Variable Perceptions of Weeds and the Implications for WRA

Curtis C. Daehler\textsuperscript{1} and John G. Virtue\textsuperscript{2}
\textsuperscript{1}Department of Botany, University of Hawai‘i
\textsuperscript{2}Dept of Water Land & Biodiversity Conservation, Adelaide, Australia
“Weeds are enemies to man. Before an enemy can be controlled and destroyed, it must be identified” (p. 1)

Lorenzi and Jeffery

Weeds of the United States and their Control

Use photos and drawings in this book to identify the weeds …
Issues  Defining the objective

What are we trying to identify with WRA?

“Without man there would be no weeds” (p. 1)

Muzik, *Weed Biology and Control*
Issues

What are we trying to identify or screen out with WRA?

Risk = likelihood x consequences

‘Escapes’ Naturalization Roadside “weeds”

Eragrostis tenella

“harmless” Stone, 1970
Issues  Defining the objective

“Invaders” ?

_sensu_ Richardson et al 2000

_Phaius tankervilleae_

Issues  Defining the objective

What are we trying to screen out with WRA?

“Weeds” of mis-managed pasture
Issues  Defining the objective

What about natural areas?

Natural area weed
“a plant that prevents attainment of management goals”
Randall 1997
A recent weed science text

(Ross and Lembi)

Plants that interfere with the growth of desirable plants and that are unusually persistent and pernicious. They negatively impact human activities and as such are undesirable.
Issues    Defining the objective

“The greatest value will come from an emphasis on the more troublesome elements of the vegetation” (p. xvii)

King, *Weeds of the World*
WRA targets to screen out

Clear and substantial impacts

Weed impacts

severe moderate minor negligible

Economic
Quality of life
Quantifiable ecological impacts
Alternate WRA targets to screen out

Weed impacts

severe  moderate  minor  negligible

Increasing subjectivity?

Impacts range from substantial to minor or poorly defined
Why specify a target?

• Necessary to determine WRA effectiveness
• Optimal WRA structure or calibration may differ, depending on objective

Increasing subjectivity?

severe

negligible
Australia/New Zealand
Weed Risk Assessment System

49 questions
- climate/distribution
- domestication
- weed elsewhere
- undesirable traits
- plant type
- reproduction
- dispersal
- persistence attributes

Prediction

Score 1-6 evaluate
< 1 not a pest
> 6 pest
Issues

Weed elsewhere?

• Four “weed elsewhere” questions have a major impact on WRA scores

• Someone called it a weed? (e.g. on a website)
• Someone labeled it as “invasive”? 
• The species is listed in a weed book?

Premise: Behavior elsewhere might predict behavior in Hawai‘i
Issues  Weed elsewhere?

3.02  *Garden/amenity/disturbance weed* -- an intrusive weed

3.03  *Weed of agriculture/horticulture/forestry* -- causes productivity losses and/or costs due to control

3.04  *Environmental weed* -- documented to alter the structure or normal activity of a natural ecosystem

3.05  *Congeneric weed*  

Up to 12 points total
Problems with “weed” references

“Weeds of the United States and Their Control”

“In some cases, a plant is a weed just because it does not have proper aesthetic value”

“Monocot Weeds3”

“In this volume are treated the adventive members of nine families”

Ruderal life history ≠ Economic or intrusive impacts
Endemic to Hawai‘i, “rare to extremely rare” NatureServe Rank G2 (Imperiled)

“found in arid, rocky regions”

*Ipomoea tuboides*
A Geographical Atlas of World Weeds
Holm (1979)

Weed elsewhere?

- “sparingly naturalized”
- one known location

Serious weed ✓
Principle weed ✓
Common weed
Present (rank of importance unknown)
Flora (confirming evidence needed)

Dianthus armeria
Issues Weed elsewhere?

Problems with “environmental weed” references and websites

Criteria for listing not provided

Naturalization $\neq$ Environmental weed (e.g. decreased native biodiversity)
Issues

Weed elsewhere?

Misinterpretation of website intent seems common

Institute of Pacific Islands Forestry

Pacific Island Ecosystems at Risk (PIER)

Plant threats to Pacific ecosystems

Plant Threats to Pacific Ecosystems

“invasive and potentially invasive plant species”
Issues Weed elsewhere?

