The Protection of Wildlife Under Washington's Growth Management Act

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I. Introduction

Set down there not knowing it was Seattle, I could not have told where I was. Everywhere frantic growth, a carcinomatous growth. Bulldozers rolled up the green forests and heaped the resulting trash for burning. The torn white lumber from concrete forms was piled beside gray walls. I wonder why progress looks so much like destruction.[1]

Two hundred years ago, Seattle was an old-growth Douglas-firwestern hemlock forest.[2] Tens of millions of migrating salmon spawned in Pacific Northwest rivers each year, supporting scores of Indian tribes.[3] Puget Sound and the Washington coast were only just being surveyed by George Vancouver[4] and Robert Gray.[5] Today, two hundred fourteen native natu-

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1. JOHN STEINBECK, TRAVELS WITH CHARLEY 162 (1962).

2. *See generally* ARTHUR KRUCKEBERG, THE NATURAL HISTORY OF PUGET SOUND (1991).

3. In the 1860s, the Columbia River drainage produced some 16 million wild salmon and steelhead per year. Thomas J. Eley & T.H. Watkins, *In a Sea of Trouble: The Uncertain Fate of the Pacific Salmon*, 55 WILDERNESS 18, 20 (Fall 1991). At least 52 indigenous Indian tribes, most with salmon-based economies, are identified in ROBERT H. RUBY & JOHN A. BROWN, INDIANS OF THE PACIFIC NORTHWEST 39 (1981). The central importance of anadromous fish to the native peoples of the Pacific Northwest was summarized in United States v. Washington, 384 F. Supp. 312, 350-53 (W.D. Wash. 1974).

4. Captain George Vancouver, commanding the British ships *Discovery* and *Chatham*, explored and surveyed the Strait of Juan de Fuca and Puget Sound from April through June 1792. The records of his exploration in the Pacific Northwest are contained in GEORGE VANCOUVER, A VOYAGE OF DISCOVERY TO THE NORTH PACIFIC OCEAN, AND ROUND THE WORLD (1800) (6 volumes; *see especially* vol. 2). *See also* BERN ANDERSON, SURVEYOR OF THE SEA: THE LIFE AND VOYAGES OF CAPTAIN GEORGE VANCOUVER (1960).

5. Captain Robert Gray's ship, the *Columbia*, was the first United States vessel to circumnavigate the globe in 1789-90. In May 1792, Gray "discovered" and lay American claim to Gray's Harbor and the Columbia River. *See generally* F.W. HOWAY, ED., VOYAGES OF THE "COLUMBIA" TO THE NORTHWEST COAST, 1787-1790 AND 1790-1793

rally-spawning Pacific salmon and steelhead runs in California, Oregon, Washington, and Idaho face a high or moderate risk of extinction.[6] Less than ten percent of western Washington's original old-growth forests have escaped the chainsaw and the axe,[7] and much of that remaining is so fragmented that it cannot support those wildlife species dependent on old-growth.[8] Washington's human population now approaches five million, with many counties having grown thirty percent or more in the last decade.[9]

A. *The Growth Management Act*

Times have changed in Washington. Our repeated failure

(1941); DEREK PETHICK, FIRST APPROACHES TO THE NORTHWEST COAST (1976). Gray's discoveries significantly motivated the Lewis and Clark expedition a decade later.

6. Willa Nehlsen et al., *Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington*, 16 FISHERIES 4 (Mar.-Apr. 1991). In Washington, 87 streams or stream reaches contain at least one fish stock that is at risk. U.S. FISH & WILDLIFE SERVICE, DRAFT RECOVERY PLAN FOR THE NORTHERN SPOTTED OWL 380-81 (1992) [hereinafter SPOTTED OWL PLAN]. In April 1992, the National Marine Fisheries Service announced that it would list two runs of Snake River chinook salmon as threatened species under the Endangered Species Act, 16 U.S.C. §§ 1631-4643 (1988). Historically, the Columbia River has been the world's most productive salmon fishery; over 40 percent of Columbia chinook were produced by the Snake River and its tributaries. Up to 4 feet long and 50 pounds, the chinook is the largest Pacific salmon, and the Snake River chinooks travel the farthest distance to the highest elevation of any salmon species. They hatch in shallow gravel beds in streams in central Idaho, migrate to the ocean the following year, and spend two to three years feeding in the Pacific Ocean before returning to spawn in the streams of their birth. Comment, *Chinook Runs Join Threatened Species List*, 12 FOREST WATCH 7 (May 1992).

7. Only 2-3% of private timberlands in western Washington contain stands more than 100 years old. DARIUS M. ADAMS ET AL., INSTITUTE OF FOREST RESOURCES CONTRIBUTION NO. 74, UNIVERSITY OF WASHINGTON, FUTURE PROSPECTS FOR WESTERN WASHINGTON'S TIMBER SUPPLY 5, 10-11 (1992). Trees over 100 years old occur on about 6.6% of forest land managed by the Washington Department of Natural Resources. *Id.* at 14-18. Old-growth is found on 15% of national forest land in Oregon and Washington, with classic old-growth (at least 8 trees per acre over 300 years old or more than 40 inches in diameter) occupying less than 5% of the national forests. PETER H. MORRISON, THE WILDERNESS SOCIETY, OLD GROWTH IN THE PACIFIC NORTHWEST: A STATUS REPORT 35-43 (Nov. 1988); H. MICHAEL ANDERSON & DEANNE KLOEPFER, THE WILDERNESS SOCIETY, END OF THE ANCIENT FORESTS: SPECIAL REPORT ON NATIONAL FOREST PLANS IN THE PACIFIC NORTHWEST 6 (June 1988).

8. *E.g.*, over half of the remaining old growth on federal lands is in blocks of less than 2500 acres, and 37% of federal old growth is in stands of less than 400 acres. MORRISON, *supra* note 7, at 37-43. These small blocks may lack most or all of the biological characteristics necessary for old-growth dependent wildlife. *See* Jerry F. Franklin & Richard T.T. Forman, *Creating Landscape Patterns by Forest Cutting: Ecological Consequences and Principles*, 1 LANDSCAPE ECOLOGY 5 (1987).

9. PUGET SOUND WATER QUALITY AUTHORITY, STATE OF THE SOUND 1992 REPORT 15 (1992).

to consider systematically the ecological consequences of our land use decisions now threaten the continued integrity and health of our forested ecosystems, rivers and lakes, and Puget Sound itself. Yet our quality of life and economic well-being are both intricately bound with viable, functioning ecosystems.[10] Ecosytems in turn depend on complex interactions among living organisms and between those organisms and their physical environment.[11] Unfortunately, the traditional casual approach to landscape-level planning based only on private property rights has proved inadequate to maintain the biological diversity of our region. A different approach to regional planning is needed, one that incorporates land management principles developed by conservation biologists to ensure the long term preservation of biological diversity and ecological integrity in the Pacific Northwest. In Washington, the Growth Management Act of 1990 (GMA)[12] provides a means for implementing more ecologically enlightened planning.

The GMA was passed to counter rising threats to Washington's environmental quality resulting from uncoordinated and unplanned growth. The GMA set forth planning goals to guide local governments as they implement comprehensive plans to manage growth.[13] Among these goals are the following: "[m]aintain and enhance natural resource-based industries, including productive timber, agricultural, and fisheries industries,"[14] "conserve fish and wildlife habitat,"[15] and "[p]rotect the environment and enhance the state's high quality of life, including air and water quality."[16] To meet these goals, all counties and cities must identify and protect "critical areas,"[17]

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10. *See, e.g.*, ELLIOTT A. NORSE, ANCIENT FORESTS OF THE PACIFIC NORTHWEST 132-52 (1990); MELANIE J. ROWLAND ET AL., OLD-GROWTH FORESTS AND TIMBER TOWNS: THINKING ABOUT TOMORROW (Supplement) 29-60 (1993).

11. *See, e.g.*, CHARLES J. KREBS, ECOLOGY: THE EXPERIMENTAL ANALYSIS OF DISTRIBUTION AND ABUNDANCE 563-93 (3d ed. 1985).

12. WASH. REV. CODE ch. 36.70A (1992); 1990 Growth Management Act, 1990 Wash. Laws ch. 17 (effective July 1, 1990), *amended by* 1991 Wash. Laws ch. 32 (effective July 16, 1991).

13. WASH. REV. CODE § 36.70A.020 (1992).

14. *Id.* § 36.70A.020(8).

15. *Id.* § 36.70A.020(9).

16. *Id.* § 36.70A.020(10).

17. *Id.* §§ 36.70A.060(2), .170(1)(d). Under these provisions, counties and cities subject to the GMA must have adopted interim development regulations by September 1, 1991, and final regulations by July 1, 1994; all other counties and cities were given until March 1, 1992 to adopt protective regulations for critical areas. *See also* WASH. ADMIN. CODE § 365-190-040 (1991). Six month extentions are available under WASH. REV. CODE § 36.70A.380 (1991).

which include wetlands, lands required for aquifer recharge, fish and wildlife habitat, frequently flooded areas, and geologically hazardous areas.[18] Cities and counties covered by the GMA[19] must also inventory and protect agricultural lands, forest lands, and mineral resource lands.[20]

To assist counties and cities planning under the GMA, the Washington Department of Community Development (WDCD) has developed minimum guidelines to classify critical areas and natural resource lands.[21] Under these guidelines, critical areas designations are to "overlay other land uses including designated natural resource lands."[22] While natural resource lands should be mapped for effective regulation, critical areas are to be regulated using performance standards rather than mapping, because their boundaries rarely can be exactly delineated.[23] Existing resource management operations with long-term commercial significance, if they include designated critical areas, are to continue operation using "best management practices."[24] Operators of new or expanded oper-

18. WASH. REV. CODE § 36.70A.030(5) (1992).

19. While all counties and cities must inventory and protect critical areas, not all obligations of the GMA fall on all counties and cities. WASH. REV. CODE § 36.70A.040 (1992) imposes growth planning obligations on counties and cities on the basis of population and rate of growth; other cities and counties may choose to accept these obligations. As of December 1991, 26 counties are mandatorily or voluntarily obligated to implement the provisions of the GMA, as amended: Benton, Chelan, Clallam, Clark, Columbia, Douglas, Ferry, Franklin, Garfield, Grant, Island, Jefferson, King, Kitsap, Mason, Pacific, Pend Orielle, Pierce, San Juan, Skagit, Snohomish, Thurston, Walla Walla, Whatcom, Whitman, and Yakima. Remaining counties must meet certain statewide mandates only, such as protecting "critical areas"; these now include: Adams, Asotin, Cowlitz, Grays Harbor, Klickitat, Lewis, Lincoln, Okanogan, Skamania, Spokane, Stevens, Wahkiakum, and Whitman. GROWTH MANAGEMENT DIVISION, WASHINGTON STATE DEPARTMENT OF COMMUNITY DEVELOPMENT, 4 IMPLEMENTATION BRIEFS 1, 3-4 (Dec. 1991).

20. WASH. REV. CODE § 36.70A.170 (1992). Under this provision, counties and cities subject to the GMA must have adopted regulations to protect these resource lands by September 1, 1991. However, forest lands and agricultural lands within urban growth areas cannot be designated as resource lands under this provision unless the city or county has enacted a program authorizing the transfer of development rights. *Id.* § 36.70A.060(4).

21. WASH. ADMIN. CODE ch. 365-190 (1991). Natural resource lands are defined as "agricultural, forest and mineral resource lands which have long-term commercial significance." *Id.* § 365-190-030(15). Long-term commercial significance is determined by "the growing capacity, productivity, and soil composition of the land for long-term commercial production," together with the possibility of more intense use of the land because of its proximity to population areas. *Id.* § 365-190-030(11).

22. *Id.* § 365-190-020; *see also id.* § 365-190-040(1).

23. *Id.* § 365-190-040(2)(d).

24. *Id.* § 365-190-020. "Best management practices" are not defined in the regulations.

ations should "consider" protecting critical areas.[25] The guidelines encourage the use of "innovative land use management techniques" to conserve and protect critical areas and natural resource lands.[26]

Under WDCD's minimum guidelines, five types of critical areas are delineated.[27] Two of these types—wetlands and fish and wildlife habitat conservation areas—play potentially significant roles in maintaining ecosystem integrity and biological diversity in the Pacific Northwest.

B. Wetlands

Wetlands provide important habitat for about one-third of the plant and animal species federally listed as threatened or endangered.[28] They provide essential nesting habitat, migratory stopovers, and wintering areas for more than half of all migratory bird species found in the United States.[29] About two-thirds of U.S. shellfish and commercial sports fisheries rely on coastal wetlands for spawning and nursery grounds.[30] In Washington, wetlands are used by eighty-five percent of terrestrial wildlife species.[31]

For regulatory purposes, counties and cities are (1) directed to designate wetlands using the definition in Revised Code of Washington (RCW) 36.70A.030(17);[32] (2) "requested

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25. *Id.* § 365-190-020.

