

The Ecology Centre  
The University of Queensland

**DEVELOPMENT OF DECISION SUPPORT MODELS  
FOR WEED CONTAINMENT AND ERADICATION**

**Report V: Detectability of Branched Broomrape  
using the Double Count Method with  
Independent Observers**

Petra Kuhnert and Hugh Possingham

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### Abstract

This report presents an analysis of data collected from the double-blind survey that was conducted in 2002.

Results suggest that there are statistically significant differences between the two implemented versions of the double blind study. Data collected from the first version indicates that detectability of broomrape infestations is quite poor, while data from the second version indicates that detectability of broomrape is reasonably high. Differences between field observers were not statistically significant. Distance also appeared to have no effect on detection. Finally, other factors that might effect detectability such as land use, could not be explored due to the small sample size and inconsistencies noted with the data.

It is recommended that implementation of the double-blind survey should occur in 2003 using methodology that can avoid biases observed in the 2002 survey.



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## The Double-Count Survey

### Implementation of the Survey

A double-count survey approach was implemented in the 2002 survey to ascertain the difficulty in detecting branched broomrape under varying conditions of the landscape. This task was not intended to be an examination of observers' ability to detect broomrape but a way of estimating the false negative error rate, that is the probability or chance of not seeing broomrape less than some prescribed distance, given that it had actually emerged. This approach is widely accepted in the survey literature and amongst ecologists when surveying plants and animals.

The false negative error rate is extremely important for modelling the actual unobserved dynamics (Figure 2) of the system, which we will use to assess different management strategies, given the survey data as described by the observed system (Figure 1) and what can be detected. If we obtain an inaccurate and biased estimate of 'detectability', this has the potential to affect results, leading to management actions that are misleading and do not lead to our ultimate goal of eradication and/or containment. It is therefore important that we implement a survey approach that can lead to an estimate that is not affected by bias.

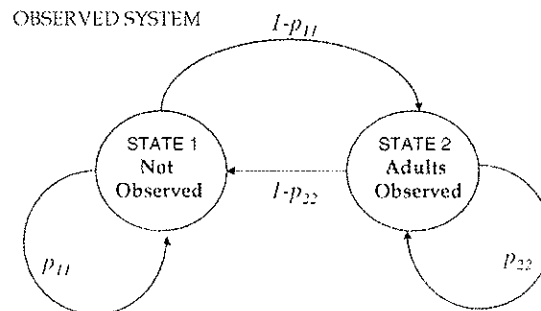


Figure 1: Dynamics of the observed system constructed for Branched broomrape based on the design and collection of survey data.

In the 2002 survey, field surveyors were asked to record the perpendicular distance from the transect to sighted infestations for a subset of paddocks using a double-blind approach in addition to the data that they collect as part of the standard

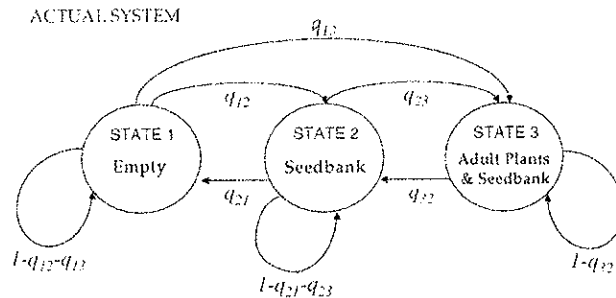


Figure 2: Dynamics of the actual system of Branched broomrape.

survey. Two versions of the double-count survey were implemented since drought during last years survey resulted in small numbers of infestations being identified. A description of each version as reported by Nick Secomb is presented below.

#### 1. Version 1

Paddocks which had been infested in previous years were targeted for inclusion in the double blind survey. Each targeted paddock was paired with another paddock which had not been infested previously. Survey teams were given property maps for surveying the whole area of land owned by a single landholder. On these maps, the pairs of paddocks for inclusion in the double blind approach were highlighted. Teams were asked to 'split up' and survey each of these paddocks on an individual basis. The same survey technique was to be used by each team member, that is if a bike was used during the first search, it was also used in the second search by the second field surveyor. The teams were asked not to collaborate between surveys and each team member chose their own survey path for each paddock but kept within the usual Z and perimeter line transect searches.

