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VIII. BIBLIOGRAPHY

Abrams, L. 1940. Illustrated flora of the Pacific States: Washington, Oregon, and California. Volume I. Stanford University Press, Stanford, California. 538 pp.

Abrams, L. 1950. Illustrated flora of the Pacific States: Washington, Oregon, and California. Volume II. Stanford University Press, Stanford, California. 635 pp.

Abrams, L. 1951. Illustrated flora of the Pacific States: Washington, Oregon, and California. Volume III. Stanford University Press, Stanford, California. 866 pp.

Abrams, L., and R. Stinchfield Ferris. 1960. Illustrated flora of the Pacific States: Washington, Oregon, and California. Volume IV. Stanford University Press, Stanford, California. 732 pp.

Ankley, G.T., D.A. Benoit, R.A. Hoke, E.N. Leonard, and C.W. West. 1993. Development and evaluation of test methods for benthic invertebrates and sediments: Effects of flow rate and feeding on water quality and exposure conditions. Environmental Research Laboratory, U.S. Environmental Protection Agency, Duluth, MN. EPA/600/J-94/186. 10 pages.

Arnett, R.H., Jr. and R.L. Jacques, Jr. 1981. Guides to Insects. Simon and Schuster, Inc. New York. 511 pages.

Asquith, A., J.D. Lattin, and A.R. Moldenke. 1990. Arthropods: The invisible diversity. Northwest Environmental Journal 6(2):404-405.

Axelrod, D.I. 1958. Evolution of the Madro-Tertiary geoflora. Botanical Review 24(7):433-509.

Axelrod, D.I. 1976. History of the coniferous forests, California and Nevada. University of California Publications in Botany 70:1-62.

Baldwin, B., S. Boyd, B. Ertter, R. Patterson, T. Rosatti, and D. Wilken. 1993. The Jepson flora project: a checklist of the California flora. The Jepson Flora Project home page. http://ucjeps.berkeley.edu/jepson_flora_project.html.

Bartolome, J. W., D. C. Erman, and C. F. Schwarz. 1990. Stability and change in minerotrophic peatlands, Sierra Nevada of California and Nevada. USDA Forest Service Research Paper PSW-198.

Batzer, H.O. 1976. Silvicultural control techniques for the spruce budworm. Pages 110-116 in U.S.D.A. Proceedings of a Symposium on the Spruce Budworm, 11-14 November 1974, Alexandria, VA. U.S.D.A. Forest Service Miscellaneous Publication 1327.

Beccaloni, G.W. and K.J. Gaston. 1995. Predicting the species richness of neotropical forest butterflies: Ithomiinae (Lepidoptera:Nymphalidae) as indicators. Biological Conservation 71:77-86.

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Forest Understory and Canopy Gap Herbivores:
VIII. Bibliography

ààà

Begon, M., J. L. Harper, and C. R. Townsend. 1996. Ecology: individuals, populations and communities. 3rd edition. Blackwell Science, Oxford. 1068 pp.

Beigel, J.K., E.S. Jules, and B. Snitkin. 1997. Proceedings of the First Conference on Siskiyou Ecology. Siskiyou Project, Cave Junction, OR. 204 pages.

Berry, R. E, J. Liu, and E. Groth. 1997. Efficacy and persistence of *Heterorhabditis marelatus* (Rhabditida: Heterorhabditidae) against root weevils (Coleoptera: Curculionidae) in strawberry. Environmental Entomology 26: 465-470.

Beschta, R.L. 1991. Stream habitat management for fish in the Northwestern United States: The role of riparian vegetation. American Fisheries Society Symposium 10:53-58.

Blossey, B., and M. Schat. 1997. Performance of *Galerucella calmariensis* (Coleoptera: Chrysomelidae) on different North American populations of purple loosestrife. Environmental Entomology 26: 439-445.

Bond, W.J. 1994. Do mutualisms matter? Assessing the impact of pollinator and disperser disruption on plant extinction. Philosophical transactions of the Royal Society of London B. 334:83-90.

Brenner, G.J. 2000. Riparian and Adjacent Upslope Beetle Communities Along a Third Order Stream in the Western Cascades Mountain Range, Oregon. Ph.D. Dissertation, Oregon State University, Corvallis, OR. 327 pages.

Bromenshenk, J.J., S.R. Carlson, J.C. Simpson, J.M. Thomas. 1985. Pollution monitoring of Puget Sound with honeybees. Science 227:632-634.

Brown, K.S., Jr. 1991. Conservation of neotropical environments: insects as indicators. Pages 349-404 in N.M. Collins and J.A. Thomas (editors). Conservation of Insects and Their Habitats. Academic Press, London.

Brown, K.S., Jr. 1997. Diversity, disturbance, and sustainable use of Neotropical forests: insects as indicators for conservation monitoring. Journal of Insect Conservation 1:25-42.

Buchmann, S.L. 1996. Competition between honey bees and native bees in the Sonoran Desert and global bee conservation issues. Pages 125-142 in A. Matheson, S.L. Buchmann, C. O'Toole, P. Westrich, and I.H. Williams (editors). The Conservation of Bees. Academic Press, London.

Buchmann, S.L. and G.P. Nabhan. 1996. The Forgotten Pollinators. Island Press, Washington, D.C. 292 pages.

Cates, R.G., R.A. Redak, and C.B. Henderson. 1983. Natural products defensive chemistry of Douglas-fir, western spruce budworm success, and forest management pr actices. Z. Angew. Entomol. 96:173-182.

Center, T.D., J.H. Frank, and F.A. Dray, Jr. 1995. Biological invasions: Stemming the tide in Florida. Florida Entomologist 78(1):45-55.

Chaney, R.W. 1948. The ancient forests of Oregon. Oregon State System of Higher Education, Eugene, Oregon. 56 pages.

VIII. Bibliography

Chen, J., J.F. Franklin, and T.A. Spies. 1992. Vegetation responses to edge environments in old-growth Douglas-fir forests. Ecological Applications 2:387-396.

Chen, J., J.F. Franklin, and T.A. Spies. 1993. Contrasting microclimates along clearcut, edge and interior of old-growth Douglas-fir forest. Agriculture and Forestry Meteorology 63:219-237.

Chen, J., J.F. Franklin, and T.A. Spies. 1995. Growing season microclimate gradients from clearcut edges into old-growth Douglas-fir forests. Ecological Applications 5:74-86.

Cousins, S.H. 1991. Species diversity measurement: choosing the right index. Trends in Ecology and Evolution 6:190-192.

Cox, M. H. 1976. Of evening songs, katydids and crickets. Environment Southwest No. 475: 3-5.

Curnutt, J., J. Lockwood, H. Luh, P. Nott, and G. Russell. 1994. Hotspots and species diversity. Nature 367:326-327.

Daily, G.C. and P.R. Ehrlich. 1995. Conservation of biodiversity in small rainforest patches: rapid evaluations using butterfly mapping. Biodiversity and Conservation 4:35-55.

Daniel, S.L., T.M. Jimerson, L.D. Hoover, E.A. McGee, G. DeNitto, and R.M. Creasy. 1995. A Field Guide to Serpentine Plant Associations and Sensitive Plants in Northwestern California. U.S.D.A., Forest Service, Washington, D.C. 338 pages.

Danks, H.V. and R.G. Foottit. 1989. Insects of the boreal zone of Canada. Canadian Entomologist 121:625-690.

DellaSala, D.A., S.B. Reid, T.J. Frest, S.R. Strittholt, D.M. Olson. 1999. A global perspective of the biodiversity of the Klamath-Siskiyou ecoregion. Natural Areas Journal 19(4):300-319.

Di Castri, F., J. Robertson Vernhes, and T. Younès. 1992. Inventorying and monitoring biodiversity. Biology International 27:1-27.

Diller, J.S. 1902. Topographic development of the Klamath Mountains. U.S. Geologic Survey Bulletin 196:1-69.

Downie, N.W. and R.H. Arnett. 1996. The Beetles of Northeastern North America. Volumes I and II. The Sandhill Crane Press, Gainesville, Florida. 1721 pages.

Dubrasich, M.E., D.H. Hann, and J.C. Tappeiner, II. 1997. Methods for evaluating crown area profiles of forest stands. Canadian Journal of Forest Research 27(3):385-392.

Dufrêne, M. and P. Legendre. 1997. Species assemblages and indicator species: The need for a flexible asymmetrical approach. Ecological Monographs 67(3):345-366.

Ehrlich, P.R. and P.H. Raven. 1964. Butterflies and plants: A study in coevolution. Evolution 18:586-608.

Eldridge, D.J. 1994. Nests of ants and termites influence infiltration in a semi-arid woodland. Pedobiologia 38:481-492.

Forest Understory and Canopy Gap Herbivores:
VIII. Bibliography

Engelbrecht, H.H. 1955. The climatology and ecology of the Pacific Coast. National Shade Tree Conference. Proceedings of the Annual Meeting 31:7-24.

Erman, D. C., and N. A. Erman. 1975. Macroinvertebrate composition and production in some Sierra Nevada minerotrophic peatlands. Ecology 56:591-603.

Evans, F.C. and W.W. Murdoch. 1968. Taxonomic composition, trophic structure and seasonal occurrence in a grassland insect community. Journal of Animal Ecology 37:259-273.

Evans, R. A. 1995. Hemlock ravines at Delaware Water Gap National Recreation Area: A highly valued, distinctive, and threatened ecosystems. Proceedings of theDelaware Water Gap 30th anniversary Symposium, November 1995. Pocono Environmental Education Center, Bushkill, Pennsylvania.

Eyre, M.D., D.A. Lott, and A. Garside. 1996. Assessing the potential for environmental monitoring using ground beetles (Coleoptera: Carabidae) with riverside and Scottish data. Annales Zoologici Fennici 33:157-163.

Faith, D.P. and P.A. Walker. 1996. Environmental diversity: on the best-possible use of surrogate data for assessing the relative biodiversity of sets of areas. Biodiversity and Conservation 5:399-415.

Falk, D.A. 1992. From conservation biology to conservation practice: strategies for protecting plant diversity. Pages 397-431 in P.L. Fiedler and S.K. Jain (editors). Conservation Biology: The Theory and Practice of Nature Conservation, Preservation, and Management. Chapman and Hall, New York.

Ferguson, D. C., C. E. Harp, P. A. Opler, R. S. Peigler, M. Pogue, J. A. Powell, and M. J. Smith. 1999. Moths of North America. Jamestown, ND: Northern Prairie Wildlife Research Center home page. http://www.npwrc.usgs.gov/resource/ distr/lepid/moths/ mothsusa.htm (Version 23FEB2001).

Ferlatte, W.J. 1974. A Flora of the Trinity Alps of Northern California. University of California Press, Berkeley. 206 pages.

Forest Ecosystem Management Assessment Team. 1993. Forest Ecosystem management: an ecological, economic, and social assessment. U.S. Department of Interior, U.S. Department of Agriculture, U.S. Department of Commerce, and U.S. Environmental Protection Agency, Washington, D.C. 729 pages.

Franklin, J.F. 1990. Old-growth reference stand network in the Pacific Northwest: Recording long-term ecosystem dynamics. Northwest Environmental Journal 6(2):423-424.

Franklin, J.F. and C.T. Dyrness. 1984. Natural Vegetation of Oregon and Washington. Oregon State University Press, Corvallis, Oregon. 452 pages.

VIII. Bibliography

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Franklin, J.F. and R.T.T. Forman. 1987. Creating landscape patterns by forest cutting: ecological consequences and principles. Landscape Ecology 1:5-18.

Freitag, R.L., W.R. Hastings, and A. Smith. 1973. Ground beetle populations near a kraft mill. Canadian Entomologist 105:299-310.

Frost, E.J. 1997. Edge effects in old-growth forests of the Klamath Mountains: evidence from the understory flora. Pages 23-36 in J.K. Beigel, E.S. Jules, and B. Snitkin (editors). Proceedings of the First Conference on Siskiyou Ecology. May 30 – June 1, 1997. Kerby and Cave Junction, OR. 204 pages.

Fujimori, T. 1971. Primary productivity of a young Tsuga heterophylla stand and some speculations about biomass of forest communities on the Oregon Coast. United States Department of Agriculture, Forest Service Research Paper PNW-123. 11 pages.

Gaston, K.J. 1998. Biodiversity. Pages 1-19 in W.J,. Sutherland (editor). Conservation Science and Action. Blackwell, Oxford, UK.

Gessel, S.P. (Principal Investigator). 1971. Unites States International Biology Program. Analysis of Ecosystems. Coniferous Forest Biome. Year 2 Proposal. Volume 1.

Ginsberg, H.S. 1983. Foraging ecology of bees in an old field. Ecology 64:165-175.

Greenslade, P. and T.R. New. 1991. Australia: conservation of a continental insect fauna. Pages 33-70 in N.M. Collins and J.A. Thomas (editors). The Conservation of Insects and Their Habitats. Academic Press, London.

Gregory, S.V., F.J. Swanson, W.A. McKee and K.W. Cummins. 1991. An ecosystem perspective of riparian zones. BioScience 41: 540-551.

Grier, C.C. and R.S. Logan. 1977. Old-growth Pseudotsuga menziesii communities of a western Oregon watershed: biomass distribution and production budgets. Ecological Monographs 47:373-400.

Grumbine, R.E. 1994. What is ecosystem management? Conservation Biology 8:27-38.

Gurevitch, J. and L. V. Hedges. 1993. Meta-analysis: combining the results of independent experiments. Pages 378-398 *in* S. M. Scheiner and J. Gurevitch, eds. Design and analysis of ecological experiments. Chapman and Hall, New York.

Hafernik, J.E. 1992. Threats to invertebrate biodiversity: implications for conservation strategies. Pages 171-196 in P.L. Fiedler and S.K. Jain (editors). Conservation Biology. Chapman and Hall,, New York.

Halaj, J., and D. H. Wise. 2001. Terrestrial trophic cascades: how much do they trickle? American Naturalist 157:262-281.

Halvorson, W.L. 1997. Changes in landscape values and expectations: What do we want and how do we measure it? Pages 15-30 in R.G. Wright (editor). National Parks and Protected Areas: Their Role in Environmental Protection. Blackwell Science, Boston. 470 pages.

Halvorson, W.L. and G.E. Davis. 1996. Ecosystem Management in the

National Parks. University of Arizona Press, Tucson, AZ.

Hanley, T.A. 1983. Black-tailed deer, elk, and forest edge in a western Cascades watershed. Journal of Wildlife Management 47(1):237-242.

