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# Use of Woody Debris Piles by Birds and Small Mammals in a Riparian Corridor

## Abstract

Woody debris piles, a natural component of rivers draining the coastal forests of the Pacific Northwest, provide a unique resource in the riparian-river corridor. We describe the distribution of woody debris piles on the Skykomish River, Washington, and examine their use by birds and small mammals. We found an average of one debris pile per 15 m of river bank; the inside of these piles was significantly cooler than the ambient environment. Over sixteen bird species were observed using the debris piles while other bird species in the area were never observed on the debris piles. The overall species richness of small mammals was greater at debris piles (9 species) than at reference sites in nearby areas without woody debris (4 species). On cobble bars, there was a greater abundance of small mammals at debris piles than at reference sites. We conclude that debris piles may provide valuable resources to both birds and small mammals particularly on otherwise barren cobble bars.

## Introduction

Rivers in the coastal forests of the Pacific Northwest region of North America transport considerable woody debris as logs, branches, and rootwads. During high flows, woody debris accumulates on gravel bars, on channel shores, in riparian forests, and even in upland forests where the channel has migrated suddenly (Bilby and Bisson 1998). Historically, debris has been an integral component of Pacific Northwest stream ecosystems (Gurnell et al. 1995). Archival records document streams that were filled with fallen trees and major river systems choked by driftwood dams (Harmon et al. 1986, Sedell et al. 1988). Debris deposition and accumulation continue to be fundamental processes in river ecosystems (Abbe et al. 1996, Bilby and Bisson 1998, Fetherston et al. 1995). Accumulations of woody debris provide potentially valuable resources for birds and small mammals in the riparian-river corridor.

Riparian areas are biologically diverse and support extensive bird and small mammal communities (Kelsey and West 1998, Lock and Naiman 1998, Raedeke 1988, Naiman and Décamps 1997). Although there is a vast literature describing the dependence of many species of birds and small mammals on downed wood in upland forests (Harmon et al. 1986, Maser and Sedell 1994), and the importance of coarse woody debris to streams and aquatic organisms (Bilby and Bisson 1998, Bisson et al. 1987, Harmon et al. 1986, Maser and Sedell 1994), the value of riverine wood as habitat for terrestrial organisms has been examined only once (Mason and Koon 1985). In the riparian-river corridor, woody debris piles may aggregate scarce food resources such as seeds, insects, and fungi and also provide shelter from predators and extreme environmental conditions (Mason and Koon 1985).

In this study, we describe riparian debris piles and their use by birds and small mammals along the Skykomish River, Washington. We examine the distribution and abundance of debris piles and compare their internal temperature regimes with the external environment. We compare the abundance and species richness of birds and small mammals between piles of different sizes, between old and newly-deposited piles, and between piles on exposed cobble bars and piles in forested areas to identify key features contributing to observed patterns. For small mammals, it is possible to document changes in the use of debris piles over the breeding season and to test the hypothesis that debris piles provide habitat that is preferable to the surrounding environment.

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## Methods

### Study Area

The North Fork of the Skykomish River drains the western slope of the Cascade Mountains in the State of Washington, USA (Figure 1). The 1.6 km study area is located on the southern bank of this fourth order river, 14.4 km northeast of the town of Index. Channel slope is 1.8% with a side slope gradient ranging from 40-80%, typical for the Pacific Northwest coastal ecoregion (Naiman et al. 1992). The Pacific Northwest coastal ecoregion is characterized by high flows during the rainy season, from October to January. These flow rates can be as much as 100 times the minimum flow during the dry season, from August to September. The meandering channel often changes course from year to year as a result of these dramatic fluctuations in flow and is marked by shifting cobble bars both on shore and within the channel. Woody debris piles are present on most cobble bars, in the riparian forest, and at the edges of the upland forest.

