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The Biodiversity Scorecard: Taking Stock of Washington's Natural Riches

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Material for this publication is drawn from the Biodiversity Assessment Framework: Draft Conceptual Model, Indicators and Metrics, a January 2010 report from Steven Walters and John Marzluff of the University of Washington's College of the Environment and School of Forest Resources. The original report was sponsored by the NOAA/National Marine Fisheries Service, the U.S. Fish and Wildlife Service, the Washington Department of Fish and Wildlife, and the Washington Department of Natural Resources. For the more technically oriented, this report is available at the Biodiversity's Council website, www.biodiversity.wa.gov

CREDITS

Editorial: Michael Kustudia, Sarah Gage

Design: Joanna Yardley

The Washington Biodiversity Council

The Washington Biodiversity Council was a public-private partnership chartered by executive order from 2004 through June 2010. Council members included private landowners, agency natural resource managers, tribal representatives, and members of the education, business, and environmental communities.

The Council was tasked by the Governor with crafting and guiding the Washington Biodiversity Conservation Strategy, a long-term vision and approach for conserving Washington's remarkable biological diversity for the benefit of all.

During its tenure, the Council:

- Defined conservation priorities through a mapping effort.
- Highlighted incentives for private landowners to protect biodiversity.
- Engaged citizen scientists and measured progress toward conservation goals.
- Assisted local governments with incorporating biodiversity stewardship practices into planning.
- Made scientific information available to decision makers and the public.
- Educated Washingtonians of all ages on the importance of biodiversity.
- Worked collaboratively with communities to enhance stewardship.

The important work of biodiversity conservation in Washington continues to be carried out by the Council's many partners.

The Biodiversity Scorecard: Taking Stock of Washington's Natural Wealth

Building the capacity to assess the condition of Washington's biodiversity.

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The Scorecard at a Glance

The Biodiversity Scorecard lays the groundwork for a comprehensive, science-based assessment of Washington's biodiversity and the human and biophysical resources that affect it.

While still under development, the scorecard will provide valuable information to decision makers and the public on the overall status of Washington's biodiversity. The scorecard holds promise to help identify and guide legislative, policy, and management priorities and objectives, as well as to help assess the effectiveness of actions to conserve biodiversity.

The Biodiversity Scorecard:

- Relies on state-of-the-science techniques employed around the world.
- Uses indicators that are selective enough to provide precision, but broad enough to draw key ecosystem relationships.
- Includes the effects of human actions and the benefits we derive from the natural world.
- Offers a snapshot in time and serves as a baseline to chart trends.
- Provides an overall index of the state's natural wealth.

Why Indicators?

Just how do you take stock of the ecological treasures that make up Washington's natural wealth?

It's been said that what gets measured, matters. Whether it's the stock exchange, baseball statistics or a grocery bill, people follow numbers. We keep a close accounting of important things, like our checkbooks. And so it is with our natural world. It's important to understand the state of biodiversity because its well-being is essential for ours. But just how do you measure Washington's natural wealth?

The Washington Biodiversity Council took up that question in the Biodiversity Scorecard. Just as a checkbook has a balance sheet of deposits and expenses, the Biodiversity Scorecard tracks nature's portfolio. In its 2007 Conservation Strategy, the Council identified the need for a scorecard that would track trends in the health of the state's natural heritage and assess the effectiveness of conservation efforts.

On behalf of the Biodiversity Council, researchers at the University of Washington drafted a measurement tool that will show the strengths and weaknesses of four key categories in our natural world over time. This ambitious framework can provide a current assessment and set a benchmark for future study.

Biodiversity: Nature's Wealth, Our Benefit

The natural world that human life depends on is so vast that it defies easy description. Scientists use the word biodiversity as shorthand for biological diversity, a term that encompasses every living thing on this planet. Consider biodiversity as science-speak for our planet's living wealth, that array of species and ecosystems that provides us with clean air to breath, clean water to drink, many of our medicines, healthy soils to grow food, fish to catch, and wild places and creatures to contemplate.

Washington's biodiversity is not only central to our region's ecological health, it's also an engine of the economy and a dominant feature in our quality of life. But biodiversity is declining here, as it is around the world.

What Are We Measuring?

