

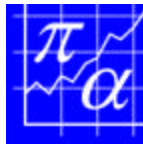
Literature Synthesis and Recommendations for
General Surveys for *Forest Understory and
Canopy Gap Herbivores* Pertinent to the
Southern Range of the Northern Spotted Owl



Pacific Analytics, L.L.C.

**Literature Synthesis and Recommendations for General
Surveys for *Forest Understory and Canopy Gap
Herbivores* Pertinent to the Southern Range of the
Northern Spotted Owl**

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Forest Understory and Canopy Gap Herbivores
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Forest Understory and Canopy Gap Herbivores:

I. Executive Summary
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I. EXECUTIVE SUMMARY

A ProCite® database was developed to initially hold 1505 bibliography records acquired by the USDA Forest Service through literature searches of Zoological Records Database (Volumes 115-136). This search covered the entomological and ecological literature from 1978 to 1999. An additional 17,720 records were added to this database based on subsequent literature searches in electronic databases. All bibliographic records were reviewed to determine their suitability for research on forest understory and canopy gap herbivores in California, Oregon, and Washington, and subsequently annotated to facilitate this research. The final database, *Understory and Gap Herbivores.pdt*, contains a total of 1422 annotated records.

This Report describes the process of record selection and construction, and features of the database. Functions and attributes of the database are discussed, and examples of citation output are provided. This report also includes content descriptions and discussion of identified publication trends, literature synthesis, and research recommendations.

A list was constructed from the database and other sources, of the species that are likely to be found in the area represented as the southern range of the northern spotted owl. The list should be considered a work in progress and new records added as they become available.

The information contained in the bibliographic citations was reviewed and analyzed for gaps in information without which land managers in the southern range of the northern spotted owl would be unable to effectively protect the ecological functions of forest understory and canopy gap herbivores. The information gaps are discussed and the rationale for strategic surveys to fill

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Forest Understory and Canopy Gap Herbivores:

I. Executive Summary

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these gaps is provided. The discussion includes recommendations for future studies.

Appendices contain supplemental information about the bibliographic database including literature search terms, categories of rejected records, descriptions of database fields, classification of records, examples of printed records, and instructions for using the database. The appendices also include a list of arthropod forest understory and canopy gap herbivore species that are likely to be found in the southern range of the northern spotted owl, and a priority list of taxa and habitats for strategic surveys.

**Forest Understory and Canopy Gap Herbivores:
II. Introduction**

II. INTRODUCTION

The Record of Decision (ROD, USDA 1994) provides extensive standards and guidelines for a comprehensive long-term ecosystem management strategy for the more than 24 million acres of federal land in the range of the Northern Spotted Owl in Washington, Oregon and California (Figure II-1). These guidelines include survey and manage recommendations for a diversity of arthropod taxa and their habitats, with the emphasis on four main functional groups: (1) coarse woody-debris chewers, (2) forest soil and litter arthropods, (3)



Figure II-1. Range of the Northern Spotted Owl in the western United States.

forest understory and canopy gap herbivores, and (4) forest canopy herbivores. To improve the understanding and management of these taxa, the U.S. Department of Agriculture, Forest Service and the U.S. Department of the Interior, Bureau of Land Management (hereafter referred to as the Agencies) has recognized the need to advance entomological and ecological research in this area. The foundation of this process lies in identifying existing knowledge gaps to provide recommendation for future studies. Literature review is part of this endeavor.

Extensive reviews of published data are necessary when addressing the fundamental question of encouraging persistence of arthropod guilds under the Northwest Forest Plan. By focusing on multiple taxa and variables, the results of a literature synthesis are highly cost effective, and have particularly broad applications.

Because of their impact on plant demography and forest community structure,

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**II. Introduction**  
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forest managers are interested in species of herbivorous arthropods inhabiting forest ecosystems. Herbivores have evolved closely with their host plants therefore; disturbance to one ultimately affects the other. The pattern of plant-herbivore interactions has been recognized as a major factor influencing patch dynamics. Insect-induced vegetation mortality can alter the forest canopy and create understory fuel accumulations that may predispose forest areas to fire. The environment of canopy gaps encourages germination of shade-intolerant plant species, adding to the mosaic diversity of the forest biota. The plant-herbivore interface has been called the major zone of interaction responsible for generating terrestrial organic diversity through reciprocal selective responses between closely ecologically linked organisms (Erlich and Raven 1964).