Where the river has cut into the bank it flows next to an established forest. There are two types of established forest at the study site: (1) predominantly 60 year-old, second-growth Douglas fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*) and (2) riparian forest composed predominantly of 40-year old red alder (*Alnus rubra*) and cottonwood (Populus trichocarpa) with western red cedar (*Thuja plicata*), silver fir (*Abies amabilis*), western hemlock, and bigleaf maple (*Acer macrophyllum*). Where the river is depositing material, there are newly formed cobble bars which support a young riparian for-

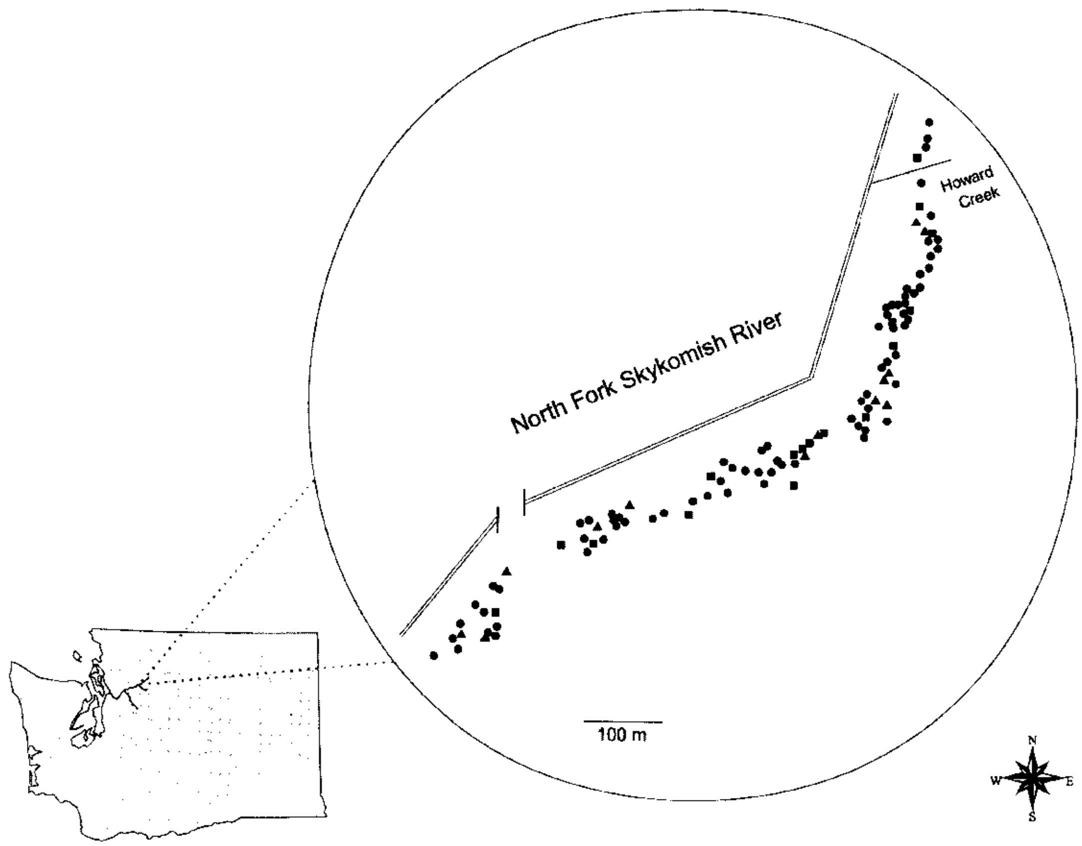


Figure 1. Study area, the North Fork Skykomish River, Washington State. Debris piles are indicated by dots. Debris piles included in the original 16-pile sample are indicated by squares. The 13 debris piles added for the final small mammal sampling are represented by triangles. The schematic includes a gap between two sampling areas, representing an unmapped 3 km portion of river.

est, composed mainly of 1 to 12 yr old red alder, willow (*Salix* sp.) and cottonwood.

In November and December, 1990, a series of three floods (approximate 40 yr recurrence interval) created new cobble bars and debris piles in the study area. We could distinguish newly deposited debris by the presence of green needles attached to the wood.

