Determinants and Welfare Implications of Noxious Weed Regulations

Final Report

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Project Output

- Ph.D. Dissertation by He Min, August 2007
  - (Major Professor: Munisamy Gopinath)

- Three Essays of the Dissertation
  - Rent-Seeking in Invasive Species Regulation: The Case of Noxious Weeds (Forthcoming *Land Economics*)
  - Technical Barriers to Inter-State Trade: The Case of Noxious Weed Regulations (Under Review)
  - Noxious Weeds' Listing Time: The Role of Invader Characteristics and Ecosystem Invasibility (Under Review)

Research Background

- Many non-native species pose serious threats to the U.S. environment, agricultural production and exports.
- The monetary cost associated with biological invasions is more than $100 billion a year, about a third of it arising from noxious-weed damages.
- Invasive weeds are spreading at the rate of 3 million acres per year in the United States.

Noxious Weed Regulations
(Noxious weed list & Noxious weed seed list)

- Federal Regulations
  - Federal Seed Act and Amendments - Federal Noxious Weed Seed List
  - Plant Protection Act - Federal Noxious Weed List
- State Level Regulations
  - State Noxious Weed Seed List (FSA Provision)
  - State Noxious Weed List (PPA Provision)

Size and Compositional differences in State Noxious Weed Regulations

Figure 1a: Size Differences in State Noxious Weed Regulation, 2002

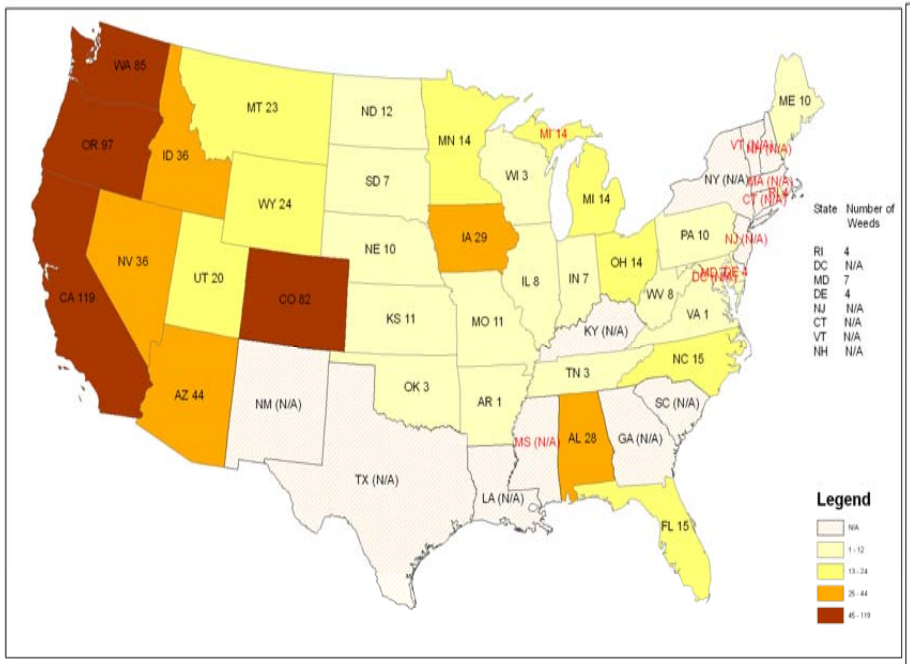
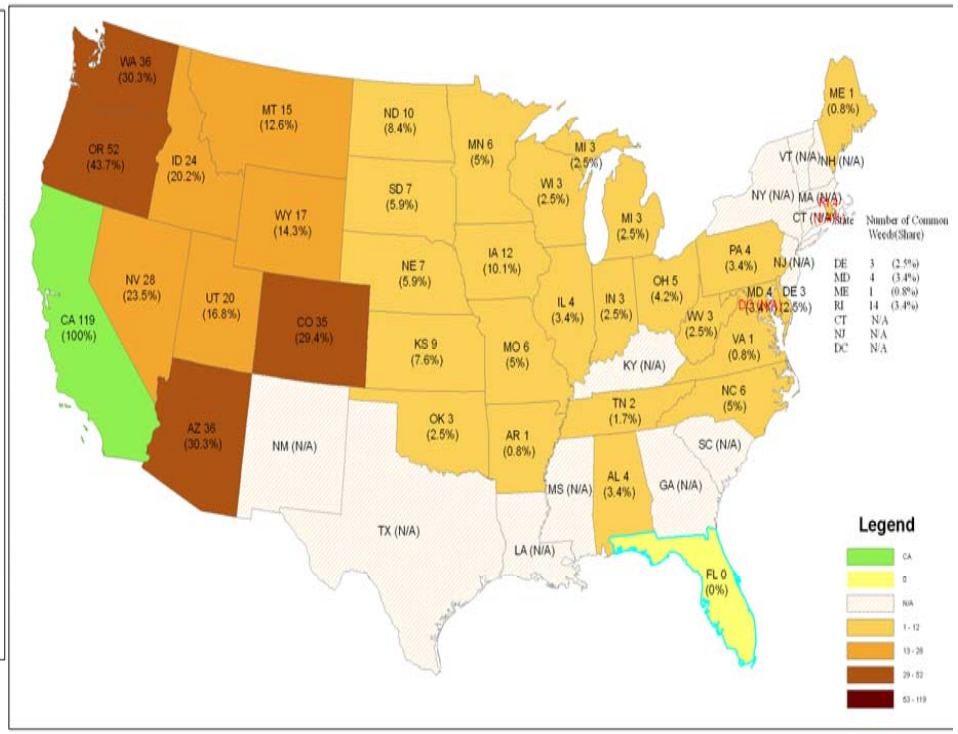
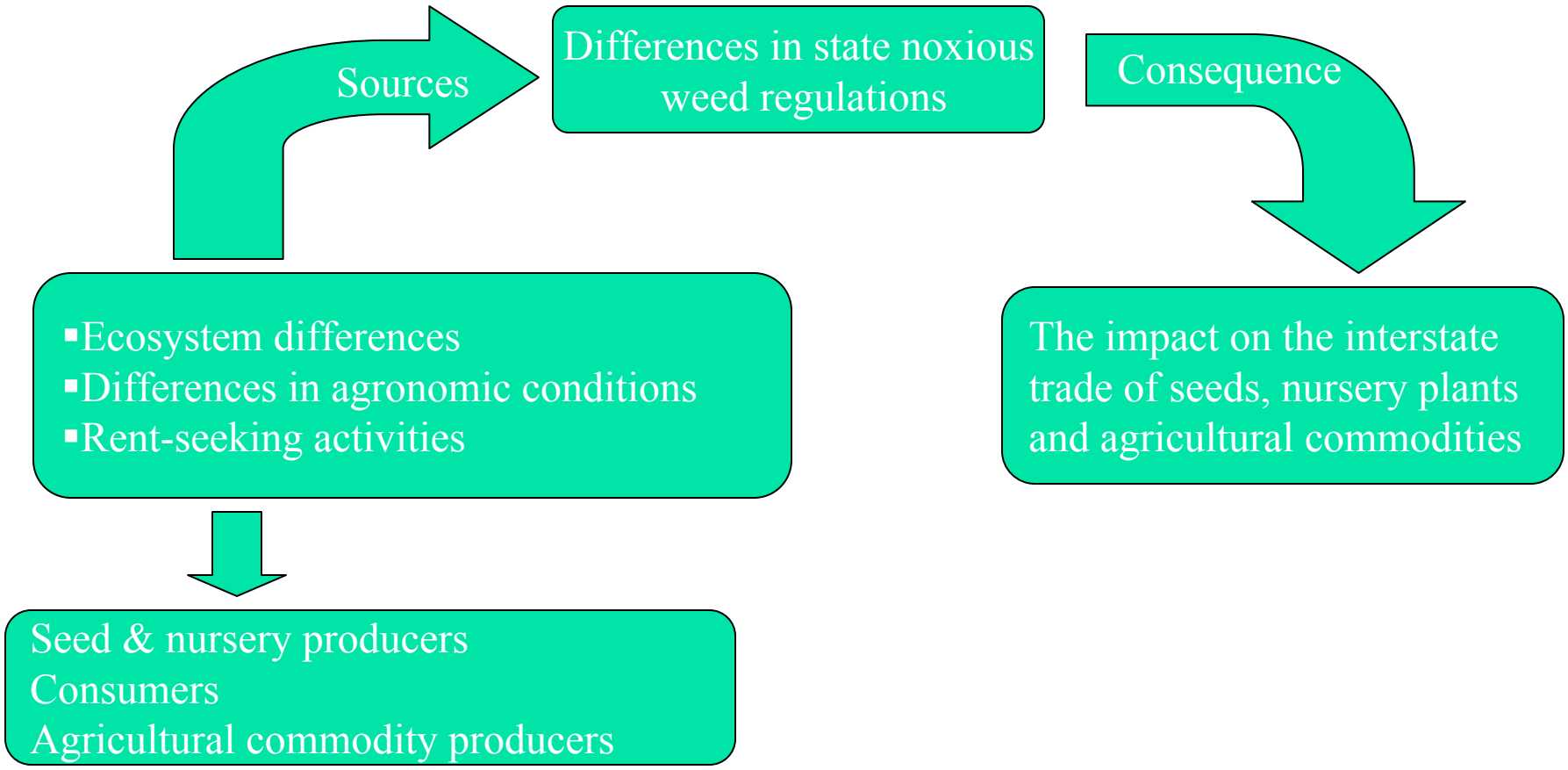