26. "Innovative land use management techniques" include purchase of development rights, fee simple purchase of the land, less than fee simple purchase, purchase with lease-back, buffering on land within adjoining development, land trades, and conservation easements. WASH. ADMIN. CODE § 365-190-040(2)(h) (1991).

27. The 5 types of critical areas are wetlands, areas with a critical recharging effect on aquifers used for potable water, fish and wildlife habitat conservation areas, frequently flooded areas, and geologically hazardous areas. *Id.* §§ 365-190-030(4), -080.

28. THOMAS E. DAHL & CRAIG E. JOHNSON, U.S. DEPARTMENT OF THE INTERIOR, U.S. FISH & WILDLIFE SERVICE, STATUS AND TRENDS OF WETLANDS IN THE COTERMINOUS UNITED STATES, MID-1970'S TO MID-1980'S 3 (1991).

29. *Id.*

30. DAVID SALVESEN, THE URBAN LAND INSTITUTE, WETLANDS: MITIGATING AND REGULATING DEVELOPMENT IMPACTS 15 (1990).

31. Habitat Management Division, Washington Department of Wildlife, *Buffer Needs of Wetland Wildlife* 1 (Feb. 1992).

32. WASH. ADMIN. CODE § 365-190-080(1) (1991). WASH. REV. CODE § 36.70A.030(17) (1992) reads as follows:

> "Wetland" or "wetlands" means areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditons. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites,

and encouraged" to adopt a "no net loss" policy toward wetland protection;[33] and (3) "should consider" using the model wetlands ordinance and other guidance prepared by the Washington Department of Ecology (WDOE).[34] Counties and cities are also directed to consider a wetlands rating system that considers wetlands function and values,[35] sensitivity to disturbance,[36] rarity,[37] and the ability to compensate for their destruction or degradation.[38] The guidelines recommend using WDOE's four-tier wetlands rating system;[39] a county or city choosing not to use this system must report the rationale for its decision to WDCD.[40] Finally, counties and cities may use

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including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities. However, wetlands may include those artificial wetlands intentionally created to mitigate conversion of wetlands, if permitted by the county or city.

33. "Counties and cities are requested and encouraged to make their actions consistent with the intent and goals of protection of wetlands, Executive Orders 89-10 and 90-04 as they exist on September 1, 1990." WASH. ADMIN. CODE § 365-190-080(1) (1991). Executive Order 89-10, issued by the Governor on December 12, 1989, adopted a goal of "no net loss in acreage or function," and directed affected agencies to identify wetlands impacts and opportunities for protection. After the proposed 1990 Wetlands Management Act failed, the Governor signed Executive Order 90-04 on April 12, 1990, which specifically mandated state agencies to use existing authorities to the maximum extent possible to protect wetlands.

34. WASH. ADMIN. CODE § 365-190-080(1) (1991). The model wetlands ordinance lists uses that are allowed within a wetland or wetland buffer; any other activity requires a special use permit, which will be granted only if the proposed activity avoids or minimizes adverse impacts to the wetland and its buffer or compensates for that impact, if the proposed activity results in no net loss of wetlands, or if denying the permit would cause extraordinary hardship. Predictably, a special use permit is required for activities traditionally associated with "development" (grading, discharge of fill, draining, flooding, driving of pilings, placing of obstructions, and construction). Additionally, however, a permit is required for activities that destroy or alter wetlands through clearing, shading, intentional burning, planting of vegetation that would alter the character of a regulated wetland, significantly changing water temperature or physical or chemical characteristics, or introducing pollutants. Local governments are not obligated to use the model ordinance, *see* 21 Wash. Op. Att'y Gen. 4 (1989), but they may use it to develop local wetlands ordinances.

35. WASH. ADMIN. CODE § 365-190-080(1)(a)(ii) (1991).

36. *Id.* § 365-190-080(1)(a)(iii).

37. *Id.* § 365-190-080(1)(a)(iv).

38. *Id.* § 365-190-080(1)(a)(v).

39. *Id.* § 365-190-080(1)(a)(i). WDOE's rating system has been issued in two publications. *See* WASHINGTON DEPARTMENT OF ECOLOGY, PUB. NO. 91-57, WASHINGTON STATE WETLANDS RATING SYSTEM FOR WESTERN WASHINGTON (1991); WASHINGTON DEPARTMENT OF ECOLOGY, PUB. NO. 91-58, WASHINGTON STATE WETLANDS RATING SYSTEM FOR EASTERN WASHINGTON (1991). The two publications are nearly identical, differing only with respect to some specialized wetland types found only on one side of the Cascades or the other.

40. WASH. ADMIN. CODE § 365-190-080(1)(a) (1991).

the national wetlands inventory[41] to determine the approximate distribution and extent of wetlands[42] and the 1989 Federal Manual[43] to identify and delineate jurisdictional wetlands.[44]

C. Fish and Wildlife Habitat Conservation Areas

Conceptually, the establishment of fish and wildlife habitat conservation areas builds on Washington's Natural Heritage Plan, which has already undertaken to identify and protect natural areas that preserve significant examples of typical and rare ecosystem types and special species.[45] As interpreted by the WDCD guidelines, the GMA goes further than the Natural Heritage Plan: fish and wildlife conservation areas are to maintain species in suitable habitats within their natural distribution so that isolated subpopulations are not created.[46] The GMA also encourages the preservation of connections with larger blocks of habitat[47] and of buffers to separate habitat preserves from surrounding incompatible uses.[48] The recommendations represent central elements in a landscape approach to protecting biological diversity in Washington.

The guidelines also provide that the following are to be designated as fish and wildlife habitat conservation areas: (1) areas with which endangered, threatened, or sensitive species have a "primary association," and which, if altered, may reduce the likelihood that the species will maintain and reproduce

41. Prepared by the U.S. Fish & Wildlife Service, pursuant to 16 U.S.C. § 3931 (1989).

42. WASH. ADMIN. CODE § 365-190-080(1)(b) (1991).

43. Available from the U.S. Fish & Wildlife Service, U.S. Environmental Protection Agency, or U.S. Army Corps of Engineers. The 1989 Federal Manual allows the presence of water to be inferred from soil characteristics in undisturbed systems, replacing the multiparameter approach used in the 1987 manual, which required quantitative sampling of vegetation, soils, and hydrology to determine the boundaries of wetlands. In 1991, the Army Corps of Engineers proposed revising the 1989 manual to impose a more restrictive technique for wetland identification and delineation. *See* 56 Fed. Reg. 40446 (1991). The proposed revisions generated much controversy and have not been adopted; consequently, the Army Corps of Engineers and all federal agencies are now using the 1987 manual to delineate wetlands, while most local jurisdictions use the 1989 manual.

44. WASH. ADMIN. CODE § 365-190-080(1)(c) (1991).

45. WASHINGTON NATURAL HERITAGE PROGRAM, WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES, STATE OF WASHINGTON NATURAL HERITAGE PLAN (1989) [hereinafter NATURAL HERITAGE PLAN].

46. WASH. ADMIN. CODE § 365-190-080(5) (1991).

47. *Id.* § 365-190-080(5)(b)(i).

48. *Id.* § 365-190-080(5)(b)(v).

over the long term;[49] (2) habitats and species of local importance;[50] (3) naturally occurring ponds smaller than twenty acres that provide fish or wildlife habitat;[51] (4) waters of the state;[52] and (5) state natural area preserves and natural resource conservation areas.[53] WDCD recognized that effective habitat conservation cannot occur without cooperation among the counties and cities within an ecological region.[54]

The 1991 amendments to the GMA[55] created a temporary committee[56] to report on "natural resources of statewide significance."[57] These are defined as "natural resources that possess outstanding natural, ecological, or scenic values, and are of the highest quality and most significant of their type."[58] The Committee was to report to the legislature by December 31, 1991, on criteria, protection standards and the need for acquisition of these natural resources.

The Committee's final report was issued on January 31,

49. *Id.* §§ 365-190-080(5)(a)(i), (c)(1) (1991); § 365-190-080(5)(c)(i). The regulation lists the three categories of protected species in the conjunctive: "Areas with which endangered, threatened, and sensitive species have a primary association." It seems unreasonably restrictive to read this language literally to require that all three species categories must be represented in any fish and wildlife habitat conservation area. Such a reading would be contrary to the approach taken by the Department of Natural Resources in constructing its Natural Heritage Plan. *See* NATURAL HERITAGE PLAN, *supra* at 19-20.

50. WASH. ADMIN. CODE §§ 365-190-080(5)(a)(ii), (c)(ii); *See also id.* § 365-19-030(9). The Washington Department of Wildlife has identified priority habitats and priority species for all lands in Washington. *See infra* text accompanying notes 101-104 and *infra* note 194. These priorities may be used by counties and cities. WASH. ADMIN. CODE § 365-190-080(5)(c)(ii) (1991).

51. WASH. ADMIN. CODE § 365-190-080(5)(a)(v) (1991); *id.* § 365-190-080(5)(b)(v). Artificial ponds created to mitigate conversion of ponds are included, if permitted by a regulatory authority. *Id.* § 365-190-080(5)(b)(v).

52. *Id.* § 365-190-080(5)(a)(vi). Waters of the state are defined in *id.* § 222-16-020 (1991). These waters should be classified using the classification system in *id.* § 222-16-030 (1992); factors to consider in such classification are given in *id.* § 365-190-080(5)(b)(vi) (1991).

53. *Id.* § 365-190-080(5)(a)(viii), (b)(viii). Fish and wildlife conservation areas to be designated as critical areas also include commercial and recreational shellfish areas, kelp and eelgrass beds, and herring and smelt spawning areas. *Id.* §§ 365-190-080(5)(a)(iii)-(iv), (b)(iii)-(iv).

54. *Id.* § 365-190-080(5).

55. 1991 Wash. Laws ch. 32 (effective July 16, 1991). *See supra* note 12.

56. 1991 Wash. Laws ch. 32 § 37. The Committee included representatives from the Departments of Natural Resources, Parks and Recreation, Wildlife, Fisheries, Ecology, and Community Development; representatives of the Parks and Recreation Commission, the Association of Washington Cities, and the Washington State Association of Counties; and three members of the public.

57. *Id.* § 38.

58. *Id.* § 38(2).

1992.[59] The Committee found that no comprehensive system of coordinated regional planning for natural resource areas exists in Washington. It recommended that such a system be implemented in connection with the GMA. As defined by the Committee, a natural resource of statewide significance provides any of the following: (1) significant habitat for plant or animal species that are identified by the state as endangered or threatened or as a candidate for such classification; (2) a biologically diverse, naturally functioning life-system; (3) a habitat corridor or linkage for wildlife migration; (4) buffering for a valuable resource area; or (5) high-quality wildlife that is in an undisturbed ecological site.[60] These recommendations reflect the same principles of conservation biology addressed in this Article.

D. *Effectiveness of Wildlife Conservation Under the GMA*

Will critical areas and resource lands, as implemented under the GMA, effectively contribute to the conservation of wildlife and wildlife habitat in Washington? The remainder of this Article will address that question. First, this Article briefly describes some aspects of biological diversity that must be understood before proceeding further. Second, it sets forth several central principles from modern conservation biology that are essential for maintaining habitat integrity and species viability and considers their applicability to critical areas and resource lands, as defined by the GMA. Third, it explains how these principles could be used to identify and protect habitat remnants in western Washington. Finally, this Article concludes by arguing that such an approach is absolutely necessary if we are to protect the biological diversity and ecological integrity of the Pacific Northwest.[61]

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59. WASHINGTON DEP'T OF COMMUNITY DEVELOPMENT GROWTH MANAGEMENT DIV., NATURAL RESOURCES OF STATEWIDE SIGNIFICANCE: FINAL REPORT OF THE TEMPORARY COMMITTEE ON NATURAL RESOURCES (1992).

60. *Id.* at 16. Additional criteria not relevant here were also used by the committee to identify natural resources of statewide significance, such as an unique geological feature or an outstanding scenic landscape. *Id.* at 16-17.

61. Although the following sections focus on conservation of biological diversity in the forested ecosystems of western Washington, the same principles apply to the conservaton of biological diversity in the forested and shrub-steppe ecosystems of eastern Washington. Dominant ecosystem types in eastern Washington are well-described in KRUCKEBERG, *supra* note 2. Certain significant ecosystems on both sides of the state, such as riparian zones and wetlands, raise special concerns because of their special importance for wildlife.