#### 2. Version 2

When it became apparent that Version 1 was not finding very many 'positives' for broomrape (mostly due to seasonal changes and the fact that landholders were actively managing their known infestations), the approach was altered.

In this version, if a survey team found an infestation of branched broomrape during their normal property survey they were asked to mark on their map where it had been found. Infestations were also identified using pink mark-

ers. An independent mapping crew then visited the site within two days and accurately mapped the infestation using a Differential Global Positioning System. Once mapped, all pink markers were removed.

A second survey team, independent of the first, was then called in to survey the paddock. They were given maps showing the infested paddock and at least two other paddocks to be surveyed. The ability of this second team to find the known infestation was recorded. The second team chose their own approach to surveying, that is, whether to survey on foot or on bike. They also chose their own survey pattern but kept within the usual Z and perimeter line transect searches.

## Analysis of Survey Data

### Methodology

Detectability functions were estimated using a Bayesian adaptation of the methodology outlined in Manly et al. (1996). Their approach was constructed in a maximum likelihood framework and focussed on estimating detection probabilities of polar bears using logistic regression functions that incorporated covariates, which could potentially affect detection. For broomrape, it is envisaged that these covariates would consist of the perpendicular distance from the transect to the sighted infestation, land use (pasture or crop) and the searching mechanism, that is, whether version 1 or version 2 was used. Manly et al. (1996) was particularly interested in obtaining abundance estimates and standard error estimates of abundance, which was achieved using a bootstrap approach. Here, we are more interested in obtaining estimates of the false negative error rate, that is, the proportion of times broomrape is not detected given that it is actually there.

The Bayesian adaptation that is developed for the detection of broomrape, uses Markov Chain Monte Carlo and more specifically, the Metropolis algorithm to obtain estimates and corresponding 95% credible intervals for each parameter in the logistic model. (Here, a credible interval is similar to a confidence interval used in standard analyses). Furthermore, since the focus is on detectability along the transect and within a given distance, the Bayesian approach allows us to estimate broomrape detectability and form credible intervals around those estimates. It also allows us to calculate probabilities of sighting the weed less than a given distance. The Bayesian model for detectability is described in detail in the Appendix.

### Estimating Detectability

An estimate of detectability is defined as the probability that at least one field observer detects the weed along the transect. This will provide us with a detectability

curve, which shows the probability that at least one observer detects the weed for a given set of distances. To obtain an overall measure of detectability, averaging across distances is not useful because this assigns equal weights to sightings made close up and further away when you are probably more interested in a person's ability to see the weed close up. To obtain a more accurate estimate of detectability, which weights closer sightings higher than sightings further away, we employ an importance function, which is exponential like, to weight probabilities on the detectability curve. Corresponding 95% credible intervals can be easily achieved in a Bayesian framework. This work is currently being revised to cater for the nature of the data we expect from the 2003 survey. (See the note in the section below on implementation of the double-count survey in 2003).

## Results

Results suggest that detectability is not affected by distance but is significantly different for the two implemented versions of the double-count study. Differences between different types of land use could not be tested due to the lack of data. Results were based on information recorded for 24 paddocks, where at least one infestation was recorded and distances were reported for those infestations.

Detectability functions displaying these results are shown in Figure 3. Estimates of detectability are indicated by the dashed line for version 1 and the solid line for version 2, while dotted lines indicate the estimated error surrounding these estimates. For the first implemented version, the chance, on average of detecting broomrape is approximately 3%, irrespective of the distance that field observers are from an infestation. The error around this estimate also indicates that 95% of the time the observer's ability to detect broomrape will be between 0% and 13%. For the second implemented version, the chance, on average, of detecting broomrape is approximately 80%, irrespective of distance. The error around this estimate indicates that 95% of the time, observer's detection rate will be between 68% and 96%. Finally, if we average across the two survey versions, our best estimate of detectability for broomrape is 0.44 with a corresponding 95% credible interval of 0 and 0.96, suggesting that detection of broomrape is difficult to quantify given the substantial differences noted with each implemented version.