Hansen, A.J., T.A. Spies, F.J. Swanson, and J.L. Ohmann. 1991. Conserving biodiversity in managed forests, lessons from natural forests. Bioscience 41:382-392.

Harris, L.D. 1984. The fragmented forest. Island Biogeography Theory and the Preservation of Biotic Diversity. University of Chicago Press, Chicago. Pp 211.

Hartley, M. J., and M. L. Hunter. 1998. A meta-analysis of forest cover, edge effects, and artificial nest predation rates. Conservation Biology 12: 465-469.

Hatch, M.H. 1953. The Beetles of the Pacific Northwest. Part 1. Introduction and Adephaga. University of Washington Publication in Biology Volume 16(1). University of Washington Press, Seattle. 340 pages.

Hatch, M.H. 1957. The Beetles of the Pacific Northwest. Part 2. Staphyliniformia. University of Washington Publication in Biology Volume 16(2). University of Washington Press, Seattle. 384 pages.

Hatch, M.H. 1962. The Beetles of the Pacific Northwest. Part 3. Pselaphidae and Diversicornia. University of Washington Publication in Biology Volume 16(3). University of Washington Press, Seattle. 503 pages.

Hatch, M.H. 1965. The Beetles of the Pacific Northwest. Part 4. Macrodactyles, Palpicornes, and Heteromera. University of Washington Publication in Biology Volume 16(4). University of Washington Press, Seattle. 268 pages.

Hatch, M.H. 1971. The Beetles of the Pacific Northwest. Part 5. Rhipiceroidea, Sternoxi, Phytophaga, Rhynchophora, and Lamellicornia. University of Washington Publication in Biology Volume 16(5). University of Washington Press, Seattle. 662 pages.

Hayslip, G.A. 1993. Region 10 in-stream biological monitoring handbook: For wadable streams in the Pacific Northwest. Environmental Services Division Laboratory, U.S. Environmental Protection Agency, Seattle, WA. EPA/910/9-92/013. 84 pages.

Hendrix, P.F., D.A. Crossley, Jr., J.M. Blair, and D.C. Coleman. 1990. Soil biota as components of sustainable agroecosystems. Pages 637-654 in C.A. Edwards, R. Lal, P. Madden, R.H. Miller, and G. House (editors). Sustainable Agricultural Systems. Soil and Water Conservation Society, Ankeny, IA.

Hering, D. 1998. Riparian invertebrates along a small stream in Oregon Coast Range and their interactions with the aquatic environment. The Coleopterist Bulletin 52(2):161-170.

Hicks, A.L. and J.S. Larson. 1997. Impervious surface area and benthic macroinvertebrate response as an indicator of impact from urbanization of freshwater wetlands. Corvallis Environmental Research laboratory, U.S. Environmental Protection Agency, Corvallis, OR. EPA/600/R-

97/075. 155 pages.

Hinchliff, J. 1994. An atlas of Oregon butterflies. The Evergreen Aurelians. 176 pp.

Hitchcock, C.L. and A. Cronquist. 1973. Flora of the Pacific Northwest. University of Washington Press, Seattle, Washington. 730 pages.

Hitchcox, S.M. 1996. Abundance and nesting success of cavity-nesting birds in unlogged and salvage-logged burned forest in northwestern Montana. M.S. Thesis. University of Montana, Missoula, Mt. 89 pages.

Holling, C.S. (editor). 1978. Adaptive Environmental Assessment and Management. John Wiley and Sons, New York.

Holmes, P.R., D.C. Boyce, and D.K. Reed. 1993a. The ground beetle (Coleoptera:Carabidae) fauna of Welsh peatland biotopes: factors influencing the distribution of ground beetles and conservation implications. Biological Conservation 63:153-161.

ISI ResearchSoft 1999. ProCite User's Guide. Institute for Scientific Information ResearchSoft, Berkeley, California.

Jensen, A. S. 1996. A review of *Sitobion*, with a description and revision of a new genus (Homoptera: Aphididae). Ph.D. thesis, Oregon State University, Corvallis.

Jepson, W. L. 1957. A manual of flowering plants of California. University of California Press, Berkeley. 1238 pp.

Johansen, C.A. 1977. Pesticides and pollinators. Annual Review of Entomology 22:177-192.

Jones, M. P. 1976. Final rulemaking: butterflies. Endangered Species Technical Bulletin 1: 3.

Kellen, W. R, D. F. Hoffmann, and S. S. Collier. 1977. Studies on the biology and ultrastructure of *Nosema transitellae* sp. n. (Microsporidia: Nosematidae) in the navel orangeworm, *Paramyelois transitella* (Lepidoptera: Pyralidae). Journal of Invertebrate Pathology 29: 289-296.

Klemm, D.J., P.A. Lewis, F. Fulk, and J.M. Lazorchak. 1990. Macroinvertebrate field and laboratory methods for evaluating the biological integrity of surface waters. Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH. EPA/600/4-90/030. 270 pages.

Kreasky, J. B, E. H. Ilcken, and W. M. Rogoff. 1977. Field crickets: observations on dispersal and control in the Imperial Valley, California. Bulletin of the Society of Vector Ecologists 3: 41-45.

Krebs, C.J. 1972. Ecology. Harper & Row, Publishers, New York. 604 pages.

Krebs, C.J. 1989. Ecological Methodology. Harper and Row, Cambridge. 654 pages.

Kremen, C. 1992. Assessing the indicator properties of species assemblages for natural areas monitoring. Ecological Applications 2:203-217.

Kremen, C. 1994. Biological inventory using target taxa: A case study of the butterflies of Madagascar. Ecological Applications 4:407-422.

Kremen, C., A.D. Merenlender, and D.D. Murphy. 1994. Ecological monitoring: A vital need for integrated conservation and development programs in the Tropics. Conservation Biology 8(2):388-397.

Lapin, B. 1995. The impact of hemlock woolly adelgid on resources in the lower Connecticut River Valley. Northeastern Center for Forest Health Research,Hamden CT. 45 pages.

Lattin, J.D. 1990. Arthropod diversity in Northwest old-growth forests. Wings 15(2):7-10.

Lattin, J.D. 1993a. Arthropod diversity and conservation in old-growth Northwest forests. American Zoologist 33:578-587.

Lattin, J.D. 1993b. Viewpoint Lessons from the spotted owl – the utility of nontraditional data. Bioscience 43(10):666.

Lattin, J.D. 1994. Non indigenous arthropods and research natural areas. Natural Areas Report 6(2):2.

Lattin, J. D. 1998. A review of the insects and mites found on *Taxus* spp. with emphasis on western North America. Gen. Tech. Rep. PNW-GTR-433. USDA Forest Service, PNW Research Station. 12 p.

Lattin, J.D. and A.R. Moldenke. 1992. Ecologically sensitive invertebrate taxa of Pacific Northwest old-growth forests. Report to the Northern Spotted Owl Recovery Team on Other Species and Ecosystems Committee. Portland, Oregon. U.S. Department of the Interior. 42 pages.

Lattin, J. D. and N. L. Stanton. 1993. A review of the genus *Melanocoris* Champion with remarks on distribution and host tree associations (Hemiptera: Heteroptera: Anthocoridae). Journal of the New York Entomological Society 101:95-107.

Lidicker, W.Z. and W.D. Keonig. 1996. Responses of terrestrial vertebrates to habitat edges and corridors. Pages 85-110 in D.R. McCullough (editor). Metapopulations and wildlife conservation. Island Press, Washington, D.C.

Longino, J.F. 1994. Project ALAS (arthropods of La Selva) Project Summary. May. Estacion Biologica La Selva, Costa Rica, Central America.

Lovejoy, T.E., J.M. Rankin, R.D. Bierregaard, Jr., K.S. Brown, Jr., L.H. Emmons, and M.E. van der Voort. 1984. Ecosystem decay of Amazon forest remnants. Pages 295-325. In: M.H. Nitecki (editor) Extinctions. University of Chicago Press, Chicago, Illinois.

Lubchenco, J., A.M. Olson, L.B. Brubaker, S.R. Carpenter, M.M. Holland, S.P. Hubbell, S.A. Levin, J.A. MacMahon, P.A. Matson, J.M. Melillo, H.A. Mooney, C.H. Peterson, H.R. Pulliam, L.A. Real, P.J. Regal, and P.G. Risser. 1991. The sustainable biosphere initiative: an ecological research agenda. Ecology 72:371-412.

Luff, M.L. 1996. Use of carabids as environmental indicators in grasslands and cereals. Annales Zoologici Fennici 33:185-195.

Luken, J.O. 1997. Conservation in the context of non-indigenous species. Pages 107-116 in M.W. Schwartz (editor). Conservation in Highly Fragmented Landscapes. Chapman and Hall, New York.. 436 pages.

Magurran, A.E. 1988. Ecological Diversity and Its Measurement. Princeton

University Press, New Jersey. 179 pages.

Mathews, D. 1988. Cascade – Olympic natural History. Raven Editions, Portland. 625 pages.

McDonald, P.M. and G.O. Fiddler. 1997. Treatment duration and time since disturbance affect vegetation development in a young California red for plantation. USDA, Forest Service Research Paper PSW-RP-233.

McEvoy, P., C. Cox, and E. Coombs. 1991. Successful biological control of ragwort, *Senecio jacobaea*, by introduced insects in Oregon. Ecological Applications 4:430-442.

Meehan, W.R., F.J. Swanson and J.R. Sedell. 1977. Influences of riparian vegetation on aquatic ecosystems with particular references to salmonid fishes and their food supply. In: Importance, preservation and management of riparian habitat: A symposium. R.R. Johnson and D.A. Jones (editors). United States Department of Agriculture, Forest Service Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-43. Pages 137-145

Merritt, G.D. 1999. Biological assessment of small streams in the coast range ecoregion and the Yakima River basin. Washington State Department of Ecology, Environmental Assessment Program publication number 99-302.

Miller, J. C. 1995. Caterpillars of pacific northwest forests and woodlands. USDA Forest Service Publication No. FHM-NC-06-95. 80 pp.

Miller, J. C., and P. C. Hammond. 2000. Macromoths of northwest forests and woodlands. USDA Forest Service Publication No. FHTET-98-18. 133 pp.

Miller, J.C. 1990. Field assessment of the effects of a microbial pest control agent on nontarget Lepidoptera. American Entomologist 36:135-139.

Miller, J.C. 1993. Insect natural history, multi-species interactions and biodiversity in ecosystems. Biodiversity and Conservation 2:233-241.

Mills, L.S. 1995. Edge effects and isolation: red-backed voles on forest remnants. Conservation Biology 9(2):395-403.

Moldenke, A.R. 1990. One hundred twenty thousand little legs. Wings 15(2):11-14.

Montgomery, D.R., G.E. Grant, and K. Sullivan. 1995. Watershed analysis as a framework for implementing ecosystem management. Water Resources Bulletin 31:369-386.

Munroe, E. 1976a. Pyraloidea Pyralidae comprising the subfamily Pyraustinae tribe Pyraustini (part). Fascicle 13.2A. Pages 1-78 *In* Dominick, R.B. et al. [Eds]. The moths of America north of Mexico including Greenland. Wedge Entomological Foundation London.

Munroe, E. 1976b. Pyraloidea Pyralidae comprising the subfamily Pyraustinae tribe Pyraustini (conclusion). Fascicle 13. 2B. Pages 81-150 *In* Dominick, R.B. et al. [Eds]. The moths of America north of Mexico including Greenland. Wedge Entomological Foundation London.

Murphy, D.D. and B.A. Wilcox. 1986. Butterfly diversity in natural habitat fragments: a test of the validity of vertebrate-based management. Pages 287-292 in J. Verner, M.L. Morrison, and C.J. Ralph (editors). Wildlife 2000, modeling habitat relationships of terrestrial vertebrates. The University of Wisconsin Press, Madison, Wisconsin.

Murtaugh, P.A. 1996. The statistical evaluation of ecological indicators. Ecological Applications 6(1):132-139.

Muth, G.J. 1967. A flora of Marble Valley, Siskiyou County, California. M.S. thesis, Pacific Union College, Angwin, CA.

National Research Council. 2000. Environmental Issues in Pacific Northwest Forest Management. National Academy Press, Washington, D.C. 259 pages.

Nehls, H.B. 1981. Familiar Birds of the Northwest. Portland Audubon Society, Portland, Oregon. 184 pages.

Nelson, S.M. and D.C. Andersen. 1994. An assessment of riparian environmental quality by using butterflies and disturbance susceptibility scores. The Southwest Naturalist 39(2):137-142.

Nelson, T.W. 1979. A flora of the Lassics, Humboldt and Trinity counties, California. M.A. thesis, Humboldt State University, Arcata, CA.

New, T.R. 1999. Limits to species focusing in insect conservation. Annals of the Entomological Society of America 92(6):853-860.

Niemelä, J. 1997. Invertebrates and boreal forest management. Conservation Biology 11(3):601-610.

Niemelä, J., D. Langor, and J.R. Spence. 1993. Effects of clear-cut harvesting on boreal ground-beetle assemblages (Coleoptera: Carabidae) in Western Canada. Conservation Biology 7(3):551-561.

Niemelä, J.R., H. Tukia, and E. Halme. 1994. Patterns of carabid diversity in Finnish mature taiga. Annales Zoologici Fennici 31:123-129.

Oakley, A.L., J.A. Collins. L.B. Everson, D.A. Heller, J.C. Howerton, and R.E. Vincent. 1985. Riparian zones and fresh-water wetlands. Pages 57-80 in E.R. Brown (editor). Management of Wildlife and Fish habitats in Forests in Western Oregon and Washington. United States Department of Agriculture, Forest Service, Pacific Northwest Region, Portland, Oregon, Publication Number R6-F&WL-192-1985.

ODA. 2001. Oregon Department of Agriculture web site http://www.oda.state.or.us/plant/ppd/gm_web/Gypsy_Moth.html Oregon Department of Agriculture, 635 Capitol St. NE, Salem, OR

Oettinger, F.W. 1975. The vascular plants of the High Lake Basins in the vicinity of English Peak, Siskiyou County, California. M.A. thesis, Claremont Graduate School, Claremont, CA.

Oliver, I. 1993. Rapid biodiversity assessment and its application to fauna conservation in production forests. Pages 31-34 in Proceedings of the Biodiversity Assessment Workshop, Marquarie University, North Ryde, Australia.

Oliver, I. And A.J. Beattie. 1993a. A possible method for the rapid assessment of biodiversity. Conservation Biology 7:562-568.

