

# Economic issues & invasive species

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## On-going research with:

- Ed Barbier, Wyoming
- Michael Margolis, Oberlin
- David Lodge and colleagues, Notre Dame
- David Finnoff, Wyoming
- Greg Parkhurst, Mississippi State
- Chad Settle, Tulsa
- Brian Leung, McGill
- Jean-Daniel Saphores, UC-Irvine
- Chris McIntosh, Wyoming
- Xiufen Wu, Wyoming



# Issues

- Risk
- Incentives
- Valuation
- Prosperity
- Mindsets



# Risk

- “Best practice” measures—prevention, eradication, and control
- Bioeconomics & joint determination
- Behavioral considerations



# Endogenous risk

$$\begin{aligned} \text{Max}_{x,Q} \int_a^b & [p(Q; \theta)V_0(m - c(x, Q)) \\ & + (1 - p(Q; \theta))V_1(m - D(x; \theta) - c(x, Q))]dF(\theta; \beta) \end{aligned}$$

## Key notions:

- Risk and its consequences
- Bioeconomic risk assessment
- Portfolio of risk reduction mechanisms
- Mitigation and adaptation and insurance
- Prevention and control
- Stocks and flows can be added

- Captures risk-benefit tradeoffs and feedbacks
- Stresses that management priorities depend on:
  - \***Tastes** of the manager
    - over time and risk bearing
  - \***Technology** of risk reduction
    - prevention, control, and adaptation

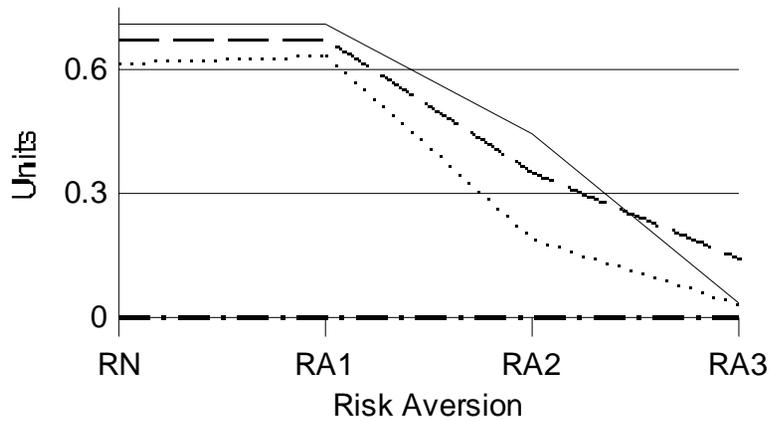
- Precautionary principle
  - To economists, we hear PP and we think *risk aversion*.
  - It is an assumption on how people might react to risk
  - To biologists, PP not an *assumption* rather it is an *outcome—long term protection of the environment*
  - PP: to look forward with purpose

# Zebra mussel example

- Four managers who differ by risk preferences (RN, RA1, RA2, RA3)
- Choice of prevention or control or both
- Probability of invasion
- Welfare
- Ambiguous comparative statics

