VI-2. Taxa

Any discussion of arthropods is almost inevitably dominated by the topic of diversity. Not only are arthropods the most abundant animals in our forests, but there is also an enormous number of different kinds of arthropods. It has been estimated that up to 50,000 species of arthropods may be found within the Northwest Forest Plan area (U.S.D.A. 2000). The task of dealing with this many species can be overwhelming, and considering high levels of taxonomic classification is an efficient approach to managing information.

We used families as the analytical unit to evaluate information gaps. Families of arthropods are generally distinguished by certain adaptive characteristics that fit into particular adaptive zones. For example, beetles that feed primarily on foliage are grouped into the family Chrysomelidae, beetles that drill into fruits, nuts, and other plant parts with adaptive snouts are grouped in the family Curculionidae. At a given locality, the various families are generally distinct and have unique habitat requirements, and therefore this taxon is useful for summarizing information.

VI-2.1. *Analysis*

To find gaps in information about specific understory and canopy gap herbivore taxa we compared the proportion of all species by family in the species list (Appendix H) against the proportion of all citations in the literature database referencing these species/families. Families that lack proportional representation in the database may indicate gaps in information. Figure VI-7 plots the proportion of species for each family in the species list versus the proportion of citations for those families in the citation database.

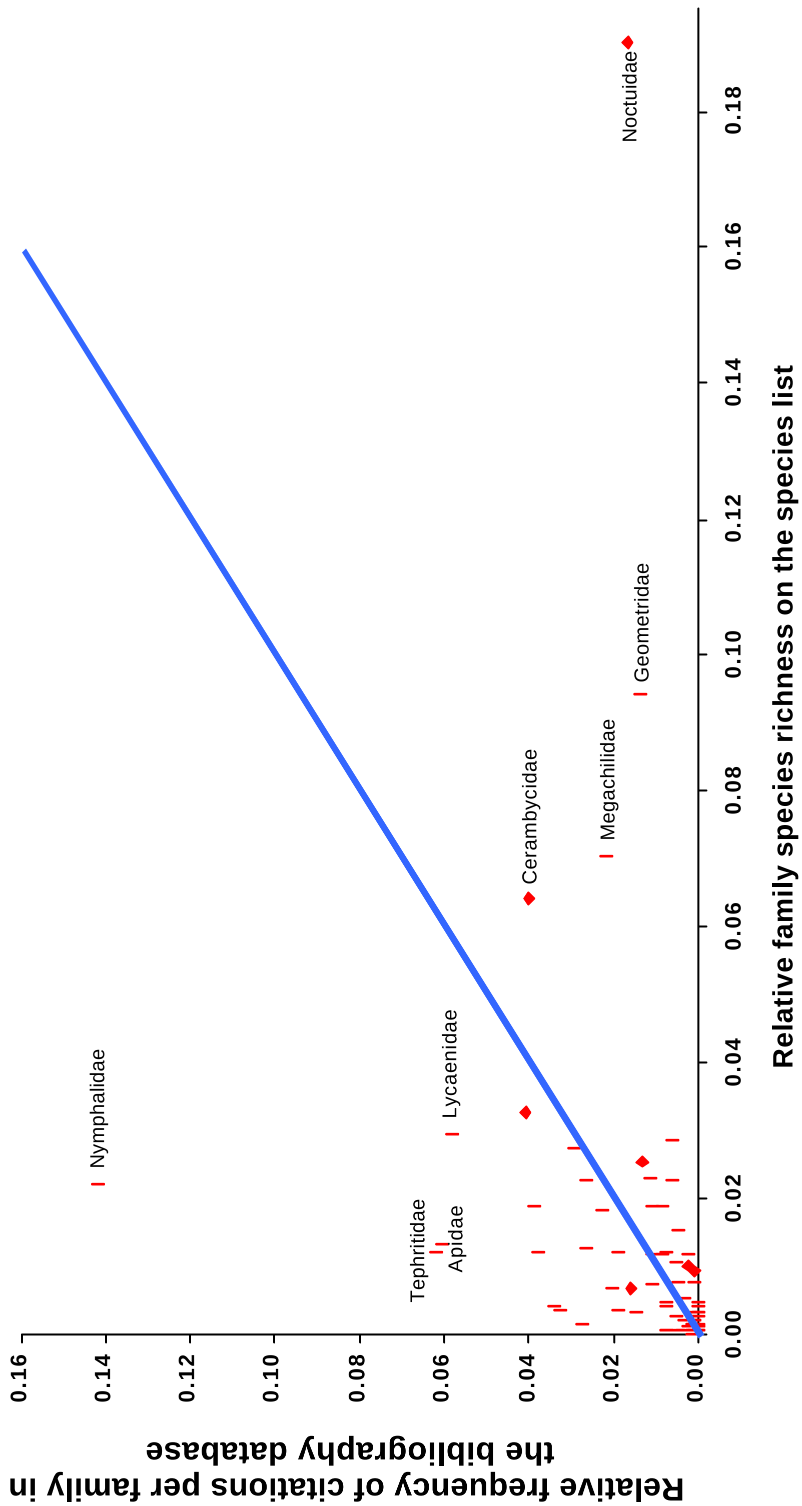

Figure VI-7. Comparison of the relative number of citations per family in the database to the relative number of species per family on the species list.

There is a weak correlation between the relative proportion of species in a family with the proportion of citations in the database. Several families have a smaller frequency of citations compared to their relative species richness (Figure VI-7). For example, the family Noctuidae comprises 373 species in the database (~19%) but these species are mentioned in only 22 citations of the database (~1.5%). Other under-represented families include Geometridae, Megachilidae, Cerambycidae, and Andrenidae. A complete list of the families with their respective frequency of citations and species indices can be found in Appendix I.

Management of species in the under-represented families would benefit from strategic surveys. The results suggest that although these taxa appear to be a dominant component of the biodiversity in the Pacific Northwest, the amount of research interest given to these groups has been minimal. Almost any type of information is needed on the distributions, habitat associations, host plants, life cycles, and microhabitats of these species. Inventories of habitat and vegetation types are useful for gathering this kind of information about these species.

Some families have a greater share of the citations than their relative proportion of species (Figure VI-7). For example, the family Nymphalidae (Fritillary butterflies) is represented by forty-three species (~2% of all species in the species list), but over 14% of all citations in the literature database refer to the species in this family. Other over-represented families include Lycaenidae (Blues and Hairstreak butterflies), Tephritidae (Fruit flies), Papilionidae (Swallowtail butterflies), and Apidae (bees) (Figure VI-7).

