From Dioramas to Dragonflies: Redefining the Role of Natural History in Environmental Science

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This paper discusses the perceived barrier between quantitative and qualitative natural history research. A short history of the evolution of natural history research will be presented, and responses by my students to a natural history experience at a stream will be described.

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Each time I teach an environmental science class, I bring my students to a stream near campus. The students are animated, glad to be freed from the confines of the lecture hall, and unaware of what faces them at the streamside. I stand in the middle of the stream, watching the water ripple across the rocks and over the toes of my battered old boots.

This stream hides many stories within its rock-bound borders, stories of the struggle of life. My students wait unsuspecting on the stream bank, unsure of what I am about to ask them. Their challenge today is to determine what life is present in the stream. These students have taken at least one semester of general biology, and most have taken traditional lab sciences such as chemistry and physics, yet none has ever taken a field environmental science course.

My students challenge me every day. They challenge my thinking, and by doing so they challenge me to continue exploring new ideas and subjects. The life of a college professor shares a key characteristic with my other passion, environmental science: The interactions among individuals, either college students or my research subjects (nymphal dragonflies), are constantly changing. The answers gleaned from one day's observation rapidly become tomorrow's questions.

The students wait at the top of the stream bank. Wearing waders is a new adventure for them, and no one has been brave enough yet to step into the cold October water. The silence lengthens; the students begin to shuffle nervously. They scuff their feet in the leaves, and springtails bounce out of the disturbed leaf piles. The wind rustles the leaves overhead, and the frantic flying of the last yellowjackets of the season can be seen in the woods behind us.

Students who enroll in my class have had little experience in conducting fieldwork. Their world is that of the fairly well controlled lab environment, an environment where variables can be quantified, and the question of "what is life?" can fit within the confines of a textbook.

That need to quantify has extended into the very heart of field science. Such terms as counts, abundances, mortality, and abiotic parameters are sprinkled profusely through most of the professional literature I read. Are numbers important? Certainly the ability to quantify observations and translate them to a common language is highly valuable. But perhaps something is missing, something that makes it difficult to answer the question of what life is.

My students do not notice the springtails beneath their feet. They do not record the overhead ballet of the dragonflies. As they step into the stream, they do not look down into the riffles to see how their actions have changed the stream community. Dutifully they record stream velocity, pH, dissolved oxygen, and temperature. They fan out to collect the stream macroinvertebrates and proceed to scrub the rocks surfaces to dislodge any additional organisms. Their quest is to describe the life found within the stream system.

As the sun starts to set behind the trees, my students gather up the nets, waders, and chemical testing gear, and they begin the short trek up the hill towards the waiting vans. During their time here, they have never once taken the time to observe their surroundings. Their focus remained on their assigned tasks; their vision was narrowed by their quest to fill in the numbers.

Did my students ever answer the question of what the stream's life was? Well, in a way they did. The definition of life was turned in the following week; neat, orderly arrays of test results, number of organisms caught, classification of the organisms, overhead canopy cover, stream temperature; the charts flowed on and on. "Life was this," they said. "The numbers tell the story."

Yet, the blank space between the numbers told more of the story. The untold, unseen observations of animal behavior, the behavior that is influenced by all the biotic and abiotic measurements they recorded, is the result of so much more than numbers. But do non-quantified observations still have a role in current field studies?

The goal of environmental science is to describe interactions, which occur between species and their changing environments. Scientists use three methods to describe these interactions: observation, modeling, and experimentation. Inferences drawn strictly from observations are considered weak compared to experimentally derived inferences (Power et al. 1998).

The field of environmental science is very diverse. The branches of environmental science chiefly concerned with agricultural pests and disease transmission, for example, are anchored firmly in quantitative methodology. The field of natural history, however, presents a unique blend of both quantitative and qualitative presentation of data.

But how are qualitative data, in the form of natural history observation, perceived by the research field? Is it an accepted form of data collection? What role does it have in increasing the knowledge base inherently needed for ethology research?

