Rachel Carson's landmark book *Silent Spring* (1962) critically helped spark modern environmentalism. Even now, its fluid prose remains evocative. The vivid imagery coupled with scientific information was both persuasive and emotionally potent. Carson's presentation drew on several themes. One was the balance of nature (1962/1987, pp. 6, 57, 66, 114, 246–248, 251). Through "eons" of history, she wrote, Earth's "developing and evolving and diversifying life reached a state of adjustment and balance with its surroundings" (p. 6). However, Carson urged, the indiscriminate use of chemical pesticides threatened that vital balance:

> Man, too, is a part of this balance. Sometimes the balance is in his favor; sometimes – and all too often through his own activities – it is shifted to his disadvantage. (p. 246)

If organisms could not adapt to the "barrage of poisons" hurled recklessly "against the fabric of life," the balance would be lost and, tragically, humans and other species would suffer a world made "unfit for all life" (pp. 8, 156, 279, 297).

Decades later, in 1992, Al Gore, too, appealed to balance in another important book for environmentalism, as its title, *Earth in the Balance*, prominently announced. Indeed, the concept of balance in nature has a long history, and belief in it remains common in American culture (Egerton, 1973; Hull et al., 2002; Jelinski, 2005; Zimmerman & Cuddington, 2007; Clifford, 2009; Ladle & Gillson, 2009).

I would like to challenge the widespread view (this essay's sacred bovine) that the "balance of nature" concept justifies environmental values. Indeed, quite to the contrary, I contend that it fosters scientifically ill-informed perspectives that ultimately work against both science and the prudential aim of environmental sustainability.

Among professional ecologists, at least, consensus has fallen squarely against any inherent balance in nature (Egerton, 1973; Botkin, 1990; Worster, 1994; Young, 2000; Cooper, 2001; Kricher, 2009). Populations do not self-regulate their size. Ecosystems do not self-regulate the number of species. Species do not keep each other "in check" for some abstract mutual benefit. Moreover, the prevalence of disturbance and environmental change – from continental drift and ice ages to local migrations and the vagaries of catastrophic weather – means that ecosystems exhibit no ultimate stability or stasis. Nature is in perpetual flux. Despite popular impressions, the balance of nature is not a *scientifically* valid concept. Indeed, this was one criticism of Rachel Carson's claims – notoriously, by industry's caustic Robert White-Stevens (*CBS Reports*, 1963, "The silent spring of Rachel Carson" [TV episode]; also see Darby, 1963), but also more sympathetically by Ira Baldwin (1962), in reviewing her book for the journal *Science*.

Of deeper concern, however, is *what counts as science* ("Sacred Bovines," April, 2012). How do nonscientists interpret the idea and its scientific status, and how do these perceptions ultimately shape public policy and personal decision making? For example, it is puzzling that belief in the balance of nature as scientifically validated persists even after basic ecological education (Zimmerman & Cuddington, 2007). Why? What is the nature of this popular way of thinking? What does it reflect about understanding of the nature of science? Appropriate delving reveals, I contend, some familiar and knotty problems involving teleology and naturalized ideals. By confounding normative and descriptive perspectives, the concept of balance muddles clear thinking about environmental issues, and about science, too. Biology educators should thus strive to dissolve misinformed views about the balance of nature.

The Specter of Imbalance

First, it is important to acknowledge that many adverse effects characterized using the "balance of nature" reflect significant environmental concerns – what Carson described as "the dire results of upsetting nature's own arrangements" (1962/1987, p. 248). Admittedly, many such problems may appear to be caused by imbalance: too much of this, or too little of that.

For example, *too many* phosphates (from laundry detergents) or *too many* nitrates (from runoff of excess fertilizer) can foster increased aquatic growth followed by eutrophication: the problematic "dead zones" in the Gulf of Mexico and elsewhere around the globe. These consequences are serious, and their sources deserve our consideration. Likewise, *too much* DDT or *too much* mercury in the environment can poison humans and other wildlife. *Too many* chlorofluorocarbons (CFCs) released from aerosol cans or damaged air conditioners can lead to ozone depletion in the atmosphere, with serious implications for the penetration of the sun's ultraviolet radiation and for climate change. *Too much* accumulation of greenhouse gases leads to climate change, with global implications. By contrast, *too little* foliage (as the outcome of deforestation) will also contribute to climate change. *Too little* vegetation (say, from burning or overgrazing) will facilitate erosion, the export of soil nutrients, and silting of rivers. Students readily recognize the outcome of *too many* births, or of *too little* food or resources (Zimmerman & Cuddington, 2007, p. 398). All these describe substantive environmental concerns. And imbalance seems, at first glance, a plausible generalized cause.