### Mapping and Sampling

All debris piles were mapped and sampled between January and November, 1991. For the purpose of this study, a debris pile is defined by two criteria. It must be composed of more than one piece of river-deposited wood and it must have dimensions greater than 1 x 3 m in area. All debris piles within 50 m of the active channel were mapped over a total distance of 1609 m (Figure 1). Length, width, maximum height, age, distance to water, substrate (soil or cobble) and distance to the edge of the forest were recorded for each debris pile. Age was categorized as new (deposited in 1990) or old (deposited before 1990). Pile size was approximated by the horizontal surface area of the debris pile.

In the spring, a stratified sample of 16 piles was selected according to pile age (old or new), location (forest = soil substrate or cobble bar = cobble substrate) and size. The stratification resulted in 2 each of the 8 possible pile types, i.e. small, old, forested piles or large, new piles on cobble bars. In the fall, an additional 13 piles were similarly selected to increase the sample size for the final small mammal trapping.

### Temperature Monitoring

Maximum-minimum thermometers were used to compare the thermal microclimate of the 16 original piles with ambient conditions. Thermometers, placed simultaneously inside and outside, were rotated between piles so that measurements were recorded at each debris pile for two 24-hr sampling periods in late August, early September and for two 24-hr periods in early November.

Temperature data were analyzed using paired t-tests to compare internal and external maximum and minimum daily temperatures (Zar 1984). Ecological systems are particularly variable systems; therefore, in these and subsequent statistical tests, P-values of $< 0.1$ were considered significant.

### Avifauna

Each of the original 16 debris piles were observed for 40, 15-min observation periods between 21 June and 4 July, resulting in a total of 160 hrs of observation. Observation periods for each pile were evenly distributed from dawn until dusk. Birds were visually identified to species and their activities were recorded. Up to two activities were recorded for each bird observed on a debris pile. Bird use of debris piles was defined as landing on the pile or on an associated snag. An individual bird's location was noted as being on a perch, on the main surface of the debris pile, inside the debris pile, or on an associated snag. All birds seen or heard during the surveys but which were not using the debris piles were also identified and recorded.

### Small Mammals

Spring and Fall Trapping: Two pitfall traps and two Sherman live traps were placed at each of the original 16 debris piles. The traps were set over six nights between 22-30 April and, again, over six nights between 29 August and 11 September. Sherman live traps were baited with oats and ground beef. Most animals were captured alive.

Final Trapping: Two pitfall traps, two Sherman live traps and two snap traps were placed at each of 29 debris piles, for a total of 174 traps. Traps were left open from 5-8 November. They were checked and rebaited once a day.

For the final trapping, one reference site was added for each debris pile. The reference site was an area at least 10 m from the pile and physically similar to the area of the pile but without woody debris. Similarity was based on percent forest cover, substrate, distance to the water, and overstory species composition. One pitfall trap, one Sherman live trap, and one snap trap were placed at each reference site, for a total of 87 traps.

We cut tail hairs, used eartags where possible, or removed a patch of dark outer hair to identify previously captured individuals. Mammals were identified to species in the field if captured alive or by the Burke Museum staff, University of Washington, if captured dead. Tail length was used to differentiate between deer mice (*Peromyscus* *maniculatus*; ≤ 96 mm) and forest deer mice (*Peromyscus keeni*; > 96 mm) (Hogan et al. 1993). Juveniles and *Peromyscus* for whom accurate identification was not possible were classified as *Peromyscus* sp. (Gunn and Greenbaum 1986). Other common and scientific names are from Jones et al. (1992).

Data are presented as total number of individuals per species and as catch per unit effort (CPUE), the estimated capture rate for one trap per 100 trap nights. CPUE was calculated following Nelson and Clark (1973):

$$CPUE= A \times 100 / (TU - IS/2)$$

Where: A = number of animals captured, I = length of trapping interval, S = number of traps snapped, TU = P x I x N, P = number of trapping intervals, and N = number of traps. Estimates of CPUE may be conservative compared to those of other authors because we classified only those traps closed due to the capture of an animal as snapped.

