

EVALUATION PLAN FOR AN EARTHWORM RAPID ASSESSMENT TOOL
TRAINING PROGRAM FOR LAND MANAGERS IN NORTHERN HARDWOOD
FOREST TYPES IN THE WESTERN GREAT LAKES REGION

FIELD PROJECT

Presented in Partial Fulfillment of the Requirements for
the Master of Education - Environmental Education in the
College of Education and Human Service Professions

By

Ryan M. Hueffmeier, B.A.

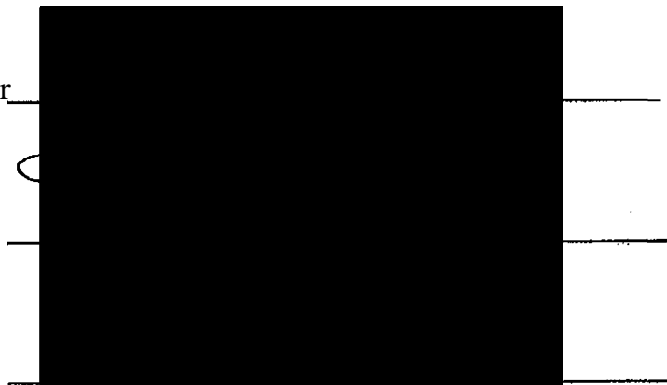
University of Minnesota Duluth 2012

Thesis Committee:

Ken Gilbertson, Ph.D., Chair

Cindy Hale, Ph.D.

Pat Farrell, Ph.D



EVALUATION OF A EARTHWORM ASSESSMENT TOOL

ABSTRACT

Invasive species are causing environmental and economic harm all across the globe. Stopping the introduction of non-native species is the most effective way to deal with them. Non-native earthworms are one particular invasive species affecting the Great Lakes region. There is a need for a rapid assessment method to understand current impacts and identifying areas still earthworm-free. Through research in Minnesota and Wisconsin an Invasive Earthworm Rapid Assessment Tool (IERAT) was developed. The IERAT is a tool for the identification of earthworm impacts using visual indicators. Once earthworms are established there is no known effective way to remove them from the landscape and it is proposed that outreach and education are an effective method to prevent new introductions and to slow the spread of earthworms in northern hardwood forests of the Great Lakes region.

This project develops the *evaluation framework* of the IERAT training. Using the framework evaluators will be assessing the tools' validity, reliability of land managers to use the tool, ability of trainers to conduct workshops, best dissemination techniques, changes in participants' knowledge, attitudes and behaviors from before and after the training, and effects on management decisions. The evaluation plan will be carried out during the second year of training season. The results of the evaluation will be used to make appropriate adjustments to the IERAT and trainings. With earthworm distribution data that the IERAT provides, land managers will be able to develop important areas of protection and work with other interested parties to protect these areas for future generations.

ACKNOWLEDGEMENTS

I would like to thank my committee members Dr's Ken Gilbertson, Cindy Hale and Pat Farrel for their support and gentle prodding. I thank Ken for his guidance, encouragement and time commitment, I thank Cindy for her ability to keep this project on the top of my priority list and assistance moving forward in my professional career and Pat for her nurturing way.

I especially want to acknowledge the immense support given by my wife Michell, thank you for listening and always being there for me. I want to say thank you to my son Rhett for providing me with motivation that I needed to finish this chapter in my academic career. And finally I would like to thank the environmental education program faculty, staff and fellow peers on the University of Minnesota, Duluth campus, I learned immensely from our interactions.

TABLE OF CONTENTS

ABSTRACT	i
ACKNOWLEDGEMENTS	ii
LIST OF FIGURES	v
CHAPTER 1	1
INTRODUCTION	1
Purpose of the Study	1
BACKGROUND	3
Invasive Species	3
Earthworms as Invasive Species in the Great Lakes	5
Invasive European Earthworm Rapid Assessment Tool	6
Invasive European Earthworm Rapid Assessment Tool Development	7
Definitions of Terms	8
Limitations of Study	10
Basic Assumptions	10
CHAPTER 2	13
LITERATURE REVIEW	13
Invasive Species	13
Invasive Earthworms	16
Land Managers	17
Environmental Education	18
Rapid Assessment Tools	20
CHAPTER 3	24
METHODOLOGY	24
Evaluation Design	24
Framework	25
Outcome	25
Conclusion	26
CHAPTER 4	28
EVALUATION PLAN	28
Targeted Audience (Subjects)	30
Training Workshop	31
Outcome Measures	32
Measurement	33
Data Collection	34
Data Analysis	35
Summary	35

CHAPTER 5	36
DISCUSSION.....	36
Evaluation Process.....	36
IERAT Evaluation Summary.....	36
Conclusion	37
REFERENCES	39
Appendix A.....	43
Invasive Earthworm Rapid Assessment Tool.....	43
Appendix B.....	54
Evaluation Focus.....	54
Appendix C.....	56
Evaluation Plan.....	56
Appendix D.....	58
Logic Model.....	58

LIST OF FIGURES

Figures

1. Study Location in Minnesota and Wisconsin Area of the Great Lakes Region...31

“Conservation is a state of harmony between men and land.”

-Aldo Leopold-

CHAPTER 1

INTRODUCTION

Natural resource managers have multiple issues to consider when deciding land management priorities. This is especially true when it comes to invasive species management. The problem is that they sometimes lack the time, resources and knowledge to tackle these complex issues. The following is a proposal for the development of an evaluation plan for training and delivery methods of an invasive earthworm rapid assessment tool targeted at Northeastern Minnesota land managers of woodlots on both public and private lands.

Purpose of the Study

A predominant ecological premise is that human systems and environmental systems are interconnected, what happens to one will have an effect on the other. This statement seems straightforward but research shows this is not as clear-cut as it appears. According to The National Environmental Education & Training Foundation (NEETF) in 2005, “Americans have low levels of knowledge on basic environmental facts, underlying science, causes of certain conditions, and important public issues.” (Coyle, 2005). According to the 2007 Minnesota Report Card on Environmental Literacy, 54% of the state of Minnesota adults has below-average knowledge about the environment (Murphy & Olson, 2008). Furthermore, the National Science Foundation Advisory Committee for Environmental Research and Education report *Transitions and Tipping Points in Complex Environmental Systems* (2009) states “We have challenges ahead in fostering an understanding of environmental science and its use in decision-making by

the public and must find innovative ways to actively engage citizens in new ways of understanding the Earth” (p.41). A key to achieving the goals of managing environmental resources and environmental protection lies in effectively communicating science to nontechnical audiences who, knowingly or unknowingly, have an interest in the health and sustainability of our shared natural resources (Barbour, Poff, Norris, & Allen, 2008). This nontechnical audience includes but is not limited to outdoor recreational users, land owners and land managers.

Land managers in particular are in need of effective communication of technical information for the conservation of the lands they manage. Land managers generally have Bachelor of Science or Master of Science degrees in their specialties, and many have been practicing land management for ten to twenty five years. Furthermore, land managers struggle constantly to balance several, sometimes conflicting, land-management objectives and the resources available are limited, fragmented and sometimes poorly organized (Thomas & Salwasser, 1989). There needs to be a move beyond simply identifying environmental issues to providing the tools needed to address the environmental issues. If the “knowledge required” exists but resides with researchers and scientific journals, and is not easily available to land managers, then the “disconnect” is one of lack of information transfer (Renz, Gibson, Hillmer, Howe, Waller & Cardina, 2009). There is a need for better information acquisition, dissemination, and application. One approach can be an assessment tool for land managers to help overcome some of these barriers. Some examples of ecological assessment tools include: tools for monitoring the long-term impacts that expanding desert metropolitan suburbs have on

adjacent wildlands; monitoring wetland mitigation and restoration; and forest soil disturbance monitoring assessments (Allen, 2009; Mack, 2006; Page-Dumroese et al., 2009).

One current problem is the impact of non-native earthworms on forest ecology. Therefore, concern is growing about the overall sustainability of northern hardwood forests (Hale, 2008). Research in the past decade has begun to illuminate landscape patterns of invasion and impacts of earthworms and the dynamics of forest change in response to earthworms (Bohlen, 2004). As of now there is no efficient and effective way for land managers to monitor their lands for invasive earthworms.

The purpose of this project is the development of an evaluation plan to assess the effectiveness of training methods for land managers on the use of an invasive earthworm rapid assessment tool. This assessment tool will allow land managers to classify the impacts of non-native earthworms on their forests using forest floor visual characteristics as well as upper soil horizon characteristics. The following sections will give a backdrop to invasive species and the need for land managers to have access to rapid assessment tools for land management in Northern Minnesota Hardwood Forests.

BACKGROUND

Invasive Species

The United States Department of Agriculture defines invasive species as one that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (National Invasive Species Information Center, 2009). Over the last couple of decades, evidence

suggests that invasive species alter ecological systems and in many cases these alterations result in profound changes including direct species replacements and changes in ecosystem processes that ultimately control plant and animal activity and have significant negative impacts on socio-ecological systems (DiTomaso, 2000; Mack & D'Antonio, 1998; McNeely, Mooney, Neville, Schei, & Waage, 2001; Pimental, McNair, Janecka, Wightman, Simmonds, O'Connell, Wong, Russel, Zern, Aquino, & Tsomondo 2001).

Invasive species are recognized as one of the leading threats to biodiversity and also impose enormous costs on agriculture, forestry, fisheries, and other human enterprises, as well as on human health. Rapidly accelerating human trade, tourism, transport, and travel over the past century have dramatically enhanced the spread of invasive species, allowing them to surmount natural geographic barriers (Wittenberg & Cock, 2001). Prevention of introductions is the first and most cost-effective option. This lesson has been learned the hard way from several cases of highly destructive and costly invasive organisms such as the zebra mussel in the Great Lakes. Had such species been intercepted at the outset, an enormous loss of native species and/or money could have been prevented (Wittenberg et al., 2001). Furthermore, according to Wittenberg (2001) the human dimension of invasive species must be acknowledged. All ecosystems worldwide are disturbed by human activities in one way or another, and people are the main driving force behind introductions of invasive species (p. 19). We can learn to understand these complex issues through environmental and conservation research and education of this human dimension. We will turn our focus of invasive species to one specifically.

