

The Dirt on Worms: Knowledge, Attitudes and Behaviors Concerning
Invasive Earthworms in the Town of Webb, NY

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Abstract

The invasion of exotic earthworms in previously earthworm-free areas eliminates the forest litter layer, alters the carbon and nitrogen cycles and reduces native plant cover. Humans are the principal agents of invasive earthworm dispersal, spreading worms both inadvertently through the horticulture industry, logging and road travel, and voluntarily through composting and the disposal of earthworm bait on land. This is the first study to focus on the human dimensions of earthworm invasion. Using a knowledge-attitudes-behavior (KAB) framework, this study explores the correlates of voluntary earthworm dispersal in the Town of Webb, NY, and attempts to determine which groups of people are spreading earthworms and through bait use and composting and how environmental knowledge and attitudes contribute to this behavior. The results uphold the knowledge-attitudes-behavior model for general invasive species eradication efforts, but not for voluntary earthworm dispersal. While general invasive species knowledge is high, only 17% are aware that earthworms are invasive. The most important factors predicting earthworm disposal in forests are infrequent participation in fishing and efforts to eradicate invasive species, while the factors predicting composting participation are the belief that earthworms have a positive effect on plant life and self-reported environmental knowledge.

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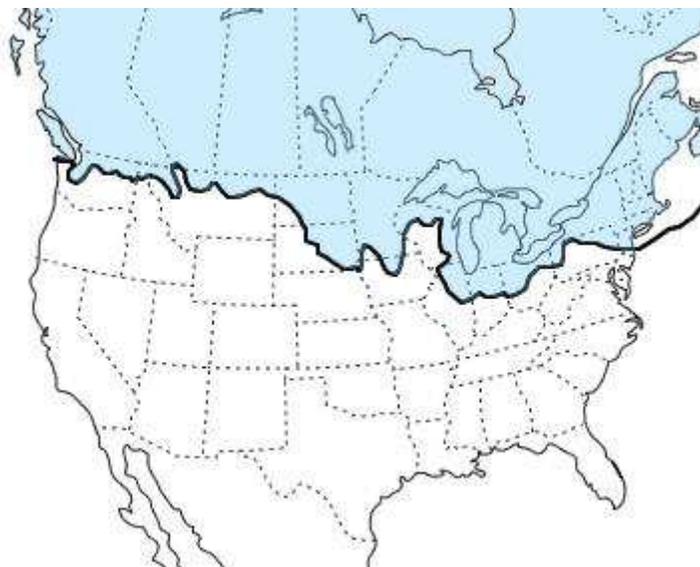
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I. Introduction

Ten thousand years ago the Pleistocene Glaciation descended on the northern portion of the present-day United States, eradicating all native earthworms in the region (James 1995). The earthworms currently present in this zone (Fig. 1), therefore, are almost all exotic species. Research in Minnesota demonstrates that the introduction of exotic earthworms into formerly earthworm-free areas accelerates forest litter decomposition, the reduction of native plant and animal habitat, and the release of carbon and nitrogen (Hale et al. 2005; Holdsworth et al. 2007). Despite these negative environmental impacts, the topic of invasive earthworms receives scant attention from environmentalists and from the general public, compared to other invasive species.

Figure 1. Southern extent of the Pleistocene Glaciation



Source: University of Minnesota WormWatch 2009

Humans remain the principal agents of invasive earthworm dispersal, spreading worms both voluntarily through the use of worms for bait and composting and

inadvertently through the horticulture and logging industries. Exotic earthworm invasion has been underway in North America for approximately 350 years, ever since the arrival of the first European settlers (Kalisz and Dotson 1989; Tiunov et al. 2006). Though humans play a critical role in the transfer of exotic earthworms to remote areas, such as inner forests, few studies analyze specifically human behaviors that promote invasion, and no published study examines public knowledge and attitudes concerning invasive earthworms. The research presented here fills this gap and explores the question: how does knowledge of invasive earthworms and attitudes towards them affect behaviors that facilitate earthworm invasion?

In his 2004 article in the *Geographical Review*, Paul Robbins calls for a new framework for invasive species research, one that encompasses the cultural and political biographies of invasion (Robbins 2004). This conceptualization gives special attention to human-environment interactions, focusing on how humans prepare the landscape for invasion or create momentum for the process. By examining the human correlates of earthworm invasion, this study draws on Robbins' emphasis on the human role in invasion pathways.

The research question on the human dimensions of invasive earthworms is examined with a case study of the Town of Webb in the Adirondack region of New York State. The Adirondack State Park is an important case because of its environmental and cultural significance as the largest unbroken temperate forest in the world (Wildlife Conservation Society 2009). Webb is the largest township in the Adirondacks and has an extensive history of logging and fishing, two practices that make it especially vulnerable to earthworm invasion. Because the use of worms for composting and bait disposal on land

are two voluntary forms of introduction, special attention is given to four main behaviors: disposal of earthworms in forests, disposal in gardens, saving earthworms for future fishing excursions and composting. Data collection draws on both face-to-face interviews and two separate written surveys. The survey confirms that knowledge of invasive earthworms is limited and positive perceptions of the species are common. While it was expected that less invasive species knowledge and more positive attitudes towards earthworms would result in human dispersal of earthworms, the results show that extent of participation in fishing and gardening activities has the most predictive power for voluntary earthworm dispersal.

Because the conceptual model requires an understanding of the human dimensions of invasive earthworms, and thus an understanding of their biology, the study begins with an overview of invasive earthworm ecology. A description of ecosystem impacts of invasive earthworms reveals “the dirt on worms” and why they pose a threat to ecosystems. This leads to a discussion of the human capacity to spread earthworms, both by creating land disturbances and through the physical act of introduction. The two modes of earthworm introduction this study focuses on are bait disposal and composting because these are voluntary dispersal actions—participants are aware that they are spreading earthworms. This section on human dimensions gives way to the conceptual model and hypotheses, which predict that age, gender, education and other demographic variables will influence knowledge of invasive species, invoke negative sentiment towards them and reduce voluntary earthworm dispersal. This model is then applied to the Town of Webb, for which the environmental and cultural histories related to earthworm colonization are described. A discussion of Webb’s environmental vulnerability leads to a discussion of

the results from preliminary studies of tourists and residents, which suggest that participation in a greater number of recreational activities is correlated with more invasive species knowledge. A results section contains the output from a series of t-tests, one-way ANOVAs and linear regressions to test the knowledge-attitudes-behavior theory as it applies to invasive earthworm dispersal. The discussion and conclusion suggest that information campaigns should target specific groups, such as gardeners and intermittent anglers, to increase overall awareness of the problem of invasive earthworms.

II. Invasive Earthworm Ecology

To justify why invasive earthworms merit study at all, this section explains the negative impacts that invasive earthworms have in previously earthworm-free ecosystems. The discussion of some of the natural limits to earthworm colonization leads to descriptions of human agency in the spread of exotic earthworms.

Ecosystem Impacts of Invasive Earthworms

Invasive earthworms threaten ecosystems in three important ways: they reduce the leaf litter layer in forests, alter the carbon and nitrogen cycles, and lead to a reduction in native plant cover. Hale et al. (2005) finds that in Minnesota forests with invasive earthworm populations, forest litter decreased over time and the leading edges of earthworm invasion experienced rapid declines in forest floor thickness. The leaf litter layer is important because it provides habitat for native animals and a source of nutrients for plants. Consumption of leaf litter can strip the forest floor down to mineral soil, thereby eliminating organic material (Alban and Berry 1994). In the Adirondacks, however, leaf litter results are inconsistent. One researcher at the State University of New York-College of Environmental Science and Forestry finds no significant differences in

leaf litter thickness between invaded and non-invaded sites (Snyder, personal communication). However, the length of the invasion period for these sites is unknown.

Earthworm invasion also has an important impact on the carbon and nitrogen cycles. The deterioration of the forest floor causes the release of carbon in the short term by decreasing soil carbon storage (Addison 2009). In a central New York forest, Bohlen et al. (2004b) find that invasive earthworm reduce carbon storage in the soil by 28%. When soil carbon is released and nitrogen levels remain the same, the C:N ratio is altered, potentially affecting the organisms that are able to grow in such soil (Bohlen et al. 2004a). However, invasive earthworms can stabilize soil carbon in the long run because they remove organic material from the surface (Bohlen 2004c). Invasive earthworms also alter the nitrogen cycle through the formation of earthworm casts, which are rich in nitrogen, stimulating nitrification and microbial activity (Bohlen et al. 2004a). The overall effects on the carbon and nitrogen cycles vary between earthworm species, forest, and soil types, but alteration of these cycles has the potential to affect the entire ecosystem (Bohlen et al. 2004a).

A third negative effect of invasive earthworms is the reduction of native plant and animal species. Earthworm invasion is significantly correlated with reduced plant species richness in Minnesota and Wisconsin (Holdsworth et al. 2007). In Minnesota, not only does the expansion of earthworm populations lead to a decline in forest-floor vegetation, but it also significantly reduces the occurrence of the endangered goblin fern, *Botrychium mormo* (Gundale 2002). Many of these ecosystem changes are due to the effects that earthworms have on the litter layer. Upon the loss of the forest litter layer, the soil becomes compacted, leading to nutrient leaching and increased soil erosion (Hale 2008;

Holdsworth et al. 2008). Although the results have not yet been quantified, these changes have the potential to reduce arthropod, salamander, and small mammal populations, as well as disturb communities of birds that nest on the ground (Hale 2008).

Another means of ecosystem change caused by earthworm invasion is the direct interaction between earthworms and other invasive plant and animal species. “Invasional meltdown” is the term given to the positive feedbacks between two or more invasive species that increase their colonization rates, allowing them to replace native species (Tiunov et al. 2006; Madritch and Lindroth 2008). One example is in Hawaii, where an invasive tree stimulated nitrogen cycling, thereby encouraging the expansion of invasive earthworm populations (James and Hendrix 2004). The earthworms became food for feral hogs, and when the hogs tore up the soil in pursuit of the worms, they created ideal conditions for the colonization of a second invasive plant. Different species of earthworms can also have positive feedbacks with each other. In previously earthworm-free regions, invasional meltdown occurs when invading epigeic species, which are worms that thrive between the litter and the top soil layer, mix oxygen and mineral soil horizons, creating a source of organic material for invading endogeic species, which inhabit the mineral soil layer (Tiunov et al. 2006).

Invasive plants originating from the same regions as invasive earthworms have great potential for a mutually beneficial relationship with each other in the land they invade. Frelich et al. (2002) find that exotic plant species originating from Europe have evolved to thrive in soils containing earthworms, and can therefore better compete in earthworm-invaded soils than some native North American plants. Similarly, an invasional meltdown in some regions involving invasive plants and earthworms can be broken by removing the

invasive plants. A study in Madison, Wisconsin finds that the removal of the invasive plants honeysuckle (*Lonicera japonica*) and common buckthorn (*Rhamnus cathartica*) reduces earthworm abundance by 38% and 63% respectively (Madritch and Lindroth 2008). The authors conclude that removing these invasive plants prevents the formation of a rich source of leaf litter for the earthworms in invaded forest sites, thereby slowing an invasional meltdown.

Invasive species do not all play an equal role in the feedbacks that facilitate the invasion of other species and the decline of native species, however. In an experiment designed to test whether invasive plants or earthworms drive changes in plant community structures in central New York, Nuzzo et al. (2009) find that there is no significant relationship between invasive plant cover and native plant abundance, but there is significantly more earthworm biomass in plant-invaded areas. Because invasive plants are more visible than invasive earthworms, they are often assumed to play a larger role in driving plant community structures. But, Nuzzo et al. (2009) counter claims that removing invasive plants will necessarily protect native plants. Instead, they conclude that the largest plant community shifts arise from non-native earthworm invasions.

Natural Limits to Earthworm Colonization

Despite widespread earthworm dispersal by humans in the past few centuries, there are several key natural limits to earthworm colonization. The factors affecting natural earthworm distributions fall into three principal categories: habitat limitations, biotic interactions, and physical constraints. Habitat limitations include climate, soil features, and litter supply. The optimal temperature for earthworms native to temperate zones is 10-20°C, and temperatures become lethal to earthworms at 25-35°C and during frost

conditions (Curry 2004). However, earthworm mortality in temperate regions is usually blamed on moisture stress compared to temperature extremes. Earthworms are most active at a soil moisture tension of 10 kiloPascals, and activity levels decline above 100 kPa.

In addition to moisture, other soil properties limiting earthworm distributions are texture, soil depth, pH, and organic content. Medium-textured soils are most conducive to earthworm populations, and because earthworms require a sufficient depth of aerobic soil for colonization, extremely shallow soils are unlikely to host large populations. Earthworms function best in soils with a pH range between 5.0 and 7.4, and are scarce in soils with a pH below 4.5 (Curry 2004; Bernard et al. 2009). Earthworm presence is positively correlated with organic C content, and populations tend to expand following the application of organic material, which is an important source of food. Earthworms prefer fertile soils with C:N ratios of less than 20:1 and fare poorly in soils with high salt concentrations. Earthworms also require a sufficient amount of leaf litter to feed upon (Hale et al. 2005). Sugar maple forests in the northeastern United States provide habitat favorable to invasive earthworms because of their rich leaf litter (Tiunov et al. 2006).

