This is to certify that the
thesis entitled

HEADWATER RIPARIAN INVERTEBRATE COMMUNITY CHANGES IN RESPONSE TO RED ALDER STAND COMPOSITION IN SOUTHEASTERN ALASKA

presented by

Christian Michael LeSage

has been accepted towards fulfillment
of the requirements for the

M.S. degree in Entomology

Richard W. Merritt
Major Professor's Signature

December 9, 2003
Date

**PLACE IN RETURN BOX** to remove this checkout from your record.
**TO AVOID FINES** return on or before date due.
**MAY BE RECALLED** with earlier due date if requested.

| DATE DUE | DATE DUE | DATE DUE |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

# HEADWATER RIPARIAN INVERTEBRATE COMMUNITY CHANGES IN RESPONSE TO RED ALDER STAND COMPOSITION IN SOUTHEASTERN ALASKA

By

Christian Michael LeSage

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Entomology

2003

# ABSTRACT

## HEADWATER RIPARIAN INVERTEBRATE COMMUNITY CHANGES IN RESPONSE TO RED ALDER STAND COMPOSITION IN SOUTHEASTERN ALASKA

By

Christian Michael LeSage

The objective of this study was to assess how management strategies of young upland forests in southeastern Alaska affect riparian invertebrate abundance, thus influencing food abundance for fish and wildlife. Southeastern Alaska forests are dominated by coniferous trees including Sitka spruce (*Picea sitchensis* (Bong.) Carr.), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), with mixed stands of red cedar (*Thuja plicata* Donn.). Red alder (*Alnus rubra* Bong.) is hypothesized to influence the productivity of young-growth conifer forests and through forest management may provide increased riparian invertebrate abundance. To assess invertebrate densities between coniferous and alder riparian habitats, leaf litter and wood debris samples were collected from eleven headwater streams on Prince of Wales Island, Alaska, during the summers of 2000 and 2001. The Acari and Collembola were the most abundant taxa collected in leaf litter. Alder litter had significantly higher mean taxa richness than conifer litter. The Acari were the most abundant group collected on wood debris. Alder wood had significantly higher mean taxa richness and biomass than conifer wood. Alder wood debris in more advanced decay stages had the highest mean taxa richness and biomass compared to the other wood debris types, while conifer late decay wood debris had the highest densities of invertebrates. The presence of alder in young-growth conifer forests appears to increase taxa richness and biomass of riparian forest invertebrates.

I dedicate this thesis to my loving parents and sister who helped me in many ways throughout my master's project and were always there for me. I also dedicate this to my beautiful little girl, Claudia Judith LeSage, who was the inspiration during all the difficult times.

# ACKNOWLEDGEMENTS

I would like to thank the Michigan State University Department of Entomology for the opportunity to enhance my education, and my committee members Dr. E. D. Walker, Dr. M. S. Wipfli, Dr. K. C. Cummins, and Dr. R. W. Merritt who provided excellent guidance throughout the course. I also thank Paul Hennon, Dave Gregovich, John Sigmar, Osvaldo Hernandez, and Ryan Kimbirauskas for assistance with field work, Bridget Vanden Eeden for help with biomass calculations, Dr. M. E. Benbow for assistance with statistics and manuscript editing, and the Merritt lab for other numerous tasks. I also want to thank Kendra Cheruvelil who introduced me to Dr. Merritt and provided assistance throughout my whole graduate experience. I thank Dr. Richard J. Snider, Dr. Martin Berg and Mr. Gary Parsons for their assistance with invertebrate identification. I would also like to thank the Department of Entomology who funded my tuition and living expenses, in part, while at Michigan State University. This research was funded by the Wood Compatibility Initiative (WCI), USDA Pacific Northwest Research Station, Portland, OR. Lastly, I would like to thank the Pacific Northwest Research Station, USDA Forest Service, Juneau, AK 99801 USA, for research funding and other logistical support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

# HEADWATER RIPARIAN INVERTEBRATE COMMUNITY CHANGES IN RESPONSE TO RED ALDER STAND COMPOSITION IN SOUTHEASTERN ALASKA

## INTRODUCTION

Southeast Alaska forests are dominated by coniferous trees, primarily Sitka spruce (*Picea sitchensis* (Bong.) Carr.), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), western red cedar (*Thuja plicata* Donn), and Alaska yellow-cedar (*Chamaecyparis nootkatensis* (D. Don) Spach). Red alder (*Alnus rubra* Bong.) frequently regenerates in these stands following disturbances, such as timber harvesting or landslides. Forest landscape management has been historically directed toward the harvest of Sitka spruce and western hemlock through clear-cutting (USDA 1997). Forest clear-cutting involves the removal of all standing timber on a section of land and can lead to the regeneration of an even-aged stand. These stands eventually become dense and can have negative effects on fish and wildlife (Wallmo and Schoen 1980; Schoen *et al.* 1981, 1988; Thedinga *et al.* 1989). Even-aged stands eventually prevent other vegetation from becoming established through canopy closure, and may completely eliminate understory vegetation for up to 100 yr (Alaback 1982, 1984; Tappeiner and Alaback 1989).

It has been documented that young-growth red alder may provide many benefits to the forest ecosystem, including more diverse vegetative understory (Hanley and Hoel 1996; Deal 1997), increased habitat quality for small mammals (Hanley 1996), and increased forage for herbivores such as deer and arthropods. Red alder is a deciduous tree that may benefit floodplain and stream ecosystems by increasing soil nitrogen content through nitrogen fixation, and by providing greater structural diversity than homogeneous conifer stands (Deal 1997). Red alder is a pioneer species that is shade intolerant and usually dies standing, thus producing woody debris, such as branches, twigs, logs, and standing dead trees, which are known to have ecological importance to terrestrial and aquatic ecosystems (Triska and Cromack 1980; Benke *et al.* 1985; McCinn 1993; Bragg and Kershner 1999; Braccia and Batzer 2001; Wipfli *et al.* 2003). Woodland floodplains may serve as temporary storage areas for leaf litter detritus, before it enters streams or rivers (Merritt and Lawson 1992; Cummins *et al.* 1989).

Small headwater streams drain the natural and harvested landscapes of southeastern Alaska, and timber harvesting eliminates a potential source of large woody debris into these streams. Many aquatic macroinvertebrates and fish depend on this woody debris (Dudley and Anderson 1982; Duncan and Brusven 1985; Wallace *et al.* 1999), which provides habitat (Hunt 1975; Sedell and Triska 1975; Anderson *et al.* 1978; Neilsen 1992; Wipfli *et al.* 2003), and can enhance channel morphology as well as sediment and water routing (Keller and Swanson 1979; Bilby and Likens 1980). The river continuum concept proposed that riparian zones influence the regulation of energy flow and nutrient cycling in forested headwater streams (Vannote *et al.* 1980; Ward *et al.* 1998). Wipfli and Gregovich (2002) reported that small headwater streams in southeast Alaska are potentially important to downstream salmonids, and Piccolo and Wipfli (2002) found over half of the prey biomass consumed by juvenile salmonids was terrestrial, originating from adjacent riparian habitat. Forest landscape management techniques affect both the forest and aquatic resources (USDA 1997); thus, forest managers are interested in finding compatible new techniques for managing the forested watersheds. According to Wipfli et al. (2002), information about red alder and its ecological role in southeastern Alaska is lacking, and most information about this species is based on research from other regions.

The focus of this study was to compare and contrast riparian invertebrate communities within mixed coniferous and red alder forests across a 0 – 55% basal area alder gradient (Table 1). Red alder has been hypothesized to influence young-growth conifer forest productivity and other forest ecosystem resources (Wipfli *et al.* 2002, 2003). Past forest management practices included thinning red alder from riparian and upland forest stands in an effort to enhance conifer productivity; however, the inclusion of red alder in young-growth conifer forests may increase the abundance of both riparian invertebrate abundance and aquatic and terrestrial invertebrates as well (Wipfli *et al.* 2003). An increase in invertebrate abundance and diversity is expected to benefit the forest ecosystem by providing more food for birds, bats, and downstream fish (Wipfli *et al.* 2002).

My overall objectives were to: 1) compare taxa richness, density, and biomass of riparian invertebrate communities associated with red alder and conifer leaf litter along headwater streams; and 2) compare taxa richness, density, and biomass of invertebrate communities associated with different decay classes (early or late) of red alder and conifer woody debris in riparian areas along headwater streams. I tested the null hypothesis that red alder and conifer leaf litter and woody debris would not differ in invertebrate taxa richness, densities, and biomass.

## METHODS

This study was conducted in the Maybeso Experimental Forest on Prince of Wales Island, southeastern Alaska (132°67'W, 55°49'N) located within the Tongass

National Forest (Figure 1). Southeastern Alaska supports a temperate rainforest which has a maritime climate, moderate temperatures, and high amounts of annual precipitation (that can exceed 500 cm per year) (Harris *et al.* 1974). The Maybeso Experimental Forest was clear-cut during the 1950's and management practices in the forest allowed red alder to grow uninhibited.

I sampled riparian zones of 10 headwater streams in the Maybeso Experimental Forest and one headwater stream in the adjacent Harris River catchment in conifer stands with 0 – 55% by basal area or 1 – 82% by canopy cover of red alder (Table 1). Streamside vegetation methods for alder basal area and percent canopy coverage were those described in Wipfli et. al. (2002). Each sampling site was one 150 m transect divided into five 30 m sections. One leaf litter sample was collected from three of the five sections randomly in 2000 and 2001. Three and four sections were randomly selected for woody debris sampling in 2000 and 2001, respectively.