Earthworms as Invasive Species in the Great Lakes

Earthworms in the Northern hardwood forests of Minnesota are considered invasive species and are shown to have the potential to cause economic and environmental harm to the native ecosystems. The Wisconsin Glaciation which ended about 12,000 years BP (12,000 years before January 1, 1950), completely removed native earthworms from the soils and destroyed all vegetation directly by the effects of ice sheets and permafrost (Callahan, Gonzalez, Hale, Heneghan, Lachnicht, & Zou, 2006; Tester, 1995). Within a very short time after the glaciers receded, probably a few months or years, the first plants started to establish in the barren environment (Tester, 1995). It has only been over the last couple of centuries that human activities have been a transportation mechanism for invasive earthworms in our region. Mechanisms such as plants and ships ballast brought over by the early Europeans and subsequently transported throughout our region by generations of fisherman, gardeners and other outdoor activities.

Earthworms are perceived to be good for soil by the general public, and are usually suggested to be beneficial for soil fertility and other soil characteristics (Callahan, et al., 2006). However, in the northern hardwood forests of Minnesota, invasions of European earthworms have resulted in dramatic changes to soil structure; these changes are associated with declines in soil nutrient availability, as well as declines in diversity and abundance of tree seedlings and herbaceous plants (Hale, Frelich, & Reich, 2005). For example, European earthworms will eat and bury large quantities of organic matter causing the disappearance of the forest floor which in turn affect the

ability of the native understory to grow (Hale, Frelich & Reich, 2006). The need for invasive earthworm education and the development of an assessment tool, for the early detection of these invasive earthworm species will be explored next.

Invasive European Earthworm Rapid Assessment Tool

Research suggests that earthworms are having negative effects on the native forested environments of Northern Minnesota. The framework of this project will be to design an evaluation for testing and dissemination of an “Invasive Earthworm Rapid Assessment Tool” or IERAT. The IERAT will be used by land managers to assess the relative impacts of invasive earthworms on forested resources. Classification will be made through forest floor visual indicators that can be measured consistently and effectively. This will provide a landscape scale assessment of invasive earthworm presence and relative abundance allowing land managers to evaluate the impacts to their lands from and help shape the resource management avenues they choose to pursue. Such avenues would be: take no action, continue monitoring, put a plan into action to slow the spread or a strategy for preventing earthworms invading existing earthworm free areas.

This project will focus on the designing of an evaluation plan for the IERAT and any indications of significant change in land manager’s knowledge, attitude and behavior towards non-native earthworms in the Western Great Lakes. Furthermore, criteria for the evaluation of the tool will be developed to assess land managers on the desired delivery method, usability and effectiveness of the IERAT. The target audience is public and private western Great Lakes land managers that may desire to evaluate and monitor the status of the lands they manage but currently lack the resources. One purpose of the

evaluation plan is to determine if the IERAT will effectively and efficiently assess the distribution and relative abundance of invasive earthworms allowing for effective education and monitoring strategies to be put in place by land managers.

Invasive European Earthworm Rapid Assessment Tool Development

The invasive European earthworm rapid assessment tool was developed from field research conducted in the summer of 2009 in nine Minnesota North Shore of Lake Superior State parks (Jay Cooke, Gooseberry, Split Rock, Tettegouche, Crosby Manitou, Temperance, Cascade, Judge Magney, and Grand Portage) two wayside rests (Caribou Falls and Kadunce) and Grand Portage National Monument. The field research consisted of recording a range of forest floor visual characteristics, upper soil horizon characteristics and tree densities from 1250 randomly selected variable radius plots throughout the parks, wayside rests and National Monument. Field crews categorized plots as (1 = potentially earthworm free) to (5 = for heavily earthworm invaded) forests. Next they extracted and identified 4000 European earthworms from 200 of the 1250 randomly selected plots in representative forest types. The earthworms where extracted from 33cm x 33cm plots using a liquid extraction method. Identification took place after the earthworms where fixed in 10% formalin for 24 – 48 hours and transferred to isopropyl alcohol for long term storage.

The IERAT is a classification system that uses the visual indicators of forest floor and upper soil horizon features to categorically classify the invasion status of a given forest stand by invasive earthworms. The classification categories are quantitatively

correlated with the number of different earthworm species and ecological groups, their relative abundance, and level of ecological impacts.

Purpose Statement

To design an evaluation *plan* to evaluate the training methods to effectively train land managers on the use of the IERAT.

Definitions of Terms

Environmental Education:

- *Constitutive definition:* The basic aim of environmental education is to help individuals and communities understand the complex nature of the natural and the built environments resulting from the interaction of their biological, physical, social, economic, and cultural aspects, and acquire the knowledge, values, attitudes, and practical skills to participate in a responsible and effective way in anticipating and solving environmental problems, and in the management of the quality of the environment (UNESCO-UNEP, 1978).
- *Operational definition:* Educational means to help land managers understand the complex nature of the natural and the built environments, and acquire the knowledge, attitudes and practical skills to make responsible land management decisions pertinent to the effects of earthworms.

Conservation Education:

- *Constitutive definition:* Is the wise use of natural resources. It tends to focus on animals, soil, water, and air as single topics in relation to their utilization for timber, agriculture, hunting, fishing and human consumption (Ford, 1986).

- *Operational definition:* Education for land managers on the effects invasive earthworms can have ecological and social systems.

Non-Formal Education:

- *Constitutive definition:* Any organized, systematic, educational activity carried on outside the frame work of the formal system to provide selected types of learning to particular subgroups in the population, adults as well as children (La Bella, 1982).
- *Operational definition:* Development of invasive earthworm rapid assessment tool workshops for land managers of Minnesota North Shore State Parks beyond formal schooling.

Rapid Assessment Tool:

- *Constitutive definition:* Defines indicators that can be measured consistently, efficiently and economically (Page-Dumroese, Abbott & Rice, 2009).
- *Operational definition:* Development of a set of visual indicators to detect the presence of invasive earthworms in Northern Minnesota Hardwood Forests types.

Invasive Species:

- *Constitutive definition:* A species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (National Invasive Species Information Center, 2009).

- *Operational definition:* Invasive earthworms in Northern Minnesota Hardwood Forests.

Exotic species:

- *Constitutive definition:* Those non-native species that occupy or could occupy park lands directly or indirectly as the result of deliberate or accidental human activities (National Park Service, 2006).

Land Managers:

- *Constitutive definition:* The definition of "land manager" is not precise, and could include skilled professionals or individuals with a small woodlot (Renz et al. 2009).
- *Operational definition:* Managers of woodlots in the Western Great Lakes region.

Limitations of Study

- This evaluation plan will be geographically limited to Northern Minnesota hardwood forest types.
- The evaluation plan will be directed toward a project that will be conducted with Western Great Lakes land managers and will not apply to a larger population.

Basic Assumptions

- Earthworms are considered invasive and are negatively impacting forest ecology.

- A means to efficiently help land managers identify and respond to invasive earthworms is a valid and beneficial effort.
- For invasive species management, land managers are limited by time, resources and training in their ability to detect potential problems.
- The development of an invasive earthworm rapid assessment tool is a logical approach to aid in the above two assumptions.

Conclusion

Research supports that there is a need for better scientific communication between those doing the research and the people that would ultimately be using the tools developed through that research. One area of interest is invasive species and the effects they can have on the environment. In particular the effects non-native earthworms in Northern hardwood forests of Minnesota are having on the native environments.

The ideal method of minimizing the impacts of invasive species is simply, prevention. This holds true with the impacts of invasive earthworms. But before there can be prevention there needs to be education on the current environmental impacts of invasive earthworms. Once a baseline is established for the environmental impacts of invasive earthworms strategies for land management can be determined. There is a need for education of land managers about the invasive nature of earthworms and an effective assessment tool for the detection of invasive earthworms in the Northern hardwood forests of Minnesota.

The development of an evaluation plan for the evaluation of training methods of an “Invasive Earthworm Rapid Assessment Tool” (IERAT) to be used by Northern

hardwood forests land managers is being presented to guide assessment of a viable positive approach toward earthworm education and management to slow their distribution.

CHAPTER 2

LITERATURE REVIEW

The purpose of this field project was to develop an evaluation plan to evaluate training methods of an Invasive Earthworm Rapid Assessment Tool “IERAT” which will be delivered to Northern Minnesota land managers in the Great Lakes Region. It is believed there is a need for education of land managers about the invasive nature of earthworms in the Northern hardwood forests of Minnesota. Furthermore, a method for the ecological monitoring of these invasive earthworms is needed.

This review will first detail, describe and define invasive species, invasive earthworms, and land managers. Second, discuss the current educational and evaluative methods for achieving ecological literacy in non-formal settings. Third, review how rapid assessment tools have been used in different disciplines and how they apply to invasive earthworm monitoring. And finally summarize the literature reviewed for this field project.

Invasive Species

Many introduced species such as, corn, wheat, domestic chickens and cattle are beneficial for the world food supply and other non –native species are used for landscape restoration and biological pest control (Pimental et al., 2001). Also, an example from research on semi arid grassland communities shows that there can even be invasions from native species into an ecosystem formally devoid of them (Van Auken, 2000).

There are non-native, non-indigenous, exotic, alien and invasive species defined in the literature. The United States Department of Agriculture defines invasive species as

one that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (National Invasive Species Information Center, 2009).

Over the last couple of decades evidence suggests that invasive species alter ecological systems and in many cases these alterations result in profound changes including direct species replacements and changes in ecosystem processes that ultimately control plant and animal activity and have significant negative impacts on socio-ecological systems (DiTomaso, 2000; Mack & D' Antonio, 1998; McNeely, Mooney, Neville, Schei, & Waage, 2001; Pimental, et. al., 2001). Invasive species are recognized as one of the leading threats to biodiversity and also impose enormous costs on agriculture, forestry, fisheries, and other human enterprises, as well as on human health. Rapidly accelerating human trade, tourism, transport, and travel over the past century have dramatically enhanced the spread of invasive species, allowing them to surmount natural geographic barriers (Wittenberg & Cock, 2001).

Prevention of introductions is the first and most cost-effective option. This lesson has been learned the hard way from several cases of highly destructive and costly invasive organisms such as the zebra mussel in the Great Lakes. Had such species been intercepted at the outset, an enormous loss of native species and/or money could have been prevented (Wittenberg et al., 2001). Furthermore, according to Wittenberg (2001) the human dimension of invasive species must be acknowledged. All ecosystems worldwide are disturbed by human activities in one way or another, and people are the main driving force behind introductions of invasive species (p. 19).

In 2006 The Ecological Society of America evaluated US national practices on biological invasions and stated that prevention is possible only early in the process, before a species arrive in a new range. Once the opportunity for eradication has passed few options remain; 1.Control of population, 2. Slow the spread and 3.Adaptation. The Ecological Society came up with six major recommendations;

1. Reduce number of pathways.
2. Institute risk screening.
3. Monitor for early invasions.
4. Provide authority and funding for eradication and control programs.
5. Fund slow-the-spread programs.
6. Establish a center for invasive species management.