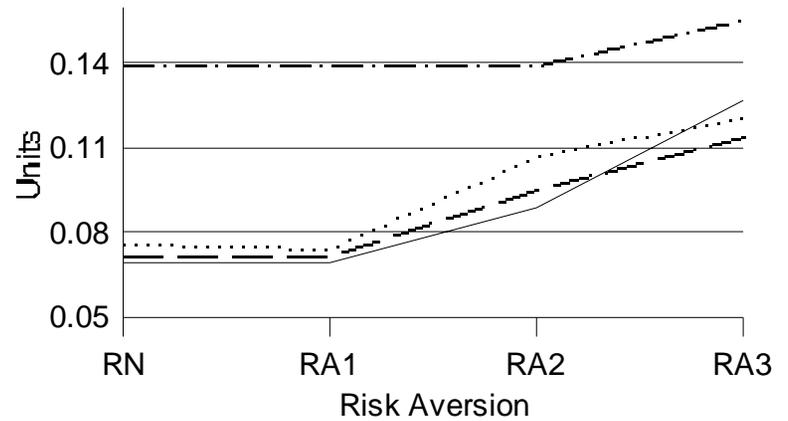
# Simulation Results 1

## Mean Annual Collective Prevention



— 0%      - - - 3%  
..... 5%      - · - · 15%

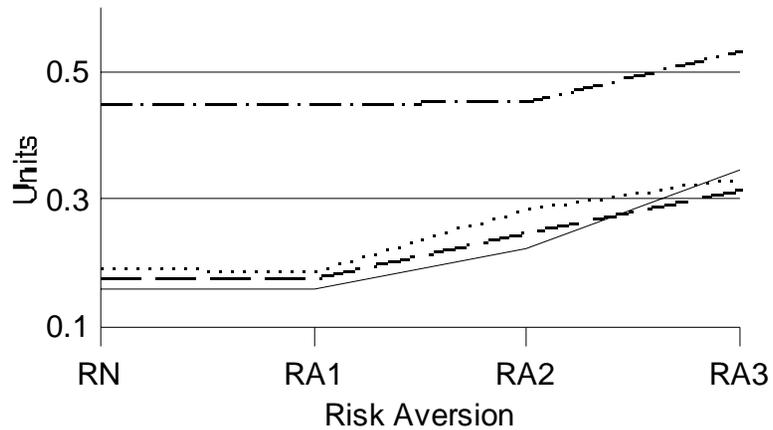
## Mean Annual Collective Control



— 0%      - - - 3%  