Management of species in the over-represented families would benefit from more specific studies. Specifically, attention needs to be given to how these species would be useful in monitoring and what questions of interest a monitoring program may answer. Since much is known about the biology of these groups, these taxa would be utilized in long-term monitoring programs. Known ecological requirements of these groups could help us understand and interpret the patterns and changes in their abundance over time. More information is needed on the potential threats to these species and their host plants and microhabitats. Additional information is required on the responses of these species to management practices, disturbances, and long-term climate change.

Other information gaps are the result of incomplete data on the number of species that occur in the region. For example, because butterflies are popular with hobbyists and professionals, the taxonomy and distribution of Lepidoptera are relatively well known. Other groups are taxonomically more challenging and identification often requires expertise that is often beyond the interest of amateur collectors. More information is needed for these groups.

In Chapter V we identified families that are relatively under-represented in the species list (Figure V-4). These include two families of true bugs (Cicadellidae and Miridae), two families of beetles (Curculionidae and Chrysomelidae) and one moth family (Pyralidae). It is theoretically possible that these families appear to be under-represented because their real species richness is low in the region, however, it is more likely that the families are under-represented because of a lack of research attention. For example, the Miridae (plant bugs) could be expected to represent a greater number of species than many other families, and the list is expected to grow almost 4 fold (Lattin personal communication[3]). Under-represented families would benefit from landscape-level strategic surveys of the region to gain at least basic knowledge of the abundance and distribution patterns of these taxa. It is especially critical for

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strategic surveys to be initiated in habitats and plant associations of particular interest or subject to higher levels of human disturbance (see VI-3 below).

It should be noted that while more information about the species richness of families can be gathered in strategic surveys, this information may be slow to accumulate because of the lack of available taxonomic expertise. For many groups of arthropods, species can only be reliably identified from genitalia or other subtle characters. This issue forces many systematically inclined entomologists to specialize on a very small selection of taxa. Because of the limited number of taxonomic specialists, species identifications may be slow (Lattin 1993, New 1995).

This situation should not discourage implementation of strategic surveys. Even though the identifications may take several years to complete, the data gathered from strategic surveys can be used to identify species-rich habitats and plant associations. Information that accumulates will provide the Agencies with some indication of the impacts of management decisions. Ultimately, the data should yield detailed information about the ecosystem functions of arthropod herbivores and the efficacy of mitigation measures.

