

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

Data for 2011

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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 by David Lightfoot and Craig Allen. 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).

Permanent pitfall traps capture ground-dwelling arthropods, gathering 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 above 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. 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), darkling beetles (Coleoptera: Tenebrionidae; detritivores), ground beetles (Coleoptera: Carabidae; predators), centipedes (Chilopoda; predators), and millipedes (Diplopoda; detritivores).

Results

The Las Conchas wildfire (June 26-August 3) was the worst on record for New Mexico (until the Whitewater Baldy fire in the Gila Wilderness in 2012), burning large portions of Bandelier National Monument and the Valles Caldera National Preserve. The fire damaged the ponderosa pine and mixed-conifer pitfall sites but not the piñon-juniper site. I sincerely thank Craig Allen for continuing the study to monitor arthropod recovery and Kay Beeley for collecting samples in July, September and October 2011; in many cases the plastic insert cups had melted, sealing the contents of the traps; and some of the nails supporting the trap lids were also bent from the heat.

The samples were sorted, and target taxa identified and counted for each trap. The data were entered into a Microsoft Excel file included with this report, along with selected data from 1992-2011 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. The species list for all target taxa is included as Appendix 1. Several taxonomic changes have occurred over the course of this study; current names are linked to old ones in the species list (Appendix 1). 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. I am also working to reconcile species names across the annual datasets. In some cases species names have changed, and in others we now have names where we formerly had only morphospecies numbers. This process will allow us to better compare richness patterns over the years.

Precipitation

Weather data for 1999-2011 were available from the three elevations of interest: Firetower TA-16, representing piñon-juniper at 6500 ft., Los Alamos TA-6 Tower, representing ponderosa pine at 7424 ft., and Cerro, representing mixed-conifer at 9160 ft. (Fig. 1). There was virtually no change in the amount of precipitation between 2007 and 2010 at piñon-juniper and ponderosa pine sites, and a 10 cm increase at the mixed conifer site, although arthropod abundance responded independently to these levels. In 2011, however, precipitation declined to levels at or close to the dry years of the early 2000's. The 2011 monthly totals for the Bandelier weather stations showed very little precipitation between January and June; rain from August to October accounted for 61% (PJ), 71% (PP) and 53% (MC) of the total for the year.

Weather data for the years before 1999 came from different locations and are contained in our earlier annual reports. I thank Kay Beeley for compiling the precipitation data and for coordinating the collection of the pitfall traps.

Ground-dwelling Arthropods

Arthropod abundances 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 stayed low through 2002. In 2003 numbers increased for most of the dominant species and declined again in 2004, and then rose sharply in 2005 (Table 1, Figs. 2, 4-10). In 2005 the PJ site received the most precipitation since this project began (Fig. 1). Arthropod numbers there were higher than in the other 2 sites during every collecting period; half of the relative abundance came from this site alone, suggesting that the PJ site is generally under marginal conditions and susceptible to drought, but that arthropods can respond quickly under periods of high precipitation. Abundance at all sites continued to be high from 2006-09, approaching that of the series of strong El Niño years of the early 1990's. In 2010 numbers started to decline at PJ and PP, but not at MC. In 2011 abundance declined at all sites: at PJ probably because of the drought, and at PP and MC because of the combined drought and fire. PP numbers dropped to levels similar to the dry years of the early 2000's. Richness fluctuates less than abundance from year to year but did increase during 2006-2007 and has since declined a little (Fig. 3). In 2011 richness declined, probably as a combination of drought and the fire. 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 (compare Figs. 4-10). It is also important to note that each El Niño / La Niña event is unique in its pattern across the state. For example, the El Niño of 1992-1994 influenced arthropod abundance (at least in part) to an extent that has not been seen again until 2005-09, including the 1997-1998 El Niño. Table 1 below compares 2005-2010 for total numbers of arthropods collected (relative abundance) and the numbers collected for the most abundant species.

Table 1. Comparison of relative abundance for selected species at the study sites.

Taxon	Relative Abund. 2006	Relative Abund. 2007	Relative Abund. 2008	Relative Abund. 2009	Relative Abund. 2010	Relative Abund. 2011
All species	12,640	20,603	19,124	21,040	19,906	9549
<i>Oriulus venustus</i> (millipede)	22	23	23	46	38	79
<i>Pardosa uncata</i> (wolf spider)	280	244	387	407	349	165
<i>Togwoteeus biceps</i> (harvestman)	1233	702	571	1285	1500	393
<i>Trachyrhinus marmoratus</i> (harvestman)	27	125	77	110	150	11
<i>Carabus taedatus</i> (ground beetle)	103	65	92	125	306	96
<i>Machilinus aurantiacus</i> (bristletail)	80	1014	1702	1735	1698	61
<i>Ceuthophilus pallidus</i> (camel cricket)	431	429	219	158	269	138
<i>Ceuthophilus utahensis</i> (camel cricket)	2759	2078	3015	5150	6953	3291

<i>Pterostichus adstrictus</i> (ground beetle)	230	8005	1054	220	321	52
<i>Eleodes extricatus</i> (darkling beetle)	503	621	746	500	545	410
<i>Eleodes obscurus</i> (darkling beetle)	106	367	436	1049	638	379

Table 2. Total numbers of target taxa collected by site and season for 2011*.

Collecting period	Piñon-juniper site	Ponderosa pine site	Mixed conifer site	Total
Oct10-Apr 11	366	240	842	1448
Apr 11-Jul 11	689	1250	2045	3984
Jul 11-Sep 11	558	500	1440	2498
Sep 11-Oct 11	241	566	812	1619
Total	1854	2556	5139	9549

*Because of the Las Conchas fire, the collecting periods are somewhat different than in years past.

Spiders were widely distributed throughout the sites (Fig. 4), with high abundance during the El Niño years of the early 1990's. Their numbers fell sharply during the drought of the mid-1990's and did not recover until 2005-2009 and started to decline in 2010. The El Niño of 1997-1998 was not a strong one for New Mexico and produced little effect on the spiders at the PJ and PP sites, but probably did influence the abundance seen at the MC site. Most of the abundance at MC comes from wolf spiders (Lycosidae), especially *Pardosa uncata* and *P. yavapa* and the small-bodied linyphiid sheet weavers. Ground spiders (Gnaphosidae) dominate at PP, while a different wolf spider, *Schizocosa mccooki*, dominates at PJ. The wolf spider *P. orophila* virtually disappeared from the PJ site during the mid-1990's through 2004, but has been collected again in low numbers from 2005-2010 (numbers fell from 30 in 2009 to 7 in 2010 to 4 in 2011 this time at PP). At the PP site, the vegetation overstory has increased in the last several years, especially in the RG part, until the Las Conchas fire burned the trees back again. Spiders are often active during the winter and in 2010 made up 53% of the arthropods collected in the April samples, and 33% of the April 2011 samples. This collection was made before the fire and shows the drop was probably due to lack of precipitation in late winter and spring.