..... 5%      - · - · 15%

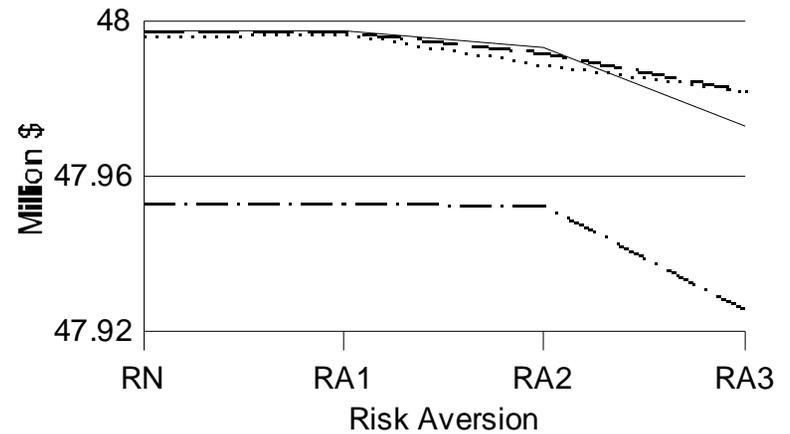
# Simulation Results 2

## Mean Annual Probability of Invasion



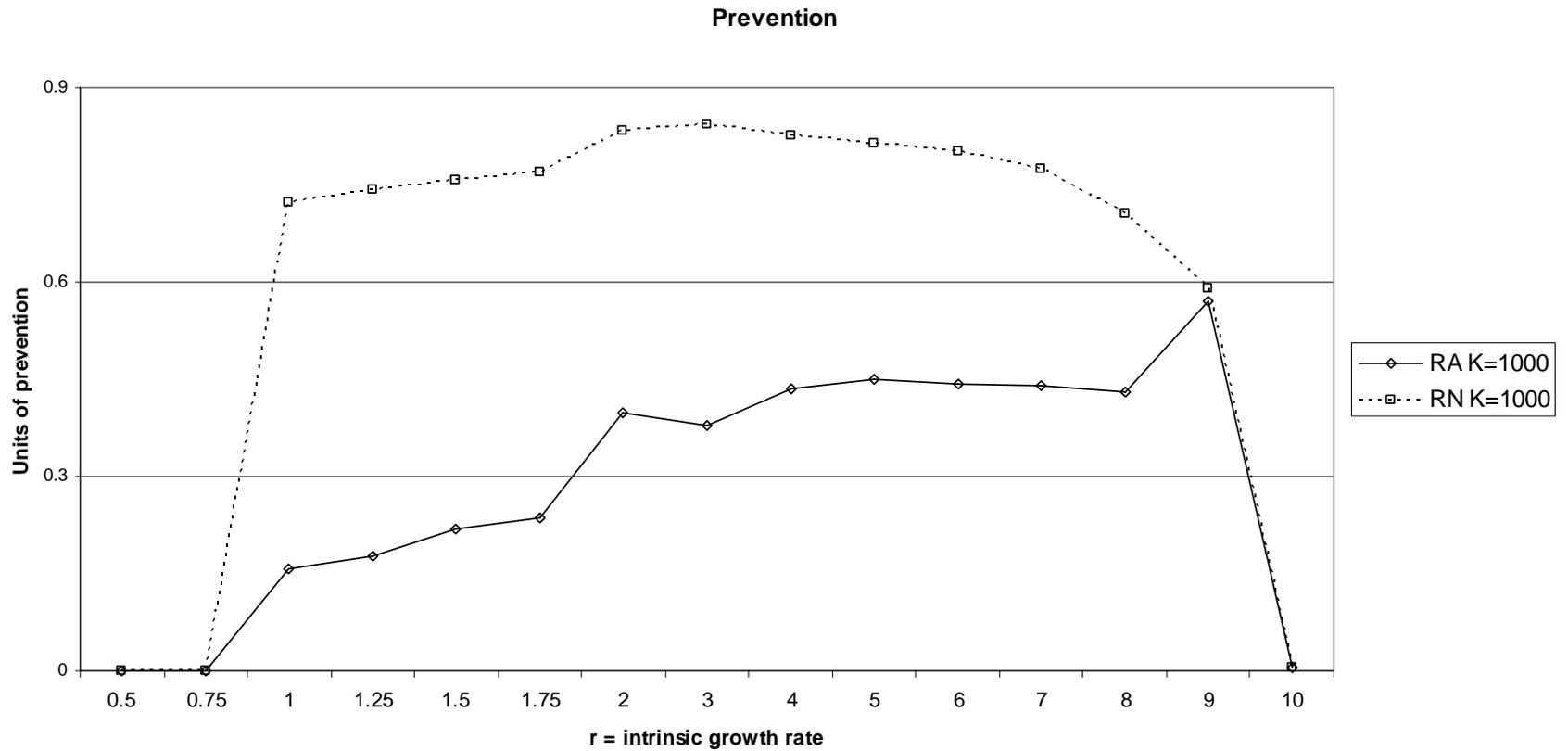
————— 0%      - - - - 3%  
 ..... 5%      - · - · - 15%