Figure II-2. Cottonwood leaf beetle, *Chrysomela scripta*, feeding on riparian foliage. (Arnett and Jacques 1981)

Furthermore, herbivores are fundamental components of forest food chains, facilitating the transfer of energy from plants to carnivores and detritivores (Krebs 1972). The diets of many forest birds, amphibians, and mammals include insects that feed on plants or are predators of herbivorous insects.



Figure II-3. Pine siskin, *Carduelis pinus*, consumes insects during the summer and feeds insects and larvae to their young. (Mathews 1988)

The ROD specifically addresses two major groups of herbivores as important to Northern Spotted Owl forests: forest understory and

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II. Introduction
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canopy gap herbivores, and forest canopy herbivores.

The focus of this project is on herbivorous arthropods inhabiting forest understory strata and adjacent areas of open vegetation. An operational definition of *forest understory and canopy gap insect herbivores* follows that in Parsons et al. (1991), to include “chewers, fluid suckers, and miners of above-ground foliage, stems, and flowers of macrophytic plants, ...[those consuming] pollen, nectar, or floral parts, ...[and those feeding] on seeds or in cones” (Parsons et al. 1991; p. 6).

This broad group of herbivores includes insect taxa found in four major habitat categories:

- (1) Understory-vegetation species** – comprising taxa inhabiting herbaceous vegetation and arboreal habitats in the forest understory,
- (2) Meadow-vegetation species** – taxa found on “above-ground foliage, flowers, and stems in natural meadows or other similar open grassy sites” (M-vg sensu Parsons et al. 1991; p. 5),
- (3) Open-vegetation species** – species inhabiting “open or disturbed areas that are not meadows (such as recent clearcut areas or road edges) on the above-ground vegetation (foliage, flowers, stems) (O-vg sensu Parsons et al. 1991; p. 6), and
- (4) Riparian-vegetation species** - including vegetation-dwellers inhabiting riparian areas (R-vg sensu Parsons et al. 1991; p. 6).

Strategic surveys have been recommended for invertebrate species within the range of the Northern Spotted Owl (USDA 1994). Strategic surveys include general surveys for species distribution and abundance as well as research on the impacts of management practices on invertebrate habitats and populations. The goal is to develop management guidelines that will preserve invertebrate

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functions within these special forests.

In order to facilitate invertebrate research and management within the range of the Northern Spotted Owl, the Agencies has asked Pacific Analytics, L.L.C. to produce a literature synthesis for forest understory and canopy gap herbivores, to identify gaps in information, and to develop recommendations for strategic surveys. Five core tasks were included in the USDA Forest Service RFQ #R6-6-00-149. These tasks include:

- Task 1.** Review published literature on herbivorous arthropod families provided by the Forest Service, and determine which of the citations may be pertinent to California, Oregon, and Washington for the forest understory and canopy gap herbivore guild.
- Task 2.** Annotate the citations found pertinent in Task 1 with information summarizing the important findings in each of the papers.
- Task 3.** Find and annotate additional bibliographic citations for literature not included in Task 1 that contain relevant information on biology or ecology, endemism, environmental or ecological requirements of taxa, and the effects of fire, timber harvest, or any other forest management practice or disturbance on these taxa.
- Task 4.** Determine which species of forest understory and canopy gap herbivores identified in the bibliography are likely to be found in the area represented as the Southern Range of the Northern Spotted Owl.
- Task 5.** Produce a report that identifies the major gaps in information without which land managers will be unable to effectively protect the ecological functions of forest understory and canopy gap herbivores. The report will prioritize taxa and habitats for future study, and will provide the rationale for strategic surveys that may help scientists and managers fill the identified information gaps.

Forest Understory and Canopy Gap Herbivores:
III. Initial Search and Examination of Literature (Tasks 1 & 2)
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**III. INITIAL SEARCH AND EXAMINATION
OF LITERATURE (TASKS 1 AND 2)**

Task 1 required an evaluation of citations on herbivorous arthropod families provided by the Forest Service to determine which citations are pertinent to California, Oregon, and Washington for the forest understory and canopy gap herbivore guild. In Task 2 the citations found pertinent in Task 1 were annotated with information summarizing the important findings in each of the papers. The goal was to construct a literature citation database to which additional records could be added.

III-1. Source of Data

A broad bibliographic search was performed by the USDA Forest Service to gather initial data for literature synthesis. A total of 69 insect family names, almost exclusively herbivorous taxa, in ten insect orders (Appendix A) were combined with three geographic names, California, Oregon, and Washington, to form a search expression. This string was used to conduct bibliography searches in Zoological Records Database (Volumes 115-136, 1978-2000/06). Results of this search were archived in a computer text file, and formed the information basis of Tasks 1 and 2 of this project.

