Canadian Earthworm Workshops Proudly Presents…

Worm Watch!©

Solving the Soil Puzzle One Piece at a Time

Worm Watch

Canadians solving the soil puzzle one piece at a time!!!

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Our Vision is to use earthworms as teachers to help us discover soil and appreciate the importance of soil ecology to sustaining agriculture, the environment, and ourselves.

Summary

Worm Watch promotes awareness of the diversity of life beneath our feet through public participation in a nationwide earthworm census. The census-takers will be students, farmers and producer groups, conservation and naturalist groups, gardeners, and interested individuals and families. They will be supplied with a Worm Watch kit containing background materials on earthworm ecology and taxonomy, instructions on how to sample and record their data, data sheets, a photographic key showing the most commonly encountered earthworm species, vials for the preservation of earthworms that could not be identified, and a list of references, including the Worm Watch website address and 1-800-number. An instructional video demonstrating the various sampling techniques will also be available for the program.

Worm Watch will offer special programs and on-site support to the schools, farmers and farm groups, and other special interest groups.

As scientists, we will use the data to collate a national earthworm species inventory and to study the distribution of earthworm species in Canada. Geographical Information Systems (GIS) technology will be used to map the distribution of earthworm species, and the habitat where they were recorded. We will be studying the data for correlations between landuse patterns (including undisturbed vs disturbed habitats, cropping systems, and tillage practices), ecozones, and earthworm populations and species diversity.

The data collected by our census-takers will significantly increase the scientific community's understanding of the biogeography of post glaciation earthworm populations, and the history of their distribution. The results will also be used to evaluate the potential of using earthworms as one of a suite of bioindicators of environmentally sustainable land use practices, and the information on species diversity and preferred habitat will be useful when considering policies on introducing earthworms for waste management, integrated pest management, soil improvement, and site reclamation.

Rationale

"Almost alone amongst his brethren, he does not inspire horror. In fact, the earthworm is almost alone among the invertebrates in the tenderness he inspires" Willam Bryant Logan 1995 from "Dirt : The Ecstatic Skin of the Earth".

In the long-term, healthy high quality soils will be the key to a sustainable environment. The biological, chemical, and physical properties of soil are essential for plant growth, regulating and partitioning of surface to ground water, and buffering, detoxifying, and scrubbing of hazardous chemicals. The soil is a reservoir of biological diversity that likely exceeds that of aboveground ecosystems.

Cultivation, summerfallow, and continuous row-cropping have lead to soil loss through erosion. The smallest and lightest particles, which are the first to be blown or washed away, carry most of the nutrients with them. As soil organic matter is lost, CO_2 is released into the atmosphere. The remaining soil particles are less capable of absorbing and holding water and nutrients, resulting in less plant growth. It gets worse, the soil's capacity to act as a sink for greenhouse gases such as nitrous oxides (NO_x), carbon dioxide (CO_2), and methane (CH_4) also drops, and atmospheric quality suffers. In all, this thin layer of soil that covers the earth's surface nurtures all terrestrial life. Unfortunately, this same layer of soil is not renewable within the human lifespan.

Earthworms are known all over the globe and are generally accepted as being good for soil and food production. Earthworms form burrows; a network of soil channels that can enhance gas exchange, and improve water infiltration rates two to ten times that in similar soils lacking earthworms. Increased water infiltration through earthworm burrows can lead to reduced surface runoff and a decrease in soil loss to erosion. These burrows can be stable for years acting to increase the extent and density of plant roots, as well as stabilising soil aggregates to improve soil structure and limit erosion. Earthworm casts commonly make-up the majority of soil aggregates in the top 10 to 20 cm of the soil profile. In soils with higher bulk densities and penetration resistance, earthworms have been shown to increase the germination rate, heading, and grain yields in barley and wheat (Lee, 1975). These increases in plant productivity have been attributed to improved nutrient and water availability due to earthworm activity.

