

**Environment and Natural Resources Trust Fund 2009 Work Program  
Final Report**

**Date of Report:** March 18, 2013  
**Date of Next Progress Report:** Final Report  
**Date of Work Program Approval:** June 16, 2009  
**Project Completion Date:** December 30, 2012

**I. PROJECT TITLE: Prevention and Early Detection of Asian Earthworms and Reducing the Spread of European Earthworms**

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**Location:** Statewide

<b>Total Trust Fund Project Budget:</b>	<b>Trust Fund Appropriation</b>	<b>\$</b>	<b>150,000</b>
	<b>Minus Amount Spent:</b>	<b>\$</b>	<b>150,000</b>
	<b>Equal Balance:</b>	<b>\$</b>	<b>0</b>

**Legal Citation: M.L. 2009, Chp. 143, Sec. 2, Subd. 6e**

**Appropriation Language:**

\$150,000 is from the trust fund to the Board of Regents of the University of Minnesota Natural Resources Research Institute for a risk assessment of the methods of spreading, testing of management recommendations, and identification of key areas for action in the state to reduce the impacts of invasive earthworms on hardwood forest productivity. This appropriation is available until June 30, 2012, at which time the project must be completed and final products delivered, unless an earlier date is specified in the work program.

**II. and III. FINAL PROJECT SUMMARY:**

We used a multi-pronged approach to quantify of the relative importance of different vectors of spread for invasive earthworms, make management and regulatory recommendations and create mechanisms for public engagement and dissemination of our project results through the Great Lakes Worm Watch website and diverse stakeholders. Internet sales of earthworms and earthworm related products posed large risks for the introduction of new earthworm species and continued spread of those already in the state. Of 38 earthworm products sampled, 87% were either contaminated with other earthworm species or provided inaccurate identification.

Assessment of soil transported via ATV's and logging equipment demonstrated that this is also a high risk vector for spread of earthworms across the landscape, suggesting that equipment hygiene, land management activities and policies should address this risk. Preliminary recommendations for organizations with regulatory oversight for invasive earthworms (i.e. MN-DNR, MDA and MPCA) include the implementation of required trainings on invasive earthworms for commercial operations involved in any enterprise using or selling earthworm or earthworm products (i.e. fishing bait, composting, etc.). Recommended trainings would be, similar to those already required of minnow bait operations. Finally, substantial efforts were completed to train, inform and actively engage diverse stakeholders in efforts to document invasive earthworm and their relative impacts across the state/region and to identify earthworm-free and minimally impacted areas worthy of protection. As a result of this project we added 716 survey points and 9,697 specimens to our database and worked directly with 40 groups and over 1300 individuals (e.g. citizens, college students-teachers, K-12 students-teachers, natural resource managers, and researchers) in 10 different states (Minnesota, Wisconsin, Ohio, New York, Massachusetts, Virginia, Pennsylvania, Alaska, Kentucky, Michigan). Five peer-reviewed publications, a second edition of the book "**Earthworms of the Great Lakes**", and two online maps were produced and disseminate our results.

#### **IV. OUTLINE OF PROJECT RESULTS:**

##### **Result 1: Risk-Assessment of Vectors of Earthworm Introduction**

###### **Description:**

In contrast to the traditional approach of species-based risk assessments, we propose to identify, describe and quantify the potential vectors of in-state spread of established earthworm species and of interstate transport and introduction of non-established earthworm species (i.e. intentional and unintentional transport of earthworms through compost, mulch, soils and fishing bait), including field-based measures of earthworm species and relative abundance present in each vector.

This will be done in a 2 step process beginning in 2009 and completed in 2010. Preliminary sampling of various in-state and interstate vectors will be conducted in summer and fall 2009 to provide an initial indication of the relative importance of different vectors and to identify any obstacles that need to be overcome in order to adequately assess their level of risk. From the preliminary sampling and analysis in 2009, more comprehensive and/or targeted sampling of the most important vectors of earthworms spread will be conducted in spring, summer & fall 2010.

A manuscript will be submitted for publication in a peer-reviewed professional journal, such as Biological Invasions, summarizing and reporting the research conducted under result 1 of this project. The delay between the 4<sup>th</sup> update and final report of this result provides adequate time for the peer-review process to be completed and final publication of the submitted manuscript.

<b>Summary Budget Information for Result 1:</b>	<b>Trust Fund Budget:</b>	<b>\$ 43,268</b>
	<b>Amount Spent:</b>	<b>\$ 43,268</b>
	<b>Balance:</b>	<b>\$ 0</b>

<b>Deliverable</b>	<b>Completion Date</b>	<b>Budget</b>
<b>1. Preliminary descriptions and risk assessment of in-state and interstate vectors of earthworm spread.</b>	December 30, 2009	Staff \$7972 Data storage \$300 Supplies \$400 Travel \$2656 <b>Total: \$11,328</b>
<b>2. Final descriptions and risk assessment of vectors of earthworm spread.</b>	December 30, 2010; Revised to June 30, 2012	Staff \$19,457 Supplies \$400 Travel \$5391 <b>Total: \$25,248</b>
<b>3. Analysis of data and preparation of a report submitted to MDA, DNR and other governmental agencies charged with managing or regulation invasive species to help promote the health of our forests. This will also be submitted for publication in a professional peer-reviewed journal (i.e. Biological Invasions)</b>	June 30, 2011; Revised to June 30, 2012	Staff \$ 6,692 <b>Total: \$6,692</b>

**Final Report Summary:**

Two documents (Appendix 1 and 2) provide the three deliverables listed above.

A draft manuscript titled “**Internet Sales as Vectors of Non-native Earthworm Introductions in the western Great Lakes Region.**” (Appendix 1) includes an introduction and literature review of the primary vectors of intra- and inter-state transport of non-native earthworms in the Great Lakes region of North America. Our assessment included all non-native earthworms to the western Great lakes region (e.g. European species that have already been established in the state), but particularly focused on Asian species in the genus *Amyntas* because they are not yet established in the state and have shown to pose severe threats to native forests in eastern states where invasions of this species are more prevalent. Internet sales of earthworm and vermicomposting (compost) were identified as a potentially important vector that had not been assessed. A combination of protocol based internet searches, targeted interviews, site inspections and purchasing earthworms from internet vendors across the country was used to quantitatively and qualitatively describe the level and nature of internet sales and vermicomposting as potential vectors for the introduction and spread of non-native earthworms in our region. This manuscript is currently in draft form. It will be submitted to internal review to selected agencies and stakeholders (i.e. MN Department of Agriculture, MN Department Natural Resources, APHIS, The Nature Conservancy, and others). Following their review a final revision will be completed and the manuscript will be submitted to a peer-reviewed scientific journal for publication (i.e. Biological Invasions). Tables X and Y below provide a summary of some of the most relevant data from the draft manuscript.

An informational brochure titled “**ABC’s of Composting with Earthworms Safely**” (Appendix 2) is the final version of a document described in earlier reports as “**Best Management Practices for Vermicomposting**”. Following external review and a final revision, it was determined that the new title better captures the contents of the document. The document is a full color, double sided, tri-fold brochure appropriate

for distribution at displays and educational events. It is also freely available for download from the Great Lakes Worm Watch website. It is intended for broad use by stakeholders, educators, vendors and the public as a resource to identify the primary ways in which vermicomposting can be a vector for the introduction and spread of non-native earthworms and what precautions can be taken to limit or prevent spread via vermicomposting. The **“ABC’s of Composting with Earthworms Safely”** is downloadable from our website  
<<http://www.nrri.umn.edu/worms/downloads/team/vermicompostingBMP.pdf>>.

The manuscript and brochure will serve as resources for a variety of stakeholders to understand the nature and level of threats posed by non-native earthworms as a group of invasive species. Given the difficulty of identifying many of these species speaks to the need to address the invasion of earthworms from a non-species specific perspective. Further, greater understanding of the potential for internet sales and vermicomposting to be important vectors leading to the introduction and spread of non-native earthworms will aid in the development and implementation of policies, regulations and educational outreach designed to limit future introduction in Minnesota and Great Lakes region of North America.

