


DEFENDERS OF WILDLIFE ECOSYSTEM SERVICES WHITE PAPER

NATURE'S BENEFITS:

THE IMPORTANCE OF ADDRESSING BIODIVERSITY IN ECOSYSTEM SERVICE PROGRAMS

ABOUT THIS PUBLICATION

Defenders of Wildlife has been a leader in addressing ecosystem services and market-based programs, one of the first nonprofit organizations to explore policies guiding these programs. This white paper examines the process for addressing ecosystem services in decision-making, in hopes that these concepts encourage policy-makers to balance the interests of nature and society.

Author: Sara Vickerman
Designer: Kassandra Kelly

Defenders of Wildlife is a national, nonprofit membership organization dedicated to the protection of all native wild animals and plants in their natural communities.

Jamie Rappaport Clark, President and CEO
Donald Barry, Executive Vice President

1130 17th Street, N.W.
Washington, D.C. 20036-4604
202.682.9400
www.defenders.org

Cover images, clockwise from top: Black-footed ferret, photo by Ryan Hagerty, USFWS; Burrowing owls, photo by Lee Karney, USFWS; Western painted turtle, photo by Gary M. Scholtz, USFWS; Canada geese, Nisqually NWR, photo by Bruce Taylor; Student at Wetzel Woods Conservation Easement during Alternative Outdoor School, photo courtesy of the Friends of Tualatin River NWR and the Conservation Registry. Back cover: Rockefeller Forest, Humboldt Redwoods State Park, photo by Bruce Taylor.

The concept of ecosystem services – or the benefits that nature provides – has gained tremendous attention over the past decade. It is a common-sense approach to management that recognizes and makes the most of nature's contributions to human communities. Solutions based on ecosystem services generally avoid up-front costs and expensive maintenance of highly engineered alternatives.

Interest in the topic has sparked a growing number of articles, conferences, and technical tools to evaluate, quantify, and monetize these services. The idea of measuring the values provided by natural systems and using that information to make better decisions in natural resource management has captured the attention of a wide range of audiences, from conservation groups to social welfare groups to developers and extractive industries.

However, significant ambiguities remain around what the concept means and how it should be implemented. As a result, it has been difficult to explain to policy-makers, planners, and business interests who struggle to understand how an assessment of ecosystem services differs from multiple use management, impact assessment, or compliance with existing environmental regulations. The concept has also been difficult to translate into policy and management and, in particular, to apply consistently across the public and private sectors.

The notion of quantifying the ecological outputs associated with specific sites and management systems inevitably means different things to different people. For some, it opens the door to large-scale impact mitigation, through the marketing of certain services to regulated parties to "offset" damage to those resources elsewhere, as in wetland and conservation banking and carbon trading. Others expect calculating the economic value of nature to provide more compelling justification for saving it. It may be that part of the broad appeal of the ecosystem services concept among economists, ecologists, policy wonks, and advocates is actually due to the fact that it offers such fertile ground to define and implement the new paradigm according to their own expertise and value systems.

Camassia blossoms in the William L. Finley National Wildlife Refuge, Willamette Valley, Oregon. Photo by George Gentry, USFWS. Varieties of camas were an important food source for native peoples in the west.

Despite these complexities, the use of ecosystem services in decision-making holds considerable promise. Including the full range of ecosystem benefits and costs may lead to better decisions in the long term by encouraging decision-makers to balance the interests of nature and society with those of the industry or agency responsible for development and/or management. The concept is also useful for helping to manage the diverse expectations stakeholders have of public lands. For example, the Forest Service recently adopted a new planning rule that mentions ecosystem services and has the potential to greatly expand the range of values addressed in the land management planning process (Forest Service, 2012). Many Forest Service staff believe that an ecosystem services approach will improve integration across programs, encourage the agency to think about fundamental attributes and processes, and move land management drivers away from utilitarian outputs like board feet and acres toward more sophisticated objectives. It is also a powerful tool to support collaborative approaches to management.

