

# Pre-Serve: A Web-Based Mapping Application for the Delivery of Geographically-Specific Pesticide Mitigation Instructions

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**Abstract:** Humanity is faced with the increasingly difficult challenge of meeting the world's growing needs for food, feed, fuel, and fiber in an environmentally sustainable manner. Herbicides are an important tool for growers; however, geographically-specific mitigation instructions may be appropriate to address environmentally sensitive areas, including threatened and endangered species habitat. Monsanto Company has partnered with Stone Environmental to develop an interactive web-based mapping program used by growers to determine if their fields fall within areas that may potentially impact threatened and endangered species. Development of this website involved extensive spatial analysis of land use, cropping practices, and other information to identify areas potentially requiring mitigation. These datasets were assembled into an ArcSDE spatial database and integrated with additional web-mapping services through an ArcGIS Server mapping application. The web tool allows users to choose one of several methods to identify the location of their field and print any applicable geographically-specific mitigation instructions.

## Introduction

### Background

- The Endangered Species Act (ESA) requires the Environmental Protection Agency (EPA) to ensure that pesticides registered under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) will not "adversely impact" U.S. federally-listed threatened and endangered species (TES) or "destroy or adversely modify" any critical habitat for that species.
- The EPA must balance the protection of TES with the benefits of pesticide use to production agriculture.
- The EPA determines whether pesticide use in a certain area may adversely impact a listed TES. If limitations on pesticide use are necessary to protect listed species in that area, the EPA will require geographically-specific pesticide use limitations in the pesticide registration terms.
- The EPA disseminates this information via Endangered Species Protection Bulletins distributed through an online system called "Bulletins Live".



Figure 1. EPA Bulletins Live web-site.

### Motivation for Pre-Serve

- The EPA's Bulletins Live site does not yet include many pesticides that could potentially impact listed species.
- As part of its stewardship program, Monsanto Company decided to proactively address communication to licensed-growers of crops containing the Roundup Ready® trait by providing appropriate glyphosate use limitations.
- This step by Monsanto was designed to support the protection of listed plant species from potential impacts resulting from the agricultural use of herbicides containing glyphosate.



Figure 2. Aerial pesticide application.



Figure 3. Buffer around a potentially treated field

### Objectives for Pre-Serve

- To provide licensed growers of Roundup Ready crops with simple, effective tools to quickly determine if their fields are within glyphosate Use Limitation Areas.
- Growers licensed to grow crops containing Roundup Ready technology are required (under the terms of the license agreement) to observe all mitigation instructions on the Pre-Serve website.

### Development Strategy

- Adopt an approach that will facilitate the communication of the spatially explicit glyphosate use limitations.
- Implement the latest web-mapping technologies to deliver high performance, high quality maps and reports.

## Pre-Serve Development

### Database Development

- Spatial data layers necessary to communicate the geographically explicit use limitations were assembled within an ESRI ArcSDE database running on top of Microsoft SQL Server.
- The most important spatial data layer, the Use Limitation Area (ULA) layer, was generated based upon a complex spatial analysis involving species locations, potential pesticide use locations, and other factors. ULAs were identified for 32 states, including Hawaii.
- Additional administrative boundaries, including state, county and Public Land Survey System layers, were added to the ArcSDE database to provide both background mapping information and spatial searching capabilities.

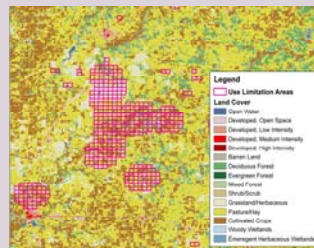


Figure 4. Spatial analysis to determine ULAs.



Figure 5. Compilation of ULA dataset across 32 states.

- Annotation feature classes were developed for states with ULAs derived from land features to ensure that the features included in their text descriptions were labeled on the maps.
- Tabular data were added to the ArcSDE database, including species identification information, species habitat descriptions, and ULA text descriptions.



Figure 6. Custom annotation feature class.

### Application Development

- Pre-Serve was developed as an ArcGIS Server application. ArcGIS Server is ESRI's latest technology for providing mapping and spatial analysis functionality over the Internet. It allows an unlimited number of users to access a common group of map services maintained at a single location.
- The application software development environment was Microsoft Visual Studio 2005 using the following technologies: Visual Basic .NET, ASP.NET, ESRI's Web ADF API, and Java Script.
- To enable faster, higher performance mapping, cached map services were used throughout Pre-Serve. This included background maps, some components of the ULA layers, and map annotation.
- In order to achieve the desired look of the mapping in both the interactive map viewer and the report, as many as five separate map services were created per map. Browser-side image blending of the map services was implemented to reduce the resource demand on the server.
- The Pre-Serve system was deployed as an application running from a single server hosting the web service, the ArcSDE database, and the ArcGIS server installation. Should demand require, the system is scalable to allow additional servers to accommodate additional computational demand.

## Pre-Serve Implementation

### Pre-Serve Step 0

- The Pre-Serve web-site is publicly accessible. No login or password is required ([www.pre-serve.org](http://www.pre-serve.org)).
- The Pre-Serve home page first describes the system's purpose.
- Users are then guided through a series of simple questions that will allow them to quickly determine if their glyphosate herbicide application requires that they proceed further into the Pre-Serve system, or exit without further action. A majority of growers will exit the system at this stage.