Earthworms can significantly affect the decomposition of organic matter in agroecosystems. They increase the rate of decomposition of organic matter directly by consumption, and indirectly by incorporating organic matter into the soil and stimulating microbial activity in the casts and around the burrows. In terms of agricultural practices, earthworm activity may be able to replace the benefits of the moldboard plow although, top soils may not be as well mixed. It has been well documented that earthworms are major contributors to the breakdown of organic matter and N cycling in zero-tillage systems. Earthworms are probably most important in zero-till and other minimum tillage systems, not only because these systems encourage earthworm populations but, because of the absence of mechanical mixing and loosening, the earthworm casts and burrows are left intact to encourage better root development.

Native earthworm species in the Pacific Northwest of the United States of America are the primary developers of forest soils as they are in areas farther south and probably on Vancouver Island and the Queen Charlotte Islands of Canada. These areas represent specialised habitats with shallow soils and limited organic matter which are not readily colonised by introduced Lumbricidae earthworms. James (1995) suggests that it might be possible to guess at the the habitat requirements for some apparently specialized earthworms from existing data. However, we do not know how many species of earthworms exist in Canada and North America or the range of most identified species.

There is a significant lack of information on the taxonomy, biogeography and ecology of North American earthworms (Fender, 1995; James, 1995; Lee, 1995; Reynolds, 1995). We need to know what earthworm species are present , where they are, and with what habitats they are associated. Lee (1995) explained that "it is not easy to find financial support for extensive survey and collecting, which are seen by many scientists as "natural history" pursuits that demand long term support". Asking for public participation to conduct a survey of earthworms would be one solution. The Earthworm's Downunder program (an Australian program run by CSIRO, Australian Department of Education, and the Double Helix Science Club) was very successful in using the Double Helix Science Club members to collect and determine the diversity and distribution of earthworm species in Australia. It was estimated that the members of the Club in one year accomplished what could be expected of a team of a few scientists in 5 years. Worm Watch which is modelled after the Australian progam, will go beyond the simple survey by collecting habitat data and emphasizing school, farm and community group participation.

Unlike most soil life, earthworms are easy to find, visible and tolerate a reasonable amount of handling. While learning about earthworms, Worm Watch participants will see soil-forming and building processes, such as decomposition, nutrient cycling, soil aggregation and porosity, in action. As part of the program, we ask people to examine and identify earthworms from different habitats. In doing so, participants observe and collect data on both the habitat and earthworms, seeing for themselves the diversity of life. They become more aware of the interconnectedness of plants, soil, and human activities in their environment, which is quickly expanded as they share their results with scientists and other interested people.

Delivering Worm Watch

The Worm Watch school program is real science for kids, with lots of back-up and activity ideas for teachers. Interactions between various organisms and their environment are difficult concepts to teach and learn. Soil ecology is generally not an attractive science because most of the life in the soil is invisible. Earthworms are publicly popular, identified with soil, and visibly demonstrate soil processes and soil-plant-organism interactions. The Worm Watch program offers an easy introduction to experimental design and further studies on the soil ecosystem.

Worm Watch is also aimed at promoting an appreciation of how farm production systems can influence soil biodiversity and quality. Farmers and gardeners can use the sampling protocol to study the effects of different crop rotations, tillage practices, and manure management strategies on earthworm populations and species diversity. Then use that information and the earthworm sampling protocol to monitor changes in the population and species diversity of earthworms with changing farming practices. At the same time farm families will collect data that will be used to map the diversity and populations of earthworms and study the value of earthworms as indicators of more sustainable farming practices. A farm group in Prince Edward Island, through the Beddeque Bay Environmental Mangement Association, is already involved in this program. Included as part of Worm Watch, will be information on how to design a scientific experiment, determine how many samples you need, record your data, and report your results Participants will be encouraged to set up their own experiments, and share their findings with fellow Worm Watchers across the country, establishing a national network of people.

