

LETTER TO THE EDITOR

'New conservation' or surrender to development?B. Miller¹, M. E. Soulé² & J. Terborgh³¹ Denver Zoological Foundation, Las Vegas, NM, USA² Environmental Studies, University of California, Santa Cruz, CA, USA³ Center for Tropical Conservation, Duke University, Durham, NC, USA**Correspondence**

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Ecologists have concluded that diversity *per se* in ecosystems is important to ecosystem function and ecological services. Meta-analyses of several hundred investigations showed that a loss of diversity negatively affected ecosystem function (Balvanera *et al.*, 2006; Cardinale *et al.*, 2006, 2011; Tilman, 2012). Specifically, research showed that loss of species diversity decreased productivity, resilience, nutrient cycling, drought tolerance, options for water management, resistance to pests and efficiency of ecosystems while increasing chances of catastrophic disease (Keesing *et al.*, 2010; Tilman, 2012; Washington, 2013). Yet, the planet's biodiversity is affected by explosions in human population, advancing technology and increasing per capita consumption (Wilson, 2002).

Lately, some propose that the future of conservation lies in managing nature for human benefit (Kareiva & Marvier, 2007; Kareiva *et al.*, 2007; Nordhaus & Shellenberger, 2007; Marris, 2011; Kareiva, Lalasz & Marvier, 2012a; Duncan, 2013). Directing conservation action for human benefit is nothing new. It recycles the ideas of Gifford Pinchot, maximum sustainable yield and the Brundtland Commission. Here, we critique some recent assumptions in the various forms of this ideology (hereafter, *ideology*), many of which use human exceptionalism as a justification: (1) nature is a warehouse for human use; (2) humans can construct new ecosystems from non-native species; (3) humans do not have to live within limits; (4) nature is resilient; (5) nature is a social construct; (6) conservationists preach too much doom and gloom; (7) people can manage nature intensively while preserving biodiversity.

Nature is a warehouse for humans

This assumption rests on protecting what humans value (Kareiva & Marvier, 2007, 2012; Kareiva *et al.*, 2007; Marris, 2011). There are arguments for protecting some species, often couched under quantifying monetary value. We would warn, however, that when economics can justify the existence of species with profit value, it also can justify the extinction of those interfering with profit. By viewing

nature as beneath us, or even more radically, formed by us, humans pretend we can manipulate nature without consequence (Washington, 2013). A quick look at the ever-worsening environmental crisis proves this anthropocentric idea false.

Alternatively, an eco-centric grounding respects the right of nature to exist with or without direct value to humanity. While humanity evolved within nature, and needed a healthy respect for it to survive, modernism has pushed us toward anthropocentrism; this self-centered dogma is now ingrained in neoliberal economic theory, governments, religions and education systems (Washington, 2013). Anthropocentrism is a large part of the *ideology*. Without recognizing the importance of intrinsic value, we will increase our separation from nature, not reconcile it. That separation will not bode well for humans as the environmental crisis worsens.

Ethics are restrictions to curb selfish actions that may cause larger harm. Science and environmental ethics influence each other in a mutually beneficial way; science showed us that humans are part of the same evolutionary line as all other species, making decisions about how humans treat the diversity of life important (Rozzi, 1999). Those decisions should be made with respect and humility, not the egoism of anthropocentrism. Yet, the *ideology* is based in utilitarian approaches, and plans for sustainability are often designed by people who view progress as economic growth and an accumulation of material goods in a market economy (Frazier, 1997).

Cultural diversity rests on biodiversity, so a loss of the latter leads to a loss of the former (Rozzi, 1999; Davidson-Hunt *et al.*, 2012). Indeed, the field of bio-cultural diversity is framed in terms of conservation (with a focus on extinction, crisis and loss, e.g. Soulé, 1986) because of the link between culture, language and healthy nature (Davidson-Hunt *et al.*, 2012). While many traditional cultures living within nature have learned from past missteps (systems living counter to nature faced natural selection), policy driven by neoliberal economics does not consider human dependence on biodiversity (Czech, 2013; Dietz & O'Neil, 2013; Washington, 2013). Just as we fight

exploitation of one group of humans by another, we should fight the loss of biodiversity by uncritical development schemes (Soulé, 1995). For more discussion of environmental ethics, see Rolston (2012) and Washington (2013).

