

are financing these installations. An introduction to this frontier of deep-sea observation, which allows real-time data acquisition and control, would have provided the reader with insight into future long-term monitoring of the deep sea.

The only part of the book that I found laborious was chapter 11, which deals with ocean conservation and policy options. Here the author describes the myriad governing bodies involved with deep ocean issues, each of which is introduced, and subsequently discussed, by acronym. The resulting alphabet soup is unappealing. Had fewer agencies been described in detail, this section would have been far more readable, and the take-home message for the reader would have been much clearer.

Koslow's personal notes throughout the book establish his unique credibility in discussing deep-sea biology. His studies of the orange roughy provide good insight into the known natural history of this species and the subsequent decline of its extensive fishery. Koslow makes a concerted effort to relate earlier descriptive chapters to the sections dealing with fisheries management and with the critical international issues yet to be resolved.

Koslow describes the key discoveries in deep-sea biology that have led to our current, and still sketchy, knowledge. Considering how little of the ocean floor has been explored, we should not wonder why the deep ocean is still the most understudied expanse of the earth's surface. *The Silent Deep* illuminates the deep sea—both its wealth of biological diversity and its vulnerability to anthropogenic assaults—and persuasively argues for protection of this vast portion of the biosphere. I highly recommend this book to anyone interested in the deep ocean.

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doi:10.1641/B580213
Include this information when citing this material.

ANOTHER PERSPECTIVE ON YELLOWSTONE'S NORTHERN RANGE

Yellowstone's Destabilized Ecosystem: Elk Effects, Science, and Policy Conflict. Frederic H. Wagner. Oxford University Press, New York, 2006. 392 pp., illus. \$64.50 (ISBN 9780195148213 cloth).

Yellowstone National Park (YNP) and its complement of native wildlife populations and diverse habitats have long fascinated both scientists and the public. Park management goals and methods have changed since this first national park was established in 1872, and ecological understanding has also evolved. Notable among many park issues that have elicited controversy is the state of Yellowstone's elk population and the elks' critical winter habitat, the northern range. "Natural regulation policy" lies at the heart of many of the concerns about YNP, and is the focus of *Yellowstone's Destabilized Ecosystem*, by Frederic H. Wagner.

Wagner makes the key point that adaptive management requires a solid monitoring program and explicit criteria by which management can be evaluated.

Wagner, professor emeritus in the Department of Forest, Range, and Wildlife Sciences at Utah State University, offers analysis, synthesis, and a personal perspective on elk effects and the science and policy conflicts surrounding Yellowstone's northern range. Wagner has also created a broader outlet for research conducted by his former student, Charles Kay, whose dissertation (Kay 1990) is one of Wagner's key sources. Wagner argues, in part on the basis of Kay's work, that ungulates were relatively scarce before the park's establishment, and this premise underpins the entire book. Also underpinning the book is Wagner's contention

that science and policy have not been separated on the northern range, and that a "pernicious effect [of this lack of separation] is that policy implications color the objectivity of scientific inference." Considered broadly, the saga of the northern range elk is a fascinating example of the scientific process and how different authors evaluate evidence and reach different interpretations.

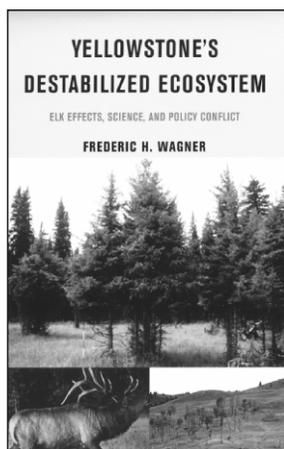
The book is organized into four major sections. Part 1 focuses on the history of the northern range dispute and provides a useful entrée for readers new to the subject. Wagner contends that the natural-regulation policy was adopted for political rather than scientific reasons. In this section, as in other places in the book, potential explanations for observed phenomena are correct but sometimes incomplete. For example, the movement of many elk (approximately 40 percent of the herd) out of the park in search of food during the winter of 1988–1989 is described as an exodus that established a tradition. Wagner mentions the extreme drought of 1988 as a catalyst for this change in movement, along with the return of a more severe winter, suggesting that forage depletion could be an important stimulus. However, the role of the 1988 fires, which burned about 34 percent of the northern range and 22 percent of the grasslands, in reducing the forage available at the outset of the 1988–1989 winter is not mentioned. Furthermore, the deep or dense snow associated with severe winters often makes the forage present on the range inaccessible to elk—thus, elk may move because they cannot get to the forage, rather than because they have depleted it. Finally, the Dome Mountain Wildlife Management area, to which many elk now migrate in winter, is managed to enhance winter forage for wildlife and may well have reinforced the initial migration. Thus, factors beyond those mentioned in the book may have played key roles.

