

CONSERVATION

Ecosystem Services for 2020

C. Perrings,^{1*} S. Naeem,² F. Ahrestani,² D. E. Bunker,³ P. Burkill,⁴ G. Canziani,⁵ T. Elmqvist,⁶ R. Ferrati,⁵ J. Fuhrman,⁷ F. Jaksic,⁸ Z. Kawabata,⁹ A. Kinzig,¹ G. M. Mace,¹⁰ F. Milano,⁵ H. Mooney,¹¹ A.-H. Prieur-Richard,¹² J. Tschirhart,¹³ W. Weisser¹⁴

The vast majority of nations have fallen far short of the Convention on Biological Diversity's (CBD's) 2010 target: to reduce the rate of loss of biodiversity (1, 2). This prompted the CBD to develop a new plan of action, supported by 20 "SMART" (specific, measurable, ambitious, realistic, and time-bound) targets for 2020 (3, 4). As the 10th Conference of the Parties (COP) of the CBD meets in Nagoya, Japan, to negotiate both plan and targets, it is critical that targets also be grounded in the real interests that people have in benefits provided by biodiversity. To evaluate targets on this basis, we use the ecosystem services framework developed by the Millennium Ecosystem Assessment (MA) (5). This framework balances resource conservation and use according to how societies value consumptive (e.g., food and fuel) and nonconsumptive (e.g., health and aesthetics) services provided by ecosystems.

The ecosystem services framework has four main consequences for target setting. First, what and how much biodiversity should be targeted for conservation depends on what services are important to maintain and with what reliability. Second, the temporal and spatial scale of targets should be based on the changing temporal and spatial distribution, and risk profiles, of ecosystem services. Third, target development and implementation should include all agencies involved with management of biodiversity and the ecosys-

tem services they support. Fourth, interdependence among ecosystem services, the benefits they provide, and the value placed on those benefits implies that targets must be conditional. Implementation of one target may be affected by implementation of another.

The CBD 2020 Targets

The 2020 targets, color-coded according to (6), are highlighted in the figure. Red refers to imminent biosecurity threats due either to collapse of ecosystems or populations or to the rapid increase of pests or pathogens. Green



addresses society's conservation goals. Blue addresses longer-term scientific, socio-economic, and institutional conditions required to meet and sustain red and green targets. Red targets are typically "short term" (2 to 5 years). Green and blue targets are typically "longer term" (10+ years). Although none of the targets are presented as short term, we red-coded three because they address imminent threats.

Several 2020 targets refer to ecosystem services, including carbon sequestration and resilience (target 15), foods, fuels, and fibers (targets 6, 7, and 13). Target 14 addresses "ecosystems that provide essential services." But aside from capture fisheries (target 6), there is no clear correspondence between ecosystem services referred to in the targets and services identified as at risk in the MA (5) and subsequent studies (1). This is especially marked for marine systems, in part because targets tend to be biased toward terrestrial systems.

All targets have, in principle, the same time horizon—2020—and apply everywhere. The spatial and temporal distribution of services and variation in rates of change in the processes involved are not considered. Targets addressing imminent threats (e.g., 6, 8, and 9) should be sensitive to the time available to act and more closely related to the threat to human well-being. Similarly, some targets (e.g., 1, 2, and 3) may only be met over time scales longer than 10 years, but their implementation requires action now.

The Convention on Biological Diversity's 2020 targets are an improvement over the 2010 target, but they could be strengthened.

There is limited attention to coordination of targets across agreements and agencies. Some targets can be achieved solely through the sum of individual country efforts (e.g., 5 and 8), others only by collaboration across international agreements and agencies (e.g., 4, 9, and 13). For example, target 9 requires action on trade and alien invasive species. Although port inspection is within the competence of member states, trade interventions are not. The World Trade Organization and the parties to the General Agreement on Tariffs and Trade would have to be willing partners to reach this target.

The conditionality of targets is partly recognized in the identification of blue targets for enabling conditions that have to be met for green and red targets to be reached. But interdependence among green and red targets is largely ignored.

What Is Missing?

Although some 2020 targets are congruent with an ecosystem-services approach, four main things are missing:

1) *Functional diversity.* Ecosystem services derive from ecosystem functions and the species that perform those functions. In some cases, individual species play a disproportionately large role in the provision of services, but in most cases, targets should focus on conserving critical functional diversity. What matters for most ecosystem services is the diversity of traits species possess (e.g., nitrogen fixers, pollinators, and nutrient recyclers) (7–10). However, only target 13, on crop and livestock genetic diversity, references functional diversity.