People can use exotics to construct people-friendly ecosystems (presumably lacking inconvenient plants and animals)

Because the *ideology* places less emphasis on intrinsic value, it is easier to rationalize the construction of new ecosystems; this degrades spiritual and cultural connections to nature (Washington, 2013). Citing the work of Lugo in Puerto Rico, Marris (2011, 145) claimed human-made systems were superior, saying 'The understory in the plantations was richer in species, had greater aboveground biomass, and used nutrients more efficiently than the native understories'. Yet, a publication by Lugo & Helmer (2004) about these same Puerto Rican forests said, 'New [novel] forests have fewer endemic species, lower soil carbon and litter stocks; and they accumulate above-ground biomass, basal area, and soil carbon more slowly than mature [native] forests of the same age' (Lugo & Helmer, 2004, 145). Even though novel and native forests in Puerto Rico have similar species richness and structural features, there are important differences, and forests in New England showed a similar result (Lugo & Helmer, 2004).

When discussing novel systems, Marris (2011) referred to studies by Sax *et al.* (2007), showing that oceanic islands with exotics had increased their species richness of plants. But such gains in richness may be transient because of competition-induced extinction of endemics, a process which can take hundreds or thousands of years (Sax *et al.*, 2007). In addition, exotic herbivores promoted the invasion of exotic plants; a meta-analysis of 63 manipulated field studies reported that native herbivores made it more difficult for exotic plants to establish, but exotic herbivores facilitated invasion of exotic plants (Parker, Burkepile & Hay, 2006). Exotic herbivores already are well-established on many islands.

A host of other studies demonstrated a decline of native fauna following introductions of exotic species on islands (Roemer, Donlan & Courchamp, 2002; Sax, Gaines & Brown, 2002; Keitt & Tershy, 2003; Croll *et al.*, 2005; Kurler, Croll & Tershy, 2008; Jones *et al.*, 2008; also see Wilcove *et al.*, 1998 and Mack *et al.*, 2000 for more about ecological damage due to exotics). Thus, Marris (2011) makes an error of scale when she proposes that richness does not change. Local richness on islands may not change, or even increase, but global diversity declines because exotic generalists replace local endemics. The trend is for increasing biological homogeneity, not diversity.

We do not have to live within limits

Nordhaus & Shellenberger (2007) openly advocate an ecological movement based on growth and production. During

the 20th century, the world's human population increased by a factor of 4, while the world economy increased by a factor of 40 (Wright, 2005). Already, we use 72% of Earth's ice-free land to provide our food and shelter (Baillie *et al.*, 2010; Tilman, 2012). By 2050, we may reach 10 billion people with a predicted per capita increase in buying power of 150% (Tilman, 2012). There is a fixed amount of energy coming to the Earth as sunlight, yet energy consumption increases (Washington, 2013). We adjust by using past sunlight in the form of fossil fuels (Czech, 2013). We cannot continue to expand human numbers and consumption when all of life relies on finite resources (Czech, 2013).

Czech (2013) and Dietz & O'Neil (2013) provided a thorough discussion of ecological economics, the steady state economy and the fallacy of eternal economic growth. While nature supplies the resources for economic transactions, modern economic theory ignores the principles of physics (e.g. the Laws of Thermodynamics) and ecology that govern those natural resources (Czech, 2008). We thus have a continuing conflict between the neoliberal economy and nature's economy (Czech, 2013). In the end, degree of growth and level of profitability determines the amount of nature's capital left for natural processes and function (Czech, 2008). Relying on economic growth to reduce poverty has been unsuccessful; for every \$100 of global growth between 1990 and 2001, only 60 cents of that \$100 went to people making less than \$1 per day (Dietz & O'Neil, 2013).

Nature is more resilient than previously thought

Resilience is the ability to withstand or recover from a stress while retaining the same structure, function and feedbacks (Graham *et al.*, 2013). Kareiva *et al.* (2012a) stated that past anthropogenically related perturbations had few catastrophic effects, and that systems can recover from powerful human disturbances (listing pulse events like Chernobyl). They also cited the extirpation of the American chestnut (*Castanea dentata*). Yet it is clear with the chestnut and other highly interactive species that consequential ecological changes did occur following their disappearance (Soulé *et al.*, 2003, 2005; Ellison *et al.*, 2005; Kotliar *et al.*, 2006).

