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Project Title: Effect of Glyphosate on Biodiversity and Habitat

Project Category: Habitat (Ecological) Protection and Rest

Rank by Organization (if applicable): 0

Total Funding Requested ($): 133,318 **Project Duration:** 2 Years

Abstract:

Usage of glyphosate-based herbicides (Round Up, Rodeo) has increased in recent years. Round-Up-Ready soybeans allow more extensive use on agricultural lands, while the prospect of Round-Up-Ready landscaping plants will encourage more urban usage. Previous laboratory investigations indicate no adverse effects of glyphosate on animals and rapid biodegradation under limited experimental conditions. Surfactants used during application, however, are harmful to fish, amphibians, and other vertebrates. Exposure of non-target plant species to glyphosate results in habitat alterations that indirectly impact animal populations, including endangered species, diversity, and ecosystem functioning. This indirect impact has been largely ignored. Glyphosate can be easily sorbed onto some soils where biodegradation will not occur. Sorption potential decreases as temperature decreases, releasing a pulse of the chemical in autumn/winter.

We will monitor both the persistence of sorbed glyphosate and its impacts on plant and animal diversity. We propose to quantify these impacts by comparing biological communities in two wetland sites (with and without glyphosate application) both pre- and post application during the 2001 growing season. We will monitor these applications to determine the extent of air borne drift and initial concentrations in both sites. We will analyze soil samples periodically to determine degradation and migration of herbicide from the application site. Effects from the herbicide will be ascertained and modeled by measuring biomass, species diversity, and community composition of macrophytes, algae, zooplankton, molluscs, amphibians, and YOY fish.

While the direct effects of glyphosate are not fully understood, even less is known about the indirect effects of glyphosate on wetland communities and habitat. This is particularly alarming with the prospect of even larger-scale applications.

Geographic Areas Affected by the Project

States:

- ☐ Illinois
- ☐ Indiana
- ☐ Michigan
- ☐ Minnesota
- ☐ New York
- ☐ Pennsylvania
- ☐ Wisconsin
- ☒ Ohio

Lakes:

- ☐ Superior
- ☐ Huron
- ☐ Michigan
- ☒ Erie
- ☐ Ontario
- ☐ All Lakes

Geographic Initiatives:

☐ Greater Chicago ☐ NE Ohio ☐ NW Indiana ☐ SE Michigan ☐ Lake St. Clair

Primary Affected Area of Concern: All AOCs

Other Affected Areas of Concern:

For Habitat Projects Only:

Primary Affected Biodiversity Investment Area: Western Lake Erie/Oak Openings

Other Affected Biodiversity Investment Areas:

Problem Statement:

Glyphosate (N-phosphonomethyl glycine) is a broad-spectrum herbicide extensively used to control annual and perennial weeds. More popularly known as Round-Up™ this post-emergence herbicide has been approved for use with over 50 agricultural crops. At present, most of this herbicide's use is for turf and right-of-way treatments (Grossbard and Atkinson, 1985), however it is used near waterways to curb the encroachment of invasive species. Increasing use of glyphosate is likely to have several different and severe impacts on non-target wetland communities. In their 1994 EPA-sponsored study, The Nature Conservancy identified coastal shores, lake plains and marshes as having the greatest amount of biological diversity unique to or dependent upon the Great Lakes ecosystem. The stresses that have the greatest impact on biodiversity elements of these systems include habitat destruction because it affects multiple systems and tends to be less reversible than other stresses. The State of the Lakes Ecosystem Conference (SOLEC) papers (1996, 1998) suggest a need to improve the basic and applied science necessary for biodiversity and conservation basinwide. Indirect impacts of glyphosate-based herbicide applications by altering wetland habitat, however, have been largely ignored. In the few habitat studies undertaken, the response of aquatic invertebrates (Linz et al. 1999), amphibians (Cole et al. 1997), and fish (Caffrey 1996) to applications of glyphosate-based herbicides appeared species-specific with decreased abundance for those species that rely on refuge habitat, complex vertical and horizontal plant community structure, and the presence of different successional stages in wetland vegetation. This lack of understanding is particularly critical considering the predicted increased use of glyphosate-based herbicides with the development of widespread Round-up-ready crops.

