

Long-Term Studies of Ground-Dwelling Arthropod
Biodiversity at Bandelier National Monument

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Introduction

This annual report summarizes recent results of an on-going long-term monitoring study of ground-dwelling arthropods at Bandelier National Monument that was initiated in 1992. Interannual variation in abundance is notoriously high in arthropod populations so that long-term monitoring is necessary to detect changes that may be due to climate or land use shifts. Studies of mountain ground-dwelling arthropods in the U.S. have been few, especially at the community level. The Bandelier study was designed to describe patterns of these communities across an elevation gradient and to associate those changes with large-scale weather patterns, such as El Niño Southern Oscillation (ENSO), which has a strong impact on the southwestern U.S. From long-term study we gain baseline data to compare with responses to abnormally dry (La Niña) or wet (El Niño) years and to detect possible time lags in responses.

In areas with high topographic variation, such as the southwestern U.S., mountains provide elevational gradients without change in latitude, so that elevation effect may be studied more clearly. The gradient extends from lower elevations, which are dry and warm, to high elevations, which are cooler and receive more precipitation. These abiotic differences produce obvious changes in plant species and cover. The ENSO cycle can be thought of as a natural "treatment" applied across the gradient.

If arthropods respond over a short period to ENSO events, we expect to see one of two likely patterns. The first is that lowland species would be less affected by drought conditions because they already live at the dry end of the gradient. Species at high elevations, which generally do not experience dry conditions, might be more strongly and negatively affected. The second is that lowland species may experience more negative conditions when their habitats become even drier, while montane species are more buffered against the severity of the drought. The purpose of our research project was to determine if data on a group of organisms living across such an elevation gradient supported one of the above predictions, or perhaps some other pattern.

Methods

This research was conducted at Bandelier National Monument, in the Jemez Mountains of north-central New Mexico. Three study sites were established across an elevation gradient from approximately 6000 ft elevation at the base of the mountains, to approximately 9500 ft elevation near the summits of the mountains. Piñon pine (*Pinus edulis*) and one-seed juniper (*Juniperus monosperma*) made up the dominant vegetation at the low-elevation site (PJ), ponderosa pine (*Pinus ponderosa*) was dominant at the mid-elevation site (PP) and several mixed conifer species, such as Douglas-fir (*Pseudotsuga menziesii*), Engelmann spruce (*Picea engelmannii*), white fir (*Abies concolor*), ponderosa pine and quaking aspen (*Populus tremuloides*), dominated at the high-elevation site (MC).

We installed permanent pitfall traps to capture ground-dwelling arthropods, to gather information on species composition and relative abundance at a site in 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 in a line, approximately 5 m apart, for a total of 30 traps at each site. (An additional mixed-conifer site, Site F, was established in 1993, in a prescribed burn area examining the effects of fire on the Jemez Mountain salamander.) The replicate lines were placed at least 200 m apart. Each trap consisted of a steel can 8 cm in diameter buried in the ground with the can opening even with the ground. A plastic cup half full of propylene glycol was placed in each can and a small wooden cover was positioned about 5 cm about each trap for protection from sunlight and precipitation. All traps were left open continuously year-round. Arthropods were collected from all of the traps in April, June, August and October. 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, appropriately sampled by pitfall traps, were tabulated. We call these "target" taxa. Other taxa that are not appropriately sampled by pitfall traps were not tabulated. Of the target taxa, only those groups that were represented by large numbers of individuals were used for analysis in this study. Those taxonomic groups included the following: spiders (Araneae; predators), bristletails (Microcoryphia; detritivores), crickets (Orthoptera: Gryllidae, Rhaphidophoridae, Stenopelmatidae; omnivores), darkling beetles (Coleoptera: Tenebrionidae; detritivores) and ground beetles (Coleoptera: Carabidae; predators).

Results

Accomplishments for 2003

All arthropod pitfall trap samples collected in 2003 were sorted, target taxa identified, and count data for each taxon/pitfall trap were recorded. The data were entered into a Microsoft Excel file (filename: bandarth2003) on a CD included with this report. Hard-copy output of the Excel data file is also provided with this report as Appendix 1. The results of the 2003 data are presented in this report along with selected data from 1992-2002 for comparison. Seasonal data were presented until the 2000 report, when the data set became too large, so that only annual data could be shown. Seasonal data are still available in the Excel files, however. The species list for all target taxa is included as Appendix 2 (filename: bandspp). Several taxonomic changes have occurred over the course of this study; current names are linked to old ones in the species list. The major sources we used for determining current taxonomic status included: 1) Ross Arnett, *American Insects*, 2) Entomological Information Service, *Nomina Insecta Nearctica*, 3) Norman I. Platnick, *Advances in Spider Taxonomy* and 4) original descriptive literature and correspondence with expert taxonomists.