As highlighted previously, since broomrape detection does not appear to be affected by distance, the relationship between the probability or chance of detecting the weed and distance remains constant, which is contradictory to our thoughts, *a priori*. This result may be due to the fact that the maximum distance recorded was 5 metres. However, a more likely explanation, given that distances of infestations recorded for both searches were consistent, if not, exact, is due to the observer's collaborating with one another about what they saw. This was apparent in the second version more so than the first and it indicates that if an observer

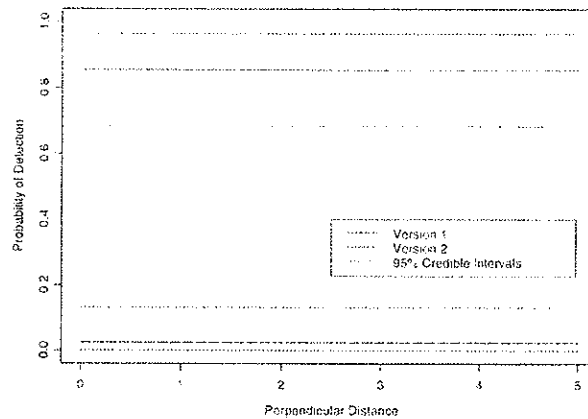


Figure 3: Detectability curves estimated for Branched broomrape using data collected using a double-blind survey approach. Dotted lines represent 95% credible intervals around the posterior mean estimates for the first (dashed) and second (solid) implemented versions of the survey.

during the first search collaborated with an observer during the second search, distance would not limit detection.

Figure 4 presents the probability of detecting broomrape less than 5 metres using this methodology. The  $x$ -axis shows mean posterior estimates and 95% credible intervals from the Bayesian model for each version as well as an overall estimate of detectability. Of notable interest is how the credible intervals for detectability (dotted lines) for each version do not overlap, indicating significant differences between versions. The overall estimate of detectability highlights the lack of precision in estimating the false negative error rate.

## Implementation of the Double-Count Survey in 2003

In an attempt to avoid observer bias and bias resulting from the implementation of the double-count survey, a new version of the survey is considered for 2003. It is envisaged that this new implementation will enable us to accurately estimate the probability (or chance) of seeing broomrape, given that it has emerged and therefore yield an estimate of the false negative error rate and corresponding confidence intervals around this estimate.

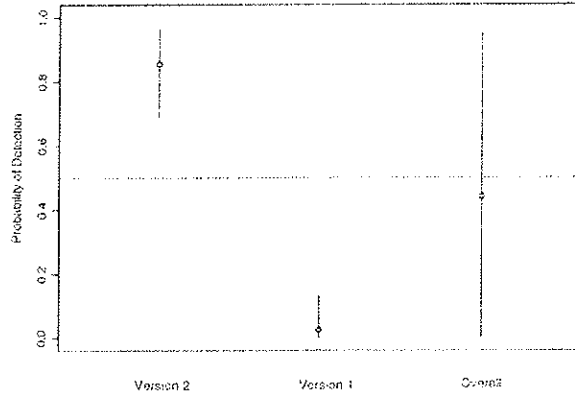


Figure 4: Probability of detection of Branched Broomrape shown for each implemented version and an overall estimate, averaged across both versions.

To achieve this result, we recommend using three 'gold standards' through the course of the double-count survey period, to conduct the second search through a paddock. The 'gold standard' would represent a field observer, not necessarily experienced at detecting broomrape, but a person that can survey paddocks in an unbiased and consistent manner. Rotating the three surveyors that act as 'gold standards' may prove beneficial, especially if one of the surveyors is not available to survey a paddock on a given day. Their surveys should be kept separate and have an identifying number but not a label. Ideally, the gold standards would be briefed about how the survey should be conducted and the importance of obtaining unbiased results.

