

## *HOW RESEARCHERS ESTIMATE THE AREA OF HERBICIDE-RESISTANT WEED INFESTATIONS.*

There are two points that need to be made about the area estimates for herbicide-resistant weeds.

1. There is a very wide margin of error in the area estimates for herbicide-resistant weeds.
2. Many of the estimates are out of date.

This article is aimed at making users aware of how researchers estimate the area of herbicide-resistant weeds and the limitations of the data.

Estimating the area of herbicide-resistant weeds is a difficult task fraught with hidden traps. The International Survey of Herbicide-Resistant Weeds asks weed scientists to estimate the number of sites and the area infested with each unique case of herbicide-resistant weeds in their state/region. The aim of these questions was to get a very general idea of the scale of resistance problems in order to identify which herbicide-resistant weeds were causing the greatest economic impact. It was known from the beginning that the area estimates would have a very wide margin of error, however it was felt that some best "guesstimate" from qualified weed scientists would be better than nothing.

Figure 1 shows the range of values that researchers can select for the number of sites (fields) of herbicide-resistant weeds, and Figure 2 shows the values for the estimated area of infestation. These area estimates are one value for the whole of the region being estimated (country or state), encompassing all crops.

<b>Sites Number</b>	-----Estimate-----
<b>Site Increase</b>	1
<b>Area Infested</b>	2-5
<b>Area Increase</b>	6-10
<b>R/S Compared?</b>	11-50
<b>Fitness Penalty</b>	51-100
	101-500
	501-1000
	1001-10000
	10001-100000
	>100000
	unknown
	<input type="radio"/> Yes <input checked="" type="radio"/> No/Unknown

**Figure 1.** Values researchers can input for the estimate of the number of sites infested by herbicide-resistant weeds.

The image shows a web form with the following fields and options:

- Species:** -----Select Species-----
- Country:** -----Estimate-----
- State or if USA:** -----Estimate-----
- Nearest City:** -----Estimate-----
- First Year:** -----Estimate----- (98, 2000)
- Area Infested:** -----Estimate----- in acres\* (dropdown menu open)

The dropdown menu for 'Area Infested' contains the following options:

- <1
- 1-5
- 6-10
- 11-50
- 51-100
- 101-500
- 501-1000
- 1001-10000
- 10001-100000
- 100001-1000000
- 1-2 million
- unknown
- 2-5 million
- 5-10 million
- 10-20 million
- 20-50 million
- >50 million

**Figure 2.** Values researchers can input for the estimate of area infested by herbicide-resistant weeds.

Table 2 presents the primary ways in which weed researchers estimate the area of infestation of herbicide-resistant weeds. For the great majority of estimates recorded in the database researchers rely upon a combination of field observations and passive testing, along with their own general knowledge of the biology and distribution of the weed species (Table 2). As indicated in Table 2 this often leads to an overestimation of the area infested with herbicide-resistant weeds. The most practical way to get an accurate estimate of herbicide-resistant weed infestations is to conduct "Random Field Sampling". Random field sampling is very expensive and time consuming and therefore is rarely done. There are many good examples of random field studies in the literature, in particular those conducted in the USA on glyphosate-resistant Horseweed (*Conyza canadensis*) (Kruger et al. 2009), in Canada on Accase inhibitor resistant Wild oat (*Avena fatua*) (Beckie et al. 2008), and in Australia on multiple resistance in Rigid Ryegrass (*Lolium rigidum*) (Llewellyn and Powles. 2001).

**Table 1.** Methods researchers have used to Estimate the Area of a Herbicide-Resistant Weed Infestation, from least accurate to most accurate.

METHOD	EXPLANATION
<b>Field Observations</b>	<ul style="list-style-type: none"> <li>Field observations may have some validity if done by an experienced weed scientist (not through second hand reports) if they know what factors to look for to suspect resistance.</li> <li>Field observations are less reliable if the weed scientist relies upon second hand reports extension agents, farmers, ag chem dealers, and industry reporting "suspected cases".</li> <li>Field observations that are not backed up by scientific tests are prone to error. Environmental conditions at herbicide application may lead to widespread weed control failure in a region on a particular species, resulting in many "suspected cases". For example there have been many reports of glyphosate-resistant common lambsquarters that have proven to be susceptible after lab and field testing.</li> </ul>
<b>Passive Testing</b>	<ul style="list-style-type: none"> <li>The researcher receives samples suspected of resistance from growers, ag chem dealers, industry, and extension agents.</li> <li>The samples are tested for resistance and researchers use the information gained to make assumptions about the prevalence of resistance in their state.</li> </ul>