Oliver, I. And A.J. Beattie. 1993b. Designing a cost-effective invertebrate survey: a test of methods for rapid assessment of biodiversity. Ecological Applications 6(2):594-607.

Opler, P. A., and J. D. Lattin. 2001. Narrative on arthropods and annelid worms of old-growth and late successional forests, mature riparian woods, and of coarse woody debris associated arthropods within the range of the northern spotted owl (*Strix occidentalis caurina*). Northern Prairie Wildlife Research Center home page. http://www.mesc.usgs.gov/pubs/online/arthropods/arthropods_annelids.html.

Opler, P. A., H. Pavulaan, and R. E. Stanford. 1995. Butterflies of North America. Jamestown, ND: Northern Prairie Wildlife Research Center home page. http://www.npwrc.usgs.gov/resource/distr/lepid/bflyusa/bflyusa.htm (Version 23FEB2001).

Parsons, G. L., G. Cassis, A. R. Moldenke, J. D. Lattin, N. H. Anderson, J. C. Miller, P. Hammond, and T. D. Schowalter. 1991. Invertebrates of the H. J. Andrews Experimental Forest, Western Cascade Range, Oregon. V: An annotated list of insects and other arthropods. USDA FS PNW General Technical Report PNW-GTR-290.

Patton, D.C. 1993. Honeybees in the Australian environment. BioScience 43:95-103.

Patton, D.R. 1977. Riparian research needs. R.R. Johnson and D.A. Jones (editors). United States Department of Agriculture, Forest Service Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-43. Pp 80-82.

Pearson, D.L. and F. Cassola. 1992. World-side species richness patterns of tiger beetles (Coleoptera:Cicindelidae): Indicator taxon for biodiversity and conservation studies. Conservation Biology 6:376-391.

Peck, M. E. 1941. A manual of the higher plants of Oregon. Binfords & Mort, Portland, Oregon. 866 pp.

Peck R. W, A. Martinez Equihua, and D. W. Ross. 1997. Seasonal flight patterns of bark and ambrosia beetles (Coleoptera: Scolytidae) in northeastern Oregon. Pan-Pacific Entomologist 73: 204-212.

Pimental, R.A. 1963. Natural History. Reinhold Book Corp., New York. 436 pages.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. Assessment and Watershed Protection Division, U.S. Environmental Protection Agency, Washington, D.C. EPA/440/4-89/001. 196 pages.

Poinar, G. O, and R. S. Lane. 1978. *Pheromermis myopis* sp. N. (Nematoda: Mermithidae), a parasite of *Tabanus punctifer* (Diptera: Tabanidae). Journal of Parasitology 64: 440-444.

Pollard E. and T.J. Yates. 1993. Monitoring Butterflies for Ecology and Conservation. Chapman & Hall, London. 274 pages.

Porter, S.D. and D.A. Savignano. 1990. Invasion of polygyne fire ants decimates native ants and disrupts arthropod community. Ecology 71:2095-2106.

Prendergast, J.R., R.M. Quinn, J.H. Lawton, B.C. Eversham, and D.W. Gibbons. 1993. Rare species, the coincidence of diversity hotspots and conservation strategies. Nature 365:335-337.

Price, P. W. 1984. Insect Ecology. 2nd edition. John Wiley, New York. 607 pp.

Puterka, G. J. 1997. Intraspecific variation in pear psylla (Psyllidae: Homoptera). Nymphal survival and development on resistant and susceptible pear. Environmental Entomology 26: 552-558.

Punttila, P., Y. Haila, N. Niemelä, and T. Pajunen. 1994. Ant communities in fragments of old-growth taiga and managed surroundings. Annales Zoologici Fennici 31:131-144.

Pyke, G.H. and L. Balzer. 1985. The effect of the introduced honeybee on Australian native bees. Occasional Paper No. 7, New South Wales National Parks and Wildlife Service, Sydney, Australia.

Rathcke, B. and E.S. Jules. 1993. Habitat fragmentation and plant-pollinator interactions. Current Science 65:273-277.

Raven, P.H. 1987. The scope of the plant conservation problem world-wide. Pages 19-20 in D. Bramwell, O. Harmann, V. Heywood, and H. Synge (editors). Botanic Gardens and the World Conservation Strategy. Academic Press, London.

Reese, K.P. and J.T. Ratti. 1988. Edge effect: a concept under scrutiny. Transactions of the North American Wildlife and Natural Resources Conference 53:127-136.

Regional Interagency Executive Committee. 1995. Ecosystem analysis at the watershed scale: federal guide for watershed analysis. Version 2.2. Regional Ecosystem Office, Portland, OR. 26 pages.

Regional Interagency Executive Committee. 1997. Riparian reserve evaluation techniques and synthesis. Supplement to Section II of Ecosystem analysis at the watershed scale: federal guide for watershed analysis. Version 2.2. Regional Ecosystem Office, Portland, OR. 26 pages + addendum to Appendix B (342 pages).

Ringold, P.L., J. Alegria, R.L. Czaplewski, B.S. Mulder, T. Tolle, and K. Burnett. 1996. Adaptive monitoring for ecosystem management. Ecological Applications 6(3):745-747.

Roland, J. 1993. Large-scale fragmentation increases the duration of tent caterpillar outbreak. Oecologia 93:25-30.

Rosenberg, D. and V.H. Resh. 1993. Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman & Hall, New York. 488 pages.

Rosenberg, K.V. and M.G. Raphael. 1986. Effects of forest fragmentation on vertebrates in Douglas-fir forests. In J. Verner, M.L. Morrison, C.J. Ralph (editors). Wildlife 2000: modeling habitat relationships of terrestrial vertebrates. Proceedings of an international symposium; October 7-11, 1984, Fallen Leaf Lake, CA. University of Wisconsin Press, Madison, WI.

Rosenberg, M. S., D. C. Adams, and J. Gurevitch. 1997. MetaWin: statistical software for meta-analysis with resampling tests. Version 1.0. Sinauer Associates, Sunderland, Massachusetts.

Roubik, D.W., J.E. Moreno, C. Vergara, and D. Wittmann. 1986. Sporadic food competition with the African honey bee: projected impact on neotropical social bees. Journal of Tropical Ecology 2:97-111.

Ruesink, J.L., I.M. Parker, M.J. Groom, and P.M. Kareiva. 1995. Reducing the risks of nonindigenous species introductions. BioScience 45(7):465-477.

Rutanen, I. 1994. Xyletinus tremulicola (Coleoptera: Anobiidae) found in Finland. Entomologia Fennica 5:201-202.

Ruzicka, V. and J. Bohac. 1993. The utilization of epigeic invertebrate communities as bioindicators of terrestrial environmental quality. Pages 79-86 in J. Salanki, D. Jeffery, and G.M. Hughes. Biological Monitoring of the Environment. A Manual of Methods. CAB International, London. 623 Pages.

Rykken, J.J., D.E. Capen, and S.P. Mahabir. 1997. Ground beetles as indicators of land type diversity in the Green Mountains of Vermont. Conservation Biology 11(2):522-530.

Sailer, R.I. 1983. History of insect introductions. Pages 15-38 in C.L. Wilson and C.L. Graham (editors). Exotic Plant Pests and North American Agriculture. Academic Press, New York.

Samways, M.J. and N.S. Steytler. 1996. Dragonfly (Odonata) distribution patterns in urban and forest landscapes, and recommendations for riparian management. Biological Conservation 78:279-288.

Sawyer, J.O. 1996. Northwest California. Pages 20-42 in R. Kirk (editor). The Enduring Forests: Northern California, Oregon, Washington, British Columbia, and Southwest Alaska. The Mountaineers Press, Seattle, Washington.

Sawyer, J.O. and D.A. Thronburgh. 1977. Montane and subalpine vegetation of the Klamath Mountains. Pages 669-732 in M.G. Barbour and J. majors (editors). Terrestrial vegetation of California. Wiley-Interscience, New York.

Saunders, D.A., R.J. Hobbs, and C.R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology 5:18-33.

Schmid, B. and D. Matthies. 1994. Seltenheit und Gefährdung. Populationsbiologische Grundlagen des Artenschutz. Naturwissenschaften 81:283-292.

Schowalter, T.D. 1989. Canopy arthropod community structure and herbivory in old-growth and regenerating forests in western Oregon. Canadian Journal of Forest Research 19:318-322.

VIII. Bibliography

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Schowalter, T.D. 1995. Canopy arthropod communities in relation to forest age and alternative harvest practices in western Oregon. Forest Ecology and Management 78:115-125.

Schowalter, T.D. 1996. Stand and landscape diversity as a mechanism of forest resistance to insects. Pages 21-27 in W.J. Mattson, P. Niemelä, and M. Rousi (editors). Dynamics of Forest herbivory: Quest for Pattern and Principle. USDA Forest Service General Technical Report NC-183. USDA Forest Service, North Central Forest Experiment Station, St. Paul, MN.

Schowalter, T.D. 2000. Insect Ecology An Ecosystem Approach. Academic Press, New York. 483 pages.

Schowalter, T.D. and D.A. Crossley, Jr. 1988. Canopy arthropods and their response to forest disturbance. Pages 207-218 in W.T. Swank and D.A. Crossley, Jr. (editors). Forest Hydrology and Ecology at Coweeta. Srpinger-Verlag, New York.

Schowalter, T.D., W.W. Hargrove, and D.A. Crossley, Jr. 1986. Herbivory in forested ecosystems. Annual Review of Entomology 31:177-196.

Schultz, J.C. 1983. Habitat selection and foraging tactics of caterpillars in heterogeneous trees. Pages 61-91 in R.F. Denno and M.S. McClure (editors). Variable Plants and Herbivores in Natural and Managed Systems. Academic Press, New York. 717 pages.

Setälä, H. and V. Huhta. 1991. Soil fauna increase *Betula pendula* growth: laboratory experiments with coniferous forest floor. Ecology 72:665-671.

Sexton, T.O. 1994. Ecological effects of post-wildfire salvage-logging on vegetation diversity, biomass, and growth and survival of *Pinus ponderosa* and *Purshia tridentate*. Unpublished manuscript on file with the Department of Rangeland Resources, Oregon State University, Strand Agriculture Hall, ,Corvallis, OR. 28 pages.

Simberloff, D.S. 1993a. How forest fragmentation hurts species and what to do about it. Pages 85-90 in W.W. Covington and L.F. DeBano (technical coordinators). Sustainable Ecological Systems: Implementing an Ecological Approach to Land Management. United States Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station General Technical Report RM-247. 363 pages.

Simberloff, D.S. 1993b. Species-area and fragmentation effects on old-growth forests - prospects for longleaf pine communities. In: S. Hermann (editor). Proceedings of a Conference on longleaf Pine Forests. Tallahassee, Florida: Tall Timbers, Inc.

Smith, D.E. 1985. Principles of Silviculture. Eighth Edition. John Wiley and Sons, New York.

Smith, J.P, R.E. Gresswell, and J.P. Hayes. 1997. A Research Problem Analysis in Support of the Cooperative Forest Ecosystem Research (CFER) Program. U.S. Department of Interior, U.S.G.S. – Biological Resources Division, Forest and Range Ecosystem Science Center, Corvallis, OR. 92 pages.

Smith, J.P. and J.O. Sawyer, Jr. 1988. Endemic vascular plants of northwestern California and southwest Oregon. Madroño 35:54-69.

Soulé, M.E. 1991. Conservation: tactics for a constant crisis. Science 253:744-750.

Southwood, T.R.E. 1978. Ecological Methods with Particular Reference to the Study of Insect Populations. Second Edition. Chapman and Hall, London. 524 pages.

Sparrow, H.R., T.D. Sisk, P.R. Ehrlich, and D.D. Murphy. 1994. Techniques and guidelines for monitoring neotropical butterflies. Conservation Biology 8:800-809.

Spence, J.R. 1979. Riparian Carabid guilds - A spontaneous question generator. Pages 525-538 in T.L. Erwin, G.E. Ball, D.R. Whitehead (editors). Carabid Beetles: Their Evolution, Natural History, and Classification. Dr. W. Junk, Publishers, The Hague. 635 pages.

Spence, J.R. and J.K. Niemelä. 1994. Sampling carabid assemblages with pitfall traps: The madness and the method. The Canadian Entomologist 126:881-894.

Spies, T.A., W.J. Ripple, and G.A. Bradshaw. 1994. Dynamics and pattern of a managed coniferous forest landscape in Oregon. Ecological Applications 4(3):555-568.

Spira, T.P. 2001. Plant-pollinator interactions: A threatened mutualism with implications for the ecology and management of rare plants. Northwest Areas Journal 21(1):78-88.

Stern, V.M. 1985. Pest and Beneficial insects associated with agriculture and riparian systems. Pages 970-982 in R.E. Warner and K.M. Hendrix (editors). California Riparian Systems. Ecology, Conservation, and Productive Management. University of California Press, Berkeley, CA. 1035 pages.

Strong, D. R., J. H. Lawton, and Sir R. Southwood. 1984. Insects on plants: community patterns and mechanisms. Harvard University Press, Cambridge. 313 pp.

Stork, N.E. 1990. The Role of Ground Beetles in Ecological and Environmental Studies. Intercept, Andover, UK. 424 pages.

Stuart, J.D., M.C. Grifantini, and L. Fox, III. 1993. Early successional pathways following wildfire and subsequent silvicultural treatment in Douglas-fir/hardwood forests, NW California. Forest Science 39(3):561-572.

Sutton, S.L. and N.M. Collins. 1991. Insects and tropical forest conservation. Pages 405-424 in N.M. Collins and J.A. Thomas (editors). The Conservation of Insects and Their Habitats. Academic Press, London.

Swanson, F.J. and J.F. Franklin. 1992. New forestry principles from ecosystem analysis of Pacific Northwest forests. Ecological Applications 2:262-274.

Swanson, F.J., J.F. Franklin, and J.R. Sedell. 1990. Landscape patterns, disturbance and management in the Pacific Northwest, USA. Pages 191-

211 in I.S. Zoneveld and R.T.T. Forman (editors). Changing Landscapes: An Ecological Perspective. Springer-Verlag, New York.

Tepedino, V.J., S.D. Sipes, and T.L. Griswold. 1999. The reproductive biology and effective pollinators of the endangered beardtongue *Penstemon penlandii* (Scrophulariaceae). Plant Systematics and Evolution 219:39-54.

Thiele, H.U. 1977. Carabid Beetles in their Environments. Springer-Verlag, New York. 369 pages.