Kareiva, Lalasz & Marvier (2012b) later hedged statements about resilience by saying that ecosystems 'demonstrate the ability of nature to bounce back once a perturbation is curtailed'. That is an important caveat. The cumulative, unrelenting impacts of development and economic growth are the factors that usually prevent ecological recovery. In the face of human population growth, increases in technology and consumption and an economic paradigm of constant growth, it is guaranteed that those impacts will continue.

The ability to recover from disturbance depends on the scale of the disturbance (level and duration), the type of system disturbed and the possibility of alternative stable states (Simberloff *et al.*, 1999; MacMahon & Holl, 2001).

Given this uncertainty, blanket predictions about nature having a high level of resilience are premature and may promote ecological tinkering.

Nature is a social construct of western thought

Some propose that nature is a construct of western thought (Cronon, 1995), but this idea ignores the reality of autochthonously evolved species and ecological interactions (Terborgh, 1999; Estes *et al.*, 2011). It is also an example of the arrogance of humanism and further divorces us from nature (see Ehrenfeld, 1978). By establishing nature as a social construct, relativists then claim that the decision to sacrifice biodiversity in the name of development is a societal choice. Economics is the human construct. Nature is real, no matter how battered. A similar proposal claims there is no longer any pristine nature (countering the claim of strong resilience), which Doak *et al.* (2013) have rebutted. If the view is utilitarian, it pays to deny nature's existence (Washington, 2013).

The public is tired of hearing messages filled with doom and gloom

How would Frederick Douglas, Nelson Mandela or Ghandi have reacted if someone complained that their message had too much doom and gloom? No one likes to hear bad news about our declining environmental conditions, but that does not mean the public should be sheltered from it. Saying that messages have too much doom and gloom deflects attention from the hard, societal choices necessary for solutions to the conservation crisis. Ignorance and denial do not make for good public policy.

We can manage nature intensively and still protect biodiversity

According to Baillie *et al.* (2010), the four largest extinction forcers are: (1) agriculture and pastureland; (2) logging; (3) residential and commercial development; (4) exotic species including livestock; forcers 1 and 2 alone cover 72% of Earth's ice-free land. Kareiva & Marvier (2012) claimed that even highly modified systems can offer conservation value and cited Daily *et al.* (2003). Daily *et al.* (2003), however, stated that the mammalian fauna in the 40-year-old study site around the Las Cruces Reserve had no guarantee of persistence. Indeed, the Las Cruces Reserve 'was key to maintaining the regional diversity of mammals because it was the sole locus of some of the most specialized species' (Daily *et al.*, 2003, 1820).

Similarly, Kareiva & Marvier (2012), citing Ostrom (2009), challenged the inevitability of the Tragedy of the Commons. The Tragedy of the Commons targets resources used by humans, not biodiversity. Trying to extend Ostrom's (2009) thoughtful ideas about resource use to

conserving biodiversity is overreaching. Ostrom's paper (2009) identified variables that affect efforts toward sustainability. Among them, she noted that it is harder to organize for sustainability across large territories than small areas, that 'users need to observe some scarcity before they invest in self-organization', that users will not manage for the future if the resource is very abundant or nearly exhausted, that self-organization is harder if the resource is mobile than if it is stationary, that large numbers of users make it more costly to organize, and that if the resource regenerates slowly and human numbers grow rapidly 'users may not understand the carrying capacity of the resource, fail to organize, and destroy the resource' (Ostrom, 2009, 420–421). Ludwig, Hilborn & Walters (1993), writing about the failure of maximum sustainable yield, noted that large levels of natural variability in a system masked the effects of overexploitation; complexity precluded a reductionist approach to management; wealth, corruption and power worked against sustainability; and thus there have been spectacular failures to manage forest and fishery industries. Clearly, successful sustainable plans are very complex and require management at multiple levels with pluralistic approaches (Berkes, 2007).

Ecological processes and interacting species push a natural system toward complexity and resilience, but economic profit requires simplification and control. That is the conundrum for those who say they can modify systems and maintain biodiversity. Will key species for ecological function, like large carnivores and megafauna, be welcome in these managed landscapes? There is no evidence, at relevant scales, that biodiversity, growing human numbers, the technological juggernaut and unregulated corporations can coexist (Soulé, 2013).