Bristletails were collected almost exclusively at PJ. Their populations seem to alternate years for high and low numbers (their life cycles extend over 2-3 years),

except that drought apparently can reduce numbers greatly, almost to the point of local extinction in some years (Fig. 5). Bristletail numbers in 2005 reached their highest levels since 1994, declined again in 2006 and increased in 2007-10. These small detritivores are an important food source for larger arthropod species but are rarely counted in arthropod studies. Many species live in mesic habitats; our *Machilinus aurantiacus* lives in wetter microhabitats in the PJ. In 2011 numbers were essentially zero.

Cricket abundance data (Fig. 6) included field crickets, Jerusalem crickets and camel 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. *Ceuthophilus pallidus* numbers at the PJ site began to decline in 2006 and dropped sharply in 2009 (Table 1), with only 4 collected in the August sample. *Ceuthophilus utahensis* numbers showed the opposite pattern by greatly increasing from 2006-2009, especially at MC. Numbers for both species increased in 2010. In 2011 abundance fell by about half at all three sites. The field crickets and scaly bush crickets (*Cycloptilum comprehendens*) are collected mostly in June and October samples; camel crickets and Jerusalem crickets in June and August samples.

Ground beetles (Carabidae) are well known indicators of moisture conditions in a variety of habitats. The arid southwest has relatively few species of this large family away from riparian or other moist habitats, and as expected, most individuals were found at the MC site (Fig. 7). Numbers declined in 1995 and 1998 at all sites, and recovered more quickly at MC than at the other two sites. In the wet years 2005-2007 the carabids increased at PJ and MC, and in 2007 at PP we collected over 8,000 specimens of *Pterostichus adstrictus*. The species is common at the Monument, but we have not seen such high numbers of any carabid during the 19 years of this study. 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. It is also possible that the numbers of *P. adstrictus* in the traps negatively affected the abundance of other taxa in those traps. By 2009-2010 numbers fell to 2006-07 levels. There are about 2 dozen species of ground beetles that regularly occur at the sites. After the *Pterostichus* spp., the next most abundant species is *Carabus taedatus*, also at MC. In 2011 numbers fell by about two thirds (Table 1).

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. The beetles are usually associated with grass or litter and much

like the carabid beetles (Fig. 7) prefer mesic habitats. They are rarely collected from PJ (Fig. 8), where they may be limited by the lack of ground cover. Virtually no staphylinids were collected at PP or MC from 2002-04. From 2005-09 numbers have increased; with a jump in numbers at MC in 2008 and at PP in 2009. Numbers dropped sharply at PP and MC in 2010 and dropped to almost zero in 2011.

Darkling beetles (Tenebrionidae) are the dominant taxon at PJ (Fig. 9), followed by scaly bush crickets and camel crickets. These beetles seem to be relatively unaffected by short-term environmental changes. For example, compare their numbers with those of spiders (Fig. 4). However, they have apparently benefited from the wet winters between 2005 and 2009. Numbers fell in 2010 to levels comparable to 2008. *Eleodes obscurus* is the dominant species and very conspicuous because of its large size (~35mm). They are one of about 10 species found on the Monument. The other species are smaller, down to 5 mm. All are detritivores. The life span for *Eleodes* species can be 5 years or more. Numbers fell by half at PJ; at PP and MC there was no change, but numbers are always low at those sites.

An additional line of pitfall traps (Line F) was established at the MC site to monitor **ants** (as a food resource for salamanders) in an area that had burned in the La Mesa fire of 1977. Abundance data for ants from pitfall traps (which primarily target solitary wandering arthropods) should be used cautiously because establishment or decline of colonies near traps can greatly affect pitfall captures. The E line is the closest line and was most similar to the F line before the burn, and so was chosen for comparison to see if the F line ant community became similar to that of the E line. However, lines E and F have varied unpredictably in relation to each other over the course of this study (Fig. 10). The pitfall traps collect about 10 species, with formicines in the genera *Camponotus* and *Formica* making up the majority. In June 2010 trap E2 contained 194 *Formica laeviceps*, an unusual occurrence probably due to the trap being near a nest opening or a foraging route. A similar occurrence in 2011 of 335 *F. laeviceps* also from trap E2 skewed the data from the generally low numbers of individuals.

Summary

Twenty 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 (Table 1). Species richness patterns show that a few species dominate a given vegetation zone and that there are many rare species, resulting in a species list with several hundred taxa (Appendix 1). In species richness the PP and MC sites are more similar to each other than they are to the PJ site. The mean number of species in a trap was 18 at PJ, 18 at PP and 17 at MC in 2010 and dropped to 14.9, 12, and 14.5 respectively, for 2011 (Fig. 3). Species show rather high site fidelity and even when a species occurs at two sites, the abundance is almost always much higher

at one. It appears that a single wet or dry year has little impact on these mostly generalist species, but a series of wet or dry years can strongly influence abundance (and richness at PJ).

The PJ site shows the most variation in abundance and changes in richness. In the last several reports new records for species tended to come from this site, but not every species is caught every year. PJ also seems to be hit hardest by droughts that occur over several years (Fig. 2). By comparison the MC site is more stable, and the PP site is increasing in abundance as overstory vegetation is returning. It is important to monitor the arthropods at the species level whenever possible, because they are not redundant. There is turnover along the gradient, of course, but the trajectories of the species may be different. For example, of the two main camel cricket species, *Ceuthophilus pallidus* at PJ is currently declining, while *C. utahensis* at PP and MC is increasing (Table 1) After the Las Conchas fire, the traps at PP and MC give us a rare opportunity to document the pattern of the arthropods' return.

Taxa of special interest from 2011

The first year we collected earwigs was 2009. The species is the introduced and widespread European earwig, *Forficula auricularia* and all have been at the MC site, as shown below.

Year	Month	Trap	No. of individuals
2009	October	A1	2
		A5	4
		A6	2
		D2	1
2010	April	D2	1
	August	A2	1
	October	A5	1
		D5	1
2011	April	A5	2
	July	A1	2
	October	A1	1
		A2	2
		A4	1

Michele Price, a systematist of the sap beetles (Nitidulidae) identified 11 species from Bandelier while she was here as postdoc (she is now faculty at Lewis-Clark State College, Lewiston, Idaho). These small beetles are common in decaying plant litter and are rarely included in ecological studies. They occur at all three sites and all seasons, although there are more species and higher abundance at PP and MC than PJ. The species from Bandelier have added to the knowledge of their distributions and habitat associations.

I have sent representatives of our ground beetles (Carabidae) to Wendy Moore, Asst. Professor, at the University of Arizona for identification.

New species for the study included:

Pardosa nr. *bucklei*, a wolf spider from April MC

Click beetle (Elateridae) species no. 17 from July PJ

Xyloryctes jamaicensis, scarab beetle, from September PP

Dicaelus sp., a ground beetle, Carabidae, from September PP – have only one other specimen from Steve Fettig's study in 2000.