Thomas, J.W., E.D. Forsman, J.B. Lint, E.C. Meslow, B.R. Noon, and J. Verner. 1990. A conservation strategy for the northern spotted owl. Report of the Interagency Scientific Committee to address the Conserevation of the Northern Spotted Owl. USDA Forest Service, U.S. Department of the Interior Bureau of Land Management, U.S. Department of the Interior Fish and Wildlife Service, and U.S. Department of the Interior national Park Service, Portland, Oregon.

Torgersen, T.R. and D.L. Dahlsten. 1978. Natural mortality. Pages 47-53 in M.H. Brookes, R.W. Stark, and R.W. Campbell (editors). The Douglas-fir Tussock Moth: A Synthesis. U.S.D.A. Forest Service Technical Bulletin 1585.

Tuchmann, E.T., K.P. Connaughton, L.E. Freedman, and C.B. Moriwaki. 1996. The Northwest Forest Plan: a Report to the President and Congress. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. 253 pages.

U.S. Congress, Office of Technology Assessment. 1993. Harmful Non-Indigenous Species in the United States. OTA-F-565. United States Government Printing Office, Washington, D.C. 391 pages.

U.S. Fish and Wildlife Service. 1992. Endangered Species Technical Bulletin 17:9-11.

USDA. 1988. Final Supplement to the Environmental Impact Statement for an amendment to the Pacific Northwest regional guide. Spotted owl guidelines. USDA. Forest Service, PNW Region, Portland, Oregon.

USDA. 1994. Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl.

USDA. 2000. Final Supplemental Environmental Impact Statement for Amendment to the Survey and Manage, Protection Buffer, and other Mitigation Measures Standards and Guidelines. Volume I – Chapters 1-4. USDA. Forest Service, Portland, Oregon.

Wallin, D.O., F.J. Swanson, and B. Marks. 1994. Landscape pattern response to changes in pattern generation rules: land-use legacies in forestry. Ecological Applications 4(3):569-580.

Wallin, D.O., F.J. Swanson, B. Marks, J.H. Cissel, and J. Kertis. 1996. Comparison of managed and pre-settlement landscape dynamics in forests of the Pacific Northwest, USA. Forest Ecology and Management 85:291-309.

Walters, C. 1986. Adaptive Management of Renewable Resources. Macmillan, New York.

Waring, R.H. and J.F. Franklin. 1979. Evergreen coniferous forests of the Pacific Northwest. Science 204:1380-1386.

Warner, R.E. and K.M. Hendrix (editors). 1985. California Riparian Systems. Ecology, Conservation, and Productive Management. University of California Press, Berkeley, CA. 1035 pages.

Warren, M.S. 1997. Conserving Lepidoptera in a changing environmental: A perspective from western Europe. Journal of Insect Conservation 1:i-iv.

Warren, M.S. and R.S. Key. 1991. Woodlands: past and present and potential for insects. Pages 155-211 in N.M. Collins and J.A. Thomas (editors). The Conservation of Insects and their Habitats. 15th Symposium of the Royal Entomological Society of London, 14-14 September, 1989. Academic Press, Toronto. 450 pages.

Weaver, J.C. 1995. Indicator species and scale of observation. Conservation Biology 9(4):939-942.

Webb, N.R. 1989. Studies on the invertebrate fauna of fragmented heathland in Dorset, U.K., and the implications for conservation. Biological Conservation 47:153-165.

Whipple, J. 1981. A flora of Mt. Eddy, Klamath Mountains, California. M.A. thesis, Humboldt State University, Arcata, CA.

Whitham, T.G. 1981. Individual trees as heterogeneous environments: adaptation to herbivory or epigenetic noise? Pages 9-27 in R.F. Denno and H. Dingle (editors). Insect Life History patterns: Habitats and Geographic Variation. 225 pages.

Whittaker, R.H. 1960. Vegetation of the Siskiyou Mountains, Oregon and California. Ecological Monographs 30:279-338.

Whittaker, R.H. 1961. Vegetation history of the Pacific coast states and the central significance of the Klamath Region. Madroño 16:5-23.

Wilcove, D.S. and J.T. Olson. 1993. The ancient forests of the Pacific Northwest: A case study in conservation and economic development. Pages 177-185 in C.S. Potter, J.I. Cohen, and D. Janczewski (editors). Perspectives on Biodiversity: Case studies of genetic resource conservation and development. AAAS Press, Washington, D.C.

Wolfe, J.A. 1969. Neogene floristic and vegetational history of the Pacific northwest. Madrono 20:83-110.

Wolfe, J.A. 1978. A paleobotanical interpretation of Tertiary climates in the northern hemisphere. American Scientist 66:694-703.

Woodruff. R. E., and W. H. Pierce. 1973. *Scyphophorus acupunctatus*, a weevil pest of yucca and agave in Florida (Coleoptera: Curculionidae). Florida Department of Agriculture and Consumer Services Division of Plant Industry Entomology Circular No. 135.

APPENDICES

APPENDIX A
LITERATURE SEARCH TERMS

Names of forest understory and canopy gap herbivore taxa used in the USDA Forest Service literature search. Herbivore specifications follow Parsons et al. (1991).

CLASS	ORDER	FAMILY
Insecta	Orthoptera	Acrididae Gryllidae Tettigoniidae
	Thysanoptera	Phlaeothripidae Thripidae
	Hemiptera: Heteroptera	Berytidae Miridae Lygaeidae Rhopalidae Scutelleridae Thyreocoridae Tingidae
	Hemiptera: Homoptera	Aphididae Cercopidae Cicadellidae Delphacidae Derbidae Dictyopharidae Membracidae Psyllidae
	Coleoptera	Buprestidae Carabidae Cerambycidae Chrysomelidae Cleridae Coccinellidae Curculionidae Dermestidae Elateridae Melandryidae

Appendix A. Continued

		Meloidae Mordellidae Scarabaeidae
	Strepsiptera	Stylopidae
	Mecoptera	Boreidae
	Lepidoptera	Arctiidae Cosmopterigidae Drepanidae Geometridae Hesperiidae Lycaenidae Noctuidae Notodontidae Nymphalidae Papilionidae Pieridae Plutellidae Pyralidae Saturniidae Satyridae Sphingidae Thyatiridae
	Diptera	Axymyiidae Bombyliidae Chloropidae Conopidae Opomyzidae Syrphidae Tabanidae Tachinidae Tephritidae
	Hymenoptera	Andrenidae Anthophoridae Apidae Cimbicidae Colletidae Halictidae Megachilidae Tenthredinidae

APPENDIX B
CATEGORIES OF REJECTED RECORDS

Types of studies deemed either irrelevant, or of low priority to research on forest understory and canopy gap herbivores.

CATEGORY OF STUDIES	PLANT FAMILY / CROP	NO. REJECTED RECORDS
Studies conducted in a variety of agricultural crop systems	ANACARDIACEAE Pistachio	4
	APIACEAE Celery Parsley	2
	ARECACEAE Dates	1
	ASTERACEAE Lettuce	3
	BETULACEAE Filbert (Hazelnut)	6
	BRASSICACEAE Collards Mustard	15
	CANNABIDACEAE Hops	2
	CHENOPODIACEAE Beet	11
	CUCURBITACEAE Cucumber Pumpkin Squash	8
	ERICACEAE Blueberry Cranberry	7

Appendix B. Continued

FABACEAE	65
Alfalfa	
Beans	
Clover	
Lentils	
Pea	
Soybeans	
JUGLANDACEAE	14
Pecan	
Walnut	
LAMIACEAE	11
Peppermint	
LAURACEAE	8
Avocado	
LILIACEAE	4
Asparagus	
Onion	
MALVACEAE	33
Cotton	
MYRTACEAE	11
Eucalyptus	
Guava	
POACEAE	34
Corn	
Rice	
Ryegrass	
Sugar cane	
Wheat	
ROSACEAE	117
Almonds	
Apple	
Caneberry	
Cherry	
Jojoba	
Pear	
Prunes	
Raspberry	
Strawberry	
RUTACEAE	38
Citrus	
SOLANACEAE	27
Pepper	
Potato	
Tomato	

Appendix B. Continued	VITACEAE Grapes	24
Total crop systems	-	408
Non-forest habitats	-	179
Out-of-region investigations	-	113
Forest canopy	-	98
Miscellaneous	-	89
Total rejected records	-	846

APPENDIX C
DESCRIPTION OF DATABASE FIELDS

DATABASE FIELD	FIELD CONTENT
Author, Analytic (01):	Author(s) of the publication
Author Affiliation (03):	Address of the senior author, or the location of where the work was done.
Article Title (04):	Title of the publication.
Article Language (05):	Language of the original document.
Language of Summary (06):	The language of article summary.
Journal Title (10):	Publication source of the material, including the publication year, volume, and pages of the journal.
Date of Publication (20):	Date of publication.
Volume (22):	Journal volume -- relevant information can be parsed from field #10.
Issue (24):	Journal issue -- relevant information can be parsed from field #10.
Page(s) (25):	Journal pages -- relevant information can be parsed from field #10.
Geographic Descriptor (26):	This field list countries and their subdivisions, such as states or provinces, that are relevant to the record.
Systematics (27):	This field provides the most recent taxonomic hierarchy to which each organism mentioned in the document is assigned. All taxonomic and nomenclature information (e.g. SP-NOV) is attached to the appropriate animal name in this field, including, in some cases, the authority for the animal name.
Identifier (28):	This field contains taxonomic names of new species, and a variety of indexing terms, including personal, corporate, and place names.
Organism Descriptor (29):	This field contains organism names, and is similar to field #28. The majority of included terms are taxonomic names; common names are used mostly for livestock and common crops, and some well-known wild organisms.

Appendix C. Continued

Super Taxa (31):	This field lists common names of broad groups of organisms to allow a faster and easier searching of broad organism groups.
Biosystematics (33)	This field contains five-digit codes and biosystematic scientific names of higher taxonomic groups above the genus level, similar to Super Taxa in field #31.
Broad Term (34):	This field contains a variety of broad category terms, including organism and geographic names.
CABICODE Heading (35):	This field contains the text equivalent to the alphanumeric CABICODES listed in the CAB Abstracts database (codes not included in the database). For example, for the heading Biological Control the CABICODE is HH100.
Concept Codes (36):	This field contains five-digit codes representing broad biological concepts mentioned in the document.
Notes (42):	This field contains the broad classification codes that describe the focus and character of each study.
Content (43):	The field gives a brief description and summary of the topic and significant findings in the document.
ISSN/Source database (44):	This field contains the International Standard Serial Number (ISSN), and identifies the source database of the record. It also lists database(s) used to generate additional information for the record. Note that all of the original citations provided by the USDA Forest Service contain the term "ORIGINAL USDA-FS RECORD" in this field.
Keywords (45):	The field contains controlled subject terms or keywords that describe the key points of the paper, including terms describing organism(s) and subject(s) mentioned in the source document. Keywords may include personal, corporate and place names, and selected chemical groups. This field may contain British spelling of some terms.

APPENDIX D
EXAMPLE OF A BIBLIOGRAPHY RECORD (#255)

DATABASE FIELD	FIELD CONTENT
Author, Analytic (01):	Dingle H//Mousseau T A//Scott S M
Author Affiliation (03):	Department of Entomology, University of California, Davis, CA 95616, USA.
Article Title (04):	Altitudinal variation in life cycle syndromes of California populations of the grasshopper, *Melanoplus sanguinipes* (F.).
Article Language (05):	English.
Language of Summary (06):	English.
Journal Title (10):	Oecologia (Heidelberg) 84(2) 1990: 199-206.
Date of Publication (20):	1990
Volume (22):	84.
Issue (24):	2.
Page(s) (25):	199-206.
Geographic Descriptor (26):	California / USA.
Systematics (27):	INSECTA- / ORTHOPTERA- / SALTATORIA- / ACRIDIDAE-. *Melanoplus sanguinipes.*
Identifier (28):	NOT AVAILABLE FOR THIS RECORD.
Organism Descriptor (29):	Acrididae / Orthoptera / Melanoplus sanguinipes / arthropods.
Super Taxa (31):	Invertebrates/ Arthropods/ Insects.
Biosystematics (33)	NOT AVAILABLE FOR THIS RECORD.
Broad Term (34):	arthropod pests / pests / animals / arthropods / invertebrates / insects / Orthoptera / Melanoplus / Acrididae / Pacific States of USA / Western States of USA / USA / North America / America.
CABICODE Heading (35):	pests, pathogens and biogenic diseases of plants.

Appendix D. Continued

Concept Codes (36): NOT AVAILABLE FOR THIS RECORD.

Notes (42): / OWL RANGE / BASIC ECOLOGY / NATURAL HISTORY / LIST.

Content (43): The life cycles of 6 Californian populations of the acridid *Melanoplus sanguinipes* were found to vary along an altitudinal gradient (90, 1400, 1500, 2150, 2650 and 2700 m). Temperature records indicated a longer season at low altitude on the coast, based on the computation of day-degrees C available for development, even though summer air temperatures were cooler than at high altitude; this was a result of warm soil temperatures. At high and low altitudes there was a high proportion of diapause eggs oviposited, while intermediate proportions of diapause eggs occurred at mid-altitudes. The low altitude, and especially sea level, populations diapaused at all stages of embryonic development, while at high altitudes most diapause occurred in the late stages just before egg hatch. Diapause was more intense at high altitudes. One result of diapause differences was delayed hatching in the sea level population. Nymphal development and development of adults to age at first reproduction were both accelerated at high altitude relative to sea level. At lower temperatures (27°C), there was a tendency for short days to accelerate development of nymphs at sea level, but not those at high altitude. In individuals at both sea level and high altitude, short days accelerated maturation of adults to onset of oviposition at warm temperature (33°C) but there was little reproduction at 27°C. Population differences for all traits studied appeared to be largely genetic with some maternal effects possible. Diapause variation at low and mid-altitudes was interpreted to be responses to environmental uncertainty and variations in development rates to be adaptations to prevailing season lengths..

ISSN/Source database (44): 0029-8549 / Zoological-Record-Volume-127, Section-13A-General-Insecta-and-Smaller-Orders / ORIGINAL USDA-FS RECORD / CAB Abstracts 1990-2000/10.

Keywords (45): Melanoplus sanguinipes/ Sexual maturation/ Altitude relationship/ Life cycle and development/ Diapause / Altitudinal variation, temperature significance & mechanisms/ Hatching / Time, relationship with altitude/ Inheritance / Altitude / Life history traits relationship, population comparisons/ Temperature / Life history trait altitudinal variation relationship/ California / Sierra Nevada/ Life history trait altitudinal variation, influences & mechanisms/ Altitude / Insect pests/ Diapause / biology / environmental factors/ agricultural entomology.