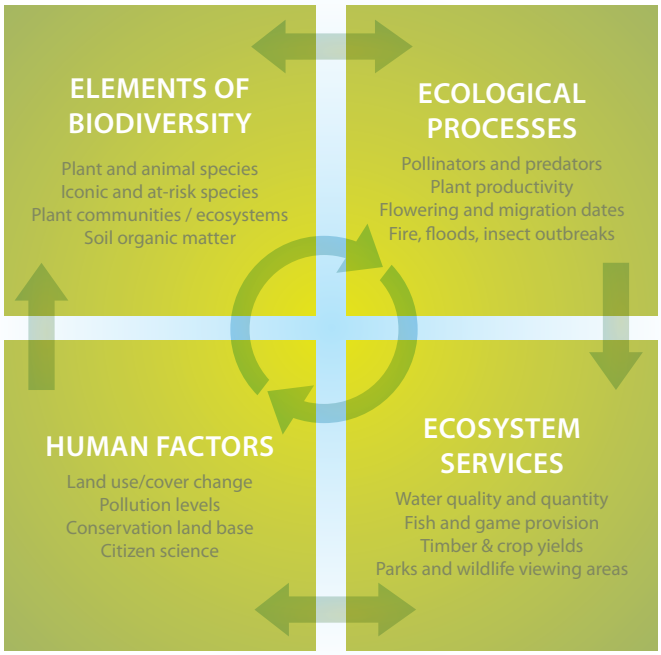
Few things are as complicated and difficult to describe as a living system. At the mention of biodiversity, some things come quickly to mind: numbers of species, or the variety of ecosystem types. By themselves, these living **elements** of the natural world can serve as rough indicators of biodiversity, using measures like acres of forest, or the number of animals on the state list of at-risk species.

But if we only measure the numbers of certain things, it would be like taking the heartbeat of a patient without examining the processes affecting that heartbeat, such as whether the patient has heart congestion or is a long-distance runner. Indicators are needed that assess the key natural **processes** that species and ecosystems depend on for existence—among them pollination, nutrients moving through a food web, and fire and flood occurrences.

Similarly, people affect the natural world in many ways. It's important that indicators look at the links between **human activities** and ecosystem health. These can encompass the uses people make of land, how many people participate in environmental education programs, and how well people control pollution levels.

Equally important, nature provides numerous benefits, the full value of which we are only now beginning to calculate. Human well-being depends on these natural benefits, often referred to as **ecosystem services**. These services range from the clean drinking water supplied by a watershed and the flood protection afforded by vegetation, to how many places we have to hike, camp, hunt, watch birds, or enjoy wildflowers. Indicators that illustrate these benefits will help create a greater sense of stewardship, heightening our awareness of the many ways that biodiversity matters and how we can play a role in its conservation.

These four facets of biodiversity—elements of the living world, ecological processes, human activities, and ecosystem services—provide the scorecard's field of focus. Taken together as a conceptual framework, they allow us to home in on the most important indicators to consider.



This graphic depicts the Scorecard's four interrelated indicator categories, with examples drawn from the set of 30 indicators, that will be used to help assess the status of Washington's biodiversity.

Indicator Categories

ELEMENTS OF BIODIVERSITY: THE PIECES THAT MAKE UP LIFE

These indicators include species, ecological communities, ecosystem components such as soils, nutrients, water, landscape patterns and other features that species depend on.

ECOLOGICAL PROCESSES: THE INTERACTIONS THAT SUPPORT LIFE

These indicators describe processes, such as pollination, nutrient cycles, and fire and flood occurrences, as well as other natural forces that either promote or hinder biological diversity.

HUMAN ACTIVITIES: HOW PEOPLE AFFECT BIODIVERSITY BOTH POSITIVELY AND NEGATIVELY

This indicator category looks at the full range of human activity, from the detrimental (such as habitat fragmentation or loss and pollutant levels) to the beneficial (such as conservation easements, state and national parks, environmental education and citizen science programs).

ECOSYSTEM SERVICES: THE ESSENTIAL BENEFITS WE DERIVE FROM BIODIVERSITY

These indicators look beyond the intrinsic ecological value of biodiversity to the essential services and amenities that we require, such as clean air and water, food and fiber, and the aesthetic enjoyment of wildlife and natural scenery.