Leaf Litter

Thirty-three leaf litter samples were collected within 1 m of the stream's edge during June and July of 2000 and 2001 (total of 66 samples) at random distances within each segment. A stovepipe core sampler (0.15 m diam.) was used to enclose each litter sample. Samples were placed into Zip lock© bags and processed in the lab within hours of collection. Invertebrates were initially separated from the litter using a Berlese funnel, and then hand sorted under magnification to collect invertebrates not separated using the funnel. Invertebrates were preserved in 80% ethanol, their body lengths measured to the nearest millimeter (excluding antennae and cerci), counted, and identified to the lowest practical taxonomic unit using Borrer *et al.* (1996), Stehr (1987, 1991), Christiansen and Bellinger (1981) and McAlpine *et al.* (1981, 1987, 1989). Invertebrate taxa richness was expressed as numbers of taxa per sample. The area of the grab sample was estimated using the equation for a circle, and invertebrate density ($\# \cdot m^{-2}$) and biomass ($mg \cdot m^{-2}$) were calculated. Invertebrate dry biomass was estimated using taxon-specific length regression equations (Rogers *et al.* 1977; Smock 1980; Sample *et. al.* 1993; Hodar 1996; Benke *et. al.* 1999). Non-animal litter components were picked and separated into alder and conifer. Each component was dried in an oven at 42°C for 24 h and weighed to quantify the dominant litter type.

Wood Debris

Wood debris samples were sorted into decay classes (early and late) and by type (alder and conifer) for a total of four classes (alder early, alder late, conifer early, and conifer late). Wood debris decay class determination was based on three criteria: amount of bark, amount of decay, and friability. Wood debris samples that were too large to fit into a 26 cm x 28 cm Zip lock© bag were cut to fit using a handsaw, and a Zip lock© bag was placed over one end to catch any dislodged invertebrates during the cutting process. Invertebrates were washed from wood samples into a five-gallon bucket with a pressurized backpack sprayer. Each wood piece was carefully dissected and visually inspected to remove all invertebrates that were not removed by pressure washing. A 250-micron sieve was used to separate the sample, and it was then placed into a 250 ml Whirlpak® bag, preserved with 80% ethanol, and picked under 10X magnification. Invertebrates were processed, identified, measured, and dry mass was computed in the same manner as those for leaf litter. Richness was expressed as numbers of taxa per sample, regardless of wood size. Wood surface area was estimated from length (13.9– 35.0 cm range) and diameter (1.8– 9.8 cm range) using the equation for surface area of a cylinder, and invertebrate density ($\# \cdot m^{-2}$) and biomass ($mg \cdot m^{-2}$) were calculated.

Density and biomass data were $\log_{10}(x + 1)$ transformed to overcome non-normal distributions. Data collected from both year's sampling events (2000 and 2001) were combined in order to increase sample size for each sample type. Multiple T-tests and ANOVAs were generated to contrast taxa richness, density, and biomass between litter types (alder or conifer) and among wood debris taxon-age classes (early and late decay for both alder and conifer) (SAS Institute 1996). Following a significant ANOVA ($p < 0.05$), a Tukey's Studentized Range (HSD) post-hoc test was used to compare means. Correlation analyses were performed using percent alder basal area and percent alder canopy cover to test for a treatment effect of alder on litter and woody debris samples. All graphs and tables are presented using nontransformed data.

## RESULTS

### Leaf Litter

A total of 50 taxa representing 15 orders and 24 families were collected from riparian leaf litter samples (Table 2). A similar number of invertebrate taxa were collected in alder (40) and conifer (39) leaf litter (Table 2). The majority of invertebrates collected in litter samples were collected in both types, although a few were only collected in one litter type. Because more invertebrates were associated with red alder leaf litter on average, mean taxa richness was significantly higher in alder litter ($p < 0.05$) compared to conifer litter (Figure 2a). Invertebrates commonly collected in leaf litter were Oligochaeta, Acari, Collembola, Coleoptera, and Diptera (Table 2, Figure 3).

Invertebrate mean densities were similar for both litter types (Table 3, Figure 2b). Acari, and Collembola were the most abundant taxa collected in leaf litter, and together comprised more than 60% of the leaf litter invertebrate community (Figure 3). Riparian invertebrate biomass was not significantly different between alder and conifer litter types (Figure 2c). The Oligochaeta were the dominant biomass component and contributed nearly 40 % for each type of litter (Table 3, Figure 4). Other groups contributing to leaf litter biomass included: Coleoptera, Diptera, Acari, Chilopoda and Diplopoda.

As the percentage of riparian alder increased, there was no correlation in litter samples between the percent of alder basal area or percent canopy cover in any attribute (taxa richness, density, or biomass).

Wood Debris

A total of 47 taxa representing 16 orders and 29 families were collected from riparian wood debris samples (Table 2). More invertebrates were associated with conifer wood debris (40) than alder wood (32), and nearly all invertebrates collected on wood debris were associated with late decay wood (Table 2). There were more taxa associated with late decay conifer wood (39) than late decay alder wood (31), and the lowest number of taxa were associated with early decay wood (Table 2).

Even though more riparian invertebrate taxa were associated with conifer wood, alder wood had significantly higher ($p < 0.05$) mean taxa richness on a per sample basis

(Figure 5a). Late decay wood had significantly higher taxa richness ($p < 0.05$) than early decay wood (Figure 6a). Invertebrates commonly associated with riparian wood debris included: Acari, Collembola, and Diptera (Table 3, Figure 7).

Mean densities for late decay wood were significantly higher ($p < 0.05$) than for early decay wood debris (Figure 6b). Invertebrate densities were similar between late decay alder wood and conifer wood; however, conifer late decay wood had higher densities. Early decay conifer had the lowest invertebrate densities. The dominant taxon collected in all wood debris samples was Acari, which comprised more than 50% of the total density for each wood type (Table 3, Figure 7). Acari, Collembola and Diptera were the most abundant taxa collected in wood debris, and together comprised more than 90% of the invertebrate community (Figures 7 and 8).

Riparian invertebrate biomass was significantly different between wood decay classes ($p < 0.05$) and wood types ($p < 0.05$) (Figures 5c and 6c). The highest invertebrate biomass was found in late decay alder wood and lowest in early decay conifer wood. Groups largely contributing to wood debris biomass included Acari, Diploda, Chilopoda, Coleoptera and Diptera (Figures 9 and 10).

There was no correlation in wood debris samples between the percent of alder basal area or percent canopy cover in any attribute (taxa richness, density, or biomass), as the percentage of stream alder increased.

## DISCUSSION

### Leaf Litter

Although there were similarities between invertebrates associated with both litter types, alder litter had significantly greater taxa richness than conifer litter (Table 2 and Figure 2a). The occurrence of red alder along these young-growth coniferous-dominated streams may provide more variety in terms of forage base for riparian invertebrates to utilize. These findings agreed with Wipfli et al. (2003) who suggested that because alder detritus decays faster than conifer, it is a more desirable food source for invertebrates. In a study conducted in some of the same headwater streams and adjacent watersheds (Prince of Wales, Alaska), Hernandez (2001) found streams with an alder-dominated young-growth riparian vegetation had a richer, more diverse fauna with higher macroinvertebrate densities. Even though taxa richness in riparian alder litter was significantly higher in this study, densities were not different between litter types.

Riparian leaf litter invertebrate densities and biomass were similar between alder and conifer litter types (Figures 2b and 2c). Because Acari and Collembola were percentage wise the most abundant invertebrates in both litter types, it would be reasonable to assume that densities would also be similar for both litter types. Other studies have also documented the dominant role of Acari and Collembola in leaf litter. Hutchens and Wallace (2002) compared invertebrate assemblages and leaf litter breakdown in streams, banks, and uplands along two southern Appalachian headwater streams. They found that Acari were the dominant noninsect group in bank and upland habitats, and Collembola were the dominant insect group comprising these two habitats. Kaczmarek (1977) studied the role of Collembola in different habitats in two forest types (43-year-old pine forest and deciduous forest) and found Collembolan numbers and biomass were higher in the deciduous forest compared to the pine forest. In contrast, my data showed higher numbers of Collembola in conifer versus alder litter, although I recorded higher Collembola biomass in alder litter compared to conifer litter.

Oligochaeta were common in riparian leaf litter samples as well. Both litter types had high densities of Oligochaeta (Table 3, Figure 3) which have been estimated to consume up to 93.8% of the total annual leaf fall on a Michigan woodland floodplain (Knollenberg, Merritt, and Lawson 1985). The Oligochaeta were the dominant biomass component in this study and contributed nearly 40 % for each litter substrate (Figure 4). Other groups contributing to leaf litter biomass included: Coleoptera, Diptera, Acari, Chilopoda and Diplopoda.

The Coleoptera (17) and Diptera (10) represented the highest diversity of invertebrates collected from riparian litter (Table 2). Three tipulid (Diptera) genera (*Limonia sp., Molophilus sp.,* and *Pedicia sp.*) were collected in riparian leaf litter samples; the latter being the most commonly collected. Tipulids have been shown to be a very diverse group associated with litter in floodplain habitats (Merritt and Lawson 1977). The dipteran families Cecidomyiidae and Sciaridae were the most numerous for both litter sample types. Cecidomyiidae has been associated with living and dead trees of different species, and Sciaridae have been associated with decaying wood as a herbivore, primarily feeding on fungus associated with decaying wood (Teskey 1976). The dipteran genus *Forcipomyia sp.* (Ceratopogonidae) was collected in several alder litter samples and Teskey (1976) described the association of some genera to moss associated with decaying wood, even though this genus was not collected in any of our wood debris samples.

Wood Debris

I observed differences in invertebrate communities associated with alder and conifer wood, and between early and late decay classes. Overall, there were more taxonomic groups collected on conifer wood than alder wood, however, on average alder wood had higher numbers of taxa for any given decay stage (Table 2 and Figures 5a , 6a). Late decay wood had significantly higher invertebrate taxa richness than early decay wood, which is in agreement Braccia and Batzer (2001) who reported an increase in invertebrate richness as wood decayed along streams in South Carolina.