II. RECOGNIZING AND PRESERVING BIOLOGICAL DIVERSITY

To effectively preserve biological diversity and ecological function, land managers and policymakers must understand that natural systems are hierarchically organized. No species is distributed uniformly over the landscape; rather, each species exists as a collection of populations, with each population occupying a particular habitat at a particular time.[62] While every population responds dynamically to fluctuating environmental conditions and changing biological interactions, each population nevertheless forms a recognizable genetic unit that retains both ecological and evolutionary identity over time.[63] The genetic diversity within a population roughly represents the ability of that population to adapt to changes in its environment.[64] In general, a species composed of many relatively large populations contains much more genetic diversity than a species composed either of small populations or a single large population.[65]

A given habitat type typically supports populations of many different species, so that each habitat type exhibits a characteristic species diversity. The populations of species occupying a given habitat type, together with the physical environment that supports and is affected by these populations, form an ecosystem.[66] Biological diversity, then, includes both the species diversity found within an ecosystem and the genetic diversity found within each species in that ecosystem.[67] Ecologically sound wildlife management must preserve both aspects of biological diversity.

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62. KREBS, *supra* note 11, at 157.

63. ROBERT LEO SMITH, ECOLOGY AND FIELD BIOLOGY 290-91 (4th ed. 1990).

64. A gene is loosely defined as the smallest discrete heritable unit contained within the cells of living organisms. *See generally* Steven M. Chambers, *Genetic Principles for Managers*, *in* GENETICS AND CONSERVATION: A REFERENCE FOR MANAGING WILD ANIMAL AND PLANT POPULATIONS 15-46 (Christine M. Schonewald-Cox et al. eds., 1983); Otto H. Frankel, *The Place of Management in Conservation*, *in* GENETICS AND CONSERVATION: A REFERENCE FOR MANAGING WILD ANIMAL AND PLANT POPULATIONS 1, 3 (Christine M. Schonewald-Cox et al. eds., 1983).

65. Hal Salwasser, *Managing Ecosystems for Viable Populations of Vertebrates: A Focus for Biodiversity*, *in* ECOSYSTEM MANAGEMENT FOR PARKS AND WILDERNESS 87, 89-91 (James K. Agee & Darryll R. Johnson eds., 1988); Bruce A. Wilcox, *In Situ Conservation of Genetic Resources*, *in* THE PRESERVATION AND VALUATION OF BIOLOGICAL RESOURCES 45, 64-65 (Gordon H. Orians et al. eds., 1990).

66. MICHAEL BEGON ET AL., ECOLOGY: INDIVIDUALS, POPULATIONS, AND COMMUNITIES 591-92 (1986).

67. *See* Allen Cooperrider, *Conservation of Biodiversity on Western Rangelands*, *in* LANDSCAPE LINKAGES AND BIODIVERSITY 40, 40-44 (Wendy E. Hudson ed., 1991).

In the United States, most wildlife management has been devoted to the production of harvestable surpluses of a limited number of game species,[68] rather than to the maintenance of genetic diversity or species diversity. Biological diversity has been protected only as an incidental byproduct of habitat manipulation for game species. Inevitably, however, this species-by-species approach to wildlife management fails to prevent the loss of biological diversity, as individual organisms followed by entire populations of nongame wildlife species disappear from areas managed for game production. Once a population disappears from an area, its successful reintroduction is usually difficult:

> [G]iven enough biological knowledge about a species and enough time, effort, and money to apply that knowledge, reintroduction can be made to work. It is, however, an expensive and labor-intensive procedure. . . . It requires a tremendous amount of cooperation among private individuals, government agencies, conservation organizations, corporations, and so on. Because so many different interests are usually involved, especially with an endangered species, it almost always becomes highly politicized.[69]

Because of limited data, personnel, and funding, only a few species can be directly managed or protected using this "species approach" to conservation. While a range of sophisticated technological treatments are available to care for critically threatened or endangered species—including short-term propogation and reintroduction to the wild, long-term propogation without foreseeable reintroduction, relocation, transplantation, fostering, embryo transfer, artificial insemination, artificial incubation, and artificial rearing—such treatments are characteristically expensive, so that very few species actually benefit from their use.[70] The species approach cannot successfully stem the rising tide of human-caused extinctions of flora and fauna.[71] A more comprehensive approach is necessary to effec-

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68. G. TYLER MILLER, JR., RESOURCE CONSERVATION AND MANAGEMENT 443 (1990).

69. Tom J. Cade, *Using Science and Technology to Establish Species Lost in Nature*, *in* BIODIVERSITY 279, 285 (E.O. Wilson ed., 1988).

70. William Conway, *Can Technology Aid Species Preservation?* *in* BIODIVERSITY 263, 264-65 (E.O. Wilson ed., 1988).

71. Current estimates of the global rate of species extinction range from about 20,000 to 50,000 species per year. *See, e.g.*, John C. Ryan, *Conserving Biological Diversity*, *in* STATE OF THE WORLD 1992 9, 9 (Lester R. Brown, project director, 1992); E.O. Wilson, *The Current State of Biological Diversity*, *in* BIODIVERSITY 3, 13 (E.O.

tively conserve biological diversity.

Protection of habitat is the single most effective means of preserving biological diversity.[72] The "ecosystem approach" (or "landscape approach") to biological conservation seeks to protect entire assemblages of species by protecting their habitat—by protecting entire ecosystems, with all their constituent biological and physical elements. Protecting a single wildlife refuge that provides important habitat for hundreds of species of plants and animals may cost less than the recovery effort for a single species on the brink of extinction,[73] and the species occupying a network of such refuges generally have far better chances of survival.[74]

Wilson ed., 1988). These rates of extinction are thousands of times higher than those present before human intervention, based on background extinction rates calculated by paleontologists. *See, e.g.*, David M. Raup, *Biological Extinction in Earth History*, 231 SCIENCE 1528 (1986); David M. Raup & J.J. Sepkoski, Jr., *Periodicity of Extinctions in the Geologic Past*, 81 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES U.S.A. 801 (1984). While the vast majority of modern human-caused extinctions are occurring in tropical regions, several species native to Washington have also become extinct and scores of others are at risk. *See infra* notes 101-111 and accompanying text. In the United States, hundreds of species are listed as threatened or endangered under the Endangered Species Act, 16 U.S.C. §§ 1631-4643 (1988), and hundreds more should be listed but have been delayed by administrative resistance and lack of funding.

72. Ryan, *supra* note 71, at 24. "Habitat" refers to the actual places where a species can live, because the environmental conditions are suitable and because other requirements are met, such as food availability, shelter from predators, nesting and resting sites, etc. "Niche" refers to the particular ways in which a species uses its habitat. Thus, many species may occupy the same habitat by using it in different ways—i.e., by occupying different niches.

73. MILLER, *supra* note 68, at 440.

74. *See generally* LARRY D. HARRIS, THE FRAGMENTED FOREST—ISLAND BIOGEOGRAPHY THEORY AND THE PRESERVATION OF BIOTIC DIVERSITY (1984).

After this Article was accepted for publication, the Forest Service assembled a "Scientific Analysis Team" to recommend a mitigation strategy for protecting biodiversity on federal lands in the Pacific Northwest. That strategy was prepared in response to Seattle Audubon Soc. v. Moseley, 798 F. Supp. 1484 (W.D.Wash. 1992), which enjoined timber sales in Northern spotted owl habitat until the Forest Service prepared a plan that would maintain viable populations of all vertebrate species existing on its lands, as required by the National Forest Management Act, 16 U.S.C. §§ 1600-1614 (1988). In March 1993, the Scientific Analysis Team issued its report. *See* JACK WARD THOMAS ET AL., U.S. FOREST SERVICE, VIABILITY ASSESSMENTS AND MANAGEMENT CONSIDERATIONS FOR SPECIES ASSOCIATED WITH LATE-SUCCESSIONAL AND OLD-GROWTH FORESTS OF THE PACIFIC NORTHWEST (1993). The report's recommendations for protecting biodiversity in old-growth forests found on federal land are similar to those presented in this article for forests subject to the GMA. It recommends setting aside large tracts of high-quality habitat, managing the matrix between preserves to buffer them from damage and to enhance the biological value of protected areas, protecting critical areas occupied by rare species and indicator species, and monitoring management activities for their effect on wildlife. *Id.* at 19-22, 485-86. The report estimates that implementation of its entire strategy would produce a high

To maintain the functional and structural integrity of an ecosystem, we may choose from only two approaches: preserve the entire ecosystem in its natural state so that all human disturbances are completely excluded, or intelligently manage the ecosystem by preserving the processes and features that are essential for its continuing ecological integrity. Intelligent management is much more difficult and much less certain than strict preservation of entire ecosystems;[75] but because only a tiny fraction of the Pacific Northwest will ever be preserved in its natural state,[76] we must implement ecologically sound management of lands that are not pristine but that are nevertheless essential for preserving biological diversity. To discover what constitutes ecologically sound management, we must look to the central principles that have developed in modern conservation biology.

III. Central Principles of Conservation Biology

The intellectual roots of conservation biology extend at least to the formation of the Wildlife Society in the 1930s,[77] which was formed in part to apply "scientific principles" to the management of game species. Independently, beginning in the late 1960s, academic ecologists began to develop a new generation of mathematical models[78] and an increasingly sophisticated understanding of species interactions and ecosystem processes.[79] By the time of the First International Conference

probability of long-term population viability for 482 of the 512 species for which adequate data were available; the ecological requirements of another 149 species are too poorly understood to allow any viability estimate. *Id.* at 19-22.

75. For example, at least eleven *categories* of ecosystem attributes are involved in determining the structure and function of ecological communties. RICHARD T.T. FORMAN & MICHAEL GODRON, LANDSCAPE ECOLOGY 486-87 (1986). These range from the natural processes that create landforms to the size, shape, distribution, and longevity of habitat patches.

76. *See infra* notes 116-17 and accompanying text.

77. The very first article to appear in the Wildlife Society's new journal referred to wildlife management as "the new and growing field of conservation biology." Paul L. Errington & F.N. Hamerstrom, Jr., *The Evaluation of Nesting Losses and Juvenile Mortality of the Ring-Necked Pheasant*, 1 JOURNAL OF WILDLIFE MANAGEMENT 3, 3 (1937).

78. The seminal work of the period is ROBERT H. MACARTHUR & EDWARD O. WILSON, THE THEORY OF ISLAND BIOGEOGRAPHY (1967). This small book provided a conceptual framework for understanding population dynamics in habitat "islands" that still animates much of modern conservation biology.

79. *See, e.g.*, MARTIN L. CODY & JARED M. DIAMOND EDS., ECOLOGY AND EVOLUTION OF COMMUNITIES (1975); ROBERT M. MAY, STABILITY AND COMPLEXITY IN MODEL ECOSYSTEMS (1973); ROBERT H. WHITTAKER, COMMUNITIES AND ECOSYSTEMS

on Conservation Biology in 1978, these two lineages, theoretical and applied, had merged.[80] In 1986, the Society for Conservation Biology was formed, and within four years at least sixteen major universities offered graduate programs in conservation biology.[81] Conservation biology had developed into a separate, recognized field of study emanating from the biological sciences but drawing broadly on disciplines such as law and planning as well.[82] Conservation biology now forms the core of a developing new paradigm in resource management: "Only the dead and yet unborn could be unaware of the maelstrom of change sweeping through forest and wildlife management cir-

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(1975); Simon A. Levin & Robert T. Paine, *Disturbance, Patch Formation, and Community Structure*, 71 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES U.S.A. 2744 (1974); Eugene P. Odum, *The Strategy of Ecosystem Development*, 164 SCIENCE 262 (1969).

80. The volume that ensued from the 1978 conference is MICHAEL E. SOULÉ & BRUCE A. WILCOX EDS., CONSERVATION BIOLOGY: AN EVOLUTIONARY-ECOLOGICAL PERSPECTIVE (1980). For a brief summary of the intellectual history of conservation biology, see Peter F. Brussard, *The Current Status of Conservation Biology*, 66 BULLETIN OF THE ECOLOGICAL SOCIETY OF AMERICA 9 (Mar. 1985).

81. Susan K. Jacobson, *Graduate Education in Conservation Biology*, 4 CONSERVATION BIOLOGY 431, 434-40 (1990). The sixteen universities responding to Jacobson's survey were Colorado State University, University of Colorado, Cornell University, Duke University, University of Florida, University of Georgia, University of Hawaii, Iowa State University, University of Maryland, University of Michigan, Montana State University, Stanford University, Texas A&M University, Tufts University, University of Washington, and University of Wisconsin.