At the heart of the discussion regarding the role of natural history in environmental science research is the perception of science as being bias-free. French (1994) defines science as being objective (reason-based and passion-free), non-religious, experimental in verification of theories, and linked to technology. French (1994) also states "Its [science] self-confidence is increased by every successful manipulation of nature." Is this an endorsement of a total experiment-based ecological methodology, or does it still allow for the inclusion of natural history? Macfadyen (1975) delineated the importance of experimental science over natural history but defined the use of each methodology in terms of hierarchical organization of the natural world.

The modern form of natural history first appeared in the scientific community in the 1700's (Farber 2000). The two principal scientists at this time were Carl Linnaeus and Georges Leclerc. Neither man was formally trained in natural history, although Linnaeus had medical training which covered the fields of medical botany, anatomy, and physiology (Farber 2000). Leclerc's interest in natural history came from a more physical science background, but he would later become director of the Royal Garden in France (Farber 2000).

The work of both men laid the groundwork for the future acceptance of natural history as a scientific discipline. It also served to ground natural history firmly as an accepted science. Prior to the 1700's, natural history observation was less quantified and consisted of qualitative recordings of natural events. With the acceptance of the classification scheme promoted by Linnaeus, the split widened between the pure qualitative recording of nature and the quantitative recording of specific events.

With the advent of the Victorian era, interest in natural history increased dramatically. Numerous social clubs were formed to further the study of natural history. Several professional societies dealing exclusively with the study and preservation of natural history artifacts also began during this time. Kohler (2002) describes the debate between the field and experimental biologists of this time as being between "closet" armchair science and expeditionary science.

Fieldwork had the ability to provide direct impressions, while lab-based experiments provided truly objective analysis. The collection of rare antiquities became the passion of the time. While interest in specimens increased, scientific knowledge was kept separate.

Natural history became a science of dioramas: nature safely confined behind glass, mere representations of what might have been. Specimens were carefully conserved and then placed in naturalistic settings for the enjoyment of the general public and the use of researchers. But can interactions between species be represented by static dioramas?

Scientists at this time used the image of authenticity of nature to define their own laboratory practices. A Victorian-era chemist wrote "[L]aboratory work brings the student into direct contact with Nature. In the lecture room the student forms an idea, as in a panorama, of the general appearance of the country; not as it is in the laboratory, as in a walk through a given district, that he first learns what the land he is traveling through is really like" (Kohler 2002). Hence the laboratory has appropriated direct field experience.

In America, natural history enjoyed a resurrection during the late nineteenth century (Farber 2000). The onslaught of increased efficiency in firearms, rampant industrialization of wilderness areas, and commercial exploitation of species caused a movement to protect the remaining natural areas. During this time, interest in the study of natural history skyrocketed. Nature writers drew the public into their sphere of experience through their novels, and Americans flocked to the outdoors with their cameras and binoculars.

Unfortunately, as natural history was enjoying rejuvenation in the public sphere, the role of natural history in the scientific sphere was in sharp decline. Research began to focus on experimental explanations of hereditary instead of on classification and observation. Most importantly, the divide between professional scientists and amateur natural history practitioners continued to widen. As time continued, the chasm between the analytical, quantitative branch and the observational, qualitative branch of natural history became insurmountable.

The late 1800's was also a time of criticism between field and lab biologists. As further emphasis was placed on lab science, field biologists were considered to be superficial, and their contributions were deemed to be of little value. One entomologist was recorded to have written at this time that "from one point of view there is no harm in labeling a dead entomologist 'Natural History specimen: Dried. Handle with care.' As that is all he really is" (Kohler 2002).

Several factors have influenced the decline in use of natural history in environmental science research. Wilcove and Eisner (2000) suggest that the demise of natural history is due to a natural tendency of scientific inquiry to become more theoretical as the science matures. The unifying theoretical "umbrella" serves to encapsulate previously unconnected observations (Wilcove and Eisner 2000). In essence, the theoretical framework masks the uniqueness of the individual observations.