III-2. Database Construction

In the first phase of database construction, the archival literature file was downloaded from the USDA Forest Service web site, and imported into a ProCite® (Version 5, ISI ResearchSoft 1999) database using custom-designed Biblio-Link II. (Version 5.0, ISI ResearchSoft) configuration files. The archival literature file contained a total of 1505 literature records published between 1978 and 1999. Although the search returned several citations with earlier publication dates (Woodruff and Pierce 1973; Cox 1976; Jones 1976; Munroe

Forest Understory and Canopy Gap Herbivores:
III. Initial Search and Examination of Literature (Tasks 1 & 2)
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1976a, b; Kellen et al. 1977, Kreasky et al. 1977), overall, the coverage of the pre-1978 literature was unsatisfactory.

Imported literature records were sorted alphabetically in an *AUTHOR / TITLE / DATE* hierarchy, and numbered in ascending order. Five duplicate records (Poinar and Lane 1978, Berry et al. 1997, Blossey and Schat 1997, Peck et al. 1997, Puterka 1997) were removed from the database, thereby reducing the database holdings to a total of 1500 records. All records originating from this initial bibliographic search were coded with "Original USDA-FS Record" in field #44 (Appendix C) to facilitate their tracking after new citations from additional literature searches (see Task 3 below) have been added to the database.

III-3. Selection of Records

All records imported into the database were evaluated for their relevance to research on forest understory and canopy gap herbivores in California, Oregon, and Washington, as specified by the USDA Forest Service. A total of 846 citations (57%) were excluded from the database (Figure III-1 NOTE: the percentage data given in this and the following pie charts represent only approximations of the database structure since the majority of papers fell in more than one category).

The largest category of rejected records comprised investigations conducted in agricultural communities (Appendix B). A total of 408 publications in the original data set reported on studies with insect taxa feeding on a variety of crop plants, primarily of the families Rosaceae (29% of records in agricultural systems), Fabaceae (16%) and Rutaceae (9%). Almost 60% of the rejected records in this category represented work in California, reflecting the state's agricultural dominance.

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III. Initial Search and Examination of Literature (Tasks 1 & 2)**

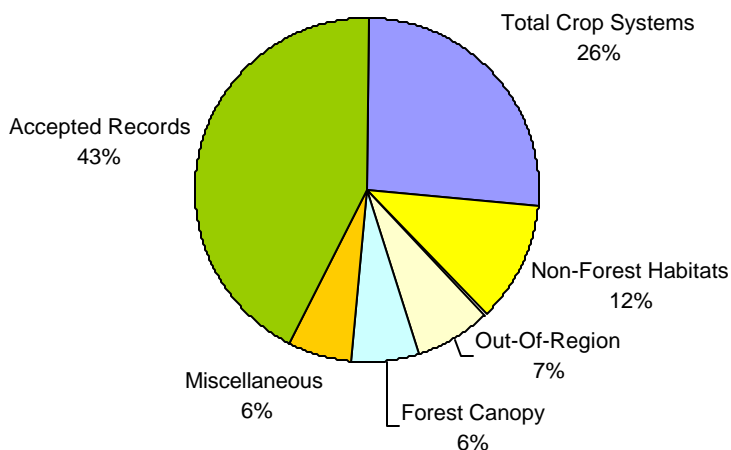


Figure III-1. Status of 1505 original records provided for evaluation. Forty-three percent of the records met the selection criteria for inclusion in the database.

The second largest class of excluded records comprised studies focusing on herbivore species inhabiting non-forest habitats such as deserts, ocean sandy dunes, and urban environments (n = 178 studies). We made an exception in this respect with studies that reported on non-forest-dwelling, often endemic, subspecies of taxa that normally inhabit forest habitats. For example, a widely distributed nymphalid butterfly, Edith’s checkerspot, *Euphydryas editha*, often found in mountain meadows, has a subspecies, the Bay checkerspot butterfly, *E. editha bayensis* that is endemic to the San Francisco Bay area in California. In this, and similar cases, papers with the “main” species and all of its subspecies were included in the database. As many as 113 excluded studies originated outside California, Oregon, and Washington.

