

WeedSearch: A new tool for estimating time and cost of eradication

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Abstract

The first questions often asked in planning a new weed eradication project are “How much will this cost?” and “How long will this take?” A new tool is available to resource managers to help answer these questions. WeedSearch is the first comprehensive estimating tool for the cost and time of eradicating weed populations. It is an Excel program based on the work of Australians Oscar Cacho, an economist, and Paul Pheloung, an expert in weed risk assessment. In order to use the model, a resource manager enters specific details about the weed’s biology and the amount of time invested in searching for it, and the costs of control. The model outputs are estimated time to eradication, cost and probability of success. An estimate of the total number of hours spent searching for weeds and the number of hours spent killing weeds once they have been found is also simulated. We ran WeedSearch using red sesbania (*Sesbania punicea*) as a model and changed some of the input parameters to demonstrate the range of applications of this model. WeedSearch is available for free online (<http://www-personal.une.edu.au/~ocacho/weedsearch.htm>), and the software will continue to evolve as much appreciated feedback is received by the authors.

Introduction

Land managers often struggle with the uncertainty of planning weed eradication projects. WeedSearch is a new tool available to resource managers to help answer common eradication project planning questions such as how much time, money and search effort should be expected to feasibly eradicate a weed population. This model combines population dynamics and search theory to calculate the probability that a weed invasion will be eradicated based on the amount of time invested in searching for it. It is run in Microsoft Excel and is based on the work of Paul Pheloung, Australia’s Department of Agriculture, Fisheries and Forestry, and Oscar Cacho, School of Economics, University of New England, Armidale, Australia. WeedSearch is available for free for the purpose of dissemination of scientific information (software and manual available at <http://www-personal.une.edu.au/~ocacho/weedsearch.htm>) with the disclaimer that this program is a work in progress and feedback on the model will be much appreciated.

It requires input of a number of parameters relating to logistic considerations, detectability, biological characteristics, management effectiveness, and economics. The values for some of these parameters may not be easy to find, but experienced weed managers may be able to come up with educated guesses and then undertake sensitivity analysis. Model inputs are listed below (more specific information can be found in the WeedSearch Software Manual (Cacho and Pheloung 2007).

Initial conditions: total search area, density of mature plants

Biology: pre-reproductive period, maximum longevity of seeds, seeds per square meter, mortality of first-year juveniles, size of mature plant, plant longevity, population growth rate.

Economics: fixed project costs (independent of weed density) and variable costs (dependent on density of infestation)

Management: search pattern, searches per year, search time, detectability, search speed, effectiveness of control

Methods

We chose the management program for red sesbania (*Sesbania punicea*) in Dry Creek, located in Sacramento and Placer counties, as a test of the WeedSearch model. Red sesbania, a native of South America, was highly invasive in South Africa before biocontrol releases reduced populations there, and is currently expanding its range in California along the rivers of the Central Valley (Hoffman and Moran 1998). In South Africa it was invasive along river banks and in wetlands where it formed dense thickets, restricted access to water bodies,

and caused increased flooding and erosion of channels (Hoffman and Moran 1991). All parts of the plant are toxic, and the seeds have been shown to inhibit the germination and normal development of a wide variety of plants (Van Staden and Grobbelaar 1995).

The Dry Creek red sesbania management program began in 2004 with a Flood Protection Corridor Program grant from the California Department of Water Resources (DWR). The management area is approximately 40 miles long, from Granite Bay in Placer County to Rio Linda in Sacramento County. After the grant funds were expended in 2006, Sacramento Area Flood Control Agency requested support from local agencies and resource management groups along the Dry Creek watershed and those groups continue to make yearly contributions toward the program.

The parameters used to run the WeedSearch model are listed in Table 1, and in the WeedSearch Manual (Cacho and Pheloung 2007). The Manual is available on-line and gives a clear, easy to use description of how to run the model and interpret the results. We found that WeedSearch did not perform reliably with Excel 2007 so we recommend using Excel 2003. We began with the perennial base case model provided with WeedSearch and modified the parameters according to our experience with red sesbania in the Dry Creek watershed. Most of the values in Table 1 were estimates, or default values were used. The number of seeds per square meter was estimated from an actual count performed by Frank Wallace, Sacramento Weed Warriors (unpublished data). He counted 2,200 pods on one mature plant, and multiplying by 6 seeds per pod, and dividing by an estimated area per mature plant of 1.5 m² gives 8,800 seeds produced per square meter. We assumed each plant would live ten years and that the seed longevity is 10 years. Recently we learned that in South Africa seed longevity is as short as 3 years under flooded conditions in some areas (Hoffman, J.H. pers. com.). However, in the American River Parkway in Sacramento, red sesbania eradication programs have been underway for over 10 years and seedlings are still found.