Rove beetle (Staphylinidae) sp. 17 from September MC

Calosoma sp., a ground beetle (Carabidae) from October PJ

In July 2012 I will be presenting Bandelier data on a family of small litter-dwelling spiders (Linyphiidae) at the American Arachnological Society meeting in Green Bay, Wisconsin. Long-term datasets on this family are very rare.

Abstract

Brantley, S.L., Draney, M.L., D.B. Richman, and L. Wiener. New Mexico Linyphiidae: a preliminary look at species and response to precipitation patterns.

The arid southwestern U.S. is perhaps not considered a likely place to collect linyphiids, since they are associated more commonly with wetter habitats. However, they do occur at high elevations, along rivers, and even in drier areas during years of increased precipitation. In this presentation we focus on linyphiids collected from New Mexico, a state with biomes ranging from Chihuahuan Desert to the Rocky Mountains. Our presentation is in two parts: 1) species richness and collection localities known from NM museum material, and 2) habitat and precipitation associations for species from a long-term pitfall trapping program at Bandelier National Monument in north-central NM. In collections at UNM and NMSU we have specimens from about 70 species, including some large range extensions. Most areas of the state have not been sampled comprehensively, and we expect interesting distribution patterns, given the "sky island" effect of isolated mountains in the region. At Bandelier National Monument, 14 years of data from 3 elevations (piñon-juniper 1948m, ponderosa pine 2454m, and mixed-conifer 2712m) showed most species were collected between October and April and most were associated with mixed-conifer habitat. Abundance was low in the dry early 2000's but numbers increased greatly with wetter conditions beginning in 2005. Dominant taxa were *Disembolus angineus* (piñon-juniper), and *Helophora* sp., *Mermessus taibo* and *Pityohyphantes minidoka* (at the higher elevations). Because of their preferences for mesic microhabitats, linyphiids are good candidates for tracking regional climate change, especially winter precipitation. Current drought and wildfires increase the need to document the state's diversity.

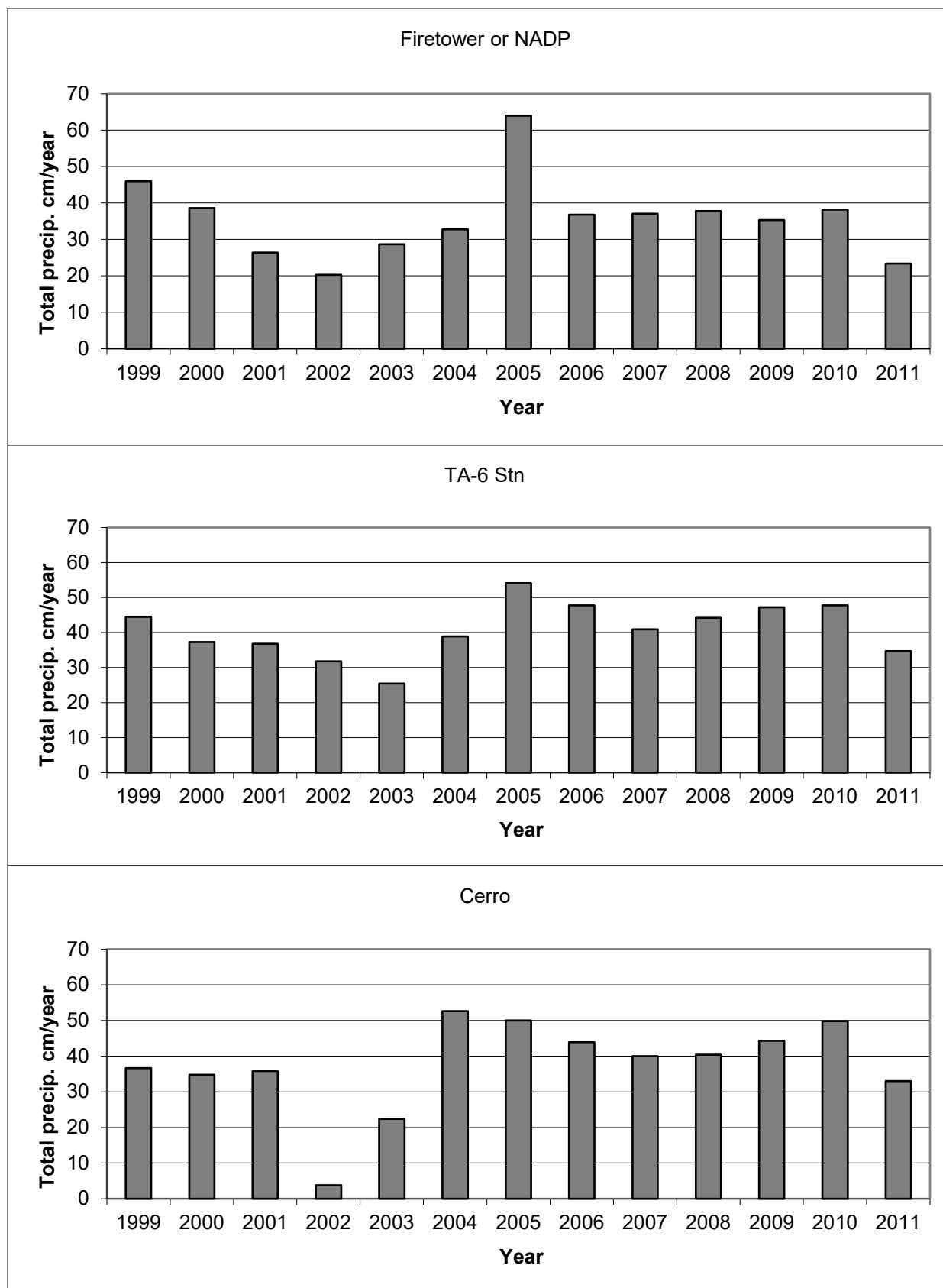


Fig. 1. Bandelier precipitation.