However, while any of these variables may explain significant environmental changes, the assessment of "too much" or "too little" entails something deeper. "Balance" involves something more than cause and effect. It is not just an equilibrium of various physical forces. It implies an expected endpoint, a goal, or a standard of comparison, and thus also a value system. The standard is an ideal or norm, foundational to *evaluation*, or *value judgment*. Balance signifies *good*. As implied in a *balanced* meal, a *balanced* financial status, or a *balanced* appraisal.

The American Biology Teacher, Vol. 76, No. 4, pages 286–290. ISSN 0002-7685, electronic ISSN 1938-4211.
DOI: 10.1525/abt.2014.76.4.13

But what is the benchmark or standard for assessing "balance" in nature, or what nature "ought" to be? One frequently encounters references to natural foods or medicines or to human nature, as though nature plainly exhibits observable ideals which, by virtue of their very existence, may be accepted as justified. The cryptic value inherent in "balance" and its relation to "nature" at least invites one to explore the deeper *meaning* of the concept. How does it function in reasoning in various contexts? Especially, how do values intersect with conceptualizing a balance of nature, and how does that shape our commitments and actions?

○ The Meaning of Balance

The concept of "balance of nature" is found in many cultures. In Western culture it is centuries old, advanced at least since Aristotle. At the same time, its meaning has always been somewhat vague or ambiguous, or subject to debate (Egerton, 1973). As documented among a cross section of university students, contemporary interpretations of the concept vary widely (Zimmerman & Cuddington, 2007, see pp. 397–400 for the quotations that follow; also see Hull et al., 2002). For some it is about population regulation; for others, coordinated species interactions. For yet others, it expresses harmony. Or homeostasis. Or the absence of destabilizing disturbance. One might begin to wonder whether people can communicate effectively using the same phrase. Still, despite the spectrum of characterizations, one feature is remarkably consistent. Namely, the "balance of nature" inevitably seems to refer to how nature *is supposed to be*, or *should* be. Namely, it has a potent normative dimension.

The normative thinking is rarely explicit (or likely even conscious), but it is evident in two ways. First, comments about balance reflect an assumption of underlying order, to which nature, ostensibly, unavoidably adheres. For example, in students' words, the balance of nature is "when everything in *nature is in order*." "Every living things *plays its part*." There is also purpose, manifest in unspecified guiding powers. Each species is "*doing what they're supposed to be doing*." It is "a condition that *naturally establishes itself*," or develops on its own when not disturbed. It is "where the physical environment *wants to be*" (all italics added for focal emphasis).

Rachel Carson, too, echoed the same sentiments in *Silent Spring*. She cautioned against "upsetting *nature's own arrangements*" (p. 248), implying an inherent, self-defined order. The "delicate balance of populations" was a means "by which nature accomplishes *far-reaching aims*" (p. 57). There exist "intimate *and essential* relations between plants and the earth" (p. 64). Nature reaches "a homoeostasis *based on the needs of the species* present" (p. 400; again, all italics added). For Carson, nature's balance was a form of intrinsic order.

The origins of attributions of inherent order are not difficult to fathom. Humans project them onto nature. They interpret species on the basis of how purpose and intention shape their own actions. The "balance of nature" thus reflects an anthropomorphic and teleological perspective of ecological causality. Most people cannot explain how concrete mechanisms might explain a "balanced" state. They do not appreciate how quasi-stability might emerge as a byproduct of uncoordinated proximal causes. For them, the alternative view is that nature *just is* balanced. And it is balanced *because it is supposed to be* balanced. That there is an inherent natural order is accepted without question or reflection.

In popular views, nature *ought* to be balanced in a second sense, as well. Namely, balance is also good, or desirable. Nature "should" embody that quality. The normative goal is not just anticipated or expected. It is a valued ideal. One student described the balance of

nature as "the point in the ecological system *where things are right* (i.e., population)." Namely (another noted), "where each species is *thriving* and *doing what they're supposed to be doing*." In other words, "where everything in the ecological system can function and live *properly*," or "there is a *proper* food chain." That is, no improprieties intrude. Accordingly, "the *needs* of a being *are satisfied*." Harmony is thus achieved, when "every living thing *plays its part*, and in its own way *helps* the other living things around it. In turn it is *helped by* other living things." Balance occurs when the factors of species and environment *"all contribute to a 'common good.'"* Even across variable interpretations, the balance "of nature" almost always refers to an imagined ideal, or norm.

