Measuring performance of invasive plant management efforts

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Environmental Studies Department
University of California at Santa Cruz

5 October 2006
California Invasive Plant Council
Rohnert Park, California
California Department of Parks and Recreation (DPR)

early adopter of performance measurement in state government

won an award for “Best in Class” from California Council for Quality and Service

key DPR staff member Denzil Verardo, now retired, very active in California Performance Review
Key attributes of an effective performance measure

quantitative
measured annually
suitable for display as a figure or map
non-statistical
inexpensive
straightforward
capable of aggregation across scale
(“rolled up” from park to district)

source: DPR 2004
Key attributes of an ineffective performance measure

- not measured annually
- figure full of chart-junk
- expensive
- confusing
- not directly linked to management objectives

(source: DPR 2004)
Key management objectives

**Eradication**
Eliminate all sites (no reinvasion)

**Elimination**
Eliminate all sites (reinvasion possible)

**Containment**
Eliminate all outliers (reinvasion possible)

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**Site elimination**
Local extinction of a species (no above-ground plants emerging from a seed bank)

**Key insight**
Elimination of some sites often precedes elimination of all sites
A key obstacle to elimination: The seed bank

Plants removed, white-edged nightshade (Solanum marginatum), Matakana Island, Bay of Plenty, NZ

![Graph showing number of plants removed over time](source: Auckland Regional Council)

![Map of California showing distribution of plants](source: CDFA)
*Coincya monensis*
star mustard, Isle of Man cabbage

photo by Andrea Pickart

detected in Humboldt County in early 1997
only known location in California
invasive in Pennsylvania and elsewhere
eradication effort initiated in early 1997

### The data: 4 columns in a spreadsheet

<table>
<thead>
<tr>
<th>Species</th>
<th>Site</th>
<th>Year</th>
<th>Pop. size</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. monensis</em></td>
<td>Site A</td>
<td>1997</td>
<td>6,000</td>
</tr>
<tr>
<td><em>C. monensis</em></td>
<td>Site A</td>
<td>1998</td>
<td>1,470</td>
</tr>
<tr>
<td><em>C. monensis</em></td>
<td>Site A</td>
<td>1999</td>
<td>n.a.</td>
</tr>
<tr>
<td><em>C. monensis</em></td>
<td>Site A</td>
<td>2000</td>
<td>487</td>
</tr>
<tr>
<td><em>C. monensis</em></td>
<td>Site A</td>
<td>2001</td>
<td>1,132</td>
</tr>
<tr>
<td><em>C. monensis</em></td>
<td>Site A</td>
<td>2002</td>
<td>481</td>
</tr>
<tr>
<td><em>C. monensis</em></td>
<td>Site A</td>
<td>2003</td>
<td>511</td>
</tr>
<tr>
<td><em>C. monensis</em></td>
<td>Site A</td>
<td>2004</td>
<td>174</td>
</tr>
<tr>
<td><em>C. monensis</em></td>
<td>Site A</td>
<td>2005</td>
<td>274</td>
</tr>
</tbody>
</table>
Site Status: an effective performance measure

Site Status, *Coincya monensis*, Humboldt Co.

- √ quantitative
- √ measured annually
- √ suitable for display as a figure or map
- √ non-statistical
- √ inexpensive
- √ straightforward
- √ capable of aggregation across scale
  (“rolled up” from park to district)

![Bar chart showing site status from 1997 to 2005]

Legend:
- Unreported
- Active: population size > 0
- Surveillance: population size = 0 for < 3 years
- Historical: population size = 0 for > 3 years

Data:
- 1997: Unreported
- 1998: Active
- 1999: Surveillance, Historical
- 2000: Active
- 2001: Surveillance, Historical
- 2002: Active
- 2003: Surveillance, Historical
- 2004: Active
- 2005: Surveillance, Historical
Coincya monensis Invasion and Control

Vicinity of Lupine Ave, Manila

Raoul Island, New Zealand

Seven plant species targeted for eradication:

- Mysore thorn (*Caesalpinia decapetala*)
- African olive (*Olea europaea*)
- black passionfruit (*Passiflora edulis*)
- peach (*Prunus persica*)
- purple guava (*Psidium cattleianum*)
- yellow guava (*Psidium guajava*)
- Brazilian buttercup (*Senna septemtrionalis*)

Site status, Raoul Island
Brazilian buttercup (*Senna septemtrionalis*)

- **Active**: (pop. size > 0)
- **Surveillance**: (pop. size = 0)
### Raoul Island