Late decay wood also had significantly higher densities than early decay wood, and late decay conifer had the highest mean invertebrate densities overall. This may be a response to a higher number of cracks and crevices associated with conifer decay processes, providing increased refugia for invertebrates (Wipfli *et al.* 2003) or possibly due to greater food availability as the decay process progresses.

Acari and Collembola were the most abundant groups on conifer wood debris in the study. Abbott and Crossley (1982) also observed that these two groups were the dominant taxa of decaying wood in North Carolina. Diptera densities were higher than Collembola for both alder wood decay types.

Higher numbers of Diptera subsequently resulted in significantly higher invertebrate biomass between wood and decay types. Diptera was the dominant component in biomass for both alder decay types comprising 31% for early decay and 40% for late decay. In contrast, Braccia and Batzer (2001) found little evidence that invertebrate density or biomass was affected by woody debris decay classes in a southeastern forested floodplain wetland in South Carolina.

Previous studies have documented the important role that invertebrates play in woody debris decomposition in uplands, and invertebrate density and diversity have been found to increase in woody debris as it decays (Abbott and Crossley 1982; Irmler *et al.* 1996). I also found this relationship to be true in riparian wood debris samples in this study. Riparian late decay wood had significantly higher invertebrate taxa richness, densities, and biomass than early decay wood, regardless of type. Riparian alder wood debris contributed to significantly higher invertebrate taxa richness and invertebrate biomass along southeast Alaskan headwater streams.

In terms of diversity, the orders Diptera (14) and Coleoptera (9) had the most representatives collected from riparian wood debris (Table 2), which is in agreement with the findings of Braccia and Batzer (2001). Members of the dipteran family Cecidomyiidae were the most numerous in all samples including litter, a group that is associated with many species of living and dead trees (Teskey 1976). Sciaridae (Diptera) also were abundant in all samples except early decay alder, and these two dipteran families have been associated with the fungi of decaying wood (Teskey 1976). The family Tipulidae (Diptera) was more abundant in wood debris than in litter samples, but only two genera (*Limonia sp.* and *Pedcia sp.*) were collected in association with wood debris. There were several dipteran families collected in alder wood debris that were not collected in litter, and their associations with decayed wood have been mainly anecdotal (Teskey 1976). These included larvae of *Cramptonomyia spenceri* (Pachyneuridae) which has been found associated with decaying alder (Vockeroth 1974); *Symmerus cogulus* (Mycetophilidae) associated with decaying wood (Munroe 1974); and

*Xylophagous sp.* (Xylophagidae) that are predators recorded from decaying wood (Teskey 1976).

The only occurrence of the chironomids, *Boreochlus sp.* and *Krenopelopia sp.*, were collected on a single late decay conifer piece which also had other midge genera (*Metriocnemus sp.* and *Paraphaenocladius sp.*). The latter genera accounted for nearly all of the Chironomidae collected in the study, and Teskey (1976) reported members of this genus colonizing damp, decaying alder in well-shaded forests of British Columbia, Canada. However, I collected *Paraphaenocladius sp.* in all samples, including alder and conifer wood debris and litter samples.

I collected a rare representative, or possibly an undescribed species, of *Caurinus sp.* (Mecoptera) which has been found associated with both late decay wood types and recorded from moist forested sites (Russell 1979).

## CONCLUSION

The results of this study showed that a riparian component of red alder provided a richer, more diverse riparian invertebrate community with higher standing crop biomass than riparian zones without an alder component. Small headwater streams dissect the landscape of southeastern Alaska and these forested streams form an arterial network of pathways that are influenced by riparian vegetative cover that in turn influence larger downstream ecosystems. Riparian forest landscapes can influence stream allochthonous inputs as well as provide critical habitat for terrestrial invertebrates which fall prey to fish, particularly juvenile salmonids (Piccolo and Wipfli 2002).

These results support the importance of providing a red alder component to the young-growth upland forests of Prince of Wales Island and perhaps to other similar watersheds. Increasing or promoting red alder should benefit riparian invertebrate richness, diversity, and biomass through the colonization of riparian wood and litter, and lead to a potential increase in a terrestrial invertebrate food source for downstream salmonids. Wipfli and Gregovich (2002) indicated that the biomass of flying insects, consisting primarily of Diptera, Lepidoptera and Plecoptera, significantly increased in stream drift as the percent basal area of red alder increased along riparian zones. Although this study did not find the same relationship with regard to increased litter and wood invertebrates with increased percent of basal alder, it did demonstrate that the mere presence of riparian alder can increase riparian invertebrate richness, diversity and biomass that could contribute to increased production that may be realized by higher trophic levels.

Table 1. Riparian forest red alder percentages of headwater streams of Maybeso Experimental Forest and adjacent Harris River watershed Prince of Wales Island, Alaska.

| Study site* | Basal Area (% red alder)[1] | Canopy Cover (% red alder)[2] |
|---|---|---|
| Big Spruce | 31.5 | 66.3 |
| Broken Bridge East | 47.3 | 80.7 |
| Broken Bridge West | 38.7 | 82.4 |
| Brushy | 53.3 | 66.0 |
| Cedar 1 | 35.6 | 73.4 |
| Cedar 2 | 3.8 | 22.0 |
| Gomi | 25.0 | 60.4 |
| Lost Bob | 0.0 | 1.4 |
| Upper Good Example | 1.5 | 11.4 |
| Upper Morning | 3.9 | 12.9 |
| Mile 22 | 29.2 | 59.2 |

*sites and methods as described in Wipfli et al. 2002

[1]percent red alder as a proportion of total stand basal area

[2]percent canopy cover based on viewing tube

**Table 2. Invertebrates collected in various riparian litter and wood debris samples in Maybeso and Harris River catchments on Prince of Wales Island, Southeast Alaska**

| | | | | | | LEAF LITTER | | WOOD DEBRIS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Alder | | Conifer | |
| Phylum | Class | Order | Family | Genus | Species | Alder | Conifer | Early* | Late* | Early* | Late* |
| Tardigrada | | | | | | | | | | x | x |
| Annelida | | | | | | | | | | | |
| | Oligochaeta | | | | | x | x | | x | | x |
| Arthropoda | | | | | | | | | | | |
| | Arachnida | | | | | | | | | | |
| | | Araneae | | | | x | x | x | x | x | x |
| | | Opiliones | | | | x | x | x | x | | x |
| | | Acari | | | | x | x | x | x | x | x |
| | | Pseudoscorpiones | | | | x | x | x | x | x | x |
| | Copepoda | | | | | | | | | | x |
| | Malacostraca | | | | | | | | | | |
| | | Isopoda | | | | x | x | | x | | x |
| | Diplopoda | | | | | | | | | | |
| | | Polydesmida | | | | x | x | | | | |
| | | Julida | | | | x | x | x | x | x | x |
| | Chilopoda | | | | | | | | | | |
| | | Lithobiomorpha | | | | x | | x | | | |
| | | Geophilomorpha | | | | x | x | | | | x |
| | Pauropoda | | | | | | x | | | | |
| | Hexapoda | | | | | | | | | | |
| | | Collembola | | | | | | | | | |
| | | | Neanuridae | | | x | x | | x | x | x |
| | | | | *Morulina* | | | | | | | |
| | | | | *Neanura* | | | | | | | |
| | | | | *Brachystomella* | | x | x | x | x | x | x |
| | | | Onychiuridae | | | | | | | | |
| | | | | *Onychiurus* | | x | x | | x | | x |
| | | | Isotomidae | | | x | x | x | x | x | x |
| | | | Tomoceridae | | | x | x | x | x | | x |

Table 2. (cont'd)

| | | | | | | LEAF LITTER | | WOOD DEBRIS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Alder | | Conifer | |
| Phylum | Class | Order | Family | Genus | Species | Alder | Conifer | Early* | Late* | Early* | Late* |
| | | | | *Tomocerus* | *elongata* | | | | | | |
| | | | | *Tomocerus* | *sp.* | | | | | | |
| | | | Dicyrtomidae | | | | | | | | |
| | | | | *Ptenothrix* | *atra* | x | x | | x | x | x |
| | | Hemiptera | | | | x | | | | | |
| | | Homoptera | | | | | | | | | |
| | | | Aphididae | | | x | x | | x | | x |
| | | | Coccidae | | | x | x | | x | | x |
| | | Coleoptera | | | | | | | | | |
| | | | Carabidae | | | | | | | | |
| | | | | *Leistus* | *ferruginosus* | | | | | | x |
| | | | Ptiliidae | | | | | | | | |
| | | | | *Actidium* | *crotchianum* | x | x | | | | |
| | | | Leiodidae | | | | | | | | |
| | | | | *Agathidium* | | x | | | | | |
| | | | Scydmaenidae | | | | | | | | |
| | | | | *Lophiodes* | | x | | | | x | x |
| | | | Staphylinidae | | | | | | | | |
| | | | | *Batrisodes* | *albionicus* | | | | | | x |
| | | | | *Cupila* | *clavicornis* | | x | | | | x |
| | | | | *Lucifotychus* | | | x | | | | |
| | | | | *Megarthrus* | *pictus* | x | x | | | | |
| | | | | *Micropeplus* | *tesserula* | x | | | | | |
| | | | | *Phlaeopterus* | | | | | x | | |
| | | | | *Sonoma* | | x | | | | | |
| | | | | *Stenus* | *sp. 1* | | x | | | | |
| | | | | *Stenus* | *sp. 2* | | x | | | | |
| | | | | *Unknown* | | x | x | | x | x | |
| | | | Scarabaeidae | | | | | | | | |
| | | | | *Aegialia* | *cylindrica* | x | | | | | |
| | | | Byrrhidae | | | | | | | | |