Conclusion

Kareiva & Marvier (2012) stated that much in present conservation is anecdotal, and it needs to be more firmly based in data. Yet, conservation science united traditional wildlife management with academic theory (Soulé, 1986). This synthesis gave an evolutionary-ecological view to conservation issues, and academic standards gave it rigor. There are peer-reviewed journals, such as this one, and the competition is steep. Significant additions to ecological theory from conservation science include the value of highly interactive species to ecosystem integrity, area effects, effects of fragmentation, risks for small populations, population models, viable populations, genetic models, effective population size, trophic cascades, ramifications of climate change and changing the overall emphasis from managing single species as a resource to the importance of nature's diversity (Soulé & Wilcox, 1980; Soulé, 1986; Soulé & Terborgh, 1999). Kareiva & Marvier (2012) acknowledge none of these.

We agree with Kareiva & Marvier (2012) that children need more exposure to nature, humans determine the fate of conservation in an area, we should cooperate with corporations when such cooperation yields benefits to both wildlife and people (remembering that corporations have severely

harmed people, indigenous cultures and nature; Doak *et al.*, 2013), and conservation can provide benefits to humans. There are aesthetic, spiritual, educational, recreational and commercial benefits to nature protection; many issues important to biodiversity are also important to humans (Washington, 2013). These ideas are not new.

Yet, the assumption that managing nature for human benefit will preserve ecological integrity is ungrounded and does not address the root causes of biological destruction, such as the paradigm of unlimited economic growth, unabated consumption and ever-increasing human numbers. Much of the latter will occur in tropical countries, expanding agriculture and increasing threats to protected areas (Laurence, Sayer & Cassman, 2014). We contend that the *ideology* rests more on delusion and faith than on evidence.

The ethic of the *ideology* is utilitarian and sometimes parallels neoliberal economic philosophy. Increasingly, the boards of the larger environmental NGOs are dominated by financial and corporate interests whose values are antithetical to the protection of ecosystem integrity (view the NGO websites). Despite the optimistic expectations of the environmental Kuznets curve, increasing affluence magnifies, rather than reduces, human impacts on nature (Dietz, Rosa & York, 2007; Czech, 2013). Robinson & Redford (1991), Wright (2005), and others stated that when human populations grow, technology improves, and participation in market economies increases, humans inevitably deplete resources. As biodiversity declines, so does cultural diversity (Rozzi, 1999). Very few cultures can withstand the onslaught of market economies.

The center of traditional conservation is the preservation of biodiversity for ecosystem function and evolutionary potential (Soulé, 2013). Doing this requires networks of protected lands; connectivity is a critical tenet (Soulé & Terborgh, 1999). Laurance *et al.* (2012) included a group of over 200 authors, all agreeing that large areas protected for biodiversity are necessary. Of course, for land outside of protected areas, conservation strategies must include human uses with as little damage to nature as possible. But increasingly, only within parks and protected areas will many large animals critical to ecological processes persist. Overall, we need a broader conservation politic that motivates people to care for nature and mobilizes them to act on that belief (see Johns, 2009).

Barnosky *et al.* (2013) recently produced a multi-authored document on saving humanity's life-support systems. They stated that the extinction of biodiversity, climate change, loss of ecosystems, pollution and ever-increasing numbers of people devouring the planet's resources all act synergistically to lead us in a dangerous direction. Over 1400 scientists around the world have endorsed that report. Too often, humans view these factors individually instead of through their interactions. Furthermore, Barnosky *et al.* (2013) stated, 'Until now, these have often been viewed as "necessary evils" for progress, or collateral damage that, while unfortunate, would not ultimately stand in the way of serving the needs of people' (Barnosky *et al.*, 2013, 4). The *ideology* seems to continue

the idea that they are collateral damage along the road to development.

