A COMPARISON OF HOVEL MASS TO GROUND LITTER MASS ALONG THE WEST FORK OF OAK CREEK

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Abstract: Flash-flood prone riparian corridors may contain large amounts of plant debris (grasses, leaves, and other plant materials) suspended in woody streamside vegetation. These bunches of organic matter suspended on branches are known as hovels and provide important habitat for arthropod communities (spiders and mites in particular). Our study looks at the importance of hovels in relation to ground litter habitat in an area that experiences frequent flooding, which removes much of the organic litter along the stream. We hypothesized that along a flash-flood prone stream in the southwest that litter mass within hovels would be as large or larger than litter mass on the forest floor within the annual flood zone. We also quantified biomass of these structures by volume. Ours is the first study to quantify hovel biomass along gradients, and to compare mass of hovel to ground litter. We conclude that hovels may be an important component of riparian ecosystems, and in some ecosystems litter mass suspended in trees/shrubs may actually be higher than litter mass on the ground.

Keywords: hovel, habitat, stream, flood, arthropod

INTRODUCTION

Unregulated rivers in the Southwestern US are highly influenced by their flooding regimes (Michener and Haeuber, 1998) and may create unique and important streamside structures known as litter hovels (Loeser et. al, 2006). Litter hovels are created when floating debris such as grasses, leaves and other organic materials get caught in shrubs and trees that have branches above the receding flood line. The hovel structures are important because they provide habitat for many different arthropod communities and may support as much as six times higher abundance of arthropods compared to the surrounding vegetation and ground litter (Loeser et. al, 2006). In turn arthropods are a food source in the larger food web of terrestrial ecosystems (Schoener 1989, Raley and Anderson 1990). The quantities of hovels present in an ecosystem may be an important indicator as to the total amount of food available to other species in the food web such as the amphibian and avian communities. However, no study has examined how mass of hovels may compare to ground litter.

Because flood-prone canyons in the southwest experience frequent high intensity floods, hovels may serve as one of the only structures which maintain litter mass in these canyon ecosystems. Ground-litter mass is predictably low along such streams, and is frequently replaced by annual scouring. Hovels may remain suspended in streamside vegetation for many years due to its compact matted form. Thus, in addition to being important for biodiversity (Loeser et al. 2006), hovels may play an important ecosystem role by supporting high litter mass over multiple years.

We studied hovels along the West Fork of Oak Creek, in Cocconino County, Arizona, a model unregulated southwest canyon ecosystem with high intensity annual flash flooding. This study site was able to provide a platform to address a comparison of hovel mass to ground litter mass without having to factor in the impacts of dams and other man made disruptions. Our study focused on deposition zones opposite to the cutting edge of the stream along sinuous bends because in most creeks, a high retention of organic matter collects in areas of lower current velocities (Huryn, et. al, 1987). Our hypothesis was that a comparison of hovel mass and ground litter mass would show hovel mass to be greater than ground litter mass.

METHODS

Site

We chose the West Fork of Oak Creek as our study site. The creek winds its way through Oak Creek Canyon, which is a part of the Kaibab Plateau. The coordinates of our study area were: 35°01'29.42N 111°44'34.89W. The area is managed by the Forest Service as a wilderness area as a part of the Cocconino District.

Plots were established upstream from the first access point at Red Rock State Park. We measured all hovels on the fist ten major creek bends along the deposition side of the creek. Our study focused on the bends in the creek as being most probable to have more collection, because in most creeks, a high retention of organic matter collects in areas of lower current velocities (Huryn, et. al, 1987). The curves of creeks are divided into two types: the outside edge of the curve, which travels at a slightly higher velocity and is called the cutting edge, and the interior portion of the curve which travels at a slower rate, and is known as the deposition side. After taking all factors into account we concluded that studying the deposition side of curves would be most pertinent to our study question. The scour line was also taken into account when determining our study area. A scour line is a visible mark along the river bank showing the removal of debris by flooding; it is marked by an exposure of rock and change in vegetation intensity. The center of each bend was identified and used as a reference point to identify the plot perimeter. From this center point the baseline was established above the scour line. A line parallel to the baseline was created along the stream edge and from each end of this stream line non-parallel lines were drawn to the baseline. This created a trapezoid shaped plot at all ten river bends. Plot sizes ranged from 280 to 850 square meters in size. Generally the larger bends and therefore the larger plots were located in the lower portions of the creek, and the smaller plots farther upstream. This was due to water volume.