There are potential benefits and hazards associated with applying an ecosystem service framework to resource decisions. The advantages include:

- Improving accountability as measurement systems evolve to address ecological values that have not be- quantified in the past;
- Making investments more strategic as a result of objective assessment of options;
- Engaging a more diverse set of stakeholders in decision-making;
- Providing alternative compliance options for developers;
- Diversifying income for landowners who provide ecosystem services;
- Creating jobs in research, monitoring, consulting and restoration; and
- Improving the overall effectiveness of resource management on public and private lands.

The potential disadvantages include:

- Exacerbating the existing fragmented approach to management by adding yet another layer of assessment requirements and goals, thereby undermining rather than encouraging systems approaches;
- Ignoring the complexity of ecosystems and oversimplifying management objectives;
- Shifting the emphasis of management to a limited suite of utilitarian goals, thereby alienating stake holders who traditionally support conservation; and
- Continuing to overlook the fundamental ecological attributes and processes that contribute to the functioning of healthy ecosystems.

The ecosystem services approach is the latest in a long list of conceptual approaches that are intended to improve the practice of natural resource conservation and management yet tend to be replaced by the "next shiny object" before they reach fruition. As a result, there is a limited window of time in which to get this approach right and to capture what conservation benefits are valuable from its somewhat unique conceptual frame. This report outlines an approach to ecosystem services that will be relatively straightforward to implement, that allows for continuous learning and improvement over time, and could appeal to business and conservation interests.

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1 Defining the Concept: Utilitarian and Intrinsic Approaches

The diversity of perspectives on and expectations of an ecosystem services approach results in part from the difficulty interested parties have had in coming to agreement on a definition. Extractive industries, for example, often see agriculture and timber production as the ultimate ecosystem services – products provided by nature for the benefit of humans. Even among conservation groups, a similarly utilitarian definition sometimes emerges.

For example, in developing a framework for addressing ecosystem services based on the Millenium Ecosystem Assessment, academic researchers and government officials developed a classification for the "services" derived from nature but tend to neglect to address biodiversity and other underlying attributes that make it possible for people to enjoy and consume the services. The assessment has led to the creation of four categories of services: provisioning – which include commodities like timber, water, and food; supporting – which include things like nutrient cycling and soil formation; regulating – which refers to protection from climate extremes and disease outbreaks; and cultural services that capture aesthetic, spiritual and recreational benefits (Millennium Ecosystem Assessment, 2005). Biodiversity – or nature – got lost in the shuffle and is generally not included as a "service" in many typologies.

This interpretation – which is based on two fundamental assumptions – set the stage for continuing controversy about whether the ecosystem services paradigm is good or bad for nature. These assumptions include the notion that services must benefit humans directly to be counted, and that biodiversity is not a "service," per se. We challenge both of these assumptions and propose instead that ecosystem services refer to the *benefits that nature provides, including intrinsic values, and that whether biodiversity is technically a service or not, it needs to be addressed and considered in all ecosystem service assessments, goal-setting, and management decisions.*

A more inclusive definition of ecosystem services recognizes that the natural world that is the source of food, water, clothing, building materials, air and other essential life support systems cannot be separated from the diversity of life that form both its foundation and its ultimate expression. Natural landscapes with a diversity of native species help facilitate the pollination of flowers and crops, and protect against damaging storms and wildfires, and insect infestations. Nature also offers cultural and spiritual benefits, recreational opportunities, and aesthetic values, while maintaining a "genetic library" (itself an ecosystem service) of global biodiversity as a source of future insights and innovations benefiting people. Lightly managed lands and waters help maintain climatic conditions to which people have adapted (Executive Office of the President, 2011).