Biotic limitations to earthworm colonization include predation, species competition, and parasitism. Predators of earthworms include birds, shrews, badgers, red foxes, centipedes, flatworms, salamanders, and ground beetles (Curry 2004; Snyder, personal communication). Invasive earthworms also fall prey to pathogens and are parasitized by the cluster fly and the anoetid mite (Curry 2004). However, the extent of earthworm colonization is most limited by their natural rate of movement. Earthworm colonies have an average dispersal rate from an initial introduction site of about 10 meters per year

(Tiunov et al. 2006; Hendrix et al. 2008; Hale 2008). This indicates that the presence of exotic earthworms in remote areas of the northern United States is not due to the natural progression of native earthworms from the south. Humans play a crucial role in facilitating earthworm invasion in these northern areas.

III. The Human Dimensions of Invasive Earthworms

One way humans contribute to earthworm colonization is by causing landscape changes that create suitable habitats for earthworms. Kalisz and Dotson (1989) performed one of the first studies of the impact of land disturbance on exotic earthworm distributions, concluding that some degree of disturbance is a necessary prerequisite to earthworm invasion. Land disturbance creates a conducive environment for earthworms by altering both the chemical composition of the soil and nutrient availability. Clearing land can create a suitable earthworm habitat because although this process eradicates the forest litter layer, there is improved soil fertility and food quality in the cleared area (Curry 2004). This explains why areas that have been extensively logged are prime sites for earthworm invasion (Kalisz and Dotson 1989). Gundale et al. (2005) find that in Michigan, logging sites are significantly more likely to be invaded than similar sites near roads without a history of logging. The reverse process of afforestation leads to increased earthworm populations in fertile soil, but earthworm biomass declines in infertile soils (Curry 2004). Abandoned human settlements in Europe become hotbeds for earthworm activity once vegetation begins to grow in (Tiunov et al. 2006). Former mining sites are unlikely to contain earthworms when left alone, due to a lack of organic matter (Curry 2004). However, when mining lands are rehabilitated through liming of the soil and the accumulation of organic content, these areas host hearty earthworm populations.

Yet some researchers contest the idea that land disturbance is a necessary precursor to earthworm invasion. James and Hendrix (2004) revised the Kalisz and Dotson (1989) theory of prerequisite land alteration upon their discovery of earthworms in areas without severe land use or habitat fragmentation. Tiunov et al. (2006) agree that anthropogenic land transformation is not required for earthworm colonization, although it can be conducive to the growth of larger populations. What is most important to earthworm establishment in remote areas is human transport of worms and cocoons. As James and Hendrix (2004) write, the “only factor clearly necessary for successful establishment is the arrival of the exotic species, without which there can be no invasion” (81).

Humans have facilitated the spread of invasive earthworms in the United States for over 350 years (Kalisz and Dotson 1989; Tiunov et al. 2006). Upon arrival to North America, settlers dumped ballast, a mixture of soil and gravel used to balance ships, on land, thereby depositing the first exotic earthworms hidden within the soil. Today, while ballast-dumping remains an uncommon dispersal vector, five principal human activities contribute to the spread of invasive earthworms: logging, road travel, horticulture, composting, and the use of worms for fishing bait. Logging facilitates earthworm dispersal not only because clearing land creates suitable soil conditions for earthworms, but because eggs and cocoons trapped in equipment and truck tires are carried into logging sites, where there is a wealth of forest litter for growing worms to feed upon (Tiunov et al. 2006; Hale 2008). A similar unintentional mode of exotic earthworm transport is dispersal along roads caused by vehicle travel. Vehicles spread earthworms near roads in the same manner as in logging sites when eggs and cocoons become lodged in vehicle tires. Hale (2008) writes that earthworm distributions are strongly associated

with roads, and Cameron and Bayne (2008) find that road age is a significant predictor of earthworm populations in Alberta, Canada. The older and more highly-traveled the road, the greater the earthworm biomass in the surrounding soil will be. These factors indicate that a higher number of passing vehicles means more opportunities for unintentional earthworm dispersal. The building of roads and homes is also a mode of inadvertent introduction due to the importation of gravel and soil during the construction process (Tiunov et al. 2006; Cameron and Bayne 2008). Cameron et al. (2007) also note that seismic lines, or paths of cleared land used for oil and gas exploration, often experience earthworm invasion. Just as along roads and logging areas, these invasions are caused by vehicular dispersions.

The horticulture industry is another typically unintentional mode of exotic earthworm introduction. When plants are shipped from foreign regions, they are often packed with soil containing earthworms. A 2003 risk assessment of invasive earthworms in Minnesota rated the use of potted plants in nursery stock as a high-risk pathway for earthworm dispersal (Proulx 2003). Increasing trade and globalization only leads to the further exchange and transportation of exotic soils in both rural and urban gardens (Hendrix et al. 2008). However, the transplantation of exotic earthworms through horticulture is not always unintentional. Due to the perception that earthworms improve soil fertility and have positive effects on plant growth, some horticulturalists deliberately introduce worms into their gardens (Curry 2004).

Two other routes of intentional introduction are through the vermicomposting and bait industries (Edwards 1998; Hendrix et al. 2007). The exotic *Lumbricus rubellus* is a popular compost worm in temperate regions and is often selected for use in community

mulch piles. Yet compared to these concentrated, one-time composting introductions, the bait industry serves as the most important vector for widespread and scattered exotic earthworm introduction in remote areas (Hale et al. 2005). Earthworm invasions are often documented as radiating outward from boat launches, campsites, and popular fishing spots when anglers decide to dispose of excess bait on land (Cameron et al. 2007; Hale 2008). There is more genetic diversity among earthworm populations at boat launches than at most other sites, suggesting multiple introductions over time from anglers dumping bait (Hale 2008). Because bait disposal and composting are the most visible and discrete instances of human-mediated earthworm introduction, they have a greater potential to be stopped than unseen and involuntary introductions through heavy equipment use, vehicle travel, and horticulture.

This study focuses on understanding the driving forces behind the voluntary introduction of exotic earthworms through the use of worms for bait and composting. The term “voluntary” is used loosely, because in many cases, people may not know that the species they are transporting to or leaving at outdoor sites, such as boat launches, are not native and potentially harmful to the area. Intentional earthworm introductions into gardens and compost piles indicate that the negative impacts of earthworm invasion are not well-understood by the public. This demonstrates that the human behavior of earthworm dispersal is closely tied to levels of knowledge about invasive earthworms and attitudes towards these species. A lack of familiarity with the concept of invasive earthworms and the perception that they are a positive influence on the environment may translate into behavior that encourages their spread.

Despite the importance of humans as vectors for earthworm dispersal, research on human knowledge and perceptions of invasive earthworms is sparse. Keller et al. (2007) compiled the only published study of deliberate earthworm introduction in the Great Lakes. To assess the impact of angler behavior on earthworm introduction, their survey targets anglers, asking how they dispose of worms used for bait. The authors conclude that the prevention of future invasions will require educating anglers not to dispose of worms on land. The link between knowledge and behaviors that promote the invasion of other exotic plant and animal species is supported by several other studies of the human-invasive relationship (Steele et al. 2006; García-Llorente et al. 2008; Gates et al. 2009). Steele et al. (2006) uses interviews and questionnaires to test awareness of invasive plants in West Virginia, finding that about a third of landowners can identify at least one invasive species. The authors cite the need for research into whether awareness of exotic species can translate into behavior against them in the form of land management strategies. Similarly, García-Llorente et al. (2008) examine knowledge, perceptions, and attitudes regarding invasive species in Spain and the implications for management. Participants who demonstrate a better understanding of invasive species are more likely to contribute funds to support eradication. In the United States fishing industry, Gates et al. (2009) focus on the role of anglers' knowledge of aquatic nuisance species in the transport of such species across state boundaries.

While these studies mainly uphold the relationship between knowledge and behavior, one report explicitly focuses on the connection between attitudes, values, and behaviors in the management of invasive tree mallow (*Lavatera arborea*) (Fischer and van der Wal 2007). The researchers find that attitudes and values influence decision-making in the

conservation context. Because research on public knowledge and attitudes towards invasive species is limited to these few studies, further inquiry is needed on the social drivers of human dispersal. Given the gaps in the literature on human knowledge and attitudes towards invasive earthworms and the unique role of humans in their dispersal, the Town of Webb study assesses the factors that influence human knowledge, attitudes, and behaviors regarding invasive earthworms.

IV. Research Conceptualization

This study frames the behavior of voluntary earthworm dispersal as a function of knowledge of and attitudes towards earthworms, invasive species, and the environment in general. The three specific behaviors it focuses on are the disposal of worm bait on land, the use of worms for composting, and the deliberate introduction of worms into gardens. The knowledge-attitudes-behavior approach, which stems from Benjamin S. Bloom's 1956 work in educational psychology, is also often used for predicting environmental behavior (Bloom et al. 1956). In a study on adolescent environmental behaviors, Meinhold and Malkus (2005) find that environmental knowledge is an important moderator for pro-environmental attitudes and behaviors. Likewise, Persson et al. (2009) observe that increased knowledge of environmental effects is causing more Swedish people to safely return unused prescription drugs to the pharmacy due to environmental concerns, rather than security concerns. Barr (2007) also applies the knowledge-attitudes-behavior framework to a study of household recycling in the U.K. Recycling, reuse, and reduction behavior differ significantly according to environmental knowledge, values, and concern.

This framework is also applied to social research on invasive species, namely for assessing motivations for invasives management. Steele et al. (2006) use informant interviews in West Virginia and a survey of landowners to study knowledge and management of invasive plants. While the research team is unable to prove that knowledge of invasive species translates into management efforts, they do find awareness-building to be an important preventative strategy. In their study of attitudes towards invasive tree mallow (*Lavatera arborea*) in the U.K. and its interaction with the puffin, Fischer and van der Wal (2007) conceptualize their survey based on attitude-behavior theories. They focus on the connection between environmental attitudes and values, which they understand as much more long-term views that serve as guiding principles in people's lives. The researchers find that attitudes, as determined by values and perceptions of the environment, determined management choices for tree mallow. The use of attitude-behavior theory in invasive species research is, therefore, appropriate to studies involving a single invasive species. The Town of Webb study assumes that environmental knowledge and concern both influence the behavior of voluntary earthworm dispersal, as indicated in the conceptual model (Fig. 3).

education is a significant predictor of knowledge of environmental issues, and that boaters' environmental knowledge has a significant positive correlation with generally responsible environmental behavior.

Age is another demographic variable thought to influence environmental attitudes. Olli et al. (2001) find a significant positive relationship between age and environmental behavior in the form of sustainable or "green" lifestyles choices. On the contrary, Cottrell (2003) finds a negative relationship between age and environmental concern, meaning that younger boaters are more concerned about the environment than their older counterparts. Similarly, the study by García-Llorente et al. (2008) on social perceptions of invasive alien species in Spain finds that age is significantly negatively correlated with willingness to pay for eradication of such species. Olli et al. (2001) note that for the elderly raised in the 1930s, environmental behaviors such as recycling and reuse were sometimes associated with experiences of scarcity (Olli et al. 2001). Younger generations, however, were raised believing that they have the ability to tackle environmental problems and were taught to behave in a sustainable manner.

Another potentially important predictor of environmental attitudes is gender. Ecofeminism claims that women are better connected to their environments than men are and will express more environmental concern (Olli et al. 2001). Yet Olli et al. (2001) argue that there is little evidence that proves that women are significantly and consistently more environmentally concerned than men. Schahn and Holzer (1990), however, demonstrate in their survey of 167 German adults that gender serves as a moderator between general environmental attitudes and behavior. The effect of gender is less significant for a second sample of those in conservation groups. This suggests that

while gender does have some impact on environmental behavior across the larger population, environmental concern as represented by participation in environmental groups is a much more immediate predictor of environmental behavior.

Income is another background variable represented in this study's conceptual model. In general, income and environmental behavior have a positive relationship (Olli et al. 2001). It is hypothesized that when people build wealth over the course of several years and feel financially secure, their concentrations shift to values such as political participation and the environment. Among those of lower socioeconomic status, survival needs tend to prevail, displacing environmental considerations. For instance, de Porter (2001) cites food, shelter, and income as "primal motivations" that must be met before people can concentrate on the implications of introducing invasive species (210). Those with lower incomes are therefore likely to be less environmentally concerned.

The amount of time people spend with nature is also thought to predict both environmental knowledge and concern. Staples (2001) writes of the disconnectedness between urban children and nature. The fact that these children have little to no experience in planting a garden or tending to livestock means that their environmental knowledge can merely be intellectual, and not hands-on. Staples connects this concept to the topic of invasive species because a reduction in time spent in nature causes declining environmental awareness, which leads to apathy or indifference towards the influx of invasive species. This speaks to the importance of the urban-rural divide in predicting both environmental knowledge and attitudes, which is reflected in the childhood/adult environment box of the conceptual model. Increased time spent in nature, such as the

hands-on environmental experience of rural children that Staples alludes to, can lead to both place attachment and heightened environmental concern (Ryan 2005).