Biodiversity Conservation: It's All Connected

The scorecard's four indicator categories are interrelated in myriad ways. Here are a couple of possible illustrations:

Bumble bees or other native insects (elements of biodiversity) pollinate (an ecological process) balsamroots and apple trees (more elements of biodiversity) that produce flowers and fruit (another ecological process) ultimately for human consumption and aesthetic enjoyment (ecosystem services). But people (human activities) can affect bees both positively, by stewarding habitat, and negatively, by using pesticides inappropriately.

Or imagine morel mushrooms in a Douglas fir and ponderosa pine forest following a controlled burn. There's a human activity (fire management) that affects elements of biodiversity (trees and morels) that promotes an ecological process (nutrient cycling) that yields an ecosystem service (tasty morels as a food source).

Central to the scorecard is the emphasis on connections among each of these components and, moreover, that we are measuring them in some way, whether it's bee populations, pollination rates, fruit production, pesticide use, or conservation efforts. The scorecard can bring together existing data in new ways to yield important insights about Washington's natural heritage.

Selecting the Scorecard Indicators

Initially the list of possible biodiversity indicators appeared almost infinite. In an important early step, the researchers interviewed potential users of the scorecard, experts in indicator methods, and members of the Biodiversity Council itself. These interviews provided useful guidance on indicators to include and insights on how the scorecard might be used. Another early step was to review the vast literature on environmental indicators.

To define the scope and narrow the possible approaches, the Council adopted a set of principles that describe the scorecard's objectives, inform the criteria for selecting indicators, and point to how the framework might best be assembled and maintained.

Principles underlying the scorecard:

- Use the best available and appropriate science.
- Select a sufficient number of indicators but no more than necessary.
- Conduct an objective assessment free of "grades" or rankings that could imply advocacy.
- Separate indicators from specific policy or regulatory definitions.
- Maintain and update indicators in a neutral forum, separate from policy- and decision-making.
- Allow for advances in technology and scientific understanding.
- Integrate citizen science both to collect valid, cost-effective data and to engage the public.

The researchers used these principles as well as additional guidelines from the literature to develop criteria for examining a potential indicator.

Indicator criteria:

- Is it quantifiable?
- Is it measurable and meaningful at different time scales (short term and long term) and different spatial scales (such as in a watershed, a county, or across the whole state)?
- Is it especially relevant to measuring status and trends in one of the four indicator categories?
- Does it contribute to the scorecard's comprehensiveness?
- Is it particularly sensitive to change so it could provide an early warning, like a canary in a coal mine?
- Does it describe something notable about nature's benefits to people (ecosystem services)?

"Choosing indicators is the art of measuring as little as possible with the highest possible policy significance. It is not only a scientific exercise but also a matter of art." - United Nations Environmental Programme

An extensive review resulted in an initial list of 136 potential indicators—an ungainly number. Subsequent expert technical review led to a final draft set of 30 indicators. While still a large number, it is on par with many similar efforts. And, rather than simply a laundry list, the chosen indicators are interrelated and most have existing metrics to quantify them.

By assigning numerical values to the indicators, they can be selected and tallied in various ways to yield insights about particular categories, or combined for a big picture assessment of biodiversity's current status.

With its breadth, the Biodiversity Scorecard was designed to comprehensively describe the myriad facets of biodiversity, but still be adaptable enough to inform a wide range of management, policy, and decision-making needs.

Citizen Science and the Biodiversity Scorecard

Citizen science—a term used for programs that partner volunteers with scientists to perform research—is integral to the design of the Biodiversity Scorecard. Citizen science programs already collect significant amounts of cost-effective data, such as the North American Breeding Bird Survey.

By expanding existing citizen science programs and developing new ones, we can sustainably fill data gaps and engage and educate new audiences about the importance of conserving biodiversity.

The Biodiversity Indicators

The following chart of 30 indicators comprises a streamlined set of relevant measures for describing biodiversity, the ecological and socioeconomic factors that affect it, and the ecosystem services that it provides.