The Millenium Ecosystem Assessment itself appropriately characterizes biodiversity as an essential underpinning of ecosystem health and function with subsequent effects on ecosystem services provided by ecological systems. Biodiversity is necessary in the provision of direct benefits to humans, along with the persistence, stability, and productivity of natural systems. A technical report from the Forest Service explains that "the diversity of the plant, animal, and microbial species living within a community influence critical processes including plant productivity, soil fertility, water quality, nutrient cycling, pollution and waste reduction, biomass accumulation, resistance to disease and disturbance, and other environmental conditions that affect human welfare." (Smith, et al., 2011).

A 2012 paper in Bioscience discussed the notion that these two approaches represent fundamentally different value systems. Biodiversity advocates support a bio-centric view which assigns intrinsic value to all life on earth. Ecosystem service supporters hold anthropocentric views in which nature has instrumental value because it supports human well-being. The article goes on to suggest that these approaches are not mutually exclusive, and that "there is an urgent need for the community to move beyond the *either biodiversity or ecosystem services* debate to one that acknowledges that both biodiversity and ecosystem services – both intrinsic and instrumental values – are important." (Reyers et al., 2012). A public attitude survey conducted for The Nature Conservancy confirmed that nearly equal numbers of the U.S. population see nature as important for its intrinsic value as for its utilitarian value (TNC, 2010), so this approach is clearly a politically viable one.

A damp winter morning on a floodplain habitat, Smith and Bybee Wetlands Natural Area, near Portland, Oregon. Photo by Bruce Taylor, Oregon Habitat Joint Venture.

2 GETTING ECOSYSTEM SERVICES RIGHT

Despite these differences, the concept of ecosystem services has now been sufficiently developed to begin crafting policy around ecosystem services and taking steps to implement the approach through management decisions. Oregon adopted ecosystem services legislation in 2009 that established a policy of protecting ecosystem services across all land uses by protecting land, water, air, soil, and native flora and fauna. It also directs state agencies to "consider mitigation strategies that recognize the need for biological connectivity and the overall ecological viability of restoration at a landscape scale," to improve the overall effectiveness of mitigation programs. Senate Bill 513 defined ecosystem services as "the benefits that human communities enjoy as a result of natural processes and biodiversity" (Oregon Legislative Assembly, 2009).

There are several high profile examples of ecosystem service program implementation in Oregon. Most notably, Clean Water Services, a utility near Portland, pays private landowners to restore streamside vegetation to cool water for fish rather than building expensive cooling towers for wastewater treatment facilities. Other utilities and municipalities across the country are looking at natural infrastructure options to comply with the federal Clean Water Act. Conservation banking is a similar strategy that expands compliance options under the Endangered Species Act.

Getting ecosystem services right requires addressing three essential components:

First, the biological foundation – including the composition and functioning of both natural and human-dominated systems – must be addressed more directly than is currently common:

1. **Assessments of ecosystem services must address both intrinsic and utilitarian values in order to appeal to a wide range of stakeholders.** Human communities and natural ecosystems derive benefits from well-functioning, diverse systems. These benefits include a wide variety of tangible products of direct utility to people, along with spiritual and cultural values.

2. **Healthy and diverse ecosystems provide a broader range of services than degraded or simplified systems.** Well-functioning systems are less vulnerable to the adverse effects of climate change and other stressors. These systems contain native plants and animals and natural processes, including ecological disturbances. Biodiversity offers the essential underpinning for most other services. Fish, wildlife, and plants can also be considered "end products" within an ecosystem services framework. In any case, biodiversity must be addressed explicitly in ecosystem service management programs.

3. **Managing land and water for ecological integrity requires a holistic approach applied at multiple scales.** Ecosystem service programs implemented at a local scale should nest within broader ecological and social systems.

Second, resource assessment and management strategies and the policies that drive them must reflect an understanding of the underlying science and the social/economic forces that shape decisions.

4. **A more coordinated, integrated system for tracking the status of biodiversity and other ecosystem services is needed, balancing scientific credibility with practicality to ensure that it is implemented.** The tracking system should take advantage of existing information and capabilities in the public and private sectors, and meet the needs of government, business, tribes and non-profit organizations. The starting point could be the development of a core set of ecological integrity and biodiversity indicators, along with a short list of specific benefits that nature provides for consideration in planning decisions.