The problem is complex and interdisciplinary, includes many pathways, a tremendous diversity of organisms that are invasive, and the vulnerability of all terrestrial, marine and freshwater ecosystems. With this complexity there is a strong basis for rapid implementation of cost-effective solutions (Lodge, 2006). The public outnumber professional land managers and there is a need for providing standard protocols for citizens to use in monitoring local habitats. When eradication is not feasible, a “slow-the-spread” strategy is a rational management choice particularly when the environmental or economic costs of allowing an invader to proceed unmanaged are likely to outstrip management costs (Lodge, 2006).

Invasive Earthworms

Invasive species go through three stages; non-natives are introduced and establish a self-sustaining population, next many non-native species remain localized and are not detected by humans and the last step non-natives become abundant and spread to new locations, sometimes after years. This last stage is when they earn the name invasive because of their abundance and they are causing detectable ecological changes that are viewed as harmful (Lodge, 2006).

European earthworms in the Great Lakes region have gone through this three stage process. The last glacial episode wiped out all the native earthworms in our region, completely removing native earthworms from the soils directly by the effects of ice sheets and permafrost (Callahan, 2006). According to Gates (1974) and Reynolds (1994), the first importations of earthworms into the U.S. began 450 years BP when European settlers brought over plant material, some of which contained earthworms.

Earthworms move in two ways: on their own or by the help of something else. On their own, dispersal rates of European earthworms are around 10 meters a year (Tiunov, Hale, Holdsworth & Vsevolodova-Perel, 2006; Marinissen & Van den Bosch, 1992). Over the last couple of centuries human activities have been a transportation mechanism for invasive earthworms in our region. Mechanisms such as; plants and ships ballast brought over by the early Europeans and subsequently transported throughout our region by generations of fisherman, gardeners and other outdoor activities. And according to Hale (2008), human-mediated dispersal of earthworms is much more important to the

continued expansion of invasive earthworms than is natural spread from diffusion of existing populations.

Earthworms are perceived to be good for soil by the general public, and are usually suggested to be beneficial for soil fertility and other soil characteristics (Callahan, et al., 2006). However, in the Northern hardwood forests of Minnesota, invasions of European earthworms have reached the third level of invasion discussed by Lodge, "...causing detectable ecological changes that are viewed as harmful" (2006). European earthworm activities have resulted in dramatic changes to soil structure; these changes are associated with declines in soil nutrient availability, as well as declines in diversity and abundance of tree seedlings and herbaceous plants (Hale, Frelich, & Reich, 2005). For example, European earthworms will eat and bury large quantities of organic matter causing the disappearance of the forest floor, which in turn affect the ability of the native understory to grow (Hale, Frelich & Reich, 2006). This process is further complicated by the fact that different feeding and habitat preferences between earthworm species may affect ecosystems differently (James, 1998).

Land Managers

The professional definition of "land manager" is not precise, and could include skilled professionals or individuals with a small woodlot (Renz et al. 2009). Land managers struggle constantly to balance several sometimes conflicting, land-management objectives and the resources available are limited, fragmented and sometimes poorly organized (Thomas & Salwasser, 1989). Management of natural resources is necessarily a site and object specific endeavor that often is conducted within a localized cultural

arena (McPherson, 2004). McCool and Kruger (2003), from the United States Department of Agriculture, state: “land managers are increasingly called on to make decisions at larger, landscape-level scales while having little understanding of both the ecological and social processes operating at those scales. Research can help make those decisions more informed.”

Environmental Education

According to The National Environmental Education & Training Foundation (NEETF) in 2005, “Americans have low levels of knowledge on basic environmental facts, underlying science, causes of certain conditions, and important public issues.” (Coyle, 2005). According to the 2007 Minnesota Report Card on Environmental Literacy, 54% of Minnesota adults have below-average knowledge about the environment (Murphy & Olson, 2008). Furthermore, the National Science Foundation Advisory Committee for Environmental Research and Education report *Transitions and Tipping Points in Complex Environmental Systems* (2009) states “We have challenges ahead in fostering an understanding of environmental science and its use in decision-making by the public and must find innovative ways to actively engage citizens in new ways of understanding the Earth” (p.41). A key to achieving the goals of managing environmental resources and environmental protection lies in effectively communicating science to nontechnical audiences who, knowingly or unknowingly, have an interest in the health and sustainability of our shared natural resources (Barbour, Poff, Norris, & Allen, 2008). Orr defined this as “ecological literacy” or a need for a multidisciplinary environmental knowledge that provides direct contact with natural systems for students at all levels

(1989). With an awareness of self, place, personal, and social values, ecological literacy implies a broad understanding of how people as societies relate to each other and to natural systems, and how they might do it sustainably (1992).

Much of what Orr proposes has been incorporated into the field of environmental education. The North American Association for Environmental Education (NAAEE) states in its mission statement that: "... for the purpose of achieving environmental literacy in order for present and future generations to benefit from a safe and healthy environment and a better quality of life...NAAEE recognizes the need for a coherent body of information about environmental issues and that information and analysis are only part of an effective education program. To be truly effective, this body of knowledge must be integrated into all aspects of the curriculum and into all types of education institutions for the widest array of audiences" (NAAEE, 2000). The basic aim of environmental education is to help individuals and communities understand the complex nature of the natural and the built environments resulting from the interaction of their biological, physical, social, economic, and cultural aspects, and acquire the knowledge, values, attitudes, and practical skills to participate in a responsible and effective way in anticipating and solving environmental problems, and in the management of the quality of the environment (UNESCO-UNEP, 1978).

Scott and Gough, suggest that there are nine categories of focus and objectives for those who espouse and promote environmental learning (2003, p.8). One such focus is "conservation understanding" which is defined as those using the natural and /or built environments as heuristics or experienced-based technique to achieve conservation

and/or sustainability goals (2003). Ford defines conservation education as the wise use of natural resources. It tends to focus on animals, soil, water, and air as single topics in relation to their utilization for timber, agriculture, hunting, fishing and human consumption (1986). Roth suggested, much of what has been taught as conservation or environmental education has been future oriented, but also needs to be able to demonstrate how conservation activities benefit people today not just in future generations (2008). These goals for ecological literacy can be achieved through non-formal education.

Non-formal education proceeds in a planned but highly adaptable way in institutions, organizations and situations outside the sphere of formal schooling; for example, field trips and museum visits, educational television and radio programs, and other such activities. This is distinguished from informal education which applies to situations in life that come about spontaneously; for example, within family circles, the neighborhood, and so on (Tamir, 1990). La Bella, defined it as any organized, systematic, educational activity carried on outside the frame-work of the formal system to provide selected types of learning to particular subgroups in the population, adults as well as children (1982). Invasive earthworm monitoring and education falls into this category of non-formal conservation education.

Rapid Assessment Tools

There needs to be a move beyond simply identifying environmental issues to providing the tools needed to address the environmental issues. If the “knowledge required” exists but resides with researchers and scientific journals, and is not easily

available to land managers, then the “disconnect” is one of lack of information transfer (Renz. et al., 2009). A proactive approach to the management of natural, social and cultural resources, such as the native hardwood forests of the Great Lakes region, is a European earthworm rapid assessment tool.

Up to 80% of the upland mesic hardwood landscapes are likely to be earthworm impacted. However, determining the actual status of invasion will require stand-level assessments. Such assessment can identify where earthworm invasion is a factor so that land managers can better understand current and potential future forest conditions (Holdsworth, A., Frelich, L., & Reich, P., 2007). Monitoring should be concentrated in areas where initial introductions are most likely to occur (Lodge, 2006). According to Nick Proulx of the Minnesota Department of Natural Resources (2003), utilizing glacial boundaries, terrestrial vegetation surveys, and known earthworm distributional information should give a rough estimate of “high-risk” areas and outline where future regulatory and educational efforts would be most useful (p. 10).

Providing standard protocols for citizens to use in monitoring local aquatic and terrestrial habitats can be extremely cost effective, as long as the potentially high cost of false positive reports can be controlled (Wasson et al. 2002, Hegamyer et al. 2003). Furthermore, community engagement with monitoring depends largely on protocols that are easy to obtain and understand and accompanied by training manuals and sources of assistance. Examples include protocols developed by the Ecological Monitoring and Assessment Network such as; Frog Watch, Ice Watch and Plant Watch (Pollock, 2005).

Rapid assessment tools have been used in many disciplines. A simple Google search will retrieve assessment tools for HIV, health-care, waste management, human resource management, and ecological assessments. Some examples of ecological assessment tools include: tools for monitoring the long-term impacts that expanding desert metropolitan suburbs have on adjacent wildlands; monitoring wetland mitigation and restoration; and forest soil disturbance monitoring assessments (Allen, 2009; Mack, 2006; Page-Dumroese et al., 2009). Lee Frelich, director of The Center for Hardwood Ecology at The University of Minnesota has proposed a 4 point scale assessment tool used for earthworm distribution that he uses with his graduate students (L. Frelich, personal communication, March 24, 2010).

Summary

Research on invasive species over the last few decades has shown that non-native, invasive species are having profound effect on native ecosystems. One current problem is the impact of European earthworms on the forest ecology of northern hardwood forest types in the Great Lakes region. Therefore, concern is growing about the sustainability of northern hardwood forests in the Great Lakes region. Non-formal conservation education and monitoring by local land managers is seen as the best prevention of the further spread of these ecosystem engineers. Experiential learning theory puts forward that people learn best through hands on experiences suggesting that a hands-on workshop will be the best way to deliver to IERAT when compared to the delivery of other training methods. An assessment tool, also called the “Invasive Earthworm Rapid Assessment Tool” (IERAT) is an important part of effective education and management of forests and lands about the

impacts of earthworms. This project will design a plan to evaluate the “Invasive Earthworm Rapid Assessment Tool” once it has been implemented.

CHAPTER 3

METHODOLOGY

The purpose of this field project was to write an evaluation plan for Great Lakes Worm Watch (GLWW) to evaluate the delivery, use and dissemination methods of an “Invasive Earthworm Rapid Assessment Tool” (IERAT) (See Appendix A). Consequently, the plan determined the needed level of IERAT training for land managers to effectively and to efficiently assess the distribution and relative abundance of invasive European earthworms in the Great Lakes region. The plan includes evaluation criteria, which is intended to guide future evaluation. This in turn, guides decisions related to the training methods, material dissemination and changes in land manager’s knowledge, attitudes and behaviors toward forest management relative to invasive earthworms.