The long-term population dynamics of the northern Yellowstone elk are the subject of part 2. Wagner presents an excellent summary of how the population has changed during the period for which census records exist (1923–2003).

For the prehistory period before YNP was established, Wagner relies on Kay's dissertation research. Kay (1990) inferred low elk population densities in pre-Columbian time and suggested that aboriginal hunting was an important control on elk populations. This notion certainly warrants consideration, but the prehistory size of the elk population has not been resolved in the scientific community, and even Wagner acknowledges the uncertainty of reconstructing the past. It is unfortunate that he considers differing views as "one-sided, negative arguments seeking to falsify Kay's hypothesis." Nonetheless, Wagner's estimate of the elk population from 1850 to the present is nicely illustrated in figure 5.1, which merges the prehistory population inferences with the census record. Wagner raises the important question of whether the elk population is now entering a new phase, given the exodus of elk during winters and the 1995 reintroduction of wolves, and underscores the critical need for well-designed monitoring to evaluate the ecological consequences of these patterns.

The effects of elk on ecosystem structure and function are the focus of part 3. The review of elk browsing in the context of aspen decline and the condition of sagebrush steppe is useful, although Wagner stresses his conclusion that "the weight of the evidence now points to low [elk] numbers in prehistory" as he interprets the vegetation record. Genetic analyses that bear on the frequency of establishment of aspen clones in the northern range were not mentioned (e.g., Tuskan et al. 1996). Interesting work by contributor Richard Kiegley on how the architecture of conifers may be altered under browsing pressure is also reviewed. The role of fire for the conifers is mentioned tangentially, but the slow reestablishment of Engelmann spruce stands burned in the 1988 fires may reflect the natural course of succession in this forest type rather than browsing by elk. The discussion of interactions among species that make up the ungulate guild is nicely presented. In keeping with his premise, Wagner asserts that the biomass of animals

wintering on the northern range in the 1880s was very likely no more than one-third of the biomass in the 1990s. Further, he suggests that herbivory pressure in the 1990s must have been around six times the pressure in 1872. The discussion of riparian systems reviews the multiple arguments regarding willow decline and includes a nice section on the riparian fauna. A chapter on erosion coauthored by Kiegley includes a careful reanalysis of experimental data that demonstrates increased runoff in the presence of grazing. Regarding bioenergetics, Wagner disputes results from previous published studies that suggest compensatory plant growth in response to grazing. A concise chapter on nitrogen biogeochemistry rounds out this third part of the book, which concludes with a synthesis of Wagner's primary conclusions about the ecology of the northern range.



The final part of the book addresses the general role of science in policy. Wagner asserts that YNP research since the 1970s has not provided an accurate and objective assessment of the northern range ecosystem. This part of the book is largely a critique of park science that mixes some worthwhile and valid points with others that are anecdotal and not widely held. Furthermore, the dark description of park oversight of science does not hold for many scientists who have conducted research in YNP and published widely in peer-reviewed journals. As a scientist who has conducted research in Yellowstone for nearly 20 years (with external funding),

I can assert from personal experience that the park staff has never attempted to direct our research, to influence the interpretation of our data, or to discount findings that differ from their a priori expectations. Although I do not discount the veracity of others' experiences, readers should be wary about their generality.

Examples of how different scientists can reach different conclusions are also found in these final chapters—for instance, Wagner's conclusion that aboriginal hunting was a key influence in Yellowstone during pre-Columbian times, and Boyce's (1998) inference that such effects are "essentially untestable and highly unlikely." Science must consider multiple interpretations, and scholarly disagreements can ultimately advance understanding. Wagner makes the key point that adaptive management requires a solid monitoring program and explicit criteria by which management can be evaluated. Some disputes regarding the northern range might have been resolved had a long-term, rigorous effort been in place; however, even the best of monitoring programs will be unable to resolve the question of what constitutes "natural."

In summary, Wagner's book includes new and informative analyses; an extensive, albeit not complete, synthesis of relevant literature; and strong personal opinion. His main thesis is nicely encapsulated in a concluding statement: "The subsequent [after 1967] laissez-faire implementation of natural regulation by the park has been contrary to...the goal of restoring and maintaining the natural state of the northern range" (p. 333). Scientists and managers who have followed the northern range controversies will want to read this book. Students interested in science-policy interactions would find it valuable to read Wagner's book along with other publications on the subject (e.g., Boyce 1998, National Research Council 2002) that have differing perspectives. Collectively, these would provide a useful example of the importance of ongoing dialogue within science and between science and policy.

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doi:10.1641/B580214

Include this information when citing this material.

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