5. **A new accounting system is needed, that addresses a broad range of ecological conditions that will be enhanced or diminished as a result of management actions.** Decisions regarding resource management, and decisions that impact natural resources, need to consider all potential benefits and costs to project developers and society at large,

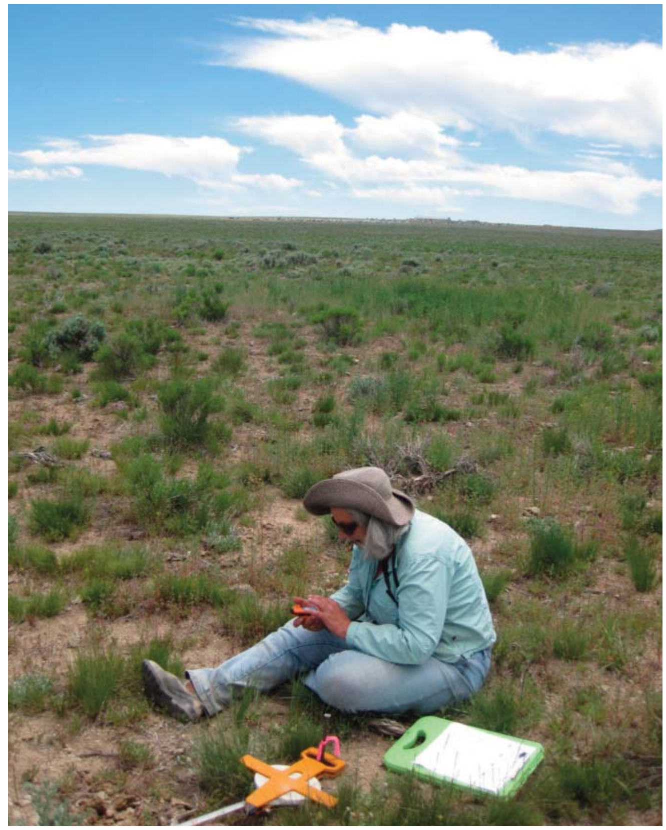
not just the ones that can be financially quantified in the short term. Projects that take advantage of natural processes can often save money, but it is neither necessary nor appropriate to assign dollar values to all ecological attributes in order to consider their importance to present and future generations of people.

6. **While additional information on natural and cultural attributes of any system is helpful, lack of information should not cause paralysis.** Implementing adaptive management with continuous learning and adjustment is necessary to manage ecosystems for a broad spectrum of benefits.

Third, unless advocates of this approach can move rapidly beyond the academic and bureaucratic techno-babble phase into a space where the media, the public and policy-makers can grasp the meaning and relevance of ecosystem services, the idea will fail to gain wide acceptance and will not result in meaningful changes.

7. **Advocates of an ecosystem services approach must improve their ability to communicate the importance of protecting ecosystem services.** The science and practice of addressing ecosystem services must include clear and coherent communication with audiences beyond academia and government.

8. **Ecosystem services, biodiversity, and sustainability are intrinsically linked and should be treated as such in policy and management.** Doing a credible job in assessing and managing ecosystem services requires a systems approach that dovetails with sustainability and biodiversity goals to create an efficient, integrated systems approach to management. This approach will improve efficiency and reduce costs. It is fundamentally an interdisciplinary and multi-stakeholder collaboration that depends on credible information and trust.



Berta Youtie of Eastern Oregon Stewardship Services conducting the field portion of a habitat assessment using the Sagebrush-Sage grouse metric, near Prineville, Oregon.

3 Opportunities for Action

Following are some opportunities for addressing these three essential components, with an emphasis on the national level:

1. President Obama should issue an Executive Order directing federal agencies to consider the positive and negative impacts on ecosystem services before initiating or funding climate change adaptation projects.