**Table 2. (cont'd)**

| | | | | | | LEAF LITTER | | WOOD DEBRIS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Alder | | Conifer | |
| Phylum | Class | Order | Family | Genus | Species | Alder | Conifer | Early* | Late* | Early* | Late* |
| | | | | *Exomella* | *pleuralis* | x | | | x | | |
| | | | | *Lioligus* | *nitidus* | x | | | | | |
| | | | Elateridae | | | | | | | | |
| | | | | *Ctenicera* | | | | | x | | x |
| | | | Cantharidae | | | x | | | | | x |
| | | | Cerambycidae | | | | | x | | | |
| | | | Curculionidae | | | | x | | x | | |
| | | | | *Steremnius* | *carinatus* | | x | | | | |
| | | | | *Sthereus* | *horrideus* | | x | | | | |
| | | Mecoptera | | | | | | | | | |
| | | | Boreidae | | | | | | | | |
| | | | | *Caurinus* | | | | | x | | x |
| | | Diptera | | | | | | | | | |
| | | | Tipulidae | | | x | | | | x | |
| | | | | *Limonia* | | x | x | | x | | |
| | | | | *Molophilus* | | | x | | | | |
| | | | | *Pedicia* | | x | x | | x | | x |
| | | | Pachyneuridae | | | | | | | | |
| | | | | *Cramptonomyia* | *spenceri* | | | x | x | | |
| | | | Mycetophilidae | | | | | | | x | |
| | | | | *Symmerus* | *cogulus* | | | x | x | | |
| | | | Sciaridae | | | | x | x | x | x | x |
| | | | Cecidomyiidae | | | x | x | x | x | x | x |
| | | | Ceratopogonidae | | | | | | | | |
| | | | | *Forcipomyia* | | x | | | | | |
| | | | | *Probezzia* | | | | | | | x |
| | | | Chironomidae | | | | | | | | |
| | | | | *Boreochlus* | | | | | | | x |
| | | | | *Krenopelopia* | | | | | | | x |
| | | | | *Metriocnemus* | | | | x | x | x | x |
| | | | | *Paraphaenocladius* | | x | x | x | x | x | x |

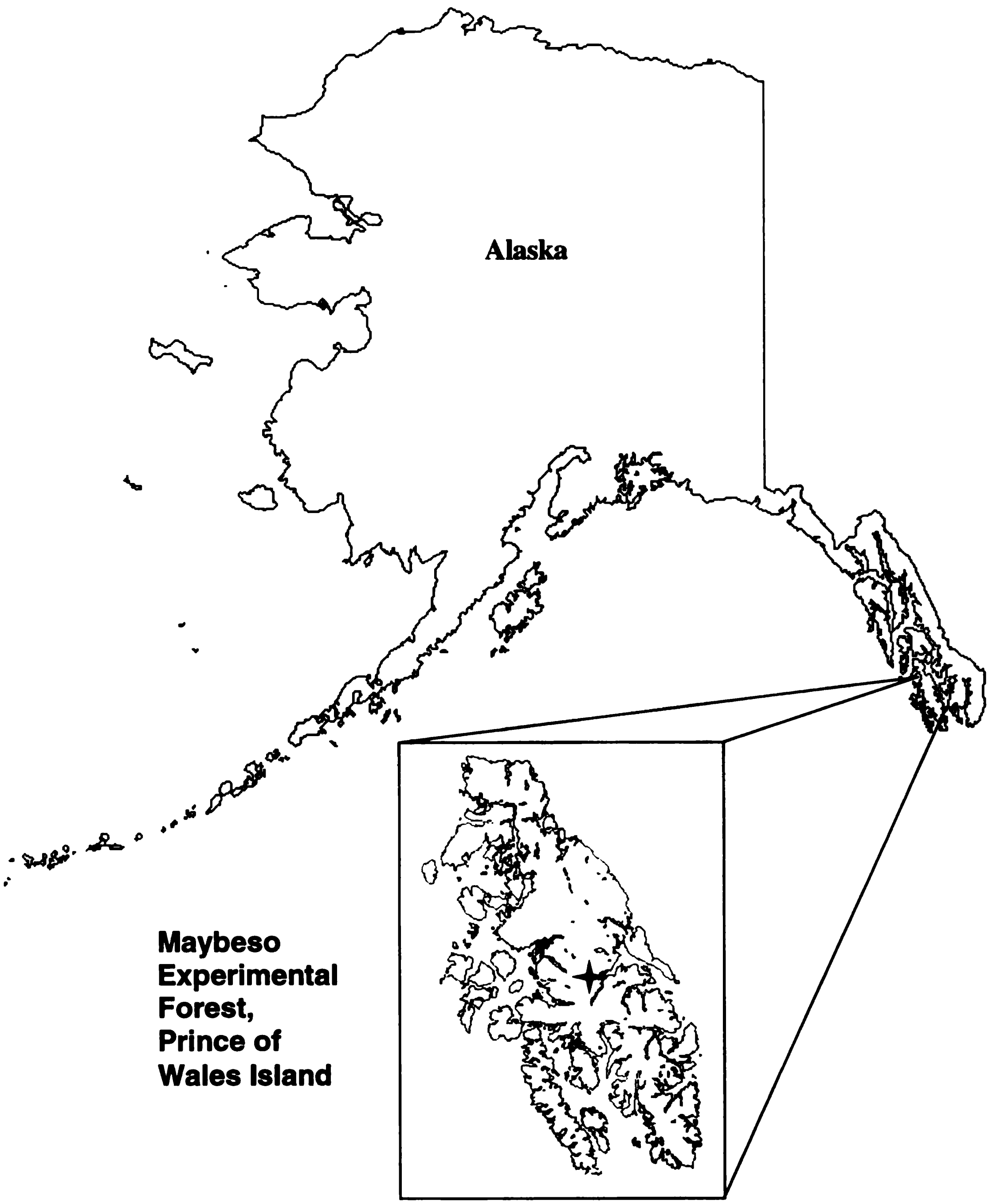
**Table 2. (cont'd)**

| | | | | | | LEAF LITTER | | WOOD DEBRIS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Alder | | Conifer | |
| Phylum | Class | Order | Family | Genus | Species | Alder | Conifer | Early* | Late* | Early* | Late* |
| | | | Xylophagidae | | | | | | | | |
| | | | | *Xylophagous* | | | | | x | | |
| | | | Empididae | | | | | x | | x | |
| | | | Platypezidae | | | x | | | | | |
| | | Lepidoptera | | | | | | | | | x |
| | | Hymenoptera | | | | | | | | | |
| | | | Diapriidae | | | x | x | | | | |
| | | | Formicidae | | | x | x | | | | x |
| | Gastropoda | | | | | | | | | | |
| | | | #1 | | | x | x | x | x | x | x |
| | | | #2 | | | x | x | x | x | x | x |
| **Total** | | | | | **65** | **40** | **39** | **20** | **31** | **20** | **38** |

* Early decay and late decay wood debris

Table 3. Riparian invertebrate density ($\# \cdot m^{-2}$) and dry biomass ($mg \cdot m^{-2}$) for select taxa collected along headwater streams of Maybeso Experimental Forest and adjacent Harris River watershed Prince of Wales Island, Alaska.

| | LEAF LITTER | | | | WOOD DEBRIS | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Alder | | | | Conifer | | | |
| | Alder | | Conifer | | Early Decay | | Late Decay | | Early Decay | | Late Decay | |
| TAXA | ($\# \cdot m^{-2}$) | ($mg\ m^{-2}$) | ($\# \cdot m^{-2}$) | ($mg\ m^{-2}$) | ($\# \cdot m^{-2}$) | ($mg\ m^{-2}$) | ($\# \cdot m^{-2}$) | ($mg\ m^{-2}$) | ($\# \cdot m^{-2}$) | ($mg\ m^{-2}$) | ($\# \cdot m^{-2}$) | ($mg\ m^{-2}$) |
| Acari | 1,050 | 44 | 1,034 | 53 | 892 | 43 | 1,930 | 94 | 707 | 28 | 2,850 | 126 |
| Collembola | 942 | 26 | 1,067 | 14 | 198 | 1 | 427 | 3 | 350 | 1 | 580 | 2 |
| Coleoptera | 125 | 107 | 50 | 53 | 21 | 54 | 29 | 123 | 6 | 1 | 23 | 59 |
| Diptera | 260 | 51 | 239 | 20 | 241 | 54 | 782 | 366 | 100 | 11 | 597 | 31 |
| Other | 198 | 159 | 153 | 74 | 46 | 19 | 284 | 319 | 29 | 11 | 161 | 235 |
| Totals | 3,151 | 653 | 3,146 | 610 | 1,398 | 172 | 3,452 | 905 | 1,193 | 52 | 4,212 | 453 |


Alaska
Maybeso Experimental Forest, Prince of Wales Island

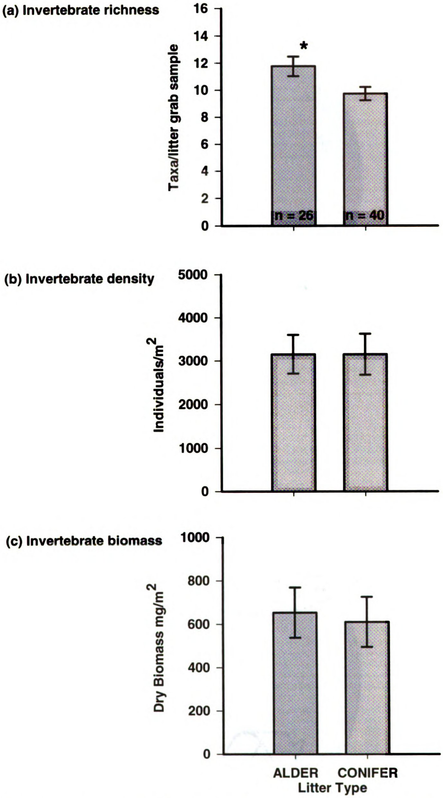



**Figure 2.** (a) Invertebrate taxa richness (number of distinct taxa/litter grab sample), (b) density (individuals/$m^2$), and (c) invertebrate dry biomass (mg/$m^2$) among leaf litter grab samples (error bars = +/-1 SE). Means with * are significantly different ($p<0.05$).