Ground-dwelling Arthropods

The year 2003 was characterized by some relief from drought conditions, although New Mexico continues to be in drought status. Weather data for 1999-2001 were available

from the three elevations of interest: Firetower TA-16, representing pinyon-juniper at 6500 ft., Los Alamos TA-6 Tower, representing ponderosa pine at 7424 ft., and Cerro (or NADP), representing mixed-conifer at 9000 ft. (Fig. 1). Data for years before 1999 came from different locations and are contained in our earlier annual reports.

Arthropod numbers were high when this study began in 1992, an El Niño year (Fig. 2). Numbers declined at all sites in the drought of 1994-1995 and have stayed low through 2002. In 2003 numbers of dominant species increased to levels seen in 2000 (see table below). Some groups showed a decline beginning in 2001: *P. mackenziana*, *T. biceps*, and both *Ceuthophilus* species. The rest did not start declining until 2002: *O. medianus*, *T. marmoratus*, *M. aurantiacus*, and the 5 beetle species. This pattern suggests that no ground arthropod taxon remains unaffected by longer-term drought; although some groups manage a single dry year well. Arthropod species numbers have also declined since 1992-1993 (Fig. 3), were relatively steady through 2000, and then dropped again in 2001. Species numbers increased in 2003 to the levels of 2000. Not every species was collected every year, making long-term studies of particular importance in characterizing the biodiversity at the sites. While richness and abundance fluctuate seasonally and annually, the dominant species tend to remain dominant. Species are well known to respond independently to environmental factors, so that responses of one species are not necessarily indicative of the responses of others. The table below compares 2000-2003 for total numbers of arthropods collected and the numbers collected for the most abundant species.

Taxon	Relative Abundance 2000	Relative Abundance 2001	Relative Abundance 2002	Relative Abundance 2003
All species	7188	5862	1230	7308
<i>Oriulus medianus</i> (millipede)	185	111	19	93
<i>Pardosa mackenziana</i> (wolf spider)	253	87	22	81
<i>Togwoteus biceps</i> (harvestman)	202	83	0	139
<i>Trachyrhinus marmoratus</i> (harvestman)	369	429	22	99
<i>Machilinus aurantiacus</i> (bristletail)	94	767	2	1677
<i>Ceuthophilus pallidus</i> (camel cricket)	121	30	27	243
<i>Ceuthophilus utahensis</i> (camel cricket)	2324	825	171	1389
<i>Carabus taedatus</i> (ground beetle)	428	498	67	307

<i>Pterostichus adstrictus</i> (ground beetle)	458	459	36	197
Subfamily Aleocharinae (rove beetle)	896	314	36	318
<i>Eleodes extricatus</i> (darkling beetle)	269	316	54	324
<i>Eleodes obscurus</i> (darkling beetle)	117	297	54	199

Spiders were widely distributed throughout the sites (Fig. 4), with high numbers at the PJ site in 1992, although by summer 1993 through autumn 1994 more spiders were collected at the MC site. It is likely the drought in 1995 reduced numbers at all sites. Numbers have been increasing more rapidly at the MC site, are relatively steady at PP and most variable at the PJ site. In 2001 abundance at all sites was reduced to similar levels and in 2002 stayed low, even for mixed conifer species, which usually have the highest numbers. In 2003 the abundance of many taxa returned to levels similar to those of 2000 (see table below), but spider abundance has not changed much. In fact, spider abundance has remained rather low since the drought period around 1995. MC species showed a larger increase in 1997, 1999 and 2000 than PP or PJ, but this was reduced in the drought of 2001. Most of the abundance at MC comes from wolf spiders (Lycosidae), especially *Pardosa mackenziana*. Ground spiders (Gnaphosidae) appear to dominate the PP, while a different wolf spider, *Schizocosa mccooki*, dominates at PJ.

Bristletails were collected primarily at PJ, although in wetter years they turned up at PP as well. Their populations seem to alternate years for high and low numbers, except that drought apparently can reduce numbers greatly, to the point of local extinction in some years (Fig. 5). These small detritivores are an important food source for larger arthropod species.

Cricket abundance data (Fig. 6) included field crickets, camel crickets and Jerusalem crickets. The species are rather restricted by habitat: Jerusalem crickets (*Stenopelmatus fuscus*), field crickets (*Gryllus* sp.) and one camel cricket (*Ceuthophilus pallidus*) are found primarily at the PJ site; field crickets and the other camel cricket (*C. utahensis*) are found at the PP site; *C. utahensis* is found primarily at the MC site. Numbers in 2001 - 2002 were reduced at all sites approximately to 1995 levels. In 2003 numbers increased in PJ and MC, and declined slightly in PP. See table 1 above to compare *C. pallidus* and *C. utahensis*.

