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Essays and Perspectives

The benefits of evolution education for natural resources managers

Israel D. Parker[a,*], Aaron N. Facka[b], Therese A. Catanach[c], Eddie K. Lyons[d]

[a] Texas A&M Natural Resources Institute, 578 John Kimbrough Blvd., College Station, TX 77843, United States
[b] Oregon State University, Institute for Natural Resources, Portland, OR 97207, United States
[c] The Academy of Natural Sciences of Drexel University, 1900 Benjamin Franklin Parkway, Philadelphia, PA 19103, United States
[d] McNeese State University, McNeese State University, Harold and Pearl Dripps Department of Agricultural Sciences, 4205 Ryan Street, Lake Charles, LA 70629, United States

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ABSTRACT

Managers are a strength of policy implementation in the changing and complex landscape of natural resources management. We argue future managers will require additional educational emphases such as coursework in evolution to confront emerging issues in this dynamic profession. An emphasis on more management-oriented evolution education at the collegiate level will help the next cohort of managers as they face changing management and policy realities. Our goal for this paper is to demonstrate the need for training in evolutionary theory for all natural resources professionals by (1) showing emerging needs for evolutionary theory in management, (2) detailing the strengths and uses for evolutionary theory, and (3) recommending strategies for increasing wildlife biologists' knowledge of evolution and its potential effect on wildlife management. Incorporating evolutionary thought and foresight into management decisions essentially forces managers to consider each of their actions and the complex set of consequences that may arise in both the short and long-term. We believe that through academic and post-graduate training, evolutionary theory can be understood and applied by managers in decision-making processes.

Introduction

For over 20 years, natural resources professionals have emphasized that on-the-ground natural resources managers (e.g., state and federal biologists) can benefit from an understanding of genetics and evolutionary theory. As early as 1989, observers were noting that wildlife managers rarely explicitly incorporated theoretical concepts that included behavior and evolution into management programs (Gavin, 1991). The absence of evolutionary concepts in wildlife management occurred even as complex genetic and evolutionary considerations were incorporated into overarching natural resources management policies. Calls for improved evolution education and increased consideration of evolutionary consequences of management actions increased in the early 2000s (Bleich and Oehler, 2000; Crandall et al., 2000; Alters and Nelson, 2002; Ashley et al., 2003). Amidst these calls, we contend that more should be done to prepare future wildlife biologists and natural resource managers for the changing management landscape. This is not a criticism of current natural resources managers. Instead, we hope that emphasizing more management-oriented evolution education at the collegiate level will help the next cohort of managers as they face changing management and policy realities. Our goal for this paper is to demonstrate the need for training in evolutionary theory for all natural resources professionals by (1) showing emerging needs for evolutionary theory in management, (2) detailing the strengths and uses for evolutionary theory, and (3) recommending strategies for increasing wildlife biologists' knowledge of evolution and its potential effect on wildlife management.

There are many excellent treatises on the need for evolutionary thought in conservation biology and wildlife management and various strategies for integrating them (e.g., Gavin, 1991; Crandall et al., 2000; Wiens and Graham, 2005; Kinnison and Hairston, 2007). Rather than arguing these points we focus on the need for future natural resources managers to fundamentally understand evolutionary biology and integrate this knowledge into management planning. Therefore, we argue there is a need to provide

* Corresponding author.
E-mail address: israel.parker@ag.tamu.edu (I.D. Parker).

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practical illustrations of how evolutionary theory and thinking directly affect management. We offer this paper as a review of evolutionary principles and applications that students and current managers can consult to stimulate their own thinking on the role of evolution in management.

The basic theory of evolution is taught at multiple levels through the academic careers of students in the biological sciences. Moreover, evolution as a concept is repeatedly revisited in courses throughout undergraduate education curriculums and classes. However, we believe that universities can more effectively teach evolution for practitioners. Collectively, we have taught thousands of college students, from diverse backgrounds, in our roles as graduate assistants, teaching assistants, lecturers, professors, and as working scientists and wildlife managers. Yet, a common theme has emerged from our interactions with many of those students. Concepts in evolution and behavior, topics critical to natural resources management, consistently failed to interest students. In our discussions with students, evolution was often seen as extraneous to core lessons such as flora and fauna identification, wildlife-capture techniques, timber and range management, and population ecology. Additionally, students may often be interested in evolution, but fail to see its importance to on-the-ground natural resources management. Today's students are tomorrow's managers who help develop and implement wildlife management plans and policies. These policies increasingly contain genetics and evolutionary biology components; thus, underlining the need for an explicit understanding of these concepts and the consequences of not considering them (Gavin, 1991; Festa-Bianchet, 2013).