Interested in more details? Read the report at www.biodiversity.wa.gov

ELEMENTS OF BIODIVERSITY

Indicator	How Is It Measured?	Why Is It Important?
Plant and animal diversity	Measures taxonomic groups (such as birds, mammals, plants, reptiles, amphibians, fish, invertebrates), assessing as available: • Relative richness, the number of native species as opposed to individuals • Relative balance/evenness, the relative degree that each species is represented.	• Species richness and evenness are the most basic measures of biodiversity.
Species occurrence/ abundance trends	• Iconic species • State-designated at-risk species	• Iconic species have cultural significance for public involvement. • Declining population trends of at-risk species could provide an early warning of change in species richness in the near future.
Plant community/ ecosystem diversity	• Distribution of native vegetation • Distribution and quality of critical and rare ecosystems, as identified by the Washington Natural Heritage Program	• Beyond from their contribution to overall biodiversity, plants are intrinsically important for food and habitat. • Historical trends indicate significant changes in the distribution of plant species and communities.
Landscape composition and pattern	• Percent cover • Largest patch index • Landscape diversity • Contagion index (a measure of aggregation/ connectivity) • Riparian vegetation	• Land cover (primarily vegetation) composition and spatial patterns are broad-scale, relatively measured indicators of both habitat and ecosystem integrity. • Patch sizes and landscape diversity provide measures of relative dominance of specific land cover types. • Contagion gives a rough measure of ecosystem connectivity or fragmentation. • Riparian vegetation relates to both habitat provision and water quality.
Biotic integrity	• Index of Biotic Integrity	• Index of Biotic Integrity measures not only biological diversity, but also the status and intactness of ecosystems.
Soil organic matter	• Soil organic matter	• Soil conditions, a basis for nutrient and water cycles and life itself, reflect ecosystem integrity, and provide a rapid indicator of systemic changes.

ECOLOGICAL PROCESSES

Indicator	How Is It Measured?	Why Is It Important?
Functional diversity	• Pollinators, seed dispersers • Predators	• Pollinators and predators serve important (keystone) roles in ecological processes.
Phenological trends	• Leaf-on and off dates • Flowering dates • Timing of migrations	• Seasonal trends and changes are indicative of systemic change, and can affect population persistence. This is an important indicator of climate change impacts.
Plant productivity	• Net primary productivity	• Measures of plant productivity provide a broad-scale assessment of the health and persistence of plant communities.
Disturbance regimes	• Occurrence and abundance of bird species that are disturbance-sensitive, tolerant or dependent • Spatial extent of fire, insect outbreaks, floods, and wind-throws • Occurrence rates of droughts and floods	• Trends in bird species guilds that are adapted to intrinsic disturbance processes are indicators of disturbance levels. • Significant changes in disturbance regimes can adversely affect species, ecosystems, and human well-being. • Significant fluctuations in water volumes affect ecosystem functions, and the species and humans that depend on them.
Nutrient fluxes and concentrations	• Water Quality Index	• Significant increases in material deposition and/or vegetation losses can lead to abnormally high nutrient levels. • Low water quality can harm downstream aquatic ecosystems .

ECOSYSTEM SERVICES

Indicator	How Is It Measured?	Why Is It Important?
Water provision and quality	• Area of municipal watershed lands in natural land cover • Amount of water derived from municipal watersheds	• Water is the source of all life. • This indicator can be used with landscape measures to illustrate water quality benefits derived from maintaining ecosystem integrity.
Fish and game provision	• Yields of fish and game species	• Fishing and hunting for sport and sustenance are a direct service of biodiversity.
Resource provision	• Yields of timber, crops, and commercial fisheries	• Food and fiber represent a direct service of biodiversity and ecosystem integrity.
Parks and green space	• Usage rates for hiking, camping, and other wildland activities	• Outdoor recreation occurs on lands that provide plant and wildlife habitat.
Wildlife viewing	• Participation rates	• Wildlife viewing offers opportunities for public engagement in biodiversity conservation and can provide an estimate of where wildlife can be found.
Reducing impacts of invasive species	• Species and communities impacted • Costs of mitigation	• This indicator measures the specific impacts of invasive species on ecosystem integrity and resilience as well as the associated costs..
Reducing impacts of herbivores	• Extent of damage by browsers and grazers	• Biodiversity contributes to ecosystem resilience; this indicator, when linked with others (e.g., predator trends, functional diversity), can illustrate how the loss of diversity reduce resilience.
Flood mitigation	• Landscape pattern within federally designated moderate to high risk flood zones	• Flood and erosion mitigation are benefits derived from maintaining landscape integrity.
Carbon sequestration	• Measures of carbon uptake capacity	• This measure indicates landscape-level contributions to climate change mitigation through vegetation-specific measures.
Aesthetic impacts on housing and land prices	• Land value as function of natural land characteristics (e.g. proximity to a remnant forest)	• The economic benefits of landscape aesthetics also serve to promote biodiversity and ecosystem integrity.
Reducing pest abundance	• Insect defoliation damage	• This indicator illustrates how biodiversity contributes to ecosystem resilience and how the loss of diversity can affect it.