We measured all hovels within the plot area that were fully suspended from a shrub or other woody material; any that were not fully suspended were excluded because of size and difficulty with finding the hovel perimeter. Measurements of length, depth, and width were recorded for all specimens. Four representative samples (small, medium, large, and extra-large) were colleted at each location for biomass estimation based on size. Some of the largest hovels could not be obtained due to logistical constraints and concerns over habitat degradation, therefore our mass estimation equation is biased towards small hovels, and this could be a source of error.

The other data component involved ground cover percentage estimation and collection of ground litter. The approximate center was identified in each of the ten Oak Creek test plots, and a researcher tossed a quarter meter plot over the shoulder. This was done in four directions creating four subplots within the larger plot. Ground cover within the subplot was estimated and written on a paper bag. Ground litter was then collected from within the subplot and placed within the bag and marked with plot and subplot number.

Upon returning to the laboratory at The Evergreen State College the collected samples were dried prior to being measured for mass. The hovel and ground cover samples were dried in an oven for twenty four hours at 21.4 degrees Celsius. Because of the large number of samples, they were dried in two batches. All hovel and ground cover samples were weighed in grams with precision to two significant digits.

Calculation Methods

All statistical analysis was done using SPSS version 13.0. We used linear regression to create an equation to calculate the biomass of the hovels based on directly estimated hovel volume (see above) and mass (Mass (g) =0.015 (volume (cm^3)) + 46.174; $r^2 = 0.56$; $P = 0.018$). To our knowledge, this is the first mass equation available for hovels. Estimates of volume (cm3) from direct measurements in the field of the non-collected hovels were fit to this equation to provide estimates of mass (g) for all hovels at each site.

Hovel mass was compared to ground litter mass in a one way ANOVA to establish if there was a significant difference between the two variables.

RESULTS

Of the 919 hovels that were measured as part of this project, the largest had a volume of 38700 cm3 (0.0378 m3) and the smallest a volume of 1 cm3. The average size of a hovel collected from Oak Creek Canyon was 788 cm3.

There was a general trend that the plots further down stream had more numerous and larger hovels. These lower plots also were larger in area because the bends were larger where they were established. This could be a very important factor to bear in mind when performing analysis of the distribution of hovels because it is not a standard unit (Loeser et. al., 2006).

Ground litter was calculated for each plot using the data collected with the quarter meter plot. Although the lower plots have a greater area than the plots further up the stream, a linear regression showed no correlation between the mass of ground cover and the area of the plots.

The average mass of hovels was 367.266cm3/g; the average mass of ground litter was 93.4575cm3/g, which shows that hovel mass was greater than ground litter mass. A one way ANOVA showed the comparison of ground litter mass to hovel mass also proved to be significantly different (see Fig. 1; $p = 0.018$).

Biomass calculations showed that of the thirty nine specimens analyzed, the smallest calculated biomass was 0.016 g/cm3 and the largest was 0.964 g/cm3. The average biomass from the samples was 0.107g/cm3. This information was used to create a sample biomass equation (see Fig. 2; $r^2 = 0.561$; $P = 0.018$). The biomass equation was then applied to hovel measurements for samples not gathered to approximate mass.

DISCUSSION

This study showed that there is a significant difference between hovel mass and ground litter mass along the West Fork of Oak Creek, with hovels having more mass. An analysis of how hovels changed along the stream gradient from upstream to downstream was included in study design, but due to errors in data collection there was not enough data to establish a significant trend. However, there was preliminary data analysis done and a trend of more mass downstream did seem to be developing. With the collection of more data a significant trend could be identified.

