

Species Richness, Abundance, and Ratio of K- and r-selected Organisms in a Pacific Northwest Leaf-litter as Indicators of Site Disturbance

Sharon Cooper, July 7, 2009

Introduction: The leaf litter ecosystem has a complex food web whose components work together for a single purpose; to recycle nutrients and energy. Leaf litter samples were placed in Forest Park and HJ Andrews research forest for a four month period. Through anecdotal evidence as well as a review of the weather reports for that time period, it can be said that the Forest Park site experienced significant disturbances, both in terms of increased exposure to human foot traffic as well as a few bouts of extreme weather conditions, including a major thunderstorm that hit the Portland metro area on June 4, 2009 bringing wind gusts of 71 mph and intense rain that at its maximum, accumulated 0.71 inches in 20 minutes (www.oregonlive.com). The same storm system traveled over the Blue River area, but the weather was considerably less extreme in terms of precipitation (0.51 inches in 24 hours) and a maximum wind gust speed of 44 mph (www.wunderground.com). Because the Andrews site experienced less extreme weather and the litter bags were placed in well protected areas of old growth away from active research sites, it can therefore be considered relatively undisturbed by comparison to the Forest Park site. In general, the more undisturbed the location, the more abundant and diverse the species composition should be (Sheehan, 2007).

There are two hypotheses for this study: One is that the HJ Andrews leaf litter samples will have a smaller springtail to fungivorous mite ratio because these mites are K-selected organisms and springtails are r-selected organisms. The K-selected mites are considered an equilibrium species and have comparatively long life spans (1-2 years in some cases), fewer reproductive episodes, slower development, and generally larger body sizes as adults. In a stable, undisturbed environment these mites would exist in numbers approaching the carrying capacity (K). In contrast and with some exceptions, most r-selected springtails have shorter life spans, more reproductive episodes, rapid development (2-3 weeks), and smaller body sizes when fully grown. Rapid growth and reproduction in the springtails qualify them as opportunists as they can quickly take advantage of temporarily ideal conditions and reproduce at a rate closer to the maximum intrinsic rate of growth (r) until conditions change or other agents of biological resistance set in. In short, more mites should indicate a more stable and less disturbed environment which, in this case, would likely be the HJ Andrews research forest.

The second hypothesis states that a greater arthropod species (taxon) richness and abundance will be found in the same leaf litter samples taken from HJ Andrews research forest as compared to those taken from Forest Park as richness and abundance are further indicators of an environment that has not been disturbed by human activity or extreme weather events. Stable environments support a positive feedback mechanism where undisturbed leaf litter and soil promote the presence of larger and more diverse invertebrate populations, which in turn continue to convert litter into more nutrient rich soil (Sheehan, 2007). The Andrews Forest is over five hundred years old and the majority of the arthropod species found in the soil and leaf litter spend their entire lives in the same square meter of space, so the logic holds true that the richness and abundance of essentially non-motile species would be larger for an area shielded within an older forest with very little human interference.

Methods: We used the Leaf Litter protocol from the Ecoplexity website. The larger data set was comprised of 105 different leaf litter samples containing six different leaf types, placed at similar elevations (around 1000 feet) in three different locations: HJ Andrews Research Forest in Oregon, Forest Park in Oregon, and Luquillo, Puerto Rico. Half of the litterbags were placed above ground and half a few centimeters below a duff layer. All bags were placed for the same time period; February to June of 2009. For this preliminary study, we selected eight leaf litter bags, taken from HJ Andrews research forest and Forest Park only. The Andrews samples were placed in a dense stand of five hundred year old growth trees, a fair distance away (100 yards) from the service road (the end of #15-132) and in an area that was relatively undisturbed in that it was not part of another current or ongoing ecology study. By contrast, the Forest Park bags were placed very close (3-5 yards) to 53rd Drive in Portland. This area was much closer to the road and likely subject to more foot traffic and exposure to weather phenomena as a result of being in a less dense stand of trees. All bags contained a single leaf type: Douglas fir needles, recently-shed (brown), Douglas fir needles from a storm-pruned branch (green), Cecropia leaves, and red alder); none had sow bugs added to assist in shredding. The bags were weighed before site placement and then reweighed after oven drying and then placed in Berlese funnels using the Berlese funnel extraction protocol to examine the arthropod richness and abundance from each leaf litter sample. We were not overly concerned by the possible impact of different leaf litter type on invertebrate count because most fungivores, especially mites, are generalists that show no real preference for any particular tree type, but rather for particular stages of decay (Hayes, 1963).

