

**Long-Term Studies of Ground-Dwelling Arthropod
Biodiversity at Bandelier National Monument:
Relationships between arthropod community dynamics,
elevation, and precipitation in the Jemez Mountains:
Results from 1997 sample collections.**

**Contract OM
Order No. 82036-6-0105**

Prepared by

**David C. Lightfoot,
Richard A. Fagerlund
&
Sandra Brantley**

**Department of Biology
The University of New Mexico
Albuquerque, NM 87131**

Presented to

**Craig D. Allen
Ecologist
U.S. Geological Survey
Biological Resources Division
Jemez Mountains Field Station
Los Alamos, NM 87544**

September 29, 1998

Introduction

This annual report provides results of 1997 data as part of an on-going long-term monitoring study of ground-dwelling arthropods at Bandelier National Monument. A long-term study was begun at Bandelier National Monument in 1992 to monitor ground-dwelling arthropod communities in different environments across an elevation and temperature/moisture gradient to gain information on the effects of climate variation on arthropod communities in mountain environments in the Southwest. The purpose of this study was to examine the effects of annual variation in precipitation on ground-dwelling arthropod communities across an elevation gradient. In the semi-arid Southwest United States, annual precipitation is positively correlated with increasing elevation due to orographic precipitation. Mountains provide a gradient in local climatic conditions from dry, warm low elevation environments, to moist, cool high elevation environments. Such environmental gradients are reflected in plant formations, ranging from low-land deserts, to cool moist montane forests. Annual variation in regional precipitation from global climate patterns such as El Nino/La Nina events may have different effects on biotic communities at opposite ends of such elevation/moisture gradients.

This study was designed to determine patterns of ground-dwelling arthropod communities across an elevation gradient in the Jemez Mountains of New Mexico, and to determine how communities across the gradient respond to variation in regional climate resulting in abnormally wet years and dry years. The El Nino (wet)/La Nina (dry) cycles provide a regional pattern of above average annual precipitation and below average annual precipitation respectively, in the Southwest United States.

Methods

This research was conducted at Bandelier National Monument, in the Jemez Mountains of north-central New Mexico. A series of three study sites were established across an elevation gradient from approximately 1500 meters elevation at the base of the mountains, to approximately 3000 meters elevation near the summits of the mountains (Figure 1). Woodlands at the lower elevations were dominated by Colorado pinyon pine (*Pinus edulis*), and one-seed juniper (*Juniperus monosperma*). Mid elevation woodlands were dominated by ponderosa pine (*Pinus ponderosa*). Higher elevations were dominated by mixed-conifer forests, composed largely of Douglas-fir (*Pseudotsuga menziesii*), Engelmann spruce (*Picea engelmannii*), White fir (*Abies concolor*), ponderosa pine, and quaking aspen (*Populus tremuloides*).

We installed permanent pitfall traps to capture ground-dwelling arthropods, and to monitor the species composition and relative abundance's of arthropods at a site at each of the three elevation zones. Five replicate sets of traps were located at each of the three sites. Each of the five sets of traps consisted of six individual replicate traps positioned a line, approximately 5 m apart. Each trap consisted of a steel can 8 cm in diameter buried in the ground with to top open. A plastic cup was placed in each can, and the cup was filled half full with propylene glycol. A small wooden cover was positioned about 5 cm above each trap to protect the trap from sunlight and precipitation. All traps were left open continuously year-round. Arthropods were collected from all of the traps once every two months. Trap samples were sorted and tabulated to the species

level. All data were pooled for a given year.

Only arthropod taxa that are known to be ground surface active, and appropriately sampled by pitfall traps were tabulated. We call these "target" taxa. Other taxa that are not appropriately sampled by pitfall traps, or "non-target" taxa, were not tabulated. Of the target taxa, only those groups that were represented by large numbers of individuals were used for analysis in this particular study. Those taxonomic groups included the following: 1) spiders (Aranea: predators), 2) bristletails (Thysanura: Microcoryphia; detritivores), 3) crickets (Orthoptera: Gryllidae, Gryllacrididae; omnivores), darkling beetles (Coleoptera: Tenebrionidae; detritivores), and ground beetles (Coleoptera: Carabidae; predators).

