ASSESSING THE INTERACTION OF KNOWLEDGE, VALUES, AND ATTITUDES IN ECOLOGICAL-THINKING REGARDING INVASIVE EARTHWORMS

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Abstract. The narrative that earthworms are "good" has dominated ecology education for decades. Few people are aware that earthworms are exotic from Europe and Asia and are harmful to northern forests; even fewer people change their attitude toward earthworms once they learn this information. This study examined the factors that contribute to an individual's attitude toward earthworms, and how those factors are used when discussing earthworm processes and impacts. Personal values, experience, and knowledge were assessed to give a broad representation of what shapes an individual's attitudes. We found that individuals with higher levels of education, typically scientific professionals, had more sophisticated accounts of ecosystem functions and earthworm processes that acknowledged the potential negative effects of worms. However, unlike force dynamic and system and model-based accounts, those who gave phenomological accounts were more likely to adapt their attitude toward earthworms. Individuals with more sophisticated knowledge tended to exhibit ecocentric values. These findings indicate the need to develop targeted education programs about earthworms, forest ecology, and invasive species management in order to reach different audiences.

INTRODUCTION

Globalization has led to a drastic rise in the spread of species from one area of the world to another. Invasive species—plants, animals, microbes, etc. that are present in an area where they are not normally found—are no longer an endemic issue. Non-native species are affecting every region of the world to some extent. In the United States alone there are approximately 50,000 invasive species, which cause an estimated $120 billion in control and damage costs annually (Pimentel et al. 2004). Previous and current research regarding invasive species has focused on their ecological and economic impacts. This research is vital to enhance the scientific community's knowledge of these species so that informed policy and management decisions can be made. However, to-date the social facets of invasive species management is a relatively unexplored area of research. Environmental management of virtually any kind is tied to the public; understanding what individuals think of invasive species, and *why*, is vital to develop effective management strategies (Schütter et al. 2010, Bremner and Park 2007). Assessing local individuals' knowledge, attitudes, and values regarding an ecological issue provides invaluable information about what is required to educate, or in some cases shift an individual's decision.

Numerous studies have found that students often rely on preconceived heuristics and informal knowledge to make a socio-ecological decision (Hogan 2002, Covitt et al. 2009). Rather than referring to information gleaned from the classroom or textbooks, students were more likely to rely on their knowledge and values from "relevant everyday practices," such as gardening or fishing (Covitt et al. 2009). These findings call into question the efficacy of science education—does it have a purpose in decision-making education if students' decisions are primarily value-based? (Kolstø 2006). Canonized education research has acknowledged that there is a link between values and knowledge in individuals' decision-making processes; however the exact interaction between the two remains unclear (Kolstø 2006).

Additionally, knowledge and values interact to create an individual's embedded decisions, or attitudes. Attitudes are the evaluative judgments that integrate and summarize cognitive or affective reactions (Prislin and Crano 2008). Attitudes are the fluid—although typically engrained—decisions humans use to categorize new information. These categorizations are often instantaneous and "disproportionately influenced by the first few pieces of information that come to mind" (Schwarz 2008). These knee-jerk reactions that integrate new information into our pre-existing attitude complexes indicate that the human mind may not be as rational or adaptable as initially thought. This, coupled with individuals' tendency to rely on their personal experiences instead of learned information, points to the need for a better understanding of the links between knowledge, values, and attitudes. Environmental education curricula that understand the interaction between those three factors would foster students' abilities to interrelate values with complex conceptual issues so that they can learn to build qualified arguments and reasoned claims that take all relevant components of a problem into account (Hogan, 2002).

