

**Decomposition of Different Wood Species in Tenderfoot Creek, Michigan**

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## Abstract

*Decomposition rates of six riparian wood species [speckled alder (*Alnus rugosa*), quaking aspen (*Populus tremuloides*), sugar maple (*Acer saccharum*), eastern hemlock (*Tsuga canadensis*), eastern white pine (*Pinus strobus*) and balsam fir (*Abies balsamea*)] were studied in a Michigan stream. In June 2000, dried wood samples (~12 cm in length) of each species were tethered to bricks and placed in the stream. Amount of mass lost and macroinvertebrate colonization were measured after 11, 22, 33, and 46 days. The greatest amount of decay occurred between days 33 and 46, with species having total mass losses between 3.81% to 6.66%. Sugar maple was the only species to show a significantly lower decomposition rate than the other species studied. Macroinvertebrate colonization was dominated by midge larvae (Diptera: Chironomidae) and net-spinning caddisflies (Trichoptera: Hydropsychidae), with abundances of 44% and 31% respectively, of the total species identified. My hypothesis that the conifer species would decompose faster than the deciduous species did not prove correct. I would have expected conifers to be slower, due chemicals.*

## Introduction

Throughout the year, allochthonous inputs, such as leaf litter, woody debris, and other coarse particulate organic matter (CPOM) contribute to the heterotrophic production of the streams they enter. CPOM input is important because heterotrophic production requires a source of non-living organic matter as well as the presence of microorganisms to break down that matter and release its stored energy (Allen, 1995). Leaf litter has been cited as the major source of allochthonous input in most streams, and therefore the processing and breakdown of leaves has been the focus of most studies conducted in the last few decades (e.g. Anderson and Sedell, 1979; Maloney and Lamberti, 1995). In contrast, the decomposition of woody debris in stream ecosystems has received relatively less attention. Studies show that in some coniferous forests, wood comprises 70% of annual detritus input and in deciduous forests anywhere from 15-49% (Anderson and Sedell, 1979). Understanding the role of woody debris in a stream habitat is essential because it is basic to the dynamics of the stream ecosystem. Not only does debris create habitat for aquatic organisms that contribute to the processing of its

material, but during breakdown the debris also provides a source of fine detritus that is utilized by downstream consumer communities (Melillo *et al.*, 1983).

I studied the decomposition of six species of wood in a northern Michigan stream that obtains woody debris from riparian stands of these species. The objective of the study was to determine the rate of decomposition for each of the different wood species. I also quantified the macroinvertebrates that colonized the different species in order to determine if their presence contributed to decomposition. Although wood decomposes rather slowly, I hypothesized that the conifers, or softwoods, would decompose at a faster rate than the deciduous species, due to the harsh chemicals, such as terpenes, that would inhibit decomposition. I also hypothesized that a greater number of macroinvertebrates would colonize the conifer species, which would contribute to rapid decomposition.

### **Materials and Methods**

**Study Site.**-- The study was conducted in Tenderfoot Creek, a stream located in the western half of the Upper Peninsula of Michigan. The stream is an outflow of Tenderfoot Lake, which lies partly on the property of the University of Notre Dame Environmental Research Center (UNDERC). Tenderfoot Creek flows north through the UNDERC property and then joins the Ontonagon River, which empties into Lake Superior. The experiment was conducted 3 km downstream of Tenderfoot Lake. At the study site the stream was 6 m wide and had an average water depth of 0.45 m. The mean temperature of the water during June and July was 22°C.

The riparian vegetation of Tenderfoot Creek provided a very limited canopy for the stream, as it was dominated by young trees and shrubs (Maloney and Lamberti,

1994). The wood species used for the study were all common to the stream's riparian zone, and were collected within 30 m of the creek. The species studied were speckled alder (*Alnus rugosa*), quaking aspen (*Populus tremuloides*), sugar maple (*Acer saccharum*), eastern hemlock (*Tsuga canadensis*), eastern white pine (*Pinus strobus*), and balsam fir (*Abies balsamea*). Dead wood was collected from the ground directly below trees that were located in monotypic stands to ensure that the wood was properly identified and not mistaken for another species. Only branches with a diameter of 1.5-2.5 cm were collected.