APPENDIX E
CLASSIFICATION OF DATABASE RECORDS

Broad classification categories describing the basic focus and character of each study (database field #42).

CODE	DESCRIPTION
"BASIC ECOLOGY"	Studies of the basic ecology and behavior of arthropods (e.g. population ecology, evolution, genetics, mating behavior).
"CONSERVATION"	Studies addressing conservation issues and listings of endangered and threatened taxa.
"DISTURBANCE" "FIRE" "LOGGING" "DROUGHT" "FLOOD" "FREEZE" "HABITAT DESTRUCTION" "COMPETITION"	Studies focusing on the effect of disturbance on arthropods and their habitat. Disturbance types include: fire, logging, drought, flood, freeze, habitat destruction, and competition with exotic invaders.
"ENDEMISM"	Studies including rare and endemic species.
"EXOTIC"	The work focuses directly on, or contains references to non-indigenous, or invasive species, which may include either plant or insect taxa.
"FOREST CANOPY"	Papers including some canopy-dwellers that inhabit young trees in open habitat situations, and taxa that feed on host tree species in the forest understory and riparian habitats (e.g. sapling stands, Christmas tree plantations, alder thickets).
"HABITAT"	The work addresses issues in animal-habitat interactions such as habitat selection, habitat quality or disturbance.
"NATURAL HISTORY"	Study provides description of the species' general biology, and natural history, such as phenology, lists of host plants, and geographic distributions.

"SEEDS & CONES"	Papers focusing on species of herbivores that feed in flower heads/seeds of herbaceous vegetation (e.g. Tephritidae), or in seeds, cones and twigs of saplings and forest orchard tree.
"SENSITIVE SPECIES"	Studies with species listed as "sensitive" in the ROD (see also Opler and Lattin 2001).
"SPECIES LIST"	Studies pertinent to the Southern Range of the Northern Spotted Owl (i.e. "Critical Habitat" in ROD). Includes studies on species that are known or presumed to occur in this region. Note that not all studies in this category were conducted in this geographical region.
"TAXONOMY"	Studies with a taxonomic or systematics focus, such as taxonomic keys, species lists, phylogenetic studies, taxa descriptions and revisions.

APPENDIX F
EXAMPLES OF ANNOTATED RECORDS

(1) Frey D. F. and Leong K. L. H. Can microhabitat selection or differences in 'catchability' explain male-biased sex ratios in overwintering populations of monarch butterflies? Animal Behaviour 45(5) May 1993. 1025-1027.

Keywords: *Danaus plexippus*/Population sex ratio/Male biased/Habitat preference/Terrestrial habitat/Microhabitat selection, influence on male biased sex ratio/Overwintering population/California /Male biased sex ratio, effect of microhabitat selection & catchability

Notes: BASIC ECOLOGY / HABITAT / OWL RANGE

Content: Populations of butterflies often have male-biased secondary sex ratios. Monarch butterflies, *Danaus plexippus*, at their overwintering sites in California have male-biased adult sex ratios. The behavioral ecology of this species was studied with mark-release-recapture experiments to explain this phenomenon. Choice of roosting location (i.e. clustering height on trees) was independent of sex, suggesting that selection of clustering microhabitat is similar between male and female monarchs and does not constitute a strong hypothesis regarding male-biased sex ratios. The overall capture sex ratio (1.42) was not significantly different from the estimated sex ratio (1.41) indicating no difference in catchability between sexes. Given the results of this experiment and the fact that sex ratios are equal at emergence, but male-biased sex ratios are found throughout the overwintering season, the most probable explanation for this phenomenon seems to be female-biased mortality along the summer and autumn migration routes to overwintering sites in California.

(2) Root R. B. The life of a Californian population of the facultative milkweed bug, *Lygaeus kalmii* (Heteroptera: Lygaeidae). Proceedings of the Entomological Society of Washington 88(2) 1986: 201-214.

Keywords: *Chrysochus cobaltinus*/*Tetraopes basalis*/*Danaus*/*Asclepias eriocarpa*/California /Monterey county, hastings reservation/Population density on food plant *hyalomya robusta*/*Leucostoma gravipes*/Hemipteran *hosts/Lygaeus kalmii*/Recorded/California/Recorded from hemipteran host lygaeidae /Food plants/*Asclepias eriocarpa*/Life cycle & ecology/Population density/Life cycle, food habits & ecology on food plant/Feeding/Omnivorous feeding/Necrophagy /Insects/Number of generations /Voltinism/Life cycle/Dipteran parasites/*Hyalomya robusta* & *leucostoma gravipes*/Predators /*Rhynocoris ventralis*/Recorded/Distribution within habitat/Adult dispersal patterns/Prey /*Lygaeus kalmii*/

Notes: OWL RANGE / NATURAL HISTORY / BASIC ECOLOGY

Content: *Lygaeus kalmii* is bivoltine in Monterey County, California. A major portion of the spring generation develops at sites distant from milkweeds; these nymphs feed on insect carrion as well as the seeds of *Lepidium nitidum* (Cruciferae) and other forbs. Cohorts reared in the absence of milkweeds survive well and produce viable offspring. The adults of the spring generation undertake dispersal flights during the late morning and afternoon on sunny days. Following dispersal, these adults are closely associated with *Asclepias eriocarpa,* a host that they can apparently locate by using olfactory cues. Milkweed seeds do not become available until several weeks after the spring adults disperse; the bugs do not copulate during first part of this interval. The large populations of adults that move to *A. eriocarpa* during June and July can do considerable damage to the plants. These voracious adults also scavenge the numerous insects that are trapped in the milkweed pollinia, cannibalize each other, and, interestingly, attack the pupae of the monarch butterfly, *Danaus plexippus*, and the egg masses of the milkweed beetle, *Chrysochus cobaltinus*. The second generation feeds heavily on milkweed seeds. The reduviid, *Rhynocoris ventralis*, is a predator of adult *L. kalmii*.

(3) Sims S. R. and Shapiro A. M. Pupal color dimorphism in California *Battus philenor* (L.) (Papilionidae): mortality factors and selective advantage. Journal of the Lepidopterists' Society 37(3) 1984: 236-243.

Keywords: *Battus philenor*/Cryptic coloration/Metamorphosis /Pupation site related to pupal colour dimorphism/Dimorphism /Pupal colour dimorphism effect on avian predation/ Hymenopteran parasites/*Brachymeria ovata*/ Percentage mortality/Mortality /Hymenopteran parasites & avian predators/Predators /Aves/Mortality rate, pupal colour dimorphism effect/California /Mortality factors & pupal colour dimorphism *brachymeria ovata*/Lepidopteran hosts/*Battus philenor*/Prevalence /*Battus philenor* (Lepidoptera), host mortality/California /Lepidopteran host, percentage mortality

Notes: OWL RANGE / BASIC ECOLOGY / HABITAT

Content: Estimates of *Battus philenor* (L.) pupal mortality were made in central California. Summer mortality of first and second generation pupae from unspecified causes ranged from 9-20%. *Brachymeria ovata* (Say) (Hymenoptera: Chalcididae) attacked and killed *B. philenor* in the pupal stage. Rates of parasitism varied between populations but not between pupae on narrow twigs or broad tree trunk habitats. A field experiment was conducted in a natural habitat of *B. philenor* to determine the selective advantage of pupal color dimorphism. Cryptic and non-cryptic pupae were affixed, its pairs, to narrow twigs in foliage or tree trunks and exposed to predators. Non-cryptic pupae in each pupation habitat suffered relatively more predation and lower survivorship. The extent of selective advantage conferred by cryptic coloration varied according to pupation substrate and season. Predation was greatest during the summer and on exposed tree trunks. The results indicate that *B. philenor* has greater survival on the pupation sites most frequently used in nature.

APPENDIX G
USING THE BIBLIOGRAPHY DATABASE

The bibliography ProCite® database was customized for efficient storage and management of bibliographical data in order to facilitate research on forest understory and canopy gap herbivores. The review and analysis of the database content allows users to identify data patterns and trends that can be critical in planning and design of future investigations and strategic surveys.

Installing the Database

Insert the CD containing bibliography ProCite® files into the CD ROM drive in your computer. Make a new directory on your computer hard drive called Understory and Canopy Gap Herbivores. To do this, open the "My Documents" folder on your desktop. From the "File" menu select "New/Folder". Type "Understory and Canopy Gap Herbivores" and hit the return key. Open "My Computer" on your desktop and double click on the "CD Drive" icon. Select the files "Understory and Canopy Gap Herbivores.pdt" and "Understory and Canopy Gap Herbivores.pdx" and copy them to the new folder.

Change the properties of these two files to Archive. To do this, right click on one of the file icons and select "Properties". Click in the open box next to "Archive" and uncheck the selected box next to "Read Only" (Figure G-1). Do this for each of the two files.

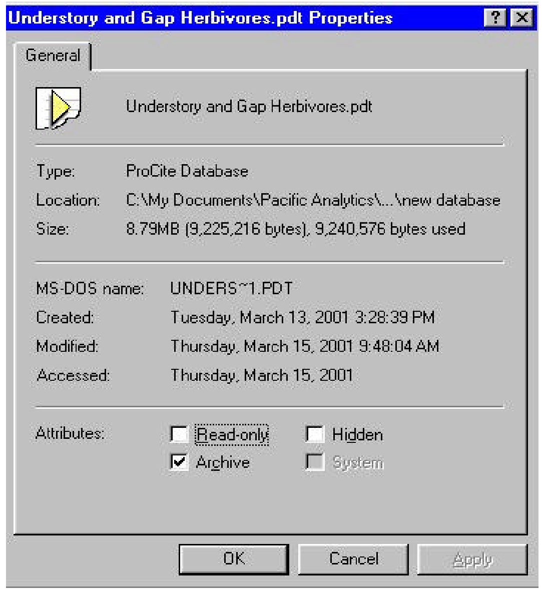

Figure G-1. Properties dialog box. Check Archive box.

A modified workform, *Gap herbivores.pwf*, (included with database files) must be copied into the *Forms* folder of the ProCite® directory in order to view all records fields. Select the file "*Gap herbivores.pwf*" on the CD and copy it to the "C:\Program Files\ProCite5\Forms" folder.

To view records in this workform, click the Mark List button on the ProCite® Tool Bar. From the Database Menu select Edit Marked Records/ Global Change Workform. In the dialog box select Gap herbivores from the list and click OK. Records will then appear in a custom workform designed to provide information pertinent to this project.

Searching the Database

It is assumed that all prospective users of this database have a working knowledge of ProCite® software. Detailed instructions on specific bibliography management tasks can be found in the ProCite® User's Guide (ISI ResearchSoft

1999). The database contains a total of 23 fields. Each ProCite® field was assigned a unique field number that identifies its position in the database (e.g. *Journal Title* in field #10). Unlike field labels the user cannot modify field numbers. Appendices C and D provide descriptions of the content of each database field with an example of a bibliography record. A quick search of literature can be obtained by viewing records in pre-defined *Field Content Lists* (*Terms* tab) that alphabetically display all authors, journal names, article titles, and keywords contained in the database (Figure G-2).

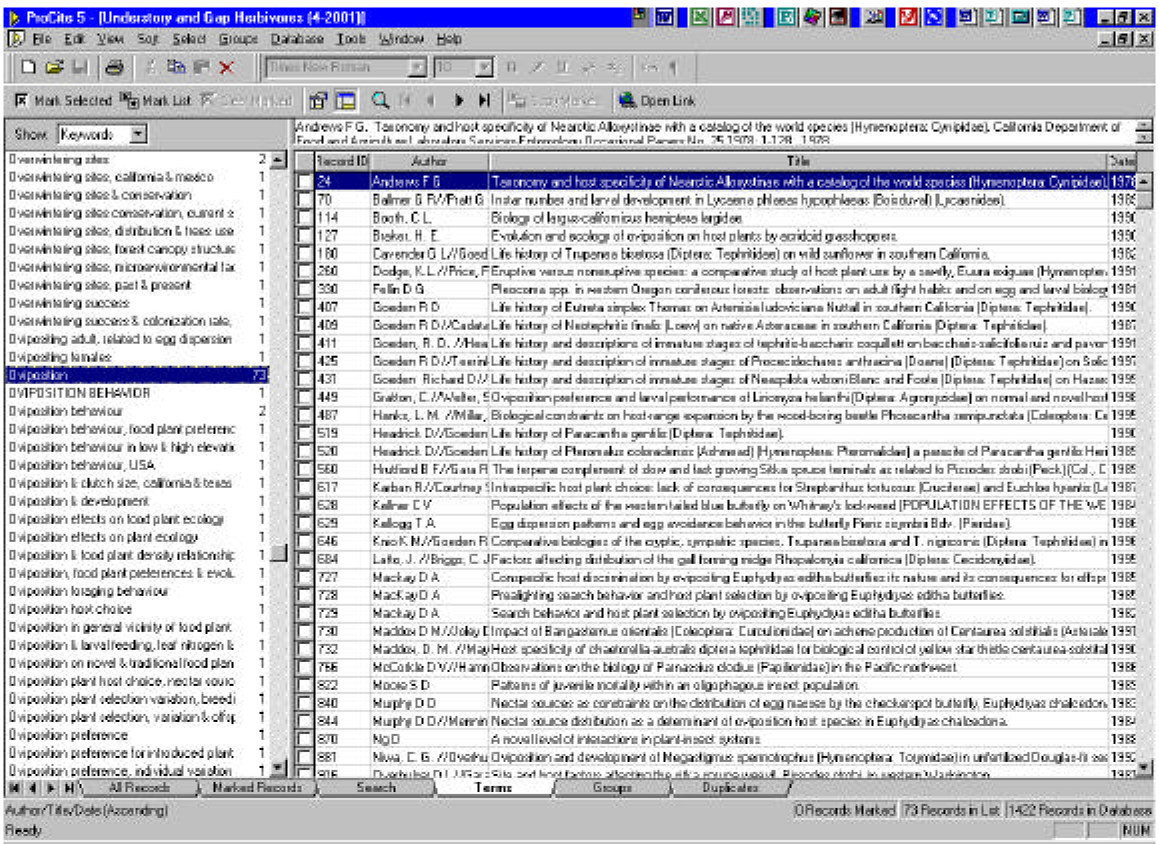

Figure G-2. Pertinent records can be viewed in *Field Content Lists* under the *Terms* tab.