Appendix J contains a list of the families from the Species List (Appendix H) along with the number of citations that occur in each of the broad classification categories (GROUPS) listed in Appendix E. Priorities were produced only for those GROUPS for which taxonomic priorities were considered appropriate. We attempted to assign priorities objectively, based on information available in the literature. However, the literature does not contain specific guidance for prioritizing taxa research needs. We used a quantitative approach to establish priorities based on identified information gaps. The general lack of relevant information and the diversity of opinions held by experts required some subjective consideration during the assignment process. It is our intention that this report and the accompanying citation database contain sufficient information for those who wish to form their own priority list. The following procedure was used to assign priorities for families.

We calculated a priority rating, that equaled to the number of citations for each family in each of the GROUPS categories divided by the proportion of the Species List represented by the family. For example, Noctuidae made up about 19% of the species list, and included 11 citations in the Basic Ecology database GROUP. Thus, the Basic Ecology priority rating for Noctuidae is 11/0.19 = 57.89. Priority ratings were calculated for families in selected classification categories and the families were sorted in ascending order by their priority rating.

Next, the families that comprised more than 2% of the species on the Species List (18 families) were weighted for a higher priority. We reasoned that more numerous families may have a larger impact on the ecology of the region and therefore deserve more attention. These families were then moved to the top of the priority list.

Finally, taxa priority recommendations provided by entomologists and forest ecologists during consultations were taken into account in priority assignments. The taxa in the priority table (Appendix K) were rearranged slightly to reflect these recommendations. We realize that this process is somewhat arbitrary, however, it is based largely on objective consideration of the literature available and the status of the Species List. We used this method because no other generally accepted method to rank research priorities for taxa was found in a comprehensive literature search. The results of this analysis are reported in Appendix K.

VI-2.2. *Recommendations*

Under-Represented Families

Information gaps were identified for several insect families (see below). As a result, we recommend strategic surveys that target these families to fill the information gaps. Specimens collected during strategic surveys and inventories of habitats and plant associations could be forwarded to taxonomic experts for identification and compilation of the information. Data regarding the taxonomy, distributions, habitat associations, host plant preferences, life cycles, and microhabitats are needed for the following families:

COLEOPTERA - BEETLES

Cerambycidae	Longhorn Beetles
Curculionidae	Snout-Nose Beetles
Elateridae	Click Beetles
Melandryidae	False Darkling Beetles

HETEROPTERA – TRUE BUGS

Berytidae	Stilt Bugs
Lygaeidae	Seed Bugs
Miridae	Plant Bugs
Scutelleridae	Shield-Backed Bugs
Tingidae	Lace Bugs

HOMOPTERA – TRUE BUGS

Cicadellidae	Leafhoppers
Diaspididae	Armored Scales
Delphacidae	Planthoppers
Coccidae	Soft Scales
Adelgidae	Conifer Aphids

HYMENOPTERA – BEES AND WASPS

Andrenidae	Burrowing Bees
Anthophoridae	Carpenter Bees
Colletidae	Yellow-Faced Bees
Halictidae	Sweat Bees
Megachilidae	Leafcutting Bees
Tenthredinidae	Common Sawflies

LEPIDOPTERA – BUTTERFLIES AND MOTHS

Geometridae	Inchworm Butterflies
Hesperiidae	Skippers
Noctuidae	Owlet and Underwing Moths
Pyralidae	Snout and Grass Moths
Saturnidae	Giant Silkworm Moths
Satyridae	Wood Nymph Butterflies
Sphingidae	Sphinx Moths

Over-Represented Families

Many families have been studied in more detail and much is known about their taxonomy, habitat requirements, and natural history. These families include many species that could be valuable in monitoring programs as indicators of habitat conditions and integrity. More information is needed on how these species respond to disturbance and management, and what potential threats exist for these taxa, their host plants, and microhabitats. It is recommended that strategic surveys for these groups focus on how they can be used for monitoring. Further, we recommended research on how these taxa respond to fire, changes in habitat size, plant species composition, and shifts in global climate. We suggest that families that could presently be used as indicator taxa include:

LEPIDOPTERA – BUTTERFLIES AND MOTHS

Lycaenidae	Blues and Hairstreak Butterflies
Nymphalidae	Fritillary Butterflies
Papilionidae	Swallowtail Butterflies

DIPTERA – FLIES

Tephritidae	Fruit Flies

HYMENOPTERA – BEES

Apidae	Bees

Non-Indigenous Species

Non-indigenous species are those taxa that occur outside their natural habitat range. Accidentally introduced foreign pest species arrive in the US at the rate of about 11 new species per year, and seven of these are likely to become pests with serious economic impacts (Sailer 1983). There is already a large reservoir of exotic arthropod species that are potentially harmful to American agriculture. It has been estimated that over 2000 arthropods of foreign origin have been established in the continental United States (U.S. Congress 1993). Sailer (1983) estimates that this list may eventually reach over 4000 species after the available information in the literature has been completely analyzed.