82. *Id.* at 434. The influence runs both ways. For example, the National Research Council incorporates principles of conservation biology in its recommendations to agencies planning for international development. *See* BOARD ON SCIENCE AND TECHNOLOGY FOR INTERNATIONAL DEVELOPMENT, U.S. NATIONAL RESEARCH COUNCIL, CONSERVING BIODIVERSITY: A RESEARCH AGENDA FOR DEVELOPMENT AGENCIES 4, 35-75 (1992). Federal agencies have adopted principles of conservation biology in managing for rare, threatened, or endangered species. *See, e.g.*, SPOTTED OWL PLAN, *supra* note 6, at 100-02 (1992). Indeed, principles of conservation biology formed the basis for the report of the Interagency Scientific Committee to Address the Conservation of the Northern Spotted Owl (the so-called "Thomas Report"). David Wilcove & Dennis Murphy, *The Spotted Owl Controversy and Conservation Biology*, 5 CONSERVATION BIOLOGY 261, 261 (1991) (Wilcove and Murphy were members of the Interagency Scientific Committee). Principles of conservation biology are incorporated in the WDCD guidelines for identifying fish and wildlife conservation habitat areas. *See supra* text accompanying notes 21-26. Federal courts have recognized the existence of conservation biology as a scientific discipline. *See, e.g.*, Northern Spotted Owl (Strix occidentalis caurina) v. Hodel, 716 F. Supp. 479 (W.D. Wash. 1988) (rejecting decision of U.S. Fish & Wildlife Service to not list the northern spotted owl under the Endangered Species Act because the Service disregarded expert opinion on population viability given by conservation biologists, and instead merely asserted its own expertise); *see also* Sierra Club v. Marita, 769 F. Supp. 287 (E.D. Wis. 1991) (rejecting plaintiff's motion to supplement the administrative record with expert testimony, on the ground that the voluminous written record set forth the principles of conservation biology sufficient to allow effective judicial review).

cles these days. Concepts and issues in conservation biology, endangered resources, and landscape ecology have overwhelmed more traditional concerns of public land managers, most of whom were caught unprepared. . . ."[83]

Even though the theoretical and experimental bases of conservation biology are expanding rapidly, we can derive several central principles from this growing body of research that should guide policymakers and land managers who seek to protect biological diversity when identifying and managing critical areas and fish and wildlife habitat conservation areas under Washington's Growth Management Act:

- Preserve large natural "core areas" so that the ecosystems contained within them function normally and without human interference.
- Minimize further habitat fragmentation.
- Preserve a network of habitat fragments that contains all habitat types necessary for the species assemblages that are to use them and buffer them from outside forces.
- Use the habitat requirements necessary to protect viable populations of "key species" as the guide for selecting habitat fragments to protect.
- Preserve habitat fragments large enough to support viable populations of several species of plants and animals.
- Preserve habitat fragments that include rare or particularly valuable habitat types.
- Preserve existing connections among habitat fragments and between habitat fragments and large natural "core areas" and create new connections where necessary.
- Manage areas adjacent to habitat fragments and corridors to buffer them from outside forces.

These principles are discussed in the following sections.

83. Raymond Guries, *Of Bulldozers and Bunnies: Forest Biodiversity for the Common Man*, 6 CONSERVATION BIOLOGY 153, 153 (1992) (book review).

A. *Preserve Large Natural "Core Areas"*[84] *So That the Ecosystems Contained Within Them Function Normally and Without Human Interference*

In 1967, Robert MacArthur and Edward O. Wilson proposed the theory of island biogeography, which explains patterns of species diversity and abundance observed on oceanic islands as a function of island size and distance from the mainland.[85] As this theory was verified and extended by research over the next several years, it became clear that it applied not only to oceanic islands, but also to "habitat islands," remnants of natural or rare habitats surrounded by a "sea" of altered land uses.[86] Most wildlife refuges, parks, natural areas, and wilderness areas can be considered functionally to be islands, because the uses to which surrounding lands are dedicated often restrict their ability to support the species of plants and animals found within the protected habitats.[87] Building on the theory of island biogeography, scientists have clarified the manner and mechanisms of extinction in isolated patches of habitat[88] and have developed a system of guidelines for land

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84. By "large natural core areas," I refer generally to large tracts of unaltered habitat set aside in parks, wilderness areas, and other preserved areas, as explained in the following pages. "Natural area preserves," as the term is used in WASH. REV. CODE ch. 79.70 (1992), refers to much smaller areas of residual unaltered habitat, essentially what I describe in part II, *infra*.

85. *See* MACARTHUR & WILSON, *supra* note 78.

86. Michael E. Soulé, *Land Use Planning and Wildlife Maintenance: Guidelines for Conserving Wildlife in an Urban Landscape*, 57 JOURNAL OF THE AMERICAN PLANNING ASSOCIATION 313, 314 (1991). Conservation biologists refer to the developed or manipulated lands surrounding intact patches of habitat as a "matrix."

87. "Any patch of habitat isolated from similar habitat by different, relatively inhospitable terrain traversed only with difficulty by organisms of the habitat patch may be considered an island." Daniel S. Simberloff, *Equilibrium Theory of Island Biogeography and Ecology*, 5 ANNUAL REVIEW OF ECOLOGY AND SYSTEMATICS 161, 162 (1974).

88. Complex sets of interacting factors determine species composition and abundance in habitat patches; conversely, disruption of these factors or their interactions can result in the extinction of species from isolated habitat patches. A leading conservation biologist has assembled the following partial list of major factors that can control species composition and abundance:

use planners and policymakers.[89]

The central lesson of island biogeography theory for preserving wildlife is that individual reserves should be large.[90] When analyzed statistically, area alone accounts for most of the differences in species richness in habitat islands.[91] The size of the preserve produces three ecological responses: small preserves accelerate the extinction of the species;[92] small preserves tend to contain fewer habitat types than larger preserves;[93] and larger preserves support larger populations of

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Regional landscape structure:
Heterogeneity
Perimeter-area ratio
Connectivity
Fragmentation
Configuration
Juxtaposition
Patch size and patch size frequency distribution
Pattern of habitat layer distribution

Regional landscape function:
Disturbance processes (areal extent, frequency or return interval, rotation period, predictability, intensity, seasonality)
Nutrient recycling rates
Energy flow rates
Patch persistence and turnover rates
Rates of erosion, geomorphic, and hydrologic processes

Community or ecosystem structure:
Substrate and soil variables
Slope and aspect
Vegetation biomass and physiognomy
Foliage density and layering
Horizontal patchiness
Canopy openness and gap proportions
Abundance, density and distribution of key physical features (e.g., cliffs, outcrops, sinks) and structural elements (e.g., snags, down logs)
Water and resource availability
Snow cover

Community or ecosystem function:
Biomass and resource productivity
Herbivory, parasitism, and predation rates
Colonization and local extinction rates
Patch dynamics (fine scale disturbance processes)
Nutrient cycling rates
Human intrusion rates and intensities

Reed F. Noss, *Indicators for Monitoring Biodiversity: A Hierarchical Approach*, 4 CONSERVATION BIOLOGY 355, 359 (1990). Mathematical models incorporating these factors are much more complex and sophisticated than those originally developed by MACARTHUR & WILSON, *supra* note 78, but they better reflect the ways living organisms use habitats and more accurately identify those factors whose disruption is likely to cause species extinction. Fortunately, policymakers and land managers need not grasp the mathematics in order to apply the lessons of the models.

89. Soulé, *supra* note 86, at 314.

90. Fred L. Bunnell & Laurie L. Kremsater, *Sustaining Wildlife in Managed Forests*, 6 NW. ENVTL. J. 243, 260 (1990).

91. *Id.* (*citing* T.H. Hamilton et al., *The Environmental Control of Insular Variation in Bird Species Abundance*, 52 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, U.S.A. 132 (1964); C.A. Gavareski, *Relation of Park Size and Vegetation to Urban Bird Populations in Seattle, Washington*, 78 CONDOR 375 (1976)).

92. Bunnell & Kremsater, *supra* note 90, at 260. However, area alone may not accurately predict extinction rates for highly mobile species, such as birds. *See* Mike Brown & James J. Dinsmore, *Habitat Islands and the Equilibrium Theory of Island Biogeography: Testing Some Predictions*, 75 OECOLOGIA 426 (1988).

93. Denis A. Saunders et al., *Biological Consequences of Ecosystem Fragmentation: A Review*, 5 CONSERVATION BIOLOGY 18, 25 (1991).

each species.[94] While large preserves clearly are important for wildlife protection, they nevertheless may be inadequate to preserve all resident species.

Based solely on the area they encompass, Washington's three national parks[95] and several large wilderness areas[96] might be thought to protect sufficient habitat to preserve Washington's wildlife. Valuable as these parks and wilderness areas are for the protection of plant and animal species, however, they are inadequate to preserve all native species because they do not contain all natural systems necessary to preserve biological diversity. The national parks in Washington, like most national parks in the United States, were created to preserve natural landscapes possessing outstanding scenic or recreational values; any protection of biological diversity or ecosystem integrity occurred only coincidentally or as an afterthought.[97] Most congressionally designated wilderness areas protect high-elevation lands, including substantial areas covered by alpine vegetation and ice and snow, and excluding low-elevation forests that are critically important for a great many species of wildlife.[98] In fact, the great majority of low and mid-

94. Soulé, *supra* note 86, at 314.

95. Mount Rainier National Park, North Cascades National Park, and Olympic National Park.

96. All but one of the large wilderness areas in Washington are in the Cascades, most of them north of Snoqualmie Pass. Adjoining North Cascades National Park are Mount Baker Wilderness, Pasayten Wilderness, Lake Chelan-Sawtooth Wilderness, and the Glacier Peak-Henry M. Jackson Wilderness complex; adjoining Mount Rainier National Park are Norse Peak Wilderness, and the William O. Douglas-Goat Rocks Wilderness complex; Alpine Lakes Wilderness is isolated from the other preserves. The only other large preserve is Wenaha Tucannon Wilderness in southeastern Washington and northeastern Oregon.

97. For example, the original boundaries of Mount Rainier National Park were drawn to preserve only the minimum area necessary to protect the spectacular scenic vistas of the mountain; lands that were potentially economically viable were specifically excluded. "Mount Rainier National Park itself can be interpreted as an example of scenic preservation designed to the specifications of big business and frontier individualism, not the needs of the environment." ALFRED RUNTE, NATIONAL PARKS: THE AMERICAN EXPERIENCE 66-67 (2d ed. 1987). In the Pacific Northwest, the timber industry has traditionally fought to exclude forest lands from national parks; their opposition delayed the establishment of Olympic National Park for almost 50 years, from the first proposal for a park in 1890 until designation in June 1938, and they successfully excluded large tracts of low- and mid-elevation forest land from the park. *See* CARSTEN LIEN, OLYMPIC BATTLEGROUND: THE POWER POLITICS OF TIMBER PRESERVATION (1991).

98. At least 667 species of plants and animals are associated with low-elevation old-growth forests. THOMAS ET AL., *supra* note 74, at 19. Seventy-seven animal species use these forests as their primary breeding habitat and 65 other animal species use them as their primary feeding habitat. Thomas A. Spies & Jerry F. Franklin, *Old*

elevation forests are primarily used for resource extraction (especially timber harvesting) with most of the rest having been converted to commercial, residential, or agricultural use.[99] Consequently, within the remaining forest patchwork in the Pacific Northwest, species with large home range requirements are beginning to disappear from regions where natural habitats are highly fragmented.[100]

The northern spotted owl[101] and marbled murret[102] may be the best known and most controversial of Washington's endangered and threatened species, but they are not the only casualties of human decisions regarding land and natural resources. The Washington Department of Wildlife (WDW) currently lists twenty-nine species of animals as threatened or endangered.[103] The Washington Department of Natural Resources (DNR) lists two hundred forty-two plant species,[104] two hundred fifty-seven terrestrial ecosystem types,[105] and one hundred eighteen aquatic and wetland ecosystem types[106] as priorities for protection. Of the three large mammalian carnivores native to Washington—the grizzly bear,[107] gray wolf,[108]

Growth Dynamics in the Douglas-Fir Region of Western Oregon and Washington, 8 NATURAL AREAS JOURNAL 190, 194 (1988) (*citing* E.R. BROWN ED., PACIFIC NW. REGION, U.S. FOREST SERVICE, MANAGEMENT OF WILDLIFE AND FISH HABITATS IN THE FORESTS OF WESTERN OREGON AND WASHINGTON (1985) (two parts)). For a general discussion of the importance of low-elevation forests for wildlife in the Pacific Northwest, *see* HARRIS, *supra* note 74, at 44-68.

99. *See generally* NORSE, *supra* note 10, at 27-32.

100. Bunnell & Kremsater, *supra* note 90, at 261. For example, it appears that forests currently protected in designated wilderness areas are unable to support self-sustaining populations of northern spotted owls. Jonathon Bart & Eric D. Forsman, *Dependence of Northern Spotted Owls Strix occidentalis caurina on Old-Growth Forests in the Western USA*, 62 BIOLOGICAL CONSERVATION 95, 99 (1992).