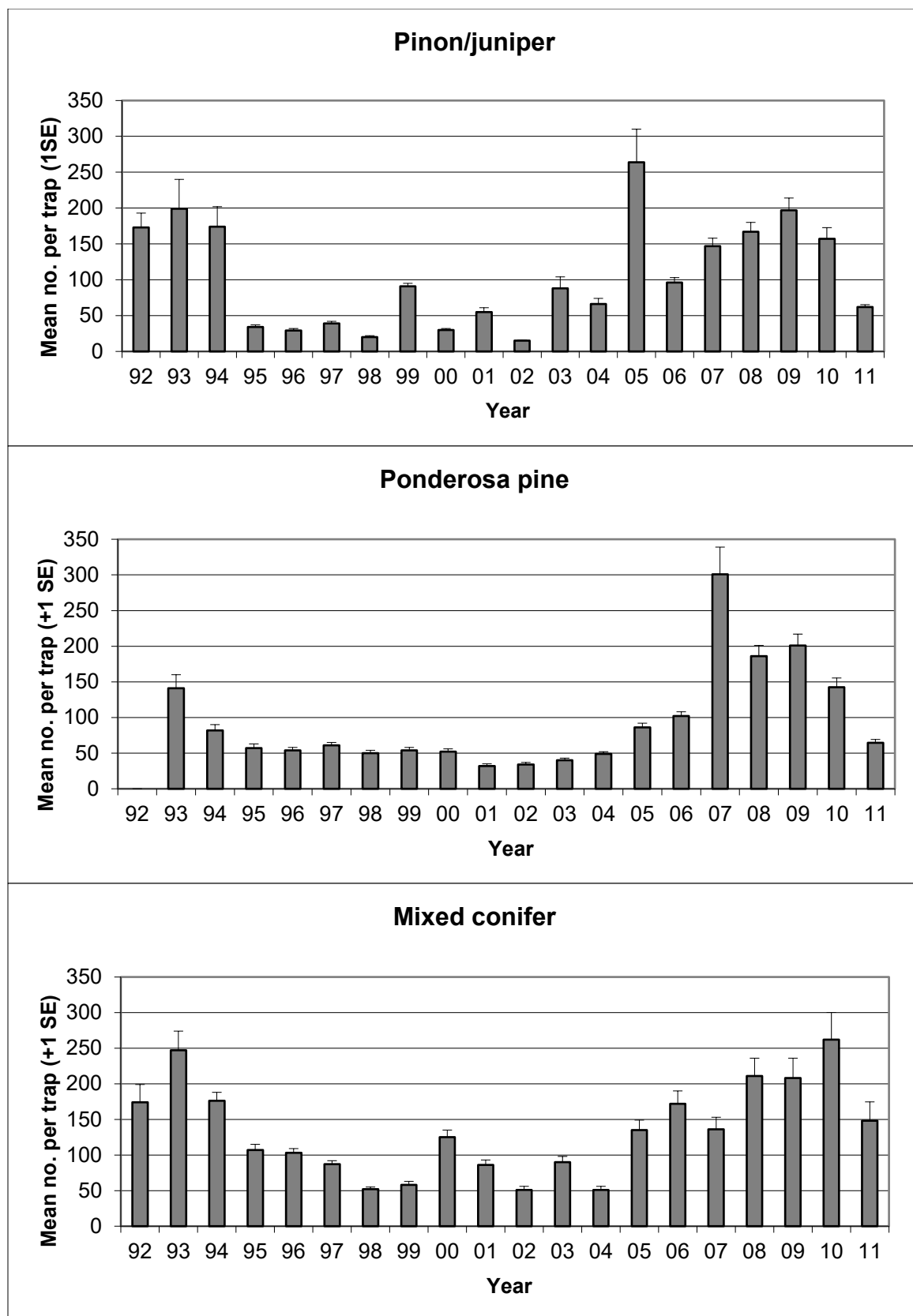


Fig. 2. Mean arthropod relative abundance by site and year.

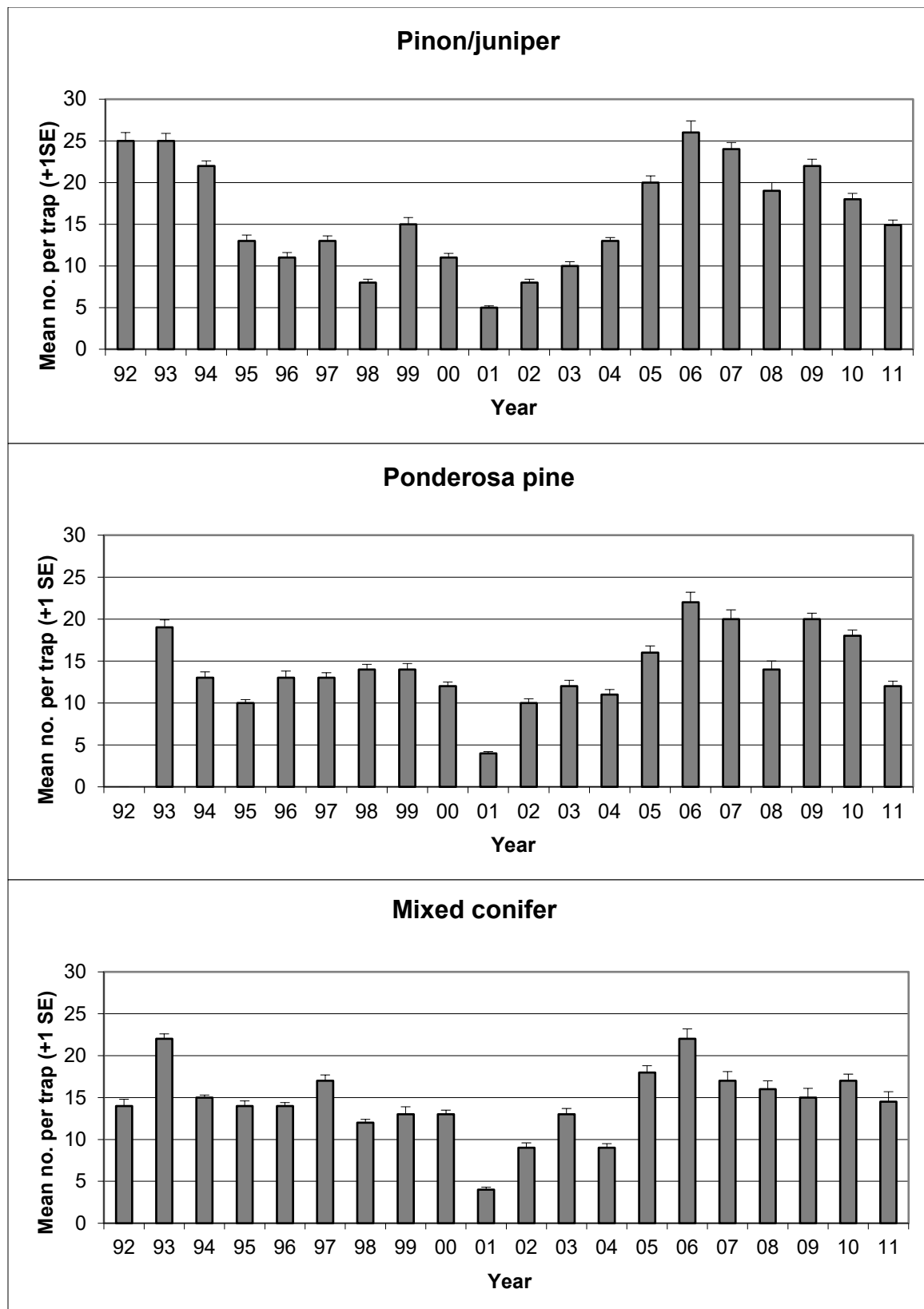


Fig. 3. Mean arthropod species richness by site and year.