Some introduced insect taxa that have been regarded as beneficial for human food production (e.g., the honeybee, biological control agents), may have unexpected negative effects in natural systems, by displacing or disrupting native arthropod populations. The introductions of some non-indigenous arthropods are considered potentially dangerous (e.g., gypsy moths, etc.). Exotic species may change the ecosystem attributes over large landscapes by modifying ecological interactions (U.S. Congress 1993). The populations of some introduced species have reached destructive numbers and caused serious economic damage to natural and agricultural systems (Sailer 1983). Most of the insect taxa that are considered serious pests are introduced species (U.S. Congress 1993).

Invasive, non-indigenous species present a significant challenge to environmental resource managers (Center et al. 1995). Non-indigenous species can alter nutrient cycling regimes, contribute to the development of monocultures, and drive native species to extinction (Ruesink et al. 1995). Non-indigenous species that have successfully established may out-compete and exclude native species, and thus represent a form of biotic disturbance. The challenge for natural area managers lies in developing methods to assess changes in forest communities due to biological invasions and how to control them.

Deliberately or accidentally introduced arthropod species have generally not been considered in conservation and environmental efforts in the Pacific Northwest (Lattin 1994). However, accumulated evidence indicates that even undisturbed forest stands can be invaded and altered by alien arthropod species, such as the European gypsy moth (*Lymantria dispar* (L.) and hemlock wooly adelgid (*Adelges tsugae* Annand). The European gypsy moth was introduced from Europe in 1866 and became widely established throughout the New England area. It has caused severe damage to forest trees and changed the structure of mature Northeast forests. The Asian gypsy moth represents an even larger threat to Pacific Northwest forests, and efforts are being taken to prevent it from becoming established here (ODA 2001).

The hemlock wooly adelgid was first introduced into the United States from Asia in the 1920s and is believed to be responsible for widespread hemlock defoliation. This exotic herbivore changes forest energy inputs, disturbs micro-climatic environments, and alters the physical habitat structure of hemlock forests. Resource managers expect the adelgid to continue to spread, and entire hemlock forests may be threatened (Lapin 1995, Evans 1995). The presence of invasive, non-indigenous species in conservation areas is a very important management consideration.

Conservation of natural areas will depend on our ability to detect, control, and eradicate non-indigenous species. Luken (1997) recommends that natural resource managers develop methods to eliminate existing populations of non-indigenous species and limit the introduction of new species by making natural areas more resistant to invading species. Maintaining natural biological diversity is one method of enhancing the natural resistance to the establishment of non-indigenous species.

Assessing and maintaining biological diversity begins with long-term monitoring of biological communities. Monitoring provides information about critical points of species entry and the types of human activity most conducive to the import and establishment of exotic species, and it discovers initial populations of pest species for eradication. Monitoring information is also useful in identifying those communities where non-indigenous species can likely cause problems, and those that are more resistant to invasions.

We recommend that strategic surveys focus on what habitats are susceptible to invasion by non-indigenous species, what conditions help or hinder the establishment of non-indigenous species (e.g., does fire help non-indigenous species become established), how natural biological diversity can be enhanced to prevent or limit non-indigenous species, and what are the impacts of non-indigenous species on native species and natural ecosystems. .

VI-3. Habitats and Plant Associations

A plant community or association is the assemblage of species that occur in a particular area. A habitat type is a group of plant communities or associations that occur under similar abiotic conditions. In coastal northwestern California, for example, there are five habitat types that occur along an elevation/exposure gradient (Figure VI-8). Each habitat type is composed of a series of plant associations. For instance, within the Port Orford Cedar habitat type there are five plant associations (and three subtypes), each dominated by Port Orford Cedar but containing a different mix of understory vegetation (Figure VI-9).