Figure 1b: Compositional Differences in State Noxious Weed Regulation, 2002



Research Framework



Rent-Seeking in Invasive Species Regulation: The Case of Noxious Weeds

Research Methods

- Weed list as the consequence of the interplay of the supply and demand for invasive species (IS) protection.
- Demand side
  - Protection for local eco-system
  - Interest groups view weed regulations as a way to increase private rents.
- Three economic interest groups
  - Seed Producers: price-enhancement and agronomic protection effects.

    $\pi_s[p_s(L), \mathbf{W}_s, L, \mathbf{A}]$ $\quad \frac{d\pi_s}{dL} = \frac{\partial \pi_s}{\partial p_s}\frac{\partial p_s}{\partial L} + \frac{\partial \pi_s}{\partial L}$
  - Commodity producers: market-price and agronomic protection effects.

    $\pi_m[p_m, p_s(L), \mathbf{W}_m, L, \mathbf{A}]$ $\quad \frac{d\pi_m}{dL} = \frac{\partial \pi_m}{\partial p_s}\frac{\partial p_s}{\partial L} + \frac{\partial \pi_m}{\partial L}$
  - Consumers : market-price and ecosystem preference effects

    $V[p(L), Y, L, \mathbf{I}]$ $\quad \frac{dV}{dL} = \frac{\partial V}{\partial p}\frac{\partial p}{\partial L} + \frac{\partial V}{\partial L}.$
- Supply side: Policymakers

Research Method (Continued)

State *i*'s choice of *L* depends on state *j*'s choice because the extent of any similarity in the two states' lists affects the competitive framework in both states. Social planner's problem for *i*-th and *j*-th states

$$G^i(L_{ij}) = \max_{L_{ij}} \left\{ B(L_{ij}; L^*_{ji}, \mathbf{I}_{ij}, \mathbf{A}_{ij}, \omega^c_{ij}, \omega^s_{ij}, \omega^m_{ij}) - C(L_{ij}; L^*_{ji}, \mathbf{I}_{ij}, \mathbf{A}_{ij}, \omega^c_{ij}, \omega^s_{ij}, \omega^m_{ij}) \right\}$$
$$G^j(L_{ji}) = \max_{L_{ji}} \left\{ B(L_{ji}; L^*_{ij}, \mathbf{I}_{ji}, \mathbf{A}_{ji}, \omega^c_{ij}, \omega^s_{ij}, \omega^m_{ij}) - C(L_{ji}; L^*_{ij}, \mathbf{I}_{ji}, \mathbf{A}_{ji}, \omega^c_{ij}, \omega^s_{ij}, \omega^m_{ij}) \right\} \quad (1)$$

A Nash-type solution for regulatory overlap.