Again, Carson exercised this meaning as well. At least indirectly. Balance was more than some dynamic equilibrium. It was the proper end-state to be respected and preserved, and to be recovered if lost. Left untouched, the upland plains of the West exhibited, she wrote, a "*perfect* balance," a "stable *and desirable* goal" (p. 66). Wanting to destroy that balance for grazing cattle thus hardly represented progress, as others contended. Similarly, upsetting nature's own arrangements led to "*dire* results," as in the case of coyotes and field mice (p. 248). The normative dimension of the balance of nature contributed significantly to the moral impetus of Carson's presentation. The prospect of interfering with an ideal balance that expressed an inherent order was ill conceived and *morally wrong*.

In summary, teleology and naturalized norms permeate popular conceptions of the balance of nature. In this, they reflect the concept's heritage. For centuries, the balance of nature embodied Christian theology, with its principles of divine beneficence and providence in nature (Egerton, 1973; Botkin, 1990; Jelinski, 2005). The view of balance thus parallels belief in so-called Intelligent Design. Here, the focus is on ecology rather than evolution. For this reason, the persistence of balance-of-nature thinking might be of special concern to biology educators.

Of deeper concern, however, might be how this style of thinking shapes environmental perspectives and decision making, both personal and public (Dizard, 1994; Kempton et al., 1995; Hull et al., 2002). First, the analysis here clarifies that while appeals to the balance of nature presumably reflect (plainly, simply, scientifically) the way nature is, they are constitutively permeated with human values and ideology. Normative and descriptive dimensions are conflated. Naturalizing a norm or value into a presumed fact of nature functions to short-circuit the responsibility of properly justifying that norm or value ("Sacred Bovines," Feb. 2007, Feb. 2008). Arguing ethically in favor of a vision of nature is very different than arguing scientifically (from empirical evidence) that it *is* a certain way. This conflation of argument types is unproductive, both for environmental discourse and – just as importantly – for an understanding of scientific reasoning. No balance-of-nature principle should be accepted as a scientific basis for environmental decisions. Rather, one should call upon anyone presenting such an argument to articulate and justify the implicit *values*. In that case, one needs arguments about ethical warrant, not scientific credibility.

A second concern about using the balance-of-nature concept in environmental discussions is how it tends to shift focus away from the critical issues. In such cases, environmental action seems to rely on accepting a personal interpretation of nature (despite appeals to science). But all the problems noted above, framed in the language of too much, too little, and balance, are ultimately about human health and maintaining an environment that supports life: poisoning the food we eat or the water we drink; irradiating our skin; changing our agricultural seasons; losing soil nutrients; depleting our fishing stocks; exhausting available food; or increasing the frequency of catastrophic weather that devastates our communities. These and most other environmental issues are fundamentally not about an abstracted nature. They are about us. Our survival and well being. Allusions to balance in nature divert us from the core issues.

Students need to learn that if you dump mercury into the bay where you live, it should not be surprising when the mercury later appears in the food chain, poisoning the fish and eventually the people that live there. That was the unfortunate lesson in Minamata, Japan, in the 1950s and '60s. There was no inherent principle of "balance" that protected the residents from harm. There was only tragedy, due to ecological shortsightedness (Allchin, 1999).

Nothing particularly majestic or transcendental justifies the goal of sustainability. It is mere prudence. Prudence informed by ecological science. When environmental arguments shift to nebulous values about the integrity of nature – an independent "other" deserving our respect – it is all too easy for profit-mongers to discount them as gibberish from overly sentimental "tree-huggers." The science gets lost. And for those who know and appreciate the science – and are sometimes called upon to defend its integrity – that disregard of knowledge is tragic. We should all be deeply concerned when ecology is eclipsed from informing us about the consequences of our actions. We are thereby blinded to inconvenient truths. Climate change and other urgent environmental problems become cast as matters of personal ideology and fuzzy values – *and therefore dismissed*. That is what the balance of nature ultimately means in public discourse.