Different habitat (and plant association) types can have very different assemblages of arthropods, reflecting fine-scale differences in the conditions of

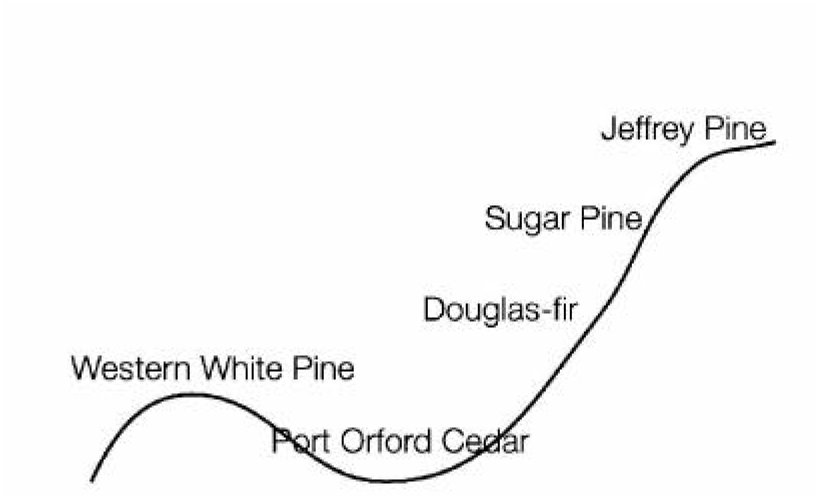

Figure VI-8. Relative topographic position of the primary habitat types on serpentine soils in Northern California (Daniel et al. 1995).

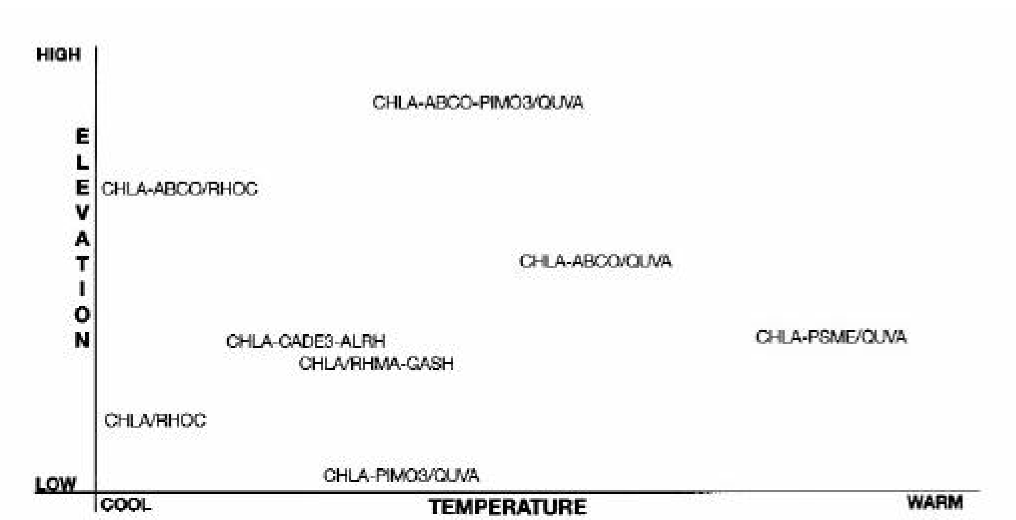

FIGURE 14 . Relative relationships of plant association in the Port Orford Cedar series based on elevation and temperature.

Figure VI-9. Relative relationships of plant associations in the Port Orford Cedar habitat type based on elevation and temperature (Daniel et al. 1995).

these habitats (Lattin 1993). The arthropod species that occur in a plant association are limited by the host plant species and various environmental conditions. The functions of arthropods in various habitat and association types can vary as much as the host plant species mix.

While the flora of the region has been well studied (e.g., Whittaker 1960, 1961, Muth 1967, Ferlatte 1974, Oettinger 1975, Sawyer and Thornburgh 1977, Nelson 1979, Whipple 1981, Jones 1986, Daniel et al. 1995, and others), the associated arthropod fauna is less well known. Less than 10% of the citations in the database contain arthropod information about habitat or plant association types in the region of interest.

Arthropod associations with riparian habitats are the most frequently referenced in the database (16 citations), followed by serpentine, late-successional, and young forests (13 each). Special habitats like bogs and meadows are referenced in only a few citations. Species lists are not available for any of the mentioned habitat or plant associations. The lack of publications on arthropods in various habitat types and plant associations represents a large information gap. Strategic surveys of all habitat types and plant associations would increase our knowledge of arthropods that occur here. However, this is a task that could be accomplished only with a strong commitment of budget and personnel.