	<ul style="list-style-type: none"> <li>• Some researchers make errors when using this test data to estimate the prevalence of resistance. For instance they may find 60% of the samples that they test are resistant, and then conclude 60% of the fields in their state (or the test region) are infested with resistant weeds. This is not the case as the collection of samples was biased, only samples highly suspected of resistance are submitted for testing. This leads to a massive overestimation of resistance.</li> </ul>
<b>Active Testing</b>	<ul style="list-style-type: none"> <li>• At weed seed maturity the weed scientist travels in the test area looking for heavy infestations of target species.</li> <li>• They collect samples from fields where resistance is highly suspected and then test for resistance.</li> <li>• Researchers then report the percentage of samples that test positive for resistance and often make the same mistake as above (passive testing) by concluding that this indicates the percentage of fields in a region that have resistance.</li> </ul>
<b>Elevator Samples</b>	<ul style="list-style-type: none"> <li>• If the weed seed and crop seed is of similar size and difficult to screen out then extracting weed seeds from grain samples (at grain delivery points) can be a cost effective method of estimating the area of herbicide-resistant weed infestations.</li> <li>• Researchers conduct random sampling of grain from the elevator - recording the origin of each sample and the percentage of grain samples that contain the target species.</li> <li>• Once samples are collected researchers test for resistance and report the percentage of grain samples (including those that did not have any weed seed contamination) with resistance.</li> <li>• Researchers can then multiply the acres of crop in the test region by the percentage of resistant samples to get a rough estimate of the area infested with herbicide-resistant weeds.</li> <li>• This method only works for select weed/crop combinations. For instance it works very well for wild oat samples in wheat (Beckie et al. 2008) but not for pigweed species in corn.</li> </ul>
<b>Random Field Sampling</b>  Most Practical Scientific Technique  Beckie et al. 2008, Kruger et al. 2009, Llewellyn and Powles 2001	<ul style="list-style-type: none"> <li>• Researchers first define the target weed species to be tested (ie: Waterhemp and Common Ragweed), the target crops (ie: corn, soybean) and the test area (counties, region).</li> <li>• Using GIS, they overlay a grid onto the test area with an appropriate amount of sample points (each intersection of the grid will be a sample location).</li> <li>• They can then determine the GPS locations of each of the grid intersections and at weed seed maturity they can travel to each grid intersection (using GPS) and sample from the nearest field with the target crop.</li> <li>• At each site they record the estimated densities of target species and record the percentage of fields that do not have the species present.</li> <li>• They then collect weed seed samples using appropriate sampling techniques within the field and follow a standard protocol for each sample site (eg: sampling in a W configuration over 1 acre from more than 40 plants).</li> <li>• Once samples are tested for resistance they can then calculate the percentage of fields infested with resistant weeds and multiply by the acres of crop in the test region to get the area infested.</li> </ul>

Weed scientists have long had guidelines on how to screen for and document resistance (Heap, 1999, Beckie et al. 2000) however they have no guidelines on how to estimate the area of herbicide-resistant

weed infestations, nor do they record how they have estimated the area of infestation at the time they enter their data into the survey. This leads to great uncertainty and error in the data because researchers are using different criteria to estimate herbicide-resistant weed infestations. To rectify this we aim to develop guidelines soon and to redesign the database to allow the collection of more detailed data on the distribution of herbicide-resistant weed infestations.

### *Estimates are out of date*

Researchers are eager to report the first case of a new resistant weed biotype in their state, and typically they will update the case for the first two years after it is reported. But as their interests turn to different cases of herbicide-resistant weeds or other research they do not continue to update the case. These are effectively abandoned entries, and will remain that way until:

1. The researcher receives enough prompting to update the case
2. Another researcher becomes interested in the case and picks it up.

In the Quik Stats section of each case you will find the date that the case was last updated.

**QUIK STATS ( last updated Mar 05, 2009 )**

We aim to prompt researchers to update cases on a regular basis.

## *REFERENCES*

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