Although application of glyphosate is usually directed towards some target group of nuisance plant species in a particular area, various amounts of herbicide become adsorbed onto soil particles or drift to adjacent areas. In addition to drift, glyphosate can be transported in soluble or adsorbed forms away from areas of application to non-target communities. This introduction of potentially active forms of glyphosate into the latter communities threatens their integrity. Several physical, chemical and biological processes degrade glyphosate, but the sorption of glyphosate to soil constituents can stabilize the compound. Degradation within aerated soils initially is rapid, but decreases over time, invalidating first-order kinetics. However, there is incomplete understanding of breakdown in oxygen-stressed marsh sediments and concerns about the toxicity of chemicals that are co-applied with glyphosate (surfactants). Indeed, the fate of glyphosate is mediated by water solubility (surfactants), metal complexation and adsorption, which are in turn mediated by environmental conditions, such as moisture, temperature, and pH.

While the pool of soluble glyphosate in soil or water is progressively depleted by degradation, it is replenished as glyphosate desorbs from clays and other materials. This provides inputs of reactive herbicide that may occur at a rate that is generally slower than decomposition but more variable. Fluctuations in environmental conditions can drive peaks in release of the compound from bound forms. Increases in mobility of the herbicide have been identified in field experiments that were not anticipated from batch studies because mobility under field conditions is affected simultaneously by degradation, non-equilibrium distribution, transport with colloids and matrix and preferential flow within the soil. For

example, desorption of glyphosate from soil particles increases with decreasing temperature. Lower temperatures also reduce decomposition of soluble glyphosate, but this varies with soil pH. Thus, it is extremely difficult to predict pool sizes of reactive glyphosate under field conditions. This study will investigate the fate of glyphosate within a Lake Erie coastal marsh setting and its impact on biodiversity within the coastal community.

Proposed Work Outcome:

We propose to evaluate the potential threat of glyphosate to aquatic communities by relating its persistence to impacts on a freshwater marsh in northern Ohio. This system is particularly well-suited to study because: 1) the young glacial till soils of northern Ohio are unique in their retention capacities for many chemicals, 2) extensive background information is available for the site location, and 3) such wetlands have been identified as having high habitat value for biological diversity in the Great Lakes region.

Field Site and Treatment Rationale: The proposed study will be carried out in the Winous Point marshes, one of Ohio's largest coastal wetland complexes covering some 2,000 ha near the western shore of Lake Erie. These diked marshes are privately owned by the Winous Point Marsh Conservancy and have been managed by professional wildlife biologists since 1946. They contain a combination of shallow water, emergent vegetation, and some woody plants on higher elevations. Growth of emergent aquatic macrophytes is stimulated by periodic lowering of the water level from mid-May through early August. Glyphosate has been applied to selected areas of the marshes to control nuisance species (e.g., Lythrum salicaria, Phragmites australis, Typha sp.) for many years. This application occurs late in the growing season (August) and the marsh complex contains sites with and without a history of treatments. We will use the latter sites as our reference locations for the field portion of this study. The sites with a history of glyphosate-based herbicide treatments will receive an August application of this chemical.

Application rates and timing will be specified. During application we will deploy sediment and cellulose traps to determine the extent and direction of aerial drift, thus quantifying the initial zones of application. Immediately following application (and monthly thereafter) soil, sediment and water samples will be collected for glyphosate and metabolite concentrations. The herbicide should be adsorbed and retained by soils and sediments during the warm seasons following application in late summer. As the temperatures drop in autumn, the herbicide is likely to be desorbed.

Aquatic Community Analyses: During the 2001 growing season, we will carry out a monthly, non-destructive sampling program of the biological community in sites with and without a history of glyphosate-based herbicide application. This sampling program will continue following an aerial herbicide application (August 2001) to those sites where the chemical has also been used in the past. Latent effects will be monitored by repeating the sampling program during the spring of 2002. During that time, frog eggs will also be harvested from impacted and reference sites and analyzed for hatching success and developmental abnormalities in growth chambers.