While the benefits of general regional surveys to insect conservation may be well worth the commitment, the information may not have immediate application to the Agencies' management in the region. However, some special habitats contain plant species of particular interest, and investigations of arthropods associated with these habitats and plant species may help the Agencies manage and conserve the functions of these arthropods. Of particular interest would be arthropods associated with bogs, meadows, serpentine soils, riparian buffers, and late-successional forests.

VI-3.1. *Analysis*

Bogs

Minerotrophic peatlands (bogs or fens) are relatively small meadow wetland habitats (< 3 ha) surrounded by forest vegetation. They are common throughout Klamath/Siskiyou region and are important habitat types in terms of biodiversity and recreation (Erman and Erman 1975, Bartolome et al. 1990). When created on serpentine soils they support a unique flora, including many sensitive and rare plants such as the California Pitcher plant (*Darlingtonia californica*; Figure VI-10), Siskiyou Indian paintbrush (*Castilleja miniata* ssp *elata*), western bog violet (*Viola primulifolia* ssp. *occidentalis*), butterwort (*Pinguicula vulgaris* ssp. *macroceras*), and Del Norte willow (*Salix delnortensis*).

Figure VI-10. California Pitcher plant bogs occur in cool, perennially wet, low- to middle-slope elevations, and contain several sensitive and rare plants (Daniel et al. 1995)

Although bogs are not particularly susceptible to alterations by fire, they can be adversely affected by road building, mining, tree harvesting, and the introduction of exotic insects (Daniel et al. 1995). More information about the native arthropods that occur in these habitats and the functions they perform would assist Agencies in the management of these special aquatic habitats. Particularly, native pollinators and herbivorous arthropods need to be documented here and the habitats need to be monitored for exotic arthropods displacing native species, especially in more susceptible disturbed areas.

Port Orford Cedar Habitat Type

Figure VI-11. Pacific rhododendron understory below Port Orford Cedar trees (Daniel et al. 1995).

Other plant associations for which research on arthropod herbivore interactions would be highly beneficial are those occurring in the Port Orford Cedar habitat type (Figure VI-11). Port Orford Cedar (Chamaecyparis lawsoniana) often grows in the understory of conifer stands found on serpentine soils. The cedar shares the understory with chinquapin (Castanopsis spp.), Pacific rhododendron, (*Rhododendron macrophyllum*), salal (*Gaultheria ovatifolia*), red huckleberry (*Vaccinium parvifolium*), dwarf Oregon grape (*Berberis nervosa*), western azalea (*Rhododendron occidentale*), and many other shrubs and herbs.

Management issues regarding Port Orford Cedar include the problems of disease, soil fertility, and competition with understory shrubs (Daniel et al. 1995). Arthropod understory herbivores may be important in this habitat type, enhancing soil fertility and limiting competition with other understory plants. Management that encourages native arthropods in this habitat would benefit this unique tree. The trees may also benefit from monitoring for non-indigenous arthropod species that may spread disease.

Riparian Habitats

Riparian buffer zones are important habitats, lying at the sometimes-contentious interface between forestry and fisheries management (Swanson and Franklin 1992). Dendritic in distribution, riparian zones have been recognized as crucial because of their position as sites of connectivity between aquatic systems and adjacent upslope forests (Meeham et al. 1977, Gregory et al. 1991, Beschta 1991), and because of their use by more than 400 wildlife species in Oregon alone (Oakley et al. 1985). Riparian habitats support a unique assemblage of plants and animals and encompass a great diversity of landforms and microenvironments. Although they occupy only a small proportion of the landscape, riparian areas have been called one of the most critical habitats in the Pacific Northwest forests in need of further studies (Gregory et al. 1991).

Riparian zones are often defined in terms of the ecological functions they perform, such as providing shade to aquatic systems and regulating sediments and organic debris entering streams from adjacent upslope forests. The rich diversity of riparian herbivorous arthropods may also be defined in terms of their ecological functions (Asquith et al. 1990, Parsons et al. 1991, Lattin 1993a). Riparian arthropods are an important source of energy in the food chain of adjacent aquatic systems (Patton 1977, Meeham et al. 1977), and there is evidence that arthropods contribute to the health of streamside vegetation by performing a variety of functions (e.g., Spence 1979, Gregory et al. 1991, Hering 1998). For example, herbivorous insects prune dead and dying plant parts, thereby contributing to nutrient cycling processes They also facilitate the release of energy stored in vegetation by pre-processing leaves, and dropping nutrient–filled fecal matter. The fecal matter is then readily available to microorganisms and is broken down further, thus quickly replenishing nutrient-depleted soils.

