Hovel formation dependent upon the location of riparian vegetation

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ABSTRACT

The formation and abundance of leaf-litter hovels may be dependent upon flooding streams and vegetation structure. Hovels are suspended debris matted in streamside vegetation that play an important role in supporting insect biodiversity (Loeser et al., 2006). Although previous studies on hovels have occurred in frequently flooding streams of the Southwestern U.S., our research took place in the Pacific Northwest where to our knowledge, no previous studies exist. The November 2006 floods of an upland river (Nisqually River, Mt. Rainier Park) and a lowland stream (McLane Creek) granted us opportunity to record and compare hovel abundance across a range of Pacific Northwest habitats. By measuring hovel size, density and the vegetation structure in which hovels were found, we addressed basic questions about hovel presence along Pacific Northwest water courses. We suggest that basic structural factors define the relationship between the landscape, the hydrology of the waterway and hovel formation.

KEY WORDS:
Riparian habitat, hovel, debris, flood regime, *Thuja plicata*, *Alnus rubra*, *Acer circinatum*, *Rubus spectabilis*, *Acer macrophylum*, *Tsuga heterophylla*, O*plopanax horridum*, *Pseudotsuga menziessi*

INTRODUCTION

Riparian habitat is in constant flux and always vulnerable to change. Variables in riparian landscapes that affect change include variations in velocity and duration of cyclic flooding, which alter riparian landscapes annually (Bornette et al., 1997). Flooding is one of the natural processes in which we can see the physical destruction of riparian landscapes giving way to new habitats.

In systems where habitat change is recurrent due to flooding, it is common to find elevated and entangled debris deposits, termed "hovels" by Loesser et al. (2006), which may provide important ecosystem services. Channels that undergo recurrent flooding often lead to the creation of hovels, which are imperative to the diversity, and abundance of arthropod species (Loeser et al., 2006). In fact, debris which is initially swept up during flooding and then later deposited along the ground or bunched around vegetation, is a regular feature along channels where annual, flash, or heavy flooding occurs (Loeser et al., 2006). The debris formations provide an important habitat for the shelter and safety of arthropods and spiders (Loeser et al., 2006).

Although previous work has focused on the ecological significance of, termed Hovels, in Southwest flash-flood streams (Loeser et al. 2006) our study examines the presence of these structures along a major river and creek side habitat in the Pacific Northwest, where flood regimes can also be dramatic. Additionally, while Loeser et al. (2006) demonstrate the ecological importance of hovels for arthropods, it is still unclear which environmental factors are necessary for hovel formation. Ecological structure and flood regimes may be particularly important in hovel formation. We examined two sites where flooding varied in velocity and length of time during winter 2006/07. The intensity of flooding events may be a key factor in determining the density and frequency of hovels. When floodwater exceeds an active creek bank, more vegetation is flooded with debris, which may lead to greater hovel formation. Our observations along a major upland, high velocity river (Sunshine Point, Nisqually River, Mt. Rainier) and a lowland creek (McLane Creek) in the Pacific Northwest provided an opportunity to evaluate two systems subject to different flooding regimes with different riparian structural attributes.

METHODS

Study Site

Our first site was $^1/_2$ km. east of the Nisqually entrance at Mount Rainier National Park, in a stand dominated by Western Hemlock (*Tsuga heterophylla*) and Red Alder (*Alnus rubra*), and classified as an *Alnus rubra/ Rubus spectabilis* community type **(**Franklin et al. 1988**)**. This stand sits a quarter of a km. directly north of the Nisqually River at a elevation of 2023 ft. in mostly alluvial soil. The undergrowth is mostly comprised of mature salmon berry (R*ubus spectabilis*), devil's club (O*plopanax horridum*), and vine maple (A*cer circanatum*). Woody debris, fallen trees and concrete residues remaining from Sunshine Point Campground cover the forest floor and sides of the river-bed. The stream sits half a meter deep in relation to the forest floor on either side. In November 2006, Mt Rainier National Park received 18 inches of rain in a 36-hour period. At Sunshine Point Campground flood recession carved out small stream banks and allowed for the collection of smaller streams fed by snowmelt to combine with the Nisqually River, creating a new habitat for hovel formation.