Ryan (2005) finds that while participation in outdoor recreation increases attachment to natural areas, merely living next to a natural area increases levels of environmental advocacy. Place attachment, or the sense of connectedness that people gain by spending time in a given locale, can work both for and against invasive species. If people have lived in a natural area for a long time and have become attached to it, they are likely to oppose changes to the landscape, especially visible ones such as invasive plant species. If people are fairly new to an area and still exhibit place attachment to their former landscape, they may import plants or animals from their previous environments to help adjust to new conditions (Brook 2003). Therefore, how long people have lived in the Town of Webb is an important component of their environmental attachment and concern for the area.

The idea of time spent in nature is represented in three separate boxes in the conceptual model. First, “childhood/adult environment” represents the life stages at which people live in a natural area. Living in a rural or natural area can influence the amount of outdoor recreation experience people have, which is represented as an intervening variable. Another intervening variable in the conceptual model is land management experience. If people are employed in land management, they tend to spend more time in the outdoors and have greater environmental knowledge, even if they are not from a rural area or participate in outdoor recreation.

Another important background variable present in environmental behavior literature is political viewpoint. Those who support a more egalitarian agenda are more likely to

exhibit environmental concern, and those who are liberal are “more willing to support an agenda seeking social and environmental change” (Olli et al. 2001). This is because liberals are less supportive of dominant social and economic structures. Likewise, Cottrell finds that political ideology is significantly correlated with environmental concern. Specifically, liberalism that supports a strong role for the government is an indicator of such concern, as well as of pro-environmental behaviors and support for environmental policies.

One important component of environmental attitudes specifically relating to invasive species is perception of the species. Veitch and Clout (2001) write that the “shape, size, colour and general ‘appeal’ of a species, whether it is invasive or not, can seriously influence public perception” (66). While earthworms are generally not as appealing to the public as fuzzier, more charismatic creatures, their perceived benefits to society give them greater likeability (Brown et al. 2002; Fischer and van der Wal 2007). Charles Darwin is credited with first changing public perceptions of earthworms by portraying them as beneficial to soil fertility and plant life (Brown et al. 2002). Due to this practical garden use, earthworm colonization would appear to be helpful instead of an invasive or detrimental process. The intervening variables of environmental knowledge and attitudes regarding invasive species are thus expected to predict the behavior of voluntary earthworm dispersal.

V. Hypotheses

The hypotheses of this study are represented in the conceptual model. Age, gender, income, education, and childhood/adult environment are all demographic variables expected to influence environmental knowledge and attitudes through the intervening

variables of political views, outdoor recreation experience, and land management experience. Residents who are younger, female, have higher incomes, higher education levels, are from more rural backgrounds, have richer outdoor experience and more land management experience are expected to have more environmental and invasive species knowledge in addition to more pro-environmental attitudes. Those who are familiar with the concept of invasive earthworms are expected to show more concern about earthworm introductions and be willing to take steps against continued invasion. Those who have less knowledge of earthworms as invasive are expected to be older male residents with lower income and education levels and less environmental experience. These respondents are expected to be indifferent towards or have positive perceptions of earthworms and are more likely to exhibit behaviors that promote earthworm invasion, especially the disposal of bait worms in the forest.

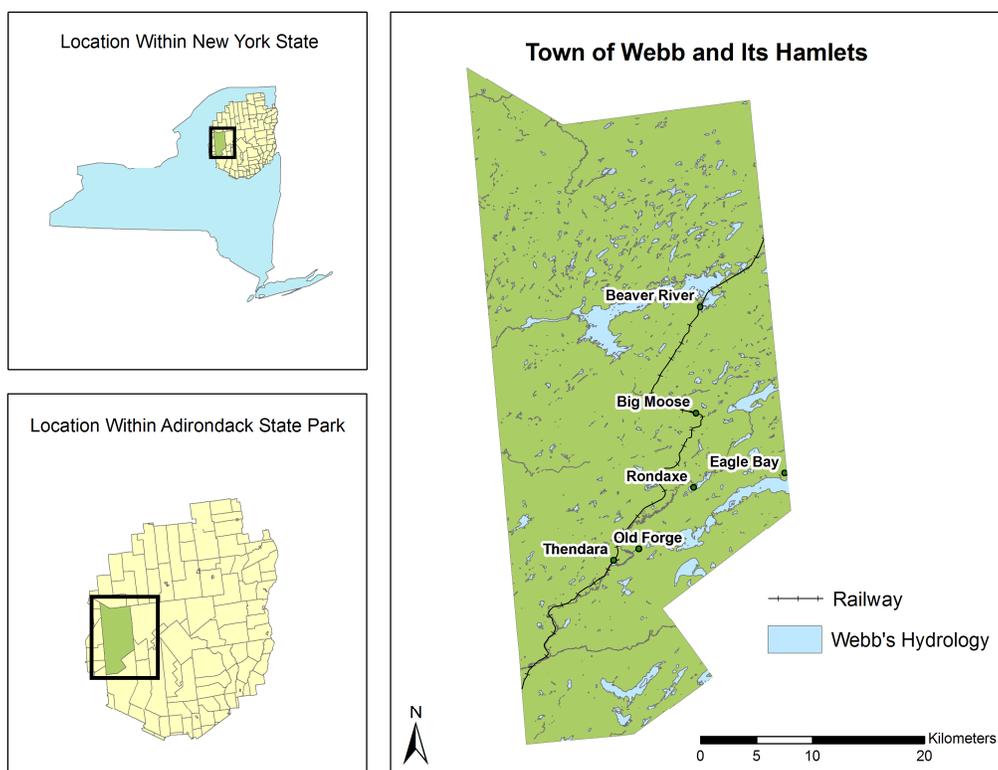
VI. Environmental and Land Disturbance History of the Town of Webb

This section highlights the biological, cultural and political vulnerabilities of the *landscape* of the case study region to earthworm invasion. Land disturbance trends such as road construction and logging are important because they set the background for present-day earthworm-related traditions and risks. Earthworms are better able to colonize areas that have seen some form of human disturbance. Cultural and political biographies of the Town of Webb highlight relevant disturbances, such as the tradition of worm use for bait and a bustling logging industry.

The Town of Webb in the Adirondacks is an important case study for the human dimensions of invasive earthworms because it is one of the last large wilderness areas in an urbanized Northeast region with a vast expanse of lakes and streams (Terrie 1994).

Webb is the largest township in the Adirondacks and has an extensive history of logging and fishing within its borders, two activities known to increase the risk of earthworm invasion. The most prominent hamlets in the town are Old Forge, a popular tourist destination, Thendara, Big Moose, and Eagle Bay (Fig. 2). Webb has a population of 2,000, which increases to 3,000 in the summer months (Gail Murray, personal communication).

Figure 3. Geography of the Town of Webb



Source: Adirondack Park Agency
 Projection: NAD 1983 UTM Zone 18N

European settlement of what is now the Town of Webb began in the 1790s, presenting some of the first opportunities for the invasion of European earthworm species. In 1792, Alexander Macomb bought a stretch of land that contained most of present-day Webb (Grady 1966). After a series of early land transfers, a settler John Brown purchased

210,000 acres of land, stretching from the Moose and Beaver River Valleys and including First through Fourth Lake on the Fulton Chain. Brown found it difficult to encourage settlement in his tracts due to the prevailing notion that the Adirondacks were a wasteland. Settlers found little value in the characteristically acidic soils, which made agriculture unsustainable. However, ample opportunities for hunting and fishing in the vast forests and abundant lakes and streams encouraged the development of several sporting clubs (White 1985). The first was the Brown's Tract Association, which set the trend for other privately-owned sporting clubs, including the Bisby Club and Adirondack League Club, the latter of which remains vibrant today. Due the newly-appreciated recreational value of this region, settlers continued to arrive, and by 1850, visitors were able to travel to Old Forge by wagon (Grady 1966).

One risk factor for earthworm invasion in the Town of Webb stemming from settlement is the construction of roads and railroads. In 1890, Dr. W. Seward Webb, whose name is given to the Town of Webb, began to finance and construct a railroad from Herkimer through the western Adirondacks (White 1985). In 1832, the railroad reached the Fulton Chain area, now known as Thendara, encouraging the further development of private camps, hunting and fishing clubs and a healthy tourism industry (Hochschild 1962). Both the construction of railroads and the influx of tourists contribute to the risk of earthworm invasion. In addition, most logging enterprises in the region established small railway lines to facilitate shipping of lumber from the forests to the mills and for export (Kudish 2005). While these smaller lines are no longer in operation, the Scenic Adirondack Railway currently operates out of Thendara and travels northward through the Town of Webb to Lake Placid (Adirondack Scenic Railway 2009).

The popularity of the region stems from interests other than recreation as well. The 1869 book, *Adventures in the Wilderness; or Camp-Life in the Adirondacks*, became a best-seller and advertised the “healing qualities” of the region (Terrie 1994). That year, throngs of tourists flocked to the Adirondack region. Old Forge remains the principal tourist destination in the Town of Webb today. Traditionally, Webb’s tourists have originated mainly from New York, Pennsylvania, and Ohio (Beetle 1948). However, the increasing mobility of the world’s residents suggests that they have a greater capacity now than ever to intentionally or inadvertently track in invasive species, including earthworms.

An extensive history of logging in Webb also makes the town especially vulnerable to earthworm invasion. Logging in the Adirondacks began in the eighteenth century when the French and British cut timber for building ships, especially for use as ship masts (Henshaw Knott 1998). In Webb, the first known logging enterprise was established when John Brown ordered the construction of a dam, a sawmill, and a gristmill across Old Forge Lake (Grady 1966). The industry became more pronounced in the town towards 1800, and in 1850, New York State became the nation’s top producer of timber (Welsh 1995). As one book on Webb’s history quips, “almost every Adirondack clearing has a lumber camp in its past” (Beetle 1948, 6). The hamlet of Thendara in particular became a boom town for lumbering in the mid-1800s. Previously referred to as Fulton Chain, it hosted three main lumbering enterprises: The Brown’s Tract lumbering company remained influential alongside the Deis planning mill and the larger Pullman Brothers mill. Together, the companies reached peak production between 1900 and 1922, together providing work for over 300 lumberjacks (Beetle 1948).

A technological development for the logging industry in the twentieth century has important implications for the distribution of exotic earthworms in the area. In 1915, tractors began to replace horses for hauling logs and began to see widespread use in the 1940s (Welsh 1995). Increased demand for forest products following World War II necessitated increased rates of tree cutting. Woodcutters began to switch over to more mechanized methods, including tractors and the gasoline-powered chainsaw, which was invented in 1927. These developments likely exacerbated the introduction of earthworms into previously remote forest areas. While the clearing of land created habitat suitable for earthworms, the influx of truck tires and equipment had the potential to carry in new species of earthworm eggs and cocoons.

One barrier to earthworm introduction in previously logged areas derives from New York State's constitution. The "forever wild" clause, adopted in 1894, prohibits logging or any other type of forest extraction process on state-managed land (Henshaw Knott 1998). The New York State legislature established the Forest Preserve of the Adirondacks in 1895 out of its state land holdings and, under the "forever wild" clause, prohibited timber cutting in this area. In 1983, the Forest Preserve was composed of 2,476,000 acres of land, or about 41.8 percent of the Adirondack Park's 5,927,600 acres (Brown 1985). This policy has led to reforestation of logging sites, shielding Forest Preserve areas from both land disturbance and earthworm introduction through logging equipment. Once exception to the policy arose after the 1950 blowdown in the Adirondacks, a severe storm that felled enough timber to build over four thousand average-size homes (Brown 1985). To reduce debris, the state made 183 separate

contracts with private lumbering companies to remove the downed timber. It is likely that limited quantities of earthworms were introduced in the Forest Preserve at this time.

Today, the lumber industry in Webb is in decline. The practice faces threats from reduced construction demands and a limited availability of timber supply (Henshaw Knott 1998). These constraints have combined with increased pressure from the state's Department of Environmental Conservation (DEC) to sell lumbering lands to the state. Declining profitability has been an important factor driving loggers to make the sale. While state ownership of these forested lands has the potential to reduce earthworm introductions through logging, the state offers loggers a fixed price for their land, a policy that encourages clear-cutting of timber. This is because loggers want to obtain the highest possible profit from the wood before turning the lands over to the state. The flurry of activity to clear the timber increases the risk of earthworm invasion.

Another crucial pathway for earthworm introduction in the Town of Webb is the fishing industry. Numerous historical accounts of fishing in the area specifically mention the use of earthworms for bait and some discuss the potential of obtaining such bait from the soil. A 1920 article on fishing in the Adirondacks advises tourists that they will be able to dig for worms around human settlements, but finding earthworms in the deep woods will be unlikely (Billow 1920). This supports the theory that there were no earthworms in the region before settlers moved in. Billow (1920) advises visitors who do not wish to search for worms that they should pack worms from home in moss and transport them to the Adirondacks. The article essentially calls for the introduction of earthworms to the Adirondacks.

Other residents recall using worms for bait as children in the 1930s at Big Moose Lake in northern Webb. One angler recalls finding a worm hotspot at a campsite with buried garbage (Barlow 2004). She often tied these worms to strings to fish for trout and bullheads. Another 1930s angler recalls fishing with worms at Andes Creek in Big Moose. When the worms ran out, he and his family would use grasshoppers. These accounts speak to the ease with which children were able to dig up worms for bait in Webb in the 1920s and 30s. They also speak to the importance of worm use as a fond childhood memory, suggesting that the practice has traditional value.