For example, clicking on a specific term (e.g. oviposition) in the left pane of the *Terms* tab under *Keywords*, will display all records in the right pane of the view (n = 73 records) that contain the word "oviposition" in their keyword field (Figure V-2). Similarly, all papers in the database co-authored by a specific author, e.g. R. A. Arnold (n = 19 records), can be viewed by selecting this author's name in the left pane of the *Terms* tab under *Authors*.

All records were assigned to several broad classification categories, to briefly describe the focus and character of each study (Appendix E). This strategy was adopted in order to standardize the database content, and to enhance quick search capabilities of the user. Note, however, that the use of classification categories can facilitate only a basic evaluation of the database content. Examples of classification categories include: papers on basic insect ecology, disturbance papers, articles dealing with conservation issues, taxonomic studies, and papers focusing on arthropod-habitat interactions. All articles investigating herbivore species known or likely occurring within the Southern Range of the Northern Spotted Owl are coded to that effect. These records represented one source of data used to generate an herbivore species list for this physiographic region.

The database contains results of prior literature searches under two grouping categories: (1) classification codes from Appendix E, and (2) names of insect orders and families. All literature records in these groups can be examined under the *Groups* tab (Figure G-3). For example, one can individually view citations falling into the "Taxonomy" (n = 373 records) or "Habitat" (n = 205 records) categories, or examine all records that focus on specific taxa such as Orthoptera (n = 40 records), Hymenoptera (n = 284 records), Tettigoniidae (n = 1 record), or Chrysomelidae (n = 51 records).

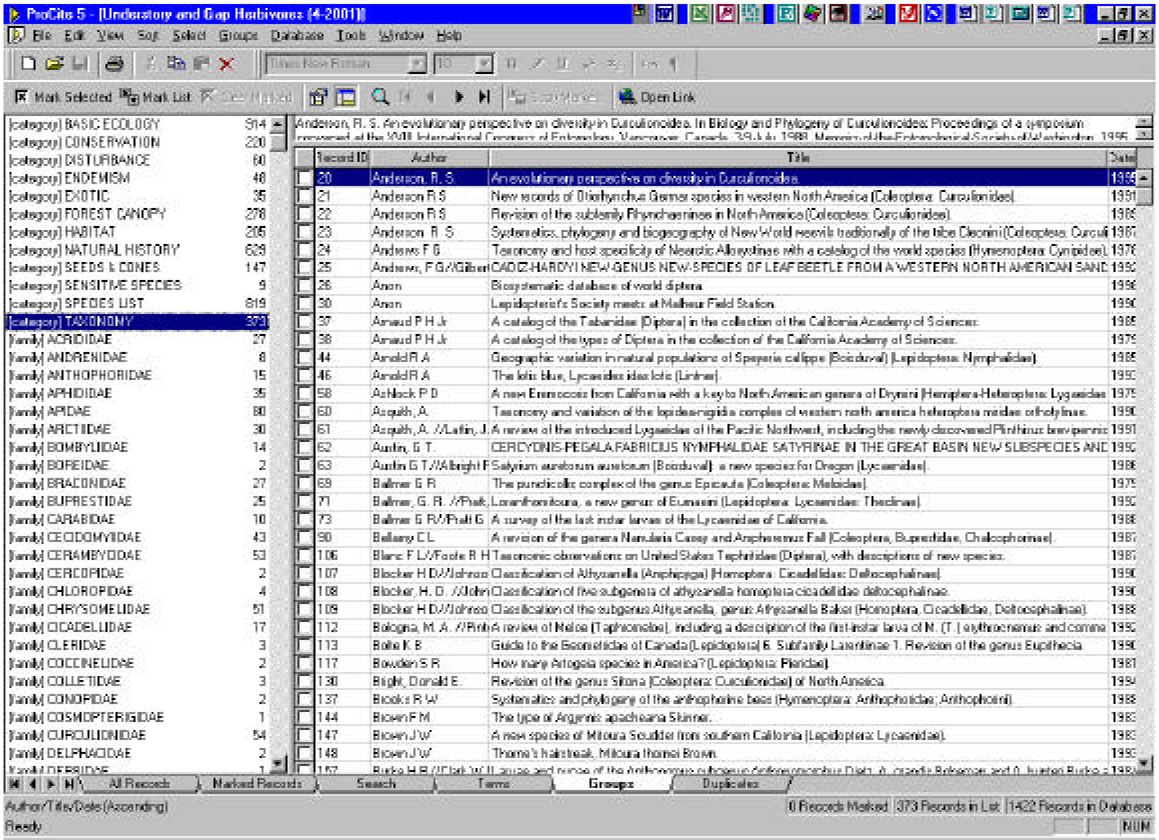

Figure G-3. *Groups* Tab in ProCite provides a list of grouping categories that include citations pertinent to a selected topic.

A more comprehensive search can be performed with custom-defined search strings and expressions within individual, or across all record fields in the database. Simultaneous searches of all database fields are strongly recommended as the content of some fields may be missing in some records. Advanced search expressions can be built using common logical operators, wild cards, field identifiers, and relational operators listed in the ProCite® User's Guide (ISI ResearchSoft 1999).

Printing of Annotated Bibliography

An annotated bibliography list can easily be generated from this database. A basic citation, including the author(s), publication year, article title, journal title, volume and pages can be printed from fields 1, 4, and 10. The bibliography can then be annotated by appending additional record fields such as notes (field #42), content description (field #43), and keywords (field #45) to each record selected for printing. Specific fields, and desired journal output styles (e.g. *Animal Behaviour* or *Environmental Entomology*), can be selected under *Configure Bibliography* options in ProCite®. Appendix F provides an example of three annotated and formatted records printed from this database.

APPENDIX I
FAMILY PROPORTIONS

A list of the families from the species list (Appendix G) showing the relative species richness, and citations frequency in the database. Families in **GREEN** are those with a proportion of citations lower than their proportion of species. Families in **BLACK** are those with a proportion of citations higher than their proportion of species. Families with lower proportions indicate more research needs than families with higher proportions.

FAMILY	Proportion of Citations/Family in Database	Proportion of Species/Family in Species List
Noctudiae	0.0166	0.1900
Geometridae	0.0136	0.0942
Megachilidae	0.0219	0.0703
Cerambycidae	0.0400	0.0642
Andrenidae	0.0060	0.0285
Tenthredinidae	0.0060	0.0224
Cicadellidae	0.0128	0.0255
Anthoporidae	0.0113	0.0229
Elateridae	0.0045	0.0153
Hesperiidae	0.0083	0.0188
Notodontidae	0.0023	0.0117
Melandryidae	0.0008	0.0092
Lygaeidae	0.0106	0.0188
Colletidae	0.0023	0.0102
Diaspididae	0.0008	0.0076
Sphingidae	0.0053	0.0107
Tabanidae	0.0075	0.0122
Thyatiridae	0.0000	0.0046
Psyllidae	0.0000	0.0041
Syrphidae	0.0083	0.0117
Thripidae	0.0045	0.0076
Dermestidae	0.0000	0.0031
Scutelleridae	0.0000	0.0031
Satyridae	0.0000	0.0025
Tingidae	0.0030	0.0051
Phlaeothripidae	0.0015	0.0031
Mordellidae	0.0000	0.0015

Appendix I, continued

FAMILY	Proportion of Citations/Family in Database	Proportion of Species/Family in Species List
Pseudococcidae	0.0008	0.0020
Tettigoniidae	0.0008	0.0020
Rhopalidae	0.0008	0.0020
Halictidae	0.0106	0.0117
Lasiocampidae	0.0015	0.0025
Thyreocoridae	0.0000	0.0010
Cimbicidae	0.0000	0.0010
Drepanidae	0.0000	0.0010
Berytidae	0.0008	0.0015
Cercopidae	0.0015	0.0020
Dictyopharidae	0.0000	0.0005
Opomyzidae	0.0000	0.0005
Axymyiidae	0.0000	0.0005
Membracidae	0.0015	0.0015
Conopidae	0.0015	0.0015
Cosmopterigidae	0.0008	0.0005
Derbidae	0.0008	0.0005
Plutellidae	0.0015	0.0010
Chloropidae	0.0030	0.0020
Delphacidae	0.0015	0.0005
Boreidae	0.0015	0.0005
Coccidae	0.0023	0.0010
Dioptidae	0.0015	0.0000
Miridae	0.0294	0.0275
Gryllidae	0.0053	0.0025
Saturnidae	0.0075	0.0046
Adelgidae	0.0038	0.0005
Bombyliidae	0.0106	0.0071
Meloidae	0.0075	0.0041
Aphididae	0.0264	0.0224
Riodinidae	0.0045	0.0005
Arctiidae	0.0226	0.0183
Buprestidae	0.0189	0.0122
Gelechiidae	0.0075	0.0005
Danaidae	0.0075	0.0005
Curculionidae	0.0407	0.0326
Tachinidae	0.0158	0.0066
Scarabaeidae	0.0143	0.0031
Pyralidae	0.0264	0.0127
Acrididae	0.0204	0.0066
Lymantriidae	0.0189	0.0036

Appendix I, continued

FAMILY	Proportion of Citations/Family in Database	Proportion of Species/Family in Species List
Chrysomelidae	0.0385	0.0188
Pieridae	0.0377	0.0122
Tortricidae	0.0271	0.0015
Lycaenidae	0.0581	0.0295
Cecidomyiidae	0.0324	0.0036
Papilionidae	0.0339	0.0041
Apidae	0.0603	0.0132
Tephritidae	0.0618	0.0122
Nymphalidae	0.1418	0.0219

APPENDIX J
FAMILY CITATION CATEGORY FREQUENCIES

Family citation frequencies in each of the major classification categories.

FAMILY	Basic Ecology	Conservation	Disturbance	Endimism	Exotics	Habitat	Natural History	Seeds & Cones	Sensitive Species	Taxonomy
Acrididae	20	0	2	1	2	3	10	0	0	4
Adelgidae	0	0	0	0	0	0	0	0	0	0
Andrenidae	5	0	0	0	0	2	5	0	0	4
Anthoporidae	9	0	0	0	0	0	12	0	0	7
Aphididae	19	0	0	0	0	4	18	0	0	16
Apidae	57	2	1	0	0	7	36	0	0	11
Arctiidae	26	0	1	0	5	0	8	0	0	3
Axymyiidae	0	0	0	0	0	0	0	0	0	0
Berytidae	0	0	0	0	0	0	0	0	0	0
Bombyliidae	11	0	0	0	0	1	12	0	0	10
Boreidae	0	0	0	0	0	0	2	0	2	2
Buprestidae	10	0	1	0	0	2	16	0	0	12
Cecidomyiidae	36	0	1	0	0	1	7	27	0	4
Cerambycidae	28	8	3	7	0	4	25	1	0	15
Cercopidae	2	0	0	0	0	0	0	0	0	0
Chloropidae	0	0	0	0	0	1	4	0	0	1
Chrysomelidae	36	1	1	2	3	2	22	2	4	11
Cicadellidae	3	0	0	0	0	0	15	1	0	16
Cimbicidae	0	0	0	0	0	0	0	0	0	0
Coccidae	0	0	0	0	0	0	0	0	0	0

Appendix J	continued									
FAMILY	**Basic Ecology**	**Conservation**	**Disturbance**	**Endimism**	**Exotics**	**Habitat**	**Natural History**	**Seeds & Cones**	**Sensitive Species**	**Taxonomy**
Colletidae	1	0	0	0	0	0	3	0	0	3
Conopidae	2	0	0	0	0	1	1	0	0	0
Cosmopterigidae	0	0	0	0	0	0	1	0	0	1
Curculionidae	32	0	2	0	6	1	23	17	0	15
Danaidae	0	0	0	0	0	0	0	0	0	0
Delphacidae	0	0	0	0	0	0	2	0	0	1
Derbidae	0	0	0	0	0	0	1	0	0	1
Dermestidae	0	0	0	0	0	0	0	0	0	0
Diaspididae	0	0	0	0	0	0	0	0	0	0
Dictyopharidae	0	0	0	0	0	0	0	0	0	0
Dioptidae	0	0	0	0	0	0	0	0	0	0
Drepanidae	0	0	0	0	0	0	0	0	0	0
Elateridae	0	0	0	0	0	1	6	0	0	4
Gelechiidae	0	0	0	0	0	0	0	0	0	0
Geometridae	9	1	0	0	1	2	10	2	0	7
Gryllidae	5	0	0	0	0	1	2	0	0	2
Halictidae	11	0	0	0	0	1	10	0	0	4
Hesperiidae	6	2	2	1	0	3	7	0	0	4
Lasiocampidae	0	0	0	0	0	0	0	0	0	0
Lycaenidae	38	51	17	156	3	26	42	0	1	24
Lygaeidae	7	1	1	0	0	0	7	7	0	7
Lymantriidae	0	0	0	0	0	0	0	0	0	0
Megachilidae	9	2	0	0	0	2	21	0	0	6
Melandryidae	0	0	0	0	0	0	1	0	0	0
Meloidae	4	2	0	1	0	0	8	0	0	8
Membracidae	0	0	0	0	0	0	2	0	0	2
Miridae	17	0	0	0	0	4	24	8	1	2
Mordellidae	0	0	0	0	0	0	0	0	0	0

Forest Understory and Canopy Gap Herbivores:
Appendix J. Family Citation Category Frequencies

Appendix J	continued									
FAMILY	Basic Ecology	Conservation	Disturbance	Endimism	Exotics	Habitat	Natural History	Seeds & Cones	Sensitive Species	Taxonomy
Noctudiae	11	0	0	0	2	1	12	2	0	8
Notodontidae	1	0	0	0	0	0	3	0	0	0
Nymphalidae	63	128	23	21	7	85	42	1	1	22
Opomyzidae	0	0	0	0	0	0	0	0	0	0
Papilionidae	30	6	3	0	2	8	23	0	0	13
Phlaeothripidae	1	0	0	0	1	0	2	1	0	0
Pieridae	45	3	3	1	1	7	16	0	0	10
Plutellidae	0	0	0	0	0	0	2	0	0	2
Pseudococcidae	0	0	0	0	0	0	0	0	0	0
Psyllidae	0	0	0	0	0	0	0	0	0	0
Pyralidae	24	0	0	0	4	3	14	15	0	6
Rhopalidae	0	0	0	0	0	0	1	0	0	1
Riodinidae	0	0	0	0	0	0	0	0	0	0
Saturnidae	7	0	0	0	0	1	4	0	0	4
Satyridae	0	0	0	0	0	0	0	0	0	0
Scarabaeidae	4	0	0	0	0	3	17	0	0	11
Scutelleridae	0	0	0	0	0	0	0	0	0	0
Sphingidae	0	0	0	0	1	0	1	0	0	0
Syrphidae	6	0	0	0	0	1	6	0	0	3
Tabanidae	2	0	0	0	0	0	8	0	0	6
Tachinidae	15	2	0	0	1	2	9	1	0	2
Tenthredinidae	3	0	0	0	0	1	6	0	0	5
Tephritidae	20	0	1	0	1	1	69	16	0	29
Tettigoniidae	0	0	0	1	0	0	1	0	0	1
Thripidae	4	0	0	0	0	0	2	0	0	3
Thyatiridae	0	0	0	0	0	0	0	0	0	0
Thyreocoridae	0	0	0	0	0	0	0	0	0	0
Tingidae	0	0	0	0	0	1	2	0	1	2