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References

- Baillie, J.E.M., Griffiths, J., Turvey, S.T., Loh, J. & Collen, B. (2010). *Evolution lost: status and trends of the world's vertebrates*. London: Zoological Society of London.
- Balvanera, P., Pfisterer, A.B., Buchmann, N., He, J.S., Nakashizuka, T., Raffaelli, D. & Schmid, D. (2006). Quantifying the evidence for biodiversity effects on ecosystem functioning and services. *Ecol. Lett.* **10**, 1146–1156.
- Barnosky, A.D., Brown, J.H., Daily, G.C., Dirzo, R., Ehrlich, A.H., Ehrlich, P.R., Eronen, J.T., Fortelius, M., Hadly, E.A., Leopold, E.B., Mooney, H.A., Myers, J.P., Naylor, R.L., Palumbi, S., Stenseth, N.C. & Wake, M.H. (2013). Scientific consensus on maintaining humanity's life support systems in the 21st Century: information for policy makers. Berkeley, California: Department of Integrative Biology and Museum of Paleontology, University of California-Berkeley.
- Berkes, F. (2007). Community-based conservation in a globalized world. *PNAS* **104**, 15188–15193.
- Cardinale, B.J., Srivastava, D.S., Duffy, E., Wright, J.P., Downing, A.L., Sankaran, M. & Jouseau, C. (2006). Effects of biodiversity on the functioning of trophic groups and ecosystems. *Nature* **443**, 989–992.
- Cardinale, B.J., Matulich, K.L., Hooper, D.U., Byrnes, J.E., Duffy, E., Garnfeldt, L., Balvanera, P., O'Conner, M.I. & Gonzalez, A. (2011). The functional role of producer diversity in ecosystems. *Am. J. Bot.* **98**, 572–592.
- Croll, D.A., Maron, J.L., Estes, J.A., Danner, E.M. & Byrd, G.V. (2005). Introduced predators transform subarctic islands from grassland to tundra. *Science* **307**, 1959–1961.
- Cronon, W. (1995). The trouble with wilderness. In *Uncommon ground: rethinking the human place in nature*: 69–90. Cronon, W. (Ed.). New York: W.W. Norton & Co.
- Czech, B. (2008). Prospects for reconciling the conflict between economic growth and biodiversity conservation with technological progress. *Conserv. Biol.* **22**, 1389–1398.
- Czech, B. (2013). *Supply shock: economic growth at the crossroads and the steady state solution*. Gabriola Island: New Society Publishers.
- Daily, G.C., Ceballos, G., Pacheco, J. & Sanchez-Azofeifa, S.G. (2003). Countryside biogeography of neotropical mammals: conservation opportunities in agricultural landscapes of Costa Rica. *Conserv. Biol.* **17**, 1814–1826.