Additional revenues were provided to augment this effort through a Federal Grant: **“Reducing human-mediated spread of non-native earthworms in vulnerable northern hardwood forests”**, CSREES USDA-AFRI Biology of Weedy and Invasive Species in Agroecosystems. Lead primary investigator David Andow and co-investigators, Terry Hurley, George Host, and Cindy Hale. Funded in 2010, 3 year project, award amount \$491,000

Results from the federal grant that contributed to Result 1 include independent internship projects that assessed selected potential vectors of non-native earthworm introduction and spread, including:

Christianson, Drew. 2010. **Effects of fishing tournaments on earthworm introductions in Minnesota’s Laurentian region**. Presented at the 2010 Minnesota-Wisconsin Invasive Species Conference, November 8-10, 2010, St. Paul, MN. Abstract Booklet page 6.

Northbird, David. 2010. **Demand for earthworm bait**. Presented at the 2010 Minnesota-Wisconsin Invasive Species Conference, November 8-10, 2010, St. Paul, MN. Abstract Booklet page 62.

## **Result 2: Testing Effectiveness of Management Recommendations**

### **Description:**

Management recommendations resulting from previous work in 2008 and further developed through the information provided by Result 1 of this project (i.e. equipment hygiene, public land-use restrictions, bait labeling or restrictions, etc.) will be field tested to determine the cost-benefit and relative effectiveness of different

recommendations to actually limit the spread/introduction of different earthworm species.

Rebecca Knowles of the Leech lake Band of Ojibwe Department of Resource Management will provide primary coordination and management these activities including, recruitment, training and supervision of undergraduate interns from the UMD, State colleges and Tribal colleges. Informed by a previous project in 2008 and our preliminary result in 2009 from Result 1, the project partners will collaborate to identify, describe and prioritize a list of management recommendations they want to explicitly test. Sampling methods and protocols will be developed for each and field testing/sampling will be conducted in 2010. For example, if we want to test the effectiveness of logging equipment hygiene on limiting the spread of earthworms; we may collect samples of soil from equipment treads and underbodies and inspect them for earthworms and earthworm egg cocoons before and after implementation of hygiene protocols. This will allow us to quantify the cost vs. benefit based on the actual effects of the management recommendation on earthworm and egg cocoon presence, absence and relative abundance.

A manuscript will be submitted for publication as a General Technical Report summarizing and reporting the research conducted under result 2 of this project. The delay between the 4<sup>th</sup> update and final report of this result provides adequate time for the peer-review process to be completed and final publication of the submitted manuscript.

**Summary Budget Information for Result 2: Trust Fund Budget: \$ 44,046**  
**Amount Spent: \$ 44,046**  
**Balance: \$ 0**

<b>Deliverable</b>	<b>Completion Date</b>	<b>Budget</b>
<b>1. Identify &amp; describe the specific management recommendations we will field test for effectiveness</b>	February 30, 2010; Revised to June 30, 2011	Staff \$ 5,351 <b>Total: 5,351</b>
<b>2. Develop sampling protocols for each management recommendation to be tested</b>	June 30, 2010; Revised to June 30, 2011	Staff \$ 8,107 <b>Total: 8,107</b>
<b>3. Conduct field testing/sampling for each management recommendation to be tested</b>	December 30, 2010; Revised to August 30, 2011	Staff \$ 11,378 Undergraduates \$ 6,867 Data storage \$300 Supplies \$ 800 Travel \$8,047 <b>Total: 27,392</b>
<b>4. General Technical Report: results of testing regional management recommendations</b>	June 30, 2011; Revised to June 30, 2012	Staff \$ 2,946 Publication \$ 250 <b>Total: 3,196</b>

**Final Report Summary:**

The draft manuscript (Appendix 3) provides the four deliverables listed above.

It will be finalized for publication in the coming months and is intended for submission as a US Forest Service General Technical Report titled “**Non-native Earthworms Transported on Treads of ATVs and Logging Equipment in Northern Hardwood Forests of Minnesota, USA**”.

Forests of glaciated regions of North America evolved over thousands of years in the absence of earthworms. Multiple species of European and Asian earthworms now exist in northern forests across the Great Lakes region. Abundant and ecologically diverse communities of non-native earthworms are altering the health and functioning of northern hardwood forests in Minnesota. Humans are a primary source of introduction and spread of these invasive species. This study quantified the relative risk of earthworm spread resulting from soil transport via of all-terrain vehicles (ATVs) and logging equipment in sugar maple (*Acer saccharum*) dominated hardwood forests of the Chippewa National Forest, Minnesota, USA. Soil collected from tires and underbodies of ATVs and logging vehicles were found to contain significant numbers of live earthworms and viable earthworm cocoons. It was concluded that ATV travel and logging activity may be an important vector of continued introductions and spread of invasive earthworms in our region. The greatest threat comes from the transport of earthworm invaded soil picked up on treads and vehicle bodies which move further into the forest from invasion fronts or that are subsequently transported to other sites. We recommend a combination of operator education, equipment hygiene, and land-use and management policies to limit the introduction and spread of non-native earthworms through soil transport by off-road vehicles and logging equipment.

**Result 3: Regulatory Responses to Early Detection of Asian Earthworms**  
**Description:**

In cooperation with governmental agencies (including but not limited to DNR, and USFS) and based on results 1 & 2, a plan for regulatory responses will be developed to respond to early detection of earthworm species not already established in the state (i.e. *Amyntas* species) including possible control or eradication measures and monitoring for incipient invasions of new species. These will be summarized in a General Technical Report. The delay between the 4<sup>th</sup> update and final report of this result provides adequate time for the agency-review and adoption to be completed before the final report.

The project manager and projects partners will also collaborate to present the outcomes of results 1, 2 & 3 at national ecological and/or land managers conferences. Our results will serve as a model for others across the country who are also facing the threat of invasive earthworms.

**Summary Budget Information for Result 3:** Trust Fund Budget: \$ 2,462  
 Amount Spent: \$ 2,462  
 Balance: \$ 0

Deliverable	Completion Date	Budget
1. Technical Report: cooperative regulatory response procedures	October 30, 2011	\$ 1470

2. Meet with 2-3 regulatory agencies in the development of the technical report.	December 30, 2011	\$ 992
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**Final Report Summary:**

In fall of 2012 we began interagency discussions related to the development of a **“Draft Strategic Plan - Earthworm Regulatory Recommendations”** (Appendix 4). The discussions includes staff from MN Department of Natural Resources (DNR), MN-Department of Agriculture (MDA), MN Pollution Control Agency (MPCA), APHIS, and other interested parties.

Since earthworms are a group of organisms that are terrestrial but have a substantial aquatic pathway for introduction the line between the roles of MDA (terrestrial invasive species) and DNR (aquatic invasive species) can be unclear. However, these agencies have a history of working collaboratively in such situations and anticipate doing so with invasive earthworms. It appears that an opportunity exists to collaboratively develop recommendations for limiting the continued introduction of earthworms involving DNR, MDA and interested NGO’s like The Nature Conservancy that may be interested in supporting legislative action in some form.

One suggestion to be pursued would be to develop a training protocol related to earthworms as part of the current licensing requirements for bait minnows. The DNR’s approach with minnows thus far is to focus on identifying species that are allowed to be sold, and those that are not, and then providing training and licensing to minimize the threats. The biggest issue for minnows, as for earthworms, is not identifying species that should be allowed, but rather, developing a licensing and training system that sufficiently ensures reasonable compliance. See Appendix 4 with a description and links for what is currently done for minnows.