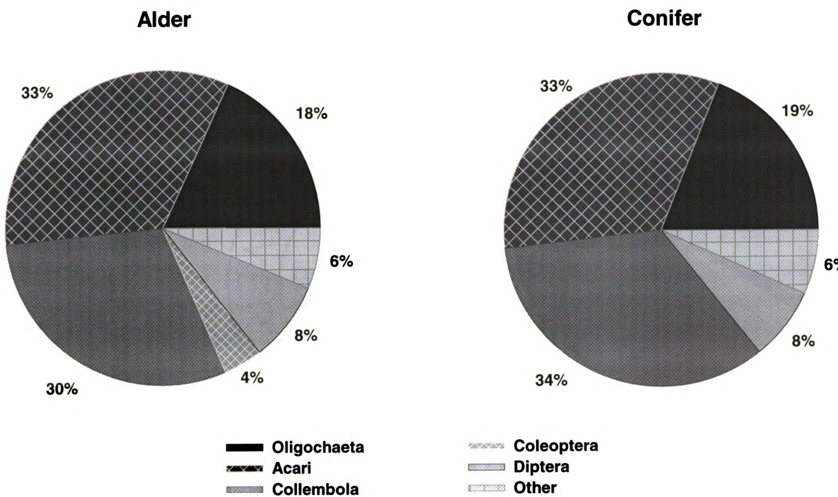



Figure 3. Percentage of invertebrates, based on densities, present among litter samples.

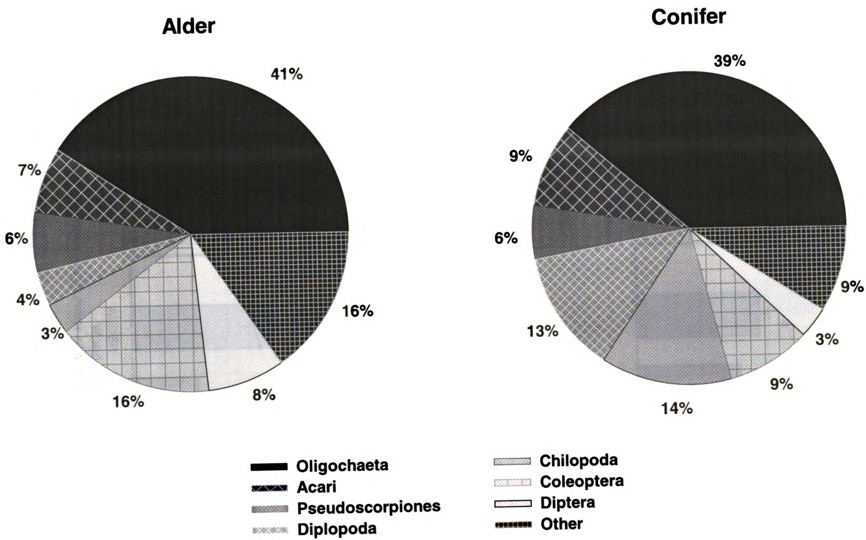



Figure 4. Percentage of invertebrates, based on dry biomass, present among litter samples.

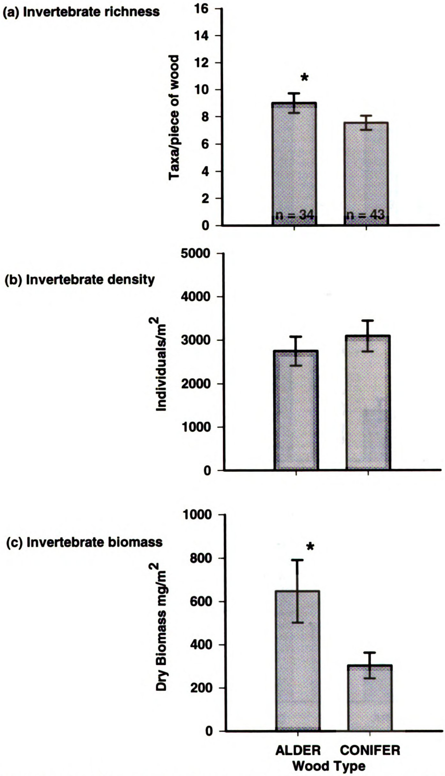



**Figure 5. (a) Invertebrate taxa richness (number of distinct taxa/piece of wood), (b) density (individuals/$m^2$), and (c) invertebrate dry biomass ($mg/m^2$) among wood debris samples (error bars = +/-1 SE). Means with * are significantly different ($p<0.05$).**

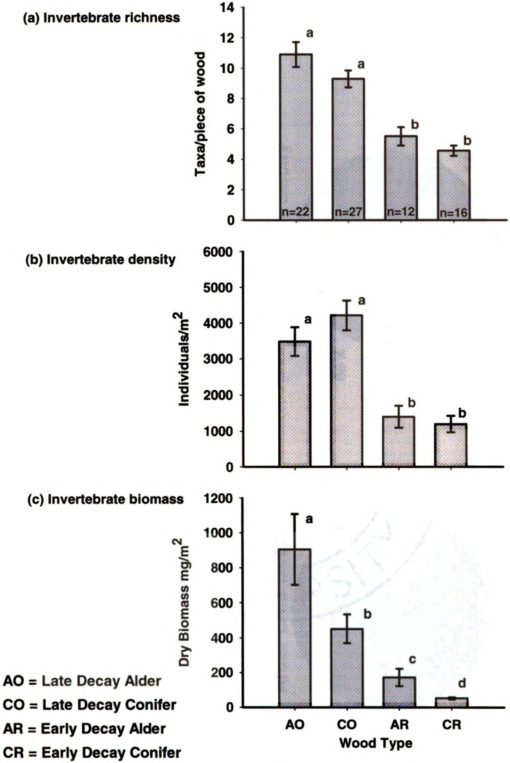



**Figure 6. (a) Invertebrate taxa richness (number of distinct taxa/wood debris sample), (b) density (individuals/$m^2$), and (c) invertebrate dry biomass (mg/$m^2$) among wood debris samples (error bars = +/-1 SE). Means with letters are significantly different ($p<0.05$).**

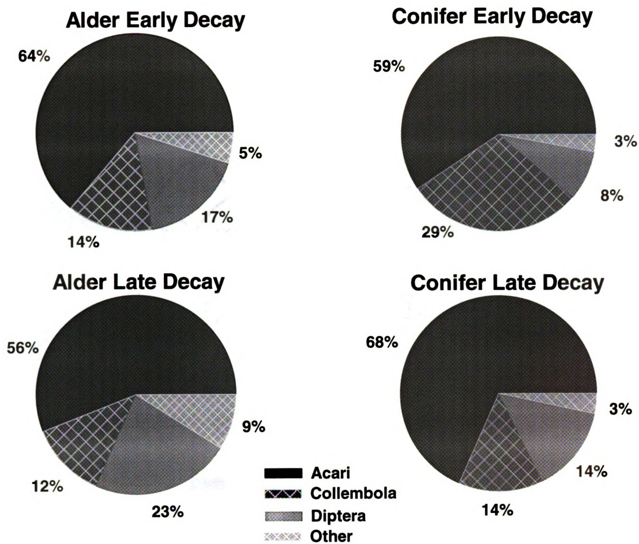



Figure 7. Percentage of invertebrates, based on densities, present among wood samples.

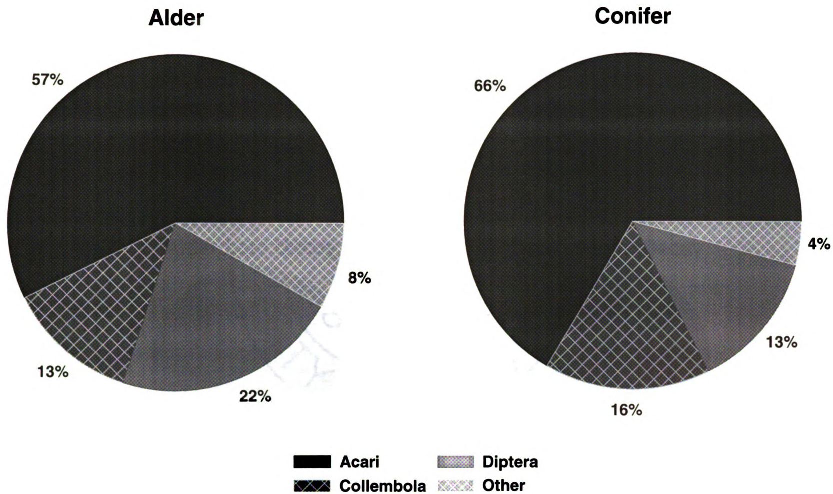



**Figure 8. Percentage of invertebrates, based on densities, present among wood debris samples.**

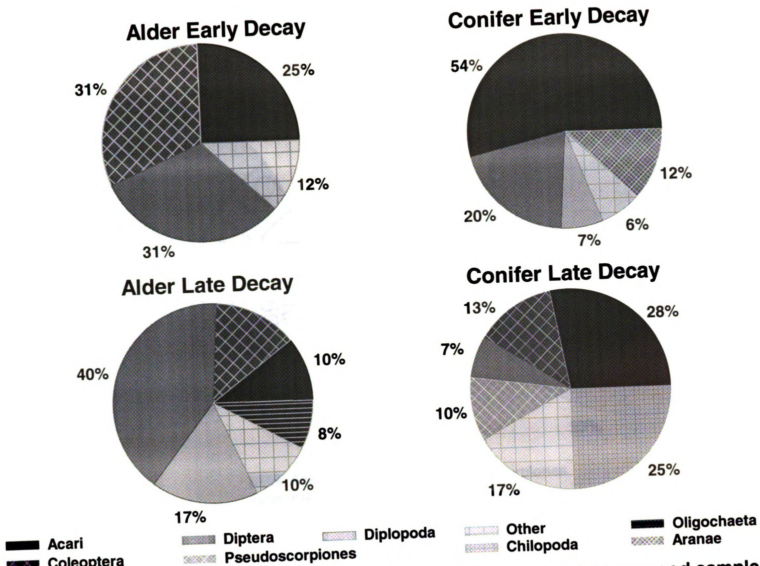



Figure 9. Percentage of invertebrates, based on dry biomass, present among wood samples.