Evaluation Design

The purpose of the evaluation plan was to determine which evaluation criteria will ascertain the effectiveness and efficiency at which the IERAT training methods will train land managers to accurately determine the distribution and relative abundance of non-native earthworms in the Western Great Lakes region, allowing for effective education and monitoring strategies to be implemented by land managers. The process of the evaluation plan development is intended to (See Appendix B):

- Determine the best means of evaluation criteria for the IERAT.
- Determine criteria for selection of trainers (or instructors) of land managers to use the IERAT.

Objectives:

- Design an evaluation plan that may include an instrument to determine:
 - The criteria for providers, or instructors, to be adequately qualified to teach IERAT assessment to land managers.
 - The criteria to verify the level of training land owners/managers need to effectively and efficiently use the IERAT to ensure consistent and comparative results across a range of different users.
- Design a plan that will determine the most appropriate evaluation tools and process for the IERAT.
- Design a plan that will determine any shift in knowledge, attitudes and behaviors of land managers related to invasive earthworms.

Framework

The evaluation plan is a means to assess the IERAT. It includes:

1. Design of the evaluation instrument(s)
2. Condition of testing (when the evaluation will be given, to whom, and when in the management training process)
3. How analysis of the instrument(s) are best conducted to best guide the training and educational delivery of IERAT.

Outcome

Since no evaluation instrument(s) for assessing land managers knowledge, attitudes, behaviors and best practices for disseminating the assessment tool specific to the use of

the IERAT was available, instruments were be developed through the evaluation plan.

The evaluation plan will include the following:

1. Instructor selection criteria
2. Land manager selection criteria
3. Earthworm education program and IERAT outcomes
4. Post IERAT and land manager education program outcomes

The following IERAT outcomes will be assessed:

- IERAT training methods:
 - Which dissemination method worked best for the various audiences.
- Provider's ability to teach land managers the following:
 - The role earthworms play in the local ecosystem.
 - Humans' potential to aid in the dispersal of non-native earthworms.
 - Develop management strategies to mitigate the impacts of non-native earthworms on their lands.
 - Collection of data on earthworm presence, absence and relative abundance using the IERAT.

Conclusion

This proposal outlines the criteria for an evaluation plan to assess an IERAT's usability, efficient dissemination and effects on land managers in the Great Lakes region.

The proposed outcomes cover four areas; best practices for the dissemination of the IERAT, changes in participant's knowledge, attitude and intentions from before and after their use of the IEART, ability to develop management strategies and accuracy in the use

of the IERAT. The proposed outcomes guide the development of evaluation instrument(s) by directing instrument questions to assessing how effective the IERAT has been in reaching the desired outcomes.

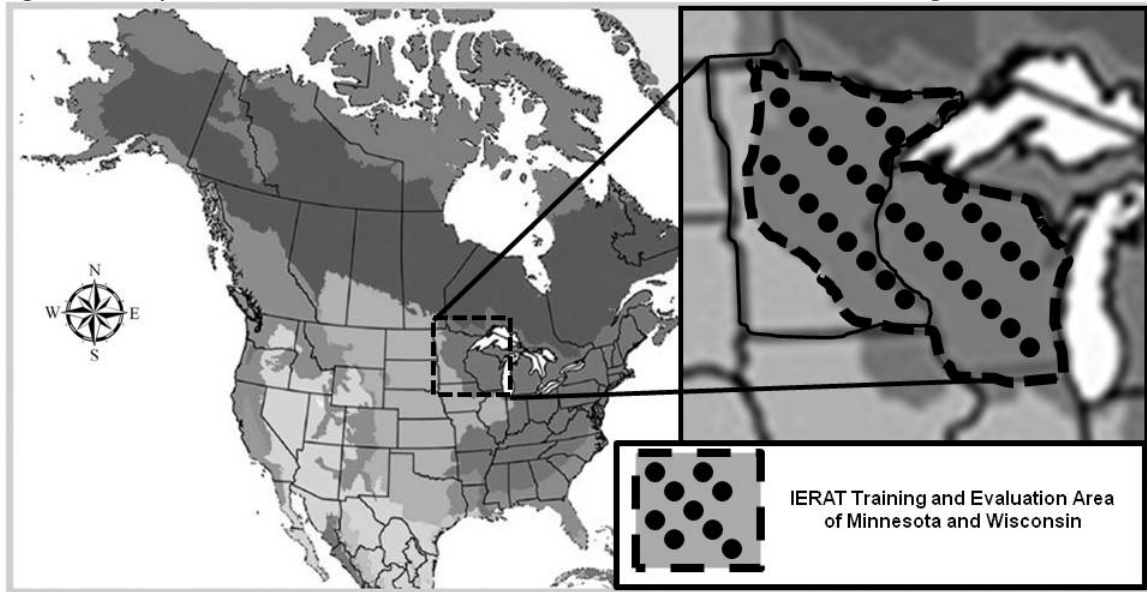
CHAPTER 4

EVALUATION PLAN

A mixed-method formative evaluation design will be utilized to assess the tool called the “invasive earthworm rapid assessment tool” (IERAT). Evaluators will be assessing IERAT training methods, reliability and validity, to guide future improvements of the IERAT. The plan will be implemented as an assessment that will guide the Great Lakes Worm Watch (GLWW) staff on the training of trainers for the dissemination and implementation of the IERAT tool across the Western Great Lakes region (Figure 1). IERAT evaluations will be conducted in four phases

- Phase 1 IERAT Training workshop:
 - GLWW staff will determine which IERAT delivery method is the most effective, by targeting a diverse group of private and public land managers (e.g. The Nature Conservancy, departments of natural resources, National Forest lands, and private forestland owners). This will be accomplished through focus groups, administration of knowledge and attitude surveys and on-site visits intended to determine participants’ demonstrated ability to use the tool accurately.
 - GLWW staff will design the instruments that will be used to assess all participating land owners/managers for their knowledge, attitudes, and behaviors with respect to the prevalence and impacts of non-native earthworms on coastal forest resources.
- Phase 2 IERAT will be ground-truthed:

- GLWW staff will go to sites that participants have classified using the IERAT and conduct their own classification to compare for consistency in IERAT use. Staff will conduct assessments of IERAT use at 10% of all sites that were classified by participants trained to use the IERAT in the given assessment year.
- GLWW staff will conduct quantitative earthworm extractions at sites where participants conducted the IERAT. GLWW staff will use the liquid mustard extraction technique (Hale, 2005), which consists of pouring a mustard-water mixture (40 g ground yellow mustard, 4 L water) on the soil surface and collecting all emerging earthworms.
- Phase 3 IERAT focus group
 - GLWW staff will conduct a focus group to determine the usability of the IERAT, participants' knowledge, attitudes and perceived behaviors and the best method for dissemination of the IERAT.
- Phase 4 data will be synthesized and analyzed.
 - GLWW staff will collect and summarize all data to determine changes in participants' knowledge, attitudes, and behaviors, to determine the effectiveness of the IERAT. They will also determine the most effective dissemination methods and the overall effectiveness of the IERAT training.
 - GLWW staff will analyze all data.
 - GLWW will recommend improvements to the IERAT.

Figure 1. Study Location in Minnesota and Wisconsin Area of the Great Lakes Region

Targeted Audience (Subjects)

The target audience for the evaluation will be Great Lakes Worm Watch (GLWW) staff and IERAT trainers. GLWW staff and land managers in the Great Lakes region from both public and private agencies will be contacted to participate in this evaluation of the IERAT. The Great Lakes region is defined as the hardwood forested areas of northern Minnesota and Wisconsin. Criteria for selecting participants used in testing IERAT training will include:

- Public - managers of woodlots in the Great Lakes region. Those who manage public forested areas who have the potential to be adversely affected by invasive earthworms.
- Private - managers of woodlots in the Great Lakes region. Those who manage private forested areas who have the potential to be adversely affected by invasive earthworms.

- ≤ 5 acres of hardwood forest
- actively managed woodlots
- adjacent to public land

Participants in IERAT training workshops and implementation of IERAT will be land managers in the Great Lakes region, both public and private. The specific nature of the IERAT and the intended audience allows for participant selection using non-probability purposive sampling. Public land managers will be selected by contacting the respective Minnesota and Wisconsin natural resource departments, National Forest lands, The Nature Conservancy, and other organizations that may be brought to the evaluator's attention through communication with the above organizations. This sampling method is a subcategory of purposive sampling called snowball sampling (Creswell, 2009). In snowball sampling, once participants meet the selection criteria, they will be asked to recommend others that meet the criteria. The first 20 land managers to agree will be included in the evaluation. Private land managers will be contacted through the Minnesota Woodland Advisor program and the first 20 woodlot owners to agree will be included in the evaluation.

Training Workshop

Two training workshops will be given. One for public land managers (n=20) and one for private land managers (n=20). Due to the hands on nature of the field based IERAT training GLWW staff feels it beneficial to both groups to conduct trainings separately. Both trainings will consist of:

9:00 – 9:15 – Welcome and outline of the day

An IERAT training packet (See appendix A) will be given to all participants

9:15 – 9:45 - background on earthworms and the current research of earthworm effects in northern hardwood forests.

9:45 – 10:00 – break

10:00 – 11:00 - IERAT field training in two heavily invaded dominant forest types (Aspen/Birch, Sugar Maple) in the region;

11:00 – 11:15 - instructions on how to deliver the IERAT data to GLWW and future applications of the tool.

11:15 – 11:30 – Additional questions

Outcome Measures

The following outcomes will be assessed (See appendix D)

IERAT training methods:

- Best training practices for participants will be assessed through focus groups, knowledge, attitude and behavior survey for the purpose of making the training of the IERAT as efficient and effective as possible.
- Participants' ability to use the IERAT will be assessed to determine the usability, effectiveness and reliability of the tool. GLWW staff will randomly pick sites that participants have conducted IERAT assessments and conduct their own assessments using the IERAT.
- Quality of the trainers' delivery skills during workshop will be assessed through the focus groups, knowledge, attitude and behavior survey and on-site visits with randomly selected participants.

Managers (public/private) will be assessed on their ability to:

- Explain the role earthworms play in the local ecosystem.
- Discuss their awareness of humans potential to aid in the dispersal of non-native earthworms.
- Develop management strategies to mitigate the impacts of non-native earthworms on their lands.
- Use the IERAT to collect data on earthworm presence, absence and relative abundance.