2. Federal and/or state policy-makers and appropriators should provide policy direction to agencies to work together to develop integrated, cross-jurisdictional, multi-scale ecological measures and indicators that address habitat/biodiversity/ecological integrity, and a limited suite of specific services like water, carbon sequestration and hazard mitigation. The effort

would benefit from the designated leadership of a federal agency like USGS, but must involve other agencies as well as the private sector.

3. Updated policies are needed that direct federal agencies to consider biodiversity and ecosystem services in land use plans and water developments, and to include natural infrastructure options where appropriate. Many existing policies and programs already authorize this approach, but some single-purpose programs, especially water projects, may require policy changes.

4. Develop a new accounting system for federal land management accomplishments that highlights the connection between public benefits and ecological conditions and a reward system for agency staff that is directly tied to the new system, not based on traditional outputs.

5. Convene experts and practitioners to examine ecosystem valuation methods and applications, and develop best practices to improve the consistency and effectiveness of both monetary and non-monetary valuation. Engage policy-makers and integrate the findings into decision-making concerning land and water management and investment decisions.

Monarch butterfly lingering on a liatris plant. Photo courtesy of the Missouri Department of Conservation.

4 List of Ecosystem Services

The following table was adapted from a 2002 paper in Ecological Economics by Rudolf S. de Groot et al., and a similar version also modified and used by Earth Economics. The original version reflects the human-centric bias that is typical in ecosystem services typologies by focusing on the direct, tangible benefits to humans.

In this version of the table, the categories of functions (regulation, habitat, production and information) were removed, and additional columns were added to emphasize the point that ecosystems are inherently valuable to all forms of life, and to human communities as well.

Further, several service categories were collapsed to narrow the list to twenty. It is not an exhaustive list, but a reasonable starting point less likely to overwhelm the non-specialist. There are many typologies of ecosystem services, and regardless of the chosen categories, the taxonomy should highlight both the intrinsic and utilitarian values to ensure the broadest possible acceptance of the concept.

Girl scouts learning about nature from USFWS employee Molly Monroe, Ankeny National Wildlife Refuge.

List of Ecosystem Services, *1-12 services*[1]

	Services	Ecosystem Infrastructure and Processes	Examples of Goods and Services	Ecological Benefits	Social Benefits	Economic Benefits
1	Gas regulation	Role of ecosystems in biogeochemical cycles like carbon sequestration	Clean, breathable air, disease prevention habitable planet	X	X	X
2	Climate regulation	Influence of land cover and biological mediated processes on climate	Maintains vegetation, crops, human communities	X	X	X
3	Disturbance Moderation	Influence of ecosystem structure on dampening environmental disturbances	Moderates effects of extreme events like fires, flooding, coastal erosion	X	X	X
4	Water quality and quantity	Role of land cover in regulating runoff, filtering, retention and storage of fresh water	Natural irrigation, drainage, navigation, supports aquatic organisms and municipal uses	X	X	X
5	Soil retention and formation	Vegetation and soil organisms, weathering of rock and accumulation of organic matter	Promotes integrity of ecosystems and agricultural productivity	X	X	X
6	Nutrient cycling	Role of biota in storing and recycling nutrients	Promotes healthy and productive soils, climate, water regulation	X	X	X
7	Waste treatment	Role of plants and animals in breaking down nutrients	Pollution control, detoxification, filtering dust	X	X	X
8	Pollination	Role of animals in pollinating plants	Pollinating wild plants and crops	X	X	X
9	Biological control	Population control of insects and pathogens	Pest and disease control, reduces crop damage	X	X	X
10	Habitat and biodiversity	Suitable living and breeding space for wild plants and animals	Maintenance of biological and genetic diversity – basis for most other functions and harvested species	X	X	X
11	Food	Conversion of solar energy into edible plants and animals	Hunting, gathering, agriculture	X	X	X
12	Raw materials	Conversion of solar energy into biomass	Construction materials, fuel, fodder, fertilizer		X	X

[1] Adapted from De Groot, Rudolf S., Matthew A. Wilson and Roelof M. J. Boumans. A Typology for the Classification, Description and Valuation of Ecosystem Functions, Goods and Services. Ecological Economics 41 (2002) 393-408.