An understanding of individuals' knowledge, attitude, and value complexes is increasingly important in cases where public knowledge is overwhelmingly wrong about a species, as is the case of the common earthworm (*Lumbricus terrestris*) in upper North America. Although the dominant narrative of earthworms is unyieldingly positive (soil tillers, enrichers, etc.), they are invasive and quickly altering northern forest ecosystems by reducing leaf litter and consequentially biodiversity, increasing runoff, changing soil nutrient content, accelerating carbon loss, etc. A study conducted by PJ Bohlen et al. found that these many cascading geochemical, biological, and physical effects are likely to intensify in the future due to increased human activity and climate change (2004). In 2011 a panel of scientists named "Vegetation change facilitated by earthworms in North American forests" as one of the top fifteen global conservation issues in the world (Sutherland et al. 2011). Despite these clearly negative effects earthworms continue to retain their positive connotation throughout the majority of the United States. Any management strategy for this ecological crisis must shift public opinion and knowledge of earthworms to be effective.

This study sought to further an understanding of individuals' thought processes regarding earthworms by examining the interactions between knowledge, values, and attitudes. This was accomplished through four main research questions: 1) what is the relationship between level of education and level of knowledge (sophistication)? 2) Is there an association between levels of knowledge and individual's attitudes toward earthworms? 3) Which individuals are more likely to shift their attitude toward earthworms? 4) Is there a correlation between level of knowledge and values?

METHODS

This research used data from a previous study "Investigating People's Understanding of Earthworm Ecology" conducted by Lina Yamashita. Yamashita used qualitative interviews to assess various professional groups' understanding of invasive earthworms, with the ultimate goal of improving education about this and related issues (Yamashita, 2007). A total of forty-four twenty-one question long interviews were completed. The interviews ranged from simple did-you-know questions to a more complex card sorting activity. Generally, each question attempted to show the extent of the individual's ecological thinking (Yamashita 2007).

From the original forty-four interviews, a subset of twenty transcripts was chosen for this study. Transcripts were selected to form a wide cross-section of professions, ages, and education levels (Table 1). Additionally, only interviews with an adequate discussion of values and measurable breadth of knowledge were included in the subset.

A combination of emergent and preset coding was used to analyze the data (Taylor-Powell and Renner 2003). Values were coded emergently by examining the objects or concepts people specifically discussed as important to them. Categories were then created for any themes of valuation that were recurrent.

Knowledge was coded using a preset learning progression scheme that considered individuals' general ecological knowledge in addition to familiarity with earthworms and their environmental processes and effects. The progression was based on the Pathways Project, which uses three levels of sophistication to describe individuals' accounts: force-dynamic, phenomenological, and system and model based (Moore et al. 2014). In force dynamic accounts an individual focuses on very basic and often visible processes. Phenomenological accounts are more sophisticated than force dynamic; these individuals have some understanding of the processes that occur, but are often unable to describe how they happen. Finally, systems and model-based accounts are the most sophisticated because they demonstrate an in-depth understanding of how and why ecosystem processes occur. Individuals' full transcripts were coded. Any demonstration of knowledge or information was coded, which then combined to yield one overall code for the subject's level of sophistication.

An individual's attitude was coded as positive, negative, or mixed feelings toward earthworms and their effects. Additionally, evidence of adaptive attitude formation was coded in individuals who were previously unaware that earthworms are invasive. Those who demonstrated some process of consideration or assimilation of the new information (rather than outright rejection) were considered to have some level of adaptive formation.

The analyses of the data are preliminary. No multivariate statistical analysis has been conducted. Current results are from basic counts and the researcher's observations of correlation between variables. Inter-rater reliability has yet to be completed.

Possible Sources of Error

There were a few potential sources of error in the data, mostly due to the fact that this study used an already existent data set for a purpose that was slightly different than the 2007 study. For example, Yamashita did not always press people to fully gauge their level of sophistication. Some individuals may have been able to provide more detail about a specific ecological process had they been asked to.

Additionally, in the 2007 interviews individuals were not specifically asked to describe what they "valued most". Instead, this information was gathered from any instances that occurred in answers to the original questions. In some cases the researcher had to interpret statements, since the subjects' stances could not be clarified or confirmed. As with any qualitative coding a researcher's interpretations of data may not be completely accurate.