HUMAN FACTORS

Indicator	How Is It Measured?	Why Is It Important?
Land base under conservation protection	• Distribution and extent of public, private,w and trust lands dedicated or amenable to biodiversity conservation	• Public and private land holdings either implicitly or explicitly maintained for biodiversity reflect potentially available species habitat, and preservation of key ecosystem functions. • Such a measure reflects human contributions to biodiversity conservation and ecosystem integrity.
Land use management	• Land cover composition of private land under growth management and critical area ordinances	• Growth management policies define limits to urban/suburban development and protect critical areas (steep slopes, wetlands, etc.) that can also preserve ecosystem integrity and provide intact habitat.
Incentive programs	• Distribution and extent of private lands under forest stewardship certification	• Locations where incentive programs are in place can reflect human commitment to biodiversity.
Disturbance regimes	• Distribution and extent of land cover transitions	• This is a broad-scale indicator of potential losses or gains in habitat and landscape integrity.
Pollution level	• Levels of exposure to toxic chemicals PCB's, PBDE, dioxins, pesticides	• Measures of significant contaminants indicate factors that can impact the health and integrity of species, ecosystems, and humans.
Disturbance management	• Extent of fire suppression or controlled burn practices • Extent of natural pest management practices • Extent of windthrow abatement	• Disturbance management practices can serve as potential indicators of human commitment to preserving ecosystem integrity.
Citizen science	• Distribution and extent, and content focus of efforts within a given ecosystem type	• Citizen science programs can reflect both the specific interests and knowledge base of the general public with respect to particular species or ecosystem types. • It can also highlight opportunities for directly involving the public in measuring biodiversity indicators, particularly those with limited data.
Public engagement and education	• Distribution and extent and content focus of efforts within a given ecosystem type	• Public engagement and environmental education can reflect the specific interests and knowledge base of the public. • Environmental education can foster involvement and stewardship.

Assessing Biodiversity Across the World

The declining state of biodiversity is a significant concern worldwide. Habitat loss and climate change are chief among the many forces threatening the planet's biodiversity from the Tropics to the Arctic, and from coral reefs to alpine peaks.

International efforts such as the Millennium Ecosystem Assessment and United Nations Convention on Biological Diversity recognize the significance of such losses. Toward that end, 2010 was declared the International Year of Biodiversity. Indicator projects have been launched round the world, examining biodiversity at local, regional, and international levels.