- Davidson-Hunt, I.J., Turner, K.L., Pareake Mead, A.T., Cabrera-Lopez, J., Bolton, R., Idrobo, C.J., Miretski, I., Morrison, A. & Robson, J.T. 2012. Biocultural design: a new conceptual framework for sustainable development in rural indigenous and local communities. SAPI ENS. Surveys and Perspectives Integrating Environment and Society Vol. 5. #2. Gland, Switzerland: IUCN.
- Dietz, R. & O'Neil, D. (2013). *Enough is enough: building a sustainable economy in a world of finite resources*. San Francisco: Berret-Koehler Publishers.
- Dietz, T., Rosa, E.A. & York, R. (2007). Driving human ecological footprint. *Front. Ecol. Environ.* **5**, 13–18.
- Doak, D.F., Bakker, V.J., Goldstein, B.E. & Hale, B. (2013). What is the future of conservation. *Trends Ecol. Evol.* **29**, 1–5.
- Duncan, E. 2013. The Economist Special Report: Biodiversity. All Creatures Great and Small (Sept. 14, 2013). <http://www.economist.com/news/specialreport/21585091-biodiversity-once-preoccupationscientists-and-greens-has-become-mainstream> (accessed November 2013).
- Ehrenfeld, D. (1978). *The arrogance of humanism*. Oxford: Oxford University Press.
- Ellison, A.M., Bank, M.S., Clinton, B.D., Colburn, E.A., Elliot, K., Ford, C.R., Foster, D.R., Kloeppel, B.D., Knoepp, J.D., Lovett, G.M., Mohan, J., Orwig, D.A., Rodenhouse, N.L., Sobczak, W.V., Stinson, K.A., Stone, J.K., Swan, C.M., Thompson, J., Holle, B.V. & Webster, J.R. (2005). Loss of foundation species: consequences for the structure and function of forested ecosystems. *Front. Ecol. Environ.* **3**, 479–486.
- Estes, J.A., Terborgh, J., Brashares, J.S., Power, M.E., Berger, J., Bond, W.J., Carpenter, S.R., Essington, T.E., Holt, R.D., Jackson, J.B.C., Marquis, R.J., Oksanen, L., Oksanen, T., Paine, R.T., Pickett, E.K., Ripple, W.J., Sandin, S.A., Scheffer, M., Shoener, T.W., Shurin, J.B., Sinclair, A.R.E., Soulé, M.E., Vrtanen, R. & Wardle, D.A. (2011). Trophic downgrading of planet Earth. *Science* **333**, 301–306.
- Frazier, J. (1997). Sustainable development: modern elixir or sack dress? *Environ. Conserv.* **24**, 182–193.
- Graham, N.A.J., Bellwood, D.R., Cinner, J.E., Hughes, T.P., Norström, A.P. & Nyström, M. (2013). Managing resilience to reverse phase shifts in coral reefs. *Front. Ecol. Environ.* **11**, 541–548.
- Johns, D. (2009). *A new conservation politics: power, organization building, and effectiveness*. Oxford: Wiley-Blackwell.
- Jones, H., Tershy, B., Zavaleta, E., Croll, D., Keitt, B., Finkelstein, M. & Howald, G. (2008). Severity of the effects of invasive rats on seabirds: a global review. *Conserv. Biol.* **22**, 16–26.
- Kareiva, P. & Marvier, M. (2007). Conservation for the people. *Scientific American*: Nov. 50–57.
- Kareiva, P. & Marvier, M. (2012). What is conservation science? *Bioscience* **62**, 962–969.
- Kareiva, P., Watte, S., McDonald, R. & Boucher, T. (2007). Domesticated nature: shaping landscapes and ecosystems for human welfare. *Science* **316**, 1866–1869.
- Kareiva, P., Lalasz, R. & Marvier, M. (2012a). Conservation in the Anthropocene: beyond solitude and fragility. <http://thebreakthrough.org/index.php/journal/past-issues/issue-2/conservation-in-the-anthropocene/> (accessed January 2013).
- Kareiva, P., Lalasz, R. & Marvier, M. (2012b). Anthropocene Revisited. <http://thebreakthrough.org/index.php/journal/debates/conservation-in-the-anthropocene-a-breakthrough-debate/anthropocene-revisited/> (accessed January 2013).
- Keasing, F., Belden, L.K., Daszak, P., Dobson, A., Harvell, D., Holt, R.D., Hudon, P., Jolles, A., Jones, K.E., Mitchell, C.E., Myers, S.S., Bogich, T. & Osfeld, R.S. (2010). Impacts of biodiversity on the emergence and transmission of infectious diseases. *Nature* **468**, 647–652.
- Keitt, B. & Tershy, B.R. (2003). Cat eradication significantly decreases shearwater mortality. *Anim. Conserv.* **6**, 307–308.
- Kotliar, N.B., Miller, B.J., Reading, R.P. & Clark, T.W. (2006). The prairie dog as a keystone species. In *Conservation of the black-tailed prairie dog: saving North America's western grasslands*: 53–64. Hoogland, J.L. (Ed.). Washington: Island Press.
- Kurle, C., Croll, D.A. & Tershy, B.R. (2008). Introduced rats indirectly change marine rocky intertidal communities from algae- to invertebrate-dominated. *Proc. Natl. Acad. Sci.* **105**, 3800–3804.
- Laurance, W.F., Useche, D.C., Rendeiro, J., Kalka, M., Bradshaw, C.J., Sloan, S.P., Laurance, S.G., Campbell, M., Abernethy, K., Alvarez, P., Arroyo-Rodriguez, V., Ashton, P., Benítez-Malvido, J., Blom, A., Bobo, K.S., Cannon, C.H., Cao, M., Carroll, R., Chapman, C., Coates, R., Cords, M., Danielsen, F., De Dijn, B., Dinerstein, E., Donnelly, M.A., Edwards, D., Edwards, F., Farwig, N., Fashing, P., Forget, P.M., Foster, M., Gale, G., Harris, D., Harrison, R., Hart, J., Karpanty, S., Kress, W.J., Krishnaswamy, J., Logsdon, W., Lovett, J., Magnusson, W., Maisels, F., Marshall, A.R., McClearn, D., Mudappa, D., Nielsen, M.R., Pearson, R., Pitman, N., van der Ploeg, J., Plumptre, A., Poulsen, J., Quesada, M., Rainey, H., Robinson, D., Roetgers, C., Rovero, F., Scatena, F., Schulze, C., Sheil, D., Struhsaker, T., Terborgh, J., Thomas, D., Timm, R., Urbina-Cardona, J.N., Vasudevan, K., Wright, S.J., Arias-G, J.C., Arroyo, L., Ashton, M., Auzel, P., Babaasa, D., Babweteera, F., Baker, P., Banki, O., Bass, M., Bila-Isia, I., Blake, S., Brockelman, W., Brokaw, N., Brühl, C.A., Bunyavejchewin, S., Chao, J.T., Chave, J., Chellam, R., Clark, C.J., Clavijo, J., Congdon, R., Corlett, R., Dattaraja, H.S., Dave, C., Davies, G., Beisiegel, B de M., da Silva, R, de N., Di Fiore, A., Diesmos, A., Dirzo, R., Doran-Sheehy, D., Eaton, M.,