The use of artificial bait is also a tradition in Webb among more advanced anglers. Old Forge is the birthplace of a type of artificial bait called the “devil bug” (Buck 1975). Made of deer fur, the contraption attracts bass by mimicking the movement of a beetle. While much less popular in the wake of more advanced fishing technology today, the devil bug became hugely popular in the 1920s, selling over 50,000 by mail order in 1922. The “bug’s” success highlights the growing importance of artificial bait at that time. Artificial bait came to be viewed as a standard for expert anglers, and the use of earthworms was considered amateur. William Chapman White, one of the most famous writers of the Adirondacks, notes of fly fishermen in the 1950s, “they are set for the opening of the Adirondack trout season, except for one demeaning detail. If they want any trout, they must dig a mess of worms” (White 1985, 250). This suggests that trout anglers were able to find an abundance of worms in the ground, but also that earthworm use was disparaged. White (1985) identifies two camps of Adirondack anglers that tend to look down on each other: the trout enthusiasts who use live bait and worms, and the

bass anglers who use artificial lures. To the latter class, those who use earthworms appear far too primitive.

Research on the distributions of invasive earthworms in the Town of Webb is currently underway. Bernard et al. (2009) find that invasive earthworms are rare in the Adirondacks compared to nearby Madison County. One explanation they offer is that Adirondack soils are acidic and poorly-buffered, creating inhospitable conditions for earthworm colonization. Still, anecdotal evidence attests that it is possible to dig for earthworms for use while fishing. Given the human-mediated risk factors for earthworm invasion in the Town of Webb, it is crucial to assess the reasons for voluntary earthworm dispersal by humans in the region.

VII. Pilot Studies

This section describes the results of preliminary surveys used to test the conceptual model for voluntary earthworm dispersal. As a means of verifying the basic concepts of invasive species knowledge, attitudes, and behavior in the Town of Webb, I conducted a pre-test comprised of both a survey of tourists (Appendix B) and face-to-face interviews with residents. The tourist survey partly confirms the relationship between environmental experience and knowledge, as well as between environmental knowledge and pro-environment attitudes and behaviors. The Town of Webb Visitor Information Center distributed the survey to incoming tourists and residents between October and November 2009, generating 28 responses. The age range of the respondents is 40 to 69 with a mean age of 55. About half are male and the other half are female. Seventeen of the respondents, or 61%, marked that they have previously gone fishing in Webb, and 88% of these anglers reported that they have ever used worms for bait. The most common

means of obtaining earthworms is to purchase them at a convenience store. All of the anglers selected nightcrawlers as their worm of choice, and only one respondent uses another worm in addition, which is the meal worm.

Because earthworm disposal is more directly related to invasive earthworm introduction than simple worm use, the survey also tests disposal methods. Thirty-nine percent of anglers using worms dispose of unused worms in the lake or river, 21% save them for future use, and 14% dispose of them on shore. While this suggests that only a small percentage of anglers introduce earthworms to the forest floor, two respondents wrote in that they put unused earthworms in their gardens. These respondents both strongly agree that earthworms have a positive influence on the environment. In general, the disposal of worm bait in forests, lakes and gardens corresponds with less familiarity with invasive earthworms and more positive perceptions of these species. This suggests that unfamiliarity with the concept of invasive earthworms contributes to positive attitudes towards earthworms and an increased likelihood of promoting their spread.

Another important result of this preliminary survey is that invasive earthworm knowledge is not extremely uncommon. Twenty-one percent of respondents somewhat agree that they are familiar with the concept of invasive earthworms. One possible explanation for this is the frequent discussion of invasive species in local publications and media. A 2003 *Adirondack Life* magazine article features invasive earthworms, recommending that anglers avoid dumping bait in the woods and that residents check the roots of newly purchased plants for worms (Stager 2003). Still, half of the preliminary survey respondents believe that earthworms have a positive effect on the ecosystem.

The interviews were more helpful in determining some of the driving forces behind attitudes towards earthworms. I conducted 13 interviews between October and November 2009. Participants were approached face-to-face at local businesses in Old Forge. The age range is approximately 20-70 with an equal distribution of gender. One of the goals of the interviews was to assess fishing behavior related to earthworm dispersal. Four of those interviewed reported that they go fishing in the Town of Webb, and all use worms only on occasion when fishing. One of the insights gained is that anglers were more likely to use worms when fishing with children. One participant noted, "I only use worms when I fish with my kids. Otherwise, I use artificial lures." Another woman responded that she uses glow worms for fishing with her young cousins because of the way they light up in water. This suggests that earthworms are considered an easier form of bait to use, but other types, such as artificial bait, are more effective. Because of these responses, I find it important to test as correlates of earthworm use the perceived effectiveness of earthworm bait and whether anglers are likely to use such bait in the absence of their children. The interviews also generated important information on the availability of earthworms in Webb. There are five shops in the Old Forge area that sell worms: one bait shop, two convenience stores, a hardware store, and a camping resort. The most popular worm sold at these stores is the nightcrawler, but most provide meal worms, roundworms, green worms, trout worms, dillies, and glow worms upon request.

Because the mere use of worms for bait does not necessarily translate into earthworm dispersal, the pilot interviews also test disposal methods. Another insight gained from the interviews is that worm disposal methods vary, with participants responding that they dump unused worms in the forest, gardens and the trash. Generally, those who purchase

bait worms tend to save them for the next fishing trip, while those who dig for worms return them to the ground. This may be representative of the environmental value of equilibrium, or returning to nature what has been taken from it.

The interviews also test invasive species knowledge and attitudes. Residents generally feel that they are aware of environmental issues affecting the Adirondacks, and those who reported involvement in more recreational activities also reported greater knowledge of environmental issues. Two out of thirteen people identified invasive species as important environmental concerns without being prompted. Others, when asked which invasive species they are aware of, replied, “the milfoil” (half of all residents), referring to Eurasian watermilfoil (*Myriophyllum spicatum*), or zebra mussels (*Dreissena polymorpha*) (5 residents). While almost all residents are familiar with the concept of invasive species, over half had trouble identifying more than two individual species. Not one resident responded “earthworms” when prompted with the question, “which invasive species are you aware of?” One resident had previously heard of invasive earthworms. She had “read about them somewhere,” but couldn’t “remember why they’re a problem.” This demonstrates low levels of knowledge about invasive earthworms in the Town of Webb, contrary to the tourist survey results.

Another important observation is that while there is widespread knowledge of invasive species in general, other environmental issues take priority. The environmental issues most commonly identified by participants are acid rain, water mercury content, and tourists. There appears to be generally negative sentiment towards transient visitors, who are assumed to “trash the place” and “leave their garbage everywhere.” These responses demonstrate both that concern about invasive species is tempered by other environmental

considerations and that residents demonstrate stronger environmental “place attachment” to the Town of Webb than do tourists. For the latter reason, I find it important to determine in the full-length survey whether residents of the Town of Webb live there permanently or seasonally. This is included in the childhood/adult environment box on the conceptual model.

Concerns about other environmental issues may take precedence over invasive species because of the perceived human capacity to remedy the other problems. While residents communicated some dismay about the takeover of invasive species, many did not seem optimistic that the issue can be resolved. As one woman said, “people should be doing something about invasive species. But they’re almost unstoppable. You can’t solve it. There are too many ways things can get here.” This perceived inevitability of invasive species is an important component of environmental attitudes. The perception that invasive species are inevitable logically leads to attitudes of indifference or apathy towards invasion. Still, a 2006 survey finds that the average American is willing to make a one-time payment of \$48 to delay the encroachment of invasive species, even when told that this invasion would be inevitable (McIntosh et al. 2009). It is important to know if sentiments of inevitability make people less concerned that they may be transporting invasive species.

VIII. Mail Survey

While the preliminary survey and interviews are important for highlighting overarching trends in the Town of Webb and for adjusting the conceptual model, a larger sample size is needed to accurately determine the importance of demographic variables in predicting environmental knowledge and attitudes, as well as voluntary earthworm

dispersal behavior. In March of 2010, I mailed a postcard to 400 residents of the Town of Webb, inviting them to participate in a survey on recreation and environmental practices that would be mailed to them within a week. Names and addresses were randomly selected from tax maps available from the Adirondack Park Agency's GIS CD. I narrowed the list of residences to those coded as year-round dwellings as opposed to seasonal homes in order to ensure that the survey reached permanent residents who could have a potentially year-long impact on Webb's environment. I eliminated repeat addresses from my selection, and used the Hawth's Tools extension on ArcMap to randomly select 400 addresses from a list of approximately 750. A week after the preliminary postcard was sent, I mailed the selected residents an eight-page survey (Appendix D), which contains a mix of categorical and Likert-scale questions. A letter to residents on the front of the survey assures confidentiality and provides both my contact information and that of Colgate's Institutional Review Board, which approved the survey with an exemption from review (Appendix A). A week after the survey was mailed, I sent the residents a follow-up postcard thanking those who had already returned their surveys and asking those who had not to please consider doing so. I consulted Arlene Fink's *The Survey Kit* (2003) and Don A. Dillman's *Mail and Telephone Surveys* (1978) for both the timing of my mailing and my questionnaire style. I chose to describe the survey as assessing recreational practices and environmental issues so as not to bias respondents in their answers on earthworm use and attitudes towards invasive species by revealing the more specific topic of invasive earthworms. At the end of the survey, I provided a brief summary of the detrimental effects of invasive earthworms.

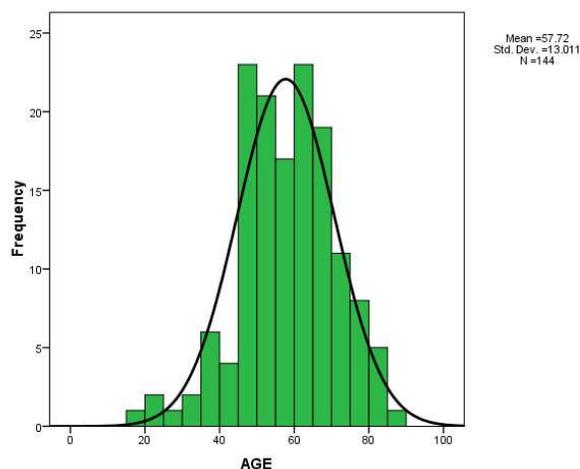
IX. Results

General population characteristics

Aside from two surveys that were returned as undeliverable, the mail survey generated 148 responses, or return rate of exactly 37%. This high rate of return for a mail survey may be attributed to the nature of the population being studied. The homeowners in Webb are generally of retirement age and active in recreation and environmental activities, making them more inclined to respond to a survey advertised as “Webb and the World Outdoors.” Furthermore, the use of the pilot survey and interviews in the town may have allowed word of the study to spread through social networks in the area.

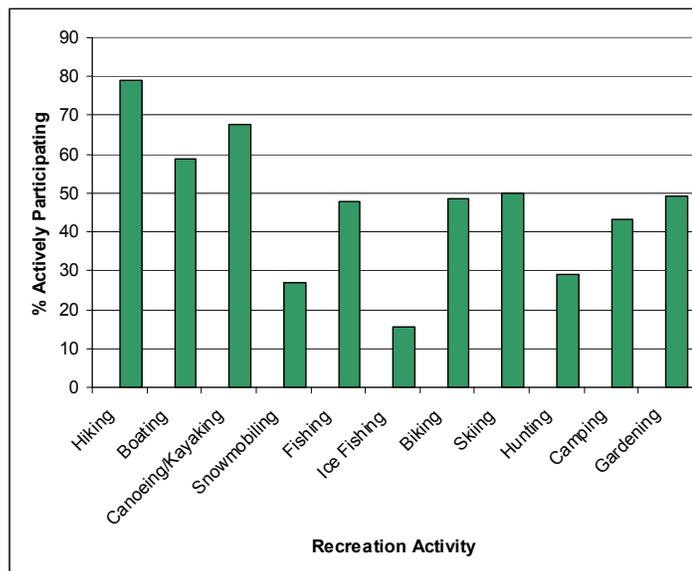
Of the mail survey respondents, 62.2% are male. Ages range from 15 to 85 with a mean age of 57.7, following a normal distribution, as shown in Figure 4. This higher mean age is indicative of Webb’s popularity as a retirement destination. Residents are on average moderately conservative, with 45.2% responding that they are at least somewhat conservative, and 29.1% responding that they are neutral. While the survey targets those who live year-round in the Town of Webb, 6 of the 148 respondents (4.1%) are seasonal residents. This is because addresses were selected according to cadastral code for year-round housing without knowledge of whether residents actually dwell there year-round. The survey responses of the seasonal residents are included in the analysis.