Implementation of the double-count approach would occur as part of the larger survey for detecting broomrape infestations (see Figure 5). Once an infestation is located using the standard survey methodology described in the previous section, perpendicular distances from the transect to the initial sighting would be recorded, the survey method would be documented (i.e. bike or on foot), land use would be recorded along with the survey transect that it was located on (i.e. perimeter or Z) and the location of the infestation would be recorded and subsequently mapped using a global positioning system (GPS) but not marked in the paddock. To ensure that we obtain perpendicular distances and not sighting distances, the following explanation should be given to participating field observers:

1. Walk the transect

2. If a weed is sighted along the transect, keep walking until you reach a point along the transect that brings you closest to the infestation.
3. Turn at right angles and record the distance (approximately) to the infestation from the transect.

The 'gold standard' can then be brought in to survey the target paddock and at least two other paddocks nearby using the same method for surveying that the standard field surveyor used. Note, the order of the paddocks to be searched should be randomised so the 'gold standard' would not know which paddock was the target paddock. Distances would be recorded for any infestation found using the above methodology and the infestation would be marked for the mapping team to map and manage the infestation. This survey concept is outlined in a flow chart shown in Figure 5. At random time intervals, the 'gold standard' should also be given 3 'empty' paddocks to survey.

Before the commencement of the 2002 survey, it was difficult to ascertain just how many paddocks should be included in the double-count survey to provide good estimates of detectability and therefore good estimates of the false negative error rate.

A simulation study was conducted to investigate the statistic described in the previous section. Results to date indicate that we need data on at least 50 infested paddocks using the double-count methodology to estimate detectability with good precision. Moreover, the methodology for estimating detectability is sensitive out towards the tails of the distribution, that is, at larger distances. In its present form, the method is not flexible enough to estimate the rate of decline away from the transect and hence an observer's ability to detect broomrape away from the transect, especially for small sample sizes. Work currently being conducted will aim to provide a more robust estimator for detectability, which will be ready in time for the start of the Spring survey in 2003.

## Acknowledgments

We value the interesting discussions with John Virtue, Nick Secomb, Tony Pople, Bill Venables and Charis Burrridge on the issue of detectability.

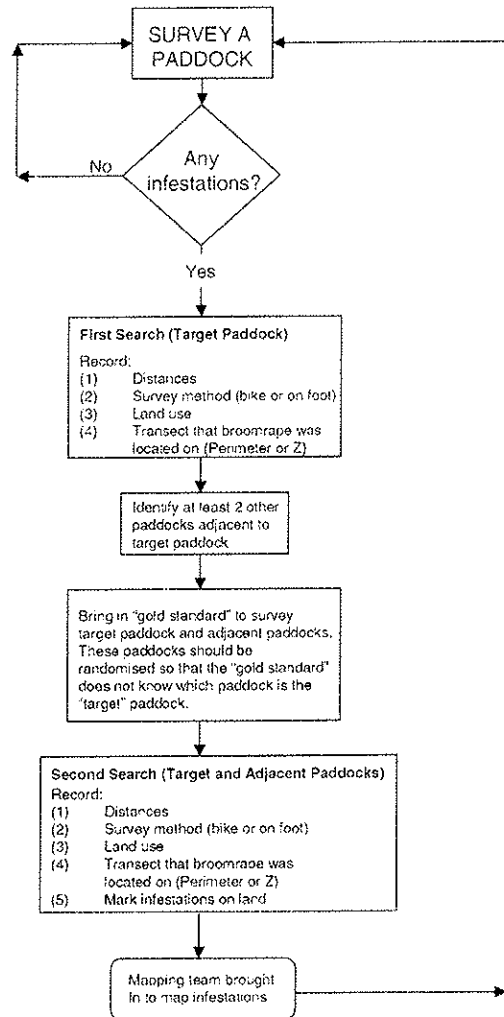


Figure 5: Flow chart illustrating the new survey methodology.