2) *Environmental uncertainty and target adjustment.* How much diversity it is critical to maintain depends on the range of environmental conditions expected. The greater the expected variation in environmental conditions, the greater the required diversity within groups providing particular functions. Ecological functioning may change as environmental conditions change (11, 12). Targets for diversity within functional groups of species should adjust with changes in expectations about the state of the environment.

3) *Interactions between targets.* Target 3 explicitly recognizes harmful environmental

¹Arizona State University, Tempe, AZ 85287, USA ²Columbia University, New York, NY 10027, USA. ³New Jersey Institute of Technology, Newark, NJ 07102, USA. ⁴Sir Alister Hardy Foundation for Ocean Science, Plymouth, PL12PB, UK. ⁵Universidad Nacional del Centro, Buenos Aires, Argentina. ⁶Stockholm University, SE-106 91 Stockholm, Sweden. ⁷University of Southern California, Los Angeles, CA 90089, USA. ⁸Pontificia Universidad Católica de Chile, Santiago, Chile. ⁹Research Institute for Humanity and Nature, Kyoto, 603-8047, Japan. ¹⁰Imperial College London, Ascot, SL5 7PY, UK. ¹¹Stanford University, Stanford, CA 94305, USA. ¹²Muséum National d'Histoire Naturelle, 75231 Paris 05, France. ¹³University of Wyoming, Laramie, WY 82071, USA. ¹⁴Friedrich-Schiller-Universität, Jena 07743, Germany.

*Author for correspondence. E-mail: Charles.Perrings@asu.edu

STRATEGIC GOALS	TARGETS: BY 2020...
Address underlying causes of biodiversity loss by mainstreaming biodiversity across government and society.	1. All people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably. 2. The values of biodiversity are integrated into [national accounts], national and local development, and poverty reduction strategies.... 3. Incentives [including subsidies] harmful to biodiversity are eliminated, phased out, or reformed in order to minimize negative impacts.... 4. Governments, business, and stakeholders ... have taken steps to achieve or have implemented plans for sustainable production ...
Reduce direct pressures on biodiversity and promote sustainable use.	5. The rate of loss and degradation, and fragmentation, of natural habitats [including forests] is [at least halved] [brought close to zero]. 6. [Overfishing is ended, destructive fishing practices are eliminated, and all fisheries are managed sustainably.].... 7. Areas under agriculture, aquaculture, and forestry are managed sustainably, ensuring conservation of biodiversity. 8. Pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity. 9. Invasive alien species are identified, prioritized, and controlled or eradicated, and measures are in place to control pathways.... 10. To have minimized the multiple pressures on coral reefs and other vulnerable ecosystems affected by climate change....
Improve status of biodiversity by safeguarding ecosystems, species, and genetic diversity.	11. At least [15%][20%] of terrestrial, inland-water, and [X%] of coastal and marine areas are conserved.... 12. The extinction and decline of known threatened species has been prevented.... 13. The loss of genetic diversity of cultivated plants and domestic farm animals in agricultural ecosystems and of wild relatives is halted....
Enhance benefits to all from biodiversity and ecosystem services.	14. Ecosystems that provide essential services and contribute to health, livelihoods, and well-being, are safeguarded.... 15. Ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration....
Enhance implementation through participatory planning, knowledge management, and capacity building.	16. Access to genetic resources is [promoted] [facilitated] [enhanced], and benefits are shared.... 17. Each party has developed, adopted, ... and implemented, an effective, participatory, and updated national biodiversity strategy and action plan. 18. [[Have [sui generis legal] systems in place to protect] traditional knowledge, innovations, and practices relevant to biodiversity ...].... 19. Knowledge, the science base and technologies relating to biodiversity, its values, functioning, status, and trends, are improved. 20. Capacity (human resources and financing) for implementing the convention has increased [10-fold].

effects of agricultural subsidies. But potential interactions between most other targets are ignored. Targets 7 and 13 would be expected to have well-understood effects on the supply of ancillary ecosystem services and on species not directly exploited in the production of crops or livestock (13–15). Also, target 6 addresses threats to fish production. Its implementation would affect and be affected by implementation of targets for other ecosystem services, including regulation of climate (16, 17).