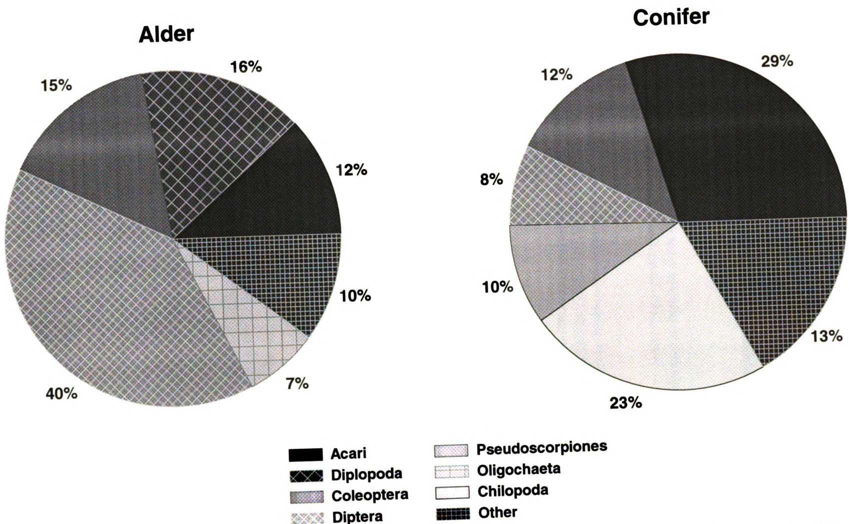



Figure 10. Percentage of invertebrates, based on dry biomass, present among wood debris samples.

# LITERATURE CITED

## Literature Cited


Abbott, D.T. and Crossley, D.A. 1982. Woody litter decomposition following clear-cutting. Ecology **63**: 35-42.

Alaback, P.B. 1982. Dynamics of understory biomass in Sitka spruce-western hemlock forests of Southeast Alaska. Ecology 63:1932-1948.

Alaback, P.B. 1984. Plant succession following logging in the Sitka spruce-western hemlock forests of Southeast Alaska: implications for management. General Technical Report PNW-173. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. 26 p.

Anderson, N.H., Sedell, J.R, Roberts, L.M. and Triska, F.J. 1978. The role of aquatic invertebrates in Processing of wood debris in coniferous forest streams. The American Midland Naturalist. 100(1): 64-82.

Arnett, R.H. 1968. The beetles of the United States (a manual for identification). Ann Arbor, Mich., American Entomological Institute. 1112 p.

Bilby, R.E. and Likens, G.E. 1980. Importance of organic debris dams in the structure and function of stream ecosystems. Ecology **61**: 1107-1113.

Benke, A.C, Henry, R.L., Gillespie, D.M. and Hunter, R.J. 1985. Importance of snag habitat for animal production in southeastern streams. Fisheries **10**: 8-13.

Benke, A.C., Huryn, A.D., Smock, L.A., and Wallace, J.B. 1999. Length-mass relationships for freshwater macroinvertebrates in North America with particular reference to southeastern United States. Journal of the North American Benthological Society **18**: 308-343.

Borror, D.J., Triplehorn, C.A., and Johnson, N.F. 1996. An introduction to the study of insects (6th ed.). Philadelphia : Saunders College Pub., 875 p.

Braccia, A., and Batzer, D.P., 2001. Invertebrates associated with woody debris in a southeastern U.S. forested floodplain wetland. Wetlands **21**: 18-31.

Bragg, D.C., and Kershner, J.L. 1999. Coarse woody debris in riparian zones. Journal of Forestry April: 30-35.

Christiansen, K. and Bellinger, P. 1981. The Collembola of North America north of the Rio Grande. Grinnell College. Grinnell, Iowa. 1322p.

Culp, J.M. and Davies, R.W. 1985. Responses of benthic macroinvertebrate species to manipulation of interstitial detritus in Carnation Creek, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences **42**: 139-146.

Cummins, K.W., Wilzbach, M.A., Gates, D.M., Perry, J.B., and Taliaferro, W.B. 1989. Shredders and riparian vegetation: leaf litter that falls into streams influences communities of stream invertebrates. Bioscience **39:** 24-30.

Deal, R.L. 1997. Understory plant diversity in riparian alder-conifer stands after logging in Southeast Alaska. Research Note PNW-RN-523. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. 8 p.

Dudley, T. and Anderson, N.H. 1982. A survey of invertebrates associated with wood debris in aquatic habitats. Melandria **39**: 1-21.

Duncan, W.F.A., and Brusven, M.A. 1985. Energy dynamics of three low-order southeast Alaska streams: Allochthonous Processes. J. Freshwater Ecol. 3(2): 223-248.

Hanley, T.A. 1996. Small mammals of even-aged, red alder-conifer forests in southeastern Alaska. Canadian Field-Naturalist 110:626-629.

Hanley, T.A., and Hoel, T. 1996. Species composition of old-growth and riparian Sitka spruce-western hemlock forests in southeastern Alaska. Canadian Journal of Forest Research 26:1703-1708.

Harris, A.S., Hutchinson, O.K., Meehan, W.R., Swanston, D.N., Helmers, A.E., Hendee, J.C., and Collins, T.M. 1974. The forest ecosystem of southeast Alaska1. The setting. USDA For. Serv. Gen. Tech. Rep. PNW-12.

Hernandez, O. 2001. Benthic invertebrate community structure as affected by forest succession after clear-cut logging on Prince of Wales Island, southeast Alaska. M.S. thesis, Michigan State University, East Lansing, Michigan.

Hodar J.A. 1996. The use of regression equations for estimation of arthropod biomass in ecological studies. Acta Oecologica **17**: 421-33.

Hutchens, J.J, and Wallace, J.B. 2002. Ecosystem linkages between southern Appalachian headwater streams and their banks: leaf litter breakdown and invertebrate assemblages. Ecosystems **5**: 80-91.

Hunt, R.L. 1975. Food relations and behavior of salmonid fishes. 6.1 Use of terrestrial invertebrates as food by salmonids. *In*: Coupling of land and water systems Vol 10 (Ed. Hassler, A.D.) New York: Springer-Verlag: 137-151.

Irmler, U., Heller, K., and Warning, J. 1996. Age and tree species as factors influencing the populations of insects living in dead wood (Coleoptera, Diptera: Sciaridae, Mycetophilidae). Pedobiologia **40**:134-148.

Kaczmarek, M. 1977. Comparison of the role of Collembola in different habitats. *In* Soil Organisms as Components of Ecosystems. Ecological Bulletin (Stockholm) **25**: 64-74.

Kawaguchi, Y., and Nakano, S. 2001. Contribution of terrestrial invertebrates to the annual resource budget for salmonids in forest and grassland reaches of a headwater stream. Freshwater Biology. **46**: 303-316.

Keller, E.A., and Swanson, F.J. 1979. Effects of large organic debris on channel form and fluvial process. Earth Surface Processess. 4: 361-380.

Knollenberg, W.G., Merritt, R.W., and Lawson, D.L. 1985. Consumption of leaf litter by lumbricus terrestris (Oligochaeta) on a Michigan Woodland Floodplain. The American Midland Naturalist **113**: 1-6.

McAlpine, J.F., Peterson, B.V., Shewell, G.E., Teskey, H.J., Vockeroth, J.R., and Wood, D.M. (eds.). 1981, 1987. Manual of Nearctic Diptera, Vol. 1 & 2. Research Branch, Agriculture Canada, Monographs 27 & 28.

McAlpine, J.F and D.M. Wood (eds.). 1989. Manual of Nearctic Diptera, Vol. 3. Research Branch, Agriculture Canada, Monograph 32.

McCinn, J.W. 1993. Proceedings of the workshop on coarse woody debris in southern forests: effects on biodiversity. USDA Forest Service, Southern Research Station, Athens, GA, USA. General Technical Report SE-94.

Merritt, R.W., and Lawson, D.L. 1981. Adult emergence patterns and species distribution and abundance of Tipulidae in three woodland floodplains. Environmental Entomology **10**: 915-921.

Merritt, R.W. and Cummins, K.W. (eds) 1996. An introduction to the aquatic insects of North America, 3rd ed. Kendall/Hunt, Dubuque IA.

Merritt, R.W., and Lawson, D.L. 1992. The role of leaf litter macroinvertebrates in stream-floodplain dynamics. Hydrobiologia **248**: 65-77.

Munroe, D. D. 1974. The systemics, phylogeny, and zoogeography of *Symmerus* Walker and *Australosymmerus* Freeman (Diptera: Mycetophilidae: Ditomyiinae). Mem. Ent. Soc. Can. **92**. 183 pp.