List of Ecosystem Services, *13-20 services*

	Services	Ecosystem Infrastructure and Processes	Examples of Goods and Services	Ecological Benefits	Social Benefits	Economic Benefits
13	Genetic resources	Genetic material and evolution in wild plants and animals	Adaptation to ecological change, improve resistance to pathogens and pests	X	X	X
14	Medicinal resources	Variety in biochemical substances	Drugs, pharmaceuticals, chemical models, tools	X	X	X
15	Ornamental resources	Variety of biota in natural ecosystems with ornamental applications	Resources for fashion, decoration, worship, handicraft		X	X
16	Aesthetic resources	Attractive landscape features	Enjoyment of scenery		X	X
17	Recreation resources	Variety in landscapes with potential recreational uses	Travel, tourism, wildlife enjoyment, fishing		X	X
18	Cultural and artistic	Variety in natural features with cultural and artistic value	Nature films, books, folklore, national symbols		X	X
19	Spiritual and historic	Variety in natural features with spiritual and historic value	Use of nature for religious, historic applications		X	X
20	Science and education	Variety in nature with scientific and educational value	Use of natural systems for education, scientific research	X	X	X

5 Case Studies Highlighting the Benefits of Biodiversity[2]

Biodiversity– the variety of life on earth and the processes that sustain it, or what used to be simply called Nature – generates all kinds of benefits for humankind. Because most of the daily operations of Nature take place in the background of our consciousness, we tend to take these ecosystem services for granted. But loss of species, habitats and disruption of natural ecological processes is putting many of Nature's benefits at risk.

The biodiversity we see today is the fruit of billions of years of evolution, shaped by natural processes as well as the influence of humans (COBD, 2012). Biodiversity includes the web of life of which we are an integral part and upon which we depend.

Natural systems, including the fish, wildlife and plants within them, are valued by people for many reasons. In addition to providing food, water, clothing and building materials, nature offers cultural and spiritual benefits, recreational opportunities, and aesthetic values. Nature is also comprised of critical processes like plant productivity, soil fertility, water quality, nutrient cycling, pollution cleanup and waste reduction. Functioning natural systems are vital to the health and safety of human communities, protecting people from floods, climatic extremes, storms and insect infestations (Mace et al., 2012).

[2] This section previously published as ***Nature's Benefits*** by Luca De Stephanis, Heidi Bazille, Misty Freeman, Sue Lurie and Sara Vickerman (2013). Institute for Natural Resources and Defenders of Wildlife. http://www.conservationregistry.org/assets/0000/9622/Nature_s_Benefits.pdf

While we all depend on natural systems, humans have had profound impacts on them. We have not appropriately valued or considered nature's benefits, or the cost of replacing them, when making business and resource management decisions. Although it is challenging to assign dollar values to these services, clearly their value is not zero. (UNEP, 2008). Effective ecosystem management requires careful assessment of nature's benefits including the conservation of species, habitats and landscapes (Planet Under Pressure, 2012).

The following examples highlight the importance of protecting wildlife species that play a crucial role in maintaining functioning ecosystems from which humans derive so many benefits.

A tiger swallowtail alight on butterfly weed. Photo by Dr. Thomas G. Barnes, USFWS.

CASE STUDY: POLLINATORS

Over two-thirds of the plants on earth require pollination, including a third of the plants we eat. These plants and crops are served by a variety of bees, butterflies, moths, beetles, hummingbirds, bats, and other species that move pollen from one place to another to help plants reproduce (Kevan, 1999; Xerces, 2010). Today, scientists are concerned that populations of pollinators are failing, due in large part to human actions.