**Experimental Design.**-- The wood was cut into lengths of 12 cm using a handsaw, and dried at 105°C for 24 h. A hole was then drilled into each end of each length so it could be tethered to a brick using fishing line. Before being anchored to the brick each length was weighed ( $\pm 0.1$  g) and marked. Each brick supported one replicate of each of the six wood species. The species were tethered to the brick in a random order to minimize position effects. A total of 25 bricks was placed midstream in a randomized block design on 4 June 2000. Five random bricks were removed from the water on days 11, 22, 33 and 46. To remove each individual sample, the brick was kept underwater while the fishing line was cut and the wood sample was caught in an aquarium net held directly downstream of the brick, so as to minimize the loss of macroinvertebrates. Care was taken to keep the bricks as steady as possible to prevent the larger invertebrates from entering the drift or moving to another species of wood. The samples were placed in sealed plastic bags and kept on ice until processed

**Sample Processing.**-- Each wood sample was removed from its plastic bag and rinsed over a 250- $\mu$ m sieve to remove the macroinvertebrates. After rinsing, the wood

sample was closely examined under a light and all remaining macroinvertebrates were removed with forceps. Care was taken not to remove any bark or pieces of wood that might be loosely attached to the wood samples. The macroinvertebrates were preserved in 95% ethanol and later counted and identified to genus (or in some cases to family). Only macroinvertebrates from days 11, 22, and 33 were analyzed.

The wood samples were dried at 105° C for 24 h and then weighed. Amount of wood decomposition of each species at each time period was determined with the mean percent decrease in mass of the five replicates. A two-way analysis of variance (ANOVA) followed by a pairwise multiple comparison (Tukey Test) was used to determine if there were any statistically significant differences in decomposition rates among the six species of wood.

## **Results**

After 46 days in Tenderfoot Creek, a significant difference was found in the percentage of mass remaining of the six species of wood ( $P= 0.002$ ) and in the rate of decomposition ( $P< 0.001$ ) between time periods (Table 1). Sugar maple was the only species to show a significantly lower rate of decomposition than other species. Tukey's test indicated that sugar maple decomposed significantly less than speckled alder ( $P= 0.003$ ), balsam fir ( $P= 0.020$ ), and quaking aspen ( $P= 0.026$ ). All other species of wood decomposed at relatively similar rates (Figure 1).

There was no substantial loss of mass by any of the species during the first 33 days in the stream (Figure 1). It was not until the last two weeks that the wood began to decompose significantly. By day 46 quaking aspen had decomposed by 6.66%, balsam

fir by 6.31%, speckled alder by 5.98%, eastern hemlock by 4.50%, and white pine by 4.38%, while sugar maple had the least amount of decomposition with only a 3.81% loss of its original mass (Figure 2).

Macroinvertebrates that colonized the decomposing wood samples were dominated by midge larvae (Diptera: Chironomidae) and net-spinning caddisflies (Trichoptera: Hydropsychidae). Of all macroinvertebrates collected, midge larvae constituted 44% and caddisflies 31% of the total (Table 2). Numbers of macroinvertebrates per sample varied over time. Absolute numbers found per species of wood at each sampling increased over time, with day 33 having the greatest abundance (Figure 3).

## **Discussion**

Woody debris is among the most important allochthonous inputs to streams, but its decomposition has received very little attention in studies of the dynamics of coarse particulate organic matter. Rather, most studies have focused on leaf litter decomposition. Studies on wood decomposition are probably rare because wood decays at rates much slower than leaves, and much more time would have to be dedicated to determine accurate decomposition rates. For example, Maloney and Lamberti (1995) studied summer decomposition rates of leaves in Tenderfoot Creek, and recorded mass losses from no less than 40% up to 100% in a time span of only 42 days. In the same amount of time, wood decomposed 10%.