## Mean Annual Welfare



————— 0%      - - - - 3%  
 ..... 5%      - · - · - 15%

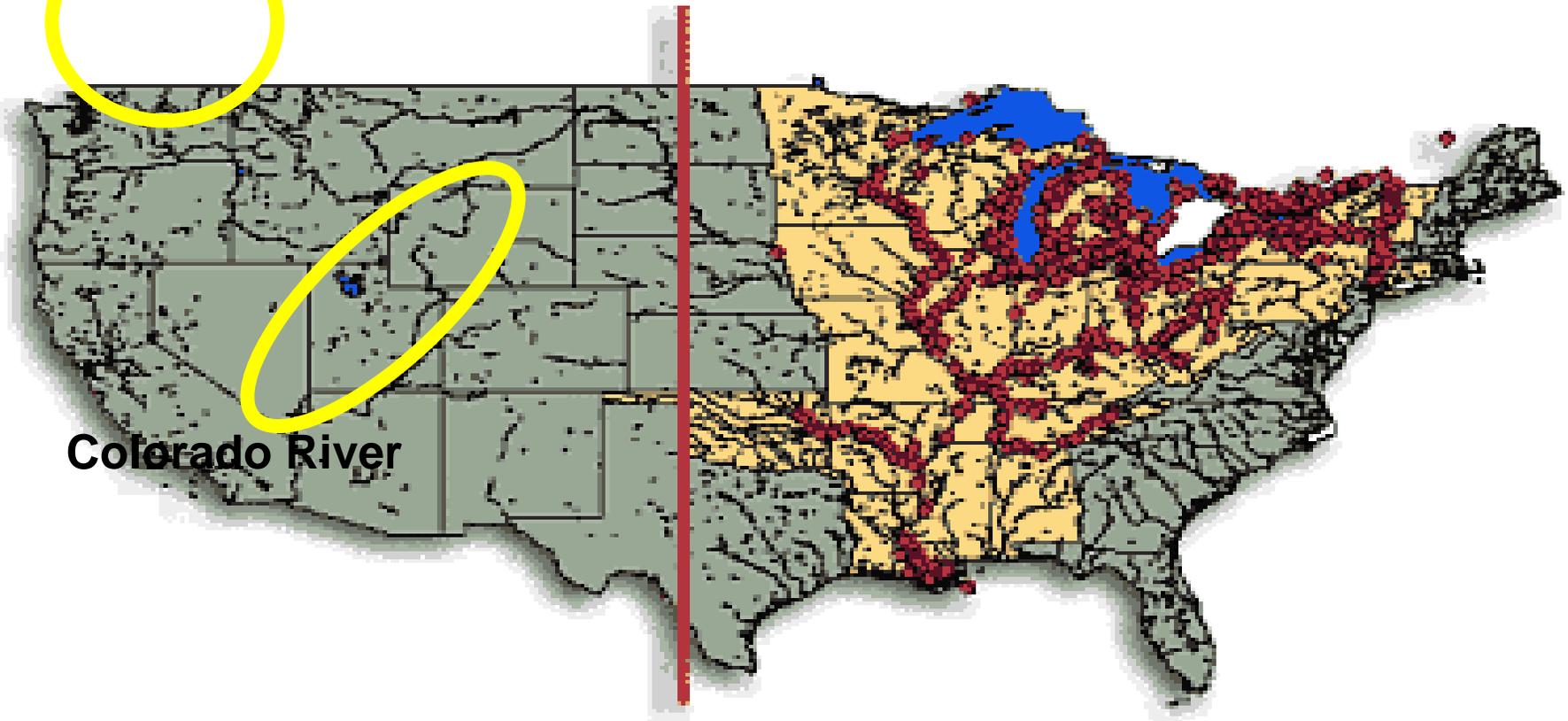
# Prevention by growth rate



# Value of preventing spread?

Columbia River

**2000 Zebra Mussel Distribution**



Colorado River

● = confirmed zebra mussel sightings from 1988 to 2000

# Real Option Theory

- Most investment decisions share 3 characteristics:
  - *Irreversibility.*
  - *Uncertainty.*
  - *Flexibility in selecting the timing of the investment.*
- The real options framework (see Dixit and Pindyck 1994) models investment decisions as **call options** (as in finance), that give the right (but not the obligation) to invest in a particular action.
- Such an approach has the potential for widespread applications to problems in resource and environmental economics.

# GEEM

- General Ecosystem equilibrium Model
- Food web style model with Arrow-Debrue style structure
- Finnoff, Tschirhart, and students
- Cows, native grass, leafy spurge
- Lamprey eels in Lake Michigan

# Other bioeconomic models

- Horan & Lupi, MSU
- Washington State
- PREISM (ERS/USDA)
- Hawaii group
- Perrings, ASU
- Olson, Maryland
- others

# What seems to matter

- Feedbacks
- Defining the baseline as target
- Opportunity costs of risky inputs
- Prevention vs control
- Preferences—whose values count?
- Uncertainty & irreversibility

# Behavioral considerations

- Low probability, high severity events
- Loss aversion
- Self-control problems
- Discounting issues

# Incentives

- Markets
  - One person deal maker
- Coordination
  - One person deal breaker



# Incentives

- Price rationing
  - Knowler and Barbier, EE 2005
  - “introducer pays” principle
- Quantity rationing
  - Horan and Lupi (EE, 2005)
  - No first best trading market that would be operational
  - Market price is overdetermined for two reasons
    - 1:1 trades inefficient.
    - Probability of invasion still public good
  - Second best trading set up
- Liability
  - Bonding requirements
  - Citizen suits

# Coordination of private actions

- Coordination and the Compensation Question
- Incentive design to achieve both voluntary participation & biological targets