Percentage of all sites that are eliminated

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Caesalpinia decapetala</td>
<td>40</td>
<td>51</td>
<td>59</td>
<td>66</td>
<td>70</td>
<td>71</td>
<td>1</td>
</tr>
<tr>
<td>Olea europaea</td>
<td>70</td>
<td>85</td>
<td>84</td>
<td>85</td>
<td>86</td>
<td>89</td>
<td>3</td>
</tr>
<tr>
<td>Passiflora edulis</td>
<td>25</td>
<td>53</td>
<td>57</td>
<td>61</td>
<td>69</td>
<td>71</td>
<td>3</td>
</tr>
<tr>
<td>Prunus persica</td>
<td>18</td>
<td>40</td>
<td>44</td>
<td>46</td>
<td>45</td>
<td>43</td>
<td>-4</td>
</tr>
<tr>
<td>Psidium cattleianum</td>
<td>64</td>
<td>89</td>
<td>77</td>
<td>76</td>
<td>77</td>
<td>80</td>
<td>4</td>
</tr>
<tr>
<td>Psidium guajava</td>
<td>54</td>
<td>77</td>
<td>85</td>
<td>79</td>
<td>71</td>
<td>81</td>
<td>14</td>
</tr>
<tr>
<td>Senna septemtrionalis</td>
<td>36</td>
<td>49</td>
<td>55</td>
<td>60</td>
<td>65</td>
<td>64</td>
<td>-2</td>
</tr>
<tr>
<td>Raoul Island mean</td>
<td><strong>44</strong></td>
<td><strong>63</strong></td>
<td><strong>66</strong></td>
<td><strong>68</strong></td>
<td><strong>69</strong></td>
<td><strong>71</strong></td>
<td><strong>3</strong></td>
</tr>
</tbody>
</table>

*Note: Species Site records are per core area.*
Performance measures that include some measure of effort

Example from Marlborough District Council, New Zealand

**Weed Alert!**

*Saffron Thistle (Carthamus lanatus)*

*Saffron thistle is a total control plant pest in the Marlborough District Council's Regional Pest Management Strategy. Land occupiers that suspect they have Saffron thistle on their property should notify the Marlborough District Council. Council will carry out the control of Saffron thistle before the plants produce seed, with the aim of eventual eradication of this plant from the Marlborough region.*

**An accidental introduction**

This plant is the most widespread weed in New South Wales in Australia, and was accidentally introduced into New Zealand as a contaminant of wheat imported from there. It was first discovered in New Zealand in 1931 and has become established in drier sites throughout the country since then.
Seven plant species targeted for eradication:

- Brazilian buttercup (*Ranunculus sceleratus*)
- Raoul Island, New Zealand

**Key management objectives**

1. **Elimination**
2. **Containment**

**Pop. size, Marlborough, NZ**

**woolly distaff thistle**

(*Carthamus lanatus*)

**Site status, Marlborough, NZ**

**woolly distaff thistle**

(*Carthamus lanatus*)

**Data**

**Acknowledgments**

- Sue Zydenbos (NZ Plant Protection Society)
- Peter Williams (Landcare Research)
- Carol West (DOC)
- Daniel Press lab (UC Santa Cruz)
- Ian Popay (DOC)
- Dan Doak lab (UC Santa Cruz)
- Jonathan Boow (Auckland Regional Council)
- Mike Ambrose (DOC)
- Marlborough District Council
- Andrea Pickart

**Person-hours/site**

<table>
<thead>
<tr>
<th>Year</th>
<th>Active (pop. size &gt; 0)</th>
<th>Surveillance (pop. size = 0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>3.9</td>
<td>5.9</td>
</tr>
<tr>
<td>2001</td>
<td>3.1</td>
<td>5.9</td>
</tr>
<tr>
<td>2002</td>
<td>10.4</td>
<td>7.8</td>
</tr>
<tr>
<td>2003</td>
<td>10.8</td>
<td>5.9</td>
</tr>
<tr>
<td>2004</td>
<td>10.8</td>
<td>7.8</td>
</tr>
<tr>
<td>2005</td>
<td>7.8</td>
<td>5.9</td>
</tr>
<tr>
<td>2006</td>
<td>5.9</td>
<td>5.9</td>
</tr>
</tbody>
</table>

**Key attributes of an ineffective performance measure**

- **not directly linked to management objectives**
- **confusing figure full of chart-junk**
- **expensive to implement**
- **measured annually**
- **not measured annually**

**Key attributes of an effective performance measure**

- **inexpensive**
- **non-statistical**
- **measured annually**
- **capable of aggregation across scale**
- **straightforward**
- **quantitative**
- **capable of aggregation across scale**
- **inexpensive**
- **non-statistical**
- **measured annually**