Despite the slow decay rate of wood debris, I expected to see noticeable differences among the species studied. More specifically, I hypothesized that the conifers

would decompose slower than would the deciduous species, because of chemical compounds in conifers that could inhibit decay. However, I did not find a difference in the rates of decomposition between these two types of wood. The only species to show a significantly lower rate of decomposition was sugar maple, a deciduous species. The species that had the highest rate of decomposition was quaking aspen, also a deciduous tree. Because the decomposition of all the conifer species fell somewhere in between these two I can't draw any conclusions about the soft and hard woods. Other studies that were carried out over a longer period of time found a difference between the decay rates of conifer and deciduous wood types. Melillo *et al.* (1983) found that wood debris of the deciduous trees studied decomposed at higher rates than the conifer species studied, what I would have expected to see given the nasty chemicals in conifers that impede decay, as well as discourage wood-eating pests when the trees are alive. One aspect of my study was consistent with that conducted by Melillo *et al.* (1983). They found that that alder decomposed faster than aspen, which decomposed faster than balsam fir, which is the same order of decomposition found in my study.

Chironomid larvae and hydropsychid caddisflies dominated the benthic macroinvertebrates colonizing the wood samples. Of the macroinvertebrates found, most are common either year-round or in warmer weather, with a majority of them emerging in summer months (Hilsenhoff, 1995). Many of the macroinvertebrates identified were also defined by their associations with wood debris, not for consumption but rather as a place to feed on algae and other small prey (Hilsenhoff, 1995). The role of invertebrates in the processing of wood is mostly indirect. As they feed on algal growth or bore into the wood, they expose more surface area to microbial colonization and to the abrasion of the

stream (Anderson and Sedell, 1979). It is difficult to say if macroinvertebrates contributed to the decomposition of the wood because few significant differences were found among decay rates of wood species. Also, no relationship was found between numbers of macroinvertebrates colonizing a sample or of preference of macroinvertebrates to colonize a certain wood species. This is not surprising because it was calculated that only 1% of the decay of woody debris in a year could be attributed to invertebrates, whereas in studies of leaf litter, macroinvertebrate consumption accounts for up to 20% of the annual degradation of leaf detritus (Anderson and Sedell, 1979). Due to the short length of this study it would be tenuous to calculate how important macroinvertebrate colonization really was.

The decomposition of wood in a stream is a very slow process that is hard to describe adequately in a short period of time. Further studies in this area should try to measure decomposition over longer periods of time, as well as find factors other than macroinvertebrate colonization that might contribute to wood decay.

| Source of Variance | DF  | SS      | MS     | F      | P      |
|--------------------|-----|---------|--------|--------|--------|
| Wood Type          | 5   | 50.987  | 10.197 | 4.026  | 0.002  |
| Day                | 3   | 83.412  | 27.804 | 10.978 | <0.001 |
| Wood Type x Day    | 15  | 31.477  | 2.098  | 0.829  | 0.644  |
| Residual           | 96  | 243.133 | 2.533  |        |        |
| Total              | 119 | 409.009 | 3.437  |        |        |

Table 1. Results of a two-way analysis of variance (ANOVA) comparing decomposition rates among wood types and amount of time spent in Tenderfoot Creek. Both wood type and amount of time spent in the stream showed significant differences between species.