Figure 4. Age distribution of survey respondents



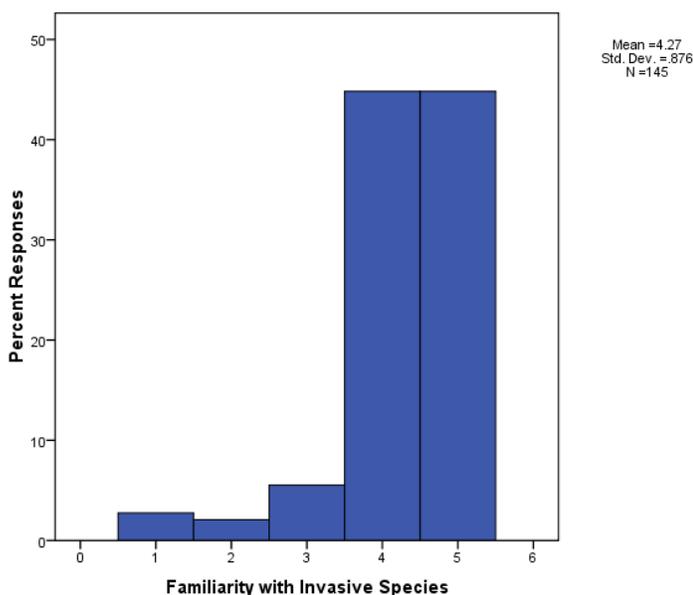
In general, the respondents are highly involved in outdoor recreation activities, with 95.9% actively participating in at least one outdoor activity. The distributions for each activity are displayed in Figure 5. The most popular form of recreation is hiking, with 79.1% of respondents actively participating. Of particular interest to this study that fishing and gardening are popular forms of outdoor recreation, with 48.0% of respondents reporting that they actively go fishing, 59.5% responding that they have gone fishing at least once, and 49.3% responding that they actively garden.

Figure 5. Percent of respondents actively involved in outdoor recreation by activity



The respondents are also knowledgeable about environmental issues, particularly about the topic of invasive species. Close to 90% agree to some extent that they are familiar with the concept of invasive species, as shown in the bar graph in Figure 6. Seventy respondents, or 47.3%, included invasive species in their top three natural resource concerns, despite the choice's placement alongside acid rain and water pollution, two examples of environmental degradation that have long been problematic in Webb. In addition, 44.9% of respondents at least somewhat agree that they donate their time or money towards the eradication of invasive species.

Figure 6. Familiarity with the concept of invasive species



Background Variables

The principal goal of the survey is to test background variables and environmental knowledge and attitudes contributing to human environmental behaviors promoting exotic earthworm introduction in Webb. The first leg of this study's conceptual model connects the background variables of age, gender, income, education, and childhood/adult environment to the intervening variables of political views, outdoor recreation experience, and land management experience.

The results show that age has a statistically significant impact on the number of recreational activities in which Webb residents participate. A one-way ANOVA produces an F-statistic of 1.713 with a p-value of .013, disproving the null hypothesis that age is not correlated with this indicator of outdoor recreation experience. Webb's older residents tend to participate in a greater number of outdoor recreation activities, likely because their retirement affords them increased leisure time, but also because over the

courses of their lives, they have had greater opportunities to participate in various forms of outdoor recreation. Age is not a significant predictor of any other intervening variables using the one-way ANOVA test.

Gender is statistically correlated with the intervening variable of land management experience using a t-test (Table 1). Men are significantly more likely to have land management experience than women in the Town of Webb, although the average respondent disagrees that he or she has land management experience at all. Likewise, the results uphold that education is significantly and positively correlated with land management experience ($p=.009$) (Table 2). Income has no significant impact on any of the intervening variables, and the null hypothesis cannot not be rejected for the effect of residents' childhood rural, suburban and urban environments. However, as demonstrated in Table 3, respondents who grew up in rural settings on average participate in more recreational activities and have more land management experience. Contrary to what might be expected, this group is also slightly less conservative than that which grew up in urban settings.

Table 1. Results of a t-test for the effect of gender on land management experience

	Mean for Men	Mean for Women	t-statistic	p-value
Experience in land management	2.47	1.63	3.466	.001

Table 2. Results of a one-way ANOVA for the effect of education on land management experience

	Mean High School	Mean Some College	Mean Bachelor's	Mean Master's	Mean PhD	F-statistic	p-value
Experience in land management	2.05	1.73	2.40	2.52	3.60	3.529	.009

Table 3. Mean intervening variable result by childhood environment

	Rural	Suburban	Urban
<i>Political ideology</i>	3.33	3.35	3.50
<i>Number of recreational activities</i>	5.34	5.35	4.45
<i>Experience in land management</i>	2.37	1.92	1.95

Intervening Variables

Each of the primary intervening variables has important effects on the secondary intervening variables of environmental knowledge and attitudes. While political views are not significantly correlated with environmental knowledge, they do have a statistically significant correlation with the belief that the effects of climate change will be witnessed in this lifetime (Table 4). Those who are more liberal are more confident that they will see such effects. This division reflects the highly politicized nature of the climate change issue.

Table 4. Results of a one-way ANOVA for the effect of political ideology on environmental attitudes

	Mean Strongly Conservative	Mean Moderately Conservative	Mean Neutral	Mean Moderately Liberal	Mean Strongly Liberal	F-statistic	p-value
<i>Belief that climate change will have a noticeable impact in this lifetime</i>	2.37	3.38	3.60	4.16	4.00	8.630	.000

Outdoor recreation experience is significantly positively correlated with environmental knowledge in the form of both the number of sources a person consults for environmental information and the respondent's familiarity with the topic of invasive species. As the number of outdoor activities a respondent is involved with increases, so do the number of resources they consult for environmental information and their familiarity with invasive species (Table 5). In particular, respondents who actively

participate in hiking are significantly more likely than those who do not to be familiar with the concept of invasive species ($p=.000$) (Table 6). A possible explanation is that frequent hiking allows participants to become more familiar with their landscapes and more likely to notice changes in plant communities. Another indicator of outdoor recreation experience is years involved in recreation. A one-way ANOVA finds that just as for the number of outdoor recreation activities, the variable of years of recreation experience is significantly positively correlated with invasive species familiarity ($F=2.751$, $p=.009$).

Table 5. One-way ANOVA for impact of number of outdoor recreation activities on environmental knowledge

Environmental knowledge indicator	F-statistic	p-value
Number of environmental information sources	2.754	.003
Familiarity with concept of invasive species	5.456	.000

Table 6. T-test for impact of hiking on invasive species familiarity

	Mean non-active hikers	Mean active hikers	t-statistic	p-value
Familiar with concept of invasive species	3.60	4.44	-5.086	.000

The third intervening variable represented in this study's conceptual model is land management experience. Such experience demonstrates a significant relationship with environmental knowledge, but not with environmental attitudes. Land management experience is significantly positively correlated with professed knowledge of environmental issues and familiarity with specific invasive species (Table 7). Those who have previously participated in land management are more likely to have heard of a

greater number of invasive species. However, such respondents are not significantly more likely than those without land management experience to report that they are generally familiar with the concept of invasive species. This is likely because while close to 90% agree that they have heard of the concept of invasive species, there are different levels of invasive species knowledge within that familiarity.

Table 7. One-way ANOVA for effect of land management experience on environmental knowledge

Environmental knowledge indicator	Strongly Disagree	Moderately Disagree	Not Sure	Moderately Agree	Strongly Agree	F-statistic	p-value
Considers self well-educated on environmental issues	3.64	4.24	3.88	4.14	4.92	7.720	.000
Knowledge of listed invasive species	4.49	6.41	5.00	5.95	6.92	4.316	.003

Education is one background variable that has a direct effect on environmental knowledge. While education level is not significantly correlated with knowledge of invasive species, it is significantly positively correlated with how environmentally knowledgeable respondents consider themselves to be, as well as with the number of sources they consult for information on environmental issues ($p=.000$ and $.030$) (Table 8). This means that more highly educated individuals on average consider themselves to have more environmental knowledge and to consult a greater number of sources for environmental information.

Table 8. One-way ANOVA for impact of education level on environmental knowledge

	Mean High School	Mean Some College	Mean Bachelor's	Mean Master's	Mean PhD	F-statistic	p-value
Considers self well-educated on environmental issues	3.32	3.75	4.17	4.22	4.60	5.626	.000
Number of environmental sources consulted	3.14	3.66	3.86	4.64	4.25	2.757	.030

One unexpected result is the relationship between education and the environmental attitude of the inevitability of invasive species. A one-way ANOVA confirms that there is a significant relationship between the two variables, as Table 9 illustrates. Those with the least education and those with the highest education levels are more likely to believe in the inevitability of invasive species compared to those who have obtained Bachelor's degrees as their highest level of education. This suggests that those who have graduated from college are more optimistic about the feasibility of preventing exotic species invasions, but further years of study render residents more skeptical about the potential efficacy of prevention efforts. Overall, the population disagrees that the prevention of invasive species cannot be achieved.

Table 9. One-way ANOVA for the effect of education level on sentiments of invasive species inevitability

	Mean High School	Mean Some College	Mean Bachelor's	Mean Master's	Mean PhD	F-statistic	p-value
Belief introduction of invasive species is inevitable	2.59	2.28	1.82	2.26	2.60	2.471	.048

The survey also confirms a relationship between environmental knowledge, attitudes, and donor behavior regarding invasive species. The belief that invasive species are inevitable makes residents significantly less likely to donate their time or money towards their eradication and towards environmental causes in general (Table 10). This supports the idea that perceptions of inevitability regarding invasive species lead to apathetic attitudes and little motivation to participate in eradication efforts. Similarly, recognition of individual invasive species is positively correlated with donations to both invasive species eradication and general environmental causes ($p = .031$ and $.010$ respectively).

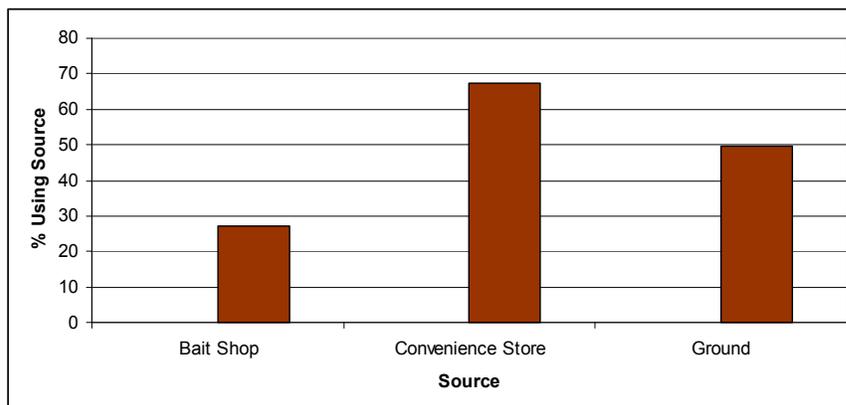
These results suggest that while knowledge of invasive species can increase preventative behavior, apathetic attitudes can reduce inclinations towards such behavior.

Table 10. ANOVA for the effect of belief that invasive species are inevitable on environmental donations

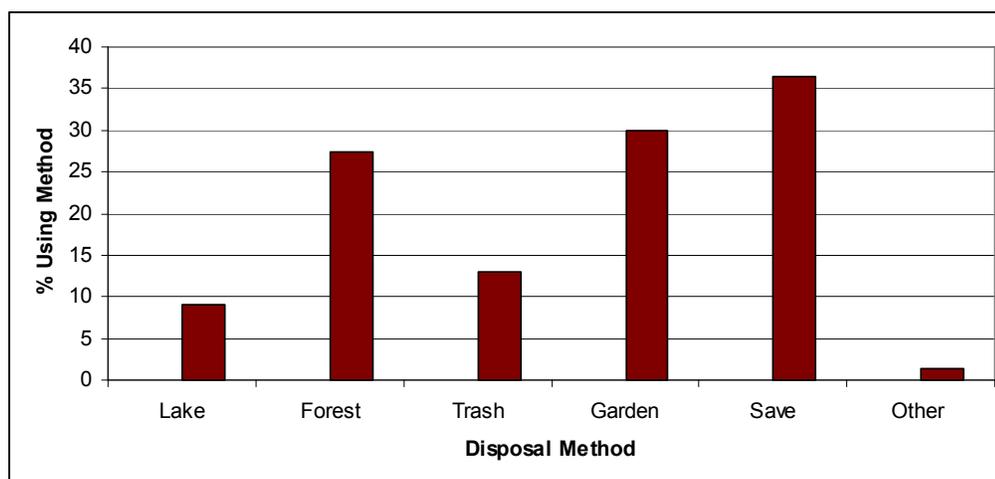
Donation type	Strongly Disagree	Moderately Disagree	Not Sure	Moderately Agree	Strongly Agree	F-statistic	p-value
<i>Invasive species eradication</i>	3.93	2.76	2.91	2.00	1.00	9.571	.000
<i>General environmental causes</i>	3.24	3.09	2.39	2.67	1.50	2.851	.026

Earthworm-Related Behavior

Part of the survey assesses high-risk behaviors for earthworm introduction in the Town of Webb. A major concern is the disposal of bait worms on the forest floor. Of the 59.5% of residents who have ever gone fishing, the vast majority (87.5%) have used worms for bait at least once. Out of all anglers, 47.7% report that earthworms are their preferred choice of bait. Just as the preliminary studies suggest, the nightcrawler is by far the most popular species of bait worm. Anglers obtain earthworms from one of three sources: a bait shop (27.3%), a convenience store (67.5%), or from the ground (46.8%) (Figure 7). The popular reliance on convenience stores is likely because worms are cheaper than in bait stores and more easily available. The popularity of purchasing worms indicates that they are commonly introduced from other areas. Because 46.8% can easily obtain earthworms from the ground, there is probable widespread invasion in human-settled areas.