- Emmons, L., Estrada, A., Ewango, C., Fedigan, L., Feer, F., Fruth, B., Willis, J.G., Goodale, U., Goodman, S., Guix, J.C., Guthiga, P., Haber, W., Hamer, K., Herlinger, I., Hill, J., Huang, Z., Sun, I.F., Ickes, K., Itoh, A., Ivanauskas, N., Jackes, B., Janovec, J., Janzen, D., Jiangming, M., Jin, C., Jones, T., Justiniano, H., Kalko, E., Kasangaki, A., Killeen, T., King, H.B., Klop, E., Knott, C., Koné, I., Kudavidanage, E., Ribeiro, J.L., Lattke, J., Laval, R., Lawton R., Leal, M., Leighton, M., Lentino, M., Leonel, C., Lindsell, J., Ling-Ling, L., Linsenmair, K.E., Losos, E., Lugo, A., Lwanga, J., Mack, A.L., Martins, M., McGraw, W.S., McNab, R., Montag, L., Thompson, J.M., Nabe-Nielsen, J., Nakagawa, M., Nepal, S., Norconk, M., Novotny, V., O'Donnell, S., Opiang, M., Ouboter, P., Parker, K., Parthasarathy, N., Pisciotta, K., Prawiradilaga, D., Pringle, C., Rajathurai, S., Reichard, U., Reinartz, G., Renton, K., Reynolds, G., Reynolds, V., Riley, E., Rödel, M.O., Rothman, J., Round, P., Sakai, S., Sanaiotti, T., Savini, T., Schaab, G., Seidensticker, J., Siaka, A., Silman, M.R., Smith, T.B., de Almeida, S.S., Sodhi, N., Stanford, C., Stewart, K., Stokes, E., Stoner, K.E., Sukumar, R., Surbeck, M., Tobler, M., Tschartnke, T., Turkalo, A., Umapathy, G., van Weerd, M., Rivera, J.V., Venkataraman, M., Venn, L., Vere, C., de Castilho, C.V., Waltert, M., Wang, B., Watts, D., Weber, W., West, P., Whitacre, D., Whitney, K., Wilkie, D., Williams, S., Wright, D.D., Wright, P., Xiankai, L., Yonzon, P. & Zamzani, F. (2012). Averting biodiversity collapse in tropical protected areas. *Nature Letter*. <http://www.nature.com/nature/journal/vaop/ncurrent/full/nature11318.html> (accessed March 2013).
- Laurence, W.F., Sayer, J. & Cassman, K.G. (2014). Agricultural expansion and its impacts on tropical nature. *Trends Ecol. Evol.* **29**, 107–116.
- Ludwig, D., Hilborn, R. & Walters, C. (1993). Uncertainty, resource exploitation, and conservation: lessons from history. *Science* **260**, 17–36.
- Lugo, A.E. & Helmer, E. (2004). Emerging forests on abandoned land: Puerto Rico's new forests. *For. Ecol. Manage.* **190**, 145–161.
- Mack, R.N., Simberloff, D., Lonsdale, W.N., Evans, H., Clout, M. & Bazzaz, F.A. (2000). Biotic invasions: causes, epidemiology, global consequences, and control. *Ecol. Appl.* **10**, 689–710.
- MacMahon, J.A. & Holl, K.D. (2001). Ecological restoration: a key to conservation biology's future. In *Conservation biology: research priorities for the next decade*: 245–269. Soulé, M.E. & Orions, G.H. (Eds). Washington: Island Press.
- Marris, E. (2011). *Rambunctious garden: saving nature in a post-wild world*. New York: Bloomsbury.
- Nordhaus, T. & Shellenberger, M. (2007). *Breakthrough: from the death of environmentalism to the politics of possibility*. New York: Houghton-Mifflin.
- Ostrom, E. (2009). A general framework for analyzing sustainability of socio-economic systems. *Science* **325**, 419–422.
- Parker, J.D., Burkepile, D.E. & Hay, M.E. (2006). Opposing effects of native and exotic herbivores on plant invasions. *Science* **311**, 1459–1461.