Ants (Hymenoptera: Formicidae; omnivores) were additionally tabulated from traps located at all high elevation mixed-conifer sites. An additional mixed-conifer site (Site F) was established in 1993 to be used for an experimental prescribed burn to examine the effects of fire on the Jemez Mountain salamander. Data on ant numbers will be used to provide information on the effects of the planned prescribed fire on ants, which are an important food resource for the Jemez Mountain salamander. The prescribed fire has not yet been implemented, so this data will provide useful background information on annual variation in ant numbers across the mixed-conifer sites without fire.

Precipitation data were obtained from one weather station located at each of the elevation zones near each of the arthropod trapping sites. Those weather stations were the Fire Tower in the pinyon/juniper zone, the "S" Site in the ponderosa pine zone, and the Quemazon Snotel in the mixed conifer zone.

SAS (Statistical Analysis Systems) software was used to analyze the arthropod data. Repeated measures analysis of variance was performed on the log-transformed (to achieve normality of the data) count data to test for differences in arthropod abundance's among the sites and over a five year period. Univariate analysis of variance was performed on data by year, to test for differences among sites across the gradient.

Results

Accomplishments for 1997-1998

All arthropod pitfall trap samples collected during 1997 were sorted, all taxa identified, and count data for each taxa/pitfall trap were recorded in data books. The data were entered into a computer database as the file name BNDBUG97. That data is provided as both an ASCII format (BNDBUG97.DAT) file and as a Microsoft Excel format (BNDBUG97.XLS) file on a floppy disk included with this report. A hard-copy output of the data file BNDBUG97 is also provided with this report as Appendix 1. The results of the 1997 data are presented in this report along with previous years data, 1992-1996, to provide six years of data to examine.

Precipitation

An El Nino event occurred during 1992-1993, resulting in average and above average precipitation at the pinyon/juniper and ponderosa pine sites, but below average precipitation at the mixed-conifer sites (Figure 2). A weak La Nina event occurred during 1994-1995, resulting in below average precipitation at the pinyon/juniper sites, but rainfall at the ponderosa pine sites remained above average, while rainfall at the mixed conifer sites remained below average. In summary, the low elevation pinyon/juniper zone experienced especially high rainfall during the El Nino event, and especially low rainfall during the La Nina event. The mid-elevation ponderosa pine and the high elevation mixed-conifer zones experienced slightly below average rainfall during the El Nino event, and above average rainfall during the La Nina event (especially 1995). Rainfall in 1996 was near average at the pinyon/juniper sites, and below average at the mixed-conifer and ponderosa pine sites. 1997 precipitation increased at the mixed-conifer and ponderosa pine zones, but remained low in the pinyon/juniper zone. Overall, annual precipitation at the low elevation pinyon/juniper zone was greatly influenced by the El Nino/La Nina events, but the higher elevation mixed-conifer and ponderosa pine zones appear to have been relatively little affected.

Ground-dwelling Arthropods

Overall repeated measures analysis of variance revealed significant differences among total numbers of individual arthropods (Figure 3), and species richness (Figure 4) over the six year period. Numbers of arthropods and arthropod species richness were significantly higher at all sites during the El Nino event, and significantly lower at all sites during the La Nina event. Differences in numbers of arthropods and species richness were relatively more pronounced from sites in the pinyon/juniper vegetation zone at the lower elevations. In 1997, numbers of arthropods remained constant in the ponderosa zone, increased significantly in the pinyon/juniper zone, and declined significantly in the mixed conifer zone (Figure 3). Species richness stayed the same in the ponderosa zone, but increased in the pinyon/juniper and mixed conifer zones (Figure 4).