Figure 8. Pre-Serve Step 1.

### Pre-Serve Step 2

- At Step 2, users are provided a more detailed map showing the counties that are impacted by localized use limitation areas. These counties are clearly identified to allow users to determine whether to exit the system or proceed.
- Users now can begin more specific definition of their field location by choosing their county or the latitude and longitude of their field.

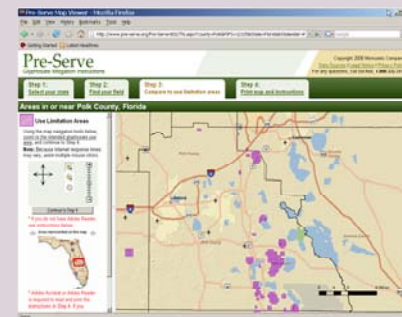


Figure 10. Pre-Serve Step 3.

### Pre-Serve Step 4

- Once a user has identified their location in Step 3, the user is instructed to proceed to Step 4 where a non-modifiable Adobe PDF report is generated.
- The Pre-Serve report generator creates a customized map and report whose content is dependent upon the current Pre-Serve mapping session.
- The report generator performs dynamic rendering of the ULA spatial layer, customized to the specific number of species found within the current map extent. The renderer was designed to handle situations where ULAs relevant to multiple species overlap the same region. In these cases, a user must be aware of multiple species habitats within the same region when following the required product use instructions.



Figure 7. Pre-Serve Step 0.

### Pre-Serve Step 1

- In Step 1, users are provided a map of the United States that highlights counties where specific glyphosate use limitations are applicable.
- Some counties contain sub-county Use Limitation Areas. A user in such a county must continue on to determine more precisely if they are impacted by additional use limitations. At this stage, users must select their state.



Figure 9. Pre-Serve Step 2.

### Pre-Serve Step 3

- In Step 3, standard map navigation tools, including zoom-in, zoom-out, pan, and a zoom-level tool, allow users to focus in on their field(s) of interest.
- An overview map provides a point of reference as users move around the map.
- The content, symbology, and labeling on the interactive map is scale-dependent to ensure that the information available to the user is optimized.

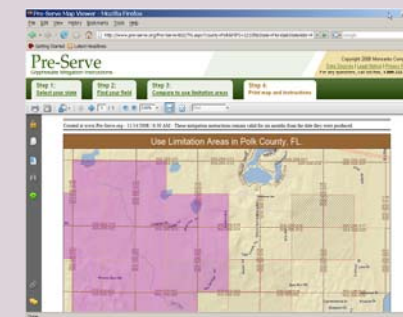


Figure 11. Pre-Serve Step 4.

## Pre-Serve Mitigation Report

- The Pre-Serve mitigation report consists of a custom generated map and legend page followed by a two page worksheet that provide growers and applicators specific limitations for proper glyphosate application within ULAs
- The custom map page provides instructions that are relevant to all areas on the map. This may include counties where no special use limitations apply, areas where county-level limitations apply, as well as the more specific Use Limitation Areas.
- Habitat descriptions for listed species that may be impacted are included in the legend, to provide licensed growers and applicators with the information required to follow the use limitations specific to their field.
- As an additional protection measure, none of the listed plant species are identified anywhere within the Pre-Serve system, only their habitat.

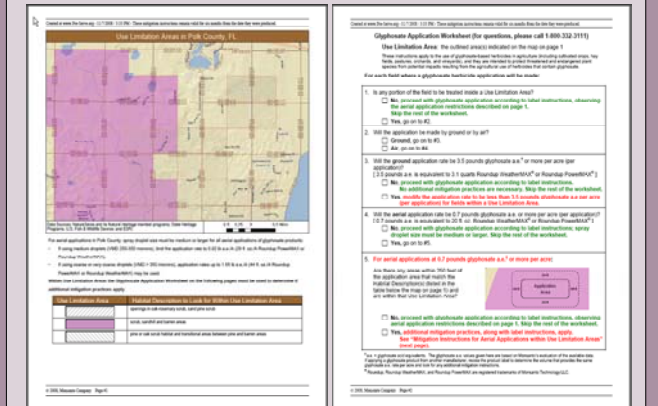


Figure 12. Pre-Serve use instructions report, pages 1 and 2.

## Summary

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- Pre-Serve was designed as a tool to protect federally-listed threatened or endangered plant species from potential impacts resulting from the agricultural use of herbicides that contain glyphosate.
- The web-based mapping system, built on ESRI's ArcGIS Server technology, delivers geographically-specific product use and mitigation instructions in order to educate licensed growers of Roundup Ready crops and pesticide applicators on the proper use of glyphosate to protect these species.
- It is anticipated that Web-mapping applications like Pre-Serve will become more common in the communication of geographically-specific pesticide use and mitigations to address endangered species and other stewardship issues.

### Future Work

- Pre-Serve will continue to evolve from a data and a functionality perspective.
- New functionality slated for Pre-Serve includes additional spatial search methods, as well as enhancements to overall performance.

### Acknowledgements

- The development of Pre-Serve was funded exclusively by Monsanto Company.
- For additional information on the web-site development, please contact Michael Winchell, Stone Environmental, 802-229-1882, mwinchell@stone-env.com.