Studies of forest canopy species were not the focus of our literature synthesis since these taxa will be addressed in future reviews. The remarkable number of

**Forest Understory and Canopy Gap Herbivores:
III. Initial Search and Examination of Literature (Tasks 1 & 2)**

available references on forest canopy species warrants a separate extensive literature review. However, as specified in the original description of this project by the USDA Forest Service, we briefly considered groups of canopy herbivores that feed on seeds, cones and twigs, and saplings of forest and orchard trees (e.g. Curculionidae, Cecidomyiidae, Tortricidae), or tree bole-attacking taxa in which many adults feed on nectar of herbaceous vegetation (e.g. Buprestidae, Cerambycidae). A relatively high frequency of forest-canopy records in the original literature set (n = 98 studies] partly reflected a labeling error in Zoological Records Database, whereby species of Scolytidae were misclassified under the family Curculionidae. As a result, although the family Scolytidae was not included in the literature search string (Appendix A), studies with these major tree bole- and canopy-inhabiting species were present in the database.

The last category of excluded records comprised miscellaneous rejections (n = 89 records). Of these, almost 45% of papers dealt with Carabidae and Cicindelidae. We decided to exclude these two families from the current review since these taxa are overwhelmingly predaceous, and, although some species forage on understory vegetation, the majority of their species inhabit the forest floor. The Carabidae and Cicindelidae are the focus of a concurrent in-depth literature synthesis of forest soil and litter-dwelling arthropods. Coccinellidae were excluded because they are almost entirely predaceous. We included studies on some predaceous taxa whose adults utilize plant pollen or nectar as a food resource (e.g. Syrphidae, Tabanidae, Tachinidae; Appendix A).

III-4. Preliminary Results

A total of 670 records from the initial citation list satisfied the selection criteria and were retained in the database. The highest number of studies in the final data set focused on Lepidoptera (53%), primarily the family Nymphalidae (47% of total Lepidoptera), Lycaenidae (19%), and Papilionidae (10%). These were

**Forest Understory and Canopy Gap Herbivores:
III. Initial Search and Examination of Literature (Tasks 1 & 2)**

followed by Hymenoptera (18%), Coleoptera (16%), and Hemiptera (10%) (Figure III-2).

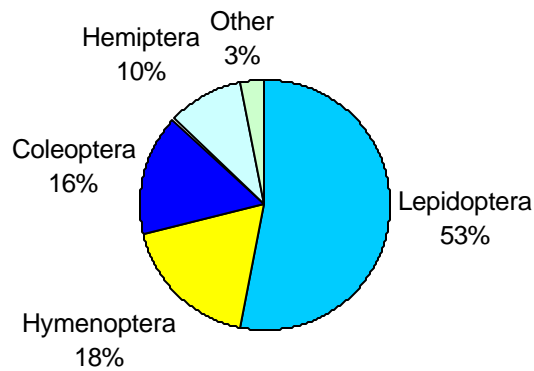


Figure III-2. The percent of major taxa represented in the initial database citations.

The majority of studies in the database investigated insect natural history (61%), and basic ecology and behavior (50%). Arthropod taxonomy and systematics were addressed in about one third of the studies (33%). About 20% of studies examined different aspects of arthropod-habitat interactions.

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**Forest Understory and Canopy Gap Herbivores:**  
**IV. Additional Searches Of Electronic Databases (Task 3)**  
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**IV. ADDITIONAL SEARCHES OF ELECTRONIC
DATABASES (TASK 3)**

Task 3 required a search of other electronic citation databases for additional bibliographic citations of literature not included in Task 1. Those citations that were found to be pertinent to California, Oregon, and Washington forest understory and canopy gap herbivore guild were added to our database. The new citations were evaluated for relevant information on biology or ecology, endemism, environmental or ecological requirements of taxa, and the effects of fire, timber harvest, or any other forest management practice or disturbance on these taxa.

IV-1. Source of Data

A broad bibliography search was performed on additional electronic databases, including Agricola (1984-2000), Biological Abstracts (1980-2000), CAB Abstracts (1990-2000), and Forestry Abstracts (1939-1995). In this search we utilized the original search strings from Task 1 and 2 (Appendix A), as well as supplementary keywords comprising the names of major orders of herbivorous insects, and broad search terms: "insect" and "arthropod." All searches were restricted to records containing the geographic names of California, Oregon and Washington. The databases yielded 17,720 citations that met the search criteria (Figure IV-1). The source database of these citations was identified in field #44 for each record (see Appendix C). These citations were archived in a computer text file, and formed the information basis of Task 3 of this project.

Information from the search of additional databases was used to supplement descriptive information for records in the Task 2 database. A manual search of literature at the Valley Library of Oregon State University was conducted, and the results were evaluated to obtain content information for records in the database.