Measurement

Measurement will occur in 3 ways (See Appendix C):

1. Written questionnaire (assessing, knowledge, attitude, and behavior)
2. Focus Group
3. Observation via site visit

Written Questionnaire

Pre and post-test surveys will be conducted to assess effects of training methods on the IERAT and changes in land manager's knowledge, attitudes and behavior.

Since no evaluation instruments for assessing land managers knowledge, attitudes and behaviors and best practices for disseminating the assessment tool specific to the use of the IERAT is available, assessment instruments will be developed. The instruments will be designed to measure knowledge, attitudes and behaviors of participants. The instruments will be pilot and field tested to assess their validity and reliability.

Focus Group

A focus group will be conducted to better provide qualitative insight into the IEART tool, trainings and the usability of the IERAT. Focus group questions will be developed through pre survey results and GLWW staff observations. Give an example of 1-2 questions.

- Did you find the hand-on portion of the training workshop beneficial?
- Did you feel that the IERAT workshop adequately trained you to use the IERAT?

Site Visits

Follow-up site visits will be conducted with land managers to see how they have incorporated IERAT results and their ability to successfully use the IERAT. GLWW staff will ask if participants have used the IERAT to inform management decisions and conduct their own IERAT assessments.

Data Collection

Pre surveys will be given to participants directly before IERAT training workshops. Post surveys will be completed via Survey Monkey one month after IERAT training completion. All survey data will be entered into Excel and the data will be summarized. Focus groups will be conducted two months after completion of IERAT training and data will be collected using a voice recorder and transcribed into Microsoft Word directly after meeting. Data will be coded and entered into Excel. Notes from site visits will be summarized and entered into Excel. All data will be stored at the Natural Resource Research Institute on a secure server.

The IERAT evaluation will start during the 2013 field season. The field season is defined as the time between when the ground thaws in the spring and the first hard freeze of the fall. The evaluation will be on-going and take place and 2nd year.

Data Analysis

Once data is all collected it will be summarized and appropriate analysis techniques will be used. Both qualitative and quantitative data analysis will be used to interpret the data.

Summary

Through a mixed method evaluation design of pre-test/post-test surveys, focus groups and on-site visits this evaluation plan lays out the foundation to conduct a thorough evaluation of the IERAT. This evaluation will aide in IERAT dissemination and improvement, determine changes in users knowledge, attitudes and behaviors towards non-native earthworms in northern hardwood forest and advancements in information about earthworms presence and relative abundance in the Great Lakes region.

CHAPTER 5

DISCUSSION

The purpose of this evaluation process was to develop a plan to evaluate an invasive earthworm rapid assessment tool (IERAT) and guide in future implementation and training for Great Lakes Worm Watch (GLWW) staff and IERAT trainers.

Evaluation Process

The importance of having a well thought out evaluation plan cannot be overstated. While designing an evaluation plan it is important to distinguish who your audience for the evaluation results and audience for the program being implemented. Furthermore, you need to decide what exactly you are trying to evaluate and how you will interpret the results of the evaluation. There are various evaluation planning guides, such as the “Framework for Evaluating Impacts of Informal Science Education Projects” by the National Science Foundation or “Program Development and Evaluation” by the University of Wisconsin – Extension. This evaluation plan was guided by “Evaluating Your Environmental Education Programs” workbook developed by Ernst, Monroe, & Simmons, (2009).. This workbook guides you through the important steps of focusing your evaluation, developing evaluation questions and communicating your results. Not only was the field project a process in developing an evaluation plan, it was an exercise in determining what could realistically be completed, compared with what ideally could be accomplished.

IERAT Evaluation Summary

- Determine stakeholders

- Determine evaluation purpose.
- Develop a logic model of program.
- Determine audience for the evaluation results.
- Determine type of evaluation.
 - Front-end
 - Formative
 - Summative
- Develop evaluation questions.
- Determine and develop most effective evaluation instrument to answer questions.
- Determine how data will be collected and analyzed.
- Summarize and report the findings.

Conclusion

Earthworm invasion is not going away and outreach and education are currently considered effective methods to slow the spread of invasive earthworms in northern hardwood forests. The IERAT is a management tool for the identification of potentially earthworm free areas and areas of severe impact. Distribution data on invasive earthworm presence and relative environmental impacts provides essential baseline information for early detection of invasive earthworms threatening earthworm-free ecosystems.

The IERAT evaluation plan will be in place to be carried out during the second year of IERAT training season. With the results of the IERAT evaluation the GLWW staff will make appropriate adjustments to the IERAT and the land manager training of

the tool. Then, GLWW staff will train the trainers to get this tool into as many hands as possible to generate a fine scale map of earthworm distribution across the Great Lakes region. With the earthworm distribution map land managers will be able to develop important areas of protection and work with other interested parties to protect these areas for future generations.

EVALUATION OF A EARTHWORM ASSESSMENT TOOL

REFERENCES

- Allen, C. (2009). Monitoring Environmental Impacts in the Upper Sonoran Lifestyle: A New Tool for Rapid Ecological Assessment. *Environmental Management*, 43, 346-356.
- Barbour, M. T., Poff, N. L., Norris, R. H., & Allen, J. D. (2008). Perspective: Communicating our science to influence public policy. *Journal of North American Benthological Society*, v27. 562-569.
- Bohlen, P. J., Scheu, S., Hale, C. M., et al. (2004). Non-native invasive earthworms as agents of change in northern temperate forests. *Frontiers in Ecology and the Environment*, 2, 417-435.
- Callahan, M. A. Jr., González, G., Hale, C. M., Heneghan, L., Lachnicht, S. L., & Zou, X. (2006). Policy and management responses to earthworm invasions. *Biological Invasions*, 8. 1317-1329.
- Coyle, K. (2005). What Ten Years of NEETF/Roper Research and Related Studies Say About Environmental Literacy in the U.S. The National Environmental Education & Training Foundation, Washington, D.C.
- Creswell, J. (2009). *Research Design; qualitative, quantitative and mixed methods approaches*. London, UK: SAGE Publications.
- DiTomaso, J.M.(2000). Invasive weeds in rangelands: species, impacts, and management. *Weed Science*, 48, 255–265.
- Ernst, J., Monroe, M. & Simmons, B. (2009). Evaluating Your Environmental Education Programs: A workbook for practitioners. Washington DC: North American Association for Environmental Education.
- Ford, P. (1986). Outdoor Education: Definition and Philosophy.
- Gates, G. (1974). Contributions to North American earthworms (Annelida) on American earthworm genera. I. Eisenoides (Lumbricidae). *Bulletin of Tall Timbers Research Station*. 13, 1-17.
- Hale, C. M. (2008). Evidence for human-mediated dispersal of exotic earthworms: support for exploring strategies to limit further spread. *Molecular Ecology*, 17, 1165-1169.

- Hale, C. M., Frelich, L., E. & Reich, P. B. (2005). Exotic European earthworm invasion dynamics in northern hardwood forests of Minnesota. *Ecological Applications*, v15, 848-860.
- Hale, C.M., Frelich, L., E. & Reich, P. B. (2006). Changes in cold-temperate hardwood forest understory plant communities in response to invasion by European earthworms. *Ecology*, 87(7), 1637-1649.
- Holdsworth, A., Frelich, L., & Reich, P. (2007). Regional extent of an ecosystem engineer: earthworm invasion in northern hardwood forests. *Ecological Applications* 17, 1666-1677.
- James, S. (1998). *Earthworms and Earth History*. Boca Raton, United States: St. Lucie Press.
- Jennett, P. A., Sinclair, L. B., & Harrison, R. V. (2003). Methods, tools, and techniques of evaluation. In D. Davis, B. E. Barnes & R. D. Fox (Eds.), *The continuing professional development of physicians: From research to practice* (pp. 275-316). Chicago: American Medical Association.
- La Belle, T.J. (1982). Formal, Nonformal and Informal Education: A Holistic Perspective on Lifelong Learning. *International Review of Education*, 28, n.2, 159-175.
- Loss, S R, R M Hueffmeier, C M Hale, G E Host, G Sjerven, and L E Frelich. In press. A visual method for rapidly assessing earthworm invasions in northern hardwood forests. *Natural Areas Journal*.
- Mack, J. (2006). Landscape as a Predictor of Wetland Conditions: An Evaluation of the Landscape Development Index (LDI) with a Large Reference Wetland Dataset from Ohio. *Environmental Monitoring and Assessment*. 120, 221-241.
- Mack, M. C., & D'Antonio, C. M., (1998). Impacts of Biological Invasions on Disturbance Regimes. *Trees*, 13, 195-198.
- Marinissen, J., & Van den Bosch, F. (1992). Colonization of New Habitats by Earthworms. *Oecologia*. 91, 3, 371-376.
- McCool, S., & Kruger, L. (2003). Human Migration and Natural Resources; Implications for Land Managers and Challenges for Researchers. *United States Department of Agriculture Forest Service General Technical Report*.
- McNeely, J.A., Mooney, H.A., Neville, L.E., Schei, J. P., & Waage, J.K. (2001). *Global Strategy on Invasive Alien Species*. IUCN, Gland.

- McPherson, G. (2004). Linking Science and Management to Mitigate Impacts of Nonnative Plants. *Weed Technology*, 18, 1185-1188.
- Millsap, E. R. & Maydeu-Olivares, A. (2009). *The SAGE Handbook of Quantitative Methods in Psychology*. London, UK: SAGE Publications
- Murphy, T. & Olson, A., et al. (2008). The Third Minnesota Report Card on Environmental Literacy; A survey of adult environmental knowledge, attitudes and behavior. Retrieved December 12, 2009 from the World Wide Web: <http://www.mnseek.net>.
- National Invasive Species Information Center. U. S. Department of Agriculture. Retrieved October 10, 2009 from the World Wide Web: <http://www.invasivespeciesinfo.gov/whatis.shtml>
- National Park Service. (2006). Management policies 2006. U.S. Department of the Interior, National Park Service, Washington, D.C.
- National Science Foundation Advisory Committee for Environmental Research and Education. (2009). Transitions and Tipping Points in Complex Environmental Systems. National Science Foundation. Retrieved October 09, 2009 from the World Wide Web: <http://www.nsf.gov/geo/ere/ereweb/advisory.cfm>.
- North American Association of Environmental Education mission statement (2010). Retrieved March 23, 2010 from the World Wide Web: <http://www.naaee.org/about-naaee/mission>
- Orr, D. (1989). Ecological Literacy. *Conservation Biology*. 3(4), 334-335.
- Orr, D. (1992). Ecological Literacy: education and transition in a post modern world. Albany, NY. SUNNY Press.
- Page-Dumroese, D., Abbott, A., & Rice, T. (2009). Forest Soil Disturbance Monitoring Protocol. Volume 1: Rapid Assessment. United States Department of Agriculture. Gen. Tech Report WO-82a
- Pimental, D., McNair, S., Janecka, J., Wightman, J., Simmonds, C., O'Connell, C., Wong, E., Russel, L., Zern, J., Aquino, T., & Tsomondo, T. (2001). Economic and environmental threats of alien plant, animal, and microbe invasions. *Agriculture, Ecosystems and Environment*. 84, 1-20.
- Pollock, R. (2005). Community-Based Monitoring in Support of Local Sustainability. *Local Environment*. 10, 211-228.