Results and Discussion

The results of the model are shown in Figure 1. The results table includes the years to eradication, total search hours, total control hours and total cost, and the two accompanying probability graphs present the same information on time and cost to eradication in a more detailed manner. In the results table, the 25th percentile, for example, indicates that there is a 25 percent probability that eradication will be achieved in 21 years or fewer. Under search hours in the results table, an average of 2058 hours would be used over 21 years, so the average search labor would be about 100 hours per year. For control effort, 924 hours over 21 years would be expended, for an average of 44 hours per year. The mean cost in Figure 1 is \$226,800 over 21 years, indicating an average annual cost of about \$10,800. This run assumes a search area of 98 ha, therefore the cost would be about \$110 per hectare per year. The probability graphs shown in Figure 1 present more detailed information than the percentiles in the results table. For example, here we can see the probability that an invasion will be eradicated in 20 years or fewer is about 18 percent, but if the effort is continued for 4 more years the probability of success increases to close to 100 percent.

It is easy to alter the numbers and observe how the results change. For instance, if the initial density of mature plants per hectare is reduced from 100 to 10, we found the time to eradication decreased to 19 years and cost of eradication decreased to \$178,000.

The amount spent so far on the Dry Creek sesbania program is presented in Table 2. It includes the initial DWR grant (2004 to 2006), projected costs for the next ten years of treatment (2007 to 2016), actual costs for 2007 and 2008 for comparison, and an additional estimate for another 12 years based on the results of the time to eradication predicted using the WeedSearch model. There are two totals included at the bottom of the table, one is without the initial DWR grant and the second total includes the DWR grant. The original DWR grant was used to map the infestation, obtain permitting, remove mature woody sesbania, and complete one year of follow-up spray of seedlings. In comparing the two projected amounts, the WeedSearch estimate appears quite low, but is more aligned with the costs of the program after the initial mature plant removal. This indicates that in the case of this Dry Creek example, WeedSearch may be more useful as an estimate of yearly maintenance

costs after a mature infestation of perennial plants has been removed, than in estimating the total costs of the eradication effort. One source of the difference may be permitting costs which are high at the beginning of a project and are not included in the model.

We encourage others to experiment with this new tool, especially for planning and educational purposes, and share your results with the developers.

Literature Cited

- Cacho, O., and P. Pheloung. 2007. WeedSearch: Weed Eradication Feasibility Analysis Software Manual. CRC for Australian Weed Management Project 1.2.8.
- Hoffmann J. H. and Moran V. C. 1991. Biological control of *Sesbania punicea* Fabaceae in South Africa. *Agriculture Ecosystems and Environment* 37: 157-174.
- Hoffmann J. H. and Moran V. C. 1998. The population dynamics of an introduced tree, *Sesbania punicea*, in South Africa, in response to long-term damage caused by different combinations of three species of biological control agents. *Oecologia* 114: 343-348.
- Van Staden J. and Grobbelaar N. 1995. The effect of sesbanimide and Sesbania seed extracts on germination and seedling growth of a number of plant species. *Environmental and Experimental Botany* 35: 321-329.

Table 1. WeedSearch Model Parameters for Red Sesbania in Dry Creek Watershed	
Initial Conditions	
Total search area (ha)	98
Density of mature plants per ha	100
Maximum years	30
Biology	
Pre-reproductive period (yr)	1
Maximum longevity of seeds (yr)	10
Seeds per square meter	8,800
Mortality of first year juveniles	0.95
Size of mature plant (m ²)	1.5
Plant longevity (yrs)	10
Growth rate (lambda)	1.2
Economics	
Fixed costs	
Administration (\$ per year)	10,000
Transportation to site (\$ / yr)	500
Variable costs	
Labor input (\$ / hr)	35
Labor input (hr / plant)	0.01
Chemical input	
(\$ / liter)	24
(liter / plant)	0.01
Machinery input	NA
(\$ / hr)	NA
(hr / plant)	NA
Management	
Search pattern	Parallel
Searches per year	2
Search time (hr / ha)	1
Detectability of adults (m)	10
Detectability of juveniles (m)	2
Search speed (mi / hr)	1000
Effectiveness of control (% kill)	99

Table 2. Dry Creek Red Sesbania Program Economics (US Dollars)	
Initial DWR Grant 2004 to 2006	[372,000]
Yearly Program Costs (Projected in 2006) and Actual*	
2007	(41,200) 39,088*
2008	(41,200) 46,078*
Projected Future Costs (Projected in 2006)	
2009	(41,200)
2010	(24,950)
2011	(24,950)
2012	(24,950)
2013	(24,950)
2014	(24,950)
2015	(24,950)
2016	(24,950)
Total estimated 10 year cost in 2006	298,250
<i>Project out to 24 years based on WeedSearch model Prediction</i> (12 more years after 2016 at \$15,000/year)	180,000
Total cost 30 year project EXCLUDING initial DWR removal grant	478,250
Total 30 year projected cost INCLUDING initial DWR removal grant	850,250

Figure 1. WeedSearch Model Results Table and Probability Graphs for Dry Creek Sesbania Example

RESULTS	Percentiles						
	Mean	SD	10	25	50	75	90
Prop. successful	1.000						
Variable	Mean	SD	10	25	50	75	90
Time to eradication (yr)	21.0	4.1	20.0	21.0	22.0	23.0	23.0
Search hours	2,058.0	402	1,960	2,058	2,156	2,254	2,254
Control hours	923.9	688	302	414	716	1,390	1,937
Cost (\$000, PV)	226.8	56.3	194.6	204.0	222.0	258.2	292.5

