Web-based cost-benefit-analysis for regional weed management

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1 September 2015

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Introduction

The web application “Cost Benefit Analysis for Regional Weed Management” enables a cost-benefit analysis to be conducted for a Weed Management Programme proposed for inclusion in a Regional Management Plan as required by the New Zealand Biosecurity Act 1993. It is suitable for any of the four species-led programme types defined in the National Policy Direction for Regional Pest Management: Exclusion; Eradication; Progressive Containment; Sustained Control. The model assumes that the weed would spread logistically in the absence of the programme (“No Management”) and that “Management” would prevent this spread. The costs associated with both the “No Management” and “Management” cases and the difference, the Net

Present Value, are defined in the next three sections. In the remaining section "Weed Management Programme Types" we define the invasion trajectories with and without management for each of the four species-led programme types. The details of the model along with a worked example for a "containment" programme (now defined as Sustained Control) are published in the New Zealand Journal of Agricultural Research (Bourdôt *et al.*, 2015).

No Management

The total area of the land management units that would be occupied by the weed in the absence of the proposed weed management programme is $A_{NM}(t)$ hectares in year t. The costs ($/ha) of lost production due to the infestation on these land management units in year t are

$$C_{NM}(t) = A_{NM}(t) \times \text{cash operating surplus} \times f$$

where f is the percentage reduction in cash operating surplus ($/ha) due to the presence of the weed.

The total costs are the annual costs discounted (with a discount rate i) and summed over the time frame chosen for the analysis $t = 0$ to $t = t_{\max}$ years:

$$TC_{NM} = \sum_{t=0}^{t=t_{\max}} C_{NM}(t) \times (1+i)^{-t}$$

Management

$A_M(t)$ is the land area (ha) of the infestation in year t in the presence of management. The implementation costs $I(t)$ and lost production costs ($/ha) due to the infestation are

$$C_M(t) = A_M(t) \times \text{cash operating surplus} \times f.$$

The total costs are the annual costs discounted (discount rate i) and summed over the time frame $t = 0$ to $t = t_{\max}$ years.

$$TC_M = \sum_{t=0}^{t=t_{\max}} (C_M(t) + I(t)) \times (1+i)^{-t}.$$

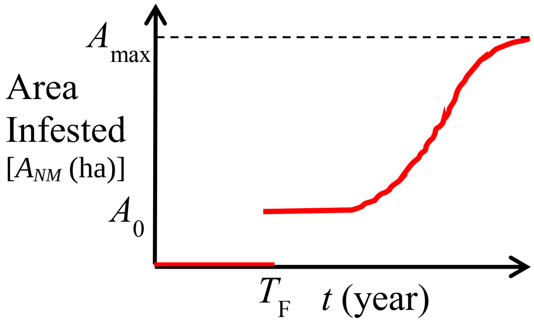
Net Present Value of the weed management programme

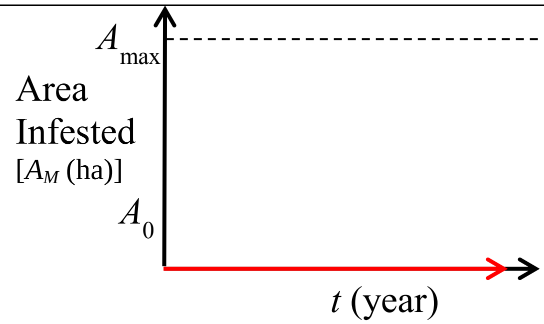
The NPV is the difference between the total costs for no management and management:

$$NPV = TC_{NM} - TC_M$$

Weed Management Programme Types

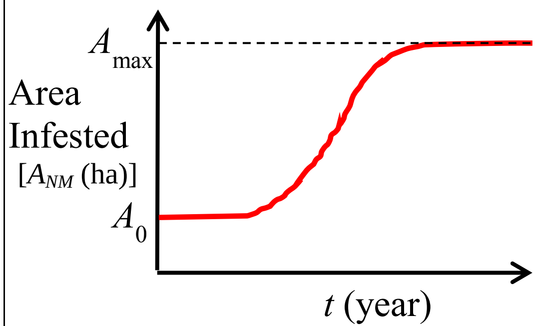
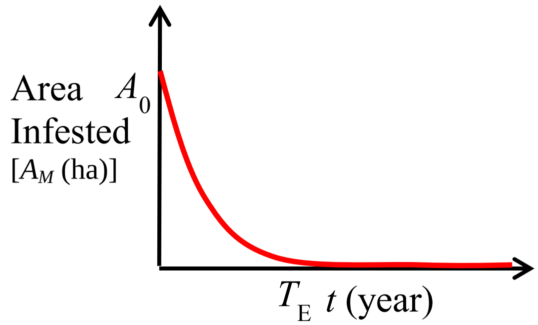
1. Exclusion