The chasm between modern field and laboratory science is growing at an increasing rate. The two fields have diverged so completely from each other that the objectives of each are now vastly different. Kohler (2002) writes that experimental biologists seek to reveal cause and effect, while field biologists work towards describing, naming, and classifying. While descriptions of causal reasoning are still present in field biology, it is used in tandem with spatial and locational reasoning (Kohler 2002).

Field biology incorporates place in its research; variability is ever present. Laboratory science is inherently homogeneous. It is the laboratories' uniformity that gives them their credibility. Kohler (2002) writes, "We credit science done in labs because we know, or think we know, what kind of place they are, and that the same rules of procedure and evidence apply in all." The credibility of laboratory science is also tied in with the image that is portrayed, that of white lab-coat wearing academics, whereas the field biologist is generally viewed as a less reputable, less academic explorer.

The splitting of the environmental science research field into disparate paths of reflection and discourse presents natural history scientists with a unique challenge. Traveling too far down one specific path makes it difficult to communicate with the other avenues. Brues (1951) states that this widening of the science realm has determined "that the young naturalist who entered professional life half a century ago has seen the whole face of biological science change so completely that he can no longer see the forest for the trees."

In the middle of this intellectual wilderness, Brues (1951) holds out a ray of hope when he writes "on the far horizon some lone 'naturalist' … still clings to the precarious supposition that the divergent phases of natural history are amenable to integration without loss of clarity or dignity."

The disconnection between natural history and environmental science research creates a potentially damaging situation for the future health of the field. Belovsky et al. (2004) offer several suggestions that could be implemented to strengthen the science of ecology. They suggest that the field of ecology is not providing rapid enough answers to the most basic ecological issues: determinants of species' abundance and distribution, as well as the relationships between living things and their environments (Belovsky et al. 2004). They suggest that the "sluggishness" of ecological study is in fact due to conceptual impediments and offer that one of the ways to improve the strength of ecology would be to increase the integration of both empirical and theoretical science (Belovsky et al. 2004).

Belovsky et al. (2004) also discuss the role of natural history in environmental science. They suggest that natural history and experimentation (lab science) are both valuable. Natural history provides qualitative identification of patterns, and then experimentation can be used to verify the patterns. When one side is valued over the other, a disjointed picture of ecosystem functioning can result.

Mayer (2006) suggests an alternate view on how natural history can be incorporated into environmental science. He labels natural history as one point on the triangle which defines biodiversity (Figure 1).

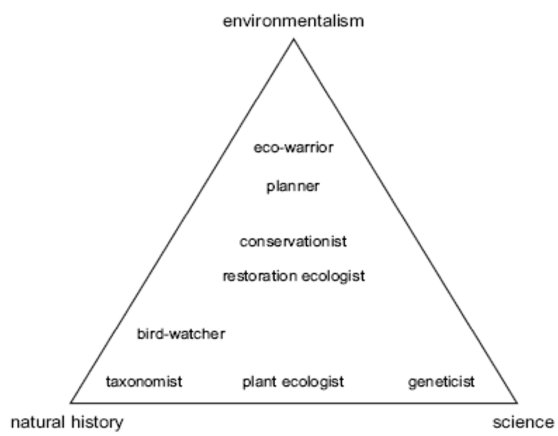

Figure 1. The relative influence of three thought styles (vertices) on how different interest groups frame their understanding of biodiversity. Adapted from Mayer 2006.

The other points, environmentalism and science, complete the boundaries. Although the terms contained within Mayer's triangle are easily associated with their respective corners (i.e., taxonomist-natural history; geneticist-science; eco-warrior-environmentalism), they are not considered separately. All three points aid in defining the central term.

In his example, Mayer notes the position of "restoration ecologist," but the label "environmental scientist" could easily be put in its place. The importance of Mayer's graphical representation is that it assigns a role to natural history research. Science and natural history are distinct research fields, but they are still connected.

It is time to dust off the forgotten relics of the natural history collections and venture once more back into the field. Natural history has the power of providing much needed baseline data on understudied or overlooked ecosystems.