Figure 7. Sources of earthworm bait

Because earthworm use alone does not necessarily translate into exotic earthworm introduction, bait worm disposal methods in this population are extremely important. Saving earthworms for future use is the most common method of handling surplus earthworms (36.4%). Yet 29.9% of anglers deposit unused worms in their gardens, and 27.3% dispose of earthworms on the forest floor, thereby facilitating invasion of remote regions (Figure 8). The high levels of earthworm bait use indicate that forest regions near fishing areas are likely zones of invasion.

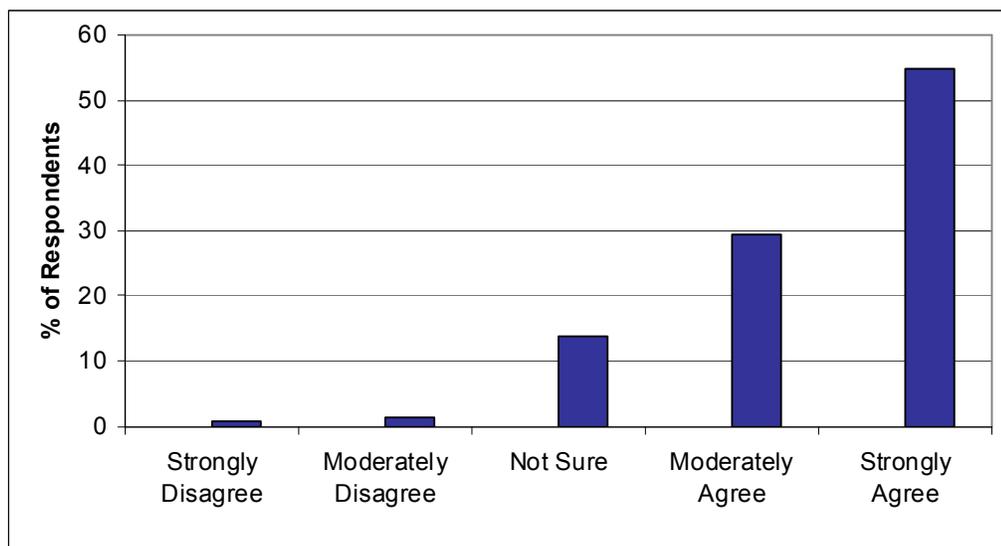
Figure 8. Popularity of bait worm disposal methods

Another important contributor to earthworm invasion is composting activity. Twenty-three respondents, or 15.5%, maintain a personal compost pile. The one respondent who marked “other” for her earthworm bait disposal method wrote in that she places unused earthworms in her compost pile. While 15.5% is not a majority, this percentage indicates that composting remains a risk for invasive earthworm dispersal in Webb. In addition, close to half of respondents actively participate in gardening, which speaks to the potential risks of invasion posed by horticulture in the area. Gardeners may purchase new plants that are transported with earthworms in their soil, and positive experiences with worms in gardening may contribute to the perception that worms are good for the soil and for plant life.

None of the background variables of age, gender, income, education and child/adult environment have any significant correlation with earthworm dispersal behavior. Such a specific outcome variable requires more closely-related independent variables. While knowledge of invasive earthworms is not found to be significant for predicting voluntary earthworm dispersal, the lack of knowledge about these species compared to exotic plants is noteworthy. Exactly 17% of respondents have heard of invasive earthworms before and have heard of them from a variety of sources. The most popular sources are television, magazines, the radio, friends or family, and schools and universities. Yet the average resident can recognize at least five different invasive species. This comparative lack of knowledge of earthworms combines with an overwhelmingly positive attitude towards earthworms. As shown in Figure 9, close to 85% of residents believe that earthworms have a positive impact on the soil. In addition, 57% of anglers feel that the use of

earthworms for bait is an important tradition in the Town of Webb, indicating that they have favorable sentiments towards these species.

Figure 9. Belief that earthworms have a positive impact on plant life



Four linear regressions are used to test the predictive power of the independent variables on the outcome variables of saving earthworms for future fishing excursions, forest-floor disposal, disposal in gardens and composting. The independent variables displayed in the results tables are primarily those that remain significant. A linear regression for predicting the retention of earthworms for future fishing trips finds three significant predictors: donation towards invasive species eradication, frequency of earthworm use when fishing, and frequency of participation in fishing (Table 11). Those who go fishing more often and use worms more frequently are significantly more likely to save their worms for future use. Anglers who donate their time or money towards the eradication of invasive species are less likely ($p = .005$) to save their worms, indicating that they use at least one of the other disposal techniques, placing earthworms on land or in the water.

Table 11. Results of a linear regression to predict the retention of earthworms for future fishing excursions

Independent variables	Beta	p-value	
<i>Donates time or money to eradicate invasive species</i>	-0.315	0.005	
<i>Frequent use of earthworms when fishing</i>	0.242	0.027	
<i>Frequent participation in fishing</i>	0.349	0.002	
Model statistics	Adjusted R ²	F-statistic	p-value
	0.221	7.524	0.000

For forest-floor disposal, one independent variable remains significant in a linear regression (Table 12). Frequent participation in fishing is negatively correlated with earthworm disposal in forests ($p=.004$), suggesting that anglers who fish more often do not have an interest in disposing of worms in their surroundings so immediately, but have more of an interest in using them later. The donation of time or money to eradicate invasive species is positively correlated with forest-floor disposal, and is close to achieving significance ($p= .080$).

Table 12. Results of a linear regression predicting earthworm disposal in forests

Independent variables	Beta	p-value	
<i>Frequent participation in fishing</i>	-0.325	0.004	
<i>Donates time or money to eradicate invasive species</i>	0.196	0.080	
Model statistics	Adjusted R ²	F-statistic	p-value
	0.130	6.370	0.003

The disposal of worm bait in gardens is another mode of introduction for earthworms in areas near human settlements that are likely to already host exotic populations. Both

age and active participation in gardening are significant positive predictors of earthworm disposal in gardens ($p=.036$ and $p=.008$), as shown in Table 13. Older anglers who enjoy gardening are more likely to bring worms home to their gardens. While this suggests that an underlying motivation is to improve soil fertility and plant growth in these gardens, the belief that earthworms have a positive impact on plant life does not achieve significance. This is likely because the belief that earthworms are good for plants is so widespread.

Table 13. Results of a linear regression predicting earthworm disposal in gardens

Independent variables	Beta	p-value	
<i>Active participation in gardening</i>	0.301	0.008	
<i>Age</i>	0.234	0.036	
Model statistics	Adjusted R ²	F-statistic	p-value
	0.112	5.680	0.005

Four factors have predictive power for use of a personal compost pile. The belief that earthworms have a positive impact on plant life, donations towards the eradication of invasive species, and training in natural resource management are all positively correlated with composting, while only the first variable achieves significance (Table 14). Self-reported knowledge of environmental issues is negatively correlated ($p=.043$) with participation in composting. The divergent directions between natural resource management and knowledge of environmental issues for the outcome variable of composting are surprising because natural resource management generally enhances environmental knowledge. This suggests that self-reported environmental awareness is not an accurate indicator of environmental knowledge. Overall, the belief in a positive

impact on plant life is the strongest driver of composting, indicating that attitudes towards the earthworm are significantly related to this outcome dispersal behavior.

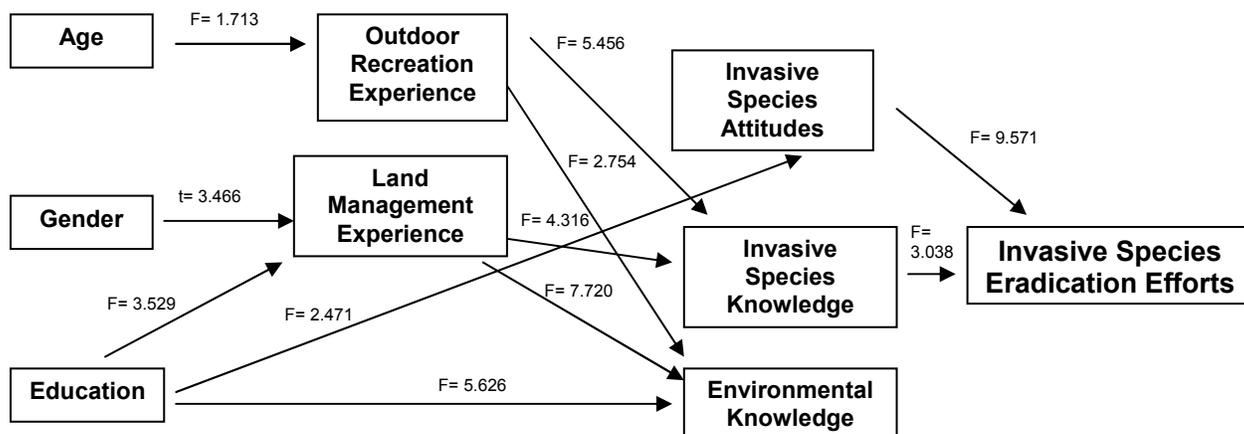
Table 14. Results of a linear regression to predict use of a personal compost pile

Independent variables	Beta	p-value	
<i>Belief that earthworms have a positive impact on plant life</i>	0.227	0.009	
<i>Donates time or money to eradicate invasive species</i>	0.163	0.065	
<i>Self-reported knowledge of environmental issues</i>	-0.187	0.043	
<i>Training in natural resource management</i>	0.178	0.055	
Model statistics	Adjusted R ²	F-statistic	p-value
	0.097	4.421	0.002

X. Discussion

These results alter the conceptual model and hypotheses of Figure 3, because only the background variables of age, gender, and education influence the intervening variables of outdoor recreation and land management experience in the Town of Webb (Figure 10). A greater number of outdoor experiences increases environmental knowledge and especially familiarity with invasive species. Land management experience also increases invasive species knowledge in Webb. Political views influence environmental attitudes about climate change, but are not significantly correlated with attitudes towards invasive species. The population in Webb is characterized by recreationally active and environmentally knowledgeable residents. Familiarity with invasive species and other environmental issues is high, but recognition of invasive earthworms remains low at 17%.

Figure 10. Updated conceptual model displaying only significant relationships



One possible source of error in this study is the uneven gender distribution. Of the 88 people who fish, 78.8% are male, suggesting that fishing is a gendered practice in the Town of Webb. However, more males returned the survey than females, so the results may be skewed.

Overall, the results demonstrate that the knowledge-attitudes-behavior model is applicable to the topic of invasive species, and in particular to invasive earthworms because of the crucial human agency in earthworm colonization. Earthworm invasion is essentially a human-induced practice.

The most surprising result of this study is that anglers who donate time or money towards the eradication of invasive species are more likely to compost and less likely to save their bait earthworms for future use. This suggests that the lack of awareness of earthworms' invasive status combined with positive perceptions of earthworms encourage these people to continue to dump earthworms in the forest. Of the 21 people who report disposing of earthworms in the forest, 2, or 9.5%, report being aware that earthworms are invasive. This indicates that either these anglers are unconcerned that

they are introducing exotic earthworms or that they are unaware that that all species of earthworms are invasive in upstate New York.

Another crucial finding is that frequency of participation in fishing activities and frequency of bait worm use are deciding factors in whether earthworms are saved for the next trip or disposed of on land. Anglers who fish often are more likely to save their worms and less likely to contribute to earthworm invasion through dumping bait. This pattern is likely the result of economic reasoning. If recreational anglers seldom use earthworms, it would be more logical to dispose of them than to save them. In this case, economic efficiency in saving earthworms may slow invasion. This practical economic concern is more important to anglers than environmental concerns of earthworm invasion, especially because most anglers are unaware that earthworms are invasive or have some negative impacts on native plants. Yet the belief that earthworms have a positive impact on plant life remains an insignificant predictor of all methods of bait worm disposal, even for those who put earthworms in their gardens. This is likely due to the widespread belief that earthworms are good for the soil. Those who do not dump worms on land are just as likely as those who do to believe that this activity does not harm plant life. It is therefore important to promote awareness of the ecosystem effects of invasive earthworms.

This study helps to inform where policymakers should target invasive earthworm awareness campaigns. Due to the popularity of gardening in the Town of Webb and the positive correlation between gardening and compost use, garden clubs are an important outlet for invasive earthworm information. Because one-time users of earthworm bait are more likely to dispose of worms in the forest than more regular anglers, information

campaigns should also focus on tourists and residents who are more likely to fish during peak season. It may be that the best way to reach out to this group is through media such as television, radio, and the internet. Minnesota's WormWatch, the only group actively pursuing an invasive earthworm awareness campaign, distributes signs in bait shops to alert customers not to dump their bait (Keller et al. 2007). In Webb, such a campaign would likely be more effective in convenience stores, where most anglers obtain their worms.

XII. Conclusion

As the first to examine knowledge and attitudes towards invasive earthworms, this study brings to light the extent to which public knowledge of invasive earthworms is limited, positive attitudes towards earthworms are strong and the risk of continued earthworm invasion is high. The ease with which almost half of anglers in the Town of Webb are able to extract worms from the soil for fishing suggests widespread invasion in human settlements. However, the more remote interiors of the forest are potentially earthworm-free. In order to keep this land pristine, risky behaviors such as composting and improper bait disposal must be prevented. Some of the hurdles for changing earthworm-related behavior are the strong tradition of earthworm use in the town, the overwhelming perception that earthworms are good for the soil and for plants, and the perceived benefits of composting.