4) *Trade-offs between targets.* Different services require different diversity. How much diversity is critical depends on the set of services we need. But species that support a service such as climate regulation are different from species that support a service such as food production (18, 19), and there may be trade-offs between them. That is the core message of the MA (5). Targets need to be set in recognition of these trade-offs. It may not be possible to meet all of the 2020 targets.

Options for the Future

The 2020 targets are a significant improvement over the 2010 target and its indicators (2), but they could be strengthened. If there have to be 20 targets, they should address the 20 highest-priority threats to critical ecosystem services and should not include omnibus targets (e.g., targets 14 and 15) that necessarily fail the SMART test. Setting such priorities is a political process that reflects national perceptions of both the relative importance of different services and their relative vulnerability. For example, the

2020 targets to be considered at CBD COP10. Authors compiled headline text to be discussed by COP delegates on each of the targets [from (21)], and color-coded according to (6) (see text for explanation of code). Bracketed terms have not been agreed upon and are to be debated. For expanded text on each target, see Supporting Online Material.

importance of preserving genetic information in rare and endangered species is fairly well recognized. But the importance of maintaining species needed to protect many other services during a period of rapid environmental change is not as widely appreciated. Identifying what we collectively lose from failing to meet different targets is an important step toward target prioritization.

Collective action to identify and implement biodiversity targets is needed most where people have the weakest incentive to take the biodiversity impacts of their actions into account. Open-access common pool resources—like the high seas—are especially vulnerable. But collective action is also needed where services at risk are of high social value.

Toward these ends, efforts to establish an Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) are in their closing stages (20). IPBES would create capacity to evaluate both progress toward biodiversity targets and the costs of falling short. Such resources could provide an opportunity to put in place a more structured sequence of objectives for the collective management of biosphere change.

References and Notes

1. S. H. M. Butchart *et al.*, *Science* **328**, 1164 (2010).
2. Convention on Biological Diversity Secretariat, *Global Biodiversity Outlook 3* (CBD, Montreal, 2010).
3. H. Mooney, G. Mace, *Science* **325**, 1474 (2009).

4. G. M. Mace, J. E. M. Baillie, *Conserv. Biol.* **21**, 1406 (2007).
5. Millennium Ecosystem Assessment, *Ecosystems and Human Well-Being: General Synthesis* (Island Press, Washington, DC, 2005).
6. G. M. Mace *et al.*, *Curr. Opin. Environ. Sustain.* **2**, 3 (2010).
7. P. B. McIntyre, L. E. Jones, A. S. Flecker, M. J. Vanni, *Proc. Natl. Acad. Sci. U.S.A.* **104**, 4461 (2007).
8. D. E. Bunker *et al.*, *Science* **310**, 1029 (2005).
9. M. E. Bracken, S. E. Friberg, C. A. Gonzalez-Dorantes, S. L. Williams, *Proc. Natl. Acad. Sci. U.S.A.* **105**, 924 (2008).
10. M. Solan *et al.*, *Science* **306**, 1177 (2004).
11. M. T. Bulling *et al.*, *Philos. Trans. R. Soc. Lond. B Biol. Sci.* **365**, 2107 (2010).
12. J. A. Godbold, M. Solan, *Mar. Ecol. Prog. Ser.* **396**, 273 (2009).
13. P. A. Matson, W. J. Parton, A. G. Power, M. J. Swift, *Science* **277**, 504 (1997).
14. J. Pretty, *Philos. Trans. R. Soc. Lond. B Biol. Sci.* **363**, 447 (2008).
15. M. R. W. Rands *et al.*, *Science* **329**, 1298 (2010).
16. J. B. C. Jackson *et al.*, *Science* **293**, 629 (2001).
17. B. Worm *et al.*, *Science* **314**, 787 (2006).
18. D. Tilman, K. G. Cassman, P. A. Matson, R. Naylor, S. Polasky, *Nature* **418**, 671 (2002).
19. Y. Malhi *et al.*, *Science* **319**, 169 (2008).
20. A. Larigauderie, H. Mooney, *Curr. Opin. Environ. Sustain.* **2**, 9 (2010).
21. CBD, *Revised and Updated Strategic Plan: Technical Rationale and Suggested Milestones and Indicators* (CBD, Montreal, 2010); www.cbd.int/doc/meetings/cop/cop-10/official/cop-10-09-en.pdf.
22. The authors are associated with the ecoSERVICES and bioSUSTAINABILITY projects of DIVERSITAS.

Supporting Online Material

www.sciencemag.org/cgi/content/full/330/6002/323/DC1

10.1126/science.1196431