Our second site, McLane Creek, is a perennial stream that flows through a second-growth lowland forest of Douglass-fir (*Pseudotsuga menziessi*) and Western Red Cedar (*Thuja plicata*) in the south Puget Sound. Along the river-bed there is a large concentration of sword fern (*Polystichum munitum*), devil's club (*Oplopanax horridum*) and salmon berry (*Rubus spectabilis*). Although McLane Creek is perennial, its water level drops dramatically in the summer – near zero cubic feet per second – and it tends to flood in the winter, sometimes reaching 700 cubic feet per second (http://www.co.thurston.wa.us). McLane Creek flows from the south in Capitol State Forest (Olympia, WA.) to the north, draining in to the Eld Inlet of the south Puget Sound. Some trees have fallen into and across the stream, creating logjams that slow the flow of water in effected areas. Unlike the stream at Mt. Rainier, McLane Creek has cut a deep enough channel so that soil erosion may enable hovels to entangle in the exposed root systems of the steep embankments. While it is more common to find hovels suspended in vegetation within, or overhanging the creek channel, eddies and debris dams allow for annual flooding to effect plant-life on the forest floor.

Collection Method

At both Sunshine Point Campground and McLane Creek sites, we mapped eight, 5x10m plots parallel to the stream (Fig.1). Plots were chosen systematically within 100 meters of each other along the streambed. Sites were chosen subjectively to include a quantity of hovels in each area based on visual estimation. Larger plots were then divided into five 5x2 meter plots so that the existing 5-meter measurements continued to run parallel with the stream (Fig. 1). We thus used quadrants to group together hovels that were similar in distance from the stream. In each quadrant we recorded the circumference of each hovel, the distance the hovel was from the center of the stream, and the structure in which it was supported it (i.e. plants, root systems). In our most extensive data set for Mt. Rainier, we used a two-way ANOVA to test for the effects of sampling plot location and vegetation type on hovel formation.

RESULTS

In the 400 square meters recorded at McLane Creek there were a total of 40 hovels. In comparison, there were a total of 110 hovels recorded in the Sunshine Point Campground at Mt. Rainier (a more than two-fold difference). At McLane, 87.5% of hovels sat within 4 m from the center of the stream; 7.5% of the hovels sat between 4-6 m from the stream and 5% sat beyond 6 m of the stream (Fig. 2). In eight, 5x10 meter quadrants, no hovels were found beyond 8 meters from the center of the stream, proving that most observed hovels of McLane Creek sat closest to the central water flow.

At Sunshine Point Campground a less dramatic trend was observed in hovel abundance relative to the measured distance from the center of the stream (Fig. 2). Thirty-nine percent of the hovels sat within 4 m, 50% sat between 4-8 m, and 11% were found between 8-10 m of the stream. When compared to McLane Creek, hovel abundance at Sunshine Point was more continuous over a larger relative distance from the active stream.

The over-all average hovel circumference, when data from both McLane Creek and Sunshine Point are pooled, was 17.4 centimeters. The average circumference at McLane Creek was 3.4 cm smaller than the hovels collected at Sunshine Point. At both McLane Creek and Sunshine Point Campground, no collected data provided a significant correlation between the location and circumference of hovels. At McLane Creek, within 4 meters from the center of the stream, we recorded an average circumference of 15.1 cm and between 4-8 m an average of 17.8 cm (Fig. 3). The average hovel circumference at Sunshine Point within 4 m of the stream was 18.3 cm; between 4-8 m: 19.1 cm; and between 8-10 m: 21.3 cm.

Sunshine Point Campground and McLane Creek both showed similar trends in what structures supported hovels. Seventy percent of the hovels at McLane Creek were housed in the riparian shrubs, salmon berry, devil's club*,* sword fern*,* and vine maple. Almost 76% of hovels at Sunshine Point were housed in the same shrub species. At McLane Creek, 20% were suspended in the deciduous tree's, vine maple, and red alder. And at Sunshine Point, 9.5% of hovels were housed in these trees as well as the coniferous, western hemlock (Fig. 4). The size of hovels suspended in riparian shrub and exposed root systems were, on average, more than 4 centimeters larger than the average size of hovels suspended in larger coniferous and deciduous trees (data not shown). In a Two-way ANOVA that accounted for sampling plot location, vegetation type, and interactions between location and vegetation, we found no significant difference between vegetation types in the number of hovels they supported (P = 0.69).