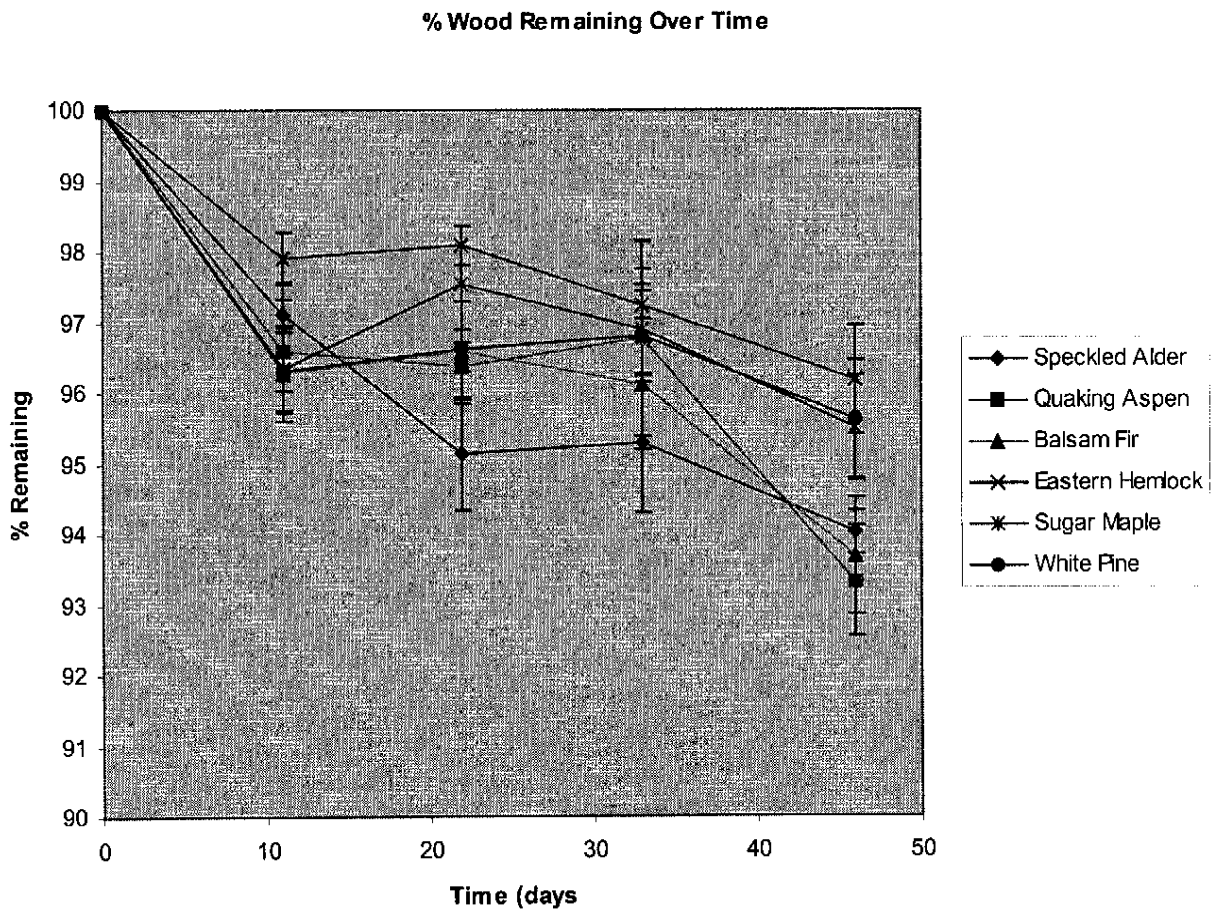