Further study with a larger sample of people who are aware of invasive earthworms is needed to determine if this knowledge has the capacity to change attitudes and behaviors regarding the species. This can be achieved with a shorter survey that will encourage more people to respond as to whether or not they heard of invasive earthworms, as well

as questions about how learning about this problem has caused a change in voluntary worm dispersal. As time passes, familiarity with the concept of invasive earthworms will likely increase, but this knowledge is only meaningful if it translates into concern and effective action towards prevention.

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Appendix A. Letter of approval from Colgate Institutional Review Board**COLGATE UNIVERSITY**

13 Oak Drive
Hamilton, NY 13346

Institutional Review Board

MEMORANDUM

DATE: October 14, 2009

TO: Dara Seidl

FROM: Bruce C. Hansen, Institutional Review Board Chair

RE: IRB Proposal “**ER-F09-11**”

Colgate’s Institutional Review Board (IRB) has reviewed and approved your proposal entitled “**Human Perceptions of and Behaviors Influencing Invasive Earthworms in Webb, NY**” for the use of human participants in your research. The research meets the ethical standards adopted by the Federal Government for research with humans as they are explained in the Belmont Report. This approval is in effect for one year from this date and is the only IRB approval required for research conducted at Colgate University. If you conduct your research at another institution, you may need to secure IRB approval from that institution. Feel free to contact me again if the protocol for the study changes substantially.

The IRB wishes you much success with your research.

Sincerely,



Bruce C. Hansen
Asst. Professor of Psychology
Neuroscience Program
Chair, Institutional Review Board

Appendix B. Pilot survey distributed at the Old Forge Visitor Information Center,
November 2009



This survey is being conducted as part of an undergraduate research project on the environmental history, fishing culture, and perceptions of non-native species in Webb, NY. As a participant, you will respond to questions about current environmental issues in the Adirondacks, as well as your own recreational practices. Your participation will help policy-makers determine which environmental strategies best match the interests of those who visit the Town of Webb. All information obtained from this survey will be confidential and used solely for research purposes.

Q1. What brings you to Webb today?

Check all that apply, and **circle** your primary reason.

- | | |
|---|--|
| <input type="checkbox"/> Outdoor recreation | <input type="checkbox"/> Visiting friends or family |
| <input type="checkbox"/> Shopping | <input type="checkbox"/> History of the town |
| <input type="checkbox"/> Change of scene | <input type="checkbox"/> Other (please specify) <input type="text"/> |

Q2. In the Town of Webb, in which recreation activities do you actively participate?

Check all that apply, and **circle** your top activity.

- | | |
|--|--|
| <input type="checkbox"/> Hiking | <input type="checkbox"/> Fishing |
| <input type="checkbox"/> Kayaking/Canoeing | <input type="checkbox"/> Swimming |
| <input type="checkbox"/> Boating | <input type="checkbox"/> Camping |
| <input type="checkbox"/> Snowmobiling | <input type="checkbox"/> Skiing |
| <input type="checkbox"/> NONE | <input type="checkbox"/> Other (please specify) <input type="text"/> |

Q3. Have you ever been/do you plan to go fishing in Webb?

- Yes
 No (skip to back)

If **yes**, do you ever use worms for bait?

- Yes (answer the box(es) below)
 No (skip to back)



If you use worms for bait, how do you obtain these worms?

Check all that apply.

- Purchase at a bait shop
 Purchase at a convenience store
 Dig them up from the ground
 Other (please specify)

How often do you use worms for bait?

times per year **OR** times per month

What do you do with left-over worms?

- Dispose of them in the lake/river
 Dispose of them on shore
 Dispose of them in the trash
 Save them for the next fishing trip
 Other (please specify)

If you purchase worms for bait, which types do you typically buy?

Check all that apply.

- Nightcrawlers
 Round worms
 Meal worms
 Dillies
 Trout worms
 Green worms
 Other (please specify)

The following questions measure your perceptions of environmental issues in the Adirondacks. Please **circle** your level of agreement to each of the following statements.

Q4. *I am familiar with the environmental issues facing the Adirondacks.*

Strongly Disagree 1 Somewhat Disagree 2 Not Sure 3 Somewhat Agree 4 Strongly Agree 5

Q5. *I am familiar with the concept of invasive species.*

Strongly Disagree 1 Somewhat Disagree 2 Not Sure 3 Somewhat Agree 4 Strongly Agree 5

Q6. *Invasive species are among the top three environmental concerns for this area.*

Strongly Disagree 1 Somewhat Disagree 2 Not Sure 3 Somewhat Agree 4 Strongly Agree 5

Q7. *Earthworms have an overall positive influence on the ecosystem.*

Strongly Disagree 1 Somewhat Disagree 2 Not Sure 3 Somewhat Agree 4 Strongly Agree 5

Q8. *I am familiar with the concept of invasive earthworms.*

Strongly Disagree 1 Somewhat Disagree 2 Not Sure 3 Somewhat Agree 4 Strongly Agree 5

Q9. Where do you obtain information on environmental issues?

Check all that apply, and circle your most important source.

- | | |
|--|--|
| <input type="checkbox"/> Newspapers | <input type="checkbox"/> Magazines |
| <input type="checkbox"/> Internet | <input type="checkbox"/> Environmental groups |
| <input type="checkbox"/> Television | <input type="checkbox"/> Government sources |
| <input type="checkbox"/> Radio | <input type="checkbox"/> School or university |
| <input type="checkbox"/> Friends or family | <input type="checkbox"/> Other (please specify) <input type="text"/> |

Q10. Which of the following invasive/non-native species have you heard of?

Check all that apply.

- | | |
|--|---|
| <input type="checkbox"/> Zebra mussel | <input type="checkbox"/> Emerald ash borer |
| <input type="checkbox"/> Japanese knotweed | <input type="checkbox"/> Asian longhorned beetle |
| <input type="checkbox"/> Giant hogweed | <input type="checkbox"/> Garlic mustard |
| <input type="checkbox"/> Common buckthorn | <input type="checkbox"/> Purple loosestrife |
| <input type="checkbox"/> Eurasian watermilfoil | <input type="checkbox"/> Water chestnut |
| <input type="checkbox"/> NONE | <input type="checkbox"/> Earthworms (any species) |

Additional details about you

Q11. What is your gender?

- Male
 Female

Q12. What is your age?

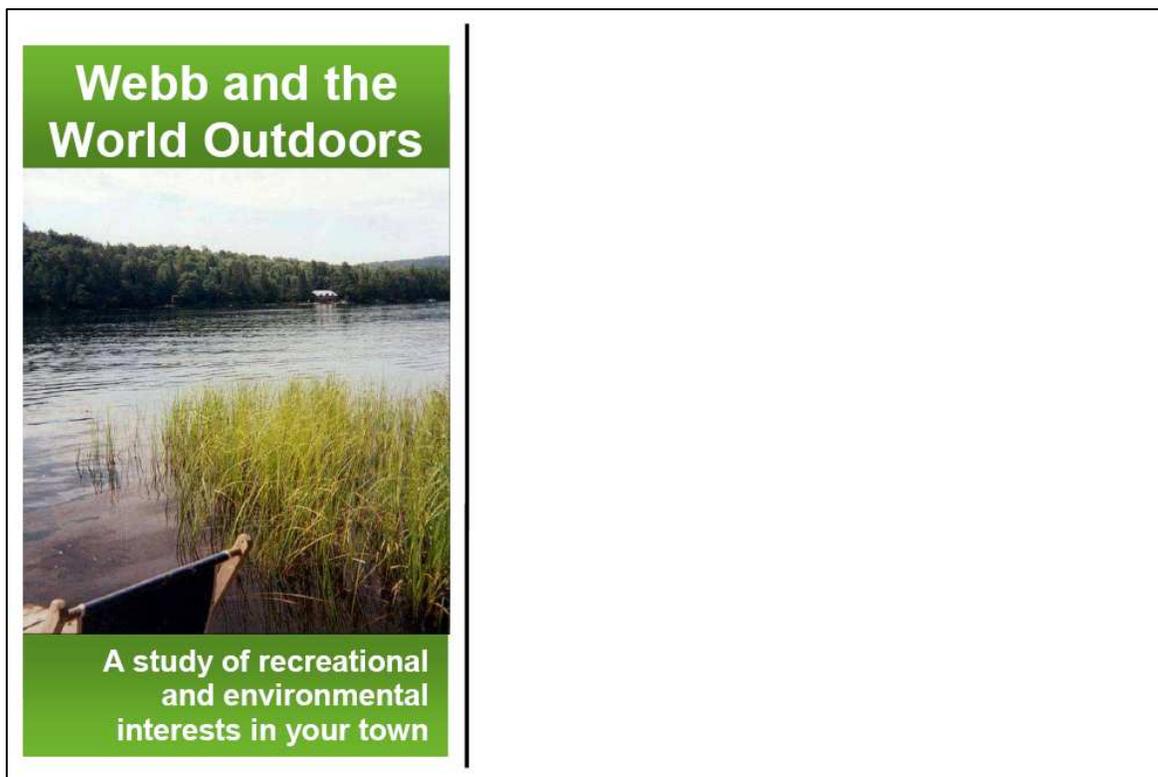
Q13. What is your home zip code?

Thank you for completing this survey!

You may have noticed a number of questions on invasive species, and on earthworms in particular. Recent conservation research has drawn attention to invasive worms for their detrimental effects on leaf litter thickness and native plant cover. If you have any questions about this survey or your rights as a participant, feel free to contact:

Dara Seidl
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13 Oak Drive
Hamilton, NY 13346
Phone 516-455-7158 | Email: dseidl@students.colgate.edu
or the Chair of the Institutional Review Board at IRB_chair@psych.colgate.edu

Appendix C. Preliminary postcard delivered to Town of Webb mail survey sample,
February 2010



February 24, 2010

Dear Resident of the Town of Webb,

Allow me to introduce myself. My name is Dara Seidl, and I am a student at Colgate University working on my honors thesis in geography. My research focuses on environmental issues and recreation in the Town of Webb. This topic is important because it identifies factors that influence environmental practices and paints a picture of the various natural resource interests at play in the Adirondacks.

Within the next week, a survey will be mailed to your home. The study is an opportunity for you to express your views on environmental issues related to your town. Through your participation, you will help determine which environmental policies best match the interests of residents of the Town of Webb.

Your name was randomly selected from the households in your town in order to obtain a representative sample. If you have questions or concerns about the study beforehand, please contact dseidl@students.colgate.edu or (516)-455-7158, and I would be happy to respond.

Thank you in advance for your help.

Sincerely,
Dara Seidl
Dara Seidl



Appendix D. Text of mail survey, delivered March 2010

Webb and the World Outdoors



An effort to understand recreational practices and environmental priorities in your town.

March 1, 2010

Dear Resident of the Town of Webb,

Allow me to introduce myself. My name is Dara Seidl, and I am a Colgate University student working on my honors thesis in geography. My research concerns the reasons for different attitudes and traditions regarding natural resources in the Adirondacks. I have chosen the Town of Webb as good location to study these issues. This topic of environmental attitudes and practices is critical for both the ecological and economic resources of the Adirondacks.

The survey contained in this booklet poses questions about current environmental issues in the Adirondacks, as well as your own recreational practices. Your participation will help policy-makers determine which environmental strategies best match the interests of residents of the Town of Webb. Because you have been selected as part of a random sample of residents, your thoughts and concerns are of great importance. You will be representing other residents who share your opinions. Please note that all information obtained from this survey will be confidential and used solely for research purposes, and your name will never be disclosed or associated with your responses.

The survey will take approximately 20 minutes. Completed questionnaires may be returned in the enclosed postage-paid envelopes, or sent to the address on the back cover. It would be very helpful to receive your completed questionnaire before **Monday, March 15th, 2010**, but I am still interested in receiving your survey beyond that date.

If you have any questions about the study or your rights as a participant, feel free to contact me using the information on the back cover.

Thank you for your help,

Dara Seidl
Dara Seidl



Instructions

There are approximately 36 questions in this survey. Section One begins with a glance at your outdoor recreation activities, and Section Two asks specifically about your fishing practices. Section Three includes questions about environmental perceptions and priorities in general, while Section Four focuses on the example of invasive species. The fifth and final section asks for more details about you for statistical purposes.

Most questions will ask you to either check a box or circle your answer. Questions that are in the form of a statement are used to ask to what extent you agree with that statement. Please circle your response, as shown below.

Example:

Strongly Disagree
1

Somewhat Disagree
2

Not Sure
3

Somewhat Agree
4

Strongly Agree
5

Most participants find this survey to be an enjoyable experience, and we hope you do too!

Section One

Your Recreation Activities

Q1. Which of the following recreation activities do you participate in?

Check all that apply.

- | | | |
|--|--|--|
| <input type="checkbox"/> Hiking | <input type="checkbox"/> Fishing | <input type="checkbox"/> Hunting |
| <input type="checkbox"/> Boating | <input type="checkbox"/> Ice Fishing | <input type="checkbox"/> Camping |
| <input type="checkbox"/> Canoeing/Kayaking | <input type="checkbox"/> Biking | <input type="checkbox"/> Gardening |
| <input type="checkbox"/> Snowmobiling | <input type="checkbox"/> Skiing/Snowboarding | <input type="checkbox"/> None of these |

Q2. Circle your top recreation activity in the box above.