- Proulx, N. 2003. Ecological Risk Assessment of Non-indigenous Earthworm Species. Minnesota Department of Natural Resources, 500 Lafayette Rd. St. Paul, MN 55155, Prepared for U.S. Fish and Wildlife Service, International Affairs, Division of Scientific Authority.
- Renz, M., Gibson, K., Hillmer, J., Howe, K., Waller, D. & Cardina, J. (2009). Land Manager and Researcher Perspectives on Invasive Plant Research Needs in the Midwestern United States. *Invasive Plant Science and Management*. 2, 83-91.
- Reynolds, J. (1994). The distribution of the earthworms (Oligochaeta) of Indiana: A case for the post quaternary introduction theory for Megadrile migration in North America. *Megadrilogica*. 5, 3, 13-32.
- Scott, W., & Gough, S. (2003). Categorizing Environmental Learning. *NAAEE Communicator*. Spring, 8.
- Tamir, P. (1990). Factors Associated with the Relationship between Formal, Informal, and Nonformal Science Learning. *Journal of Environmental Education*. 22, 2, 34-42.
- Tester, J. R. (1995). *Minnesota's Natural Heritage: An Ecological Perspective*. Minneapolis, MN: University of Minnesota Press.
- Thomas, J., & Salwasser, H. (1989). Bringing Conservation Biology into a position of Influence in Natural Resource Management. *Conservation Biology*. 3, 123-127.
- Tiunov, A., Hale, C., Holdsworth, A., & Vsevolodova-Perel, T. (2006). *Biological Invasions Belowground; Earthworms as Invasive Species*. Springer Netherlands.
- UNESCO-UNEP. (1978). The Tbilisi Declaration: Final report intergovernmental conference on environmental education. Organized by UNESCO in cooperation with UNEP, Tbilisi, USSR, 14-26 October 1977, Paris, France: UNESCO ED/MD/49.
- Wittenberg, R., & Cock, M. J. W. (2001). *Invasive Alien Species: A Toolkit of Best Prevention and Management Practices*. Wallingford, Oxon, UK. CAB International, xvii – 228.

EVALUATION OF A EARTHWORM ASSESSMENT TOOL

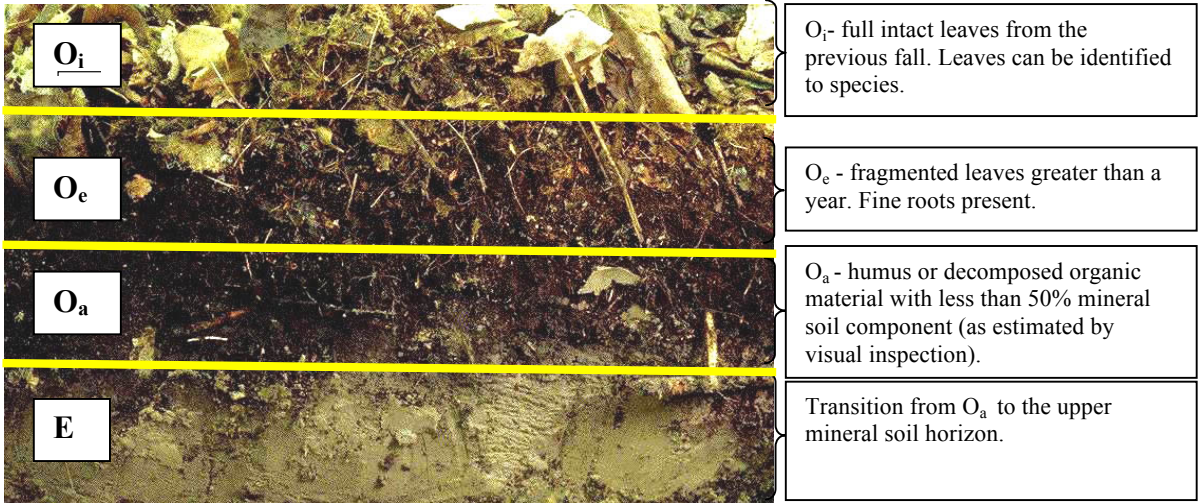
Appendix A

Invasive Earthworm Rapid Assessment Tool

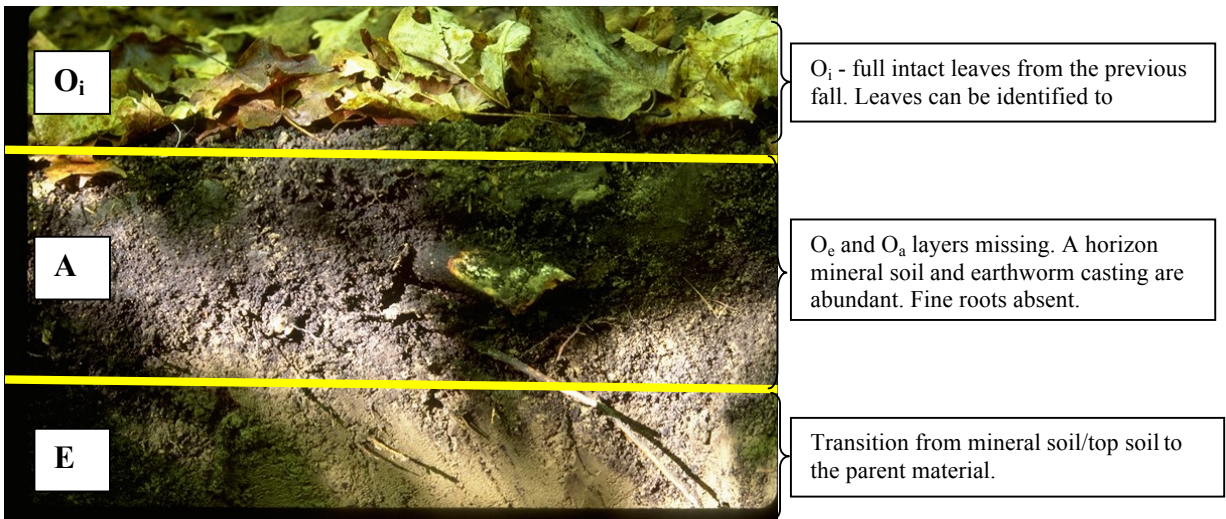
Site Name: _____		
Method used to determine location; <input type="checkbox"/> GPS Other: _____		
Latitude: N ____ . _____ ° Longitude: W - ____ . _____ °		
FF category: (1-5)	<input type="checkbox"/> previous year's litter only;	<u>middens</u> (circle one)
	<input type="checkbox"/> fragmented leaves present, >1yr;	abundant - present - absent
	<input type="checkbox"/> intact, layered ff present;	<u>casts</u> (circle one)
		abundant - present - absent
comments:		

1. Leaf litter greater than one year is present (O_i and O_e present).
 - 1a. Yes (go to 2)
 - 1b. No, Leaf litter (O_i) is from last fall only (go to 6)
2. Small fragmented relatively undecomposed leaves greater than one year present.
 - 2a. Yes O_e present (go to 3)
 - 2b. No, Leaf litter (O_i) is from last fall only (go to 6)
3. Intact layered forest floor having O_i, O_e, O_a layers present, fine roots present in humus (O_a) and leaf fragments (O_e), no earthworms or earthworm signs present (burrows, castings).
 - 3a. Yes (Classification would be 1)
 - 3b. No (go to 4)
4. Forest floor consists of O_i, O_e with patches of O_a. Some small earthworms and earthworm signs are present such as small casting in humus (O_a) layer, some fine roots but not thick in forest floor.
 - 4a. Yes (Classification would be 2)
 - 4b. No (go to 5)
5. Leaf litter (O_i) from previous fall and small fragmented leaves (O_e) under intact leaves, no humus, mineral soil and earthworm casting **present** (<50% of forest floor/mineral soil interface upon visual inspection), plant roots absent or rare
 - 5a. Yes (Classification would be 3)
 - 5b. No (go to 6)
6. Mostly intact leaf litter (O_i) from the previous fall, mineral soil and earthworm casting **abundant** (>50% of forest floor/mineral soil interface upon visual inspection), plant roots absent, middens absent or present (< 9 middens in a 5 meter radius).
 - 6a. Yes (Classification would be 4)
 - 6b. No (go to 7)
7. No forest floor, no humus or fragmented leaves present, mineral soil and earthworm casting **abundant** (>50% of forest floor/mineral soil interface upon visual inspection), middens **abundant** (> 10 middens in a 5 meter radius).
 - 7a. Yes (Classification would be 5)

Intact Forest Floor

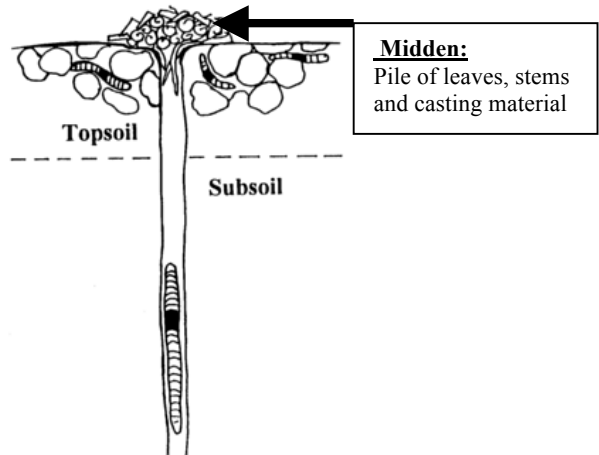


Heavily Earthworm Invaded Forest Floor



Appendix:

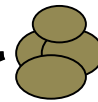
Middens: are distinctive piles of cast material around the openings to their burrows. These middens are usually about 1-5cm in diameter and 1-3cm in height with a burrow hole (2-4mm in diameter) near the center. The burrow entrances of middens also often have large numbers of leaf petioles or fragments of leaves sticking out of them. These got stuck there as the nightcrawler inhabitants attempt to pull leaves down into their burrows.