RESULTS

The data demonstrates a positive correlation between level of education and sophistication of knowledge; individuals with higher levels of education had more sophisticated accounts of ecosystem functions and earthworm processes (Figure 1). Those with Force Dynamic accounts had the lowest levels of education: high school or some college. Phenomenological accounts demonstrated a variety of education levels, ranging from high school to post bachelor's degree. Systems and model-based accounts aligned with this upward trend in education levels. Those with systems and model-based accounts either completed a four-year degree or continued to a graduate degree.

Most Soil Scientists and Foresters had systems and model-based accounts. All gardeners and vermicomposters had a phenomenological level of sophistication. Farmers were the only occupational

group to have a range of sophistication from force dynamic to systems and model based. Most manual occupations, such as farmers and gardeners, were unaware that there are no native earthworms in northern parts of the US. In contrast, most soil scientists and foresters knew that earthworms are invasive to northern forests.

Individuals with more sophisticated accounts typically acknowledged the potential negative effects of earthworms. Nearly sixty-seven percent of system and model-based accounts stated that worms could be harmful to an ecosystem. About 42 percent of phenomenological accounts acknowledged negative effects, whereas zero percent of force dynamic accounts demonstrated this understanding.

Individuals with the least and most sophisticated accounts were the *least* likely to try and reconcile the new information of earthworms being invasive with their existing narratives. Of the individuals who were unaware that earthworms were invasive prior to the interview, only those with phenomenological accounts made some effort to integrate the new information into their existing attitude. Zero percent of force dynamic and systems and model-based accounts demonstrated any sign of adaptive attitude formation. Farmers were especially unlikely to change their views of earthworms, whereas many gardeners wanted to learn more about the issue after discovering that they are invasive.

There was a wide range of demonstrated values (Table 2). The object that was most valued by individuals was ecological and system integrity. Every occupation and sophistication level made reference to the importance of retaining ecosystem functions. Energy efficiency and security was also widely valued: five of the six occupations mentioned the pressing issue of fossil fuel use.

Vermicomposters and Foresters were the occupational groups with the most ecocentric values. They were mainly concerned with ecosystem integrity, biological life and health, land preservation and natural resource conservation. Every single soil scientist demonstrated a concern for ecological and system integrity, but also exhibited some degree of anthropocentrism through valuation of resources specifically for human use or benefit. Gardeners had the widest spread of values; about half valued ecological and biological health, while the other half discussed the importance of human life and health.

Individuals with a system and model-based level of sophistication were more likely to place value on objects or concepts that contributed to a holistic ecological system. Ecological and system integrity, land conservation and preservation, biological life and health were often discussed in terms of their importance to the greater environment. There was little correlation between the phenomenological level of sophistication and a specific value structure; all but one of the value types were demonstrated across phenomenological individuals.

DISCUSSION

There is a positive correlation between level of education and sophistication, which indicates that more education does lead to increased sophistication. Additionally, individuals with sophisticated ecological thinking typically displayed a more holistic attitude towards earthworms. They had the ability to consider the negative in addition to positive. Many individuals with system and model-based accounts were reluctant to categorize earthworms as good or bad, citing how earthworms could be either depending on a person's point of view. Most of these accounts were from soil scientists and foresters who described worms' benefits for agriculture, and their harms to forest ecosystems. These results indicate that individuals have a foundational knowledge of earthworm ecology that can be expanded through education to form a more informed socio-scientific attitude.