Gathering and Sharing Data

One of the principal components of Worm Watch has been the development of national sampling protocols that are qualitative and or quantitative, and safe. There are two sampling methods. The first method, hand-sorting, is quantitative and qualitiative. It requires a hole to be dug that is no less that 15 cm both wide and long (square), and no less than 10 cm or more than 25 cm deep. The number of earthworms and their identity at one or two depths is recorded along with other information on the habitat (Appendix 1). This sampling protocol can be used by farmers and other food producers to monitor earthworms between various soil and crop management practices. This is also the procedure that would be used for monitoring earthworm populations and activities in other natural and reclaimed areas.

The second sampling protocol gives qualitative data only (Appendix 2). This method is useful in areas with shallow soil or where disturbance (even well supervised) is not possible. Earthworms are identified from under the bark or wood of decaying trees, cow or horse aged dung piles, leaves, rocks, and from the edges of lakes and streams. Data on the habitat and earthworm species and assemblages of species is then recorded. Combined, these two sampling protocols combined will give adequate data on the diversity of earthworm species in Canada.

In all cases, we insist on the reconstruction of the habitat after sampling for earthworms to a condition where the disturbance is invisible.

We have prepared a photographic key of all the common earthworms in Canada as well as regional written key under the guidance of Dr. John Reynolds, an internationally recognised expert on the systematics and taxonomy of earthworms. Dr. Reynolds has agreed to be the taxonomic advisor for Worm Watch and will be responsible for confirming the identification of all earthworm species that had not previously been recorded in Canada.

Earthworms that cannot be identified in the field by a census-taker can be preserved and sent to Worm Watch at the Lethbridge Research Centre for identification, vials and detailed instructions for preservation are provided in the Worm Watch kit. Worm Watch prefers that earthworms be identified on-site and then replaced. It is likely that participants will encounter previously unrecorded or new species of earthworms not listed in the taxonomic keys. There are numerous areas in Canada that have not been explored for earthworms, and the increase in earthworms purchased for composting, increasing international travel, and the movement of large equipment into remote areas could have introduced other species to Canada.

Data collected for Worm Watch can be submitted through the Website, by fax, phone, or mail. All the data and progress in tabulating results will be put onto the Website and published in the Newsletter. We will publish a newsletter documenting the progress of Worm Watch, including short articles pertaining to soil ecology and profiling some of the participants, and keep updated resource and reading lists. Through information on the website and in the Newsletter, we will be encouraging interaction and network building between both rural and urban groups and individuals from across the country. Students in particular, will be encouraged to submit reports outlining or depicting their observations, hypotheses, results, and conclusions. Links between schools and community and producer groups will encourage further discussion and continued experimentation and monitoring.

The success of the program is in the one-on-one support. We will have a 1-800-number and a website that will put participants in touch with someone who can answer questions about sampling, taxonomy, earthworms and soil ecology. Our web site will be linked with School.net and the existing Earthworm website maintained by Dr. Alan Tomlin at Agriculture and Agri-Food Canada in London, Ontario which offers more resources and other avenues of exploration.

Plans for the Results

As scientists, we will use the data collected by participants from different habitats to map the biodiversity and distribution of earthworms species, and examine the correlation between earthworm populations, species diversity and land use patterns. We will evaluate the potential of using earthworms as one of a suite of bioindicators to monitor soil health, in particular for use in agricultural cropping systems. Everyone can use the results to promote ecologically-based land management strategies, or as a stepping stone to learning more about how plant and soil communities interact.

The results of this program will be particularly useful for farmers because the burrowing activities of earthworms improve soil aggregate stability, aeration, the rate of organic matter decomposition, nitrogen availability to plants, and water infiltration rates compared with similar soil lacking earthworms. Earthworms can reduce the incidence of fungal diseases in crops and increase the carbon and nitrogen mineralisation in the soil by feeding on decaying plant material. Studies conducted by the Rhizosphere Ecology Research Group at the Lethbridge Research Centre have shown that conservation tillage and no tillage and certain crops have a dramatic effect on increasing earthworm populations which acts to lower the incidence of soilborne fungal diseases. These results alone have implications for integrated pest management (IPM), partnered with the species diversity and distribution we may be able to manage earthworm populations more actively to reduce the incidence of fungal disease problems in crops, orchards, and vineyards.