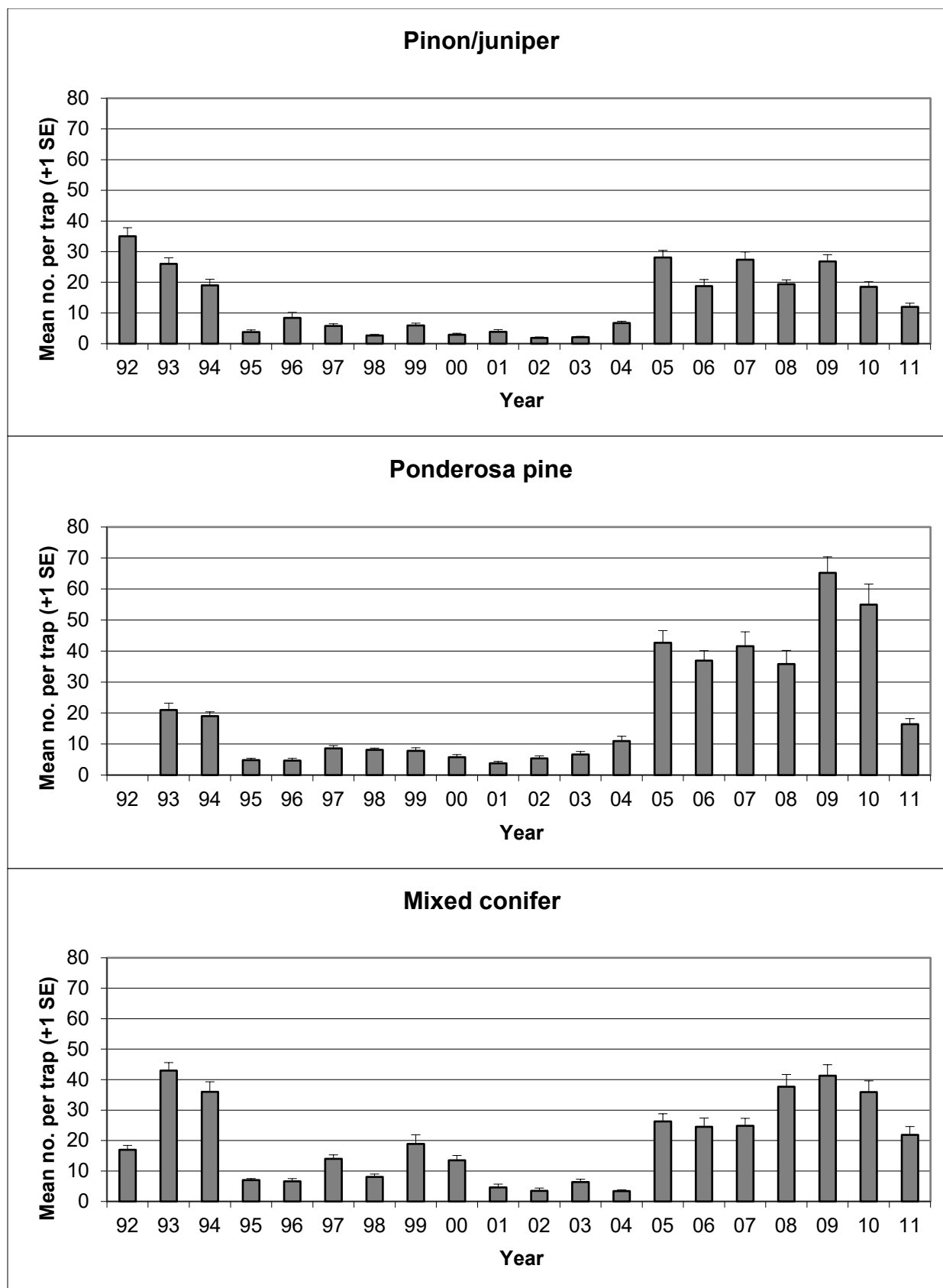


Fig. 4. Mean spider abundance by site and year.

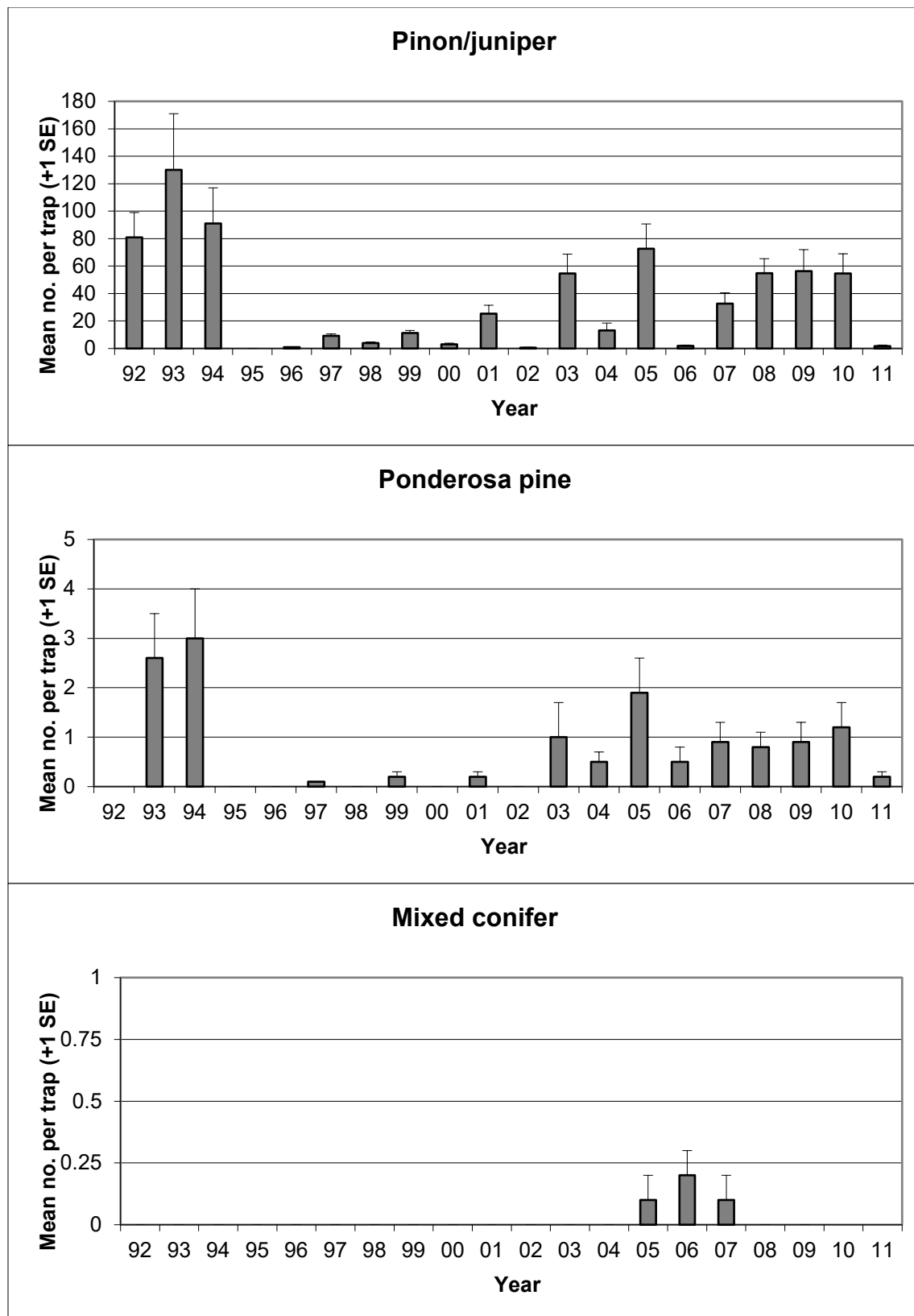


Fig. 5 Mean bristletail abundance by site and year. Note differences in y-axis values.