Neilsen, J.L. 1992. Microhabitat-specific foraging behavior, diet, and growth of juvenile coho salmon. Transactions of the American Fisheries Society **121**: 617-634.

Piccolo, J.J., and M.S. Wipfli. 2002. Does red alder (*Alnus rubra*) along headwater streams increase the export of invertebrates and detritus from headwaters to fish-bearing habitats in southeastern Alaska? Canadian Journal of Fisheries and Aquatic Sciences. **59**(3): 503-513.

Rogers, L.E., Buschbom, R.L., and Watson., C.R. 1977. Length-weight relationships of shrub-steppe invertebrates. Annal of the Entomological Society of America. **70**: 51-53.

Russell, L.K. 1979. A new genus and a new species of Boreidae from Oregon (Mecoptera). Proceedings of the Entomological Society of Washington **81**(1): 22-31.

Sample, B.E., Cooper, R.J., Greer, R.D., and Whitmore, R.C. 1993. Estimation of insect biomass by length and width. The American Midland Naturalist. **129**: 234-240.

SAS Institute Inc. 1996. SAS/STAT software changes and enhancements, through release 6.11 SAS Institute Inc., Cary, N.C.

Schoen, J.W., Wallmo, O.C. and Kirchhoff, M.D. 1981. Wildlife-forest relationships: is a reevaluation of old growth necessary? Transactions of the North American Wildlife and Natural Resources Conference 46:531-544.

Schoen, J.W., Kirchhoff, M.D., and Hughes, J.H. 1988. Wildlife and old-growth forests in southeastern Alaska. Natural Areas Journal 8:138-145.

Sedell, J.R., Triska, F.J., and Triska, N.S. 1975. The processing of conifer and hardwood leaves in two coniferous forest streams: I. Weight loss and associated invertebrates. Verh.Internat.Verein.Limnol. **19**: 1617-1627.

Smock, L.A. 1980. Relationships between body size and biomass of aquatic insects. Freshwater Biology. **10**: 375-383.

Stehr, F. W. 1987. Immature insects Vol 1. Dubuque, Iowa : Kendall/Hunt Pub. Co. 2 v.

Stehr, F. W. 1991. Immature insects Vol 2. Dubuque, Iowa : Kendall/Hunt Pub. Co. 2 v.

Tappeiner, J.C. II, and Alaback, P.B. 1989. Early establishment and vegetative growth of understory species in the western hemlock-Sitka spruce forests of Southeast Alaska. Canadian Journal of Botany 67:318-326.

Thedinga, J. F., Murphy, M. L., Heifetz, J., Koski, K.V., and Johnson., S.W., 1989. Effectsof Logging on Size and Age Composition of Juvenile Coho Salmon (*Oncorhynchyus kisutch*) and Density of Pre-smolts in Southeast Alaska Streams.

Canadian Journal of Fisheries and Aquatic Sciences. 46:1383--1391

Teskey, H. J. 1976. Diptera larvae associated with trees in North America. Ottawa: Entomological Society of Canada. 53 p.

Triska, F.J., and K. Cromack, Jr. 1980. The role of wood debris in forests and streams. *In* Forests: fresh perspectives from ecosystem analysis. Proceedings 40th Biological Colloquium, Oregon State University Press, Corvallis, OR USA. pp 171-190.

U.S. Department of Agriculture (USDA) Forest Service. 1997. Tongass land management plan revision: final environmental impact statement. Appendix, Vol. 1. U.S. Department of Agriculture Forest Service R10-MB-388e.

Vannote, R.L., Minshall, G.W., Cummins, K.W., Sedell, J.R., and Cushing, C.E. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences **37**: 130-137.

Vockeroth, J.R. 1974. Notes on the biology of Cramptonomyia spenceri Alexander (Diptera: Cramptonomyiidae). Journal of the Entomological Society British Columbia **71**: 38-42.

Ward, J.V., Bretschko, G., Brunke, M., Danielopol, D., Gibert, J., Gonser, T., and Hildrew, A.G. 1998. The boundaries of river systems: the metazoan perspective. Freshwater Biology. **40**: 531-272.

Wallace, J.B., Eggert, S.L., Meyer, J.L. and Webster, J.L. 1997. Multiple trophic levels of a forest stream linked to terrestrial litter inputs. Science. **277**: 102-104.

Wallace, J.B., Eggert, S.L., Meyer, J.L., and Webster, J.R. 1999. Effects of resource limitation on a detrital-based ecosystem. Ecological Monographs **69**: 409-442.

Wallmo, O.C., and Schoen, J.W. 1980. Response of deer to secondary forest succession in Southeast Alaska. Forest Science 26:448-462.

Wipfli, M.S. 1997. Terrestrial invertebrates as salmonid prey and nitrogen sources in streams: contrasting old growth and young-growth riparian forests in southeastern

Alaska, U.S.A. Canadian Journal of Fisheries and Aquatic Sciences. **54**: 1259-1269.

Wiplfli, M.S. and Gregovich, D.P. 2002. Export of invertebrates and detritus from fishless headwater streams in southeastern Alaska: implications for downstream salmonid production. Freshwater Biology. **47**(5): 957-969.

Wipfli, M.S., R.L. Deal, P.E. Hennon, A.C. Johnson, T.L. De Santo, T.A. Hanley, M.E. Schultz, M.D. Bryant, R.T. Edwards, E.H. Orlikowska, and T. Gomi. 2002. Managing young upland forests in Southeast Alaska for wood products, wildlife, aquatic resources, and fishes: problem analysis and study plan. General Technical Report PNW-GTR-558. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Wipfli, M.S., R.L. Deal, P.E. Hennon, A.C. Johnson, R.T. Edwards, T.L. De Santo, T. Gomi, E.H. Orlikowska, M.D. Bryant, M.E. Schultz, C. LeSage, R. Kimbirauskus, and D.V. D'Amore. 2003. Compatible management of red alder-conifer ecosystems in southeastern Alaska. *In* Monserud, R.A., Haynes, R., and Johnson, A. (eds.). Compatible Forest Management. Kluwer Academic Publ., Dordrecht, The Netherlands. Pp. 55-81.

# APPENDIX

Appendix 1

Record of Deposition of Voucher Specimens*

The specimens listed on the following sheet(s) have been deposited in the named museum(s) as samples of those species or other taxa, which were used in this research. Voucher recognition labels bearing the Voucher No. have been attached or included in fluid-preserved specimens.

Voucher No.: 2003-10

Title of thesis or dissertation (or other research projects):

HEADWATER RIPARIAN INVERTEBRATE COMMUNITY CHANGES IN RESPONSE TO RED ALDER STAND COMPOSITION IN SOUTHEASTERN ALASKA

Museum(s) where deposited and abbreviations for table on following sheets:

Entomology Museum, Michigan State University (MSU)

Other Museums:

Investigator's Name(s) (typed)
CHRISTIAN LESAGE

Date December 8, 2003

*Reference: Yoshimoto, C. M. 1978. Voucher Specimens for Entomology in North America. Bull. Entomol. Soc. Amer. 24: 141-42.

Deposit as follows:

Original: Include as Appendix 1 in ribbon copy of thesis or dissertation.

Copies: Include as Appendix 1 in copies of thesis or dissertation.
Museum(s) files.
Research project files.

This form is available from and the Voucher No. is assigned by the Curator, Michigan State University Entomology Museum.

# Appendix 1.1

## Voucher Specimen Data

Page 1 of 5 Pages

| Species or other taxon | Label data for specimens collected or used and deposited | | Number of: Eggs | Larvae | Nymphs | Pupae | Adults ♀ | Adults ♂ | Other | Museum where deposited |
|---|---|---|---|---|---|---|---|---|---|---|
| | USA, AK, Prince of Wales Island | | | | | | | | | |
| TARDIGRADA | Maybeso Catchment | 7/03/2000 | | | | | | | 5 | MSU |
| OLIGOCHAETA | Maybeso Catchment | 6/21/2001 | | | | | | | 4 | MSU |
| ARANEAE | Maybeso Catchment | 7/06/2001 | | | | | | | 1 | MSU |
| OPILIONES | Maybeso Catchment | 7/06/2001 | | | | | | | 1 | MSU |
| ACARI | Maybeso Catchment | 7/04/2000 | | | | | | | 16 | MSU |
| PSEUDOSCORPIONES | Maybeso Catchment | 7/05/2000 | | | | | | | 2 | MSU |
| COPEPODA | Maybeso Catchment | 7/01/2000 | | | | | | | 6 | MSU |
| ISOPODA | Harris Catchment | 7/05/2000 | | | | | | | 2 | MSU |
| POLYDESMIDA | Maybeso Catchment | 7/05/2000 | | | | | | | 1 | MSU |
| JULIDA | Harris Catchment | 7/05/2000 | | | | | | | 6 | MSU |
| LITHOBIOMORPHA | Maybeso Catchment | 7/05/2000 | | | | | | | 1 | MSU |
| GEOPHILOMORPHA | Maybeso Catchment | 7/05/2000 | | | | | | | 4 | MSU |
| PAUROPODA | Maybeso Catchment | 7/10/2001 | | | | | | | 1 | MSU |
| COLLEMBOLA | | | | | | | | | | |
| Neanuridae *Morulina* | Harris Catchment | 6/30/2000 | | | | | | | 2 | MSU |
| " *Neanura* | Harris Catchment | 6/30/2000 | | | | | | | 2 | MSU |
| " *Brachystomella sp.* | Maybeso Catchment | 7/09/2001 | | | | | | | 4 | MSU |

(Use additional sheets if necessary)

Investigator's Name(s) (typed)
CHRISTIAN LESAGE

Date December 8, 2003

Voucher No 2003-10
Received the above listed specimens for deposit in the Michigan State University Entomology Museum.