○ An Alternative to Balance

How, then, might one limit teleology and naturalized norms in thinking about environmental issues? What other more appropriate concepts or metaphors might one adopt? Plumbing *Silent Spring*, one finds other significant themes. For example, in one passage, Carson used another concept to characterize the balance of nature as

> a complex, precise, and highly integrated system of relationships between living things which cannot safely be ignored. (p. 246)

That is, a key relevant feature of ecosystems is their complexity, not their overall "balance," equilibrium, or stability. There are multiple relationships among species and between them and their abiotic setting. The interactions form a complex causal network. An effect in one place can ripple throughout the entire system. Any change, even if apparently modest, has many potential downstream consequences. In some cases, the effects may be minimal because they are distributed and dampened, or buffered in a sense. Or they may cascade through many successive effects, widening the scope and amplifying the scale of the change. It is the compounded sequel effects of too much or too little – or of any change – that ultimately matters, not any state of "imbalance" per se. Complexity, not balance, is central.

Cases of complexity in ecosystems, and of causal effects cascading through them, are not unfamiliar to ecologists – or to biology educators. For example, consider the effect of a reduction in wolves in the Yellowstone region. The first consequence was an increase in the prey population of elk. Just an increase, not an "overabundance" as reported in the popular media (Clifford, 2009). The elks did what elks do: they foraged. The expansion of elks left the trees bare, which left the beaver population without a key resource. The decline of beavers changed the waterways, with further effects on fish and insects. All that from one initial change.

Another fascinating case is the outcome of habitat fragmentation in a tropical dry forest in Venezuela, as documented in a 2001 study led by John Terbough (Kricher, 2009, pp. 165–166). Flooding from a new hydroelectric dam transformed a formerly contiguous forest into island patches. Many resulting fragments were not large enough to support the top predators. Again, with less predation, herbivorous species expanded, sometimes to as much as 200× the density found in unbroken forests. With increased browsing, the seedlings of canopy tree species, in particular, did not fare well. Intense competition also favored plants with strong antiherbivore defenses. The composition of the forest changed completely. The simple change of fragmentation had profound, ecologically remote, changes: what Terbough called "ecological meltdown."

Finally, consider the case of some salt marshes in south Atlantic states (Silliman & Bertness, 2002; Kricher, 2009, pp. 157–158). The marsh periwinkle, a small snail, grazes on salt marsh cordgrass. But they are also preyed upon by blue crabs and diamondback terrapins. The result? The grazing of cordgrass is limited. When predators were excluded in test areas, the snails ate and ate, and the cordgrass virtually disappeared, leaving mud flats similar to those found in other areas. Was that a case of "balance"? Or just the outcome of multiple interactions?

These three examples, among many others, illustrate the complexity of causal networks in ecosystems (for other dramatic cases, see Estes et al., 1998; Allchin, 1999; O'Shaughnessy, 2008). Small changes can lead to substantial and often unpredictable consequences. The specter of "imbalance" is ultimately the specter of unintended effects cascading through complex ecosystems. Due to successive ecological interactions, modest changes may inadvertently yet adversely affect human interests on a grand scale.

Carson clearly appreciated the role of complexity, too. In particular, she cautioned against regarding such complex systems as susceptible to human control. "The 'control of nature'," she famously proclaimed, "is a phrase conceived in arrogance, born of the Neanderthal age of biology and philosophy" (p. 297). Indeed, for a while the working title of her book, suggested by her editor, was "The Control of Nature" (Lear, 1997, p. 324). Complexity and the corresponding problematic control of nature may be an appropriate theme to replace the balance of nature in environmental thinking (on the dilemma of control, see McPhee, 1990).

A prudent policy response to a scientific understanding of ecological complexity is caution and, in a sense, anthropic humility. Carson criticized the nonchalance in efforts to manipulate natural systems, from fire ants and gypsy moths to mosquitoes and agricultural pests. She railed against blindness to (or ill-informed disregard of) environmental consequences, an attitude that we might call *ecological hubris*. The corresponding environmental posture would be a principle of noninterference. This variant of the Precautionary Principle parallels the Hippocratic doctrine of "first, do no harm." Namely, one should avoid disturbing a complex system whose interactions are not fully understood – and which may, in principle, not be fully decipherable. Tread lightly, some say. Notably, that is less an ideology of nature than a prudent position informed by an ecological understanding of complexity.