Photo by Pacific Analytics

Figure VI-12. Riparian habitat along a third order stream in the Cascades Range of Western Oregon.

Scientists have identified several research information gaps that are critical to the management of riparian systems (Smith et al. 1997, Brenner 2000). They call for the development of efficient, logistically feasible, standardized inventory and monitoring protocols that provide documentation of the basic ecological characteristics of understory habitats, identify unique species, ecosystem processes, and habitat elements that require special management attention (Regional Interagency Executive Committee 1995, 1997, Brenner 2000). An efficient monitoring design requires detailed information about the temporal and spatial variation of populations. This information could be gathered during strategic surveys of herbivorous arthropods in riparian habitats. The strategic surveys will also provide information about species-habitat associations and relationships between specific characteristics of habitats and associated ecosystem processes and functions.

More data are needed on the effectiveness of riparian reserves and buffer zones as dispersal habitats and functional connectivity corridors between other habitat types. The lack of habitat data for the associated dependent terrestrial species has stalled progress on assessing the efficacy of riparian reserves and buffers (Tuchmann et al. 1996). Strategic surveys of herbivorous arthropods in areas adjacent to riparian reserves can help fill this information gap and provide information necessary to assess the riparian management success.

Old-Growth and Managed Regenerating Forests

The total areas and average patch size of old-growth forests have declined significantly from levels in presettlement times (Harris 1984, National Research Council 2000). As more of the old growth and mature forests have been cut, they have been replaced primarily with single species, even-aged forests. This activity has created a new set of problems for forest management. Timber harvest and encouragement of single species regeneration have changed the forest structure and left smaller patches of remaining stands, which has had a negative impact on the distribution and abundance of many native plants and animals (Harris 1984, Roland 1993, Punttila et al. 1994, Schowalter 1996).

Forest structure changes dramatically after timber harvest. In the past, understory vegetation was typically removed with the use of herbicides. Legacy components of old-growth forests such as tree snags and coarse woody debris may be largely removed from managed stands. Cut stands are often replaced with a single tree species such as Douglas-fir; the result is a simplified forest structure, without the diversity of microhabitats that normally occur in natural forests. New standards and guidelines limit the use of herbicides, and provide for retention of coarse woody debris, however, conditions in managed regenerating forests after harvest may be different from those in areas disturbed by natural events (Schowalter and Crossley 1988, Schowalter 1989, Sexton, 1994, Hitchcox, 1996, McDonald and Fiddler 1997).

Wildlife are hypothesized to select forests with specific vertical and horizontal structural characteristics of the forest canopy and understory (Thomas et al. 1990). Hansen and others (1991) found that some of the unique structural characteristics of old forests create suitable habitat for the northern spotted owl. These characteristics include multilayered, multispecies canopies and understories, dominance by large conifers, large snags, and many fallen logs. Similar structural attributes may exist in younger forest stands (Dubrasich et al. 1997). Some herbivorous arthropods may help create the forest structure preferred by the northern spotted owl and other sensitive species. The influence of these arthropods on forest structure needs to be investigated more thoroughly.

Forest openings created as a result of timber harvest have left much of the remaining forest subject to edge effects (Frost 1999). Studies have shown that timber harvest can create artificial edges that alter the characteristics of adjacent uncut stands and may reduce the quality of habitat for species that are associated with forest interior conditions (Reese and Ratti 1988, Saunders et al. 1991, Lidicker and Koenig 1996).

The effects of artificially created edges have been well documented for Pacific Northwest wildlife (e.g., Hanley 1983, Rosenberg and Raphael 1986, Mills 1995, Lidicker and Koenig 1996) and for forest understory vegetation (e.g., Chen et al. 1992, 1993, 1995, Frost 1999). The effects of habitat edges on understory arthropod herbivores have only recently been given attention by scientists in the Pacific Northwest (Schowalter personal communication[4]).

Forty-seven species of plants and animals are thought to be uniquely dependent or closely associated with old, undisturbed forests (Wilcove and Olson 1993), and most likely cannot survive without the old-growth forest structure. Young, regenerating forests do not provide these important elements of natural forests. Consequently, forest managers are challenged to devise management protocols that will restore legacy components and natural conditions quickly in young, regenerating stands.

