipitation received in this meadow is approximately 216 centimeters per year (P. Steel, unpublished data). The water treatments include control plots in which no additional water is added, winter addition plots in which 406 additional millimeters of water is added from January 4 to April 3, and spring addition plots in which 406 additional millimeters of water is added from April 3 to June 30. The water added to the selected plots comes from a seasonal mountain spring located above the meadow. This water has been tested and found to have nitrogen enrichment similar to that of the natural rainfall in the area and is diverted to a 4,500 liter irrigation tank, which is located 35 vertical meters above the meadow (K. B. Suttle, personal communication).

Both the winter addition and spring addition plots have sprinkler systems set up within each plot to distribute the additional water in a form similar to precipitation, by falling evenly over the entire plot area. The plots for both winter addition and spring addition have identical frequency, amount, and duration of water addition. For 87 days the sprinklers are set to add, after every third dawn, 14 to 16 millimeters of water over a two hour period and this water application patterns persist unaltered by natural occurrences even during the November and April months when the meadow receives its most intense rains. (K. B. Suttle, personal communication).

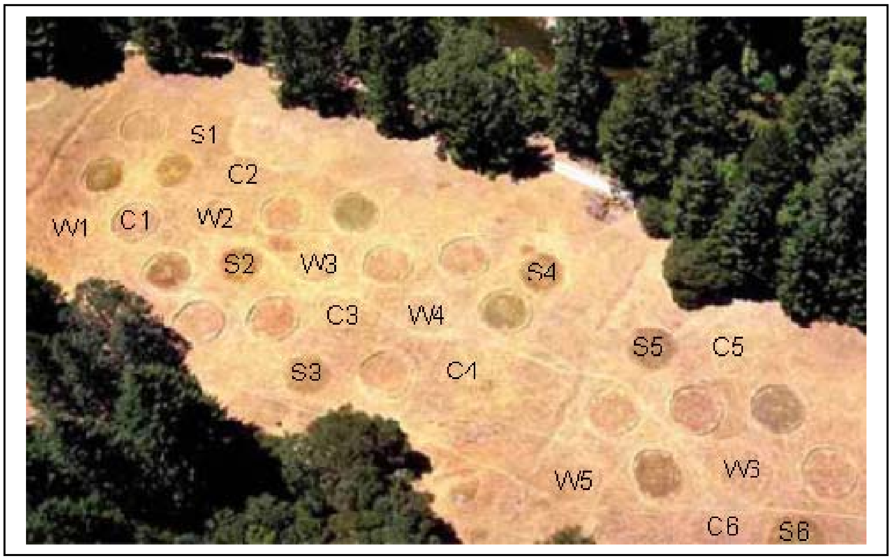

Figure 2: A July 2002 bird's eye view of the study site. "C" designates the 6 ambient control plots, "W" designates the 6 treatments with a winter addition of water, and "S" designates the 6 treatment with a spring addition of water.

Microarthropod Collection The presence of a microarthropod community was sampled by taking 36 soil cores, two cores per plot, from each of the 18 plots. I took the cores from two opposite ends of the plot and at the same location in each plot. The cores were cylindrical with a diameter of 3.81 centimeters and a depth of 6 centimeters. Each plot's two soil cores were immediately placed in one of 18 polyvinyl chloride (PVC) containers, which I made by rubber band securing polyvinylidene chloride film (saran wrap) around one end of the container. The open end was covered by rubber band securing 1 millimeter mesh (window screen) around the container. This was to prevent the entrance or exit of larger organisms. These soil samples were transported to an offsite research facilitation site located in Pomona, California, approximately 12 hours from the A.C.R.R. Due to this long transit period the samples were randomly placed within a 36 slot cardboard box entirely shaded with a white cloth. After every 4 hours of transit time I misted the samples with Evian water to prevent soil dehydration and randomly rearranged them in order to try and evenly distribute the travel period's possible affects on the soil samples.

At the research facilitation site I extracted the microarthropods from the soil sample by using Berlese funnels. Berlese funnels use environmental stimulants to take advantage of the avoidance behavior of microarthropods (Fuhrmann 2005). The research facilitation site had 18 Berlese funnels, of Sandra M. Clinton's, Gina Benigno's, and my design, set up with heat as the environmental stimulant on the microarthropods. Because heat was the environmental stimulant of choice the experimentation took place within a cold room which I kept at 21º Celsius in order to have a preferable air gradient for the soil and leaf litter samples to dry out at a steady and even pace (S. M. Clinton, personal communication).