The results from the adaptive attitude formation analysis suggest that having too little or too much knowledge can actually inhibit an individual's ability to analytically handle new information. Frequently

those who rejected the notion that earthworms are invasive and could therefore be "bad" used the argument that many invasive species are not actually harmful. For example, one gardener used the instance of non-native plants: "Exotic is not necessarily bad and invasive is not bad to a certain point either… There are invasive plants that aren't necessarily invasive to the environment if they're kept in check." A farmer with an in-depth understanding of soil ecology summarized what seemed to be the sentiment of many individuals: "we have a lot of invasive species that we can live with. Just because they are invasive doesn't mean we don't want it." This thought-process effectively aligns the new contradictory information with their engrained attitude that earthworms are beneficial. Individuals who had an average level of sophistication were better able to consider the implications of earthworms being invasive. This could be due to their lack of a mechanistic understanding—if someone does not know exactly why or how earthworms produce castings, till the soil, etc. they may not be opposed to seeing these processes as negative. Not knowing all the links between processes could actually give individuals the malleability to shift their attitude.

There is a positive correlation between level of sophistication and ecocentric values. Those with more sophisticated accounts were more likely to value things based on their contribution to the larger ecosystem. Education could be an explanatory factor between values and level of sophistication, since there was also a positive correlation between level of education and sophistication. This result suggests that education can play a role in shaping individuals' values, and therefore their attitudes and decisions further down the line.

This study highlights the intertwined nature of knowledge, values, and attitudes. Our findings reveal that education has the potential to shift individual's knowledge and attitudes about earthworms, which is a positive implication for invasive species management. By considering individuals' knowledge and value systems managers should be able to develop targeted education strategies that effectively incorporate public opinion.

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APPENDIX

TABLE 1. A breakdown of the subjects' personal attributes: sex, profession, education, and age.

Sex		Profession		Level of Education		Age	
Female	8	Forester	3	High School	2	25-35	5
Male	12	Farmer	4	Some College	3	35-55	9
		Soil Scientist	4	Finished College	8	55-75+	6
		Vermicomposter	3	Post Bachelors	7		
		Gardener	5				
		Professor	1				

TABLE 2. Tally of instances of value types.

Valued Object or Concept	Count
Ecological & System Integrity	12
Biological Life & Health	3
Energy Efficiency & Security	5
Aesthetics	1
Land Conservation & Preservation	5
Human Life & Health	3
Food Production & Availability	3
Natural Resource Conservation	2
Accurate Scientific Information	1

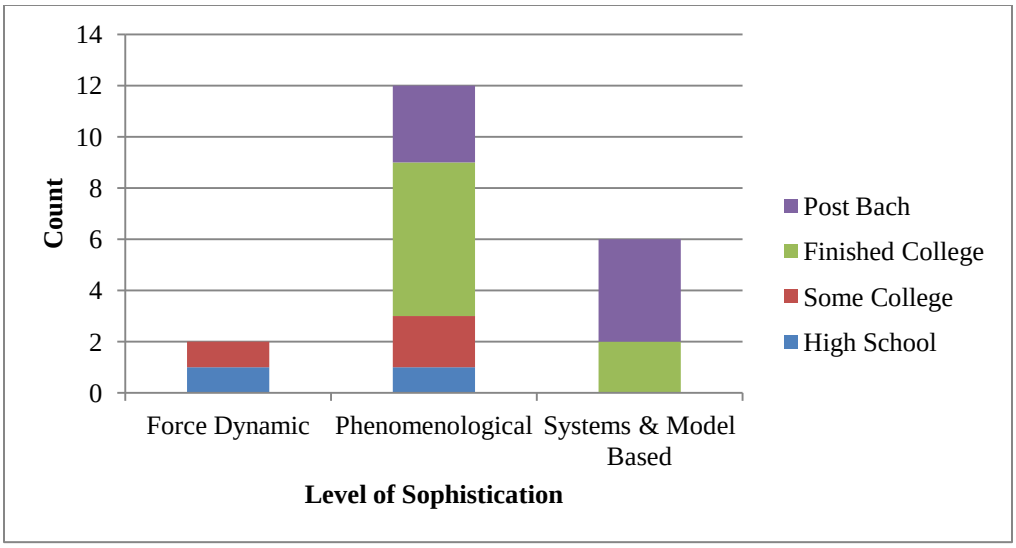

FIGURE 1. The amount of education of each sophistication level. There is a positive correlation between education and sophistication.