Examination of different taxonomic/trophic groups of arthropods revealed that different groups dominated at different ends of the gradient, and exhibited different responses to variation in precipitation. Spiders were most abundant at low elevations during the El Nino, highest at high elevations at the end of the El Nino, and relatively equally, but significantly abundant across all elevations following the La Nina event (Figure 5). In 1997, spider numbers decrease significantly in the pinyon/juniper zone, but increase significantly in the ponderosa pine and mixed-conifer zones. Bristletails occurred primarily only at low elevations, and increased during the El Nino, but disappeared entirely during the La Nina (Figure 6). Bristletails appeared in traps from the ponderosa pine zone only during the El Nino event. Numbers of bristletails increase significantly in the pinyon/juniper zone from 1996, but were still substantially lower than during the 1993 El Nino event (Figure 11). Crickets increased significantly at high elevations during

the El Nino event, and declined during the La Nina, especially at low elevations (Figure 7). Cricket numbers did not change much at low elevation sites during the entire time period. In 1997, crickets increased significantly in the ponderosa zone, decreased significantly in the mixed conifer zone, and remained the same in the pinyon/juniper zone. Darkling beetles were most abundant at low elevations, and increased significantly at higher elevations during the La Nina event, while remaining relatively consistent at the low elevation sites (Figure 8). Darkling beetle numbers remained the same across all vegetation zones during 1997. Ground beetles were most abundant at high elevations sites, and increased at all elevations during the El Nino event, but declined at high elevations during the La Nina event (Figure 9). In 1997, ground beetle populations declined significantly in the pinyon/juniper zone, but remained the same in the ponderosa and mixed-conifer zones.

Ant numbers varied across the six mixed-conifer sites from 1993 to 1996 (Figure 10). Numbers of ants were significantly greater at sites B and D in 1993, and D in 1994, and A and B in 1995, A, B, and D in 1996, and no significant difference among sites in 1997. Overall, sites A, B, and D tend to have higher numbers of ants than the other sites. The planned burn site, Site F, tends to have average numbers of ants over time compared to the other five sites. Numbers of ants across all sites were lowest in 1995, following the La Nina event, rising again in 1996, but again declining in 1997.

Discussion and Conclusions

Overall, in 1997 precipitation increased in the higher elevation mixed-conifer and ponderosa pine zones compared to previous years, yet remained below the long-term average for the mixed-conifer zone, and above average for the ponderosa pine zone. Precipitation was relatively low in the pinyon/juniper zone, but close to the long-term average. Arthropod abundance's tended to increase at the low elevation pinyon/juniper sites, but declined in at the mixed-conifer sites, while remaining relatively constant at the ponderosa pine sites. 1998 was another El Nino year, so we expect to find a similar pattern to 1992/1993 when those precipitation and arthropod data are analyzed.

These results generally support the hypothesis that drier low elevation ground-dwelling arthropod communities are impacted relatively more by below average precipitation years, while higher elevation communities are relative less affected by dry years. In this study, the low elevation sites received above average rainfall during the El Nino events, and below average rainfall during the La Nina event, with a gradual increase back to near average amounts by 1997. In contrast the high elevation sites received below average rainfall during the entire time period, except at the end of the La Nina event. An investigation into the relationships between precipitation, elevation, and El Nino/La Nina cycles may determine if this pattern is typical or not in the Southwest United States.

Increased precipitation from El Nino events in the Southwest United States occurs mostly during the winter months from Pacific frontal systems that are steered farther south than usual by the jet stream. This type of precipitation occurs fairly evenly across a variety of landscapes, but generally greater amounts fall at higher elevations due to orographic precipitation. In contrast,

approximately half of the precipitation in the Southwest occurs during the summer as convectional storm cells. Convectional storm cells generally originate over mountains, and higher elevations of mountains receive more precipitation from these storms than surrounding lowlands. Perhaps during La Nina events, high elevation montane areas still receive typical summer rainfall, while low elevation areas receive lower than average winter and summer rainfall. An analysis of precipitation data from weather stations across elevation gradients in the region will be necessary to determine actual rainfall patterns relative to El Nino and La Nina events and to elevation.

These findings are important in that they provide us with a better understanding of how variation in annual precipitation can influence biotic communities across elevation gradients in semi-arid regions. In particular we found that low elevation zones are impacted more by precipitation patterns resulting from El Nino/La Nina events than higher elevations. Overall arthropod abundance and species richness at low elevations were also impacted more by El Nino/La Nina events than arthropod assemblages at higher elevations, yet different taxonomic groups of arthropod exhibit different response patterns. This information can have important resource management implications when considering the sensitivity and stability of species assemblages across such elevation/moisture gradients. We have also learned that individual species and taxonomic/trophic groups exhibit very different distribution patterns and response patterns to environmental variation, and we must be careful about generalizing such patterns.