<table>
<tr><th>No management</th><th>Management</th><th></th></tr>
<tr>
<td>

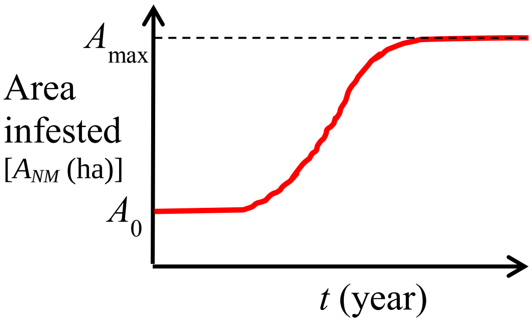
After T_F years of absence, the weed is found to occupy an area of A_0 hectares. The weed then spreads logistically:
$$A_{NM}(t) = \frac{A_0 A_{\max}}{A_0 + (A_{\max} - A_0)e^{-r(t-t_F)}}$$
where $A_{\max}$ is the maximum infested area and
$$r = \frac{-1}{T_{90}} \times \ln\left(\frac{A_0(1/0.9-1)}{A_{\max} - A_0}\right)$$
where T_{90} is the time (years) needed to reach 90% of the maximum infested area.</td>
<td>

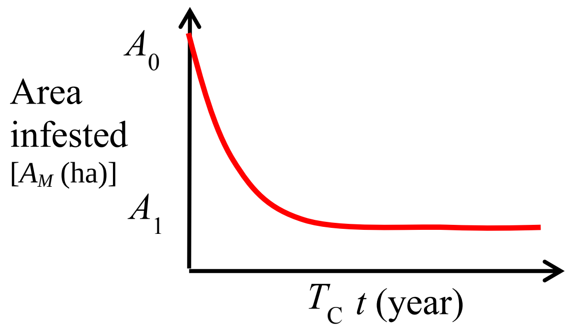
$$A_M(t) = 0$$</td>
<td>Exclusion</td>
</tr>
</table>

2. Eradication

No management	Management	
 $$A_{NM}(t) = \frac{A_0 A_{max}}{A_0 + (A_{max} - A_0)e^{-rt}}$$	 The weed spreads according to the equations $$A_M(t) = \begin{cases} \frac{A_0 A_{max}}{A_0 + (A_{max} - A_0)e^{-rt}} & t < T_E \\ 0 & t \geq T_E \end{cases}$$ where A_0 is the initial infested area, A_{max} is the maximum infested area and $$r = \frac{-1}{T_E} \times \ln\left(\frac{A_{max} - pA}{p(A_{max} - A_0)}\right) < 0$$ where T_E is the time (years) to reach eradication. Eradication is defined here as the time (years) needed to reach p = 0.01% of the initial infested area.	**Eradication**

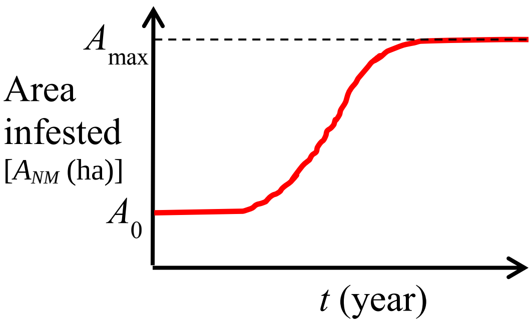
3. Progressive containment

<table>
<tr><th>No management</th><th>Management</th><th></th></tr>
<tr>
<td>


$$A_{NM}(t) = \frac{A_0 A_{\max}}{A_0 + (A_{\max} - A_0)e^{-rt}}$$
</td>
<td>


The weed spreads according to the equations:
$$A_M(t) = \begin{cases} A_1 + (A_0 - A_1)e^{-rt}, & t < T_C \\ A_1, & t \geq T_C \end{cases}$$
where A_1 is the desired area within which the weed is to be contained, A_0 is the initial infested area (ha) and $r = \frac{-1}{T_C} \times \ln(p)$ where T_C is the time (years) to reach containment. Containment is defined here as the time (years) needed to reach $A_1 + p \times (A_0 - A_1)$ with p = 0.01%.
</td>
<td>Progressive containment</td>
</tr>
</table>

4. Sustained control

<table>
<tr><th>No management</th><th>Management</th><th></th></tr>
<tr>
<td>


$$A_{NM}(t) = \frac{A_0 A_{\max}}{A_0 + (A_{\max} - A_0)e^{-rt}}$$
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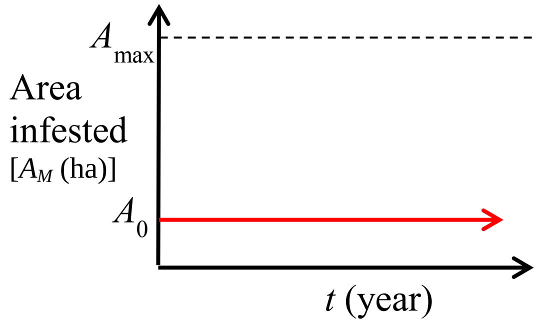
<td>


The weed spreads according equation
$A_M(t) = A_0$
</td>
<td>Sustained control</td>
</tr>
</table>

Reference

BOURDÔT GW, BASSE B, KRITICOS DJ & DODD M (2015) A cost-benefit analysis blueprint for regional weed management: *Nassella neesiana* (Chilean needle grass) as a case study. *New Zealand Journal of Agricultural Research* **DOI: 10.1080/00288233.2015.1037460**.