Natural resources professionals have diverse educational backgrounds covering a multitude of management, ecological, and theoretical emphases (Peek, 1989). They represent on-the-ground caretakers of natural resources and range from state and federal government employees to consultants and private lands managers. Increasingly, managers are confronted with problems and objectives that require broad scientific understanding to resolve. What are species? Does humanity preserve species or lineages? Do we save what we have or manage to provide the most evolutionary potential? How do we plan habitat management from a system perspective? Understanding the short and long-term evolutionary impacts of management actions allows managers to determine the best course of action. This contention is based on a few conceits: (1) we (humanity) desire certain species, ecosystems, ecosystems services and products to exist in perpetuity, (2) continued existence of these systems requires management even when direct action is not considered (non-management is a management strategy), (3) all organisms pass genetic heritage to their offspring, and (4) organisms and the ecosystems they inhabit impact each other (often in complex and unforeseen ways).

Natural resources managers are increasingly tasked with developing synthesized short-term management strategies with potentially long-term implications. Managers are directly impacting future generations of populations, species and ecosystems whether they understand evolutionary principles or not. Thus, coming to terms with evolution is not a luxury for managers, but a necessary tool they must develop and consider with each management action or plan. The manager should have a broad understanding of the genetic impacts on managed species due to the consequences of management actions (e.g., changes due to hunting; Harris et al., 2002) and the increasing role of genetics and evolution in wildlife policy. For example, Coltman et al. (2003) found that trophy hunting of big horn sheep (*Ovis canadensis*) rams resulted in population declines for weight and horn size in mean breeding males. Agriculturalists have practiced this for millennia as they cultivate various crops and livestock with an eye toward maximizing hardiness, efficiency, and production. Management actions invariably have consequences (good and bad). Sometimes evolutionary implications of management actions on target and non-target species are overlooked or not recognized.

Academic institutions and management agencies strive for comprehensive syntheses of ecological principles that guide management. However, comprehensive principles and direct illustrations must be increased throughout undergraduate education (Jacobson, 1990). We encourage the full return to the path of long-term, sustainable, and integrative thinking prescribed by management and conservation scions such as Aldo Leopold and John Muir (Leopold, 1949; Harte, 1996; Kessler and Booth, 1998). Comprehensive evolutionarily-based management strategies address many current and arising challenges in natural resources management (e.g., endangered species conservation, habitat loss and fragmentation). Such a management strategy should foremost attempt to identify and preserve adaptive diversity and evolutionary processes, be proportionate to need, and create strategies based on sound science (Crandall et al., 2000). Incorporating evolutionary thought and foresight into management decisions essentially forces managers to consider each of their actions and the complex set of consequences that may arise in both the short and long-term. We believe that through academic and post-graduate training, evolutionary theory can be understood and applied by managers in decision-making processes.

Evolutionary theory in wildlife management

Futuyma (1986) defines the theory of biological evolution as genetic change inherited from one generation to the next. Recent literature is expanding on the traditional view of evolution as solely slow progressive change over millions of years (Stockwell et al., 2003; Kinnison and Hairston, 2007). Rapid or contemporary evolution (i.e., evolution occurring within a relatively few number of generations) might commonly occur. In essence, while common evolutionary examples occur on time scales too long for a human to observe over a lifetime, evolution also occurs rapidly such as resistance to pesticides, herbicides, antibiotics, or response to changes in habitat, climate, or exotic species (Stockwell et al., 2003). This concept is popularly demonstrated by the complex of Darwin's finches (Geospizinae) on a Galápagos island in which a group of closely related finch species evolved radically different beak morphology in response to abrupt climatic changes. Each species adapted to utilize different feeding strategies and food resources as a result (Grant and Grant, 1993).

Palumbi (2001) called humans the "greatest evolutionary force" on earth due to the recurring impacts humans have on these processes (e.g., antibiotic or herbicide resistance). Managers often make decisions that counteract, manipulate, or accentuate anthropogenic impacts. This means that managers can impact the evolution of wildlife through any number of strategies even as larger anthropogenic actions (e.g., climate change, national policies) add more complexity. These environmental pressures highlight the increasing role of humanity in shaping the course of evolution for many species. Furthermore, humans are not just impactors of other species but competitors for water, air, space, and nutrients (Futuyma et al., 2001).

Humanity's ever growing presence on the planet causes complex, sometimes intractable problems for natural resources managers that further highlights the necessity of comprehensive training in evolution (Western, 2001). The new human-dominated biosphere leads to "biotic destruction" highlighted by high extinction rates coupled with degraded or retarded evolutionary processes such as speciation (Erwin, 1991; Dirzo et al., 2014). Evolution spurred by intensive selective pressure has proven incapable of adapting quickly enough to substantially counteract extinction rates (Parmeson, 2006). Comprehensive and complex conservation programs have arisen to mitigate these sobering predictions.

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