Regulatory Congruence $L_{ij} = L_{ij}(\mathbf{I}_{ij}, \mathbf{A}_{ij}, \omega^{ij}_c, \omega^{ij}_s, \omega^{ij}_m)$

The similarity between any two states' weed regulations is a function of

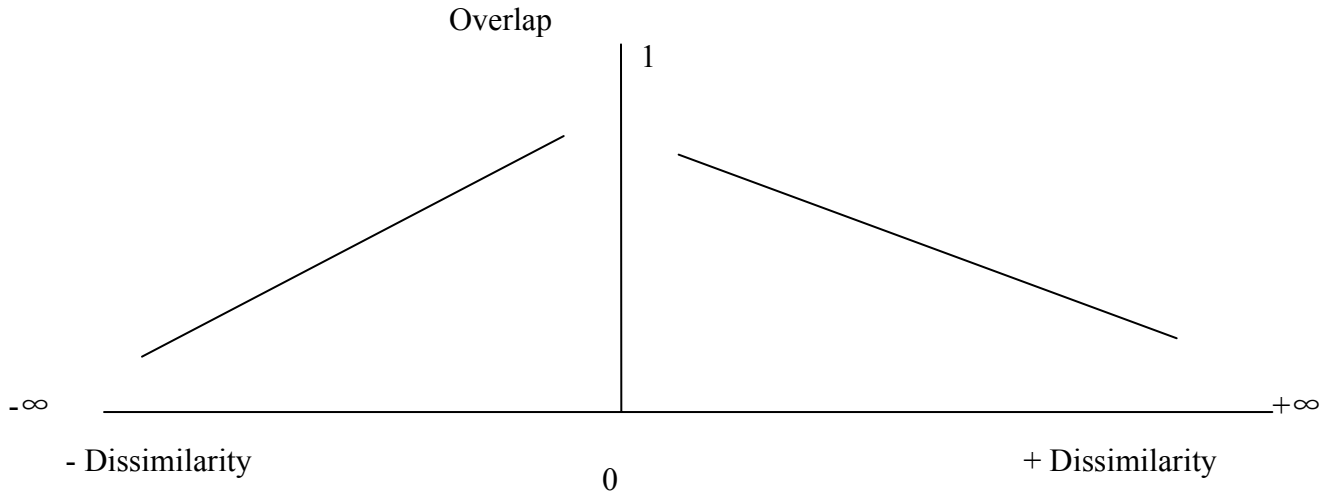
- Dissimilarities of ecosystem ***Iij***
- Dissimilarities of agronomic characteristics ***Aij***
- Dissimilarities of stakeholder lobbying efforts $(\omega^{ij}_c, \omega^{ij}_s, \omega^{ij}_m)$

Data

- Dependent Variable:
  - Weed Regulatory Congruence: L_{ij}
- Independent Variables:
  - Indexes of Ecosystem Dissimilarities $\mathbf{I}_{ij}$ (7 variables)
  - Indexes of Agronomic Dissimilarities Aij
    - Irrigated land share of total (state) cropland.
    - Wheat, corn, and other field crop land share of total cropland
  - Indexes of Lobbying Dissimilarities
    - Commodity producers' contribution share of total state contribution.
    - Seed producers' contribution share of total state contribution.
    - Consumers' contribution share of total state contribution.