Looking at the Bigger Picture (see Figure 1)

Participating in Worm Watch is an experience in science education that yields data on earthworm species distribution, population, and habitat. The data will be used to map the species distribution in terms of ecozones, provincial boundaries, and possibly individual farm land descriptions. Earthworm data can be mapped over existing soil and vegetation maps, depending on the number of points in an area, to study the presence of earthworm species specific habitats. Individual species and earthworm community structure have been shown to change both in numbers and composition with disturbance, plant community, organic amendments, soil fertility, and cropping systems management practices. Therefore, earthworms have potential as being useful indicators of environmental stress, and more sustainable land use practices. The value of using earthworms to monitor changes to soil and plant communities will depend directly on our understanding of the diversity of earthworm communities, the behaviour of individuals species (for example deep burrowing or a surface litter dweller), how the species within the community relate to

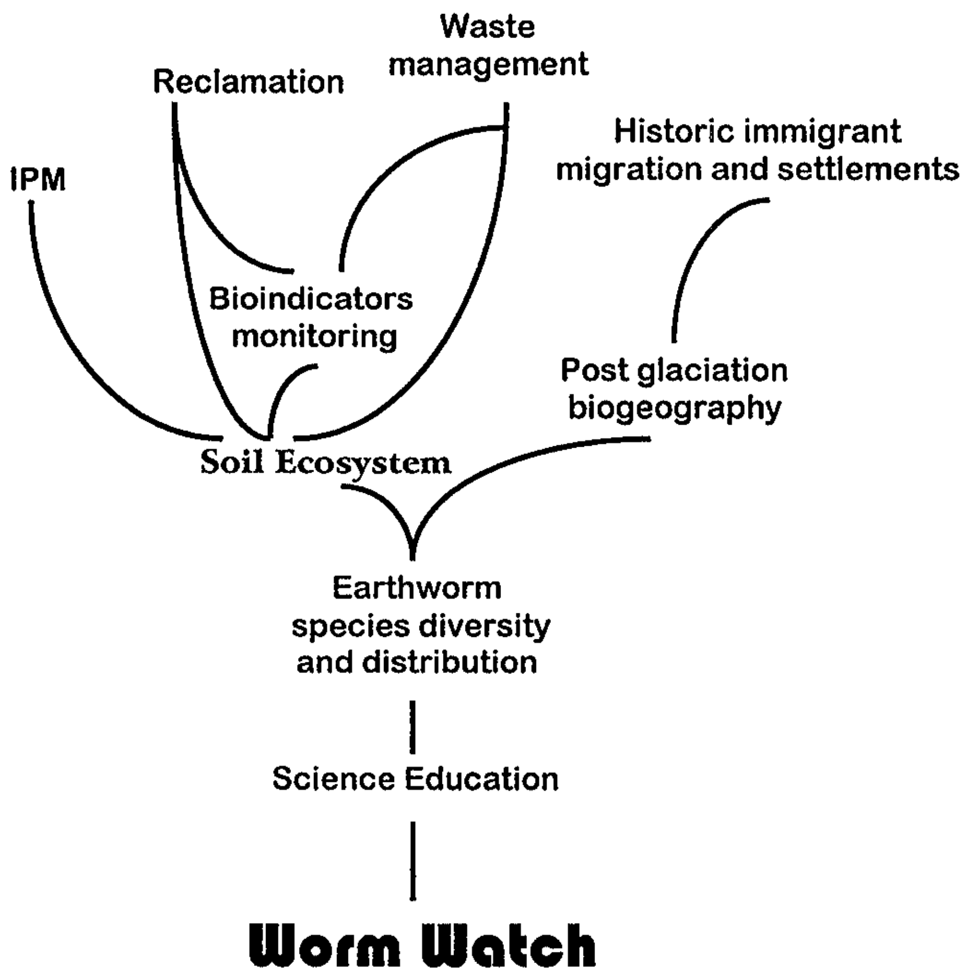

Figure 1. A conceptual diagram of some of the broader issues that could be addressed from the Worm Watch program.