101. *Strix occidentalis caurina.*

102. *Brachyramphus marmoratus marmoratus.*

103. WASH. ADMIN. CODE §§ 232-11-011, -014 (1990). Additionally, eleven species that occur in Washington were added to the proposed federal Candidate 2 species list in 1991. WASHINGTON DEPARTMENT OF WILDLIFE, 1991 ENDANGERED & THREATENED STATUS REPORT 1 (1991). Three more species are currently candidate species for possible state listing. Wash. St. Reg. 91-23-110 (1991). Because the marbled murrelet has been federally listed as threatened, 57 Fed. Reg. 45328 (1992), it will likely also be listed by WDOW, pursuant to WASH. ADMIN. CODE § 232-12-297(section 3.2) (1990). Thus, at least 44 animal species are potentially at risk in Washington.

104. NATURAL HERITAGE PLAN, *supra* note 45, at 31-37; seventeen other plant species are considered "possible extinct or extirpated in Washington." *Id.* at 38.

105. *Id.* at 43-72.

106. *Id.* at 73-88.

107. *Ursus arctos horribilis.*

108. *Canis lupus.*

and mountain lion[109]—only the mountain lion currently has a viable population in Washington.[110] Several smaller carnivore species are also in apparent decline.[111]

Such declines are observed throughout the western United States. It now appears that only the largest of national parks in western North America may be large enough to support all native mammals,[112] and even these largest parks probably are too small by themselves to preserve large carnivore species.[113] Similarly, almost all wilderness areas in the United States, outside of Alaska, have lost some of their large carnivore species.[114] Available evidence suggests that these carnivores are in

109. *Felis concolor.*

110. *See generally* KRUCKEBERG, *supra* note 2. Breeding wolves were discovered in Washington in 1990 for the first time in almost a century, having migrated from Canada into the North Cascades. WASHINGTON DEPARTMENT OF WILDLIFE, 1991 ENDANGERED & THREATENED STATUS REPORT 5-6 (1991). Two small resident populations of grizzlies are found in Washington, *id.* at 6, but both populations are apparently dependent on migration from larger populations in Canada for continued survival. *See* MITCH FRIEDMAN ED., FOREVER WILD: CONSERVING THE GREATER NORTH CASCADES ECOSYSTEM (1988).

111. *E.g.*, Canada lynx (*Lynx canadensis*), marten (*Martes americana*), fisher (*Martes pennanti*), and wolverine (*Gulo luscus*). *See generally* FRIEDMAN, *supra* note 110.

112. One study found that 55% of U.S. national parks provide inadequate near-term protection for most native vertebrates and some long-lived native plant species and concluded that even in the largest parks the prospect is dim for large, slowly reproducing and highly specialized species including large carnivores and many of the ungulates (large hoofed mammals, such as elk, deer, wild sheep and goats, and bison). Christine M. Schonewald-Cox, *Conclusions: Guidelines to Management: A Beginning Attempt*, *in* GENETICS AND CONSERVATION: A REFERENCE FOR MANAGING WILD PLANT AND ANIMAL POPULATIONS 414-45 (Christine M. Schonewald-Cox et al. eds., 1983).

113. No national park in the contiguous United States is large enough to preserve minimum viable populations of wide-ranging mammals. *See* William D. Newmark, *A Land-Bridge Perspective on Mammalian Extinctions in Western North American Parks*, 329 NATURE 430 (1987). For example, the remnant grizzly bear population of Yellowstone National Park requires over twice the area provided by the park to remain viable. *See generally* FRANK C. CRAIGHEAD, TRACK OF THE GRIZZLY (1979). The distance to other known occupied grizzly bear habitat in northwest Montana is approximately 240 km, and no migration between this habitat and the Yellowstone grizzly population has been documented in 31 years of research. David J. Mattson & Matthew M. Reid, *Conservation of the Yellowstone Grizzly Bear*, 5 CONSERVATION BIOLOGY 364, 367 (1991). Because of inadequate habitat area preserved within the park, habitat fragmentation outside the park, and isolation, long-term prospects for the Yellowstone grizzly bear population are poor under current conditions. *Id.* at 369. The situation is only slightly different for other large mammals in Yellowstone. For example, five of the seven ungulate species native to Yellowstone Park migrate regularly to low elevation habitats outside the park boundaries. Joel Berger, *Greater Yellowstone's Native Ungulates: Myths and Realities*, 5 CONSERVATION BIOLOGY 353, 354 (1991). As habitat fragmentation outside the park continues, and as hunting pressures increase, these ungulate populations also may be put at risk.

114. Bunnell & Kremsater, *supra* note 90, at 261. In a study of ten of the largest

jeopardy in part because extensive tracts of undisturbed habitat have been reduced in size and are increasingly isolated.[115]

From an ecological perspective, the best way to protect Washington's biological diversity is to set aside extensive contiguous tracts of low elevation habitat, because such tracts are important for large numbers of species and are most likely to be converted to commercial or residential use in the next few decades. Unfortunately, apart from the few isolated areas preserved in national parks and wilderness areas, very little intact low elevation habitat remains, and that which does remain is already heavily fragmented.[116] There are no large expanses of unaltered low-elevation habitat left to preserve.[117] However,

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undeveloped areas of Western North America, only the largest area was able to support sufficiently large populations of seven carnivore species into the foreseeable future. Hal Salwasser et al., *The Role of Interagency Cooperation in Managing for Viable Populations*, *in* VIABLE POPULATIONS FOR CONSERVATION, 159-73 (Michael E. Soulé ed., 1987). Even this study probably understated the seriousness of the problem, however, because it failed to consider current or future habitat fragmentation, including roading and logging already planned by the U.S. Forest Service. R. Edward Grumbine, *Viable Populations, Reserve Size, and Federal Lands Management: A Critique*, 4 CONSERVATION BIOLOGY 127, 129 (1990).

115. *See* David S. Wilcove et al., *Habitat Fragmentation in the Temperate Zone*, in CONSERVATION BIOLOGY: THE SCIENCE OF SCARCITY AND DIVERSITY 237-56 (Michael E. Soulé ed., 1986); David S. Wilcove & Robert M. May, *National Park Boundaries and Ecological Realities*, 324 NATURE 206 (1986). Presently, the primary threat to these mammals is habitat loss and fragmentation; however, even before they were threatened by dwindling habitat, their numbers were decimated by concerted hunting for furs, sport, and predator control. To the extent that hunting pressures continue, they exacerbate the effects of habitat loss and fragmentation. *See generally* PAUL EHRLICH & ANNE EHRLICH, EXTINCTION: THE CAUSES AND CONSEQUENCES OF THE DISAPPEARANCE OF SPECIES (1981).

116. In western Washington, most fragmentation of forested ecosystems has occurred in only a few decades. For example, as late as 1940, 87% of old-growth forests in Olympic National Forest were found in blocks exceeding 10,000 acres and the largest contiguous block was nearly 165,000 acres. By 1988, the largest contiguous block was 11,200 acres, and 60% of all remaining old-growth was in patches less than 100 acres in size. MORRISON, *supra* note 7, at 14-16. While trees have been replanted to replace the original forests, these young managed stands are simply not ecologically equivalent to the old-growth forests they replaced. *See, e.g.*, Spies & Franklin, *supra* note 98. Large contiguous blocks of unaltered habitat are not found outside of protected areas, and most of what is protected is not representative of the vegetation types originally present at lower elevations.

117. "Unaltered" habitat suggests that all of the critical ecosystem components are present and structured in such a way that processes function within normal limits. A further implication is that the component populations and functions will be maintained over the long term. This usage differs little from the ideal of "ecological integrity," which is common in the parlance of ecologists and conservation biologists. Jay E. Anderson, *A Conceptual Framework for Evaluating and Quantifying Naturalness*, 5 CONSERVATION BIOLOGY 347, 348 (1991).

we may have enough remnants of habitat left, of enough different types, and dispersed over the landscape in such a way, that we have management options left. If we are to protect Washington's biological diversity, we must identify and protect important habitats at lower elevations in a way that preserves their value for wildlife, while recognizing that human alteration of the environment is likely to continue.

B. *Minimize Further Habitat Fragmentation*

The first and most immediately important objective in planning for wildlife under the GMA should be to eliminate or minimize any further fragmentation of habitat. In all cases, contiguous intact habitat is better than fragmented habitat.[118] Habitat fragmentation remains the principle threat to most species in the temperate zone,[119] because it strongly interferes with the survival of individual species and populations, reduces genetic diversity in populations that are confined to one or a few habitat remnants,[120] and causes species extinctions over and above those expected from simply reducing total area of habitat.[121] In the simplest analysis, habitat fragmentation causes extinction of a population or species when the remaining fragments are smaller than the minimum home range or territory of that species.[122] Under this analysis, members of the population or species are unable to obtain sufficient resources to survive over time. But species often disappear from fragments much larger than their minimum home range,[123] and the reasons for this disappearance are more complicated than simple resource shortages.

An unmanaged landscape is inherently patchy, consisting of a mosaic of different habitat types,[124] and many species require two or more of these habitat types for their survival.[125]

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118. Janice M. Lord & David A. Norton, *Scale and the Spatial Concept of Fragmentation*, 4 CONSERVATION BIOLOGY 197, 201 (1990).

119. Wilcove et al., *supra* note 115, at 240.

120. Michael E. Soulé, *Conservation: Tactics for a Constant Crisis*, 253 SCIENCE 744, 745 (1991). In general, fragmentation probably does not significantly damage ecosystem processes until it has progressed to a relatively high level. *Id.*

121. Wilcove et al., *supra* note 115, at 245.

122. *Id.* at 246.

123. *Id.* at 246-47.

124. *See generally* F.H. BORMANN & G.E. LIKENS, PATTERN AND PROCESS IN A FORESTED ECOSYSTEM (1979).

125. *See, e.g.*, James S. Karr & Kathryn E. Freemark, *Disturbance and Vertebrates: An Integrative Perspective*, *in* THE ECOLOGY OF NATURAL DISTURBANCE AND PATCH DYNAMICS 153, 166-67 (S.T.A. Pickett & P.S. White eds., 1985).

The ability of species to use this habitat mosaic is diminished in at least three significant ways by breaking the landscape into fragments of habitat. First, fragmentation almost inevitably results in the loss of some habitat types from the mosaic. Species dependent in whole or significant part on the lost habitat types cannot survive in that landscape.[126] Second, any given fragment lacks the full range of habitats found in the original unfragmented landscape. An organism in one habitat fragment that requires a type of habitat present only in another fragment must traverse the matrix[127] between the two fragments to fulfill its requirements. If the habitat islands are too distant from one another, or the probability of finding the necessary habitat type too low because of its rarity, or the ability of the organism to travel too limited, or if the matrix is particularly harsh or difficult, the organism is as likely to perish as if it were attempting to cross an expanse of open water between two oceanic islands. Third, as fragmentation increases, the matrix itself often contributes to the extinction of species remaining in the fragments, for example, by allowing feral predators (e.g., cats, dogs), introduced competitors (e.g., starlings,[128] house sparrows[129]), social parasites (e.g., brown-headed cowbirds[130]), or biological parasites (e.g., Port Orford root rot[131]) to enter the fragments.[132]

Ironically, some of this fragmentation has been encouraged by wildlife managers. Beginning in the 1930s, a standard game management principle has been to create habitats with as much "edge" as possible,[133] based on the observation that more species are found at the intersection of two

126. "Landscape" is not a precise term, especially when dealing with habitat requirements for living organisms. If the landscape in question is a particular watershed in the western Cascades, the species whose habitat has been eliminated from that watershed will disappear from that landscape. However, if the landscape in question includes the entire range of a species, that species will become extinct.

127. The "matrix" consists of the developed or manipulated lands surrounding intact habitat fragments. *See supra* note 86.

128. *Sturnus vulgaris*.

129. *Passer domesticus*.

130. *Molothrus ater*. *See infra* note 135.

131. *Phytophthora lateralis*.

132. Wilcove et al., *supra* note 115, at 248-49.

133. For management purposes, an "edge" is the boundary between two habitat types or between a natural habitat and a managed landscape. *See, e.g.*, Jim Yoakum et al., *Habitat Improvement Techniques*, *in* WILDLIFE MANAGEMENT TECHNIQUES MANUAL, 329-403 (Sanford D. Schemnitz ed., The Wildlife Society, 4th ed. 1980).

habitats than in either one alone.[134] However, as biologists have learned more about the distribution and abundance of plants and nongame wildlife, it is now clear that many characteristics of edges inhibit rather than assist the conservation of native species. For example, the incidence of nest predation and parasitism is much higher near edges than in forest interiors,[135] and these detrimental edge effects may extend six hundred meters into the forest[136], so that even sizeable patches may consist entirely of "edge." Even game species begin to decline in abundance as the high-quality protective cover and winter habitat provided by the primeval forest are lost.[137] More fundamentally, where use of this management technique destroys already rare habitat types, such as low elevation old-growth forests or forested wetlands, simply to create more edges between habitat types, the detrimental consequences to biological diversity caused by the loss of the rare habitats far outweigh any incremental gain from newly created edges.[138]

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134. Most evidence for beneficial effects of edges on wildlife has been circumstantial and biased by a focus on a relatively small number of game species. *See* Richard H. Yahner, *Changes in Wildlife Communities Near Edges*, 2 CONSERVATION BIOLOGY 333, 334 (1988).