Results

The summary of our richness counts, total abundance as well as total counts for springtails and mites in each leaf litter sample can be seen in Table 1. The overall leaf litter decomposition data for the Forest Park and HJ Andrews research forest sites can be seen in Appendix A. There was no significant difference in the richness between any of the samples when you compare the Forest Park and HJ Andrews sites. However, the abundance of organisms from the Forest Park samples was markedly larger in the Forest Park samples (mean = 298) as compared to Andrews Forest (mean = 22). There was no significant difference in the springtail to mite ratio between the two sites although again, the average abundance of springtails was over eighteen times greater in Forest Park as compared to the Andrews forest. Similarly, average mite abundance at Forest Park outnumbered those from Andrews eleven fold.

Table 1: Summary of Arthropod Counts in Eight Surface Litterbag Samples Placed in Forest Park, Oregon and HJ Andrews Research Forest, Oregon

Sample #	Location	Litter Type	Sample Richness	Total Abundance	# of Springtails	# Mites	Sprintail: Mite Ratio
2020	Forest Park	red alder	15	205	96	78	1.23
2493	Forest Park	Douglas fir (brn)	12	451	219	131	1.67
3069	Forest Park	Douglas fir (brn)	4	238	187	44	4.25
2009	Andrews	Douglas fir (brn)	3	38	9	26	0.35
5023	Andrews	Cecropia	10	18	6	2	3.00
3463	Andrews	red alder	13	26	12	3	4.00
3066	Andrews	Douglas fir (grn)	10	11	10	1	10.00
3049	Andrews	Douglas fir (brn)	10	16	8	6	1.33

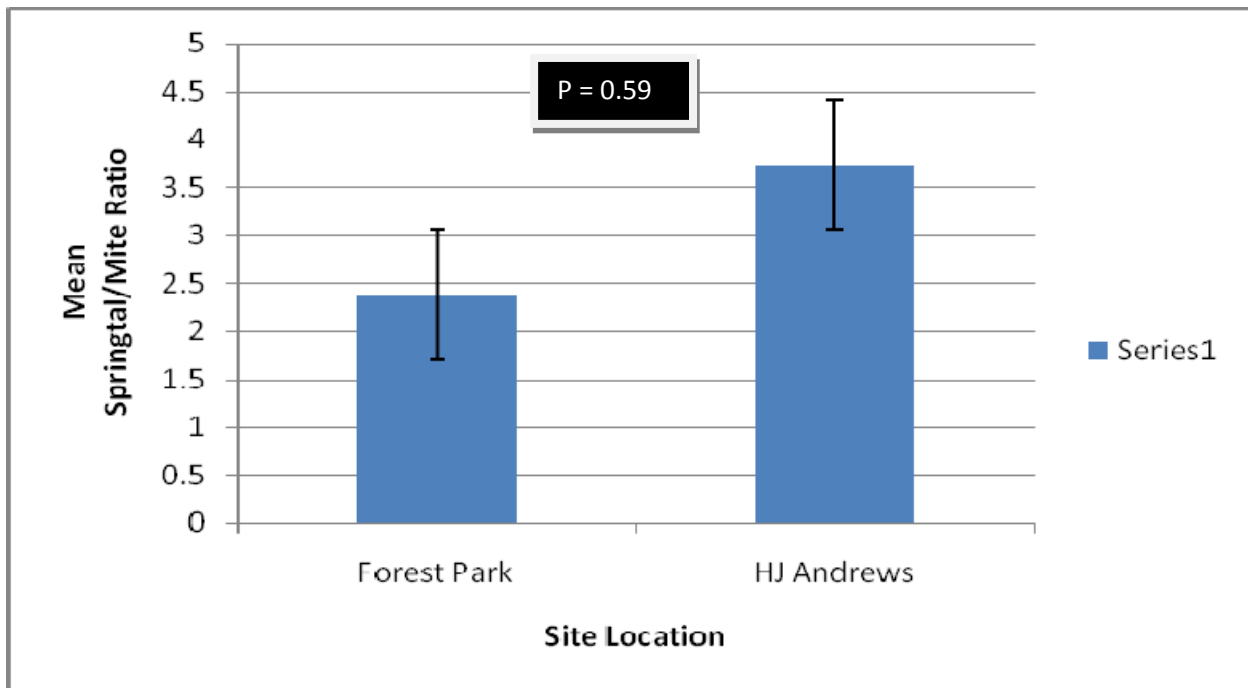


Fig. 1: Springtail to Mite Ratio Comparison between Forest Park and HJ Andrews Leaf Litter Samples