We feel we have the knowledge to develop an appropriate list of allowed earthworm species based on those that are already well established in the state (i.e. *Lumbricus terrestris*, *L. rubellus*, *Aporrectodea* spp.). The biggest issue will be to create/provide training so bait sellers know what to look for in earthworm fishing bait to ensure/minimize contamination of non-allowed species. A licensing structure similar to the one they currently have for minnows could also be successful for earthworms. Ideally the sellers of earthworms for fishing bait would be required to receive education on appropriate species and rearing conditions to prevent/minimize contamination of non-allowed species. Resources already developed by Great Lakes Worm Watch could easily be modified to be appropriate for such a training system.

There was broad consensus that education would be a preferable route to legislative action similar to Hawaii at this point (they have banned the importation of any earthworm species). However, continued monitoring for emerging species, not already established in Minnesota would be appropriate. One possible exception

might be related to currently unregulated internet sales which have shown to be a potential vector for many species of earthworms that could pose serious threats to our region (see manuscript from Result 1 above).

Discussions and collaborative efforts will continue.

Results from the federal grant (listed under Result 1) that contributed to Result 3 include independent internship projects that assessed the regulatory environment relative to earthworms as an invasive species, including:

Kallestad, Jenna and David A Andow. 2010. **Current regulatory policy for invasive earthworms in Minnesota.** Presented at the 2010 Minnesota-Wisconsin Invasive Species Conference, November 8-10, 2010, St. Paul, MN. Abstract Booklet page 62.

**Result 4: Identify Priority Areas for Protection**

Description:

A comprehensive and coordinated 3 year effort involving research and educational institutions, governmental agencies, non-governmental organizations and citizen science will inform and involve diverse stakeholders to identify earthworm-free and minimally invaded areas of the state/region in order to prioritize protection efforts and provide rapid detection and response for new species introductions. This component is critical for agencies and project partners to effectively move forward with actions recommended in Results 1-3.

**Summary Budget Information for Result 4:** Trust Fund Budget: \$ 60,224  
 Amount Spent: \$ 60,224  
 Balance: \$ 0

<b>Deliverable</b>	<b>Completion Date</b>	<b>Budget</b>
<b>1.</b> <i>Updates of Great Lakes Worm Watch and National Institute for Invasive Species Science earthworm survey protocols and online data collection system customized for various potential users/stakeholders.</i>	November 30, 2009	Staff \$ 21,050 <b>Total: \$21,050</b>
<b>2.</b> <i>Host a minimum of 36 training workshops (10-14 annually) and regular web casts with collaborators and stakeholder groups to actively support citizen-based earthworm survey activities throughout the state</i>	December 30, 2011	Staff \$ 23,250 Undergraduates \$ 6,891 Data storage \$300 Supplies \$ 150 Travel \$2,169 Express mail \$150 <b>Total: \$ 32,910</b>
<b>3.a.</b> <i>GIS data layer indicating earthworm-free, minimally invaded, moderately invaded and heavily invaded areas of the state</i> <b>3.b.</b> <i>GIS data layer of the known/estimated distributions of all earthworm species documented in the state</i>	June 30, 2012	Staff \$ 4,547 Lab fees \$ 800 <b>Total: \$ 5,347</b>
<b>4.</b> <i>peer-review publication</i>	June 30, 2012	Staff \$ 667 Publication \$ 250 <b>Total: \$917</b>



**Final Report Summary:**

LCCMR funds have helped us to secure and leverage additional funding for continued research and outreach. Results from the federal grant (listed under Result 1) that contributed to Result 4 include independent internship projects that are quantifying spread rates of earthworms, assessing the relationship between fishing pressure and earthworm invasions, and methods for identifying vernal pool habitats (see below).

Bray, Kelly P., Ryan Hueffmeier, Gerry Sjerven, George Host, and David Andow. 2012

**Quantifying the Spread of Invasive Earthworms in Minnesota's Northern Forests.** Presented at the Upper Midwest Invasive Species Conference October 29-31, 2012, La Crosse, Wisconsin.

Palokangas, Claire, Laura Christensen, Ryan Hueffmeier, George Host, and David Andow.

**Relation Between Fishing Pressure And Earthworm Impacts Near Boat Landings.** Presented at the Upper Midwest Invasive Species Conference October 29-31, 2012, La Crosse, Wisconsin.

Driskell, Stephanie, Jennifer Olker, Ryan Hueffmeier, Cindy Hale. 2012. **Identifying and Evaluating Vernal Pool Habitats Spanning a Continuum of Earthworm Invasion Status.** Presented at the Upper Midwest Invasive Species Conference October 29-31, 2012, La Crosse, Wisconsin.

The latter was used to secure federal funding from NOAA, through the Minnesota Lake Superior Coastal program (\$47,765) for a small study titled "**Evaluating vital, small forested wetlands in the Superior National Forest**". It is also being used to pursue funding through the National Science Foundation to for comprehensive assessment of the nature and mechanisms by which invasive earthworms may be negatively impacting vernal pools across the region which serve as the primary habitat for many invertebrate and vertebrate species at the base of the terrestrial food web.

Additional research that was stimulated by this LCCMR project includes:

Larson, E.R., K.F. Kipfmüller, C.M. Hale, L.E. Frelich, and P.B. Reich. (2010) Tree Rings Detect Earthworm Invasions and their Effects in Northern Hardwood Forests. *Biological Invasions* **12(5)**:1053-1067.

Loss, S R, R M Hueffmeier, C M Hale, G E Host, G Sjerven, and L E Frelich. 2013. A visual method for rapidly assessing earthworm invasions in northern hardwood forests. *Natural Areas Journal*, 33(1):21-30.

Loss, S.R., and R.B. Blair. 2011. Reduced density and nest survival of ground-nesting songbirds relative to earthworm invasions in northern hardwood forests. *Conservation Biology* 5: 983-992.

Loss, S.R., G.J. Niemi and R.B. Blair. 2012. Invasions of non-native earthworms related to population declines of ground-nesting songbirds across a regional extent in northern hardwood forests of North America. *Landscape Ecology* 27(5): 683-696.

Deliverable #1 - Updates of Great Lakes Worm Watch online resources customized for various potential users/stakeholders

Updates to Great Lakes Worm Watch website survey protocols and online data collection system have been ongoing throughout this 3 year project. Most recently, three training videos for conducting earthworm surveys for participants taking part in the Great Lakes Worm Watch project were added, including:

- Video 1: **Step 1 “mixing the mustard solution.”**  
<http://www.youtube.com/watch?v=Yt3nE0LnF9E&feature=plcp>
- Video 2: **Step 2 “Setting up the sample grid.”**  
<http://www.youtube.com/watch?v=3Non5ZB---4>
- Video 3: **Step 3 “extracting the worms!”**  
<http://www.youtube.com/watch?v=7StCMZE936c&feature=youtu.be>
- Video 4: **Step 4 “Sampling Design”**  
<http://youtu.be/k1xrxMMbLMc>

In concert with previous updates including ...

- Interactive online training tutorials, under the “Conduct your Own Surveys” section of the website, were developed to assist participants with the collection of quantitative earthworm data. The tutorials can be viewed as a whole or viewed in sections that participants can quick reference such as: Choosing a sampling location, generating geographic location data, how to use a GPS unit, sampling earthworms, how to send specimens to GLWW and ways that they would be able to analyze the data.  
<http://www.greatlakeswormwatch.org/team/conduct.html>
- Updated/adapted lesson plans for K-12 age groups (aligned to state and national standards) and non-formal environmental educators including
  - Creating and using “Earthworm Observatories”:  
[http://www.greatlakeswormwatch.org/educator/activities\\_observatory.html](http://www.greatlakeswormwatch.org/educator/activities_observatory.html)
  - The “Invasion of Exotic Earthworms” Activity  
[http://www.greatlakeswormwatch.org/educator/activities\\_invasion.html](http://www.greatlakeswormwatch.org/educator/activities_invasion.html)
- A new “Frequently Asked Questions” FAQ sheet developed from the hundreds of email questions we get each year.  
<http://www.greatlakeswormwatch.org/team/action.html>
- Final development and implementation of internal protocols for handling earthworms survey data and voucher specimens submitted so that they are adequately quality checked and participants get feedback on the data they submit so as to encourage continued contributions to the project.