Appendix J	continued									
FAMILY	**Basic Ecology**	**Conservation**	**Disturbance**	**Endimism**	**Exotics**	**Habitat**	**Natural History**	**Seeds & Cones**	**Sensitive Species**	**Taxonomy**
Tortricidae	30	0	0	0	0	2	6	20	0	4

APPENDIX K
GROUP FAMILY PRIORITIES

Basic Ecology	Conservation	Disturbance	Habitat	Natural History	Taxonomy
Noctuidae	Noctuidae	Noctuidae	Lygaeidae	Noctudiae	Noctudiae
Geometridae	Tenthredinidae	Geometridae	Arctiidae	Sphingidae	Miridae
Miridae	Andrenidae	Megachilidae	Noctuidae	Geometridae	Geometridae
Lygaeidae	Anthoporidae	Andrenidae	Geometridae	Melandryidae	Megachilidae
Carabidae	Miridae	Miridae	Megachilidae	Andrenidae	Andrenidae
Megachilidae	Carabidae	Carabidae	Curculionidae	Notodontidae	Arctiidae
Tenthredinidae	Elateridae	Lycaenidae	Miridae	Thripidae	Hesperiidae
Andrenidae	Sphingidae	Nymphalidae	Tenthredinidae	Tenthredinidae	Tenthredinidae
Hesperiidae	Aphididae	Anthoporidae	Cerambycidae	Colletidae	Cerambycidae
Anthoporidae	Curculionidae	Tenthredinidae	Elateridae	Megachilidae	Syrphidae
Cerambycidae	Arctiidae	Aphididae	Andrenidae	Lygaeidae	Elateridae
Aphididae	Geometridae	Elateridae	Carabidae	Hesperiidae	Colletidae
Curculionidae	Megachilidae	Cerambycidae	Anthoporidae	Cerambycidae	Tachinidae
Lycaenidae	Lygaeidae	Lygaeidae	Syrphidae	Elateridae	Anthoporidae
Arctiidae	Chrysomelidae	Chrysomelidae	Halictidae	Tingidae	Halictidae
Chrysomelidae	Hesperiidae	Arctiidae	Chrysomelidae	Arctiidae	Lygaeidae
Nymphalidae	Cerambycidae	Curculionidae	Bombyliidae	Rhopalidae	Thripidae
Elateridae	Lycaenidae	Apidae	Hesperiidae	Tettigoniidae	Tingidae
Sphingidae	Nymphalidae	Buprestidae	Buprestidae	Syrphidae	Curculionidae
Melandryidae	Notodontidae	Tephritidae	Aphididae	Anthoporidae	Pyralidae
Diaspididae	Colletidae	Hesperiidae	Tingidae	Carabidae	Tabanidae
Tingidae	Halictidae	Pieridae	Saturnidae	Tabanidae	Rhopalidae
Pyralidae	Bombyliidae	Cecidomyiidae	Pyralidae	Phlaeothripidae	Tettigoniidae
Pieridae	Apidae	Acrididae	Apidae	Conopidae	Chloropidae
Apidae	Pieridae	Papilionidae	Pieridae	Curculionidae	Chrysomelidae
Thyatiridae	Papilionidae	Pyralidae	Lycaenidae	Gryllidae	Acrididae
Psyllidae	Tabanidae	Tabanidae	Scarabaeidae	Aphididae	Cicadellidae
Lymantriidae	Phlaeothripidae	Notodontidae	Tortricidae	Halictidae	Aphididae
Dermestidae	Syrphidae	Syrphidae	Papilionidae	Miridae	Gryllidae
Scutelleridae	Thripidae	Halictidae	Nymphalidae	Saturnidae	Lycaenidae
Lasiocampidae	Buprestidae	Sphingidae	Tabanidae	Pyralidae	Pieridae
Satyridae	Cercopidae	Colletidae	Notodontidae	Chrysomelidae	Apidae
Chloropidae	Conopidae	Melandryidae	Sphingidae	Buprestidae	Saturnidae
Pseudococcidae	Scarabaeidae	Diaspididae	Colletidae	Pieridae	Buprestidae
Rhopalidae	Saturnidae	Thripidae	Melandryidae	Membracidae	Tortricidae
Tettigoniidae	Tephritidae	Bombyliidae	Diaspididae	Tachinidae	Notodontidae
Berytidae	Pyralidae	Tachinidae	Thripidae	Lycaenidae	Sphingidae
Membracidae	Gryllidae	Tingidae	Thyatiridae	Acrididae	Melandryidae
Mordellidae	Acrididae	Thyatiridae	Psyllidae	Bombyliidae	Diaspididae
Cimbicidae	Cecidomyiidae	Saturnidae	Meloidae	Nymphalidae	Thyatiridae
Coccidae	Tortricidae	Psyllidae	Lymantriidae	Meloidae	Psyllidae
Drepanidae	Tachinidae	Meloidae	Dermestidae	Cecidomyiidae	Lymantriidae

Appendix K, continued

Basic Ecology	Conservation	Disturbance	Habitat	Natural History	Taxonomy
Plutellidae	Meloidae	Lymantriidae	Scutelleridae	Chloropidae	Dermestidae
Thyreocoridae	Melandryidae	Dermestidae	Phlaeothripidae	Plutellidae	Scutelleridae
Adelgidae	Diaspididae	Scutelleridae	Lasiocampidae	Cosmopterigidae	Phlaeothripidae
Axymyiidae	Tingidae	Phlaeothripidae	Satyridae	Derbidae	Lasiocampidae
Boreidae	Thyatiridae	Scarabaeidae	Pseudococcidae	Apidae	Satyridae
Cosmopterigidae	Psyllidae	Lasiocampidae	Rhopalidae	Tortricidae	Pseudococcidae
Danaidae	Lymantriidae	Satyridae	Tettigoniidae	Boreidae	Cercopidae
Delphacidae	Dermestidae	Gryllidae	Cercopidae	Delphacidae	Berytidae
Derbidae	Scutelleridae	Chloropidae	Berytidae	Scarabaeidae	Mordellidae
Dictyopharidae	Lasiocampidae	Pseudococcidae	Membracidae	Tephritidae	Conopidae
Gelechiidae	Satyridae	Rhopalidae	Mordellidae	Papilionidae	Cimbicidae
Opomyzidae	Chloropidae	Tettigoniidae	Cimbicidae	Diaspididae	Coccidae
Riodinidae	Pseudococcidae	Cercopidae	Coccidae	Thyatiridae	Drepanidae
Tabanidae	Rhopalidae	Berytidae	Drepanidae	Psyllidae	Thyreocoridae
Phlaeothripidae	Tettigoniidae	Membracidae	Plutellidae	Lymantriidae	Adelgidae
Thripidae	Berytidae	Mordellidae	Thyreocoridae	Dermestidae	Axymyiidae
Buprestidae	Membracidae	Conopidae	Adelgidae	Scutelleridae	Danaidae
Cercopidae	Mordellidae	Tortricidae	Axymyiidae	Lasiocampidae	Dictyopharidae
Meloidae	Cimbicidae	Cimbicidae	Boreidae	Satyridae	Gelechiidae
Conopidae	Coccidae	Coccidae	Cosmopterigidae	Pseudococcidae	Opomyzidae
Scarabaeidae	Drepanidae	Drepanidae	Danaidae	Cercopidae	Riodinidae
Saturnidae	Plutellidae	Plutellidae	Delphacidae	Berytidae	Nymphalidae
Bombyliidae	Thyreocoridae	Thyreocoridae	Derbidae	Mordellidae	Cecidomyiidae
Tephritidae	Adelgidae	Adelgidae	Dictyopharidae	Cimbicidae	Membracidae
Gryllidae	Axymyiidae	Axymyiidae	Gelechiidae	Coccidae	Bombyliidae
Tachinidae	Boreidae	Boreidae	Opomyzidae	Drepanidae	Meloidae
Acrididae	Cosmopterigidae	Cosmopterigidae	Riodinidae	Thyreocoridae	Plutellidae
Papilionidae	Danaidae	Danaidae	Tephritidae	Adelgidae	Cosmopterigidae
Cecidomyiidae	Delphacidae	Delphacidae	Cecidomyiidae	Axymyiidae	Derbidae
Tortricidae	Derbidae	Derbidae	Tachinidae	Danaidae	Delphacidae
Dioptidae	Dictyopharidae	Dictyopharidae	Gryllidae	Dictyopharidae	Tephritidae
	Gelechiidae	Gelechiidae	Acrididae	Gelechiidae	Papilionidae
	Opomyzidae	Opomyzidae	Chloropidae	Opomyzidae	Scarabaeidae
	Riodinidae	Riodinidae	Conopidae	Riodinidae	Boreidae
	Dioptidae	Dioptidae	Dioptidae	Dioptidae	Dioptidae

APPENDIX L
INVENTORY AND MONITORING GUIDELINES

Conservation of natural areas is complicated by habitat fragmentation, invasion of alien species, development near area boundaries, commercial and recreational use, and other disturbances. In order to protect natural ecological systems, resource managers need scientifically detailed and reliable information about the species within their management jurisdictions. Specifically, managers need to know what species occur in the natural areas, what the impacts of management decisions are on those species, and how the species populations change over time. Without valid information, land managers can neither protect and maintain resources nor can they restore damaged ecosystems (Halvorson and Davis 1996, Halvorson 1997).

Inventory and monitoring of wildlife habitats have become an essential components of natural resource management. Such efforts have focused on fungi, snails, lichens, amphibians, and birds, and rarely include insects and other arthropods. The data obtained through properly designed inventory and monitoring programs provide inferences about the impacts or changes in natural areas due to management strategies. Natural resource inventory is the process of collecting and analyzing static information about biogeographical areas and their biotic components. However, nature is dynamic, not static, and needs to be managed accordingly (Halvorson 1997). Monitoring presents a long-term view of natural systems and supplies information necessary for adaptive management.

Research scientists have recognized the need for long-term studies in predicting changes in the functional processes of forest systems. Subtle, complex, or gradual forest processes manifest themselves only after decades or centuries and may not be noticed in a 2 to 3 year study. However, random or catastrophic events limit interpretation of changing processes because of the lack of baseline data. Baseline information for assessing long-term faunal changes that are certain to accompany forest management activities have been treated by Warren and Key (1991), Niemelä et al. (1993), Niemelä et al. (1994), Niemelä (1997) and others. Baseline information can be obtained through properly designed resource inventory and monitoring programs.

Natural resource management needs to be an iterative process of inventory, monitoring, and management action on a continuous basis (e.g., Holling 1978, Walters 1986, Grumbine 1994, Montgomery et al. 1995, Ringold et al. 1996, Halvorson 1997). Invoking management actions based on some baseline information and monitoring the effects gain understanding of the system and its dynamics. As knowledge accumulates, management strategies are adjusted and management becomes more effective. This is the basis of new forestry practices and adaptive management (Swanson and Franklin 1992). If we change the way we manage our natural ecosystems (forests, rangelands, aquatic systems) how will we know if the new management is actually conserving biodiversity? The answer lies with monitoring.

While monitoring does not always yield evidence of cause-and-effect relationships, it does provide information on trends and changes. And, monitoring serves as a feedback mechanism to promote better integration of conservation and development. Kremen et al. (1994) called integration of conservation and development the strongest strategy for maintaining biological diversity. Monitoring long-term population changes has been mandated as an integral component of conservation-oriented research and management in much of the Pacific Northwest, but has not yet included work on insects and other arthropods even though they are the most diverse group found in the forests.

Forest Understory and Canopy Gap Herbivores: Appendix L. Inventory and Monitoring Guidelines

Planning of long-term monitoring in Pacific Northwest forests is a complex undertaking because the environment is an intricate web of inter-relationships and dependencies. Monitoring change in these natural areas is complicated by weather patterns, habitat fragmentation, invasion of alien species, development near area boundaries, commercial and recreational use, and natural disturbances. Natural resource managers need scientifically detailed and reliable information about species within their management jurisdictions, about the impacts of management decisions to those species, and about changes in populations of those species over time.

The difficulties in planning for complex, multi-resource monitoring are mitigated by employing a step-by-step planning process. We suggest the following seven-step process for planning of long-term monitoring:

1. Prepare clear statements of the questions of interest.
2. Design the sampling systems
3. Develop sampling protocols for data collection
4. Organize the data management systems
5. Plan the analysis and interpretation systems
6. Formulate a reporting system
7. Establish a monitoring sustainability plan

Each of these seven steps need to be undertaken and completed to develop a successful monitoring plan. Furthermore, the steps need to be undertaken in a comprehensive manner. Planning decisions made in any one stage affect decisions at all the other stages.

1. Prepare clear statements of the questions of interest.

The first step in developing a monitoring plan requires clearly defining the questions of interest. Key questions are those with answers that can be efficiently estimated and that yield the information necessary for management decision-making. Monitoring programs depend upon identifying the important issues and concerns, and reducing general problems to questions of specific, measurable attributes. It is essential that much effort be spent investigating the key monitoring questions. They need to be well-considered and carefully elucidated.

General monitoring goals are essential for planning, however, monitoring programs require explicit testable hypotheses in order to differentiate indicator responses to natural environmental fluctuations and responses to anthropogenic activities. Only general goals for monitoring in Pacific Northwest forests appear in the Record of Decision (USDA 1994a).

One monitoring goal is to accurately assess the current plant, wildlife, and other natural resource inventories for planning and allocation. Accurate inventories provide baseline information about existing biological diversity, which species may be sensitive to management practices and which vary naturally, and where do species occur. The information obtained from inventories may be used to formulate hypotheses about natural and anthropogenic caused change.