“A global compendium of weeds” (Randall 2002)

We don’t use it to answer “weed elsewhere” questions in WRA.

• Useful for identifying references to be checked
Weed elsewhere?

Why not just be “conservative”?

A Geographical Atlas of World Weeds

Inflated Scores, False positives

Increasingly problematic

Potential WRA uses

Education
Identifying low risk alternatives
“Buy-in” from industry groups
Pressure growers to destroy stock
Declare as noxious
Deny entry
Weed elsewhere?

Why not just be “conservative”?

**IPPC Guidelines**

“The whole process from initiation to pest risk management should be sufficiently documented so that when a review or a dispute arises, the sources of information and rationale used in reaching the management decision can be clearly demonstrated.”

p. 133

INTERNATIONAL STANDARDS FOR PHYTOSANITARY MEASURES (ISPM No. 11)

Joe’s website list

Intrusive
Economic harm
Documented ecological harm
Issues: Evaluating retrospective tests

WRA scores versus actual plant behavior

% correct decisions
Issues: Evaluating WRA decisions

• Compared H-WRA decisions with 25 expert opinions

The expert evaluators:

• botanists/weed scientists
• first hand knowledge of weeds in Hawai‘i and other Pacific Islands
• native ecosystems
• managed ecosystems
Question to Experts

What is the plant’s current status?

- not a pest (but present)
- minor pest (minor economic/ecological harm)
- major pest (major economic/ecological harm)
Evaluating the H-WRA decisions

Species classification based on the expert surveys

- individual opinions varied
- differences in personal experience

**Classification criteria**

- **Major pest** -- at least 3 experts agreed
- **Minor pest** -- at least 3 experts agreed (but not a major pest)
- **Not a pest** -- all other species (with at least 3 evaluations)
<table>
<thead>
<tr>
<th></th>
<th>Major pests admitted (%)</th>
<th>Minor pests admitted (%)</th>
<th>Nonpests admitted (%)</th>
<th>Evaluate further (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-WRA + 2nd screen (3 agree)</td>
<td>5</td>
<td>33</td>
<td>92</td>
<td>8</td>
</tr>
<tr>
<td>1 agree</td>
<td>22</td>
<td>73</td>
<td>98</td>
<td>8</td>
</tr>
<tr>
<td>Pest elsewhere criterion alone (1 agree)</td>
<td>18</td>
<td>24</td>
<td>86</td>
<td>0</td>
</tr>
</tbody>
</table>
Weed problems

- Weed?
- Weed elsewhere?
- Weed here? [testing, calibration]
Risk: Likelihood and Consequences

Risk = Likelihood (Consequences) X Consequences

• Perhaps the most widely used formulation

Hypotheses: Separation of WRA score into L and C components will

• Reveal new patterns
• Improve separation of pests and non-pests
• Reduce “evaluate further”
Risk: Likelihood and Consequences

**Risk = Likelihood** \(\text{(Consequences)}\) \(\times\) Consequences

A function of a plant’s ability to succeed when introduced (naturalize, spread, invade)

“Invasiveness”

The (usually negative) economic, environmental and/or social effects of a weed

Impacts
Risk: Likelihood and Consequences

Partition of WRA scores into C and L elements

**Examples**

3.01 Naturalised beyond native range? \( L \)

4.01 Produces spines, thorns or burrs? \( C \)

4.12 Forms dense thickets? \( C \)

7.01 Propagules dispersed unintentionally? \( L \)

8.01 Prolific seed production? \( L \)
Risk: Likelihood and Consequences

Impacts

Consequences questions
Range
–1 to 21

Likelihood questions
– 26 to 36

“Invasiveness”

Scaled
0 to 10
Hypothesis: Separation of L and C will reveal new patterns

Risk: Likelihood and Consequences

Likelihood ("invasiveness")
- Minor pests
- Non-pests
- Major pests
- mixed

Consequences
Risk: Likelihood and Consequences

Likelihood ("invasiveness")

Consequences

- **major**
- **minor**
- **non-pest**
Hypothesis: Separation of L and C will reveal new patterns

Risk: Likelihood and Consequences

Likelihood
("invasiveness")

Consequences

Minor pests
Major pests
Non-pests
mixed
Original WRA versus LxC

Discriminant analysis

Identifies a discriminant function (“break-point”) that maximizes correct classification of pre-defined groups