Our originally proposed collaboration with National Institute for Invasive Species Science (NISS) to develop a national database for the submission of earthworm data proved to be too difficult to implement. Species identification of earthworms are difficult for untrained personnel and did not fit well into the organizational and taxonomic structure used by NISS. Their program proved too cumbersome for most of our citizen science participants to use and after several failed attempts. We designed comprehensive and detailed data collection and submission protocols now on our Great Lakes Worm Watch

website <http://www.greatlakeswormwatch.org/team/conduct.html>. While the collaboration did not yield the intended database, it served to help us identify the technical and educational issues we needed to address. Their expertise helped us to develop a program that works very well for our program and goals.

A second edition “Earthworms of the Great Lakes” was completed in fall 2012 (copies will be forwarded when we get them from the printer). This edition included:

- Descriptions of four new species, probable introduction via the vermicomposting trade.
- A summary of the IERAT (Invasive Earthworm Rapid Assessment Tool) and how to host land manager trainings.
- New research results on the impacts of invasive earthworms on ground nesting songbirds (i.e. Ovenbirds), salamanders and insects.
- The ABC’s of vermicomposting.
- Updates to the sections on ecological groups, earthworm anatomy and biology
- Completed revised and re-designed key to earthworm identification making it much more user friendly.

Deliverable #2 –Host a minimum of 36 training workshops (10-14 annually) and regular web casts with collaborators and stakeholder groups to actively support citizen-based earthworm survey activities throughout the state.

Throughout this project we hosted a total of 40 training or workshops directly reaching 1758 people (Table 1 below). Clearly the impacts go well beyond these direct contacts however, such indirect impacts are very difficult to quantify. That said, we know for the level of interest and unsolicited contacts that we reach well in excess of thousands of individuals annually. We have directly collaborated with individuals and groups in 10 states (Wisconsin, Ohio, New York, Massachusetts, Virginia, Pennsylvania, Alaska, Kentucky, Michigan) to provide services, earthworm education, training and monitoring efforts in their regions. Thirteen of these groups, from 5 states (Minnesota, Wisconsin, Ohio, New York, Massachusetts) submitted earthworm survey data which was added to our archives. See the Dissemination section of the report for a detailed list of outreach activities during the grant period.

**Table 1. Summary of trainings, workshops and outreach activities conducted.**

<b>Audiences reached via trainings and workshops</b>	<b>Numbers of trainings, workshops conducted</b>	<b>Numbers of people directly reached.</b>
Land Managers-Researchers	10	138
Public	9	495
College Students	12	130
K-12 teachers	3	25
K-12 students	6	575
<b>Total:</b>	<b>40</b>	<b>1363</b>

Deliverable #3 – 3.a. GIS data layer indicating earthworm-free, minimally invaded, moderately invaded and heavily invaded areas of the state; 3.b. GIS data layer of the known/estimated distributions of all earthworm species documented in the state

During this study (2009-12) we had data submitted and verified from 716 sample points or sites from 9 states, including a total of 9,697 earthworm specimens. Summaries of this data by earthworm species and state are provided in tables 2 and 3 below. This included substantial collaborative efforts and our complete database now includes 3,427 sample points with 20,065 verified specimens.

The data collected includes a combination site assessment level data collected using the Invasive Earthworm Rapid Assessment Tool (IERAT) and species specific earthworm data. The IERAT data (Appendix 5) illustrates the areas of Minnesota with different levels of earthworm invasion and associated ecological impacts (category 1= *earthworm-free* through category 5 = *heavily impacted*). Currently an estimated 20% of the landscape is fully earthworm-free and ~50% is minimally impacted. These areas are identified and should be targeted for priority protection and implementation of land-use practices and policies to prevent future introductions and further spread of earthworms in the areas. This data will be delivered free, online using ESRI powered ArcGIS online\*. This interactive is in its beta version titled “**Great Lakes Worm Watch IERAT Classification**” <<http://bit.ly/YstlcE>>. It will be finalized and linked to the “Research – Data” section of the Great Lakes Worm watch website when fully tested on the coming weeks.

Earthworm species specific data for Minnesota is also mapped and publicly available the ESRI powered ArcGIS online\* interactive beta map titled “**Great Lakes Worm Watch Minnesota Earthworm Species**” <<http://bit.ly/YillgV>>. It contains all quantitative species data recorded in Minnesota to date (2000-2012). Each point on the map represents one of 716+ unique sample plots. Zooming in the interactive map makes clearer many overlapping points and by clicking on a given point all earthworm species present at that sample plot are listed. Great Lakes Worm Watch will continue to add data to this interactive map as a platform for making this data publically available. In total there are 3,427 unique sample points consisting of 20,065 specimens across 10 states (Alaska, Illinois, Indiana, Massachusetts, Michigan, Minnesota, New York, Ohio, Pennsylvania and Wisconsin) represent 16 total earthworm species that will be made available through this map.

*\*ArcGIS Online is a complete, cloud-based, collaborative content management system that lets organizations manage their geographic information in a secure and configurable environment.*

**Table 2.** Earthworm species and the number of specimens identified and archived by Great Lakes Worm Watch during the LCCMR grant period 2009-2012.

List of species identified	Number of specimens archived
<i>Allolobophora chlorotica</i>	10
<i>Amyntas</i> spp.	410
<i>Aporrectodea</i> spp.	2652

<i>Aporrectodea caliginosa</i>	19
<i>Aporrectodea caliginosa</i> complex	215
<i>Aporrectodea longa</i>	17
<i>Aporrectodea rosea</i>	79
<i>Aporrectodea trapezoides</i>	3
<i>Aporrectodea tuberculata</i>	83
<i>Dendrobaena octaedra</i>	1449
<i>Dendrodrilus rubidus</i>	72
<i>Eisenia eiseni</i>	2
<i>Eisenia fetida</i>	46
<i>Lumbricus</i> spp.	3683
<i>Lumbricus rubellus</i>	402
<i>Lumbricus terrestris</i>	239
<i>Octolasion</i> spp.	227
<i>Octolasion cyaneum</i>	7
<i>Octolasion tyrtaeum</i>	82
<b>TOTAL</b>	<b>9,697</b>

**Table 3.** The number of earthworm specimens identified and archived by Great Lakes Worm Watch for each state for which data was submitted during the LCCMR grant period 2009-2012.

<b>States that submitted data</b>	<b>Number of specimens archived</b>
Alaska	2
Indiana	57
Massachusetts	663
Michigan	176
Minnesota	6008
New York	39
Ohio	1469
Pennsylvania	15
Wisconsin	1268
<b>TOTAL</b>	<b>9,697</b>

Deliverable #4 - peer-review publication

The peer-reviewed publication titled “**Earthworm Invasions in Northern Hardwood Forests: a Rapid Assessment Method**” was published in Natural Areas Journal in January 2013 (Appendix 6).

Non-native earthworms have invaded hardwood forests of boreal and north temperate North America, with substantial effects to soil, plants, and ground-dwelling vertebrates. Quantifying these invasions is necessary for understanding the scope of earthworm impacts and for identifying remaining earthworm-free areas in which to target conservation and management activities. Current earthworm sampling

methods are effort intensive and/or environmentally damaging, which prevents efficient quantification of invasions at high resolution and across broad spatial scales. A 5-level ranking system of visual classification (earthworm free – heavily earthworm invaded), based on multiple soil and forest floor characteristics was developed and provides an efficient and effective approach for rapidly assessing the distribution and relative severity of earthworm invasions in hardwood forests of the Great Lakes region.

The complete IERAT effort was made possible through the LCCMR funds and additional funds provided by:

2008-2010. MN Coastal Program Grant – “Exotic earthworm invasions: integrated research and education to achieve natural resource protection in North Shore State parks”, grant award \$46,065.