each other, and the means by which earthworms contribute to the soil processes that build soils. There is an increased need for this data, particularly with the heightened interest in introducing earthworms for site reclamation, manure management in cropped soil, and the detoxification of hazardous waste. Gates (1970) reported that vast areas of forests and grasslands on the Great Basin and Great Plains had no history of earthworm activity. Indeed, early American settlers in their journals and letters reported introducing earthworms, followed by the introduction of robins and other earthworm predators to control the exploding earthworm populations.

The results from the Worm Watch census will assist us in making informed and effective decisions regarding the use, management, and subsequent monitoring of earthworms in reclamation, remediation, and waste management situations. From a landscape perspective, the data from Worm Watch will be critical to our understanding the post-glaciation biogeography of earthworms and possibly the interaction between native and introduced earthworm species. The patterns of earthworm species distribution will also likely map the historic pattern of immigrant community migration across Canada.

Partners in the Program

Presently, Agriculture and Agri-Food Canada's Pest Management Research Centre in London Ontario, and various offices of Prairie Farm Rehabilitation Adminstration in B.C., Alberta and Saskatchewan have expressed interest in being regional information centres and earthworm species collection points.

Enthusiasm from the local schools in the Lethbridge area has been overwhelming and the program has been field tested with Grade 3 and 4 students in the Lethbridge and surrounding area, as well as in northern Montana, USA. Other partners in this program include: The Beddeque Bay Environmental Management Association (Summerside, Prince Edward Island); The University of Saskatchewan Environmental Science and Technology Extension Division (Saskatoon, Saskatchewan); Zita Roy at L'Université de Laval (Laval, Québec); Alice Casselman with the Association for Canadian Educational Resources (Missasauga, Ontario); The Faculty of Education at the University of Lethbridge (Lethbridge, Alberta) and the Alberta Conservation Tillage Society.

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The development of the protocol used in Worm Watch was funded in part by Environment Canada's Ecological Monitoring and Assessment Network and Agriculture and Agri-Food Canada's Lethbridge Research Centre. Already the protocol has been used in some of Canada's National Parks to sample earthworms for the biodiversity inventory.

I am grateful to Dr. Patricia Roberts-Pichette, Brenda Penak, Dr. Earle Warnica, and Mrs. Nancy Kimura and her Grade 4 class at Lakeview School in Lethbridge for their continued enthusiasm, assistance, and encouragement.

Appendix 1

A sample data sheet showing synthetic data collected using the hand-sorting protocol.

CANADIAN EARTHWORM WORKSHOP DATA SHEETS

c/o AAFC, Lethbridge Research Centre, P.O. Box 3000, Lethbridge Alberta, T1J 4B1

Collector's name: Mr. Smith's grade 4 class at Sunshine Elementary School
Collector's address: 1220 12 Street South, Lethbridge AB, T1K 1P5

HABITAT DESCRIPTION

Date: June 6, 1997
Time: 1:00pm
Weather conditions (cloud cover, wind, humidity): Overcast, no wind, and very humid. It looks like it might rain by the end of the day.

Temperature outside (Celcius): 18°C
Soil temperature (Celcius): 11°C

Location and Land Use (city, farm, field, under tree, near riverbank): Our class sampled for earthworms in the school playground at Sunshine Elementary School, Lethbridge. All of our samples were taken in a shady area underneath a group of elm trees. Our playground has no sprinkler system.
Vegetation: regular green grass, some clover and a few dandelions

Soil type (color, organic content, texture [sandy, clay based]): The soil was clay based, had a bit of organic matter, was medium to dark brown, and was very dry.