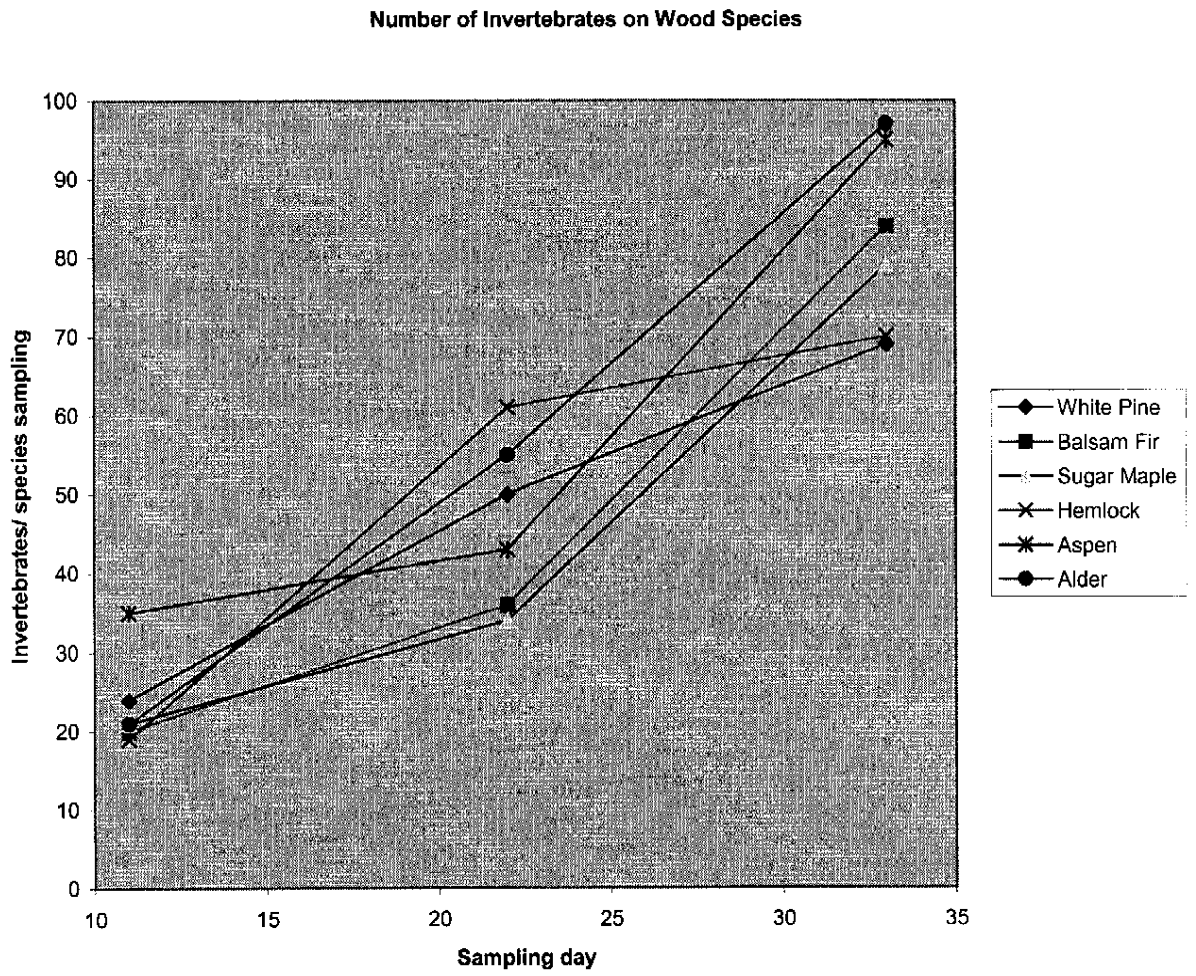