135. The Brown-headed cowbird (*Molothrus ater*) is the only obligate nest parasite in North America. It does not nest, incubate or raise its own young, but lays its eggs in the nests of other avian species. Because the cowbird inhabits open areas and edges, many bird species have escaped its parasitism by nesting in the interior of large forest tracts. Where forest is fragmented so that birds are forced to nest near or along edges of tracts, nest parasitism causes the populations of breeding birds to decline. Larry D. Harris, *Edge Effects and Conservation of Biotic Diversity*, 2 CONSERVATION BIOLOGY 330, 331 (1988). Increased predation by animals that frequent edges (e.g., jays, crows, raccoons, house cats, rats, dogs, skunks, and opossums) also contributes significantly to declining populations of breeding birds. Soulé, *supra* note 86, at 320. *See also* Stanley A. Temple & John R. Cary, *Modeling Dynamics of Habitat-Interior Bird Populations in Fragmented Landscapes*, 2 CONSERVATION BIOLOGY 340 (1988); R.F. Whitcomb et al., *Effects of Forest Fragmentation on Avifauna of Eastern Deciduous Forest*, *in* FOREST ISLAND DYNAMICS IN MAN-DOMINATED LANDSCAPES 125 (R.L. Burgess & D.M. Sharp eds., 1981); David S. Wilcove, *Nest Predation in Forest Tracts and the Decline of Migratory Songbirds*, 66 ECOLOGY 1211 (1985).

136. Yahner, *supra* note 134, at 337.

137. *See* Paul B. Alaback, *A Comparison of Old-Growth and Second-Growth Forest Structure in the Western Hemlock-Sitka Spruce Forests of Southeast Alaska*, *in* FISH AND WILDLIFE RELATIONSHIPS IN OLD-GROWTH FORESTS 219 (W.R. Meehan et al. eds., American Institute of Fisheries Research Biologists 1984); J.W. Schoen et al., *Sitka Black-Tailed Deer/Old-Growth Forest Relationships in Southeast Alaska: Implications for Management*, *in* FISH AND WILDLIFE RELATIONSHIPS IN OLD-GROWTH FORESTS 315 (W.R. Meehan et al. eds., American Institute of Fisheries Research Biologists 1984); E.R. BROWN ED., PACIFIC NW. REGION, U.S. FOREST SERVICE, MANAGEMENT OF WILDLIFE AND FISH HABITATS IN THE FORESTS OF WESTERN OREGON AND WASHINGTON (1985) (in two parts).

138. Both empirical evidence and mathematical models indicate unambiguously

Habitat islands created by human activities often have abrupt edges; a sharp edge with contrasting conditions on opposite sides of the boundary can act as a barrier to the distribution and dispersal patterns of both birds and mammals.[139] As habitat fragmentation proceeds, the amount of edge increases and the amount of interior habitat decreases. In a forested landscape, fragmentation results in the decline of animals that nest, feed, or seek shelter in forests.[140] Marginal and poor-quality fragments are abandoned first. High-quality fragments retain many species so long as some nearby tract is large enough and near enough to produce a surplus of immigrants, but as fragmentation continues, even high-quality fragments become too isolated or too small to support animal populations.[141]

C. *Preserve a Network of Habitat Fragments That Contains All Habitat Types Necessary for the Species That Are to Use Them and Buffer the Fragments from Outside Forces*

The habitat remnants left in a fragmented landscape are analogous to islands in an ocean.[142] Just as archipelagos of oceanic islands support more species than isolated islands covering the same acreage, habitat fragments in proximity to one another and connected by travel corridors support more species than isolated habitat fragments.[143] An archipelago of habitat islands that include rare or critically valuable habitat types supports more species than a similar group of habitat islands lacking rare or valuable habitat types.[144] An archipel-

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that fragmentation of rare habitat types should be stopped or minimized lest a rapid loss of species occurs. Wilcove et al., *supra* note 115, at 246.

139. Yahner, *supra* note 134, at 336.

140. Franklin & Forman, *supra* note 8, at 13.

141. *Id.* at 12; Temple & Cary, *supra* note 135, at 346.

142. *See supra* text accompanying notes 86-87. However, it is critically important to recognize that habitat remnants have been produced by fragmentation and disruption of a formerly intact landscape, so that their ecological integrity has been compromised, perhaps severely. Because populations of species remaining in these habitat remnants are typically small, they are particularly sensitive to both extrinsic human-induced disturbance and to natural disturbances. Paul R. Ehrlich & Dennis D. Murphy, *Monitoring Populations on Remnants of Native Vegetation*, *in* NATURE CONSERVATION: THE ROLE OF REMNANTS OF NATIVE VEGETATION 201, 206 (Denis A. Saunders et al. eds., 1987).

143. *See, e.g.*, Daniel Simberloff, *The Contribution of Population and Community Biology to Conservation Science*, 19 ANNUAL REVIEW OF ECOLOGY AND SYSTEMATICS 473, 477 (1988).

144. *See, e.g.*, F. William Burley, *Monitoring Biological Diversity for Setting*

ago of habitat islands with diverse, high-quality habitat supports more species than a similar group of habitat islands with monotonous or diverse but low-quality habitat.[145] Habitat remnants that lie close enough to large natural areas for species to disperse from the natural areas to the habitat remnants support more species than similar but more distant habitat remnants.[146]

This "archipelago effect" occurs because most species exist not as a single population restricted indefinitely to a single location, but rather as a "metapopulation": a group of interacting local populations that are linked by dispersing individuals.[147] While each local population might be subject to extirpation by natural disturbance or unpredicatable events,[148] the dispersing individuals act to reestablish the species where the habitat remains suitable.[149] This spatial structure also maintains genetic diversity within a species, which increases its

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Priorities in Conservation, *in* BIODIVERSITY 227-30 (E.O. Wilson ed., 1988). The first comprehensive description of habitat types in Washington was JERRY F. FRANKLIN & CHARLES T. DYRNESS, UNITED STATES FOREST SERVICE GENERAL TECHNICAL REPORT PNW-8, NATURAL VEGETATION OF OREGON AND WASHINGTON (1973). Washington's Natural Heritage Plan has produced an updated list of habitat types, which it refers to as "ecosystem elements." *See* NATURAL HERITAGE PLAN, *supra* note 45.

145. *See generally* HARRIS, *supra* note 74. The terms used to describe habitat quality are relative, not absolute, terms. "High quality" habitat is capable of providing all or substantially all the amenities normally obtained from that habitat type by those species that depend on it for those amenities. "Low quality" habitat provides some lesser portion of these amenities; consequently, low quality habitat supports fewer individuals or fewer species, or allows them to remain in the habitat for a shorter period of time.

146. Saunders et al., *supra* note 93, at 23.

147. Michael E. Gilpin, *Spatial Structure and Population Vulnerability*, *in* VIABLE POPULATIONS FOR CONSERVATION 125-39 (Michael E. Soulé ed., 1987). A local population may occupy only a few square feet, as is the case with several rare plant species, or hundreds of square miles, as with large carnivores. Thus, the adjective "local" implies a small scale only with respect to the larger metapopulation.

148. Ecologists often refer to unpredictable events as "stochastic" events. Stochasticity denotes probability over a given length of time and covering a given spatial area. For example, it is impossible to predict when a particular tree or grove of trees will be toppled by wind or consumed by fire. But in many forests it is possible to predict with high certainty that fire or windthrow will occur with a certain frequency and extent throughout the forest. *See, e.g.*, James R. Runkle, *Disturbance Regimes in Temperate Forests*, *in* THE ECOLOGY OF NATURAL DISTURBANCE AND PATCH DYNAMICS 17 (S.T.A. Pickett & P.S. White eds., 1985). The role of stochasticity in causing extinction is explained in Michael E. Gilpin & Michael E. Soulé, *Minimum Viable Populations: Processes of Species Extinctions*, *in* CONSERVATION BIOLOGY: THE SCIENCE OF SCARCITY AND DIVERSITY 19, 24-33 (Michael E. Soulé ed., 1986).

149. Daniel J. Rohlf, *Six Biological Reasons Why the Endangered Species Act Doesn't Work—And What to Do About It*, 5 CONSERVATION BIOLOGY 273, 277 (1991).

ability to adapt to changing environmental conditions.[150] Consequently, the classic species conservation strategy of protecting the best individual local populations while ignoring others will not necessarily preserve a species.[151] Viewed at the level of the landscape or metapopulation, populations shift spatially through time, often quite rapidly, which means that isolated small preserves probably will not protect species.[152] Further, habitats also shift spatially through time;[153] in this dynamic natural regime, a metapopulation depends on the availability of unoccupied habitats in which new local populations can become established; thus, any preserve system that protects only existing local populations while ignoring suitable but unoccupied habitats may nevertheless allow the metapopulation to become extinct.[154]

Utilizing these principles, planners and wildlife managers can designate and preserve an effective network of habitat fragments that will most effectively protect wildlife in a landscape managed largely for other uses. To create such a network in western Washingon, highest priority should be given to preserving three types of habitat remnants: those habitat remnants large enough to support viable populations of several species of plants and animals, those remnants that include rare or particularly valuable habitat types, and those remnants whose importance for wildlife is enhanced by their position in the ecological landscape. The object is to establish a network of protected habitat fragments representing all critical habitat types, connected to one another and to large natural core areas both by proximity and by wildlife travel corridors. Such a network would go far towards mitigating the escalating detrimental effects of habitat fragmentation on wildlife populations. The following subsections suggest specific strategies to be used in preserving or creating an effective network of habitat fragments.

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150. Gilpin, *supra* note 147.

151. Eric S. Menges, *Population Viability Analysis for an Endangered Plant*, 4 CONSERVATION BIOLOGY 52, 58 (1990).

152. *Id.*; *see* Reed F. Noss & Larry D. Harris, *Nodes, Networks, and MUM's: Preserving Diversity at All Scales*, 10 ENVIRONMENTAL MANAGEMENT 299 (1986); S.T.A. Pickett & J.N. Thompson, *Patch Dynamics and the Design of Nature Reserves*, 13 BIOLOGICAL CONSERVATION 27 (1978).

153. *See* BORMANN & LIKENS, *supra* note 124.

154. Menges, *supra* note 151, at 58.

1. Use the Habitat Requirements Necessary to Protect Viable Populations of "Key Species" as the Guide for Selecting Habitat Fragments to Protect

Given the limited financial resources available for habitat preservation and management, it is not possible to plan habitat protection measures for every species potentially at risk.[155] Instead, wildlife managers should select certain "indicator species" whose protection also protects other species and the ecosystem processes that support them.[156] An indicator species is one whose characteristics (e.g., presence or absence, population density, dispersion, or reproductive success) are used as an index for attributes too difficult, inconvenient, or expensive to measure for other species or environmental conditions.[157] Indicator species have been widely used by the U.S. Fish and Wildlife Service and the U.S. Forest Service to document the quality and quantity of available habitat for selected species of wildlife.[158] If selected according to ecologically appropriate criteria,[159] indicator species may be a valuable tool both for determining which habitat types in a landscape should receive highest priority for protection and for assessing whether the extent, pattern, and quality of habitat preserved is meeting the needs of wildlife. Five types of indicator species are particularly valuable in this regard.

Sensitive species, like the proverbial canary in the mine,

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155. *See, e.g.*, Michel E. Gilpin, *Theory v. Practice*, 2 TRENDS IN ECOLOGY AND EVOLUTION 169, 169 (1987).

156. As early as 1898, Charles Merriam of the U.S. Department of Agriculture proposed using vertebrates as indicators for temperature or life zones. *See* Peter B. Landres et al., *Ecological Uses of Vertebrate Indicator Species: A Critique*, 2 CONSERVATION BIOLOGY 316, 317 (1988).

157. *Id.* In Washington, the best known indicator species is the northern spotted owl. *See* SPOTTED OWL PLAN, *supra* note 6.