Results

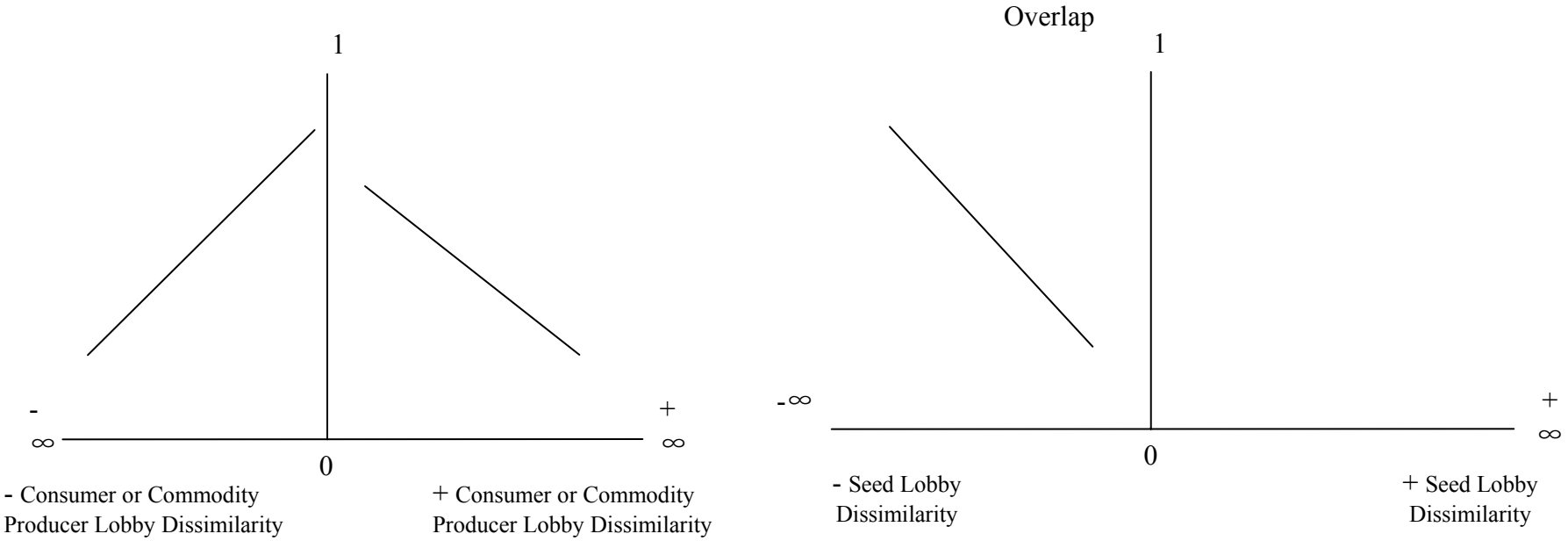
Ecological and Agronomic Dissimilarities and Regulatory Congruence



Larger ecological and agronomic dissimilarities between states lead to lower regulatory congruence.

Results (continued)

Lobbying Dissimilarities and Weed Regulatory Congruence



Seed producers favor more uniform weed regulations across states

Commodity producers and consumers prefer state-specific lists

- Technical Barriers to Inter-state Trade: The Case of Noxious Weed Regulations

Theoretical Framework

Three Agricultural Products: Seeds, Nurseries, Agricultural commodities (e.g. wheat, corn)

(Agricultural commodities are final goods, seeds are inputs in the production of agricultural commodities, and nurseries are not only final goods but also inputs for producing some agricultural commodities)

Profit function of Seed producers: $\pi_s^i [p_s(L_{ij}^*), \mathbf{W}_s^i, L_{ij}^*, \mathbf{A}^i]$,

→ Supply of seeds and Commodities (Hotelling's Lemma)

Profit function of Agricultural commodity producers: $\pi_m^i [p_m, p_s(L_{ij}^*), \mathbf{W}_m^i, L_{ij}^*, \mathbf{A}^i]$

→ Demand of seeds and Nurseries

Profit function of Nursery producers: $\pi_n^i [p_n(L_{ij}^*), p_s(L_{ij}^*), \mathbf{W}_n^i, L_{ij}^*, \mathbf{A}_n^i]$

→ Supply of Nursery plants

Indirect utility function of consumers: $V^i [p_m, Y^i, L_{ij}^*, \mathbf{I}^i]$

→ Demand of commodities and Nursery plants

Trade Flow of each goods = (supply-demand): $Q_{ij} = Q_{ij}(L_{ij}^*, \mathbf{T}_{ij})$ (2)

$$Q_{ij} = h(L_{ij}^*(\mathbf{I}_{ij}, \mathbf{A}_{ij}, \omega_{ij}^c, \omega_{ij}^s, \omega_{ij}^m), \mathbf{T}_{ij}), \quad \forall i, j \qquad (3)$$