While honey bees are the most important commercial pollinators (Michener, 2000), they are not the only ones. Many plants are more efficiently pollinated by native bees, insects and birds. Researchers in Europe have identified diversity of habitat as a necessity for ensuring the health and species diversity of pollinators upon which our food crops depend (Kremen et al., 2002, 2007).

Scientists estimate that up to 20% of grasslands and forests around the globe will be converted to agricultural land between 2000 and 2050 in order to feed the ever-expanding human population. Results of this conversion will likely increase greenhouse gas emissions, contribute to climate change and cause the loss of habitat for numerous species, including pollinators (UNEP FI, 2008).

In addition to a direct link to the growth of crops for human food, pollinators have been identified by scientists as bio-indicators of the state of the natural world (Kevan, 1999). Pollinators have been linked to pest reduction, improvement in water quality, and protection against soil erosion (Wratten, et al., 2012). The absence of a healthy population of pollinators points to other problems straining the environment, such as pesticides and diseases.

Sea otter near Monterey, California. © Frans Lanting / National Geographic Stock.

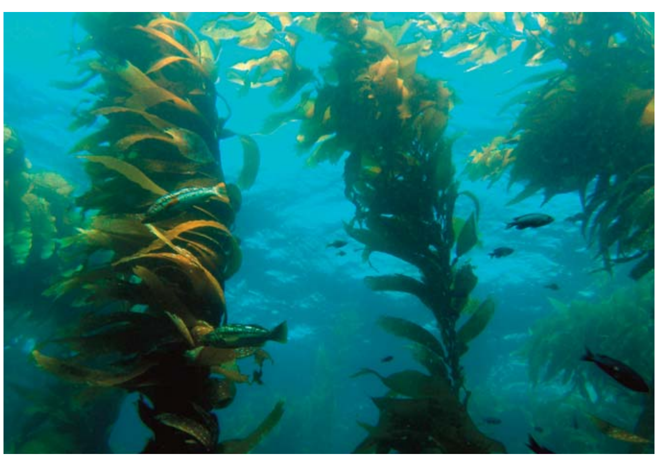
CASE STUDY: SEA OTTER

Scientists have known for some time that coastal areas are nursery grounds and travel corridors for many coastal plants, invertebrates, and fishes (Caley et al., 1996). The activities of humans have greatly altered the abundance of marine species in these areas, especially large predators that feed at the top of the food chain (Hutchings & Baum 2005).

Sea otter munching on fresh crab. © Linda Tanner / National Geographic Stock.

Sea otters are a critical top predator whose activitiesaffect the functioning of the entire ecosystem. Their interaction with other species illustrates the concept of trophic cascade, which describes what happens to an ecosystem when a top predator is removed. Sea otters live in kelp forests, which are among the most productive and species-rich habitats in the world. Otters help kelp forests to grow and thrive by eating sea urchins that would otherwise encroach on kelp beds.

When populations of sea otters decline, the impact is felt throughout the ecosystem. Sea urchins increase, reducing other species' habitat, shelter, and protection from strong currents that were once provided by kelp forests. (Estes, et al., 2004). The population of rock greenling, a dominant fish species, declines because rock greenling depend on the kelp forest for food, shelter, and egg laying habitat. (Reisewitz et al., 2006). Bald eagles will then have fewer rock greenling, sea otter pups and smooth lumpsuckers to eat. (Anthony, et al., 2008). Reduced predation by sea otters on sea stars allows mussels to increase in size and mussel beds to extend into new areas, thus further altering the ecosystem (Estes et al., 2004).



A healthy kelp forest. Photo courtesy of UC Santa Barbara.