Figure 1. Decomposition of six wood species over a 46-day period. Error bars indicate 1 SE.

**Table 2.** Average number of macroinvertebrates of different genera per wood sample (cm<sup>3</sup>) over all three sampling periods.

| <b>Taxon</b>             | <b>Maple</b> | <b>Hemlock</b> | <b>Alder</b> | <b>Aspen</b> | <b>White Pine</b> | <b>Balsam Fir</b> |
|--------------------------|--------------|----------------|--------------|--------------|-------------------|-------------------|
| <b>Plecoptera</b>        |              |                |              |              |                   |                   |
| <b>Perlidae</b>          |              |                |              |              |                   |                   |
| <i>Acroneuria</i>        | 1.2          | 0.8            | 0.5          | 2.1          | 1.2               | 0.7               |
| <b>Ephemeroptera</b>     |              |                |              |              |                   |                   |
| <b>Heptageniidae</b>     |              |                |              |              |                   |                   |
| <i>Stenonema</i>         | 1.0          | 1.0            | 0.2          | 0.4          | 0.5               | 0.6               |
| <b>Isonychiidae</b>      |              |                |              |              |                   |                   |
| <i>Isonychia</i>         | 0.1          | 0.1            | 0.1          | 0.0          | 0.0               | 0.1               |
| <b>Baetidae</b>          |              |                |              |              |                   |                   |
| <i>Paracloeodus</i>      | 0.1          | 0.1            | 0.0          | 0.2          | 0.0               | 0.1               |
| <i>Baetis</i>            | 0.0          | 0.1            | 0.2          | 0.1          | 0.1               | 0.2               |
| <b>Ephemerellidae</b>    |              |                |              |              |                   |                   |
| <i>Serratella</i>        | 0.0          | 0.3            | 0.3          | 0.1          | 0.1               | 0.0               |
| <b>Leptohyphidae</b>     |              |                |              |              |                   |                   |
| <i>Tricorythodes</i>     | 0.0          | 0.0            | 0.1          | 0.0          | 0.0               | 0.0               |
| <b>Trichoptera</b>       |              |                |              |              |                   |                   |
| <b>Hydropsychidae</b>    |              |                |              |              |                   |                   |
| <i>Hydropsyche</i>       | 3.3          | 3.8            | 3.5          | 2.4          | 2.9               | 3.0               |
| <i>Cheumatopsyche</i>    | 0.1          | 0.0            | 0.0          | 0.1          | 0.0               | 0.0               |
| <b>Glossosomatidae</b>   |              |                |              |              |                   |                   |
| <i>Glossosoma</i>        | 0.2          | 0.1            | 0.1          | 0.1          | 0.4               | 0.1               |
| <b>Polycentropodidae</b> |              |                |              |              |                   |                   |
| <i>Polycentropus</i>     | 0.1          | 0.0            | 0.3          | 0.0          | 0.1               | 0.1               |
| <b>Coleoptera</b>        |              |                |              |              |                   |                   |
| <b>Elmidae (adult)</b>   |              |                |              |              |                   |                   |
|                          | 0.1          | 0.0            | 0.0          | 0.0          | 0.0               | 0.1               |
| <b>Elmidea (larve)</b>   |              |                |              |              |                   |                   |
|                          | 0.0          | 0.1            | 0.1          | 0.0          | 0.1               | 0.1               |
| <b>Hydrophilidae</b>     |              |                |              |              |                   |                   |
|                          | 0.0          | 0.0            | 0.0          | 0.0          | 0.1               | 0.0               |
| <b>Diptera</b>           |              |                |              |              |                   |                   |
| <b>Chironomidae</b>      |              |                |              |              |                   |                   |
|                          | 4.0          | 3.5            | 4.9          | 6.1          | 4.0               | 4.1               |
| <b>Odonota</b>           |              |                |              |              |                   |                   |
| <b>Aeshnidae</b>         |              |                |              |              |                   |                   |
|                          | 0.0          | 0.0            | 0.0          | 0.1          | 0.0               | 0.1               |
| <b>Gomphidae</b>         |              |                |              |              |                   |                   |
|                          | 0.0          | 0.1            | 0.0          | 0.1          | 0.0               | 0.0               |
| <b>Macromiidae</b>       |              |                |              |              |                   |                   |
|                          | 0.0          | 0.0            | 0.0          | 0.1          | 0.0               | 0.0               |
| <b>Megaloptera</b>       |              |                |              |              |                   |                   |
| <b>Corydalidae</b>       |              |                |              |              |                   |                   |
| <i>Chauliales</i>        | 0.1          | 0.1            | 0.0          | 0.0          | 0.0               | 0.1               |
| <b>TOTAL</b>             | <b>10.3</b>  | <b>10.0</b>    | <b>10.3</b>  | <b>11.9</b>  | <b>9.5</b>        | <b>9.4</b>        |

Figure 3. Average number of macroinvertebrates per wood species over time.



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