# Target Habitat

## Weak link public goods problem

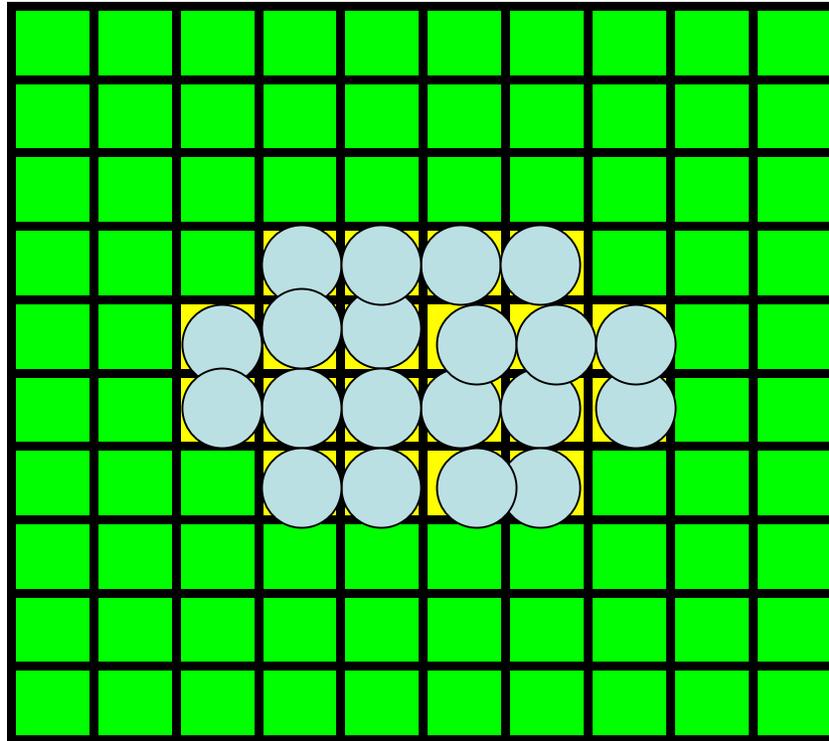


Figure C. Illustrative Example—No Subsidy