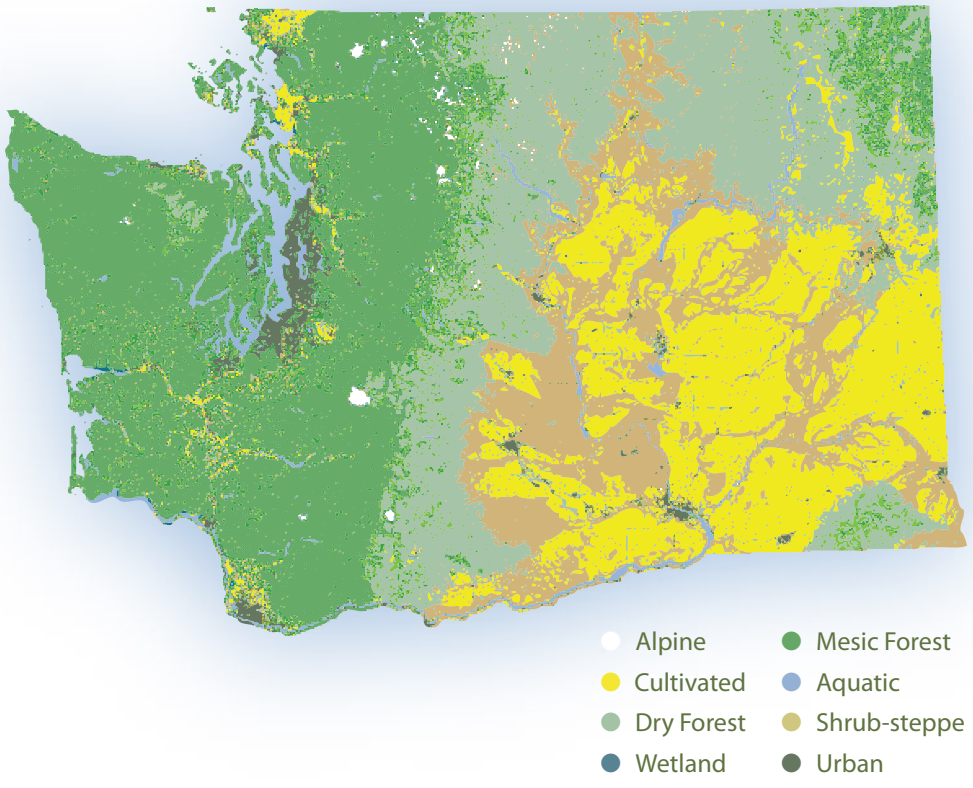
This significant global focus on biodiversity extends to our own backyard. With its complex geography, Washington State is home to an incredible natural wealth. It's vitally important to better understand its condition and value.

Testing Out the Indicators

Once the 30 indicators were selected, the next step was to examine how well the scorecard would work in an actual test case. Noting that "the devil is in the details," the Biodiversity Council asked the researchers to apply these indicators at a particular geographic scale, the major ecosystems of Washington (see map).

The researchers applied the scorecard fully to the mesic forests of western Washington and partially to the shrub-steppe of eastern Washington—two diverse ecosystems that cover more than half of the state.

MAJOR ECOSYSTEMS OF WASHINGTON



Washington's amazingly diverse flora and fauna inhabit a multitude of aquatic and upland ecosystems. Imagine everything from Roosevelt elk, salmon, and banana slugs in the cedar-hemlock rain forest of the Olympic Peninsula to sharp-tailed grouse, mariposa lilies, and western rattlesnakes in the sagebrush coulees of eastern Washington.

What did we find out about measuring the indicators?

In calculating metrics for the indicators in the test case, the researchers noted several things about the available data.

- **Data gaps occur but preliminary data are available** in each of the four indicator categories.
  - ◊ More detail is needed in some data sets.
  - ◊ Expanded monitoring efforts are needed for some data sets.
  - ◊ Citizen scientists could gather much of the needed data.
- **Most data are available at local geographic scale**—watershed or county level.
- **Two major classes of metrics exist** (see below):
  - ◊ Metrics that measure conditions relative to what is possible.
  - ◊ Metrics that measure conditions relative to recently observed trends.
  - ◊ Both types can help evaluate the status of an indicator, and going forward, both can help evaluate trends.

What's the Time Frame?

The scorecard's indicator metrics fall within two classes: those measured relative to what is possible versus those measured relative to recent observed trends.

- Indicators describing structural components—the pieces—of biodiversity, are generally measured as amounts or quantities. For example, indicators of species richness, land cover, and conservation lands are measured as proportions of the total amount potentially occurring within a given region.
- Indicators describing ecological processes—the interactions—of biodiversity, are generally measured as rates. For example, indicators describing trends in plant productivity, water quality, and resource yields are quantified as measures of current conditions relative to recent historical trends (roughly the past 5 to 20 years depending on the data set).