Data

- Dependent Variables:
  - Exports of seeds or nursery plants or agricultural commodities
- Independent Variables:
  - Regulatory congruence (weed list or weed seed list or both)
  - Per Capita personal income
  - Land-labor ratio
  - Border effect
  - Distance

Econometrics

- Three issues:
  - Censored dependent variable
  - Spatial dependency of errors
  - Endogeneity

Spatial autoregressive tobit model

$$Q_{ij} = \alpha_0 + \beta_1' \hat{L}_{ij}^* + \beta_2' T_{ij} + \mu_{ij}$$

$$Q_{ij} = 0 \quad if \ Q_{ij}^* \le 0$$

$$Q_{ij} = Q_{ij}^* \quad if \ Q_{ij}^* > 0$$

$$\mu = \lambda \mathbf{W} \mu + \varepsilon \qquad \varepsilon \sim N(0, \sigma^2)$$

EM Algorithm (Expectation-Maximum Likelihood)

- E-step: $E[Q_{ij}^* \mid Q_{ij} = 0] = x_{ij}\beta - \sigma_{ii} \dfrac{\phi(x_{ij}\beta / \sigma_{ii})}{1 - \mathbf{\Phi}(x_{ij}\beta / \sigma_{ii})}$
- M-step: $Ln(L) = -(n/2)(\ln \sigma^2 + \ln(2\pi)) + \ln |\mathbf{I} - \lambda \mathbf{W}| - (1/2)(\mathrm{Q} - \mathbf{X}\beta)' \Omega^{-1} (\mathrm{Q} - \mathbf{X}\beta)$

Stage1: Estimating λ

Stage2: Using λ to transform equation: $(\mathbf{I} - \lambda \mathbf{W})\mathbf{Q} = (\mathbf{I} - \lambda \mathbf{W})\mathbf{X}\beta + \varepsilon$

Results

- Noxious weed regulatory congruence has a positive impact on interstate trade of seeds, nursery plants and agricultural commodities.

- Inter-state trade distortion arising from consumer and commodity lobbies is about $1.1 billion in 2002. (Consumers and Agricultural commodity producers lobby for lower regulatory congruence)

- Noxious Weeds' Listing Time: The Role of Invader Characteristics and Ecosystem Invasibility

Theory

- What factors affect when a weed species on one state's (leader) regulation is added to that of another (follower) state?
- Leader: California
  - The most stringent noxious weed regulations among U.S.
  - Geographic position
  - Relatively high inter-state and international trade
- Follower: 47 contiguous states

- Ordered logit model of listing time

Results

- The similarity of soil type and average temperature between California and a follower-state also increases the likelihood of early addition of a species to the follower's NXWS list.
- The species attributes have a significant effect on the listing time of a weed species.
  - A species with strong innate reproductive potential and ecological impacts is more likely to be added to follower's list early.
- With an increase in the distance between a state and California, the species is more likely to be added later to the former's list.
- A species which is already in a state is more likely to be added earlier than later to its list.
- A species' status has the largest impact on noxious weeds' listing time.

Project's Overall Findings

- Differences in ecosystem and agronomic characteristics cause substantial cross-state variation in noxious weed regulations.
- Interest groups' lobbying has a statistically and economically significant effect on the cross-state differences in weed regulations.
- Noxious weed regulatory congruence has a positive and significant effect on inter-state agricultural trade.
- The trade distortions caused by consumers and commodity producers lobby are estimated to be about $1.1 billion in 2002
- A species status and its characteristics play an important role in determining the listing time of the species
- A species already present in a state has the most influence on the listing time.

Policy Implications

- A greater participation of weed scientists and biologists in state noxious weed boards is helpful in minimizing trade distortions caused by interest groups.
- Policies must be based on scientific principles
  - The level of protection must be appropriate to the documented risks and can not unduly restrict trade
- Policy makers should not only focus on species already in a state, but also pay attention to potential invaders.

Data

Ecosystem data based on Bailey's Classification