A board on stilts had circular holes evenly spaced to hold 18 plastic funnels with a top diameter of 7.62 centimeters and a bottom diameter of 1.5 centimeters. Suspended 15.875 centimeters above each funnel was a 40 watt powered light bulb. On the counter surface directly below each funnel bottom was a cylindrical glass vial, 6.35 centimeters in diameter and 20.32 centimeters in height, filled one third with 95% ethanol.

Once the research facilitation site had been reached I removed the 1 millimeter mesh from the top of each container and I combined each pair of soil cores and placed them in a new container. This new container was covered at one end by rubber band securing 1 millimeter mesh around the container and was made of black polyvinyl chloride tubing 7.62 centimeters in diameter and 10.16 centimeters in height. Black polyvinyl chloride tubing was selected as the material for the containers in order to increase the heat absorption of the Berlese funnel set. After I placed the pair of soil samples in their new container, I placed the container on top of the funnel and bound them together with duct tape. The containers were randomly assigned to their collection location as to omit as many biases as possible. I rechecked the ethanol every day to refill it back to the one third marking on the vial and I let the experiment run for three days, allowing most of the microarthropods to be extracted from the soil sample. After the three days I caped the vials with plastic lids and stored them safely.

This soil coring and Berlese funnel microarthropod extraction method took place on May 20, 2006. This was in order to remain as consistent as possible with the time frame K. Suttle has been collecting the first of his annual arthropod samples which he first collects on May 15. It may seem advantageous to have collected a third sample around July 20, 2006, when K. Suttle was collecting his third and last sample of the year, but by this time the earth had turned too hard to collect an adequate soil core (K. B. Suttle, personal communication).

Statistical Analysis I took the vials of microarthropods to the Vincent Resh Laboratory at the University of California, Berkeley where I viewed them through a microscope, counted, and identified them to morphospecies, which is based on their morphology, so that each plot's microarthropod abundance, morphospecies richness, number of unique morphospecies, and morphospecies biodiversity could be determined. In order to determine these, each plot's microarthropod collection was separated into different vials based on their morphology. This was done by placing the contents of each plots' Berlese funnel collection vial into a Petri dish and removing the microarthropods with a calibrated pipet into separate smaller vials based on their distinct morphospecies.

There are 3 treatments with 6 replicates each that will need to be compared for statistical significance of their microarthropod abundance, morphospecies richness, number of unique morphospecies, and morphospecies biodiversity. The null hypotheses being made is that there is no statistical difference in microarthropod abundance, morphospecies richness, number of unique morphospecies, and morphospecies biodiversity among the different plot types. For this null hypothesis it is necessary to use a calculation that can measure the differences between the means of more than two groups with only one independent variable (the water addition) so a one-way ANOVA (analysis of variance) will be used in order to determine if there is a statistical difference among the plot types as well as reduce the probability of a type I error. Additionally, if there is found to be a statistical difference it will be necessary to determine which plot types are statistically different from each other. This can be achieved through using Scheffe's post-hoc comparison test to discover where the differences are specifically located among the separate plot types.

Results

The six replicates for each treatment type (ambient control, winter addition of water, and spring addition of water) were combined to reveal the results represented in the figures below.

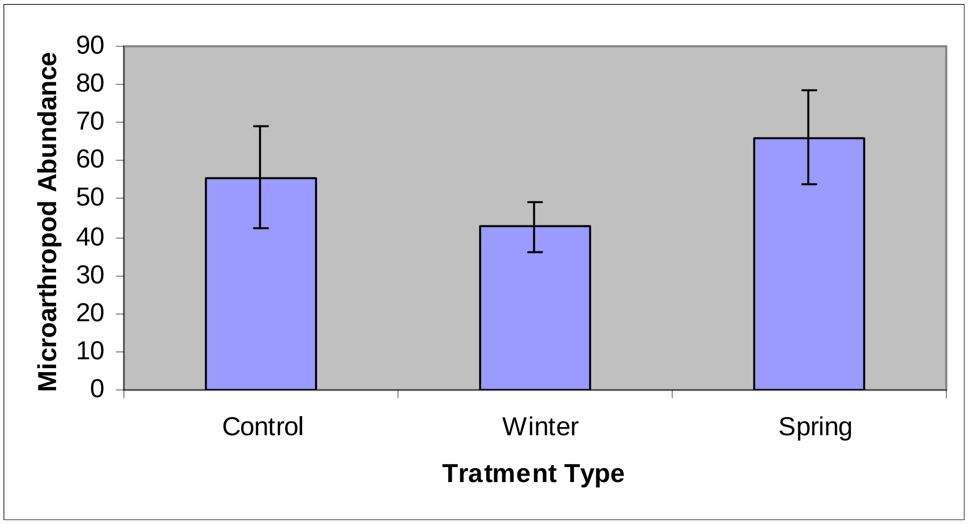

Figure 3: Includes 6 replicates per treatment to show the mean microarthropod abundance with standard error for the three treatment types. Microarthropod abundance is the number of microarthropods collected.

