Cost-sensitive risk assessment for invasive plants in the United States

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October, 2011

Setting

- Intentional global movement of non-indigenous species

- Screening international plant trade for invasive species risk
  - Leaders: Australia, New Zealand, South Africa
  - Laggard: U.S.

Risk assessment of potential plant trade

- Policy goal:
  - balance trade benefits with invasion risk
- Research goal:
  - integrate statistical and decision components
- Results:
  - Estimated net benefits from screening species for invasive species risk are substantial.

Existing approaches

- Australian Weed Risk Assessment (WRA) model (Pheloung et al. 1999).
  - Make decisions on proposed imports based on inference from a previously assembled training data set
  - Makes extensive use of expert assessments
  - Ease of use
  - Transparent process
    - though not necessarily in value judgments of where to draw the cutoff
  - Not based on formal statistical or economic foundations (Caley et al. 2006)

Essential elements

- Decision theoretic framework
- Attribute-based statistical-ecological model of invasion threat
  - Use a training data set on invaders/non-invaders to parameterize a prediction model
- Welfare estimates
  - Trade benefits
  - Losses from invasion

Decision framework

- p: estimated probability that a species is invasive
- U: utility of an action (ban or accept) given the true nature of the species (invasive, non-invasive).

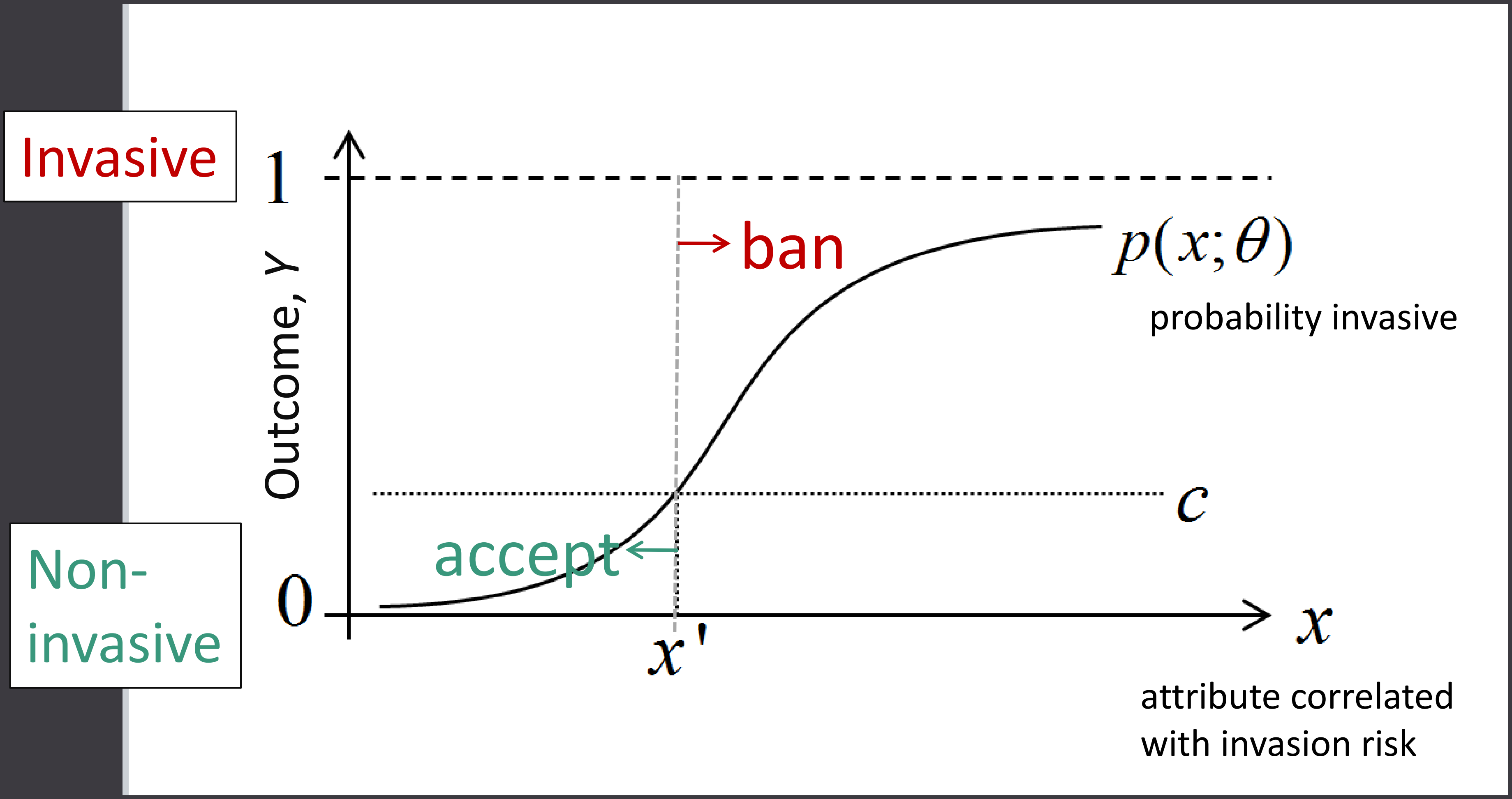
It is optimal to ban a proposal when:

Expected utility of ban > *Expected utility of accept*

$$\left\{ p \cdot U(\text{ban},\text{invasive}) + (1-p) \cdot U(\text{ban}, \text{non-invasive}) \right\} > \left\{ p \cdot U(\text{accept},\text{invasive}) + (1-p) \cdot U(\text{accept}, \text{non-invasive}) \right\}$$

$$p > \frac{[U(\text{a},\text{n}) - U(\text{b},\text{n})]}{[U(\text{a},\text{n}) - U(\text{b},\text{n})] + [U(\text{b},\text{i}) - U(\text{a},\text{i})]} = c$$

Decision structure



Decision framework

Optimal to ban a proposal when:

$$p > \frac{[U(a,n) - U(b,n)]}{[U(a,n) - U(b,n)] + [U(b,i) - U(a,i)]}$$

$$= \frac{V_T}{V_T + [V_I - V_T]} = \frac{V_T}{V_I}$$

V_T: trade benefits

(assured w/trade)

V_I: invasion losses

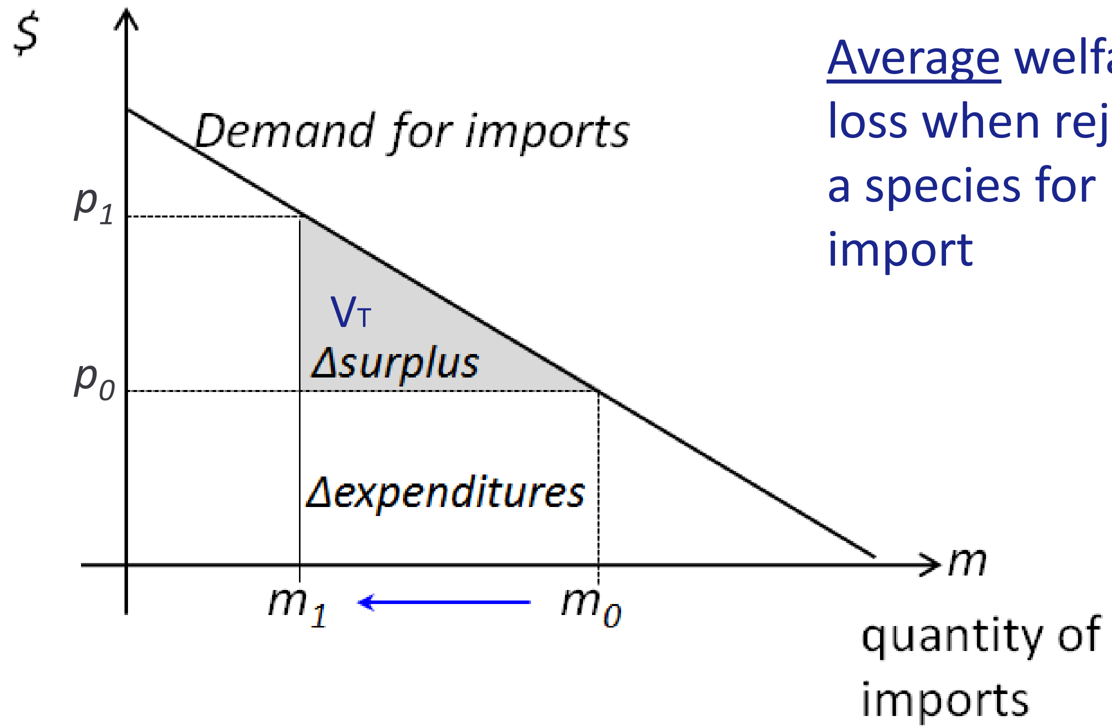
(occur with prob. *p*)

→ It's optimal to reject a proposal when the likelihood of invasion exceeds the ratio of trade benefits to invasion losses.