We compared CPUE, and species richness between piles of different ages, sizes, and locations using Wilcoxon rank sum tests. We also used linear regression to test whether distance of a debris pile from the forest was a significant predictor of small mammal CPUE or richness. CPUE comparisons between debris piles and reference sites used permutation tests for the mean of two paired samples (Good 1994).

## Results

### Pile Distribution

A total of 106 piles were mapped along the 1609 m of study area, resulting in a density of one debris pile per 15 m of riverbank (Figure 1). Debris piles covered areas ranging from 3 $m^2$ to 530 $m^2$ ($\mu$= 26.2 $m^2$, $\sigma^2$= 17.5) and were clustered at the upstream end of cobble bars and within the associated riparian forest. The largest piles were on cobble bars ($p$=0.05) and tended to be washed up against a patch of riparian forest. In some cases, vegetation growing within and directly upstream of the oldest piles was > 30 yrs old.

### Internal Pile Temperature

The average maximum daily temperature was 3.2°C cooler inside the piles than outside ($p$<0.001). Although the average daily minimum temperature inside the piles was 0.3°C warmer than outside, this trend was not statistically significant.

### Avifauna Use Patterns

A total of 125 observations of birds using debris piles (16 species) were recorded during the study period (Table 1A). American robin was the most abundant, accounting for 43% of the observations. Swainson's thrush (11%), dark-eyed junco (9%), rough-winged swallow (6%), hairy woodpecker (5%), empidonax flycatcher (5%), and Steller's jay (4%) accounted for the majority of the other observations. Eight individuals (6%) were unidentified.

TABLE 1A: Bird species observed on a debris pile.

| Common Name | Scientific Name | Feeding Guild |
|---|---|---|
| Swainson's Thrush | *Catharus guttatus* | OGF |
| Steller's Jay | *Cyanocitta stelleri* | OGF |
| Dark-eyed Junco | *Junco hyemalis* | OGF |
| White-crowned Sparrow | *Zonotrichia leucophrys* | OGF |
| Rough-winged Swallow | *Stelgidopteryx serripennis* | IAS/IASc |
| Epidonax Flycatcher | *Empidonax* sp. | IAS/IASc |
| Western Tanager | *Piranga ludoviciana* | IAS/IASc |
| Cedar Waxwing | *Bombycilla cedrorum* | IAS/IASc |
| Winter Wren | *Troglodytes troglodytes* | IGG |
| Varied Thrush | *Ixoreus naevius* | IGG |
| Calliope Hummingbird | *Stellula calliope* | OFHG |
| Rufous Hummingbird | *Selasphorus rufus* | OFHG |
| American Robin | *Turdus migratorius* | OLCF |
| Black-throated Gray Warbler | *Dendroica nigrescens* | ILCG |
| Hairy Woodpecker | *Picoides villosus* | IBG |
| Belted Kingfisher | *Ceryle alcyon* | PWP |

Eleven species were seen or heard in the study area but never observed on the piles (Table 1B). These include Golden-crowned Kinglet, Yellow Warbler, Yellow-rumped Warbler, Mountain Chickadee, Vaux's Swift, Western Wood Pewee, Spotted Sandpiper, Lincoln's Sparrow, Bald Eagle, Red-tailed Hawk, and Common Merganser.

The majority of bird activities (54%) at debris piles required only the physical structure of the debris pile, for example perching or hawking. In nearly one fifth of the activities, birds were observed

TABLE 1B. Bird species heard during surveys but never observed on a debris pile

| Common Name | Scientific Name | Feeding Guild |
|---|---|---|
| Golden-crowned Kinglet | *Regulus satrapa* | ILCG |
| Yellow Warbler | *Dendroica petechia* | LCG |
| Yellow-rumped Warbler | *Dendroica coronata* | LCG |
| Chickadee | *Parus gambeli* | ILCG |
| Vaux's Swift | *Chaetura vauxi* | IASc |
| Western Wood Pewee | *Contopus sordidulus* | IAS |
| Spotted Sandpiper | *Actitis macularia* | ISG |
| Lincoln's Sparrow | *Melospiza lincolnii* | OGF |
| Bald Eagle | *Haliaeetus leucocephalus* | CGS |
| Red-tailed Hawk | *Buteo jamaicensis* | CGH |
| Common Merganser | *Mergus merganser* | PFD |