Casting: (earthworm poop) on the surface of the soil. Earthworm cast material is composed of smooth and rounded clumps of soil which distinguishes it from the rougher, angular or crumb-like surface of soil **aggregates** that have not been worked by earthworms. Cast material is also usually very dark brown or black in color. (Think of the candy “Nerd’s”)



Soil aggregates that **HAVE** been worked by earthworms



Versus



Soil aggregates that **HAVE NOT** been worked by earthworms

Forest Floor (O Horizon): organic layer of fresh & decaying residue at the surface. May be separated into three layers (all three are not always present)...

O_i = fresh litter, often complete or nearly complete leaves readily distinguishable and even identifiable to species. Often layered or matted. If this layer is dry and fluffy and yielding an unreliable measure of thickness, compress the leaves to simulate what it would be if “layered” and then measure the thickness.

O_e = relatively undecomposed organic material that is fragmented so that it is difficult to identify as to its specific type or species. Peat-like and generally not blackened in color.

O_a = humified or decomposed organic material with less than 50% mineral soil component (as estimated by visual inspection). May be very black and mixed with worm cast material, but still maintains network of roots (dead or alive) and recognizable organic material.

Some O horizons are saturated with water for long periods or were once saturated but are now artificially drained; others have never been saturated. Some O horizons consist of undecomposed or partially decomposed litter (leaves, needles, twigs, moss, and lichens) that has been deposited on the surface; they may be on top of either mineral or organic soils. Other O layers, called peat, muck, or mucky peat, are organic material that was deposited underwater and has decomposed to varying stages. The mineral fraction of such material is only a small percentage of the volume of the material and generally is much less than half the weight. Some soils consist entirely of material designated as O horizons.

Mineral Soil or Top Soil (A Horizon): The mineral horizon below an O horizon, or at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon. If a surface horizon has properties of both A and E horizons but the dominant feature is an accumulation of humified organic matter, it is designated an A horizon.

This layer may or may not be present in any given core. It is distinguished from the O_a horizon by being composed of more than 50% mineral soil relative to organic matter. Sometimes the organic component is difficult to see, but is indicated by a black or dark brown color due to the accumulation of soluble organic molecules. Where earthworms are abundant this layer may be completely composed of worm cast material.

NOTE: in worm free conditions this layer may not be present and the E horizon begins immediately below the O horizon.

RANKING : Description of class characteristics**RANK=1**

- 1) Forest Floor (O_i , O_e , O_a) fully intact and layered
- 2) Roots present in humus and leaf fragments.
- 3) Forest floor coherent when picked up with intact recognizable layers.
- 4) No earthworms or earthworm sign present.

Plant community remains very diverse, dominated by native species, no expansion of *Carex spp.*

**RANK=2**

- 1) Humus (O_a) present in patches, may be slightly mixed with mineral soil, the rest of the forest floor (O_i , O_e) is intact (large & small fragmented leaves).
- 2) Some roots in the forest floor, but not thick. Small earthworms found in the forest floor.
- 3) No large castings or *L. terrestris* middens
- 4) Small casting may be present in the humus layer of an otherwise intact and layered Forest Floor

Plant community remains somewhat diverse, dominated by native species, minimal expansion of *Carex spp.*

RANK =3

- 1) Larger, mostly intact leaves from the previous litter fall (O_i) present, also includes mostly intact, partially decayed leaves of previous year;
- 2) Small leaf fragments (O_e) present under intact leaves;
- 3) No humus (O_a)
- 4) Mineral soil and earthworm castings present (<50% of forest floor/mineral soil interface upon visual inspection);
- 5) *L. terrestris* middens absent or rare
- 6) plant roots absent or sparse in forest floor.

Plant community may be somewhat diverse with native species and/or with broken patches of *Carex spp.*

RANK =4

- 1) Larger, mostly intact leaves from the previous litter fall (O_i) present, may also include mostly intact, partially decayed leaves of previous year;
- 2) No humus (O_a), or small leaf fragments present (O_e);
- 3) Mineral soil and earthworm castings abundant (>50% of forest floor/mineral soil interface upon visual inspection);
- 4) ***L. terrestris* middens absent or rare.** (< 9 middens per 5 meter radius)
- 5) plant roots absent in forest floor.

Plant community may be sparse OR be dominated by exotic species such as garlic mustard and European Buckthorn OR have a broken to unbroken carpet of *Carex spp.*

**RANK=5**

- 1) No forest floor (O_i , O_e , O_a) OR only larger, mostly intact leaves from the previous fall present only (O_i);
- 2) No humus (O_a), or small leaf fragments present (O_e);
- 3) Mineral soil and earthworm castings abundant (>50% of forest floor/mineral soil interface upon visual inspection);
- 4) ***L. terrestris* middens present.** (>10 middens in a 5 meter radius)
- 5) Plant roots absent in forest floor.

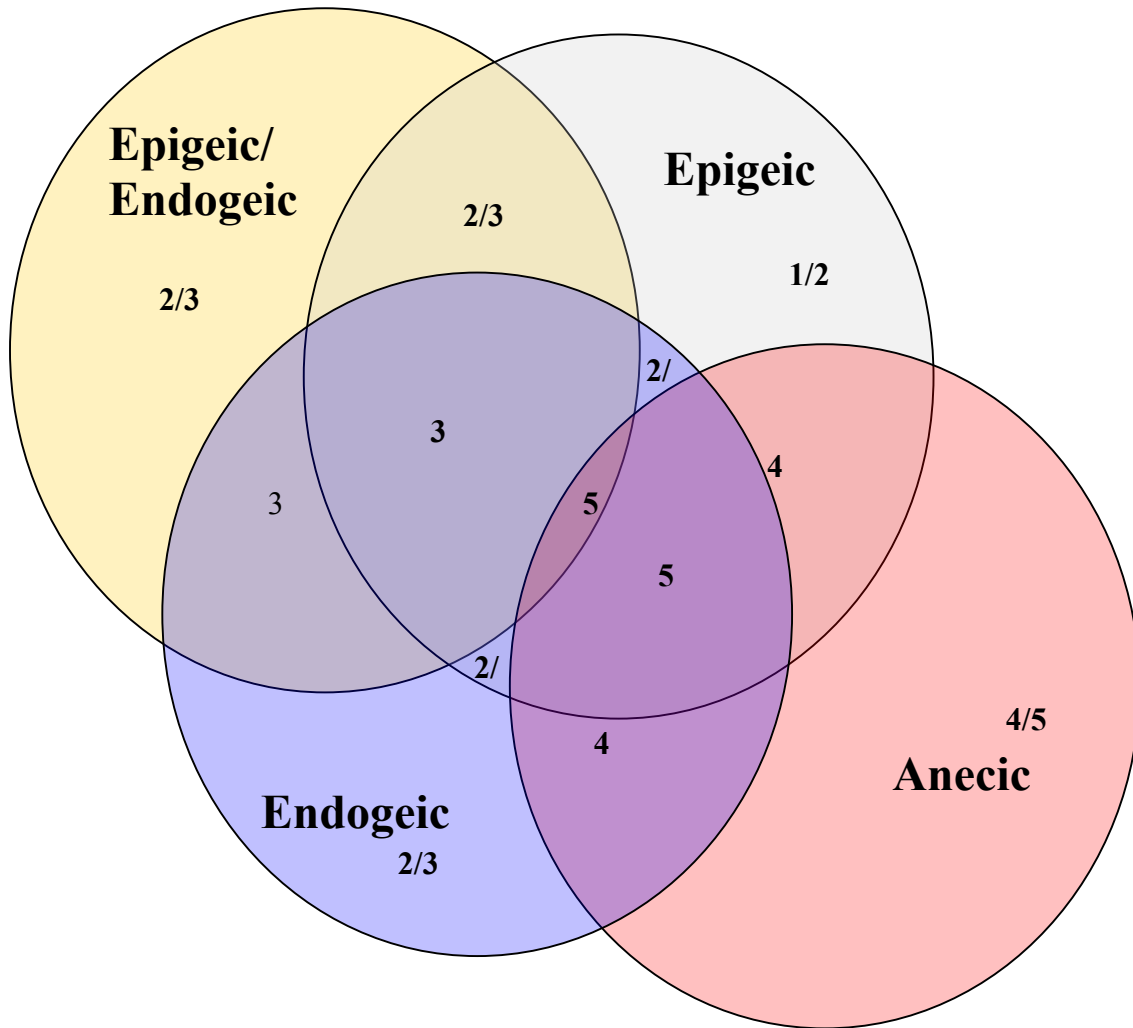
Plant community may be sparse OR be dominated by exotic species such as garlic mustard and European Buckthorn OR have a broken to unbroken carpet of *Carex spp.*



Earthworm Ecological Groups Compared with IERAT Classification

The following diagram compares earthworm ecological groups and their association with each of the IERAT classifications: The IERAT has five levels of classification on a continuum from 1 = earthworm free, to 5 = heavily invaded. There are three ecological groups associated with earthworms and they have different feeding and burrowing behaviors. Epigeic spp. are litter dwelling, Endogeic spp. are soil dwelling and Anecic spp. and deep burrowing. There are also Epigeic/Endogeic spp. that inhabit both areas and are associated with larger impacts than either the Epigeic or Endogeic spp. You will usually notice the largest ecological impacts when all three ecological groups are present.

NOTE: This does not replace the need to conduct quantitative earthworms extraction for identifying which species are present.



Middens: are distinctive piles of cast material around the openings to their burrows. These middens are usually about 1-5cm in diameter and 1-3cm in height with a burrow hole (2-4mm in diameter) near the center. The burrow entrances of middens also often have large numbers of leaf petioles or fragments of leaves sticking out of them.

Castings: (earthworm poop) on the surface of the soil. Earthworm cast material is composed of smooth and rounded clumps of soil which distinguishes it from the more rough, angular or crumb-like surface of soil **aggregates** that have not been worked by earthworms. Cast material is also usually very dark brown or black in color. (Think of the candy “Nerd’s”)

Forest Floor (O Horizon): organic layer of fresh & decaying residue at the surface. May be separated into three layers (all three are not always present)...

O_i = fresh litter, often complete or nearly complete leaves readily distinguishable and even identifiable to species. Often layered or matted. If this layer is dry and fluffy and yielding an unreliable measure of thickness, compress the leaves to simulate what it would be if “layered” and then measure the thickness.