While modern natural history studies have moved away from classic methodologies of collection and preservation, these skills are still highly valuable in the modern realm of taxa studies. Natural history also seeks to define both the sociological and philosophical implications of biological knowledge, goals that are routinely missing from lab science. Wilcove and Eisner (2000) state that natural history allows ecologists to see functional relationships in nature, which can then lead to discovery of broader ecological patterns.

I remember the endless trays of insects that I have seen in natural history museums across the United States. So much information can be found in looking at the identification tags that are placed within the boxes. Information can be found on species, sex, locality, and seasonality, but it is the information that is missing that I notice the most.

Behavioral observations cannot easily be translated into a small identification tag. The impact of environmental events is not recorded. If you are very fortunate, the original researcher's field notebook may be available, and perhaps in its weather-beaten pages the answers might be found.

While the borderland between field and laboratory science is fraught with seemingly insurmountable obstacles, it also provides us with unexplored possibilities. Kohler (2002) describes the lab-field border as a biogeographic ecotone, an area where two biota can intermingle yet neither has a clear advantage. Kohler (2002) suggests that this intermingling of tools, methodologies, and epistemologies could lead to the formation of a hybrid. The hybrid of Kohler's imagination represents the bridge between the strictly analytical laboratory world and the variable world of the field biologist.

Lab biology and natural history are not antagonists in the battleground of environmental science; instead, they should be viewed as equally valuable tools that can be used in tandem. Morin (1998) states "laboratory and field experiments each provide complementary and essential information about different kinds of organisms and ecological phenomena." Lab experiments have the benefits of providing precise details about the experimental subject. They can also directly address ecological theory (Morin 1998). The main drawback of experiments is that they tend to provide an over-simplified view of natural systems. Field science benefits from its ability to accurately describe natural systems. The main disadvantage of field experiments is that there is high variability among replications (Morin 1998).

I am not advocating that the wall of quantitative science be removed. It has a powerful function. It helps create a universal lens through which researchers can exchange insights. Perhaps it is time to integrate the two lenses, quantitative and qualitative. Let us view the world through the multi-faceted eyes of the bee. Natural history observations can help "fill in" the missing components of lab-based experiments, and in-depth lab research can define observable boundaries in the field.

Underwood (1990) suggests a research scheme in which observations and experiments are included. In the scheme, research begins with observation, continues on to the development of explanatory models, and then makes predictions based on these models. Experiments are then used to verify the predictions created from the models. The power of Underwood's scheme lies in its inclusion of both observation and experimentation. Neither one is deemed more valuable than the other; both are essential to the process.

Those scientists and individuals who observe nature walk a fine line between the professional imperative to quantify what is seen and the explorer's curiosity to record the qualitative content of their observations. Both have a place in environmental science. Analysis will always play a vital role in research, but the chasm between quantitative and qualitative analysis must be closed. The power to understand ecosystem functioning lies in the successful inclusion of both branches of natural history.

The perceived divide between quantitative and qualititative sciences is something I am faced with each time I walk down a science hallway. Students bustle about in the traditional uniform of scientists, the white lab coat, moving between chemistry, genetics, and anatomy labs. My students often have difficulty seeing me as a "true scientist" since my official uniform consists of waders and a multipocketed vest instead of a lab coat.

The current focus on technology-driven science provides wonderful opportunities for exploration, but where do non-technological observational sciences fit in? Students are so used to incorporating technology in almost every aspect of their day-to-day lives that the exclusion of technology is a foreign, and even terrifying, prospect to them. I do not know what the future is for teaching natural history or even if my efforts to engage them in direct observation of life will be successful. I only know that I will continue to promote its inclusion into the science curriculum, not as a competing "anti-technological" field but as an integral and vital component.

Qualitative natural history observation provides a universal portal into environmental science investigation. So many of my students have an innate pathological fear of science, of the numbers that they feel define science. Yet, science is so much more than numbers. It is not the numbers that drive most of us out into the field, it is the memories of the extraordinary things we have seen and the moments of life that we have been privileged enough to witness that lead us ever onward on our quests for knowledge.

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