158. *See, e.g.*, Division of Ecological Services, United States Fish & Wildlife Service, Ecological Services Manual No. 102, Habitat Evaluation Procedures (HEP) 1-1 (1980); 36 C.F.R. § 219.19 (1992). The use of indicator species has been criticized where agencies have uncritically relied on species chosen for socioeconomic or political reasons or other arbitrary criteria unrelated to the habitat trends they are to represent. For example, game species, such as elk, are not appropriate ecological indicators because their population abundance and distribution are affected by hunters and by direct population control actions to meet particular socioeconomic or political objectives; consequently, the abundance and distribution of game species probably indicate little beyond their own numbers. Landres et al., *supra* note 156, at 322. The use of an indicator species to predict the population trends of other species is suspect, as well, because each species responds to a different set of habitat factors and interacts uniquely with other species. SPOTTED OWL PLAN, *supra* note 6, at 336 app.

159. Landres, et al., *supra* note 156, at 322-23.

are sensitive to the habitat attributes of concern to managers and can provide an early indication of habitat loss or decline.[160] For a sensitive species to be an effective indicator, the population attributes being measured must be causally related to the habitat attributes being represented and should show little variability independent of those habitat attributes, as determined by the biological data available for that species.[161] For example, amphibians are probably the most sensitive vertebrate biological indicators of environmental damage in both aquatic and terrestrial ecosystems in the Pacific Northwest; a decline in amphibian populations, such as we are now witnessing, should be understood as a warning signal that ecosystem processes are at risk.[162]

Umbrella species are those whose protection also confers protection on other species by preserving valuable habitat. Umbrella species usually are large animals or high trophic-level predators[163] and are seldom found in small habitat fragments.[164] Because the protection of other species is seredipitous, an umbrella species need not be ecologically connected to other species in order to protect them. The absence of this connection means that umbrella species cannot be used reliably to indicate the population dynamics of the other species

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160. This approach is mandated by Forest Service regulations. *See* 36 C.F.R. § 219.19 (1992). Managers are to identify and select "management indicator species [whose] population changes are believed to indicate the effects of management activities," including "species with special habitat needs that may be influenced significantly by planned management programs" and species whose population changes "are believed to indicate the effects of management activities on other species of selected major biological communities or on water quality." *Id.* § 219.19(a)(1).

161. *See* Landres et al., *supra* note 156, at 322.

162. Susan C. Walls et al., *Amphibian Biodiversity of the Pacific Northwest with Special Reference to Old-Growth Stands*, 8 NORTHWEST ENVIRONMENTAL JOURNAL 53, 54 (1992).

163. *See* Rolf O. Peterson, *The Pit or the Pendulum: Issues in Large Carnivore Management in Natural Ecosystems*, *in* ECOSYSTEM MANAGEMENT FOR PARKS AND WILDERNESS 105, 112 (James K. Agee & Darryll R. Johnson eds., 1988). "Trophic level" refers to the feeding position in a food chain. Animals that feed on plants (herbivores) are low in a food chain and are said to be at a low trophic level. In contrast, high trophic-level predators feed on herbivores or on other carnivores. It is a fundamental ecological pattern that high trophic-level predators tend to be rare and wide-ranging. *See generally* PAUL COLINVAUX, WHY BIG FIERCE ANIMALS ARE RARE (1985).

164. Ehrlich & Murphy, *supra* note 142, at 202. Population dynamics of martens (*Martes americana*) and fishers (*Martes pennanti*), for example, are particularly valuable in assessing the health of old-growth forests because they are narrowly specialized for old-growth habitat types, have large spatial requirements, and are long-lived. Steven W. Buskirk, *Conserving Circumboreal Forests for Martens and Fishers*, 6 CONSERVATION BIOLOGY 318, 319 (1992).

occupying those fragments.[165] Nevertheless, umbrella species are especially valuable in protecting many plants and small animals whose responses to habitat loss are more difficult to measure, including the thousands of microorganisms and invertebrates that are essential for the maintenance of ecosystem functioning.[166]

Keystone species are those whose activities determine the distribution and abundance of other species in an ecosystem. Because they interact strongly with other species occupying a habitat type or collection of habitat types, their disappearance often leads to the decline or extinction of other species.[167] For example, large carnivores often determine the population size of their prey, and hence determine indirectly the ecological impacts of those prey species on the habitat. In addition, large carnivores such as mountain lions,[168] bobcats,[169] badgers,[170] wolves,[171] and coyotes[172] may enhance population abundances of birds by reducing the abundance of smaller predators who would otherwise reduce bird populations through nest predation.[173]

Some keystone species exert their influence in unexpected ways. For example, virtually all native tree species in the Pacific Northwest rely on mycorrhizal fungi for nutrient uptake. These fungi are dispersed throughout the forest by the northern flying squirrel,[174] who has adapted both behaviorally and physiologically to this role.[175] In a very real sense, the nutritional health of the forest depends on the activities of the northern flying squirrel. Habitat-modifying species, such as beaver[176] and moose,[177] who alter habitat by creating or main-

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165. Landres et al., *supra* note 156, at 321.

166. Perhaps 8,000 species of arthropods and well over 1,000 species of other invertebrates are found in the soil and plant litter of old-growth forests; these numbers represent some of the highest biological diversity found anywhere. These invertebrate species play a critical role in determining the structure and fertility of forest soils, yet their interactions are very poorly understood. *See* SPOTTED OWL PLAN, *supra* note 6, at 355 app.

167. Michale E. Soulé, *Theory and Strategy*, *in* LANDSCAPE LINKAGES AND BIODIVERSITY 91, 96-97 (Wendy E. Hudson ed., 1991).

168. *Felis concolor*.

169. *Lynx rufus*.

170. *Taxidea taxus*.

171. *Canis lupis*.

172. *Canis latrans*.

173. Soulé, *supra* note 86, at 320; *see also supra* note 135.

174. *Glaucomys sabrinus*.

175. CHRIS MASER, THE REDESIGNED FOREST 24-39 (1988).

176. *Castor canadensis*. The effects of beavers on their ecosystems is discussed in

taining ponds or wetlands, create and maintain a mosaic of habitats that facilitate the persistence of many other species of plants and animals.[178]

Linking species require multiple habitat types and move regularly among them. Consequently, they provide ecological links among habitat types, and their presence in a landscape suggests that a network of protected habitat fragments, perhaps together with a large natural core area nearby, contains the necessary habitat types to support these ecological links. For example, many large species, like elk and mule deer, travel yearly between summer and winter range.[179] Of special importance are migratory species, whose dependence on a particular habitat type is often exceedingly difficult to measure because of their simultaneous dependence on multiple, geographically remote habitats.[180]

Multiple population-level species. Where several species in a given area use habitat in similar ways, intensive monitoring may be directed at one of the species, whose population trends and patterns of habitat use may be assumed to represent the population trends and habitat use of the other species.[181] For example, the population trends of certain species of amphibians can be used to represent the population trends of many other species of amphibians.[182] However, because species coexist in a given habitat by dividing it up in ways that minimize competition,[183] a proposed multiple population-level species must be carefully verified to ensure that it indeed represents the other species claimed. Incorrectly assuming that other species are receiving protection as a result of that given to an indicator species can result in the loss of those other

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Robert J. Naiman et al., *Ecosystem Alteration of Boreal Forest Streams by Beaver (Castor canadensis)*, 67 ECOLOGY 1254 (1986).

177. *Alces alces.*

178. Soulé, *supra* note 86, at 320.

179. KRUCKEBERG, *supra* note 2, at 202; Berger, *supra* note 113, at 354-55.

180. Of the 215 bird species that build nests in the United States but migrate to Mexico, Central America, or South America each winter, 57 species are considered at grave risk of extinction because of deforestation in winter or summer habitat or both. Chris Wille, *Mystery of the Missing Migrants*, 92 AUDUBON 80, 82-83 (May 1991). *See also* JOHN W. TERBORGH, WHERE HAVE ALL THE BIRDS GONE? (1989); James F. Lynch, *Responses of Breeding Bird Communities to Forest Fragmentation*, *in* NATURE CONSERVATION: THE ROLE OF REMNANTS OF NATIVE VEGETATION 123 (Denis A. Saunders et al. eds., 1987).

181. Noss, *supra* note 88, at 361.

182. *See* Walls et al., *supra* note 162, at 56-66.

183. *See generally* ERIC R. PIANKA, EVOLUTIONARY ECOLOGY 239-66 (4th ed. 1988).

species.[184]

Despite the obvious usefulness of indicator species in assigning priorities to conservation efforts, it is critically important that policymakers and natural resource managers maintain their focus on ecosystem protection. Ecological interactions are exceedingly complex and they vary across both time and space. Because intensive study of ecological interactions is technically difficult, relatively few interactions have been described in sufficient detail to support precise, specific recommendations for management.[185] For the vast majority of species in the Pacific Northwest, the only feasible and scientifically defensible approach to successful conservation of biological diversity is to protect the habitats on which species depend.

2. Preserve Habitat Fragments Large Enough to Support Viable Populations of Several Species of Plants and Animals

In designing wildlife refuges, the undisputed first rule is that a large refuge is better than a small one, all other things being equal.[186] The centrality of this rule is illustrated by the importance of preserving large natural areas to maintain regional biological diversity, together with the increasingly well-documented consequences of failing to preserve large natural areas.[187] The same principles discussed in the context of large natural core areas apply to habitat remnants identified for preservation as wildlife refuges.

The largest possible habitat remnants should be identified and preserved because they are most likely to provide habitat for a large assemblage of species. Because no one knows the minimum critical size an ecosystem needs to preserve its characteristic species diversity and species composition,[188] it is prudent to protect as many large fragments as possible to preserve future options. Where a large habitat fragment already supports a diverse species assemblage of at-risk species, their presence may be taken as an indication of that fragment's

184. See R.J. Baker & Christine M. Schonewald-Cox, *Management Strategies for Improving Population Viability*, *in* THE MANAGEMENT OF VIABLE POPULATIONS: THEORY, APPLICATIONS AND CASE STUDIES 73-87 (Bruce A. Wilcox et al. eds., 1986).

185. *See* L. Scott Mills et al., *The Keystone-Species Concept in Ecology and Conservation*, 43 BIOSCIENCE 219, 222-223 (1993).

186. Simberloff, *supra* note 143, at 476.

187. *See supra* text accompanying notes 90-115.

188. Saunders et al., *supra* note 93, at 24-25.

importance for those species.[189] Large fragments often will be the only refuge for species that exist at low densities or who are specialists.[190] The area necessary to support viable populations of all species in a given habitat remnant or collection of remnants depends on the habitat needs of the species using those habitat remnants,[191] on the habitat type contained within the remnants,[192] and on the particular land uses present in the matrix in which the remnants are found.[193]

Many specialist species require stable or predictable habitat types found only in unaltered habitat islands. Because the interiors of habitat islands are most valuable for these species, the ecologically significant characteristics of those habitat islands must be protected. Even a small clearcut in a fairly sizeable remnant of old-growth forest substantially increases the vulnerability of species dependent on that old-growth habitat.[194]

3. Preserve Habitat Fragments That Include Rare or Particularly Valuable Habitat Types

Even where a given habitat fragment cannot support viable populations by itself, it may be critical for certain species because it includes rare or particularly valuable habitat that, together with other remnants and large preserves, can support

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189. This observation should not diminish the importance of preserving suitable but unoccupied habitat for the persistence of metapopulations. *See supra* text accompanying notes 147-154.

190. Wilcove et al., *supra* note 115, at 253.

191. Habitat requirements are relatively well-established, although not hard and fast predictive rules. For example, large or wide-ranging mammals typically require more habitat than small or sedentary mammals. HARRIS, *supra* note 74, at 85-86. Carnivores typically require more habitat than herbivores. *Id.* at 79. Specialists usually require more habitat than generalists, because their special requirements may occur only infrequently in any ecosystem so that they require a large extent of habitat in order to obtain their special requirements. Wilcove et al., *supra* note 115, at 253. For plants, habitat size per se is not as important as the presence of appropriate environmental conditions, although for many species these environmental conditions may be found only in a sufficiently large habitat fragment. SMITH, *supra* note 63, at 290-91.

192. For example, animals using poor quality habitat generally require more habitat than animals using good quality habitat. *See supra* text accompanying note 145.

193. In general, the greater the difference in habitat structure between a habitat island and the surrounding matrix, the larger the habitat island must be to preserve its critical biological characteristics. Larry D. Harris et. al., *Patterns of Old Growth Harvest and Implications for Cascades Wildlife*, 47 TRANSACTIONS OF THE NORTH AMERICAN WILDLIFE NATURAL RESOURCES CONFERENCE 374 (1982).