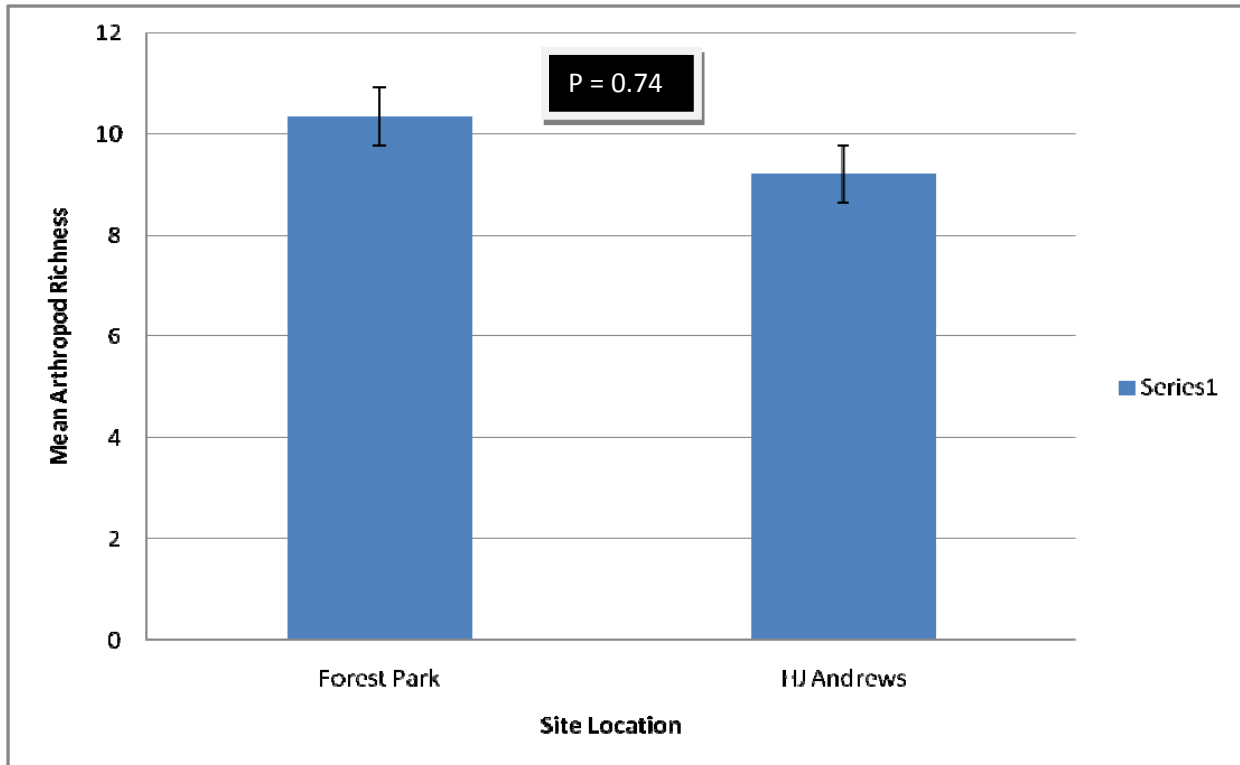


Fig. 2: Arthropod Taxon Richness Comparison between Forest Park and HJ Andrews Leaf Litter Samples