VI-3.2. *Recommendations*

Bogs

The arthropods that occur in bogs are particularly important as pollinators for rare and endemic plants. We recommend that strategic surveys focus on establishing what species of arthropods pollinate rare plants in bogs and other wetland habitats. We also recommend that these habitats be monitored for non-indigenous species that may pose a threat to rare plants or displace native pollinators.

Port Orford Cedar Habitat

The arthropods that occur in this habitat play important roles in enhancing soil fertility, spreading diseases, and modifying the structure of the understory. We recommend that strategic surveys focus on compiling a list of the arthropod

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understory herbivores that occur in this habitat. Further research can then be conducted on how these species contribute to soil fertility and nutrient recycling, and which species facilitate the spread of diseases. We also recommend that research efforts be directed towards understanding how susceptible this habitat is to non-indigenous species. We recommend that a monitoring plan be developed for this habitat when a more complete species list is available. Finally, we recommend that strategic surveys investigate how arthropod understory herbivores shape the structure of this habitat, and what conditions they may create for the regeneration of native plants in this habitat.

Riparian Habitats

We have identified five primary research information gaps that pertain to management of riparian habitats:

1. Expand knowledge of how physical, climatic, and hydrological variables influence riparian arthropod species.
    a. Identify components of the riparian arthropod fauna that are common to riparian zones across broad spatial and temporal scales and those fauna that differentiate among riparian areas at finer spatial and temporal scales, and the differences in ecosystem functions between these two groups of arthropods.
    b. Determine how upslope conditions influence riparian species.

2. Describe the functions of arthropod species in riparian zones.
    a. Identify the functions of arthropod species.
    b. Characterize riparian microhabitats and how understory arthropod species influence stream temperatures and the structure and function of riparian canopies.
    c. Determine how arthropods contribute to the stability of aquatic and terrestrial habitats.
    d. Determine the roles of riparian understory arthropods in maintaining the quality of intermittent streams, seasonal ponds and wetlands.
    e. Determine how understory arthropod herbivores use riparian habitats as corridors for dispersal and movement. Investigate specific riparian characteristics (i.e. buffer width, vegetation composition, vegetation density) in providing this function.

3. Expand assessments of the effectiveness of restoration and enhancement

techniques towards maintaining stable arthropod functions in the environment.

4. Determine how arthropods can be used to determine appropriate riparian buffer widths.

5. Develop efficient and effective monitoring procedures and methods for characterizing riparian habitats that can be applied at a variety of spatial and temporal scales, and that will evaluate the efficacy of the NWFP Aquatic Conservation Strategy and adaptive management techniques.

Old Growth and Managed Regenerating Forests

After reviewing the literature and consulting with several entomologists and ecologists, we identified ten primary research information gaps that need to be addressed by strategic surveys regarding the management of biodiversity in young forest stands.

1. Describe and quantify species-habitat associations that may be important to maintaining native biological diversity and functional ecosystem integrity (including compositional elements and spatial and temporal dynamics). Compare and contrast species assemblages in managed and natural young forests across a broad range of environmental conditions (e.g., see Schowalter 1989, canopy research).

2. Describe and quantify the functional significance of old-growth legacy components (e.g., snags, coarse woody debris, large green trees, understory vegetation diversity, seed/spore banks, and resprouting vegetation) for maintaining native biological diversity in young forests. Identify critical functions of understory arthropod herbivores and quantify the relative importance and interactive influences of spatial arrangements, temporal dynamics, and specific compositional elements.

3. Determine the functional significance of hardwood understory plant species to arthropods and other forest species and how arthropods maintain or establish conditions favorable for wildlife biological diversity. Develop methods to produce and maintain desired species compositions in managed young forests.

4. Document the spatial and temporal effects of management activities on arthropods in young forest stands. Develop methods for monitoring trophically important species.

5. Determine how arthropods could be used to accelerate development of old growth characteristics in young forest stands.

6. Determine how arthropods can be used to manage fuels and fire regimes, especially in the drier Klamath physiographic region.

7. Determine the effects of size, shape and spatial distribution of habitat patches on the movement and dispersal of understory arthropods.

8. Determine the effectiveness of narrow habitat corridors for providing functional connectivity between disjunct habitat patches.

9. Assess the importance of arthropods as a food resource in local food-web dynamics, and their trophic contribution to maintaining the diversity of higher trophic levels in young forest stands.

10. Develop techniques for restoring and enhancing arthropod diversity and abundance at disturbed sites.