Ground beetles (Carabidae) are well known indicators of moisture conditions in a variety of habitats. The arid southwest has relatively few species (but this is still a large family) away from riparian or other moist habitats. At the Bandelier sites most individuals were found at the MC site (Fig. 7). Numbers declined in 1995 and 1998 at all sites. As shown with the crickets (Fig. 6), the carabids at MC recovered more quickly than at the other two sites. However, numbers were reduced again to 1995/1998 levels for 2002. Numbers were increasing slowly in 2003, although virtually no carabids were collected at PJ or PP.

At these two sites there has been a steady decline in numbers from the El Niño years of the early 1990s. It is important to note that the larval stages of these beetles are not well sampled by pitfall trapping (they live in the upper soil), so that we have no way to assess their changes in abundance and what effect those changes may have on adult population numbers.

The rove beetles (Staphylinidae) are a large family with broad feeding habits ranging from predation to detritivory to fungivory. Many are small in size and their identification below subfamily can be difficult, especially within the subfamily Aleocharinae. At Bandelier they are rarely collected from PJ (Fig. 8), where they may be limited by the lack of ground cover. The beetles are usually associated with grass or litter. There were virtually no staphylinids collected at PP or MC in 2002. Numbers continued to be low in 2003. Rove beetles are associated with moist soil conditions and in a pattern similar to that of the carabids (Fig. 7), abundance increased at MC rather than at the lower PP elevation.

Darkling beetles (Tenebrionidae) have been present in low but consistent numbers at PP and MC over the course of this study, even during drought years (Fig. 9). These beetles are dominants at PJ, while many of the other taxa we report on are more abundant at higher elevations. These beetles seem to be relatively unaffected by short-term environmental changes. For example, compare their numbers with those of crickets (Fig. 6) or spiders (Fig. 4). In 2002 overall numbers were reduced to 1997 levels. In 2003 abundance increased at PJ and PP, but not at MC. As noted above for the carabids, we do not have information on changes in abundance for the larval stages of tenebrionid beetles, which feed on living and dead plant matter in soils.

Ant abundance (Fig. 10) at MC showed that numbers were usually greatest on lines B and D, although number on all lines were down during the 1995 drought. Because of a miscommunication we do not have the ant data for 1998-1999, but the specimens have been retained, although they are pooled for the entire site. The very high number of ants collected on line D in 1994 was probably due to a colony entrance near the pitfall trap. Abundance data from this trapping method should be used cautiously because establishment or decline of colonies near traps can greatly affect pitfall captures. Pitfall traps are primarily used to capture solitary wandering arthropods. Lines E and F were similar for 1993-1995, even though line F was the site of a prescribed burn. However, since 1996 the data are less similar, perhaps showing something about the transient dynamics of ant populations at the burn site. In 2000-2001 abundance declined on all lines to 1995 levels or below, suggesting that these two drought years have had a "leveling" effect across the site. In 2002 the B, D and E lines increased slightly. In 2003 all lines except B showed increased ant abundance.

Ant species collected at MC during 2003 were:

Camponotus modoc Wheeler

Formica neoclara Emery

Formica podzolica Francoeur

Lasius neoniger Emery

Leptothorax muscorum Nylander
Monomorium cyaneum Wheeler
Pheidole senex Gregg

Fewer species were collected in 2003 (7) than in 2002 (12). Last year there were 3 new species (*Acanthomyops murphyi*, *Lasius crypticus* and *Pheidole senex*) recorded, but only 1 individual of each was collected. Of these only *P. senex* was collected (7 individuals) in 2003.

Twelve years of arthropod data from pitfall traps have revealed habitat preferences of species from the three vegetation zones and have shown that abundances vary greatly from one year to another. Species richness patterns show that a few species dominate a given vegetation zone and that there are many rare species. The PP and MC sites are more similar to each other than they are to the PJ site, which is also the site with the most variation in abundance. Separating the effects of precipitation from other sources of variation will be difficult even with a long-term dataset. Species respond individually to environmental changes. We have characterized the arthropods from each vegetation zone, documented rare species and uncovered a few undescribed species. It appears that both wet and dry years influence abundance, but dry years have the greater impact. The value of this data set is not only in the number of years covered, but in the number of species tracked, in documenting arthropods from forests of a semi-arid region, and in the inclusion of invertebrate data for conservation/management planning.