**Performance Review**

- Early adopter of performance measures
- DPR 2004 won an award for “Best in New Zealand”
- DPR 2004 won an award for “Best in Environment”
- Key DPR staff member Denzil won an award for “Best in Quality and Service”

**Surveillance sites**

- Detection in Humboldt County in early 1997

**Ruderal communities**

- “rolled up” from park to district

**Invasive plant management efforts**

- Portrayed in this figure

**Pete Holloran**

- Environmental Studies Department, University of California at Santa Cruz

**Source:**

- DPR 2004, Marlborough District Council, New Zealand

**Invasive in Pennsylvania and elsewhere**

- Outliers

**Past performance**

- Where did we go wrong?

**Perfomance Review**

- Early adopter of performance measures

**Source:**

- CDFA, DPR 2004

**Species Site Year Pop. size**

<table>
<thead>
<tr>
<th>Species</th>
<th>Site</th>
<th>Year</th>
<th>Pop. size</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. persica</em></td>
<td>A</td>
<td>2000</td>
<td>n.a.</td>
</tr>
<tr>
<td><em>P. persica</em></td>
<td>A</td>
<td>2001</td>
<td>511</td>
</tr>
<tr>
<td><em>P. persica</em></td>
<td>A</td>
<td>2002</td>
<td>174</td>
</tr>
<tr>
<td><em>P. persica</em></td>
<td>A</td>
<td>2003</td>
<td>1,470</td>
</tr>
<tr>
<td><em>R. sceleratus</em></td>
<td>A</td>
<td>2004</td>
<td>8,163</td>
</tr>
<tr>
<td><em>C. monensis</em></td>
<td>A</td>
<td>2005</td>
<td>6,200</td>
</tr>
<tr>
<td><em>C. monensis</em></td>
<td>A</td>
<td>2006</td>
<td>2,000</td>
</tr>
<tr>
<td><em>S. septemtrionalis</em></td>
<td>A</td>
<td>2007</td>
<td>1,000</td>
</tr>
<tr>
<td><em>C. monensis</em></td>
<td>A</td>
<td>2008</td>
<td>3,000</td>
</tr>
<tr>
<td><em>C. monensis</em></td>
<td>A</td>
<td>2009</td>
<td>6,000</td>
</tr>
</tbody>
</table>

**Site Status**

- **Active** (pop. size > 0)
- **Surveillance** (pop. size = 0)
Status and effort, Marlborough, NZ
woolly distaff thistle
(Carthamus lanatus)

<table>
<thead>
<tr>
<th>Species</th>
<th>Perf. measure</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carthamus lanatus</td>
<td>sites</td>
<td>8</td>
<td>10</td>
<td>14</td>
<td>16</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>% sites eliminated</td>
<td>63</td>
<td>50</td>
<td>64</td>
<td>44</td>
<td>69</td>
<td>59</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>person-hours</td>
<td>31</td>
<td>31</td>
<td>146</td>
<td>173</td>
<td>172</td>
<td>132</td>
<td>106</td>
</tr>
<tr>
<td></td>
<td>person-hours/site</td>
<td>3.9</td>
<td>3.1</td>
<td>10.4</td>
<td>10.8</td>
<td>10.8</td>
<td>7.8</td>
<td>5.9</td>
</tr>
</tbody>
</table>

Sample data for Carthamus lanatus, Marlborough District Council, New Zealand

<table>
<thead>
<tr>
<th>Date</th>
<th>Action</th>
<th>Status</th>
<th>Number of plants</th>
<th>Person-hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Mar 2004</td>
<td>Active</td>
<td>Surveillance</td>
<td>70</td>
<td>6</td>
</tr>
<tr>
<td>7 Jan 2005</td>
<td>Surveillance</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4 Jan 2006</td>
<td>Surveillance</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Bridging the research-management divide

“[Our management plans] list achievable goals and annual targets. [Monitoring] doesn’t happen in practice, though. It’s a resource issue. You get phone calls, and things compound, so you never get around to it. . . . If you don’t show progress, people will lose faith in eradication and they won’t support it any more. We need to come up with meaningful measures that show progress towards eradication in this zone [the realm of the final inch].”

—regional council biosecurity officer, New Zealand

“The general emphasis on monitoring [eradication] of small, recently established infestations is not surprising as it offers the greatest chance of success, for the smallest cost. Because such monitoring is associated with the destruction of plants at the site, it involves very simple measurements. However, such measurements do not involve any rigorous scientific testing, and merely record success of the control measure.”