2009. Grand Portage National Monument, National Park Service – “Grand Portage National Monument- baseline earthworm survey”, 1 year project, award amount \$2,875.

## **V. TOTAL TRUST FUND PROJECT BUDGET:**

### **Personnel: \$ 107,510**

- 1) Cindy Hale, project manager- year 1=10%, year 2= 15%, year 3= 12% annual salary & fringe (project total \$26,574)
- 2) George Host, experimental design & project support – 1% annual salary & fringe for 3 years (project total \$3,889)
- 3) Gerry Sjerven, GIS specialist - 3% annual salary & fringe for 3 years (project total \$6,777)
- 4) Jane Reed, website design - 2% annual salary & fringe for 2 years (project total \$1,871)
- 5) Ryan Hueffmeier, NRRI junior scientist - 25% in years 1+3 and 50% in year 2 annual salary & fringe (project total \$47,289)
- 6) Undergraduate lab/field staff (Caitlin Leach, Gretchen Anderson) - 25% academic year salary & fringe and 50% summer salary & fringe over 3 years (project total \$21,110)

### **Contracts:**

Becky Knowles - subcontract with Leech Lake Band of Ojibwe, primary coordination of field testing of management recommendations (result 2) – 30% annual salary & fringe for 1 year (project total \$19,135).

### **Equipment/Tools/Supplies:**

- 1) Office equipment & computers - project specific data storage (project total \$900)

2) Field/Lab Supplies: earthworm sampling and preservation supplies and materials; educational materials (project total \$1750)  
Overall project total = \$ 2,650

**Acquisition, including easements: \$ 0**

**Travel:**

Travel expenses over 3 years to include lodging, meals as needed, mileage, and camping expenses in remote locations for field work, estimated a total of 91 days travel at per diem rates (lodging \$70/day + M&IE \$39/day = \$109/day), 125 days of NRRI vehicle use (\$10/day) and 16,172miles @\$0.50/mile (project total \$19,255)

**Other:**

Includes lab fees -NRRI GIS lab user fees (yrs 1&2 \$300 each and yr 3 \$200); postage for mailing sampling supplies to collaborators (\$50 in each year); publication costs for peer-reviewed journal article (\$250 x 2 publications) (project total \$1,450)

**TOTAL TRUST FUND PROJECT BUDGET: \$ 150,000**

**Explanation of Capital Expenditures Greater Than \$3,500: none**

**VI. PROJECT STRATEGY:**

**A. Project Partners:**

**Partners who will receive funds through this project include:**

- 1) Rebecca Knowles **Leech Lake Band of Ojibwe Division of Resource Management**, Ecologist – will receive \$19,135
- 2) George Host, **The Natural Resources Research Institute, University of Minnesota Duluth GIS lab**, Senior Research Scientist and GIS lab coordinator – will receive \$3,889

**Partners who will NOT receive funds include:**

- 1) Andy Holdsworth, **MN Department of Natural Resources**, Science Policy Division
- 2) Ann Pierce, **MN Department of Natural Resources**, Terrestrial invasive species coordinator
- 3) Jim Barott, **Chippewa National Forest**, Soil Ecologist
- 4) David Andow, **University of Minnesota**, Distinguished McKnight University Professor, Department of Entomology
- 5) Jim Graham, **The National Institute of Invasive Species Science, U.S.G.S. & Colorado State University**, Fort Collins Colorado –Research Scientist;
- 6) Catherine Jarnevich, **The National Institute of Invasive Species Science, U.S.G.S. & Colorado State University**, programmer

**B. Project Impact and Long-term Strategy:**

The results of this project will fill large gaps in knowledge about 1) the risks associated with different vectors of spread for invasive earthworms such as fishing

bait, vermicomposting and the movement of soils, mulch and compost; 2) what different management practices, regulatory responses and educational efforts can do to prevent further spread, 3) and what areas of the state should have the highest priority for protection. With the risk assessments in hand we can readily move towards developing highly effective strategies for limiting the spread of established earthworms and preventing introductions of species not yet present in the state, thereby protecting native forests resources from future aesthetic, biologic and economic impacts. Specifically, native plant populations, tree seedling regeneration, habitat for forest birds, amphibians and small mammals will be protected. We also expect to help limit the spread of many of the most destructive invasive plant species such as buckthorn and garlic mustard which appear to be facilitated by earthworm invasions. The results will be applicable to the state as a whole, since earthworm invasions are occurring statewide, and specifically to the hardwood forested ecosystems where large impacts have already been documented. In addition, we will provide the first coordinated data collection effort in the prairie regions and conifer dominated forests of MN. These results will be broadly applicable to the previously earthworm-free, cold-temperate regions of North America and the Eastern Deciduous Forest Biome of North America, where invasive earthworm invasions are occurring. The technology and information infrastructure created through this project will be available for free on the Great Lakes Worm Watch website and can use by others to support local and regional efforts to limit the introduction, spread and ecological impacts of invasive earthworms. It will also lay the foundation for the development of an accessible and comprehensive system to involve professionals and citizens in long-term monitoring and rapid response to invasive species invasions.

**C. Other Funds Proposed Spent during the Project Period:**

2008-2010. MN Coastal Program Grant – “Exotic earthworm invasions: integrated research and education to achieve natural resource protection in North Shore State parks”, grant award \$46,065.

2009. University of Minnesota - Undergraduate Research Opportunities Grant – “Testing Educational Effectiveness of an “*Invasive Earthworm Disposal*” Message in our North Shore, State Parks”, student - Nicole Vander Heiden, grant award \$1,700 (see “AttachmentC.doc”)

2009. Grand Portage National Monument, National Park Service – “Grand Portage National Monument- baseline earthworm survey”, 1 year project, award amount \$2,875.

2010-2013. USDA – CREES Invasive Species grant. (WoBL) “Reducing human-mediated spread of non-native earthworms in vulnerable northern hardwood forests.”, CSREES USDA-AFRI Biology of Weedy and Invasive Species in Agroecosystems. Co-PI’s include David Andow (lead PI), Terry Hurley, George Host, Cindy Hale and Rebecca Knowles. Grant award \$491,000

**D. Spending History:**

NRRI/TR-2013/09  
3015-10424-00007735



2007-08. National Forest Foundation -“Regional Assessment And Proposed Actions To Address Non-Native Earthworm Invasion Threats To Northern Forests Of The Great Lakes Region.”, award amount \$4,999

No previous trust fund dollars have been spend on this project.

## **VII. DISSEMINATION:**

The project has allowed us to greatly enhance and expand the quality and quantity of resources provided through the Great Lakes Worm Watch website <<http://www.greatlakeswormwatch.org>>. In addition to the many people we interact with directly there are thousands that access our website resources annually. In 2012, Great Lakes Worm Watch established and now maintains a Facebook page with 175+ “Likes”. We use the platform, linked to our website, to communicate research, outreach and educational opportunities <<http://www.facebook.com/pages/Great-Lakes-Worm-Watch/123279661062852>>.

A list/summary of dissemination activities is provided below:

### **Peer reviewed publications:**

- Larson, E.R., K.F. Kipfmüller, C.M. Hale, L.E. Frelich, and P.B. Reich. (2010) Tree Rings Detect Earthworm Invasions and their Effects in Northern Hardwood Forests. *Biological Invasions* **12(5)**:1053-1067.
- Loss, S R, R M Hueffmeier, C M Hale, G E Host, G Sjerven, and L E Frelich. 2013. A visual method for rapidly assessing earthworm invasions in northern hardwood forests. *Natural Areas Journal*, 33(1):21-30.
- Loss, S.R., and R.B. Blair. 2011. Reduced density and nest survival of ground-nesting songbirds relative to earthworm invasions in northern hardwood forests. *Conservation Biology* 5: 983-992.
- Loss, S.R., G.J. Niemi and R.B. Blair. 2012. Invasions of non-native earthworms related to population declines of ground-nesting songbirds across a regional extent in northern hardwood forests of North America. *Landscape Ecology* 27(5): 683-696.