O_e = relatively undecomposed organic material that is fragmented so that it is difficult to identify as to its specific type or species. Peat-like and generally not blackened in color.

O_a = humified or decomposed organic material with less than 50% mineral soil component (as estimated by visual inspection). May be very black and mixed with worm cast material, but still maintains network of roots (dead or alive) and recognizable organic material.

Some O horizons are saturated with water for long periods or were once saturated but are now artificially drained; others have never been saturated. Some O horizons consist of undecomposed or partially decomposed litter (leaves, needles, twigs, moss, and lichens) that has been deposited on the surface; they may be on top of either mineral or organic soils. Other O layers, called peat, muck, or mucky peat, are organic material that was deposited underwater and has decomposed to varying stages. The mineral fraction of such material is only a small percentage of the volume of the material and generally is much less than half the weight. Some soils consist entirely of material designated as O horizons.

Mineral Soil or Top Soil (A Horizon): The mineral horizon below an O horizon, or at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon. If a surface horizon has properties of both A and E horizons but the dominant feature is an accumulation of humified organic matter, it is designated an A horizon.

This layer may or may not be present in any given core. It is distinguished from the O_a horizon by being composed of more than 50% mineral soil relative to organic matter. Sometimes the organic component is difficult to see, but is indicated by a black or dark brown color due to the accumulation of soluble organic molecules. Where earthworms are abundant this layer may be completely composed of worm cast material.

NOTE: *in worm free conditions this layer may not be present and the E horizon begins immediately below the O horizon.*

E HORIZON: An E horizon is most commonly differentiated from an overlying A horizon by lighter color and generally has measurably less organic matter than the A horizon. The color of this horizon generally grades quickly (2-10cm) from the black or darker colors of the overlying O or A horizon. This is a mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these, leaving a concentration of sand and silt particles of quartz or other resistant materials. An E horizon is usually, but not necessarily, lighter in color than an underlying B horizon. In some soils the color is that of the sand and silt particles, but in many soils coats of iron or other compounds mask the color of the primary particles. An E horizon is most commonly differentiated from an underlying B horizon by color of higher value or lower chroma, by coarser texture, or by a combination of these properties. An E horizon is commonly near the surface below an O or A horizon and above a B horizon, but the symbol E may be used without regard to position in the profile for any horizon that meets the requirements and that has resulted from soil genesis.

SOIL TEXTURE:

Soil texture refers to the relative proportions of sand, silt, and clay particles in a mass of soil.

SAND: loose and single grained. The individual grains can readily be seen or felt. Squeezed in the hand when dry, it will fall apart when pressure is released. Squeezed when moist, it will form a cast, but will crumble when touched.

SANDY LOAM: soil containing much sand but which has enough silt and clay to make it somewhat coherent. The individual sand grains can be readily seen and felt. Squeezed when dry, it will form a cast which will readily fall apart, but if squeezed when moist a cast can be formed that will bear careful handling without breaking.

LOAM: soil having a relatively even mixture of different grades of sand and of silt and clay. It is mellow with a somewhat gritty feel, yet fairly smooth and slightly plastic. Squeezed when dry, it will form a cast that will bear careful handling, while the cast formed by squeezing soil can be handled quite freely without breaking.

SILT LOAM: soil having a moderate amount of the fine grades of sand and only a small amount of clay, over half of the particles being of the size called "silt.". When dry it may appear cloddy but the lumps can be readily broken, and when pulverized it feels soft and floury. When wet the soil readily runs together and puddles. Either dry or moist it will form casts that can be freely handled without breaking, but when moistened and squeezed between thumb and finger it will not "ribbon" but will give a broken appearance.

CLAY LOAM: fine textured soil which usually breaks into clods or lumps that are hard when dry. When the moist soil is pinched between the thumb and finger it will form a thin "ribbon" which will break readily, barely sustaining its own weight. The moist soil is plastic and will form a cast that will bear much handling. When kneaded in the hand it does not crumble readily but tends to work into a heavy compact mass.

CLAY: fine textured soil that usually forms very hard lumps or clods when dry and is quite plastic and usually sticky when wet. When the moist soil is pinched out between the thumb and fingers it will form a long, flexible "ribbon".

MUCK: well-decomposed organic soil.

PEAT: raw undecomposed organic material in which the original fibers constitute almost all the material.

SOIL CORES:	O horizon layers & thickness (cm)	A-horizon thickness (cm)	E-horizon (circle one)	Soil texture class
sub-sample #1 <i>total depth (cm):</i>	O ₁ - O _e - O _a -	1. 2. 3. Average:	<i>present / absent</i> Comments:	
sub-sample #2 <i>total depth (cm):</i>	O ₁ - O _e - O _a -	1. 2. 3. Average:	<i>present / absent</i> Comments:	
sub-sample #3 <i>total depth (cm):</i>	O ₁ - O _e - O _a -	1. 2. 3. Average:	<i>present / absent</i> Comments:	

Average Soil Texture -- Mineral Soils: average texture of the top meter of mineral soil.

- 1) get a fist full of mineral soil and remove all roots, organic material, rocks, etc.
- 2) saturate the soil with water and then squeeze out all excess by making a tight fist
- 3) attempt to form into a ball...then follow the key below to determine the texture.

<i>Sands</i>	<i>Loams</i>	<i>Silts and Clays</i>
Sand	Sand loam	Silt
Loamy sand	Silt loam	Sandy clay
	Sandy clay loam	Silty clay
	Silty clay loam	Clay

Simplified Key to Mineral Soil Texture (Brewer and McCann, 1982):

- A1 Soil does not remain in a ball when squeezed.....**sand**
- A2 Soil remains in a ball when squeezed.....**B**

- B1 Squeeze the ball between your thumb and forefinger, attempting to make a ribbon that you push up over your finger. Soil makes no ribbon.....**loamy sand**
- B2 Soil makes a ribbon; may be very short.....**C**

- C1 Ribbon extends less than 1" before breaking.....**D**
- C2 Ribbon extends 1" or more before breaking.....**E**

- D1 Add excess water to small amount of soil; soil feels at least slightly gritty.....**sandy loam**
- D2 Soil feels smooth.....**silt loam**

- E1 Soil makes a ribbon that breaks when 1-2" long; cracks if bent into a ring.....**F**
- E2 Soil makes a ribbon more than 2" long; doesn't crack when bent into a ring.....**G**

- F1 Add excess water to small amount of soil; soil feels at least slightly gritty.....**sandy clay loam or clay loam**
- F2 Soil feels smooth.....**silty clay loam or silt**

- G1 Add excess water to a small amount of soil; soil feels at least slightly gritty.....**sandy clay or clay**
- G2 Soil feels smooth.....**silty clay**

Appendix B

Evaluation Focus

<p>A. Purpose of the evaluation</p> <ul style="list-style-type: none"> • Who is the intended user of the evaluation results? <i>Program Staff, Trainers</i> • What is the intended use for the evaluation results? <i>Level of training necessary for IERAT users to effectively and efficiently use the tool, best dissemination methods, changes in land managers knowledge, attitudes and behaviors related to invasive earthworms and general IERAT improvements.</i> • Evaluation Purpose Statement: <i>The purpose of this evaluation is to determine the effectiveness and efficiency at which the IERAT training methods will train land managers to accurately determine the distribution and relative abundance of non-native earthworms in the Western Great Lakes region, allowing for effective education and monitoring strategies to be implemented by land managers.</i> 	<ul style="list-style-type: none"> • Are you able to reach consensus among major stakeholders as to the purpose of the evaluation? • Are the intended use and user of the evaluation clear, specific, and well defined? <i>Yes</i> • Will evaluation results be used? <i>Yes</i>
<p>B. Description of Program to be Evaluated <i>See attached logic model.</i></p>	<ul style="list-style-type: none"> • Are the program objectives well defined? <i>Yes</i> • Is it possible for the target objectives to be achieved with the intended target audience? <i>Yes</i> • Is the program grounded in sound assumptions? <i>Yes, conservation education, experiential learning</i> • Does the program have the potential for sufficient impact, thus warranting the time and expense of evaluation? <i>Yes</i>
<p>C. Logistical Considerations</p> <ul style="list-style-type: none"> • Available staff for the evaluation: <i>GLWW program coordinator</i> • Information needed by: <i>GLWW</i> • Resources available for the evaluation: <i>TBA</i> • Political context/external factors: <i>None identified at this point</i> 	<ul style="list-style-type: none"> • Is the desired evaluation purpose feasible given available staff, time and resources? • Given logistical constraints, can evaluation be carried out that would yield useful and relevant information?

Appendix C
Evaluation Plan

Evaluation Questions	Indicators	Information	Tools	Design and Sampling
-----------------------------	-------------------	--------------------	--------------	----------------------------

		Sources		
Did participant's knowledge, attitudes and behaviors related to non-native earthworms change after using the IERAT?	Participants responses Staff observations	IERAT participants	survey	Pretest/posttest All participants in IERAT training workshop
Where land managers able to accurately report earthworm presence, absence and relative abundance using the IERAT?	Participants responses Staff observations	Participants IERAT sites	IERAT Quantitative earthworm samples	Compare IERAT sites with GLWW staff assessments 3 subplot per plot quantitative earthworm assessment
Do land managers trained in the IERAT report data findings to GLWW?	Did GLWW receive data	IERAT Participants	GLWW dataset	Did participants share IERAT data with GLWW's website
Did land managers use the IERAT data to inform land management decisions?	Earthworms considered in management plans	IERAT Participants	Management plans	Did participants consider earthworms in their management plans
What is the preferred delivery method of the IERAT to land managers?	Participants responses Staff observations	IERAT Participants GLWW staff	Focus Group	Purposive sample: six public land managers, six private woodlot owners
How was IERAT training implemented and perceived?	Participants responses Staff observations	IERAT Participants GLWW staff	Survey Focus Group	Mixed Method Post test: all participants. Focus group: purposive sample: six public land managers, six private woodlot owners
Was there a difference in training methods needed between public and private land managers?	Participants responses Staff observations	IERAT Participants GLWW staff	Survey Focus Group	Mixed Method Post test: all participants. Focus group: purposive sample: six public land managers, six private woodlot owners
Did the IERAT meet the needs of the participants?	Participants responses Staff observations	IERAT Participants GLWW staff	Survey Focus Group	Mixed Method Post test: all participants. Focus group: purposive sample: six public land managers, six private woodlot owners
How can IERAT trainings be improved?	Participants responses Staff observations	IERAT Participants GLWW staff	Survey Focus Group	Mixed Method Post test: all participants. Focus group: purposive sample: six public land managers, six private woodlot owners