Several historic events led to the decline of the sea otter population. First, they were nearly exterminated by the maritime fur trade (Kenyon 1969). After protective measures were adopted, widely scattered populations remained isolated from each other. (Kenyon 1969, Riedman and Estes, 1990). In southwest Alaska during the 1990s the sea otter population crashed and the kelp ecosystem collapsed. Scientists suspect that killer whales were forced to change their diet to seals, sea lions, and sea otters after their earlier prey, large whales such as the blue whale, were decimated by commercial whaling. (Estes, et al., 2004). Climate change and resulting warmer waters may bring more killer whales north from the Puget Sound to feast on Alaska's sea otters.

Gray wolf, photo by John and Karen Hollingsworth, USFWS.

CASE STUDY: GRAY WOLF AND BEAVER

Throughout most of the 20th century, the absence of wolves in Yellowstone National Park enabled herbivores, such as elk and deer, to forage more heavily along streams and rivers (Beschta, 2012, 2010; Kauffman, 2010). Bountiful forage led to a surge in elk and deer populations. In the winter, elk began to travel less and browse more on young willow plants. Beavers declined, as they depend on willows to survive the winter. As a result, plant abundance and diversity declined, leading to stream bank erosion, which in turn altered stream channel morphology and floodplain function.

The decline of berry-producing shrubs led to a loss of high-nutrient foods for many species including bears and birds. Without young aspens and cottonwoods, there was less habitat for amphibians and songbirds, and their populations declined or disappeared.

Predators such as gray wolves can indirectly affect plant communities by influencing prey behavior and density, thus protecting plants from grazing pressure (Strong and Frank, 2010). The 1995/1996 reintroductions of gray wolves into Yellowstone National Park after a 70-year absence offered scientists a unique opportunity to study trophic cascade involving wolves, elk, beaver, and plant species such as aspen, cottonwoods, and willows (Ripple and Beschta, 2012).

The reintroduction of the wolf changed deer and elk behavior. Fear of wolves kept the deer and elk from spending so much time around creeks and streams, and allowed streamside vegetation to regenerate. Wolves benefitted bald eagles by providing elk carcasses to scavenge. Bears also rely on wolf-killed carcasses and eat berries found on restored shrubs. Songbirds responded to improved habitat with increased populations of yellowthroats, Lincoln's sparrows, song sparrows, and willow flycatchers (Baril, 2011). Decreased competition with elk for food caused bison populations to increase.

Beavers have begun re-colonizing Yellowstone and building dams, but their abundance and distribution have not reached historic levels. The recovery of the ecosystem is still in the early stages. (Ripple and Beschta, 2012).

North American beaver carrying a stick to its lodge. Photo courtesy of the Oregon Biodiversity Project.

Elk wintering on the National Elk Refuge near Jackson, Wyoming. Photo by Glen Smart, USFWS.

However, beaver activity has the potential to provide the following benefits:

- Reduce water temperatures and improve habitat for aquatic organisms.
- Improve habitat for fish by providing a source of detritus and woody debris.
- Increase riparian plant diversity and songbird habitat.
- Increase waterfowl, amphibians, reptiles, muskrat and river otter populations.
- Reduce excess amounts of sediment and organic material in surface runoff.
- Reduce steam bank erosion.
- Increase carbon storage in plant biomass and soils.
- Recharge the water table, increase water storage and wetland acreage (Gilgert and Zack, 2010).

Today, human pressures on biodiversity are unprecedented. The distribution and abundance of species and populations change almost continuously, and these changes are largely unrecorded. Understanding these processes is perhaps ecology's most fundamental challenge (Estes et al., 2004). Conserving charismatic endangered species is important, as they confer significant economic and cultural value. But this approach is insufficient to ensure that the full range of benefits associated with biodiversity are valued and accounted for in decisions made by businesses and governments (UNEP, 2008). While we can always use improved scientific information and should strive for more collaborative decision-making, we can no longer expect to have perfect understanding of ecosystems or absolute political consensus to implement solutions to the unfortunate state of biodiversity on planet Earth.

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Defenders of Wildlife
1130 17th Street, N.W.
Washington D.C. 20036-4604
202.682.9400
www.defenders.org