### **GLWW Seminars or Professional Presentations:**

- 1) September 10-11<sup>th</sup>, 2009 – *Impacts of Invasive Earthworms on Forest Ecology in the Great Lakes Region and Potential Management or Policy Responses*. Invited Keynote Speaker at the Ohio Biodiversity Alliance Soil Science Symposium, Cleveland, OH;
- 2) October 10<sup>th</sup>, 2009 – *The Current State of Research on the Impacts of Invasive Earthworms in Northern Temperate Forests*. Invited Seminar Speaker, [The Cary Institute of Ecosystems Studies](#), Millbrook, NY
- 3) December 4<sup>th</sup>, 2009 – *Impacts of Invasive Earthworms on Northern Temperate Forest Soils and Implications for Forest Ecology in the Great Lakes Region*. Invited Seminar Speaker - [Minnesota Association of Professional Soil Scientists](#) MAPSS Winter Technical Event, St. Cloud, Minnesota.

- 4) February 23<sup>rd</sup>, 2010 - INVASIVE EARTHWORM RAPID ASSESSMENT TOOL: Assessing the status of invasive European Earthworms in hardwood forest types for the Western Great Lakes region using visual indicators. Cloquet Forestry Review & Technology Transfer Conference, Cloquet Forestry Center, Cloquet, MN.
- 5) January 22, 2010 - *Developing Action Recommendations: Responding to the Threat of Invasive Earthworms in Western Great Lakes Forests*. Stewardship & Midwest Invasive Plant Network, East Lansing, MI.
- 6) March 1-3, 2010 - *Developing Action Recommendations: Responding to the Threat of Invasive Earthworms in Western Great Lakes Forests*. Joint Meeting of the Minnesota Chapters of the American Fisheries Society (AFS), Society for Conservation Biology (SCB), and The Wildlife Society (TWS), Nisswa, MN.
- 7) March 2010. Jess Johnson and Caleb Bilda. *Vermicomposting – best practices for preventing introduction of invasive earthworms*. Stowe Elementary Environmental Learning Resource Fair.
- 8) March 16-17<sup>th</sup>, 2010 - *Developing Action Recommendations: Responding to the Threat of Invasive Earthworms in Western Great Lakes Forests*. Western Great Lakes Research Conference, St. Paul MN.
- 9) June 8, 2010 - *Developing Action Recommendations: Responding to the Threat of Invasive Earthworms in Western Great Lakes Forests*. The National Tribal Science Forum, Grand Traverse, MI.
- 10) October 17<sup>th</sup>, 2011 - St. John's University Lecture series.
- 11) January 12<sup>th</sup>, 2012 - *An Invasive Earthworm Rapid Assessment tool for Natural Resource Managers in the Great Lakes Region*. 9<sup>th</sup> Annual Forest, Wildlife and Natural Resources Research Review, Cloquet MN.
- 12) April 12<sup>th</sup>, 2012- *Northland Community College*, Ashland Wisconsin. Guest speaker.
- 13) April 29<sup>th</sup>, 2012- Gretchen Anderson. *Vermicomposting – best practices for preventing introduction of invasive earthworms*. Stowe Elementary Environmental Learning Resource Fair.
- 14) May 1<sup>st</sup>, 2012 – University for Seniors. University of Minnesota Duluth.
- 15) June 25<sup>th</sup>, 2012 - University for Seniors. University of Minnesota Duluth.
- 16) October 2012. *Itasca Community College*, Grand Rapids, Minnesota. Guest Speaker: Natural Resources: Invasive Species.
- 17) October 2012- *Project Earth*, St. John's University, Collegeville, Minnesota. Guest Teacher: Project Earth is a day long program aimed at 7<sup>th</sup> and 8<sup>th</sup> graders and focusing on nature – science exploration
- 18) September 2012. Harbor City International School. Delivered presentation open to the entire harbor city school on earthworm impacts and citizen science involvement.
- 19) August 2012. *Minnesota State Fair*, Minnesota Department of Natural Resources, St. Paul, Minnesota. Invited to be an exhibitor representing Great Lakes Worm Watch. Tabled staffed from August 23 – September 3.
- 20) September 6-8<sup>th</sup>, 2012. *Invasive Earthworm Rapid Assessment Tool*. 9<sup>th</sup> Annual Ohio Conservation Symposium.

### **GLWW Trainings or Workshops:**

**A. Invasive Earthworm Rapid Assessment Tool (IERAT) trainings**

- a. Land use managers, research and NGO's
  - i. May 24<sup>th</sup>, 2011 - Trained researchers based in Duluth from The Nature Conservancy.
  - ii. May 25<sup>th</sup>, 2011 - Trained undergraduate field technicians from the Natural Resources Research Institute.
  - iii. June 7<sup>th</sup>, 2011- Trained researchers, land managers and field technicians from the Chippewa National Forest.
  - iv. July 20<sup>th</sup>, 2011 -Trained researchers, land managers and field technicians from the Superior National Forest.
  - v. August, 2011 – Trained ecologist, botanist and field technicians from the National Park Service, Ashland, Wisconsin
  - vi. October 6<sup>th</sup>, 2011. Trained foresters, land managers and technicians from the Fond du Lac Reservation Resource Management division.
  - vii. October 19<sup>th</sup>, 2011. Trained Minnesota Department of Natural Resources researchers, land managers and field technicians.
  - viii. June 28<sup>th</sup>, 2012. Trained undergraduate research crew and Natural Resources Research Institute staff.
  - ix. July 10<sup>th</sup>, 2012. Trained researchers, field techs from the University of Minnesota on the use of the IERAT.
  - x. August 12<sup>th</sup>, 2012. Trained researcher and field techs from the University of Minnesota on the use of the IERAT.
- b. College
  - i. May, 2011- Trained undergraduate field technicians for the WoBL “Earthworm Bait Label” study
  - ii. July 30<sup>th</sup>, 2011 – Trained graduate researcher from the University of Wisconsin Madison.
  - iii. May 10<sup>th</sup>, 2012 – Undergraduate research student, St. Cloud State College.
  - iv. May 21<sup>st</sup>, 2012 – Graduate researcher, University of Stevens Point, Wisconsin.
  - v. June 3<sup>rd</sup>, 2012 – Trained University of Minnesota Twin Cities graduate researcher with undergraduate field interns
  - vi. June 5<sup>th</sup>, 2012 – Trained university of Minnesota Duluth interns and researchers.
  - vii. June 26<sup>th</sup>, 2012 – Trained University of Minnesota Twin Cities graduate researcher and undergraduate field interns
  - viii. June 18<sup>th</sup>, 2012 - Wisconsin Alliance for Minority Participation (WiscAMP), University of Platteville, Wisconsin