- Robinson, J.G. & Redford, K.H. (1991). Sustainable harvest of Neotropical forest animals. In *Neotropical wildlife use and conservation*: 415–429. Robinson, J.G. & Redford, K.H. (Eds). Chicago: University of Chicago Press.
- Roemer, G.W., Donlan, C.W. & Courchamp, F. (2002). Golden eagles, feral pigs, and insular carnivores: how exotic species turn native predators into prey. *Proc. Natl Acad. Sci. U.S.A.* **99**, 791–796.
- Rolston, H. (2012). *A new environmental ethics: the next millennium for life on earth*. New York: Routledge.
- Rozzi, R. (1999). The reciprocal links between evolutionary-ecological sciences and environmental ethics. *Bioscience* **49**, 911–921.
- Sax, D.V., Gaines, S.D. & Brown, J.H. (2002). Species invasions exceed extinctions on islands worldwide: a comparative study of plants and birds. *Am. Nat.* **160**, 766–783.
- Sax, D.V., Stachowicz, J.J., Brown, J.H., Bruno, J.F., Dawson, M.N., Gaines, S.D., Grosberg, R.K., Hastings, A., Holt, R.D., Mayfield, M.M., O'Connor, M.I. & Rice, W.R. *et al.* (2007). Ecological and evolutionary insights from species invasions. *Trends Ecol. Evol.* **22**, 465–471.
- Simberloff, D., Doak, D., Groom, M., Trombulak, S., Dobson, A., Gatewood, S., Soulé, M.E., Gilpin, M., Martínez del Río, C. & Mills, L. (1999). Regional and continental restoration. In *Continental conservation: scientific foundations of regional reserve networks*: 65–98. Soulé, M.E. & Terborgh, J. (Eds). Washington: Island Press.
- Soulé, M.E. (Ed.) (1986). *Conservation biology: the science of scarcity and diversity*. Sunderland: Sinauer Associates Inc.
- Soulé, M.E. (1995). The social siege of nature. In *Reinventing nature? Responses to post-modern deconstruction*: 137–170. Soulé, M.E. & Lease, G. (Eds). Washington: Island Press.
- Soulé, M.E. (2013). The new conservation. *Conserv. Biol.* **27**, 895–897.
- Soulé, M.E. & Terborgh, J. (Eds) (1999). *Continental conservation: scientific foundations of regional reserve networks*. Washington: Island Press.
- Soulé, M.E. & Wilcox, B.A. (Eds) (1980). *Conservation biology: an evolutionary-ecological perspective*. Sunderland: Sinauer Associates Inc.
- Soulé, M.E., Estes, J.A., Berger, J. & Martínez del Río, C. (2003). Ecological effectiveness: conservation goals for interactive species. *Conserv. Biol.* **17**, 1238–1250.
- Soulé, M.E., Estes, J.A., Miller, B. & Honnold, D.L. (2005). Strongly interacting vertebrate species: conservation policy, management, and ethics. *Bioscience* **55**, 168–176.

- Terborgh, J. (1999). *Requiem for nature*. Washington: Island Press.
- Tilman, D. (2012). Biodiversity and environmental sustainability amid human domination of global ecosystems. *Daedalus J. Am. Acad. Sci.* **141**, 108–120.
- Washington, H. (2013). *Human dependence on nature*. New York: Routledge.
- Wilcove, D.S., Rothstein, D., Dubow, J., Phillips, A. & Losos, E. (1998). Quantifying threats to imperiled species in the United States. *Bioscience* **48**, 607–615.
- Wilson, E.O. (2002). *The future of life*. New York: Alfred A. Knopf.
- Wright, R. (2005). *A short history of progress*. New York: Carroll and Graf Publishers.