The finding of hovel mass to be significantly greater than ground litter mass could have wide ranging implications. Hovels are part of a naturally fractured habitat. The role of the hovel as refugia in a disturbed creek side has implications in the area of habitat restoration projects. Our finding that hovel mass was larger than ground litter mass could be used to incorporate hovels into restoration projects which could encourage biodiversity in a reclaimed site. Mitigating for hovels may increase arthropod density and have a positive effect on other organism communities. Attracting and keeping spiders in a creek side restoration project may also increase bird visitation. Areas being regenerated after removal of an invasive species would be particularly at risk of not having enough organic matter to house diverse arthropod communities. Furthermore, channel units have properties not found at other spatial scales and serve as an appropriate scale to coordinate interdisciplinary management goals and strategies (Doisy et al, 2002). Using channel units on this flood prone environment may give restoration planners a more effective way to conceptualize habitat restoration

Because of human activities upstream non-degradable litter may currently compose more hovel mass than at any time in history. During flooding stream flow increases sharply and then decreases, stranding materials. Coarse floating matter comprises the body of the hovel and can be whatever is picked up by the flood stream. The term Course Particulate Organic Matter (CPOM) was not used here because parts of a shoe, a sock and other such litter were found to be creating the framework for a few hovels. The ecological value of hovels may be being degraded by this introduction of man made materials, and as such a more comprehensive study of hovel structure would be useful to further illuminate this issue.

Bank side vegetation plays a large role in what is removed from the flood stream. Because of this, hovels may be more prevalent on the deposition side of the stream, as there is nearly no vegetation on the cutting edge.

Species composition studies between the adjacent woodland and hovel arthropod communities could also be done. Similarity of species composition between areas within a forest has been related to site differences in litter depth and structure (Uetz, 1979). There may be similar findings along stream sides with the exception that the hovels may be colonized by the first to arrive on the hovel “island”.

Hovels retain organic matter in a specific location. This may lead to significant amounts of nitrogen being added to an area. This habitat does not appear to have much biotic soil activity and in this environment relocation of coarse particulate organic matter might assist with nitrogen redistribution. Irregular hydrological pulses in Neotropical streams had significantly stronger impact on leaf breakdown than aquatic macro invertebrates (Rueda-Delgado et al, 2006). Similar results may be found in this habitat, even though it is a different climate, because it is also subject to flash flooding.

The importance of hovels to the overall functioning of stream side environments in flash flood prone areas needs more study to be better understood. The findings of this study showed that hovel mass is greater than that of litter mass in some areas and thereby the importance of hovels may be far greater than the amount of study that has been done on them up to this point would imply.

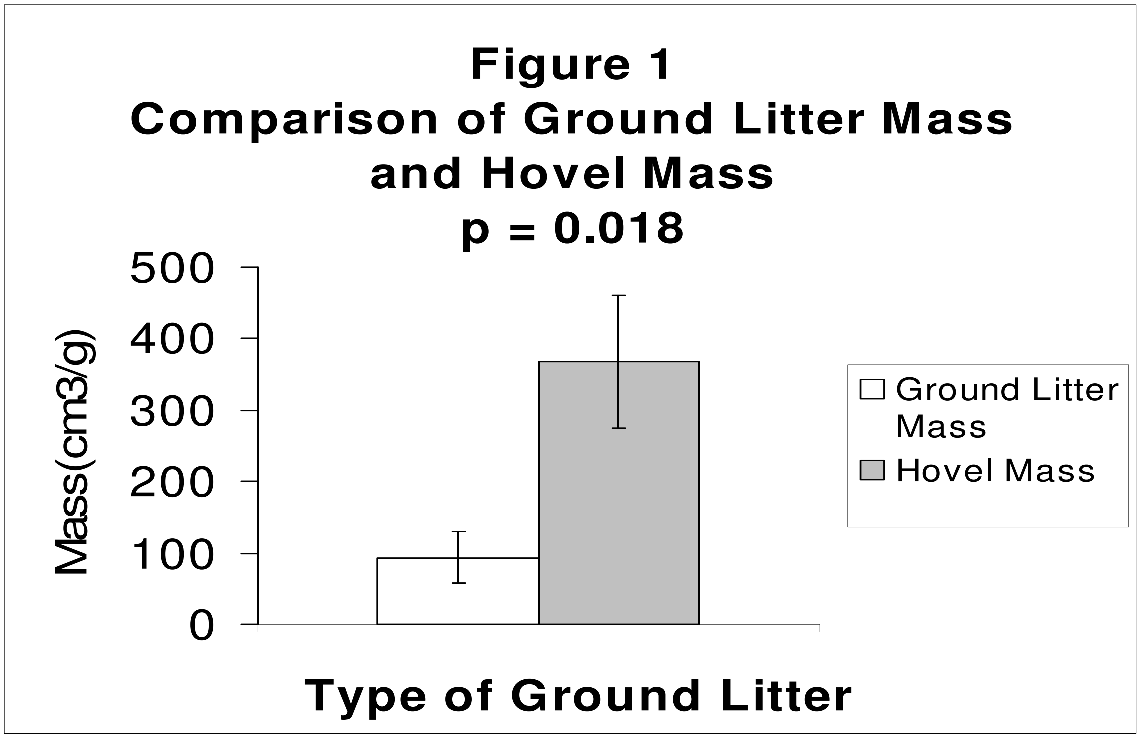
Figure 1
Comparison of Ground Litter Mass
and Hovel Mass
p = 0.018
Mass(cm3/g)
500
400
300
200
100
0
Ground Litter Mass
Hovel Mass
Type of Ground Litter