Another general goal is to measure the impact of restoration or management practices on the biota. To achieve this goal, specific hypotheses on how biological diversity changes over time and how it relates to forest management may be tested. For example, some forest managers may wish to know if the loss of stand-level biological diversity is compensated for at the landscape level. Others may have specific questions about the disruption of ecological processes and the resulting effects on forest aesthetic quality in recreational areas, and the quantity of current or potentially obtainable products from natural resources. Biological diversity information may provide inferences about the interactions between management practices and biological diversity across a wide range of spatial and temporal scales.

A third general goal for forest monitoring is to measure and quantify natural change and impacts of climate change on forest on forest resources. Specific hypotheses may have to do with the ratio of introduced and native species in disturbed and undisturbed habitats. Other specific information of interest may be about the role of functional groups and how the relative abundance of groups changes over time. Information may be sought about the special relationships between components of biological diversity and species distributions in relation to changing environments.

Ecological responses are often complex and difficult to measure accurately. Indicators are often used because they are easier to measure, and because not all species in a region or habitat can be directly observed and counted. Practical evaluation sometimes depends on surrogate information (Faith and Walker 1996). Living organisms accumulate records in their tissues, concentrating the changes and amplifying weak signals, and are therefore good indicators of environmental conditions. Sampling pollen from bees of Puget Sound, for example, gave a better overall measurement of several environmental pollutants then expensive chemical monitoring (Bromenshenk et al. 1985).

The planning of monitoring needs to include a precise definition of the responses that will be measured. They may include specific species, or groups of species (taxonomic and functional), or diversity indices. Some taxa are considered good representatives of biological diversity and make satisfactory conservation evaluation criteria (Webb 1989, Cousins 1991, Dufrêne and Legendre 1997, see also Stork 1990 and Pollard and Yates 1993). Complicated formulae have been developed for estimating biological diversity (Southwood 1978, Magurran 1988, Krebs 1989). While these formulae may be useful in specific applications, surrogate species or species of particular interest may represent the environmental condition more thoroughly and need no complicated calculations.

Monitoring of invertebrate species gives fine scale measures of changes in forest processes (Franklin 1990, Lattin 1994). Invertebrates make good indicators because of a variety of reasons (Schmid and Matthies 1994, Freitag et al. 1973, Pearson and Cassola 1992, Niemelä et al. 1993). Their small size, diversity, sensitivity to environmental variability make them good indicators of habitat heterogeneity, ecosystem biodiversity and environmental stress (Brown 1991, Hafernik 1992, Oliver 1993, Kremen 1994). Changes in the condition of a forest are often reflected in the mix of arthropod species in that forest (Niemelä 1997, Rutanen 1994, Schowalter 2000).

The use of multi-species invertebrate assemblages as indicators of environmental conditions has been demonstrated numerous times (e.g., Ruzicka and Bohac 1991, Pearson and Cassola 1992, Nelson and Andersen 1994, Weaver 1995. Daily and Ehrlich 1995, Samways and Steytler 1996). For example, the presence and abundance of invertebrate species have become the standard basis of water quality analysis (Plafkin et al. 1989, Klemm et al. 1990, Ankley et al. 1993, Hayslip 1993, Rosenberg and Resh 1993, Hicks and Larson 1997, Merritt 1999).

Some have suggested that indicators need to be screened rigorously and quantitatively before they can be used as meaningful surrogates for the response of interest (Murtaugh 1996). This is a good practice when management decisions have an impact on a critically endangered species or ecosystem, but may not be cost effective in the course of general environmental change due to management practices.

Finally, because the response varies with the sampling method, consideration needs to be given as to the exact nature of the response being measured. For example, quadrat sampling yields the number of organisms per unit area, and light trap sampling provides a measure of activity. The decision regarding selection of the sampling method might be influenced by budget and time limitations. For example, while quadrat sampling may yield a more accurate estimate of the numbers of individuals per unit area than light trap sampling, more time and resources are spent collecting the data. The Forest Service needs to choose the response that provides the information managers need, given the resources available for the project.

2. Design the sampling systems

The second step in monitoring planning is designing the sampling systems. It is expected that many quantifiable questions of interest will be elucidated in the first stage. Each key question needs then to be evaluated for utility and efficiency. Proposed questions of interest need to be prioritized based on the projected costs of collecting the data and the projected value of the knowledge to be gained. The effort expended to answer each question needs to lead to useful gains in knowledge and remain within budgetary and logistical constraints. Some questions are simply too expensive to answer efficiently. Some questions cannot be answered without controlled experimentation. Designed experiments, based on expected operational activities, need to be incorporated into the sampling system.

Expertise in statistics, biometrics, and cost/benefit analysis are required for sampling system design. Some of the design techniques that could be applied are power analysis, cost allocation analysis, sampling structure determinations, sample size determinations, scale evaluations, randomization, replication, blocking, and covariate determinations. Schedules of sampling efforts also need to be developed. Monitoring is the investigation of change over time, so timing of sampling is an essential element in sampling system design.

Another consideration in sampling system design is the type of sampling unit. The decision to use permanent plots, transects, or points selected at random is largely driven by the questions of interest. Each type of sampling unit needs to be considered and applied where appropriate. Sampling needs to be repeated at frequent enough intervals to define the period and amplitude of natural cycles.

3. Develop sampling protocols for data collection

The third step in monitoring planning is to develop the data collection system(s). Sampling protocols are necessary to standardize data collection. Data gathered in the future needs to be comparable to data gathered today in order to statistically detect significant environmental changes. Protocols need to include specific methods to be used for every habitat and each animal or plant type, descriptions of the tools necessary for data collection, and randomization schemes for determining trap placement, plant selection, or measurement device location. Trap (collection) bias and sensitivity to measurement error needs to be weighted against convenience and the appropriate sampling method applied. Protocols need to be field-tested to assure feasibility and efficiency. Field data collection crews could then be trained and tested in the use of the sampling protocols.

4. Prepare the data management systems

The fourth step in monitoring planning is the preparation of a data management plan. The data collected in each sampling exercise needs to be checked for errors and corrected. Data sets need to be entered into a database for easy access and retrieval. The database needs to be properly archived to be useful many years in the future. Monitoring requires comparisons of attributes over sometimes lengthy periods of time. It is important to recognize that data sets are expensive to obtain, and hence have significant monetary value. Not only will the archived data contribute information for future management decisions locally, they will also provide information potentially useful for forest management elsewhere in the world.

5. Plan the analysis and interpretation systems

The fifth step in monitoring planning is the development of an analysis and interpretation plan. Statistical analysis and scientific interpretation are necessary to produce logical inferences and new knowledge from monitoring data. The sampling design, collecting bias, and the statistical structure of the data need to be accounted for in the analysis plan. Techniques of exploratory data analysis (EDA), graphics, statistical distribution tests, data transformations, and modeling need to be developed in the plan. Much of the inference gained through monitoring will be evaluated by means of mathematical models. Such models include time trend analysis, survival analysis, growth and mortality models, and population change models. The appropriate model forms need to be specified in the planning process. Failure to specify analytical forms could cause gaps and inefficiencies in sampling design and data collection. Prior planning for analysis will help ensure completeness and timeliness of the sampling and prevent wasteful effort.

New methods may need to be developed to analyze taxonomic composition of communities sampled. Diversity indices only provide a course view of the taxonomic makeup of each community, and ignore non-indigenous species. Rare species may also be lost in the numeric shuffle. Population trends of species of interest can be detected, once those species are identified. Functional group profiles can be developed for special habitats and analyzed to detect changes in the status of those habitats.

6. Develop of a reporting system

The sixth step in monitoring planning is the development of a plan for the reporting the results. The new knowledge acquired through monitoring needs to be communicated to responsible resource managers and interested agencies for use in determining management decisions. Charts, tables, and maps may be the immediate products of analysis but do not stand alone. Reports need to be carefully planned and clearly written with consideration of the intended audience and the appropriate application of the findings. The reports need to clearly explain the results of data analysis and the implications to natural resource management. Monitoring reports need to be produced on time and updated on a regular schedule.

7. Develop a monitoring sustainability plan

The seventh step in monitoring planning is development of a monitoring sustainability plan. Institutional commitment needs to be developed to secure annual budgetary planning for future monitoring efforts. Monitoring happens in the context of time. Environmental changes, and trends in those changes, are often detected only after several years of data collection. Resource managers need to consider the monitoring program as an integrated part of their overall management plan, and as a permanent fixture in future budgets. Involving other stakeholders, universities, local environmental groups, and concerned citizens will help to build community commitment to the management program. Planning for sustainability and commitment is a necessary element in all long-term environmental monitoring.

In summary, monitoring of ecosystems and natural resources in Pacific Northwest forests needs to be comprehensive, cost-effective, statistically designed, executed with analytical integrity, presented to decision-makers by way of meaningful reports, charts, and maps, and updated regularly over many decades. Consideration and application of the seven steps will improve efficiency and effectiveness of knowledge acquisition and guarantee managers, regulators, scientists, and citizens useful information on which rational management decisions may be based. Conscientious planning and implementation of a properly designed monitoring plan will provide natural resource managers with the necessary prerequisites for continued good stewardship of their properties.

APPENDIX M
META-ANALYSIS

Meta-analysis is another tool that can be applied in future studies of arthropods in the Pacific Northwest. Considering the fact that a substantial amount of literature is currently being accumulated on these taxa, meta-analysis can uniquely supplement this effort by providing a quantitative information synthesis of these data. However, more information needs to be collected about herbivorous arthropods in the southern range of the northern spotted owl to obtain results from meta-analysis that will provide management solutions. Future studies should be designed such that the information could be easily adapted for meta-analysis.

Meta-analysis can fundamentally change the way scientists and managers evaluate results, and draw conclusions from ecological studies (Gurevitch and Hedges 1993, Hartley and Hunter 1998, Halaj and Wise 2001). A single experiment generally tests hypothesis relevant to individual organisms in one place at one time. Although the amount of data acquired in this manner can be copious, it is restricted to specific conditions, and general applicability of results is limited. Unfortunately, management decisions have historically been based on outcomes of a few, often single, “representative” studies. This approach carries a significant risk; extrapolations from tenuous results may provide a highly skewed analysis of complex ecological interactions.

The classic, “vote-counting” literature reviews present a partial remedy to this problem. In these reviews, studies are tallied based on whether the result is statistically significant, or not statistically significant. The conclusion is then based on the number of “votes” falling into a particular category. This approach, however, yields only qualitative results, and tells us little about the overall magnitude of treatment effects across a wide range of conditions. Although more objective, nonetheless, conventional literature reviews are logically and statistically flawed since the *p*-value of an experiment is to a great extent a function of sample size. Thus, studies with fewer replicates, which is true for the majority of investigations in natural resources, are less likely to yield significant results and detect critical patterns. This makes vote-counting reviews strongly biased towards finding no overall effects, even though treatments under review may have the potential to significantly impact the environment (Gurevitch and Hedges 1993, Rosenberg et al. 1997). Conducting more studies to gain "a better understanding" of the system will not improve our chance of detecting true biological patterns if the sample size remains small. On the contrary, this approach is costly and may lead to erroneous management decisions since we feel more comfortable making them, "encouraged" by a plethora of studies pointing in the same direction (Gurevitch and Hedges 1993, Rosenberg et al. 1997).

Meta-analysis is independent of sample size. It allows a quantitative summary of findings and identification of central tendencies in a collection of different studies with a common theme. This statistical technique has been widely applied in psychology and medicine, but its use in natural resource studies is a recent phenomenon (Gurevitch and Hedges 1993, Halaj and Wise 2001). Although the name "meta-analysis" implies "analysis of analyses," it does not reanalyze original data from reviewed studies; rather, it examines outcomes of different studies, and tests for their consistency, and estimates whether the general trend in data is low, moderate, or high (Gurevitch and Hedges 1993, Rosenberg et al. 1997).

All of the information needed to conduct meta-analysis can be extracted from the text, tables or figures in published articles reporting on experimental studies. Results of meta-analysis allow us to examine the overall magnitude and direction (+/-) of response of different groups of organisms to a particular treatment (e.g. prescribed burning, thinning, logging, application of pesticides, effects of exotic species), as well as the variability of this response within each category.

A considerable concern exists for the long-term viability of Pacific Northwest forests because of their suspected susceptibility to the loss of ecological functions of arthropods populations caused by timber management. At the same time, very little information is available on the response of this group of organisms to different forest management practices such as prescribed burning, thinning or clearcutting. The results of meta-analysis can advance our general understanding of how these disturbances affect species persistence in forest ecosystems by providing a quantitative assessment.

For example, one can examine the effect of disturbance due to fire or thinning on a variety of invertebrates. Comparisons can be made between studies with prescribed burnings occurring in different seasons to evaluate the effect of timing on the magnitude of response by understory arthropods. Based on the results, a management preference could be give to the season in which fire has a lower negative effect on arthropods. Similarly, managers can assess the importance of fire frequency in arthropod ecology by contrasting the magnitude of arthropod responses from studies of differing burning intervals.

Furthermore, examination of the variability in response to disturbance among different taxa could be used to identify indicator species. Generally, homogeneity of variance would suggest that all species are equally affected by the perturbation. However, a highly variable response among species would warrant further examination of the data to identify highly sensitive or resilient taxa. These could be given priority in future studies.

In addition, meta-analysis is a valuable tool to address landscape-level questions. For example, Hartley and Hunter (1998) showed that predation rates on forest bird nests decrease with increasing vegetation cover. Meta-analysis of their data revealed that the predation pattern was similar at three scales of landscape resolution, i.e. regardless of whether the percent forest cover was calculated from 5-km, 10-km, or 25-km radius plots. Similarly, a lower magnitude of fire effect on understory herbivores in burn units of smaller area size could suggest that a more rapid re-colonization process of habitat by arthropods is taking place. Recommendations could then be made on how the size of burn units affects the recovery process of the post-burn environment. Furthermore, if a pattern in data is consistent across studies from a wider geographic range, this would indicate that the finding is highly robust.

By the virtue of focusing on multiple taxa and variables, meta-analysis can have particularly broad applications in forest research and management. It can help us address whether disturbance at the landscape level may influence arthropod persistence. This information can be used to refine mitigation measures outlined in the Standards and Guidelines of the ROD. Thus, meta-analysis can be a highly cost-effective way in which to address questions regarding arthropods and their function in the Pacific Northwest.