194. Franklin & Forman, *supra* note 8, at 15.

viable populations of wildlife. To determine which habitat types are rare or particularly valuable, conservation biologists undertake "gap analysis," which proceeds in three steps: first, identify and classify all habitat elements of biological diversity in the region and determine which ones are distributional centers of species diversity; second, determine which habitat elements are unrepresented or poorly represented in the existing system of conservation areas; and finally, set priorities for the next round of conservation.[195] Washington DNR has already undertaken this process, identifying three hundred seventy-five habitat types as priorities for protection.[196] In western Washington, these priority habitats include estuaries, wetlands, riparian zones, and shorelines, all of which present special problems; they are especially important to wildlife but also particularly susceptible to impacts from adjacent land use. Polluted water flows downhill just as readily as unpolluted water, and sedimentation and erosion can damage or destroy the biologically significant characteristics that make these areas so valuable to wildlife.[197]

4. Preserve Habitat Fragments That Maintain and Increase the Connections Among Other Fragments and With Large Natural Areas

Simply designating a habitat fragment as a wildlife reserve

195. Burley, *supra* note 144, at 227-30; Edward Grumbine, *Protecting Biological Diversity Through the Greater Ecosystem Concept*, 10 NATURAL AREAS JOURNAL 114, 115 (1990); J. Michael Scott et al., *Gap Analysis: Assessing Protection Needs*, *in* LANDSCAPE LINKAGES AND BIODIVERSITY 15, 15-26 (Wendy E. Hudson ed., 1991).

196. *See supra* text accompanying notes 105-106. Criteria for inclusion in these priority lists included rarity (geographical extent and number of high-quality occurrences of the habitat type remaining), the rate of decline in habitat type, activities causing that decline, the ecological fragility of the habitat type, and the potential for protection. NATURAL HERITAGE PLAN, *supra* note 45, at 20-21. A similar approach is used by the Nature Conservancy for private acquisition of significant habitat types in Washington. *See* DAVID GEORGE GORDON, PRESERVING WASHINGTON'S WILDLANDS: A GUIDE TO THE NATURE CONSERVANCY'S PRESERVES IN WASHINGTON 11-15 (1993).

197. *See, e.g.*, Derek B. Booth, *Urbanization and the Natural Drainage System—Impacts, Solutions, and Progress*, 7 NORTHWEST ENVIRONMENTAL JOURNAL 93 (1991); Marc E. Boulé & Kenneth F. Bierly, *History of Estuarine Wetland Development and Alteration: What Have We Wrought?*, 3 NORTHWEST ENVIRONMENTAL JOURNAL 43 (1987); DAHL & JOHNSON, *supra* note 28; Alyn C. Duxbury, *The Physical Processes in Estuaries: An Introduction*, 3 NORTHWEST ENVIRONMENTAL JOURNAL 1 (1987); Gordon E. Grant & Fred Swanson, *Cumulative Effects of Forest Practices*, 1 FOREST PERSPECTIVES 9 (1991); Rohald M. Thom, *The Biological Importance of Pacific Northwest Estuaries*, 3 NORTHWEST ENVIRONMENTAL JOURNAL 21 (1987).

does not ensure the survival of the wildlife that use that fragment. Clearly, if a natural area or habitat fragment is not of sufficient size or quality to provide for the needs of individual organisms or a local population, then the animals must move outside the fragment:

> The notion must be rejected that habitat quality and utility can be assessed simply by evaluating characteristics and conditions within the habitat tract. Animals have needs to move and to maintain genetic continuity between small isolated subpopulations. If these needs to move throughout the landscape matrix are not considered along with the structural characteristics within the patch, the evaluation procedure will overestimate the quality or utility of the habitat.[198]

Habitat remnants should be connected with one another to allow movement among them. If remnants are not contiguous, they should be connected by habitat corridors that link them together. Natural corridors should be used wherever possible.[199] Riparian zones are particularly important corridors, used by a disproportionately large number of species.[200] The degree to which habitat is preserved within the corridors depends on the requirements of the species involved and the length of the corridor.[201] Mobile animals may be able to migrate with only minimal structural preservation of habitat in corridors (or sometimes even without corridors), while more sedentary or slow-moving animals may require a definitive corridor with its relevant habitat structure intact.[202]

For many species, habitat "stepping stones" may be necessary to provide resting places and shelter during movement from one refuge to another.[203] For these species, corridors connecting large preserves should be augmented with patches of habitat that are large enough to provide necessary food, shelter, and rest for individual organisms traveling along the corri-

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198. Larry D. Harris & Patrick Kangas, *Reconsideration of the Habitat Concept*, 53 TRANSACTIONS OF THE 53RD NORTH AMERICAN WILDLIFE AND RESOURCES CONFERENCE 137, 142 (1988).

199. Robert L. Harrison, *Toward a Theory of Inter-Refuge Corridor Design*, 6 CONSERVATION BIOLOGY 293, 293 (1992).

200. HARRIS, *supra* note 74, at 141-44. However, some deep forest species may not venture into more exposed riparian habitats. Michael E. Soulé & Daniel Simberloff, *What do Genetics and Ecology Tell Us About the Design of Nature Reserves?* 35 BIOLOGICAL CONSERVATION 19, 33-34 (1986).

201. Harrison, *supra* note 199, at 294.

202. *Id.*

203. HARRIS, *supra* note 74, at 157.

dor. Absent such stepping stones, these species will not successfully make the trip.

Where corridors and stepping stones do not remain in the landscape, they sometimes can be created through management techniques.[204] For example, riparian zones that have been damaged can be repaired relatively quickly because so many riparian plants regenerate rapidly. Second-growth stands of Douglas-fir can be manipulated to encourage the formation of habitat characteristics necessary to support corridors for old-growth dependent species. Isolated wetlands and ponds can serve as stepping stones where they are protected, together with some surrounding upland habitat, from external pressures.

5. Manage Areas Adjacent to Habitat Fragments and Corridors to Buffer Them From Outside Forces

The effective size of a habitat remnant and its ability to support wildlife is reduced unless it is buffered from outside forces.[205] For example, one study concluded that an island of old-growth Douglas-fir surrounded by clearcuts and regenerating stands had to be ten times as large as an old-growth island surrounded by a buffer zone of mature timber to provide comparable wildlife habitat.[206] Outside forces can adversely affect biologically important habitat characteristics, including energy balance, nutrient cycling, hydrological fluxes, temperature regimes, and exposure to wind.[207] The smaller a remnant is or the greater the difference in habitat structure between the remnant and the matrix, the greater the influence external forces are likely to exert and the more important it is to control those influences.[208] The effectiveness of dispersal corridors similarly may be reduced without buffering.[209] Buffers need not necessarily be preserved as parks or refuges, but they should be regulated so that activies within them impinge only minimally on the protected habitat remnant.[210]

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204. Lynch, *supra* note 180, at 138; Soulé, *supra* note 86, at 320.

205. Buffers with complex vegetational structure are especially important to protect habitat fragments in urban parks. *See, e.g.*, Carla Cicero, *Avian Community Structure in a Large Urban Park: Controls of Local Richness and Diversity*, 17 LANDSCAPE AND URBAN PLANNING 221, 237 (1989).

206. Harris et. al., *supra* note 193, at 374-92.

207. Saunders et al., *supra* note 93, at 20-22.

208. *Id.* at 24-26.

209. Harrison, *supra* note 199, at 294.

210. Soulé & Simberloff, *supra* note 200, at 23.

IV. CONCLUSION: A LANDSCAPE APPROACH TO WILDLIFE MANAGEMENT AND HABITAT PRESERVATION IN WASHINGTON

To be effective, wildlife reserves should be both large and numerous.[211] For those species most at risk, and for all mobile species generally, population viability "depends on favorable conditions in many different places and freedom for individuals to move among those places."[212] But, as we have seen, the large parks, wildlife refuges, and wilderness areas in the Pacific Northwest do not sustain enough seasonal habitat dispersed widely enough to supply the needs of all species.[213] The preservation of habitat fragments and connecting corridors discussed in the previous sections is a strategy for providing the habitat types necessary to meet those needs. Most impacts on habitat fragments originate in the matrix of altered habitat that surrounds and separates these habitat islands. To protect species diversity, viable populations, and ecosystem function, we must depart from the traditional notions of managing preserved areas without regard to the surrounding matrix and look instead toward integrated landscape management. A landscape approach to wildlife management and habitat protection "has important implications for land managers since it involves a radically new way of viewing management and requires that neighboring land uses, and hence neighboring landowners, interact in a positive way."[214]

Most of our parks, wilderness areas, and wildlife refuges are destined to become green islands surrounded by human activity of some kind.[215] Unfortunately, we are already past the point of being able to rely on these preserved natural areas to sustain Washington's wildlife. The GMA provides a framework in which habitat fragments critical to wildlife can be designated and protected. By requiring cities and counties to identify and protect wetlands and fish and wildlife conservation areas,[216] the GMA has provided a legal mechanism by which habitat islands and corridors can be protected.

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211. Bunnell & Kremsater, *supra* note 90, at 262. *See also* MICHAEL E. SOULÉ, VIABLE POPULATIONS FOR CONSERVATION (1987); Soulé & Simberloff, *supra* note 200, at 19.

212. Bunnell & Kremsater, *supra* note 90, at 260-61.

213. *See supra* text accompanying notes 95-111.

214. Saunders et al., *supra* note 93, at 26.

215. Bunnell & Kremsater, *supra* note 90, at 264.

216. *See* WASH. REV. CODE §§ 36.70A.020(9), .030(5), .060, .170 (1)(d) (1992).

The first step in implementing a landscape approach is to determine which habitat fragments must be preserved in order to provide enough habitat and habitat types for all native species in western Washington. This step may be accomplished by using the strategies outlined above and building on the system of natural areas and smaller preserves already established by federal and state land management agencies. This collection of habitat islands should include enough area to accommodate natural disturbance regimes over significant periods of time. Connections among habitat islands and between habitat islands and large natural core areas in the regional landscape should be identified and preserved or created as necessary. These islands and connections should be designated as critical areas under the GMA. They should be acquired by land management agencies where possible, and, where acquisition is not possible, through conservation easements, transferred development rights, or other innovative techniques.

The second step is to adjust the use of lands adjoining these preserves to buffer the habitat islands and corridors from outside forces. Because these adjustments in land use may involve regulation of private land, public participation must be solicited in the decision-making process. The benefits of conserving Washington's wildlife flow to all its citizens, who receive aesthetic and economic benefits, as well as ecosystem services.[217] However, most people do not realize how dependent they are on healthy, functioning ecosystems. Effective protection for habitat fragments cannot occur unless persons in local communities understand and accept the need for preserving biological diversity and are not asked to disproportionately shoulder the costs associated with that preservation. It is in this context that implementation of the GMA faces its strongest challenge. Enacting laws and promulgating regulations is no substitute for an educational program that is sensitive to human vital needs: "The future demands of ecologically responsible behavior and policies cannot be imposed by a moral dictatorship. It is dependent on the fostering of feelings that make vast numbers of rules unnecessary."[218]

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217. Ecosystem services are those amenities derived freely from normally functioning ecosystems, including such things as clean air with sufficient oxygen to breath, pure water, moderation of floods and storms, moderation of climate, etc. *See* Paul R. Ehrlich & Hal A. Mooney, *Extinction, Substitution, and Impairment of Ecosystem Services*, 33 BIOSCIENCE 248 (1983).

218. Grumbine, *supra* note 195, at 118.

Finally, effective monitoring of the success of indicator species in the preserve network allows managers and policy-makers to adjust for unexpected occurrences and miscalculations. Most or all of the habitat islands will probably require active management to overcome the ecological imbalance resulting from fragmentation or human activity.[219] Indeed, the battle to conserve species is only just begun when a system of preserves is established.

Traditional preserve management stops at the preserve boundary,[220] but ecological processes and impacts do not. The only way to preserve the long term ecological integrity of habitat remnants and preserves is to manage the surrounding matrix in a manner that minimizes the adverse effects of habitat loss and fragmentation and maximizes the long-term viability of native species requiring these fragments. The ultimate success of habitat preservation and management is assessed by whether the populations dependent on those habitats persist through time with sufficient size and genetic diversity to maintain viability.

The GMA is not self-implementing; it requires concerted work over an extended period of time, with inputs of technical information and public preferences. Still, the people of western Washington have a unique opportunity. We have magnificent national parks and other large natural areas that have been preserved, many of which include some low-elevation habitat. The great majority of our native species are still with us. Now that we have the legal tools to create a network of habitat preserves and natural areas that potentially can protect our native species of wildlife into the future, while allowing room for reasonable and measured growth of urban areas, all that remains is for us to find the will to do what must be done to secure our biological legacy.

219. Wilcove et al., *supra* note 115, at 256.

220. The results of traditional preserve management are evident to any person in an airplane passing over the boundary of Mount Rainier National Park, Olympic National Park, or any of many wilderness areas in Washington. A significant portion of the boundaries of these preserves is visible as a sharp edge between cut and uncut forest. For a striking aerial photograph of such a boundary, see Rowe Findley, *Will We Save Our Own?* 178 NATIONAL GEOGRAPHIC 106, 124-25 (1990).