DISCUSSION

These data do not support our original hypotheses. For example, we found no significant relationship between hovel distance with absolute distance from stream at a p-value cut-off of 0.05 (Fig. 2; P = 0.15). Size of hovel was also not significantly related to distance from stream (Fig. 4; P = 0.68). This could mean that the distribution of hovels is random and depends solely on idiosyncrasies associated with each individual flood. This would make sense since the very definition of hovels is non-discriminating as well: "litter that can persist attached to trees at varying heights above ground in frequently flooded areas."(Loser et al. 2006) However our data could also suggest that our sampling was not expansive or precise enough to demonstrate a pattern. From original observations we believed there was an observable pattern where the average circumference size of hovels decreased as their distance away from the stream increased. However, our data did not demonstrate this pattern (Fig. 3).

While our study has not yielded any statistical trends, we have observed patterns. For example, more intensive floods, such as the November 2006 floods at Mt. Rainer, may create hovels at a greater distance from the center of the stream (Fig. 2). McLane Creek's milder seasonal flooding may result in fewer hovels at a greater distance. Other factors like the amount of dense debris on stream-banks, may also contribute to hovel formation. For instance, Hax et al. (1996) describe how wood stays anchored during flooding. This anchored debris supports hovels and provides homes for invertebrates seeking refuge during floods. Vegetation type may also play an important part in hovel formation. Some plants, especially shrubs such as devil's club and salmon berry, may better facilitate hovel formation when compared to larger tree species (Fig. 4).

The waterway may be the most important force in the creation of hovels; the deeper a stream has cut itself into the ground, the less water will overflow into the surrounding landscape during flooding. Since hovels are created when floodwaters interact with thick vegetation that is usually found next to a stream instead of in it, it is essential for the water to flood its banks, so that floating debris can be deposited into riparian shrubs. The area we observed at Sunshine Point Campground in Mt. Rainier only carries water during high flood seasons. Because the flood-water inundated the streambed and highland alike, there was a large amount of vegetation for water and debris to interact with, increasing the likely hood that this debris would catch and form hovels. By observing the patterns of moss distribution on the large trees in the area, we concluded that at 0.45-0.6 meters up the tree, the water was still strong and persistent enough to remove all the moss on the sides of the trees facing upstream, signifying that the flood was at least that high.

Another asset of flooding beyond the creek's banks is that debris normally untouched by the river is picked up and added to the flow of debris. Since no water typically interacts with the untouched debris outside the normal waterway, the debris may have been compiling for a number of years. This debris outside of the channel contributes greatly to hovel formation, simply because it allows a greater amount of debris to swirl around in the water, ready to be caught up in unsuspecting branches. Also, the flow of the flood at our Mt. Rainer study site was not deep or powerful enough to carry extra large debris such as trees and boulders that would have destroyed the shrubs and plants that support hovels.

While our site in Mt. Rainier was relatively level with the surrounding landscape, McLane Creek cuts into the ground about one meter deep. For the most part, the hovels observed were confined to the immediate banks of the river, or to branches from surrounding plants that drooped into the flooded waters. In some areas, however, eddies and debris dams slowed the water to the point where it backed-up and flooded a bit of the vegetation on top of the banks. When the water receded from these dammed areas, debris was left behind, and hovels were created as usual. Even though McLane Creek did not experience the same substantial flooding that the stream at Mt. Rainier did, hovels were still formed due to debris dams. The difference in terrain between the two sites also made it difficult to have a completely uniform study design, and likely played a major role in structuring our results.

The methods and choice of sites for our study may have also affected our results. Changing or expanding our sampling strategy could lead to a more extensive study. The Mt. Rainier and McLane sites differ greatly. There are differences in anthropogenic development, geography, and cause and type of flooding at each site. All of these diverse factors make comparing the sites difficult if not impossible. Having the two streams in a similar locale with a controlled flood would improve our study. Differences in width of the stream also may provide an unmeasured source of variation. A more systematic method of measuring hovels might also be beneficial. For example we measured size at only one point. Measuring circumference may improve our estimates of hovel size. Use of mass or area might also improve accuracy.

None of the data recorded proved significant but from collected evidence, we have derived that hovel abundance and size in the Pacific Northwest may be due to the different aspects in varied flooded terrain. To our knowledge ours is the first study of hovels in the Pacific Northwest, only beginning to prod into a relatively unknown subject matter.

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