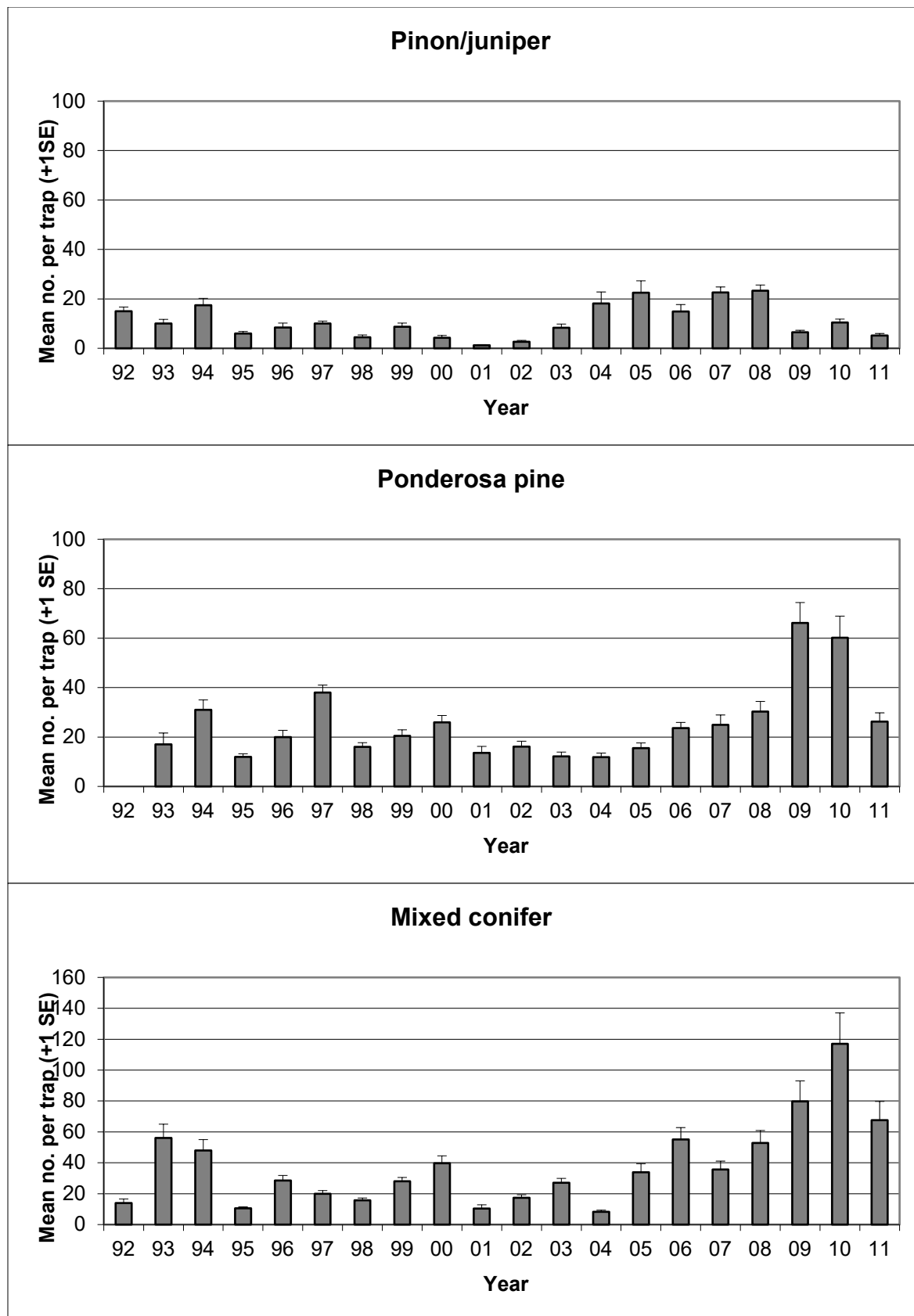


Fig. 6 Mean cricket abundance by site and year.