**B. Great Lakes Worm Watch trainings**

- a. K-12 Teachers
  - i. July 19 thru 21<sup>st</sup>, 2010 – *Citizen Science Research for Teachers*. Teacher professional development. University of Minnesota, St. Paul Campus
  - ii. May 9<sup>th</sup>, 2012 – Forest For Every Classroom. Teacher professional development, MacKenzie Environmental Education Center, Poynette, WI
  - iii. August, 2012 - Fond du Lac Tribal and Community River Watch Program Cloquet, Minnesota
- b. K-12 Students
  - i. June 26<sup>th</sup>, 2010 – Rusk County Land and Water Conservation high school camp. Tail End Camp, Bruce, Wisconsin.
  - ii. October 11<sup>th</sup>, 2011 - Superior Wisconsin Middle school 6<sup>th</sup> graders in preparation for their "Citizen Science Day".
  - iii. April 25<sup>th</sup>, 2012 - Iron Range Science and Engineering Festival. Field training with 7 graders in Northern Minnesota.
  - iv. June 28<sup>th</sup>, 2012 – White Earth Science and Math Academy. White Earth, Minnesota.
  - v. October 15<sup>th</sup>, 2012 - Cloquet Middle school 6<sup>th</sup> grade science class. presentation and earthworm survey.
  - vi. October 21<sup>st</sup>, 2012 - Denfeld High School 10<sup>th</sup> Grade science Lab. Earthworm identification.
- c. College
  - i. October 8<sup>th</sup>, 2011 - In-service teacher training for the College of St. Scholastica Graduate Teaching Licensing program
  - ii. October 27<sup>th</sup>, 2011 - In-service teacher training for the College of St. Scholastica high school science teachers field methods class.
  - iii. June 5<sup>th</sup>, 2012 – University of Minnesota Duluth Interns. Train the Trainer workshop.
  - iv. July 17<sup>th</sup>, 2012 - Wisconsin Alliance for Minority Participation (WiscAMP), Professional Development Training. Pigeon River Field Station, WI.
- d. Public
  - i. June 25 and 26<sup>th</sup>, 2011 – BioBlitz, Minnesota Department of Natural Resources, Lake Vermilion State Park.
  - ii. July 23, 2011. Sugarloaf Cove public presentation.
  - iii. September 25<sup>th</sup>, 2011 - Big Worming Week training at the Hartley Nature Center, Duluth MN.

- iv. August 22<sup>nd</sup>, 2011 - Sherburne National Wildlife Refuge. Delivered field based hands on workshop for teachers, natural resource professionals and general public.
- v. August 15<sup>th</sup>, 2012 – MinnAqua public program. Detroit Lakes, Minnesota.
- vi. August 15<sup>th</sup>, 2012 – Pikerel Lake Association. Rochert, Minnesota.
- vii. August 16<sup>th</sup>, 2012 – Headwater Science Center. Bemidji, Minnesota.
- viii. August 16<sup>th</sup>, 2012 – Bemidji State Park Event. Bemidji, Minnesota
- ix. September 30<sup>th</sup>, 2012 - Minnesota Department of Natural Resources, Moose Mountain Scientific and Natural Areas, Duluth, Minnesota. Delivered field based hands on workshop for teachers, natural resource professional and general public. Trained participants on quantitative and qualitative sampling techniques.

**Print/online/radio/TV media coverage:**

- 1) Fall 2009 – *Wisconsin's second annual big worming week!* Wood Prints, vol.26 number 4, Published by Friends of Beaver Creek Reserve.
- 2) September 3, 2009 – Cloquet Pine Journal, *Earthworms Invasion? Citizen Scientists needed for Research In Jay Cooke*. By June Kallestad
- 3) September 5, 2009 – Cook County News Herald, *Earthworms Invasion? Citizen Scientists needed for Research Along the North Shore*. By June Kallestad
- 4) September 18, 2009 – By Paul Volkmann, *Invasive earthworms on the move*. Inside the Outdoors, online at PeeVee News <<http://www.greaterlatrobe.net/pvnews.php>>
- 5) September 21, 2009 - *Spread of European earthworms threatening forests of Northeast Ohio, including sugar maples*. By Michael Scott. The Plain Dealer <[cleveland.com](http://cleveland.com)>
- 6) September 21, 2009 - *How to tell if earthworms have invaded a forest*. By Robert Higgs. The Plain Dealer Extra <[cleveland.com](http://cleveland.com)>
- 7) November 18, 2009 - *The Dirt on Worms*. By Pam Smith. Published online at [www.agweb.com](http://www.agweb.com)
- 8) December, 2009 - *Cindy Hale unearths the dark side of wiggly earthworms*. Living North Magazine, by June Kallestad.
- 9) April 29<sup>th</sup>, 2010 – *Worm Watch*. Wisconsin Public Television. <http://wpt2.org/npa/IW823wormwatch.cfm>
- 10) Winter 2010 – Sustainable Farming Association newsletter, The CornerPost. *Unearthing the dark side of earthworms: Asian “jumping” worms are new gardening threat*, by June Kallestad.

- 11) June 10<sup>th</sup>, 2010 - Northland's News Center, NBC 6, CBS3. "Students Work to save forests from invasive species". Story about earthworm monitoring work being done at Hartley Nature Center, Duluth, MN.  
<http://www.northlandsnewscenter.com/news/local/48801247.html>
- 12) April 8<sup>th</sup>, 2011- Almanac North, WDSE –PBS 8. "Asian Jumping Worms". Story about the potential impacts of the Asian earthworm species *Amyntas*.  
<http://www.wdse.org/shows/almanac/watch/almanac-north-apr-29-2011>
- 13) July 5<sup>th</sup>, 2011 – *Answer Girl: Rain draws out worms and where to find shelter from storms*. Wyoming's Casper Star Tribune, by Carol Seavey.  
[http://trib.com/news/local/casper/answergirl/article\\_6d0957c3-4b26-582f-882b-5ee92ed02c3c.html](http://trib.com/news/local/casper/answergirl/article_6d0957c3-4b26-582f-882b-5ee92ed02c3c.html)
- 14) August, 2011 – *Earthworms change the "ground rules" of native forests*. The Vermilion Sportsman Quarterly, By June Kallestad.
- 15) September 11<sup>th</sup>, 2011- *Worms in the Woods*. In the Hills, by Chris Wedeles.  
<http://www.inthehills.ca/2011/09/back/worms-in-the-woods/>
- 16) September 12<sup>th</sup>, 2011- Science Nation "Invasion of the Earthworm!"  
[http://www.nsf.gov/news/special\\_reports/science\\_nation/wormwatch.jsp](http://www.nsf.gov/news/special_reports/science_nation/wormwatch.jsp)
- 17) September 16<sup>th</sup>, 2011 – *Earthworm invasion damages trees*. PBS Newshour, by Jenny Marder. <http://www.pbs.org/newshour/rundown/2011/09/earthworm-invasion-damages-trees.html>
- 18) September 26<sup>th</sup>, 2011- Northland's News Center, NBC 6, CBS3. "Worm Week Wiggles In". Story about participating in Great Lakes Worm Watch annual Big Warming Week. <http://www.northlandsnewscenter.com/news/video/Worming-Week-Wiggles-In-130542833.html>
- 19) September 26<sup>th</sup>, 2011- *As the worm turns*. Ironwood info, by Melanie Fullman.  
[http://www.ironwoodinfo.com/news\\_2011/09/090411\\_indawoods/090411\\_indawoods.htm](http://www.ironwoodinfo.com/news_2011/09/090411_indawoods/090411_indawoods.htm)
- 20) September 26<sup>th</sup>, 2011- *The underground master of invasive species – earthworms*. Great Lakes Echo, by Brian Bienkowski.  
<http://greatlakesecho.org/2011/09/26/the-underground-master-of-invasive-species-%E2%80%93-earthworms/>
- 21) September 28<sup>th</sup>, 2011- *Get your hands dirty during Big Warming Week*. Great Lakes Echo, by Brian Bienkowski. <http://greatlakesecho.org/2011/09/28/get-your-hands-dirty-during-%E2%80%93-big-warming-week%E2%80%9D/>
- 22) October 12<sup>th</sup>, 2011 – *US pest invasion dates back to earlier settlers*. Associated Press, by Rick Callahan.
- 23) November 1<sup>st</sup>, 2011- *Earthworm research from UMD also highlighted on Science Nation*. Duluth News Tribune.  
[https://secure.forumcomm.com/?publisher\\_ID=36&article\\_id=213495&CFID=631372190&CFTOKEN=24421296](https://secure.forumcomm.com/?publisher_ID=36&article_id=213495&CFID=631372190&CFTOKEN=24421296)
- 24) November 9<sup>th</sup>, 2011 – *Tiny earthworms, big impacts; Invasive earthworms change North American landscapes, for better or worse*. Science News for kids, by Cecile LaBlanc. <http://www.sciencenewsforkids.org/2011/11/tiny-earthworms%E2%80%99-big-impact/>
- 25) January 29<sup>th</sup>, 2012 – *Are Worms Natural? The Global Warming Debate*. Nature @ WSU, by Rod Saylor. <http://wsu-nature.org/2012/01/29/are-worms-natural-the-global-worming-debate/>