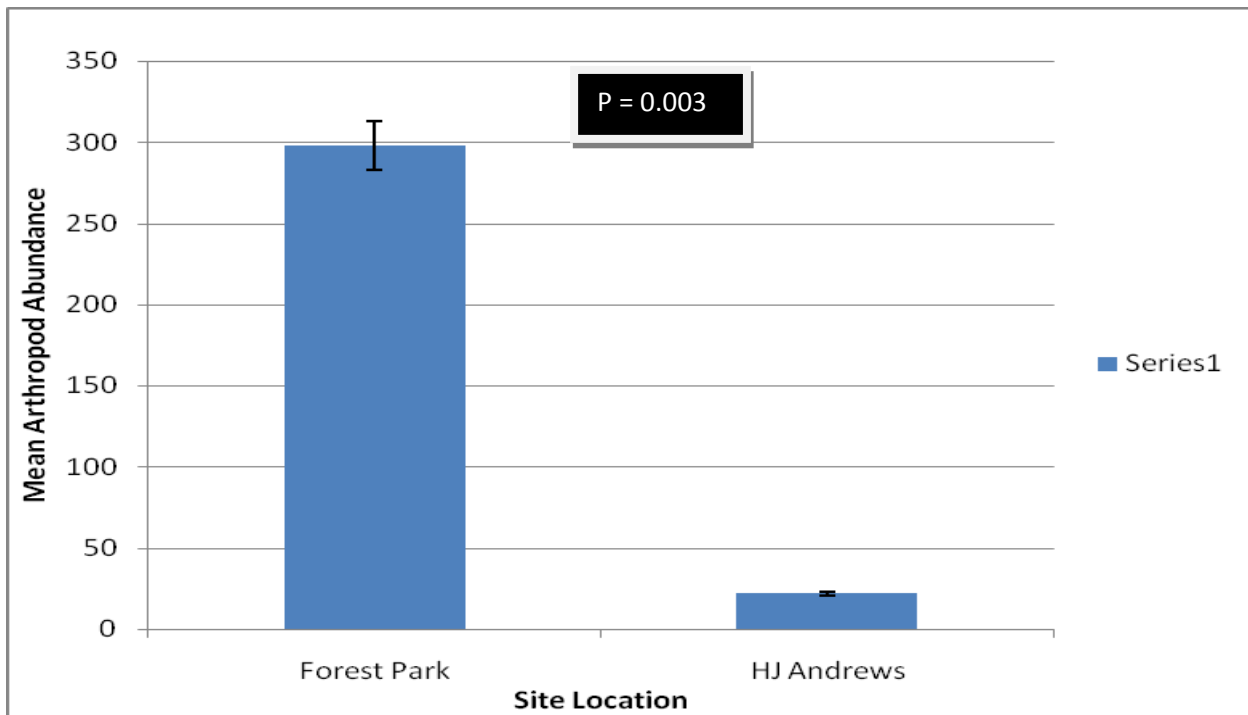


Fig. 3: Relative Arthropod Abundance Comparison between Forest Park and HJ Andrews Leaf Litter Samples

Discussion

There was no significant difference between Forest Park and the Andrews forest in terms of springtail to mite ratio or in taxon richness between the two sites so both my hypotheses are rejected. The first hypothesis suggested that a higher springtail to mite ratio would indicate an increased level of disturbance at Forest Park, but the results do not support this prediction. The second hypothesis predicted a higher species richness and abundance at a site that appears to be more protected from human activity and severe weather such as heavy rain and wind. It was interesting to see how many more organisms were collected and counted from the Forest Park samples which again, directly contradicted my second hypothesis.

Table 2: T-test Summary for Forest Park & Andrews Forest Leaf Litter Study

	P Value (T<=t) two-tail
Richness	0.739877871
Abundance	0.002778528
Sp.tail/Mite Ratio	0.586681419
% Decomp	0.379951432

One obvious factor limiting this study is that the sample size was very small due to time and material constraints. For example, there was one Doug fir leaf litter bag that contained green needles which only contained a single mite, most likely due to the fact that the sample was green and in very early stages of decomposition and not fully colonized by fungus, the food of the turtle mites which can penetrate the thick cuticle of the needle. However, this experiment lumped that data point in with all of the others taken from the Andrews site (even though it was the only green sample) in an attempt include another replicate from the same site that could contribute to a generalized assessment of the richness, abundance, and ratios of r-selected to K-selected fungivores.

The large abundance figures for arthropods in Forest Park may be causally correlated with an increase presence of big leaf maples and generally larger variety of deciduous trees planted by the Park's founders and through other management and maintenance efforts throughout the Park's natural history (<http://www.cityoffp.com/city/taskforce/forest/documents/tf-tree-walks-booklet.pdf>). The greater proportion of maple leaves in the litter layer alone could encourage a greater number of arthropod decomposers in the upper horizon of the litter in any one area. It may be that the general arthropod activity around the leaf litterbags could thus influence the number of arthropods captured inside any particular bag at any one time without significantly influencing the richness. With only eight samples, we cannot make any general statements about these kinds of trends without further study.