Having opened by challenging one of Carson's main themes in *Silent Spring*, I wish to close by respectfully endorsing her overall message. In her words:

> Sometimes we have no choice but to disturb these relationships [in nature], but we should do so thoughtfully, with full awareness that what we do may have consequences remote in time and place. (p. 64)

And that, surely, is one important reason why we teach ecology, an aim well worth contemplating on Earth Day.

References

Allchin, D. (1999). The tragedy and triumph of Minamata. *American Biology Teacher, 61,* 413–19.

Allchin, D. (2007). Social unDarwinism. *American Biology Teacher, 69,* 113–115.

Allchin, D. (2008). Monsters and the tyranny of normality. *American Biology Teacher, 70,* 117–119.

Allchin, D. (2012). What counts as science. *American Biology Teacher, 74,* 291–294.

Baldwin, I. (1962). Chemicals and pests. *Science, 137,* 1042–1043.

Botkin, D. (1990). *Discordant Harmonies: A New Ecology for the Twenty-first Century*. New York, NY: Oxford University Press.

Carson, R. (1962/1987). *Silent Spring* [25th anniversary ed.]. New York, NY: Houghton-Mifflin.

Clifford, F. (2009). Wolves and the balance of nature in the Rockies. *Smithsonian*. Available online at http://www.smithsonianmag.com/science-nature/wolves-and-the-balance-of-nature-in-the-rockies-44604810/.

Cooper, G. (2001). Must there be a balance of nature? *Biology and Philosophy, 16,* 481–506.

Darby, W.J. (1962). Silence, Miss Carson. *Chemical & Engineering News*, 1 October, 62–63.

Dizard, J.E. (1994). *Going Wild: Hunting, Animal Rights, and the Contested Meaning of Nature.* Amherst, MA: University of Massachusetts.

Egerton, F.N. (1973). Changing concepts of the balance of nature. *Quarterly Review of Biology, 48,* 322–350.

Estes, J.A., Tinker, M.T., Williams, T.M. & Doak, D.F. (1998). Killer whale predation on sea otters linking oceanic and nearshore ecosystems. *Science, 282,* 473–476.

Hull, R.B., Robertson, D.P., Richert, D., Seekamp, E. & Buhyoff, G.J. (2002). Assumptions about ecological scale and nature knowing best hiding in environmental decisions. *Conservation Ecology, 6*(2), 12.

Jelinski, D.E. (2005). There is no Mother Nature – there is no balance of nature: culture, ecology and conservation. *Human Ecology, 33,* 271–288.

Kempton, W., Boster, J.S. & Hartley, J.A. (1995). *Environmental Values in American Culture.* Cambridge, MA: MIT Press.

Kricher, J. (2009). *The Balance of Nature: Ecology's Enduring Myth*. Princeton, NJ: Princeton University Press.

Ladle, R.J. & Gillson, L. (2009). The (im)balance of nature: a public perception time-lag? *Public Understanding of Science, 18,* 229–242.

Lear, L. (1997). *Rachel Carson, Witness for Nature*. New York, NY: Henry Holt.

McPhee, J. (1990). *The Control of Nature*. New York, NY: Farrar, Straus and Giroux.

O'Shaughnessy, P.T. (2008). Parachuting cats and crushed eggs: the controversy over the use of DDT to control malaria. *American Journal of Public Health, 98,* 1940–1948.

Silliman, B.R. & Bertness, M.D. (2002). A trophic cascade regulates salt marsh primary production. *Proceedings of the National Academy of Sciences USA, 99,* 10500–10505.

Worster, D. (1994). *Nature's Economy: A History of Ecological Ideas, 2nd Ed*. Cambridge, UK: Cambridge University Press.

Young, C.C. (2000). A textbook history: use of the Kaibab lesson in teaching biology. *American Biology Teacher, 62,* 559–564.

Zimmerman, C. & Cuddington, K. (2007). Ambiguous, circular and polysemous: students' definitions of the "balance of nature" metaphor. *Public Understanding of Science, 16,* 393–406.

DOUGLAS ALLCHIN has taught both high school and college biology and now teaches history and philosophy of science at the University of Minnesota, Minneapolis, MN 55455; e-mail: allchin@sacredbovines.net. He is a Fellow at the Minnesota Center for the Philosophy of Science and edits the SHiPS Resource Center (ships.umn.edu). He hikes, photographs lichen, and enjoys tea.