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Ecological literacy: the educational foundation necessary for informed public decision making

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In this introduction to the new* Frontiers *series on Ecoliteracy, Guest Editors Catherine Cardelús and George Middendorf discuss the impetus behind the series for which innovative ecological educators were invited to discuss ways to teach ecological concepts to diverse groups in a variety of settings, with the aim of facilitating better informed decision making for environmental policy.

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In the century since Cowles' (1899) seminal study of plant succession on the sand dunes along the shores of Lake Michigan, ecology has become a foundational discipline of modern biology. Ecologists and environmental scientists have unlocked the mysteries of biogeochemical cycling, explained the distribution and disappearance of species, predicted responses to disturbance, and described the ongoing effects of climate change. Ecologists have also highlighted the role of humans in the natural world. Almost a half-century ago, Carson's (1962) explanation of the ecological concepts of bioaccumulation, biogeochemistry, and energy flow provided the public with the much-needed connection between fundamental ecosystem processes and the harmful effects of dichlorodiphenyltrichloroethane (DDT). The profound literary impact of her best-selling work led to the banning of DDT use in the US and shifted public perception from conservation to environmentalism – from simply saving natural areas to addressing larger environmental issues. Unfortunately, this shift – and the resulting plethora of environmental literature – has mistakenly conflated *environmental* literacy with *ecological* literacy, and thus has insufficiently recognized fundamental ecological concepts and knowledge. As a nation, we have difficulty in dealing meaningfully with pressing environmental issues; apparently, decades of efforts to improve ecoliteracy have spawned a literature without impact, due to an absence of ecological science in environmental policy decision making.

Historically, ecologists, like most scientists, have viewed their professional role in society as objective and quantitative – an endeavor in which they ask questions, collect and analyze data, and publish for their peers in technical journals. Relatively few have seriously engaged in communicating their science to the general public. In 1991, Klemow outlined 11 ecological concepts that should be understood by an ecoliterate person (Klemow 1991). One year later, Orr argued that all education is environmental education; he noted that environmental issues are complex, education occurs as a dialogue between students and their environment (Figure 1), the way education occurs is as important as its content, experience in the natural world is essential, and education relevant to the challenge of building a sustainable society must be based on enhancement of the learner's understanding of natural systems (Orr 1992). Other publications followed. Nichols' (2010) review of ecoliteracy identified four essential domains: concepts, sense of place, respect for others, and competencies. Nichols' domains – the foundation on which learners critically evaluate environmental issues – overemphasize the human relationship with nature and underemphasize the ecological dimensions. Because of this, it is imperative that we rebuild the ecological foundation of ecoliteracy, which is fundamental for educating the public and, ultimately, producing ecologically educated (ie ecoliterate) decision makers.

To that end, the Ecological Society of America's Education and Human Resources Committee (now the Committee on Diversity and Education) has developed a series of papers aimed at promoting an ecologically focused literacy – an understanding of how ecosystems sustain the web of life (Capra 1999). In this new series in *Frontiers*, critical issues and best practices by which ecologists gather, process, and convey ecological knowledge to the larger public will be examined. Particular focus is placed on how to reach beyond the discipline to an audience empowered to take action: to policy makers and voters in the general public. Given the current state of ecological literacy – coupled with the potentially catastrophic impacts of climate change, invasive species, pollution, decreasing biodiversity, declining fresh water,

and myriad other pressures threatening to debilitate ecosystem processes – it is critical that ecologists re-examine their societal roles and responsibilities. For the authors of these papers, the goals are to (1) help ecologists to better communicate ecology to the public, (2) develop civic responsibilities beyond publishing technical papers, (3) engage more broadly with non-scientists, and (4) form successful partnerships with policy makers, educators, and the broader community.

Ecologists must take leadership roles in order to promote ecoliteracy to the general public, but few have the experience or expertise to do so. There are several available programs, such as the Aldo Leopold Leadership Program, that actively promote the development of leadership and communication skills for academic, mid-career environmental scientists, but this is not enough. Future articles in this ecoliteracy series will examine the interface of humans and their environment, explore ways to enhance ecological education in K–12, reaffirm the need to teach natural history critical to understanding ecological issues, and investigate ways to "bridge the gap" between ecological research and teaching. Additional articles will focus on large-scale science and data collections; the role of museums, zoos, and parks; all forms of media; and information technology, writ large.

In addition to leadership, ecologists must accept the responsibility of sustained and concerted public outreach efforts, including – but certainly not limited to – social media and civic activities. We believe that communication efforts are most effective when respectful partnerships are created and dialogue promoted among all groups. We therefore propose that galvanizing the relationships of ecologists within and between their communities provides the best opportunity to positively impact the ecological literacy of the public. This can be achieved by addressing the shared values of science and religion, facilitating the development of citizen scientists, and creating partnerships with diverse stakeholder communities through engagement in collaborative ecological research.

We hope that this series will serve to kick-start an overdue conversation about improving ecologists' ability to fulfill their roles and responsibilities in fostering ecoliteracy.

Figure 1. *Earyn McGee (Howard University) and Tony Charvoz (University of Puget Sound) collect data for a lizard demography study at the Southwestern Research Station, in the Chiricahua Mountains, Arizona. Student involvement in data collection in the field facilitates knowledge of the scientific process, promotes consideration of ecological careers, and improves understanding of ecological literacy.*

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