V_T: Welfare benefits of trade

V_T: \$281K-410K

<u>Average</u> welfare loss when rejecting a species for import



p: invader probability

- Fit a model for *p* using a "training data set":
  - Plants National Database: 4,953 species (non-native; native and also identified as a pest). 22.4% are weeds
- Regression tree: recursive partitioning of explanatory variables → each branch terminates in a classification: "weed", "not weed"

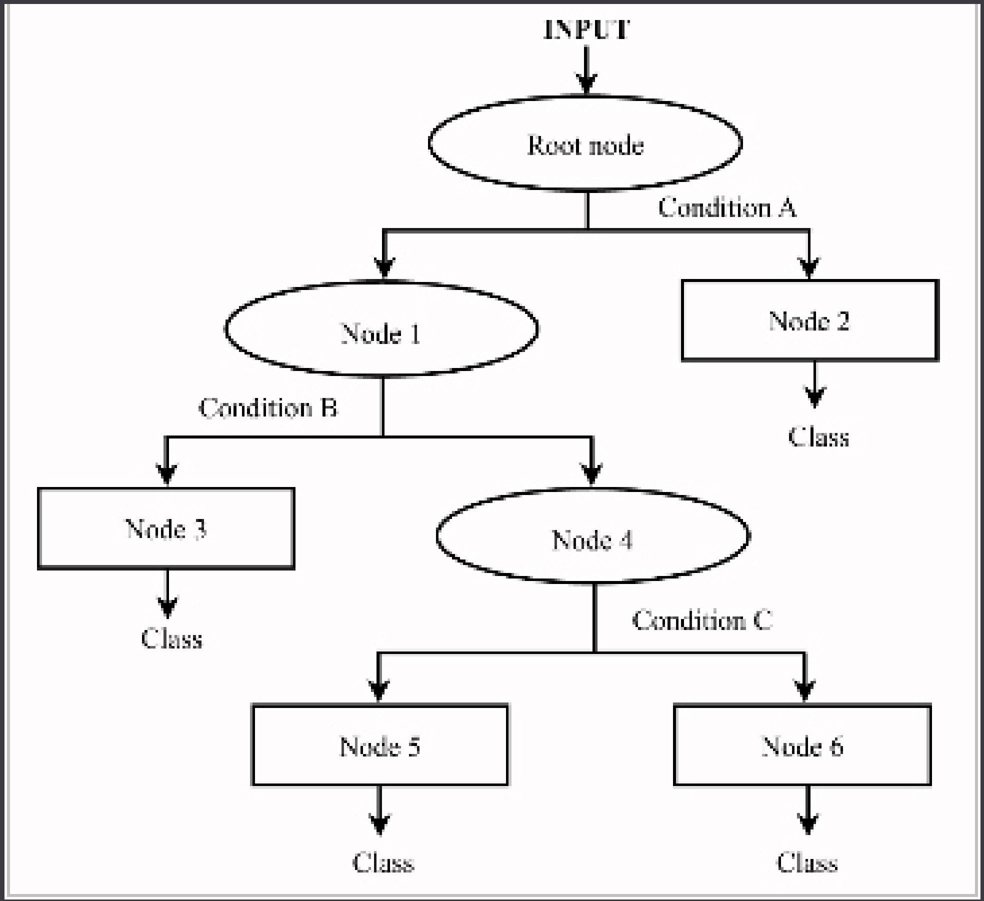


Figure from: **Rokhmatuloh 2007**

Results

V_T trade benefits		V_I invasion losses	$V_T/V_I = c$ max risk	True Positive Rate	False Positiv e Rate	Expected NB, per species
High	\$410K	\$9,320K	0.04	0.59	0.23	\$140K
Low	\$281K	\$6,391K				\$100K

Proportion of species successfully as weed or non-weed (accuracy): 75%

Summary

- Framework:
  - decomposes a complex risk management argument
  - enhances transparency of decision drivers
- Predictive models:
  - imperfect but beneficial
- Further research needs:
  - more comprehensive assessments of welfare impacts; particularly losses from invasion.