The abundance of microarthropods is measured by counting the number of microarthropods collected in each plot. Microarthropod abundance is not significantly different among the different treatment types (F=1.12, p=0.35) and there is no trend suggested.

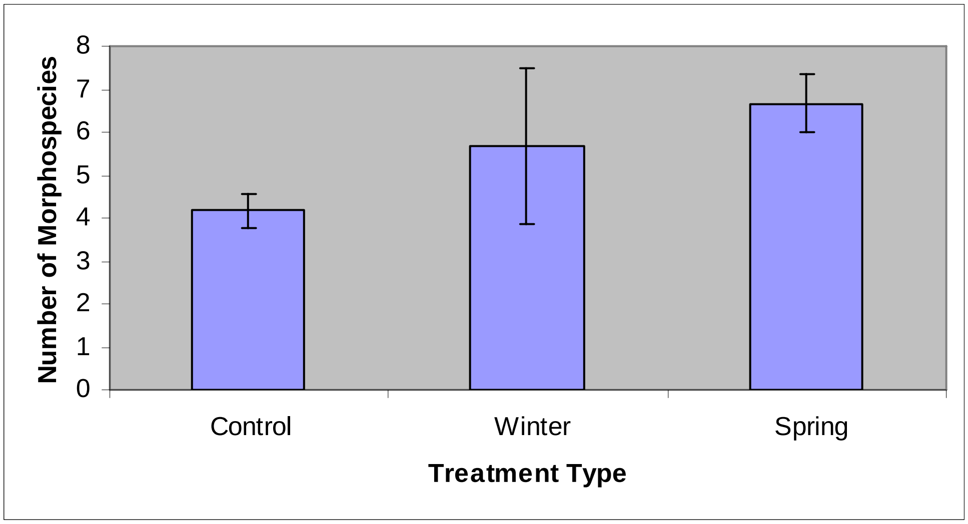

Figure 4: Includes 6 replicates per treatment to show the mean morphospecies richness with standard error for the three treatment types. Morphospecies richness is the number of morphospecies the microarthropods were separated into.

The morphospecies richness is measured by counting the number of different morphospecies for each plot. Morphospecies richness is not significantly different among different treatment types (F=1.21, p=0.32), but the trend suggests that the number of morphospecies increases with an increase in precipitation and duration in which the precipitation is added. One outlier was present in the winter treatment that was twice as high as any other within the treatment. When that outlier is lowered to half its original value the altered morphospecies rich
ness is obtained.

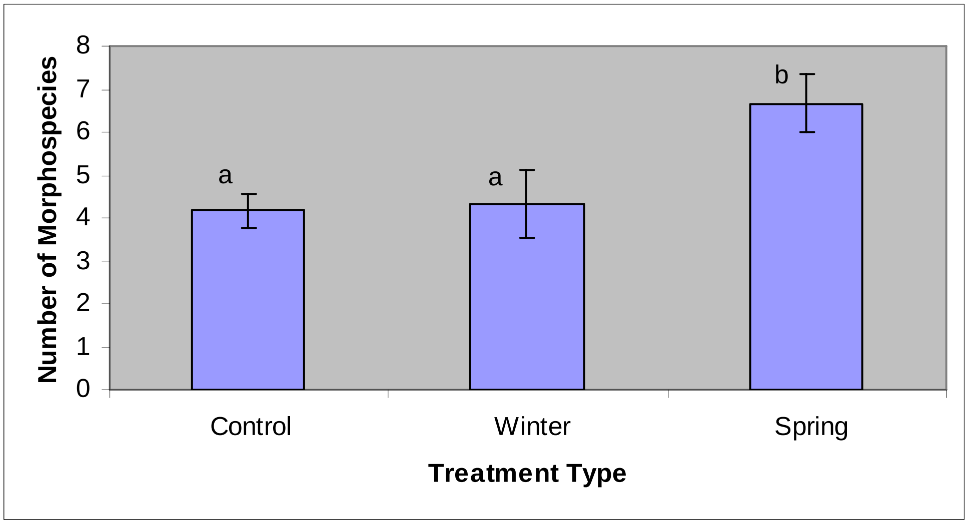

Figure 5: Includes 6 replicates per treatment to show the mean altered morphospecies richness with standard error for the three treatment types. Altered morphospecies richness is the number of morphospecies the microarthropods were separated into with an outlier in the winter treatment made uniform.