[signature] 9 DEC 2003
Curator Date

## Appendix 1.1

Voucher Specimen Data

Page 2 of 5 Pages

| Species or other taxon | Label data for specimens collected or used and deposited | Eggs | Larvae | Nymphs | Pupae | Adults ♀ | Adults ♂ | Other | Museum where deposited |
|---|---|---|---|---|---|---|---|---|---|
| | USA, AK, Prince of Wales Island | | | | | | | | |
| Onychiuridae *Onychiurus sp.* | Harris Catchment 6/30/2000 | | | | | | | 2 | MSU |
| Isotomidae | Maybeso Catchment 7/11/2001 | | | | | | | 1 | MSU |
| Tomoceridae *Tomocerus elongata* | Maybeso Catchment 7/10/2001 | | | | | | | 2 | MSU |
| " *Tomocerus sp.* | Maybeso Catchment 7/10/2001 | | | | | | | 2 | MSU |
| Dicyrtomidae *Ptenothrix atra* | Maybeso Catchment 7/05/2000 | | | | | | | 2 | MSU |
| HEMIPTERA | Maybeso Catchment 7/10/2001 | | | | | | | 1 | MSU |
| HOMOPTERA | | | | | | | | | |
| Aphididae | Maybeso Catchment 7/11/2001 | | | | | | | 1 | MSU |
| Coccidae | Maybeso Catchment 7/05/2000 | | | | | | | 4 | MSU |
| COLEOPTERA | | | | | | | | | |
| Carabidae *Leistus ferruginosus* | Maybeso Catchment 7/04/2000 | | | | | | | 1 | MSU |
| Ptiliidae *Actidium crotchianum* | Maybeso Catchment 7/06/2001 | | | | | | | 4 | MSU |
| Leiodidae *Agathidium sp.* | Maybeso Catchment 7/06/2001 | | | | | | | 1 | MSU |
| Scydmaenidae *Lophiodes sp.* | Maybeso Catchment 7/04/2000 | | | | | | | 2 | MSU |
| Staphylinidae *Batrisodes albionicus* | Maybeso Catchment 7/01/2000 | | | | | | | 1 | MSU |
| " *Cupila clavicornis* | Maybeso Catchment 7/09/2001 | | | | | | | 4 | MSU |
| " *Lucifotychus sp.* | Maybeso Catchment 7/04/2001 | | | | | | | 2 | MSU |

(Use additional sheets if necessary)

Investigator's Name(s) (typed)

CHRISTIAN LESAGE

Date December 8, 2003

Voucher No 2003-10

Received the above listed specimens for deposit in the Michigan State University Entomology Museum.

Curator Date

# Appendix 1.1

## Voucher Specimen Data

Page 3 of 5 Pages

| Species or other taxon | Label data for specimens collected or used and deposited | Number of: Eggs | Larvae | Nymphs | Pupae | Adults ♀ | Adults ♂ | Other | Museum where deposited |
|---|---|---|---|---|---|---|---|---|---|
| | USA, AK, Prince of Wales Island | | | | | | | | |
| Staphylinidae *Megarthrus pictus* | Maybeso Catchment 7/06/2001 | | | | | | | 1 | MSU |
| " *Micropeplus tesserula* | Maybeso Catchment 7/11/2001 | | | | | | | 1 | MSU |
| " *Phlaeopterus sp.* | Harris Catchment 7/05/2000 | | | | | | | 1 | MSU |
| " *Sonoma sp.* | Maybeso Catchment 7/03/2000 | | | | | | | 1 | MSU |
| " *Stenus sp. 1* | Maybeso Catchment 7/04/2000 | | | | | | | 1 | MSU |
| " *Stenus sp. 2* | Maybeso Catchment 7/04/2000 | | | | | | | 1 | MSU |
| " *Unknown* | Maybeso Catchment 7/05/2000 | | | | | | | 2 | MSU |
| Scarabaeidae *Aegialia cylindrica* | Maybeso Catchment 7/06/2001 | | | | | | | 1 | MSU |
| Byrrhidae *Exomella pleuralis* | Maybeso Catchment 7/06/2001 | | | | | | | 4 | MSU |
| " *Lioligus nitidus* | Maybeso Catchment 7/03/2000 | | | | | | | 3 | MSU |
| Elateridae *Ctenicera* | Maybeso Catchment 6/19/2001 | | | 4 | | | | | MSU |
| Cantharidae | Maybeso Catchment 7/04/2000 | | | 2 | | | | | MSU |
| Cerambycidae | Maybeso Catchment 6/21/2001 | | | 1 | | | | | MSU |
| Curculionidae *Steremnius carinatus* | Maybeso Catchment 7/01/2000 | | | | | | | 1 | MSU |
| " *Sthereus horrideus* | Harris Catchment 7/05/2001 | | | | | | | 1 | MSU |
| MECOPTERA | | | | | | | | | |
| Boreidae *Caurinus sp.* | Maybeso Catchment 7/11/2001 | | | | | | 1 | | MSU |

(Use additional sheets if necessary)

Investigator's Name(s) (typed)

CHRISTIAN LESAGE

Date December 8, 2003

Voucher No 2003-10

Received the above listed specimens for deposit in the Michigan State University Entomology Museum.

Curator Date

## Appendix 1.1

Voucher Specimen Data

Page 4 of 5 Pages

| Species or other taxon | Label data for specimens collected or used and deposited | | Number of: Eggs | Larvae | Nymphs | Pupae | Adults ♀ | Adults ♂ | Other | Museum where deposited |
|---|---|---|---|---|---|---|---|---|---|---|
| | USA, AK, Prince of Wales Island | | | | | | | | | |
| Boreidae *Caurinus sp.* | Maybeso Catchment | 7/05/2000 | | | | | 1 | | | MSU |
| Boreidae *Caurinus sp.* | Maybeso Catchment | 7/06/2001 | | | | | | | 1 | MSU |
| DIPTERA | | | | | | | | | | |
| Tipulidae *Limonia* | Maybeso Catchment | 7/11/2001 | | 12 | | | | | | MSU |
| " *Molophilus* | Maybeso Catchment | 7/11/2001 | | 1 | | | | | | MSU |
| " *Pedicia* | Maybeso Catchment | 7/04/2000 | | 13 | | | | | | MSU |
| Pachyneuridae *Cramptonomyia spenceri* | Maybeso Catchment | 7/06/2001 | | 5 | | | | | | MSU |
| Mycetophilidae *Symmerus cogulus* | Maybeso Catchment | 7/04/2000 | | 5 | | | | | | MSU |
| Sciaridae | Maybeso Catchment | 7/03/2000 | | 9 | | | | | | MSU |
| Cecidomyiidae | Maybeso Catchment | 7/10/2001 | | 2 | | | | | | MSU |
| Ceratopogonidae *Forcipomyia* | Maybeso Catchment | 7/03/2000 | | 19 | | | | | | MSU |
| " *Probezzia* | Maybeso Catchment | 7/01/2000 | | 1 | | | | | | MSU |
| Chironomidae *Boreochlus sp.* | Maybeso Catchment | 7/01/2000 | | 1 | | | | | | MSU |
| " *Boreochlus sp.* | Maybeso Catchment | 7/01/2000 | | 1 | | | | | | MSU |
| " *Metriocnemus sp.* | Maybeso Catchment | 6/21/2001 | | 1 | | | | | | MSU |
| " *Metriocnemus sp.* | Maybeso Catchment | 6/21/2001 | | 1 | | | | | | MSU |
| " *Krenopelopia sp.* | Maybeso Catchment | 7/01/2000 | | 1 | | | | | | MSU |

(Use additional sheets if necessary)

Investigator's Name(s) (typed)

CHRISTIAN LESAGE

Date December 8, 2003

Voucher No 2003-10

Received the above listed specimens for deposit in the Michigan State University Entomology Museum.

Curator Date

## Appendix 1.1

Voucher Specimen Data

Page 5 of 5 Pages

| Species or other taxon | Label data for specimens collected or used and deposited | Number of: Eggs | Larvae | Nymphs | Pupae | Adults ♀ | Adults ♂ | Other | Museum where deposited |
|---|---|---|---|---|---|---|---|---|---|
| | USA, AK, Prince of Wales Island | | | | | | | | |
| Chironomidae *Paraphaenocladius sp.* | Maybeso Catchment 7/11/2001 | | 1 | | | | | | MSU |
| " *Paraphaenocladius sp.* | Maybeso Catchment 7/11/2001 | | 1 | | | | | | MSU |
| Xylophagidae Xylophagous | Maybeso Catchment 7/04/2000 | | 1 | | | | | | MSU |
| Empididae | Maybeso Catchment 7/10/2001 | | 6 | | | | | | MSU |
| Platypezidae | Maybeso Catchment 7/02/2000 | | 1 | | | | | | MSU |
| LEPIDOPTERA | Maybeso Catchment 7/05/2000 | | 1 | | | | | | MSU |
| HYMENOPTERA | | | | | | | | | |
| Diapriidae | Maybeso Catchment 7/11/2001 | | | | | | | 1 | MSU |
| Formicidae | Maybeso Catchment 6/21/2001 | | | | | | | 10 | MSU |
| GASTROPODA #1 | Harris Catchment 6/30/2000 | | | | | | | 1 | MSU |
| GASTROPODA #2 | Maybeso Catchment 7/01/2000 | | | | | | | 1 | MSU |

(Use additional sheets if necessary)

Investigator's Name(s) (typed)

CHRISTIAN LESAGE

Date December 8, 2003

Voucher No 2003-10

Received the above listed specimens for deposit in the Michigan State University Entomology Museum.

Curator Date