Another possible explanation for the increased abundance arthropod species in Forest Park is that the rate of litter decomposition was greater at this site for this particular time period. Populations of invertebrates do vary in accordance with natural changes in season, temperature, amount of rainfall, altitude, and other

environmental gradients (Wiwatwitaya 2005, Wong & Nortcliff, 1995) I performed a t-test on leaf litter decomposition rates (as measured by percent loss of mass) between the two sites and again, found only a 62% probable difference between the two, which was higher at the Andrews site anyway (see Fig. 4 below).

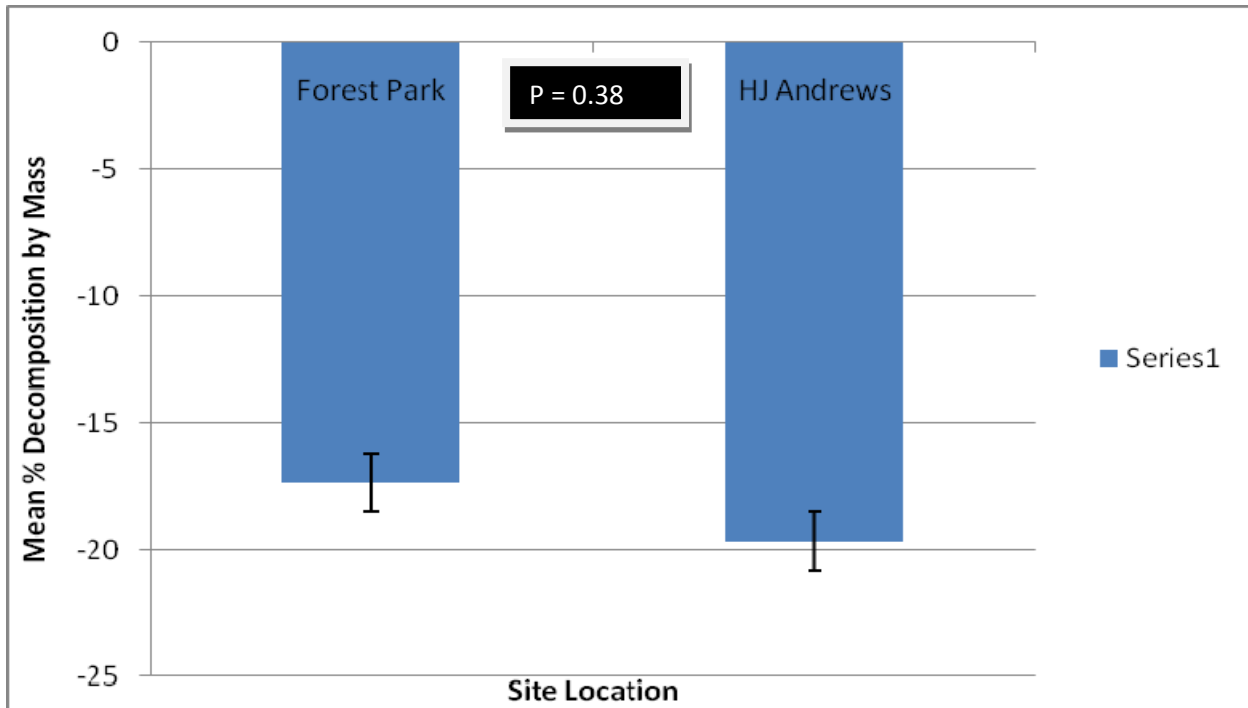


Fig. 4: Percent Decomposition Comparison between Forest Park and HJ Andrews Leaf Litter Samples

Given that these results appear to defy the ecological law that predicts a typical increase in species richness alongside an increase in abundance for a given ecosystem, it would make sense to evaluate and control the other important variables that influence invertebrate richness and abundance to clarify the relationships between these indices, as well as the relative abundance of springtails and mites in a given sample, with the level of disturbance of a given area of forest.

Since there is little difference between the decomposition rate between Forest Park and Andrews Forest, we need to go further and see if the total number of degree days for the same time period is equivalent for each region involved in this study. If that turns out not to be the case, we need to identify the variable that is exceeding that of temperature in its influence on the rate of leaf litter decomposition.

A basic manipulative experiment to test the effect of the presence of Acer species on the springtail abundance would be to raise springtails in a laboratory setting in isolated environments both with and without maple leaves.

As for the notion of a general disturbance, this idea does not accurately describe what has happened in Forest Park. More specific information is needed on the types of disturbances experienced by populated and remote forest regions. We need to know the nature of these disturbances and to test how each kind of major or minor

upheaval (flood, construction, field research) affects opportunistic species which can respond and even dominate in terms of its abundance.