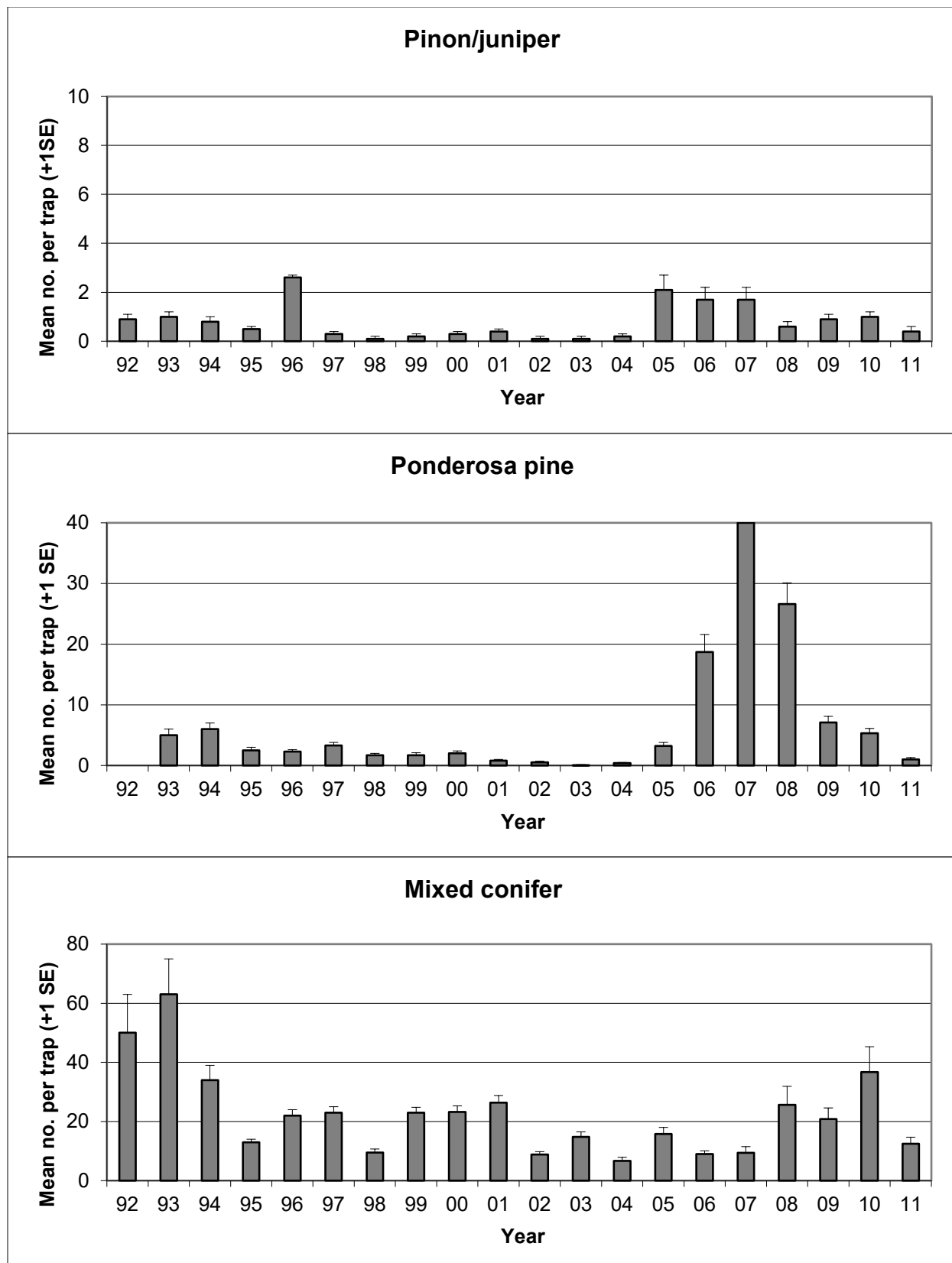


Fig. 7. Mean ground beetle (carabid) abundance by site and year. Note differences in y-axis values. See text for numbers in 2007.

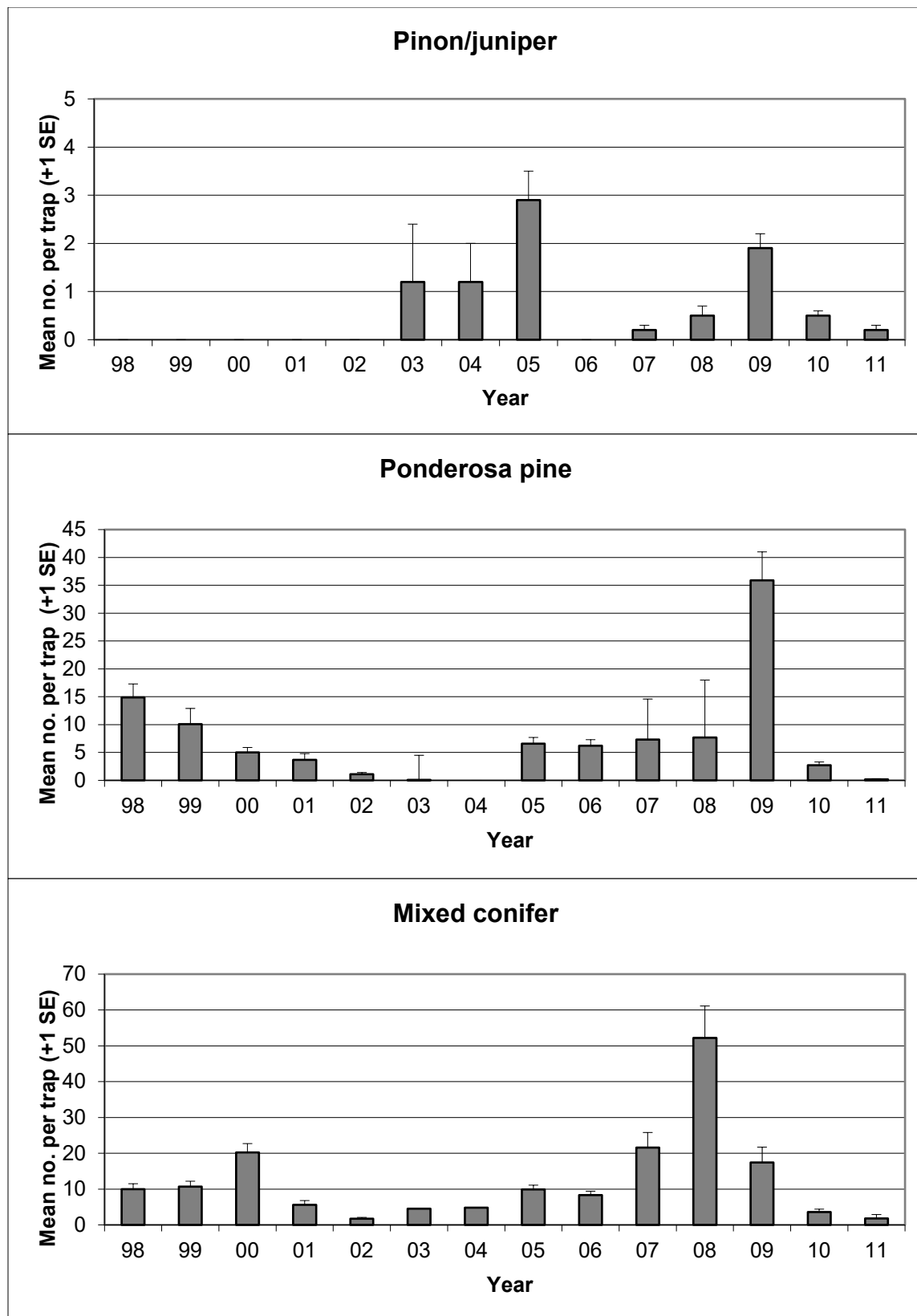


Fig. 8. Mean rove beetle (staphylinid) abundance by site and year. Note differences in y-axis values.