Forest Understory and Canopy Gap Herbivores:
IV. Additional Searches Of Electronic Databases (Task 3)

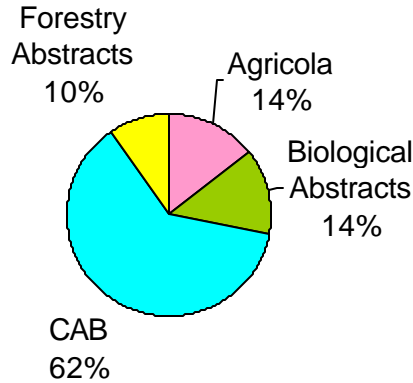


Figure IV-1. The percentage of citations obtained from a search of additional electronic bibliography databases. A total of 17,720 citations were retrieved in Task 3.

IV-2. Database Construction

Following the protocol in Task 1 and 2, the additional bibliography records were imported into ProCite[®], sorted alphabetically in an AUTHOR / TITLE / DATE hierarchy, and numbered in ascending order. All records imported into the database were evaluated for their relevance to research on forest understory and canopy gap herbivores in California, Oregon, and Washington. Those citations that did not meet selection criteria (See III-3. in Tasks 1 and 2) were removed from the database. Almost 96% (16,968 records) of citations, including approximately 6,038 duplicate records, were excluded from the database. The remaining 752 records were merged with the initial records, producing a total of 1,422 records in the final database.

IV-3. Results

The highest number of studies in the final data set focused on Lepidoptera (41%), primarily the family Nymphalidae (32% of total Lepidoptera), Lycaenidae (13%), Moths (12%), Pieridae (9%), and Papilionidae (8%). These were followed

**Forest Understory and Canopy Gap Herbivores:
IV. Additional Searches Of Electronic Databases (Task 3)**

by Hymenoptera (20%), Coleoptera (19%), Diptera (16%), and Hemiptera (11%) (Figure IV-2).

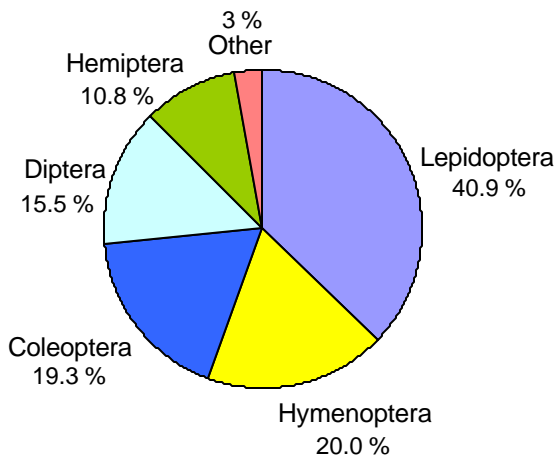


Figure IV-2. The percent of major taxa represented in final citation database.

About 64% of the studies in the database investigate basic insect ecology and behavior and 45% were natural history studies. Arthropod taxonomy and systematics are addressed in about 26% of the studies, and almost 16% of studies focused on conservation issues. Only about 14% of studies examine different aspects of arthropod-habitat interactions, and less than 5% studied the effects of disturbance on forest arthropods (Figure IV-3).

A large proportion (58%) of studies included taxa that are likely to occur in the Southern Range of the Northern Spotted Owl, comprising the Klamath physiographic provinces of California and Oregon, and the California's Coast and Cascade Ranges ("study region"). Some of these studies were conducted outside the range of the study region. In these cases, the presence and geographic distribution of host plant species were used as a guideline for determining the species' probable occurrence in this region (see Task 4 below).

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**Forest Understory and Canopy Gap Herbivores:**  
**IV. Additional Searches Of Electronic Databases (Task 3)**  
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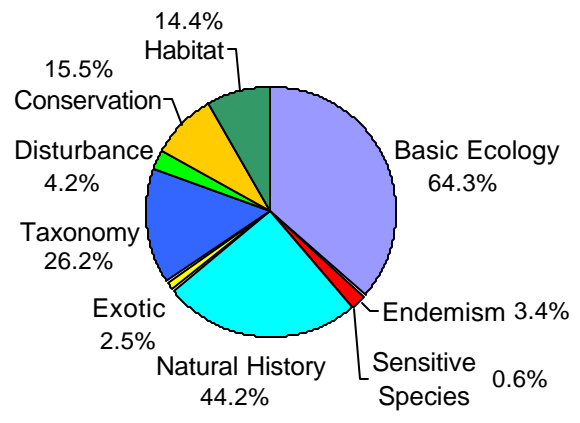


Figure IV-3. The percentage of records in the final database with information on major topics of interest. The sum of the percentages is greater than 100 because some records fall into more than one category.