## Appendix: Bayesian Model for Detectability of Broom-rape

The likelihood,  $L$  for the general model can be represented as follows:

$$L = \prod_i^n L_i$$

where

$$L_i = \begin{cases} \theta_1(x_i, u_i, v_i)/\theta(u_i, v_i) & \text{if } y_i = 1 \\ \theta_2(x_i, u_i, v_i)/\theta(u_i, v_i) & \text{if } y_i = 2 \\ \theta_{12}(x_i, u_i, v_i)/\theta(u_i, v_i) & \text{if } y_i = 3 \end{cases} \quad (1)$$

and

$$\begin{aligned} \theta_1(x_i, u_i, v_i) &= \frac{1}{W} P_1(x_i, u_i, v_i) \{1 - P_2(x_i, u_i, v_i)\} dx \\ \theta_2(x_i, u_i, v_i) &= \frac{1}{W} \{1 - P_1(x_i, u_i, v_i)\} P_2(x_i, u_i, v_i) dx \\ \theta_{12}(x_i, u_i, v_i) &= \frac{1}{W} P_1(x_i, u_i, v_i) P_2(x_i, u_i, v_i) dx \\ \theta(u_i, v_i) &= \frac{1}{W} \int_0^W \{P_1(x_i, u_i, v_i) + P_2(x_i, u_i, v_i) - P_1(x_i, u_i, v_i) P_2(x_i, u_i, v_i)\} dx \end{aligned}$$

In the above formulation,  $y_i$  represents the search where the sighting was made (i.e. first ( $y_i = 1$ ), second ( $y_i = 2$ ) or both ( $y_i = 3$ )),  $x_i$  represents a variable describing the distance,  $u_i$  represents land use and  $v_i$  represents the survey version. Here, the likelihood is comprised of the ratio of the probability of weeds being sighted across distance  $x_i$  and the overall probability of seeing the weed integrated across all distances. The probability of sighting a weed on a paddock takes into account land use (i.e. pasture or crop) and survey version implemented during search 1, search 2 or during both searches as indicated by the likelihood equations shown in Equation 1.

The function (Equation 2) describing the probability of detection is logistic (but could also be probit or represent some other function), which can incorporate linear and non-linear functions of covariates that may explain detectability.

$$P_j(x, u, v) = \frac{\exp(\alpha_j + \beta_j x + \gamma_j u + \delta_j v)}{1 + \exp(\alpha_j + \beta_j x + \gamma_j u + \delta_j v)} \text{ for } j = 1, 2 \quad (2)$$

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Parameter	Posterior Mean	SD	95% CI
Version 1 vs Version 2	-3.045	1.038	(-5.267,-1.235)
AIC	123.988	4.125	(120.89,135.60)

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Table 1: Results from fitting a model to the broomrape data.

Priors for  $\alpha_j$ ,  $\beta_j$ ,  $\gamma_j$  and  $v_j$  were non-informative Normal priors, although informative priors could be considered in situations where expert opinion is available for any of the covariates.

Estimates for each parameter in the model were obtained using Markov Chain Monte Carlo, in particular the Metropolis algorithm which used a Normal proposal distribution. The final model required a burn-in period of 10,000 iterations followed by a further 20,000 iterations from which means, standard deviations and 95% credible intervals could be obtained. Acceptance rates for the algorithm for each parameter were targeted between 30% and 50%, while convergence diagnostics using the CODA (Best et al., 1995) package confirmed convergence to the equilibrium distribution. Code was written using the C programming language and run on a DELL Latitude notebook with an Intel 686 processor and 512 Megabytes of RAM under Cygwin version 5.

Models were evaluated using the Akaike Information Criteria (AIC). The model that fitted well to the data was the one yielding the lowest AIC. This model only contained a parameter for modelling survey version,  $v$ , which was assumed to be the same for each of the searches. Table displays the posterior mean estimates, standard deviation (SD) and corresponding 95% credible intervals (CI) for this model.

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