—ecologists providing monitoring advice to managers, New Zealand
Acknowledgments

Data
Andrea Pickart
Marlborough District Council
New Zealand Department of Conservation

Useful comments
Mike Ambrose (DOC)
Jonathan Boow (Auckland Regional Council)
Dan Doak lab (UC Santa Cruz)
Holly Doremus (UC Davis)
Richard Griffiths (DOC)
Dave Kelly (Univ. of Canterbury)
Ian Popay (DOC)
Daniel Press lab (UC Santa Cruz)
Carol West (DOC)
Peter Williams (Landcare Research)
Sue Zydenbos (NZ Plant Protection Society)

Funding
National Science Foundation Graduate Research Fellowship

Dedicated to:
Raoul Island weed workers, particularly Mark Kearney, who was killed during the volcanic eruption on 18 March 2006
Eliminate all sites

Key attributes of an ineffective performance measure
- Historical population size = 0 for > 3 years
- Surveillance population size = 0 for < 3 years
- Active population size > 0

Key attributes of an effective performance measure
- Straightforward
- Inexpensive
- Non-statistical
- Suitable for display as a figure or map

Source:
- G. D. Carr
- DPR 2004
- Andrea Pickart
- Michael Ambrose
- Mike Ambrose (DOC)
- DPR 2004

Example from California Department of Food and Agriculture (CDFA):
- 5 October 2006
  - Surveillance: 0 plants, 1 person-hour

Surveillance records:
- Historical population size = 0 for > 3 years
- Surveillance population size = 0 for < 3 years
- Active population size > 0

Perf. measure:
- 2000 2001 2002 2003 2004 2005 2006

Table:

<table>
<thead>
<tr>
<th>Species</th>
<th>Site</th>
<th>Year</th>
<th>Pop. size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psidium guajava</td>
<td>A</td>
<td>1997</td>
<td>6,000</td>
</tr>
<tr>
<td>Psidium cattleianum</td>
<td>A</td>
<td>1999</td>
<td>n.a.</td>
</tr>
<tr>
<td>Prunus persica</td>
<td>A</td>
<td>1999</td>
<td>n.a.</td>
</tr>
<tr>
<td>Olea europaea</td>
<td>A</td>
<td>2000</td>
<td>1,132</td>
</tr>
<tr>
<td>Caesalpinia decapetala</td>
<td>A</td>
<td>2001</td>
<td>1,000</td>
</tr>
</tbody>
</table>

Notes:
- Historical population size = 0 for > 3 years
- Surveillance population size = 0 for < 3 years
- Active population size > 0

Outliers:
- Eliminate all outliers

Key insight:
- Often precedes elimination
- Not directly linked to management
- Not measured annually

Figure:
- Suitability:
  - Straightforward
  - Inexpensive
  - Non-statistical
  - Suitable for display as a figure or map

Chart:
- Percentage of all sites that are eliminated:
  - 1997: 63%
  - 1999: 50%
  - 2000: 64%
  - 2001: 44%
  - 2002: 69%
  - 2003: 59%
  - 2004: 56%

Population size:
- Island Co.:
  - 1997: 31
  - 1999: 31
  - 2000: 146
  - 2001: 173
  - 2002: 172
  - 2003: 132
  - 2004: 106

People:
- 3.9 person-hours/site
- 3.1 person-hours/site
- 10.4 person-hours/site
- 10.8 person-hours/site
- 7.8 person-hours/site
- 5.9 person-hours/site

Notes:
- Because such monitoring is associated with the destruction of plants at the site, people will lose faith in eradication and they won't support it any more. We need to come up with meaningful measures that show progress towards eradication in this regional council biosecurity officer, New Zealand.
- Use of person-hours/site indicates the level of effort and cost. Because such monitoring is associated with the destruction of plants at the site, people will lose faith in eradication and they won't support it any more.
- Data from Andrea Pickart.
Seven plant species targeted for eradication:

- Brazilian buttercup (Pluchea capitata)
- Solanum marginatum
- Pea (Pisum sativum)
- Psidium cattleianum
- African olive (Olea europaea)
- Coincya monensis
- Mysore thorn (Psidium guajava)

Key attributes of an ineffective performance measure:

- Active population size > 0
- Unreported

Key attributes of an effective performance measure:

- Suitable for display as a figure or map
- Quantitative
- Non-statistical
- Can be measured annually
- Inexpensive
- Capable of aggregation across scale

Example from Marlborough, NZ:

- Eliminate all sites
- Status and effort, Marlborough, NZ

Key insight:

- Local extinction of a species (no above-ground plants not kept)
- Key obstacles to elimination:
  - The seed bank
  - Complexity of the study area

Acknowledgments:

- F. & K. Starr
- Acknowledgments for funding and contributions:
  - National Science Foundation Graduate Research Fellowship
  - Dave Kelly (Univ. of Canterbury)
  - Richard Griffiths (DOC)
  - Dan Doak lab (UC Santa Cruz)
  - Jonathan Boow (Auckland Regional Council)
  - Mike Ambrose (DOC)

Useful comments:

- Marlborough District Council
- Rohnert Park, California
- Council for Environmental Management
- Marlborough District Council

Surveillance data:

- Person-hours: 31 31 146 173 172 132 106
- % sites eliminated: 63 50 64 44 69 59 56

Status and effort, Marlborough, NZ:

<table>
<thead>
<tr>
<th>Year</th>
<th>Pop. size, Marlborough, NZ</th>
<th>Raoul Island, New Zealand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>(pop. size = 0)</td>
<td>Eradication effort initiated in early 1997</td>
</tr>
<tr>
<td>1998</td>
<td>1,000</td>
<td>Status and effort, Marlborough, NZ</td>
</tr>
<tr>
<td>1999</td>
<td>36 49 55 60 65 64 -2</td>
<td>Percentage of all sites that are eliminated</td>
</tr>
<tr>
<td>2000</td>
<td>54 77 85 79 71 81 14</td>
<td>Performance measures measured annually</td>
</tr>
<tr>
<td>2001</td>
<td>18 40 44 46 45 43 -4</td>
<td>Key attributes of an effective performance measure</td>
</tr>
<tr>
<td>2002</td>
<td>64 89 77 76 77 80 4</td>
<td>Bridging the research-management divide</td>
</tr>
<tr>
<td>2003</td>
<td>36 49 55 60 65 64 -2</td>
<td>Measuring performance of invasive species</td>
</tr>
<tr>
<td>2004</td>
<td>36 49 55 60 65 64 -2</td>
<td>Collecting data for the final inch of invasive species</td>
</tr>
<tr>
<td>2005</td>
<td>54 77 85 79 71 81 14</td>
<td>Final measures for invasive species</td>
</tr>
</tbody>
</table>

Key management objectives:

- Eliminate all sites
- Control all sites
- Measure performance
}

Figure full of chart-junk: 4 columns in a spreadsheet

- Counting the number of plants
- Measuring the population size
- Assessing the status of the sites

Source:

- DPR 2004
- Marlborough District Council
- Rohnert Park, California
detected in Humboldt County in early 1997

Useful comments

New Zealand Department of Conservation

Acknowlegments

Peter Williams (Landcare Research)
Ian Popay (DOC)
Dave Kelly (Univ. of Canterbury)
Richard Griffiths (DOC)
Holly Doremus (UC Davis)
Dan Doak lab (UC Santa Cruz)
Jonathan Boow (Auckland Regional Council)

Bridging the research-management divide

any rigorous scientific testing, and merely record success of the control measure."

"[Our management plans] list achievable goals and annual targets. [Monitoring] is not surprising as it offers the greatest chance of success, for the smallest effort"

"... come up with meaningful measures that show progress towards eradication in this [situation]. Things compound, so you never get around to it. . . . If you don't show progress, it is unlikely that anyone else will."

Site status, Marlborough, NZ

- Active population size > 0
- Unreported
- Historical population size = 0 for > 3 years

Performance measure 2000 2001 2002 2003 2004 2005 2006

Key management objectives

- Eliminate all sites
- Containment
- Eradication

Carthamus lanatus

Eliminate all sites

The data: 4 columns in a spreadsheet

Site A 1998 1,470
Site A 1999 n.a.
Site A 2000 487
Site A 2001 1,132
Site A 2002 481
Site A 2004 174
Site A 2005 274

Site status, Marlborough, NZ

- Surveillance 0 plants 1 person-hour
- Active 70 plants 6 person-hours

Raoul Island mean

- 1999 2000 2001 2002 2003 2004 % change
- 1,000 1,500 500 18 40 44 46 45 43 -4

Perf. measure 2000 2001 2002 2003 2004 2005 2006

- 9 6 69 59 56
- 63 50 64 44 69 59 56
- 31 31 146 173 172 132 106

African olive (Olea europaea)

Psidium cattleianum

Passiflora edulis

Coincya monensis

Raoul Island weed workers, particularly Mark Kearney, who erupted on 18 March 2006

Outliers

√ straightforward
√ quantitative
√ inexpensive

Key insight

Emerging from a seed bank

"... not directly linked to management..."