- 26) February 2<sup>nd</sup>, 2012 – Radio interview on the Buckeye Sportsman with Dan Armitage in Ohio.  
[http://www.buckeyesportsman.net/index.php?option=com\\_content&view=category&layout=blog&id=34&Itemid=55](http://www.buckeyesportsman.net/index.php?option=com_content&view=category&layout=blog&id=34&Itemid=55)
- 27) Spring, 2012 – NRRI Now, *K-12 Citizen Scientists*. Natural Resources Research Institute, by June Kallestad
- 28) Spring/Summer, 2012 – *Impacts of earthworms in North America and around the world*. Northbound, by Cheryl Todea.
- 29) Spring/Summer, 2012 – *Earthworm impacts in northern forest ecosystems*. Northbound, by Joe Panci.
- 30) March 7<sup>th</sup>, 2012 – *Great Lakes Worm Watch*. Ecological Society of America: Ecotones, by Liza Lester. <http://www.esa.org/esablog/citizen-science/great-lakes-worm-watch/>
- 31) March 18<sup>th</sup>, 2012 – *Shalaway: The dark destructive world of earthworms*. Pittsburg Post-Gazette, by Scott Shalaway. <http://www.post-gazette.com/stories/sports/hunting-fishing/shalaway-the-dark-destructive-world-of-earthworms-517249/?print=1>
- 32) March 22<sup>nd</sup>, 2012- *Earthworms, while beneficial, can also destroy*. Farm and Dairy, by Scott Shalaway. <http://www.farmanddairy.com/news/earthworms-while-beneficial-can-also-destroy/35754.html>
- 33) March 27<sup>th</sup>, 2012 – *Earthworms ruin nutrients, moisture on forest floor says researchers*. Canada.com.  
<http://24bdnews7.blogspot.com/2012/03/earthworms-ruin-nutrients-moisture-on.html>
- 34) April 23<sup>rd</sup>, 2012 – Radio interview with WTIP North Shore Community Radio.
- 35) May 25<sup>th</sup>, 2012 – Radio interview with the Lake Superior Binational Forum.
- 36) May, 2012 – *What you should know about the earthworms in your soil*. Better Farming, by Mike Mulhern.
- 37) July, 2012 – *Non-native Earthworms on our Shores: Great for Fishing not so Great for the Woods*. From Shore to Shore, by Ryan Hueffmeier.  
[http://www.shorelandmanagement.org/downloads/july\\_aug\\_2012.pdf](http://www.shorelandmanagement.org/downloads/july_aug_2012.pdf)
- 38) August 27<sup>th</sup>, 2012 – *Earthworm Experiment: Alien Invaders*. Simple Recipes for real Science, by Kitchen Pantry Scientist.  
<http://kitchenpantryscientist.com/?p=3339>
- 39) September 6<sup>th</sup>, 2012 – Ask NRRI. Natural Resources Research Institute.  
<http://www.nrri.umn.edu/default/asknrri/compost.htm>
- 40) September 23<sup>rd</sup>, 2012 – *Great Lakes Worm Watch*. Radio station KDAL Duluth, MN. <http://kdal610.com/news/articles/2012/sep/27/great-lakes-worm-watch-on-sunday/>
- 41) October 1<sup>st</sup>, 2012 – “Workshop Teaches People About the Impact of Earthworms” WDIO 10 Duluth MN.  
<http://www.wdio.com/article/stories/S2784166.shtml?cat=11802>

**Other Outreach Activities: (ie. Exhibits, tabling, etc.)**

- 1) January 15-16<sup>th</sup>, 2010 - GLWW exhibit booth. The MN Organic Farming Conference, St. Cloud, MN.

- 2) February 20, 2010 – GLWW exhibit booth. The Sustainable Farming Association of Minnesota's 19<sup>th</sup> Annual Conference, St. Olaf College, Northfield, MN
- 3) March 9-10<sup>th</sup>, 2012 – GLWW Exhibit Booth. Minnesota Families Woodlands Conference, Duluth, MN.
- 4) April 17<sup>th</sup>, 2012 – GLWW Poster Session. Western Great Lakes Resource Management Conference. Ashland, WI. Loss, S.R., R.M. Hueffmeier, C.M. Hale, G.E. Host, G.Sjerven, L.E.Frelich. In press. *Earthworm invasions in northern hardwood forests: A rapid assessment method*
- 5) August, 2012 – Itasca County Fair. Grand Rapids, Minnesota.
- 6) August, 2012 – Minnesota State Fair Department of Natural Resources Building.
- 7) October, 2012 – GLWW Poster Session, Hueffmeier, R., G. Sjerven, G. Host. *Exotic Earthworm Invasions: Integrated Research and Education to Achieve Natural Resource Protection*. Minnesota GIS/LIS Consortium 22<sup>nd</sup> Annual Conference. St. Cloud, Minnesota.
- 8) October 29-31<sup>st</sup>, 2012 – GLWW exhibit booth and poster presentation. Upper Midwest Invasive Species Conference, Lacrosse, WI.
  - a. Kelly P. Bray, Ryan Hueffmeier, Gerry Sjerven, George Host, David Andow. 2012 *Quantifying The Spread of Invasive Earthworms in Minnesota's Northern Forests*.
  - b. Claire Palokangas, Laura Christensen, Ryan Hueffmeier, George Host, David Andow. *Relation Between Fishing Pressure And Earthworm Impacts Near Boat Landings*.
  - c. Stephanie Driskell, Jennifer Olker, Ryan Hueffmeier, Cindy Hale. 2012. *Identifying and Evaluating Vernal Pool Habitats Spanning a Continuum of Earthworm Invasion Status*.

**Other presentations/publications for which GLWW provided supporting materials:**

- 1) October 2010. Matt Bowser, U.S. Fish & Wildlife Service, Kenai National Wildlife Refuge. Exotic earthworms in Alaska: an insidious threat. Alaska Invasive Species Conference, Fairbanks, Alaska.
- 2) January 2011. Sarah Reichard. *The Conscientious Gardener - Cultivating a Garden Ethic*, University of California Press  
<http://www.ucpress.edu/book.php?isbn=9780520267404>
- 3) January 2011. Bernadette Williams, Invasive Species BMP Coordinator, Division of Forestry Bureau of Forest Sciences, Wisconsin Department of Natural Resources. Will be using GLWW images in 2 forestry publications, one addressing county forests and another for distribution to bait dealers. *In press*
- 4) January 2011. Yan Gu. *Order of Buildings and Cities: A Paradigm of Open Systems Evolution for Sustainable Design*. *In press*
- 5) March 2<sup>nd</sup> 2012. Wild Rivers Invasive Species Coalition received a grant for "Earthworm education for Anglers"
- 6) June 2<sup>nd</sup> thru Oct 24<sup>th</sup> 2012. GLWW partners with the MN DNR and the MN Landscape Arboretum to develop a sign about the effects earthworms can



- have on previously earthworm-free forests. The sign has been on display all summer at the "Dirt-o-Rama"
- 7) April thru October, 2012. Friends of the Sherburne National Wildlife Refuge worked with schools around central Minnesota to educate and collect data on invasive earthworms.
  - 8) June 25<sup>th</sup>, 2012. Oakland County Parks held "Hooked on Fishing". Waterford, Michigan.

**VIII. REPORTING REQUIREMENTS: Periodic work program progress reports will be submitted not later than December 30, 2009. A final work program report and associated products will be submitted between December 30, 2012 and February 28, 2013 as requested by the LCCMR.**

**IX. RESEARCH PROJECTS:**