Key to guild abbreviations: CGH = carnivore, ground hawker; CGS = carnivore, ground scavenger; IAS = insectivore, air sallier; IASc = insectivore, air screener; IBG = insectivore, bark gleaner; IGG = insectivore, ground gleaner; ILCG = insectivore, lower-canopy gleaner; ISG = insectivore, shoreline gleaner; OGF = omnivore, ground forager; OFHG = omnivore, floral hover-gleaner; OLCF = omnivore, lower canopy forager; PFD = piscivore, water foot-plunger; PWP = piscivore, water-plunger (modified from De Graaf et al. 1985).

simply to perch on the highest branches. Birds were also observed eating, foraging, singing, calling, and chasing. Fifteen percent of the activities included entering inside debris piles.

## Small Mammal Use Patterns

### *Spring and Fall Trapping*

The total number of mammals caught ($p$=0.02) and species richness ($p$<0.01), at each pile, increased significantly from spring to fall (Table 2).

### *Final trapping*

Nine small mammal species were captured in the debris piles compared to four at the reference sites (Table 3). Over all sites, species richness was significantly higher at the debris piles than at the reference sites ($p$=0.02). At sites on the cobble bars, there was a significantly higher CPUE for total small mammals at debris piles than at reference sites ($p$=0.02) (Table 4).

Comparing patterns between different types of piles, the only significant finding was between new and old debris piles. There were significantly more mammals caught at new debris piles than at old debris piles ($p$=0.06). This trend appears to be driven by *Peromyscus keeni* which was significantly more abundant at new than at old debris piles ($p$=0.07 when abundance at new versus old debris piles is compared for *P. keeni* alone). New debris piles also had a significantly higher species richness than did old debris piles ($p$=0.08).

TABLE 2. Small mammals captured at debris piles in the spring and fall surveys by absolute number and catch per unit effort (CPUE).

| | Spring | | Fall | |
|---|---|---|---|---|
| Species | Number | CPUE | Number | CPUE |
| *Peromyscus maniculatus* | 6 | 3.4 | 12 | 7.6 |
| *Peromyscus keeni* | 13 | 7.3 | 13 | 8.2 |
| *Peromyscus* spp. | 1 | 1.1 | 3 | 1.9 |
| *Sorex trowbridgii* | 8 | 2.2 | 12 | 3.4 |
| *Sorex monticolus* | 2 | 0.5 | 6 | 1.7 |
| *Sorex palustris* | | | 1 | 0.3 |
| *Sorex* spp. | | | 3 | 0.9 |
| *Microtus longicaudus* | 1 | 0.6 | 1 | 0.6 |
| *Microtus oregoni* | | | 1 | 0.6 |
| *Microtus* spp. | | | 2 | 1.3 |
| *Neurotrichus gibbsii* | | | 2 | 0.6 |
| *Zapus trinotatus* | | | 5 | 3.2 |
| Total | 31 | 15.0 | 61 | 30.1 |

TABLE 3. Small mammals captured at debris piles and reference sites by absolute number and catch per unit effort (CPUE). CPUE calculated for all piles together.

| | Debris Pile | | Reference Site | |
|---|---|---|---|---|
| Species | Number | CPUE | Number | CPUE |
| *Peromyscus maniculatus* | 10 | 2.2 | 5 | 2.2 |
| *Peromyscus keeni* | 6 | 1.3 | 4 | 1.8 |
| *Peromyscus* spp. | 1 | 0.2 | | |
| *Sorex trowbridgii* | 6 | 0.9 | 1 | 0.3 |
| *Sorex monticolus* | 2 | 0.3 | 1 | 0.3 |
| *Sorex palustris* | 1 | 0.2 | | |
| *Microtus longicaudus* | 3 | 0.7 | | |
| *Microtus oregoni* | 1 | 0.2 | | |
| *Neurotrichus gibbsii* | 1 | 0.2 | | |
| *Scapanus orarius* | 1 | 0.2 | | |
| Total | 32 | 6.3 | 11 | 4.6 |