Q3. Which is your primary reason for participating in outdoor recreation?

- | | |
|--|--|
| <input type="checkbox"/> Exercise | <input type="checkbox"/> Enjoying nature |
| <input type="checkbox"/> Group activity | <input type="checkbox"/> Solitary activity |
| <input type="checkbox"/> Exploring your town | <input type="checkbox"/> Other (please specify) <input type="text"/> |

Q4. Approximately how often do you participate in outdoor recreation activities? *Circle one.*

Never Once a year Once a Month 2-3 Times per Month Once a Week 2-3 Times per Week

Q5. For how many years have you been involved in your top outdoor activity? years

Q6. Do you ever go fishing?

- Yes
 No ---- **Skip to Section Three**

Section Two

Fishing in Webb

Q7. Approximately how often do you go fishing? *Circle one.*

Once a Year

Once a Month

2-3 Times per Month

Once a Week

2-3 Times per Week

Q8. Which type of bait do you use most often?

Check one.

Artificial bait

Prepared bait

Minnows

Earthworms

Grasshoppers

Other live bait (please specify)

Circle the type of bait you consider **most** effective.
~~Cross out~~ the type of bait you consider **least** effective.

Q9. Do you ever use worms for bait?

Yes --- Answer the questions below.

No --- **Skip to Section Three.**

If you use worms for bait, how do you obtain these worms?

Check all that apply.

Purchase at a bait shop

Purchase at a convenience store

Dig them up from the ground

Other (please specify)

How often do you use worms when fishing?

Rarely

About half the time

Almost always

What do you do with left-over worms?

Dispose of them in the lake/river

Dispose of them in the forest

Dispose of them in the trash

Put them in your garden

Save them for the next fishing trip

Other (please specify)

If you purchase worms for bait,
which types do you typically buy?
Check all that apply.

Nightcrawlers

Roundworms

Meal worms

Dillies

Trout worms

Green worms

Other (please specify)

Q10. *I use worms more often when fishing with my children.*

Not Applicable
0

Strongly Disagree
1

Somewhat Disagree
2

Not Sure
3

Somewhat Agree
4

Strongly Agree
5

Q11. *The use of worms for bait is an important fishing tradition in this town.*

Strongly Disagree
1

Somewhat Disagree
2

Not Sure
3

Somewhat Agree
4

Strongly Agree
5

Section Three

Webb's Natural Environment

Q12. Check your top three most important natural resource issues from the list below.

- | | | |
|--|---|--|
| <input type="checkbox"/> Climate change | <input type="checkbox"/> Energy supply | <input type="checkbox"/> Invasive species |
| <input type="checkbox"/> Acid rain | <input type="checkbox"/> Air pollution | <input type="checkbox"/> Water pollution |
| <input type="checkbox"/> Food supplies | <input type="checkbox"/> Species extinction | <input type="checkbox"/> Environmental justice |
| <input type="checkbox"/> Soil exhaustion | <input type="checkbox"/> Urban sprawl | <input type="checkbox"/> Deforestation |

Q13. *I consider myself well-educated on environmental issues.*

Strongly Disagree 1	Somewhat Disagree 2	Not Sure 3	Somewhat Agree 4	Strongly Agree 5
------------------------	------------------------	---------------	---------------------	---------------------

Q14. *It is wrong to sacrifice economic growth to protect the environment.*

Strongly Disagree 1	Somewhat Disagree 2	Not Sure 3	Somewhat Agree 4	Strongly Agree 5
------------------------	------------------------	---------------	---------------------	---------------------

Q15. *Climate change will have a noticeable effect in my lifetime.*

Strongly Disagree 1	Somewhat Disagree 2	Not Sure 3	Somewhat Agree 4	Strongly Agree 5
------------------------	------------------------	---------------	---------------------	---------------------

Q16. *I donate my time and/or money to environmental organizations*

Strongly Disagree 1	Somewhat Disagree 2	Not Sure 3	Somewhat Agree 4	Strongly Agree 5
------------------------	------------------------	---------------	---------------------	---------------------

Q17. *I tend to avoid earthworms because they are slimy.*

Strongly Disagree 1	Somewhat Disagree 2	Not Sure 3	Somewhat Agree 4	Strongly Agree 5
------------------------	------------------------	---------------	---------------------	---------------------

Q18. *Earthworms have a positive impact on plant life.*

Strongly Disagree 1	Somewhat Disagree 2	Not Sure 3	Somewhat Agree 4	Strongly Agree 5
------------------------	------------------------	---------------	---------------------	---------------------

Q19. Do you use worms for composting at your home?

- Yes
 No

Q20. Where do you obtain information on environmental issues?
Check all that apply, and circle your most important source.

- | | |
|---|---|
| <input type="checkbox"/> Internet | <input type="checkbox"/> Magazines |
| <input type="checkbox"/> Television | <input type="checkbox"/> Radio |
| <input type="checkbox"/> Newspapers | <input type="checkbox"/> Friends/Family |
| <input type="checkbox"/> Environmental groups | <input type="checkbox"/> School or University |
| <input type="checkbox"/> Other <input type="text"/> | |

Section Four

The Example of Invasive Species

Q21. *I am familiar with the concept of invasive species.*

Strongly Disagree ₁ Somewhat Disagree ₂ Not Sure ₃ Somewhat Agree ₄ Strongly Agree ₅

If you are completely unfamiliar with the concept of invasive species, please **skip to Section Five**.

Q22. Which of the following invasive species have you heard of?

Check all that apply.

- | | | |
|--|--|--|
| <input type="checkbox"/> Garlic mustard | <input type="checkbox"/> Zebra mussel | <input type="checkbox"/> Japanese knotweed |
| <input type="checkbox"/> Common buckthorn | <input type="checkbox"/> Giant hogweed | <input type="checkbox"/> Purple loosestrife |
| <input type="checkbox"/> Eurasian watermilfoil | <input type="checkbox"/> Water chestnut | <input type="checkbox"/> Asian longhorned beetle |
| <input type="checkbox"/> Earthworms
(any species) | <input type="checkbox"/> Emerald ash borer | <input type="checkbox"/> Tree of Heaven |
| | <input type="checkbox"/> Hydrilla | <input type="checkbox"/> None of these |

Q23. If you checked **earthworms** in the above question, where did you hear of this issue?

- | | |
|---|--|
| <input type="checkbox"/> Internet | <input type="checkbox"/> Magazines |
| <input type="checkbox"/> Television | <input type="checkbox"/> Radio |
| <input type="checkbox"/> Newspapers | <input type="checkbox"/> Friends/Family |
| <input type="checkbox"/> Environmental groups | <input type="checkbox"/> School or University |
| <input type="checkbox"/> Survey at Webb's
Information Center | <input type="checkbox"/> Other (<i>please specify</i>)
<input type="text"/> |

Q24. *There are more pressing environmental concerns than that of invasive species.*

Strongly Disagree ₁ Somewhat Disagree ₂ Not Sure ₃ Somewhat Agree ₄ Strongly Agree ₅

Q25. *The prevention of the spread of invasive species is not feasible.*

Strongly Disagree ₁ Somewhat Disagree ₂ Not Sure ₃ Somewhat Agree ₄ Strongly Agree ₅

Q26. *I contribute my time and/or money to the eradication of invasive species.*

Strongly Disagree ₁ Somewhat Disagree ₂ Not Sure ₃ Somewhat Agree ₄ Strongly Agree ₅

Section Five

Additional Details about You

Q27. *I have training in natural resource management.*

Strongly Disagree Somewhat Disagree Not Sure Somewhat Agree Strongly Agree
 1 2 3 4 5

Q28. *My political views are best described as:*

Strongly Liberal Moderately Liberal Neutral Moderately Conservative Strongly Conservative
 1 2 3 4 5

Q29. What is the highest level of education you have attained?

- | | |
|--|--|
| <input type="checkbox"/> Some high school | <input type="checkbox"/> Bachelor's Degree |
| <input type="checkbox"/> High school diploma | <input type="checkbox"/> Master's Degree |
| <input type="checkbox"/> Some college | <input type="checkbox"/> JD |
| <input type="checkbox"/> Associate's degree | <input type="checkbox"/> PhD |

Q30. How long have you lived in Webb? years.

Q31. Do you reside in Webb *permanently* or *seasonally* ? *Circle one.*

Q32. Which environment best describes your childhood home?

- Urban
 Suburban
 Rural

Q33. Which is your 2010 federal income tax bracket? *Check one.*

<u>Tax Bracket</u>	<u>Single Taxable Income</u>	<u>Married Filing Jointly</u>
<input type="checkbox"/> 10% Bracket	\$0 – \$8,375	\$0 – \$16,750
<input type="checkbox"/> 15% Bracket	\$8,375 – \$34,000	\$16,750 – \$68,000
<input type="checkbox"/> 25% Bracket	\$34,000 – \$82,400	\$68,000 – \$137,300
<input type="checkbox"/> 28% Bracket	\$82,400 – \$171,850	\$137,300 – \$209,250
<input type="checkbox"/> 33% Bracket	\$171,850 – \$373,650	\$209,250 – \$373,650
<input type="checkbox"/> 35% Bracket	\$373,650+	\$373,650+

Q34. What is your occupation?

Q35. What is your age?

Q36. What is your gender?

- Male
 Female

You're Done!

Thank you for completing this survey!

You may have noticed a number of questions on invasive species, and on earthworms in particular. Recent conservation research has drawn attention to invasive earthworms for their detrimental effects on leaf litter thickness and native plant cover. If you have any questions about this survey, the research in general, or your rights as a participant, please contact:

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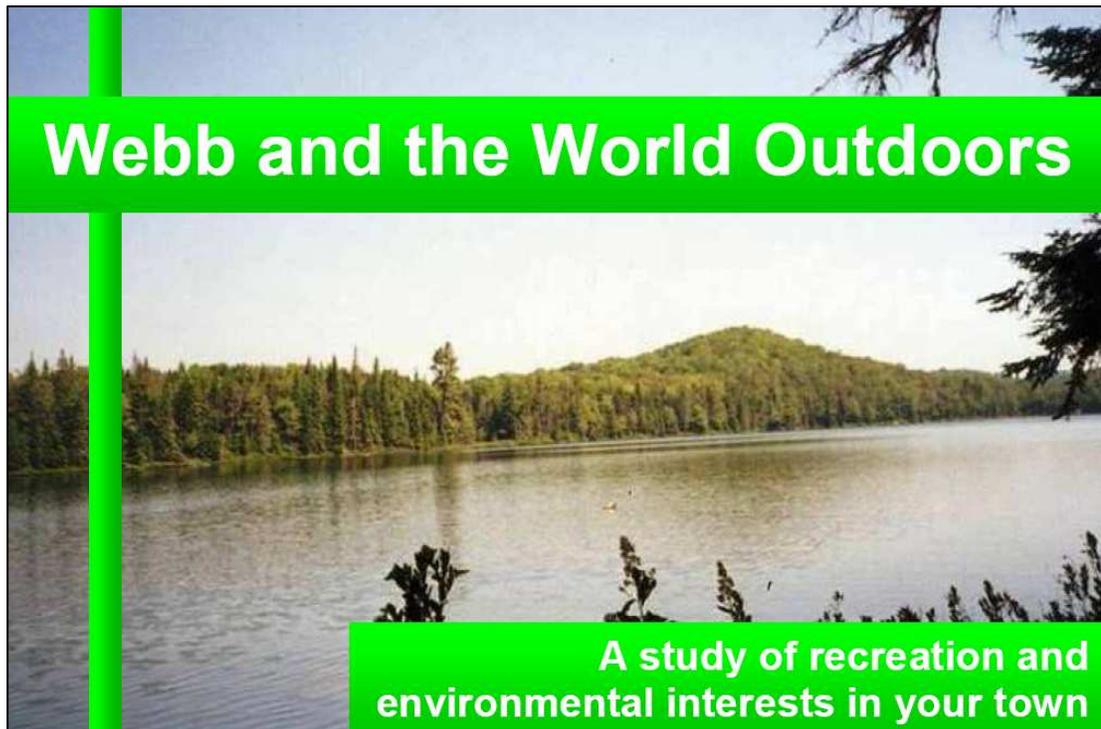
Phone: 516-455-7158 | Email: dseidl@students.colgate.edu
Or the chair of the Institutional Review Board at IRB_chair@psych.colgate.edu

The results of this study will be made available to you upon your request.



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Institutional Review Board: IRB_chair@psych.colgate.edu

Appendix E. Follow-up postcard for mail survey, delivered March 2010



March 15, 2010

Dear Resident of the Town of Webb,

Last week you received a questionnaire requesting your opinions on environmental issues and recreation in the Town of Webb. This study is part of my honors thesis in geography at Colgate University and is critical for both the ecological and economic resources of the Adirondacks.

If you have already completed and returned the survey, I thank you very much! If not, I would appreciate it if you would consider doing so at your earliest convenience. Because you have been selected from a random sample of Webb's residents, it is important that your views be reflected.

If by some chance you did not receive the survey or it has been misplaced, I would be happy to send you another one if you contact dseidl@students.colgate.edu. Thank you for your assistance.

Sincerely,

Dara Seidl
Dara Seidl