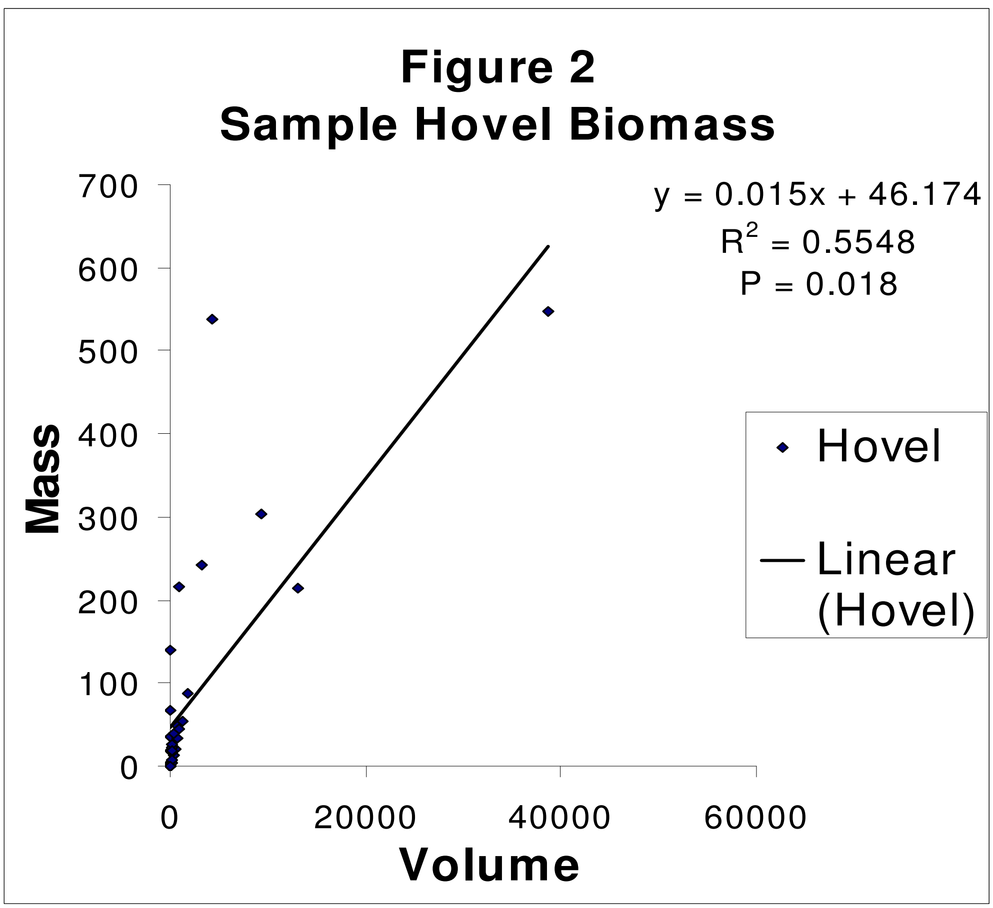
Figure 2
Sample Hovel Biomass
y = 0.015x + 46.174
R2 = 0.5548
P = 0.018
Mass
700
600
500
400
300
200
100
0
0
20000
40000
60000
Volume
Hovel
Linear (Hovel)

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