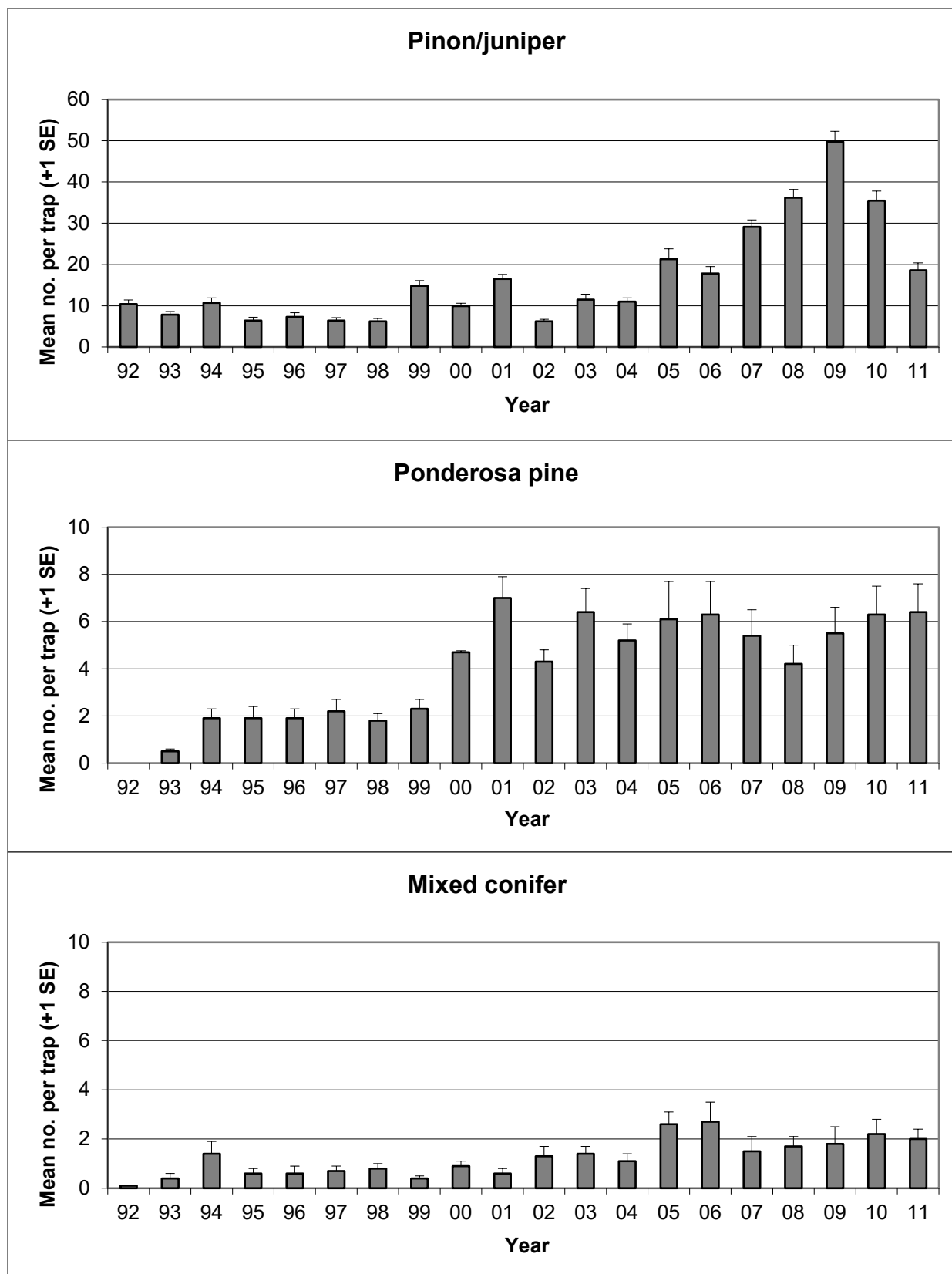


Fig. 9. Mean darkling beetle (tenebrionid) abundance by site and year. Note differences in y-axis values.

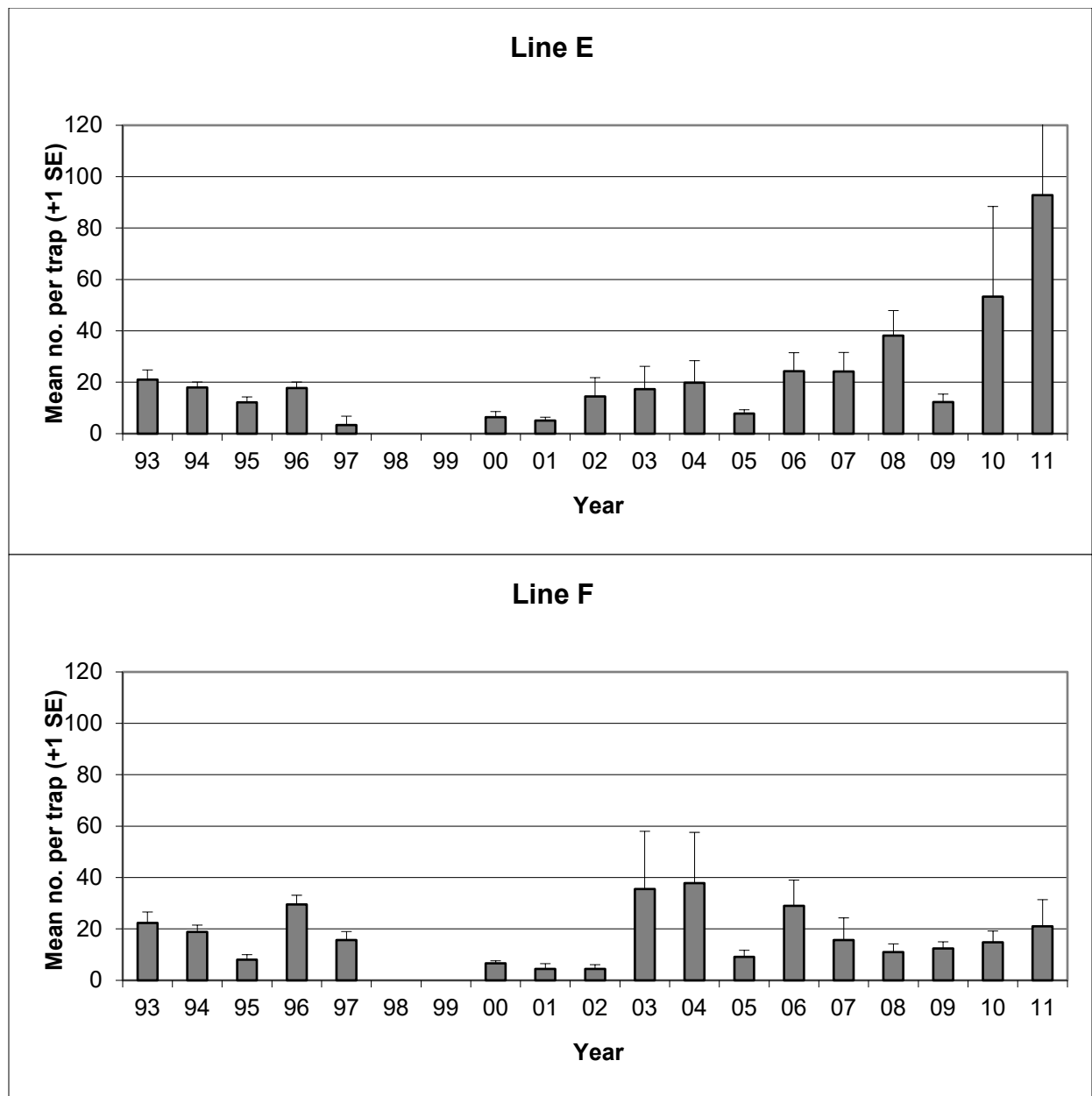


Fig. 10 Mean ant abundance on the MC E and F lines.