- **Level of computation effort varies.** Many indicators required minimal computing effort, taking advantage of the vast data-mining capacity of contemporary databases and the Internet.
- **Most data sets show agreement within an ecosystem.**
    - ◊ A subset of indicators might give as accurate an assessment—further work is needed to evaluate possible redundancies.
    - ◊ Some indicators, however, are outliers, suggesting further work is needed to determine why they tell a different story.
- **Equal weighting of indicators yielded provisional insights**, but it was recognized as a simplistic approach. A more sophisticated evaluation would give greater weight to indicators that have a proportionally larger effect on biodiversity.

These indicators provide a snapshot of current conditions; some of these indicators will have stronger meaning when measured over time. In this respect, the scorecard becomes a baseline for future assessments, which would provide a clearer picture of trends into the future.

What did we find out about combining the indicators?

The researchers combined the numbers derived from these measurements to examine how the Biodiversity Scorecard could deliver big-picture assessments. They found that a single number could be derived that represents the status of an ecosystem.

- When compared with the numbers from other ecosystems, this number could provide a measure of how well an ecosystem's biodiversity is doing relative to other ecosystems.
- When assessed over time, this number could be graphed to provide trend information—similar to a stock market index.
- Alone, such a number yields little information.

Interested in more details? Read the report at www.biodiversity.wa.gov

For example, in the test case, the combination "score" for the mesic forest ecosystem is about 70 percent, while that of the shrub-steppe ecosystem is about 60 percent. This suggests that, overall, the biodiversity of western Washington's forests is faring moderately well when contrasted to the shrub-steppe.

In a further test, the researchers examined how to aggregate the indicators to generate higher level conclusions. They took a qualitative look at interactions and connections between indicators to see what they might be able to say about ecological resilience, sustainability, and integrity.

With such versatility, the scorecard can provide valuable information to the public and decision makers on the overall status of Washington's biodiversity. The results can provide guidance to legislation, policy priorities, and management objectives, as well as providing a baseline for assessing the effectiveness of biodiversity conservation activities.

Future Promise and Work Ahead

The Biodiversity Scorecard is a promising work in progress. It lays the groundwork for an inclusive and integrative assessment of biodiversity in Washington State. By tracking changes in status and trends, the indicators can serve as pointers to why such change is occurring. Such information in turn could serve to guide more targeted policy, management, and research actions.

Still, the scorecard needs further development to realize its full potential. Interested partners are working together toward publishing a first edition of the scorecard for the state. This edition will focus on a select set of indicators, using existing data sets that are robust and likely to continue into the future.

Refinement and use of the scorecard—the indicators, metrics and derivative aggregates—will be an ongoing process. This work is being carried out by an informal working group comprising scientists and staff from Washington's natural resource agencies. Additional work focuses on building new partnerships and securing support for the scorecard's further development. These next phases of the scorecard will enable us to better understand and monitor the rich natural heritage of Washington State.

For more information on the Biodiversity Scorecard, and how you can participate in its future development, please contact the Recreation and Conservation Office, 360-902-3000.

Glossary

BIODIVERSITY – The full range of life in all its forms. This includes the habitats in which life occurs, the ways that species and habitats interact with each other, and the physical environment and the processes necessary for those interactions.

CITIZEN SCIENCE – Projects or ongoing programs of scientific work in which individual volunteers or networks of volunteers (e.g., students, nature enthusiasts, or the general public), partner with scientists to perform or manage research-related tasks such as observation, measurement or computation.

CONSERVATION – The protection, preservation, restoration, or sustainability of natural resources.

ECOSYSTEM – Biological communities made up of all of the organisms that live in a particular area, the physical environment of that area, and the interactions between the species and the physical environment.

ECOSYSTEM SERVICES – The myriad benefits that nature provides, among them flood control, water purification, crop pollination, fish and game, and beautiful scenery.

INDICATOR – A fact or trend that indicates the state, level, or condition of something.

MESIC FOREST – Forest that grows in wet or damp areas. In Washington, these forests are primarily found in the western part of the state.

METRICS – Can be singular or plural—a method of measuring something, or the results obtained from measuring something.

SHRUB-STEPPE – Grassland with a shrub component. In Washington, the shrubs are often, but not exclusively, species of sagebrush.

SPECIES – A group of organisms with the same ancestry that generally can reproduce only with each other.

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1111 Washington Street SE
P.O. Box 40917
Olympia, WA 98504-0917
360-902-3000
www.biodiversity.wa.gov