Using standard field techniques, we will quantify biomass, diversity, and community composition of macrophytes, algae, zooplankton, molluscs, amphibians, and YOY fish. These techniques include line transect surveys and percent cover determinations by species (above-ground macrophytes), plankton-net tows and settling protocols (phytoplankton, zooplankton), periphytometers (aufwuchs), handpicking (above-ground molluscs), surveys and egg collections (amphibians), and trapping with mark-and-recapture (YOY fish).

Chemical Analyses: Analysis of glyphosate and its metabolite (aminomethyl-phosphonic acid, AMPA) in soil or water is achieved with a multi-step extraction and derivatization prior to gas chromatographic analysis (Mogadati et al., 1996; Eberbach and Douglas, 1991; Lundgren, 1986; Deyrup et al., 1985). Silanized glassware reduces interference by sorption to the glass. Organic compounds are extracted from soil with aqueous triethylamine. The extract is cleaned with anion and cation exchange resins, derivatized with trifluoroacetic anhydride and trifluoroethanol, dissolved in ethyl acetate and injected into a gas chromatograph. Either an electron capture detector or a mass selective detector can be used for quantification.

Mathematical Modeling: Two mathematical models will be developed in this study and used to relate glyphosate application and persistence to structure and function of wetland communities. The first model will use results from soil, sediment and water analyses to describe the impacts of environmental factors on degradation, adsorption and desorption of glyphosate from soil/sediment particles. This model will include the physical movement of glyphosate from the area of treatment to adjacent, non-target sites. The second model will describe the energy dynamics of the aquatic food webs found in these

communities, and be used to assess the impacts of changes in community structure resulting from glyphosate treatments.

Outcome: Great Lakes' wetlands function as unique, productive and diverse transitional ecosystems between upland areas and true open aquatic habitat. As such, these wetlands receive glyphosate-containing runoff from farmland and urban landscapes, as well as broad-cast applications within the wetlands themselves. Furthermore, use of this herbicide is expected to increase greatly in the near future due to the development of resistant plants. This runoff may damage these ecosystems and threaten biodiversity including potential habitat loss for any of the 33 of Ohio's threatened and endangered wildlife species which are dependent on vegetation currently found primarily in diked Lake Erie wetlands. Although this study concentrates on one marsh setting, aerial application of glyphosate occurs over broad, basin-wide areas. The direct and indirect impacts on biodiversity noted in this study likely apply throughout the Lake Erie wetlands and the Great Lakes basins as a whole.

Project Milestones:	**Dates:**
Project Start	10/2000
method dev, site selection, field design	10/2000
fieldwork, monthly sampling of sed, biot	03/2001
glyph. application, continued sampling	08/2001
finish chemical analyses	12/2002
resample for latent impact, data analyse	06/2002
report preparation	08/2002
Project End	09/2002

☐ Project Addresses Environmental Justice

If So, Description of How:

☒ Project Addresses Education/Outreach

If So, Description of How:

Graduate students will be involved in all phases of this project. Undergraduate Ecology classes will visit the marshes for field excursions to illustrate principles and theory covered in lectures. The Winous Point Marsh Conservancy will also be directly involved with this project in its own Outreach programs.

Project Budget:

	Federal Share Requested ($)	Applicant's Share ($)
Personnel:	55,266	52,761
Fringe:	8,702	0
Travel:	5,500	0
Equipment:	0	0
Supplies:	17,000	0
Contracts:	5,000	0
Construction:	0	0
Other:	0	0
Total Direct Costs:	91,468	52,761
Indirect Costs:	41,850	0
Total:	133,318	52,761
Projected Income:	0	0

Funding by Other Organizations (Names, Amounts, Description of Commitments):

Services to be provided by the Winous Point Marsh Conservancy (Roy Kroll, Executuive Director and Wildlife Biologist) include access to the marshes, boat usage and time, field transportation, purchase of the chemicals, helicopter usage and time. The contract amount in the budget will cover just a portion of this expense.

Description of Collaboration/Community Based Support:

Roy Kroll, Wildlife Biologist and Executive Director at the Winous PointMarsh Conservancy, which itself has support and collaboration of many other groups, has offered his support and assistance in designing and completing the controlled application of glyphosate at the selected marsh sites.