Altered morphospecies richness is significantly different among the spring treatment type (F=4.69, p=0.03) and shows that the number of morphospecies increases with an increase in precipitation and duration in which the precipitation is added, but not an increase in precipitation alone.

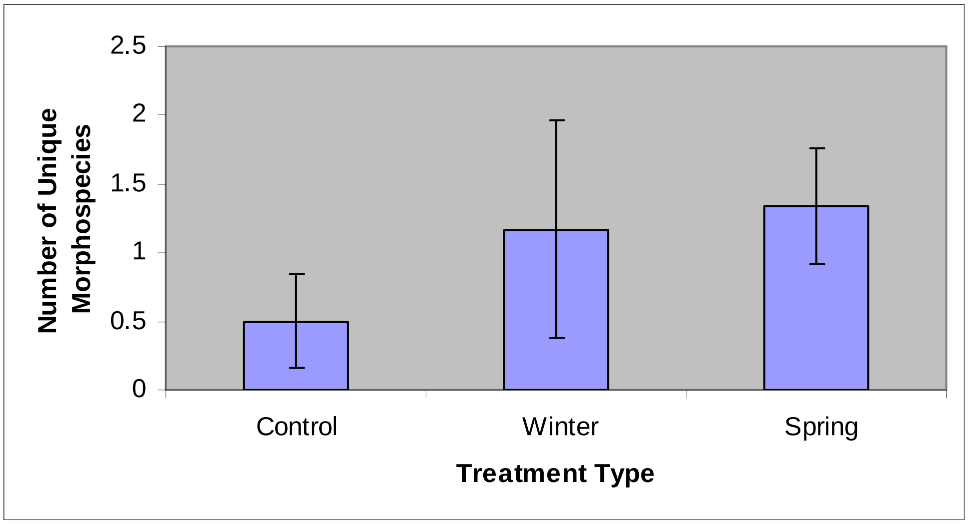

Figure 6: Includes 6 replicates per treatment to show the mean unique morphospecies biodiversity with standard error for the three treatment types. Unique morphospecies is the number of times a morphospecies only appeared once in the entire microarthropod collection.

The number of unique morphospecies is measured by counting the number of morphospecies that only occur once in the entire collection for each plot. Number of unique morphospecies is not significantly different among different treatment types (F=0.63, p=0.54), but the trend suggests that the number of unique morphospecies increases with an increase in precipitation and duration in which the precipitation is added.

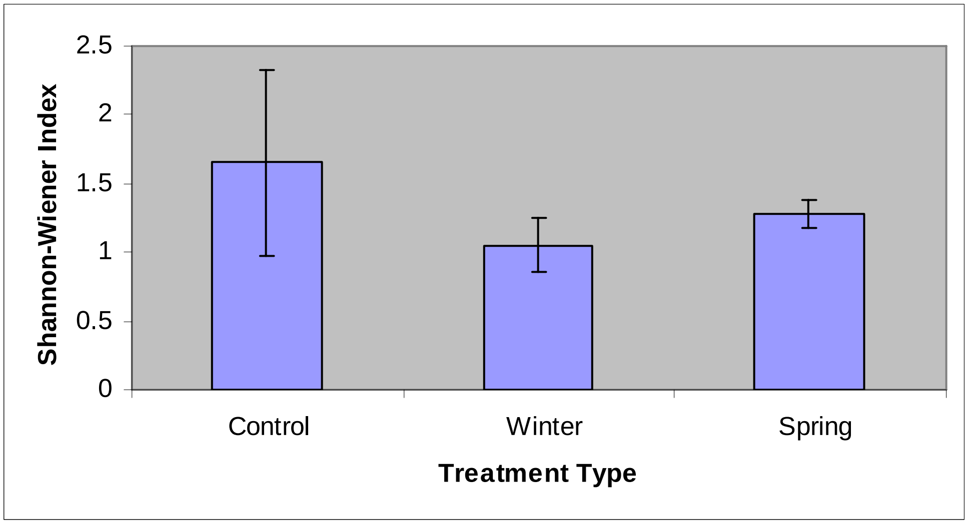

Figure 7: Includes 6 replicates per treatment to show the mean morphospecies biodiversity with standard error for the three treatment types. Morphospecies biodiversity is the calculated Shannon-Wiener index.

The morphospecies biodiversity is measured by calculating the Shannon-Wiener index for each plot. Morphospecies biodiversity is not significantly different among different treatment types (F=0.56, p=0.58), but suggests that morphospecies biodiversity is greater without an increase in precipitation.