Major versus minor pests

- 65% of data used for training
- Prediction based on remaining 35%
Risk: Likelihood and Consequences

Discriminant analysis: Major versus minor pests

- Impact not useful for discrimination
- Major pests have higher Likelihood scores

% correct
Major 68
Minor 69
P = 0.0002
Hypothesis:

Reformatting the WRA score as

\[ \text{Risk} = \text{Likelihood}(\text{consequences}) \times \text{Consequences} \]

Could:

- Improve separation of pests and non-pests
- Reduce evaluate further category
Original WRA scores versus Multiplicative Risk scores (LXC)
Discriminant analysis

Identifies a discriminant function ("break-point") that maximizes correct classification of pre-defined groups

Pests versus non-pests

No "evaluate further" category

- 65% of data used for training
- Prediction based on remaining 35%
Risk: Likelihood and Consequences

Discriminant analysis

<table>
<thead>
<tr>
<th>WRA score</th>
<th>C*L(C)</th>
<th>C, L(C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pests</td>
<td>81.8</td>
<td>91**</td>
</tr>
<tr>
<td>Non-pests</td>
<td>78.2</td>
<td>78.2</td>
</tr>
<tr>
<td>Overall</td>
<td>80.2</td>
<td>85.8</td>
</tr>
</tbody>
</table>

**P<0.01
Summary of issues

• Defining what we want to screen out

• Consistent and accurate answers to “weed elsewhere?”

• Narrowing the “evaluate further” category

• Formulation as Risk = Likelihood x Consequences
Q: What is an invasive species?
A: Invasive species are those which spread from human settings (gardens, agricultural areas, etc.) into the wild.

Rod Randall's Big Weed List

Q: What if a plant is… on this list?
A: “…one of the best predictors of a plant's invasiveness in a specific area is whether it has been observed as being invasive in other areas ... So if a plant is included on this list (and especially if it is listed multiple times), it may be wise to consider the plant to be a potential invader.

"Arable Weeds of the World"
“USA Composite List of Weeds” (WSSA 1966)
“Western Australian Prohibited List”
Issues

“This system is critically flawed”

Doesn’t take into account

• Economic benefits
• Cultural benefits
• Health benefits
• Ecological benefits

Etc.
Further assessment
(species scoring between 1 and 6)

<table>
<thead>
<tr>
<th>Tree/ tree-like shrub</th>
<th>Herb or low stature shrubby life form</th>
</tr>
</thead>
<tbody>
<tr>
<td>A) Shade tolerant OR known to form dense stands; AND B) Bird- OR clearly wind-dispersed</td>
<td>Reported as a weed of cultivated lands?</td>
</tr>
<tr>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Life cycle &lt; 4 years?</td>
<td>unpalatable to grazers OR known to form dense stands</td>
</tr>
<tr>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>yes</td>
<td>evaluate further</td>
</tr>
<tr>
<td>no</td>
<td>evaluate further</td>
</tr>
</tbody>
</table>

**Not a pest**

VINES -- must pass both tests

Daehler et al. 2004 *Cons Biol* 18:360-368.
Australia/New Zealand
Weed Risk Assessment System

49 questions
- climate/distribution
- domestication
- weed elsewhere
- undesirable traits
- plant type
- reproduction
- dispersal
- persistence attributes

Score
- 1-6 evaluate
- < 1 not a pest
- > 6 pest

25-30% “Evaluate further”
## WRA decision versus expert classifications

<table>
<thead>
<tr>
<th>Native and/or managed ecosystems</th>
<th>Major pests admitted (%)</th>
<th>Minor pests admitted (%)</th>
<th>Nonpests admitted (%)</th>
<th>Evaluate further (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H-WRA NO 2nd screen</strong></td>
<td>5</td>
<td>26</td>
<td>66</td>
<td>24</td>
</tr>
<tr>
<td><strong>H-WRA + 2nd screen</strong></td>
<td>5</td>
<td>36</td>
<td>92</td>
<td>8</td>
</tr>
<tr>
<td>Pest elsewhere criterion alone</td>
<td>18</td>
<td>24</td>
<td>86</td>
<td>0</td>
</tr>
</tbody>
</table>