TABLE 4. Mean catch per unit effort (CPUE) of small mammals by genera for debris piles and reference sites on the cobble bar and in the forest.

| Genus | Cobble Bar Debris Piles | Cobble Bar Reference Sites | Forest Debris Piles | Forest Reference Sites |
|---|---|---|---|---|
| *Peromyscus* | 8.0 | 3.9 | 4.1 | 9.5 |
| *Sorex* | 1.6 | 0.0 | 2.7 | 1.5 |
| *Microtus* | 2.7 | 0.0 | 0.0 | 0.0 |
| Total | 12.3 | 3.9 | 6.8 | 11.0 |

Size was not a significant indicator of debris pile habitat value. The smallest debris piles, <10 $m^2$, were used by small mammals as frequently as the largest piles, >100 $m^2$. Small mammals were captured at debris piles as far as 107 m from the forest edge but distance from the forest was not a significant predictor of small mammal patterns.

## Discussion

Piles of riverine woody debris, deposited in the riparian zone, are a common, natural feature of Pacific Northwest ecosystems. Debris piles can be enormous, with a footprint of over 500 $m^2$, and, once established, may withstand large flood events and become long-term features of the riverine landscape. As indicated by location and age of current vegetation, many debris piles in this study are older than 30 yrs. These debris piles have internal temperatures that are cooler than the ambient environment and provide a physical structure that enables resting and hawking by many species of birds. Small mammals were captured at debris piles in both the spring and fall, confirming that these piles are used by small mammals over the breeding season. Capture rates were higher at debris piles than at similar reference sites on the cobble bars suggesting that they might be important habitat components worthy of further investigation.

Despite their barren appearance, cobble bars are plentiful sources of insects (Rector 1991) and birds or small mammals may use debris piles to take advantage of these food resources. The physical structure of woody debris might even increase the availability of food resources, such as fungi, insects, and seeds, on the cobble bars. Debris is often ripe with fungal spores when initially deposited (Shearer and Von Bodman 1983) and these fungal colonies may grow and flourish over time. The availability of insects can be enhanced by the presence of debris piles. For example, insect populations recover from disturbances more quickly in the presence of woody debris (Anderson 1992). And, the piles create wind eddies that may aid in depositing airborne fungal sporocarps, and light seeds (Mason and Koon 1985).

### The Use of Debris Piles by Avifauna

The physical structure of debris piles was used by a variety of avian species. Over 16 species of birds were observed landing on the debris piles (Table 1A). Many other species of birds were observed or heard in the study area but were never seen using the debris piles (Table 1B). Overall, 57% of the species detected within the study area were observed on the debris piles.

Whether or not an individual from a particular species was observed on a debris pile could often be explained by functional feeding guild (Table 1). Of the species heard in the area but not seen on a debris pile, 33% belonged to feeding guilds never observed using debris piles (insectivorous shoreline gleaner, carnivorous ground scavenger, carnivorous ground hawker, piscivorous water foot-plunger). Another 33% were insectivorous canopy-gleaners. Only one insectivorous canopy-gleaner, a black-throated-gray warbler, was observed on a debris pile.

Birds used the debris piles for a variety of common activities. The majority of bird use required only the physical structure of the debris. These activities included perching, hawking, and hopping. Other observed activities were territorial; birds sang, called, and chased each other from perch to perch. Foraging was observed in some cases but the food itself could not be identified. A few birds were also observed entering inside the debris piles. The use of the internal space is interesting because, previous to this study, bird use of similar internal environments has not been well-documented.

### The Use of Debris Piles by Small Mammals

Over all three surveys, capture rates at debris piles were higher than those reported by McComb et al. (1993) for riparian forests in the Oregon coastal forests. Data from the spring and fall surveys display an increase in both species richness and abundance over the summer months. This change