Discussion

Microarthropod survival was not influenced by the addition of precipitation to the plots or by the duration in which this precipitation was added. However, there were trends suggested. Microarthropod abundance (Figure 3) shows no suggested trend and this could be because the biomass decaying has remained unaltered by the addition of water, because organic matter decaying has decreased while more microarthropods are suffering from desiccation, or because organic matter decaying has increased while less microarthropods are suffering from desiccation. The morphospecies richness (Figure 4), the altered morphospecies richness (Figure 5) and the number of unique morphospecies (Figure 6) show a trend suggesting that they both increase as precipitation increases. This could be because either less are suffering from desiccation, the increased water content in the soil is preferred, or because there is more decaying plant biomass in those plots. The altered morphospecies richness (Figure 5) shows that data can be easily thrown off by something as simple as a deer recently defecating in the location the sample is taken from and that even a single outlier can make a difference in the significance of the results. The morphospecies biodiversity (Figure 7) shows a trend suggesting that it decreases with the addition of water. This could be because the additional water is drowning some microarthropods or is detrimental to their survival, or that what those microarthropods feed on is not able to thrive in soils with increased moisture.

One reason there may not have been a statistical difference among treatments was because the samples could have been taken too early in the summer and had they been collected later in the summer greater differences would have presented themselves. Even though this experiment did not show a significant trend, the addition of water may still be influencing the plots and for this reason it would be beneficial to conduct research later in the summer. If the samples are taken later in the summer microarthropod abundance or diversity may decrease in the control and maybe even the winter water addition plots due to microarthropod desiccation. Also, the spring addition treatments of water could be allowing the microarthropods to remain moist over the dry summer and result in an increase of microarthropod abundance and diversity during this period.

It may be that there was no statistical significance in microarthropod abundance because microarthropods have been stunted by the overabundance of decaying biomass or because most of the biomass has not begun to decay yet. If the former is true then this provides another reason why it may be beneficial to conduct research later in the summer as during this time more of the plant biomass may be decaying and readily available for the organisms to process. If there is significant difference in the amount of biomass available to the microarthropods then there may also be a significant difference in the three treatments' microarthropod abundance.

Having the organisms identified to species would have provided a more accurate account of what the plots contained and this would have been valuable to the experiment. Some morphospecies may be inaccurately classified and perhaps if these were changed there would be a statistical difference among the plots. Classifying to species, or even to order, would have also been beneficial because then I could detect if there were changes in the amount of a certain functional group and from that gather what types of food were available for them to feed on.

Soil systems can often, through indirect effects, have great influence on above-ground factors. In an experiment at the Ecotron Controlled Environment Facility a simple model of grassland was created and its soil interactions were observed in relation to plant species richness (Hartley and Jones 2003). In conclusion they found that the performance of the dominant plant of the grassland community played a greater role in relation to the soil community than did the plant species richness of the grassland community. These dominant species drive the system so that plant species richness ultimately has little effect on collembola (Hartley and Jones 2003). The number of species present in a grassland community is insignificant in relation to which species are present and how they are able to function with the collembola present in the ecosystem. Function turns out to be much more crucial to the determination of collembolan populations than diversity does. In addition, the allocation of carbon within the soil community also seemed to have a potentially major role in the relation and allowed the soil biota to have effects beyond the soil. The experiment determined that collembola are highly species and site specific creatures (Hartley and Jones 2003). Collembola are subject to both direct and indirect interactions and being able to detect this change in my experiment could reveal some new and perhaps valuable results understanding this in relation to the global environment.

It is known that a change in diversity of one organism may alter the species diversity of the next trophic level (Hartley and Jones 2003). However, it has come to our attention that some species are functionally redundant and this is how they can remain unaltered by disturbances. This theory is called the "insurance hypothesis". Collembola could be functionally redundant in relation to plant community growth and this could be why they are resistant to the disturbance in plant species diversity (Liiri et al. 2002) In addition, reducing the diversity of one trophic level does not necessarily correspond to a reduction in the diversity in other trophic levels as with collembolans who are more reliant on the characteristics and attributes of the plant species present (Wardle et al. 1999).

As this study suggests it could be that these species are functionally redundant. Functional redundancy would explain the fact that although both morphospecies richness (Figure 4) and the number of unique morphospecies (Figure 6) increased with an increase in percipitation and duration there was no such pattern in microarthropod abundance.

It would be interesting to see how these organisms may have changed since the plots were initially started, but there has been no data collected to analyze this. It would also be interesting to see how these organisms vary throughout a year and how they respond during the different water additions, but again data is not available for this and these are only ideas for future experimentation.

Acknowledgements

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