Other observations and comments: We noticed that there were a lot of ants underneath the trees. ~~Yes~~ We found a worm that was tied up in a knot inside a hard clump of dirt. As we were handsorting through our sample, we came across some beetle larvae and some different kinds of seeds. We kept a few of these seeds, and our class is going to try to grow them to see what they are.

EARTHWORM NUMBERS AND SPECIES

Sample number	Depth	Number of Adults Found	Species of Adult Earthworms Found	Number of Juveniles Found	Number of Hatchlings Found	Number of Cocoons Found
1	0-10 cm	4	Aporrectodea rosea	4	0	3
	10-20 cm	2	Aporrectodea turgida			
2	0-10 cm	3	Aporrectodea rosea	1	0	1
		2	Aporrectodea trapezoides			
	10-20 cm	1	Aporrectodea rosea			
3	0-10 cm	0	—	12	1	4
	10-20 cm	0	—			
4	0-10 cm	2	Aporrectodea rosea	7	3	0
		1	Aporrectodea turgida			
		1	Aporrectodea tuberculata			
	10-20 cm					
Mean		4		6	1	2
Std. dev.		2.8		4.7	1.4	1.8

Appendix 2

A sample data sheet showing synthetic data collected using the flip and strip sampling protocol.

CANADIAN EARTHWORM WORKSHOP DATA SHEETS

c/o AAFC, Lethbridge Research Centre, P.O. Box 3000, Lethbridge Alberta, T1J 4B1

Collector's name: Céline Gratton

Collector's address: 1220 Rue St. Catherine, Val-Jalbert Québec, N0G 4V8

HABITAT DESCRIPTION

Sampling method (flipping over rocks, peeling back bark): peeling back bark on dead fall maple trees

Date: August 1, 1997

Time: 10:00am

Weather conditions (cloud cover, wind, humidity): sunny, windy, dry

Temperature outside (Celcius): 26°C

Soil temperature (Celcius): 11°C

Location and Land Use (city, farm, field, under tree, near riverbank): Sampled earthworms in forestry reserve #7 along the Saguenay river. I only sampled on dead fall maple trees. The logs were damp, and it was easy to peel off their bark.

Vegetation: The forest consisted mostly of maple trees with some beech trees throughout. Chokecherries, snakeberry, horsetails and ferns were also present. There were a few types of fungus (*Hydnum*, and bracket) growing around some of the logs, as well as some unidentified moss.

Soil type (color, organic content, texture [sandy, clay based]): The soil was red-gray, clay-based with a sandy overlayer. There was also a thick leaf layer on the ground.

Other observations and comments: From my data, it appears that *Dendrodrilus rubidus* is closely associated with maple tree bark. I wonder if this same species is also associated with spruce trees. I think that I will investigate this when I go to Qualicum, British Columbia this fall. I also took some photos of the moss growing on the dead fall, and I sent you a copy. Do you know what it is? If you do, let me know. If you don't, do you know someone who might? I will put a posting on the Worm Watch website in order to find out. Thanks

EARTHWORM NUMBERS AND SPECIES					
Sample number	Number of Adults Found	Species of Adult Earthworms Found	Number of Juveniles Found	Number of Hatchlings Found	Number of Cocoons Found
1	4	Dendrodrilus rubidus	12	0	0
2	1	Dendrodrilus rubidus	7	1	3
3	1	Dendrodrilus rubidus	8	1	1
	1	Aporrectodea tuberculata			
	1	unknown earthworm			
4	0	—	0	0	0
5	0	—	0	0	0
6	0	—	3	0	3
7	2	Dendrodrilus rubidus	0	0	0
	1	unknown earthworm			
8	1	Aporrectodea tuberculata	5	0	1
9	6	Dendrodrilus rubidus	1	0	1
Mean	2		4	0.2	1
Std. dev.	2.1		4.3	0.4	1.2