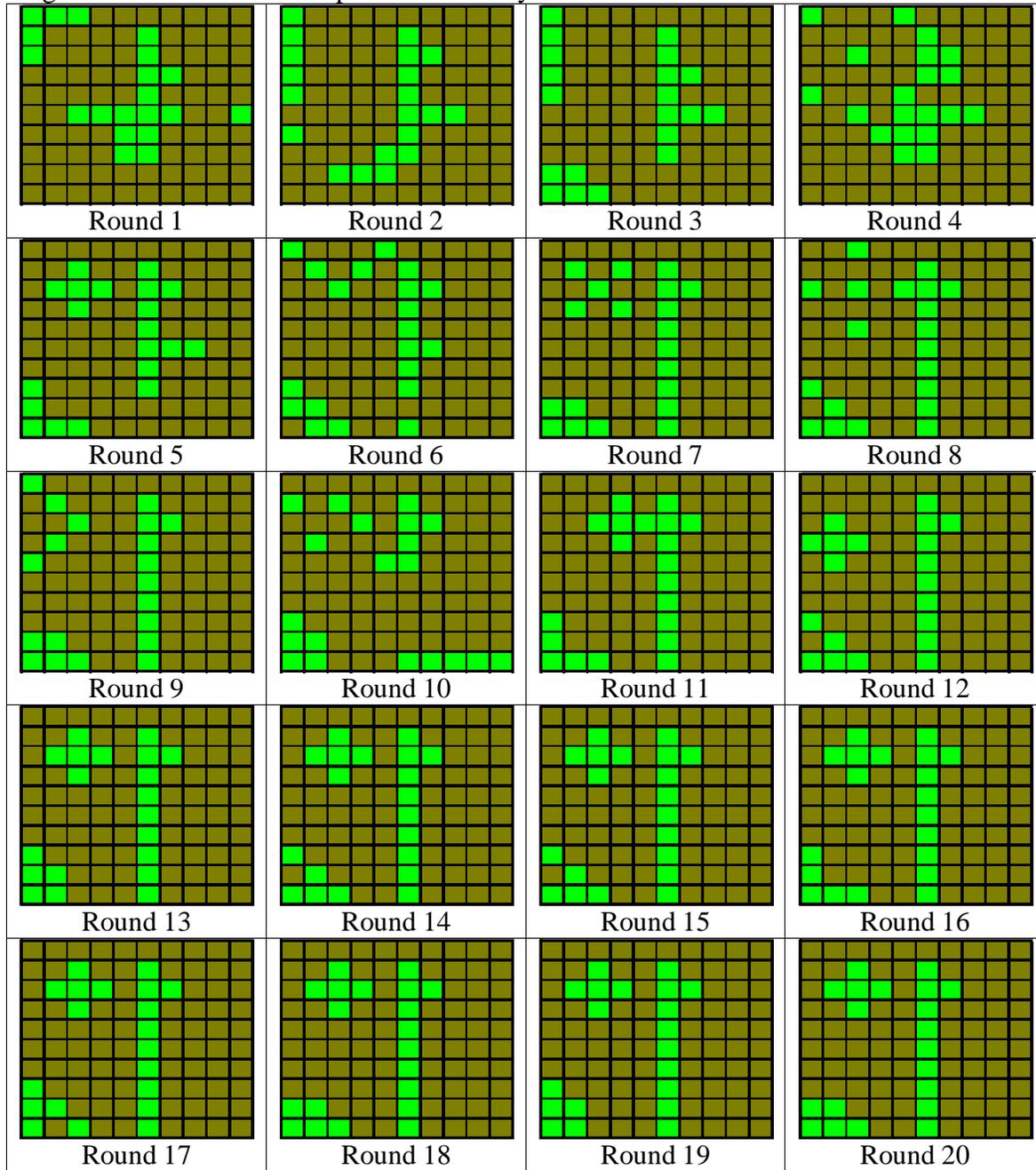
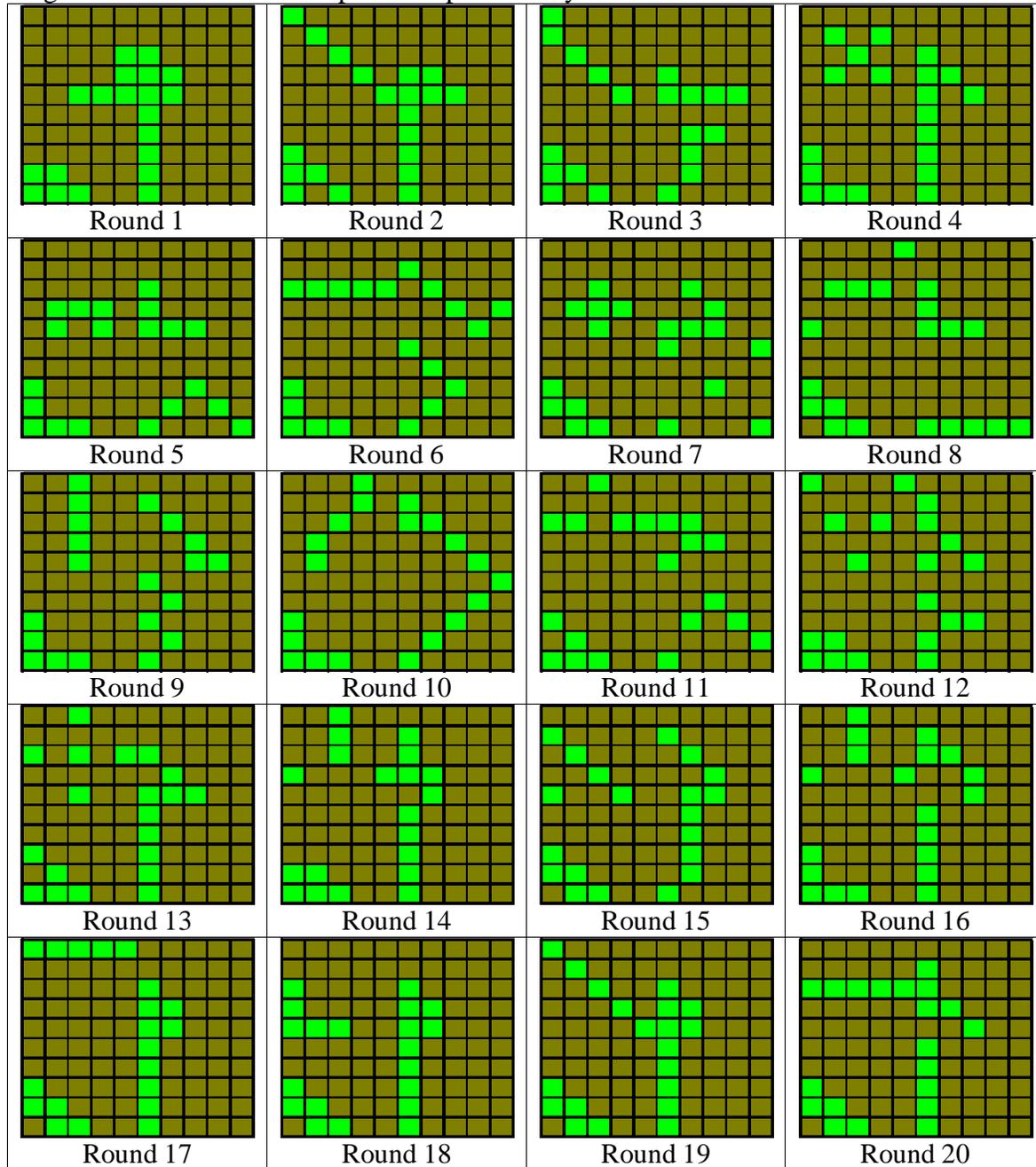
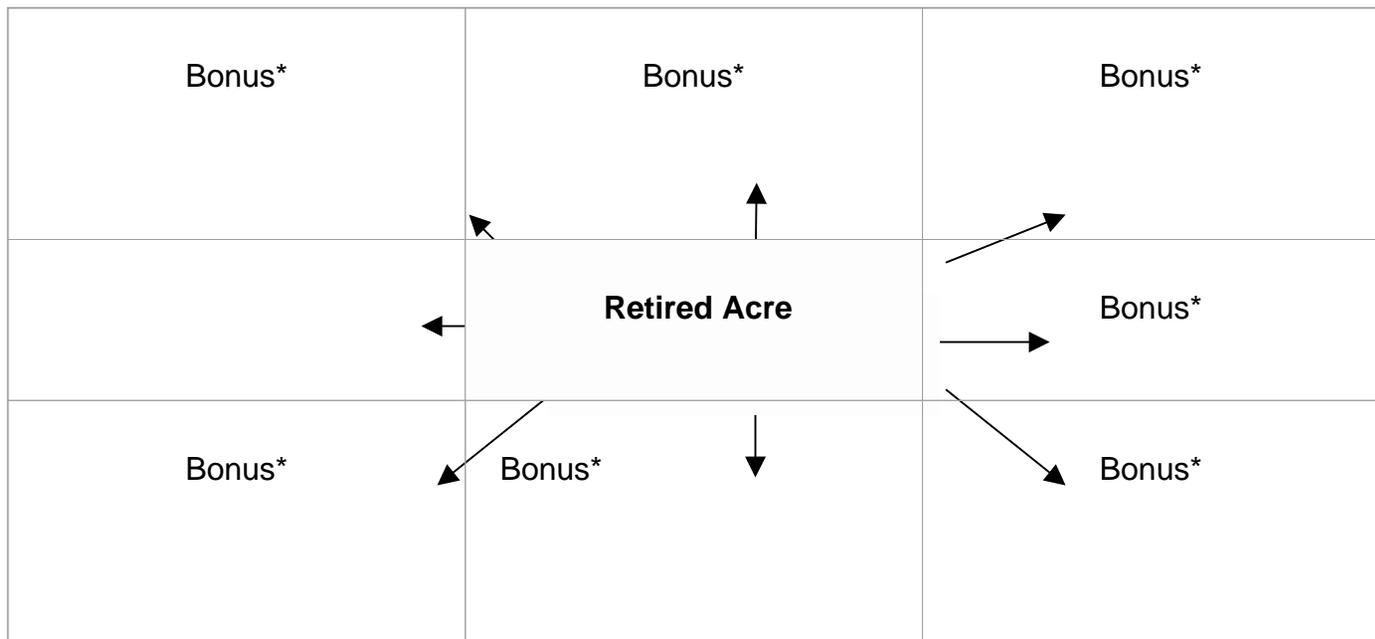


Figure D. Illustrative Example—Simple Subsidy



# Agglomeration Bonus

- e.g., Oregon—river bank acreage retirement program



# Subsidy system

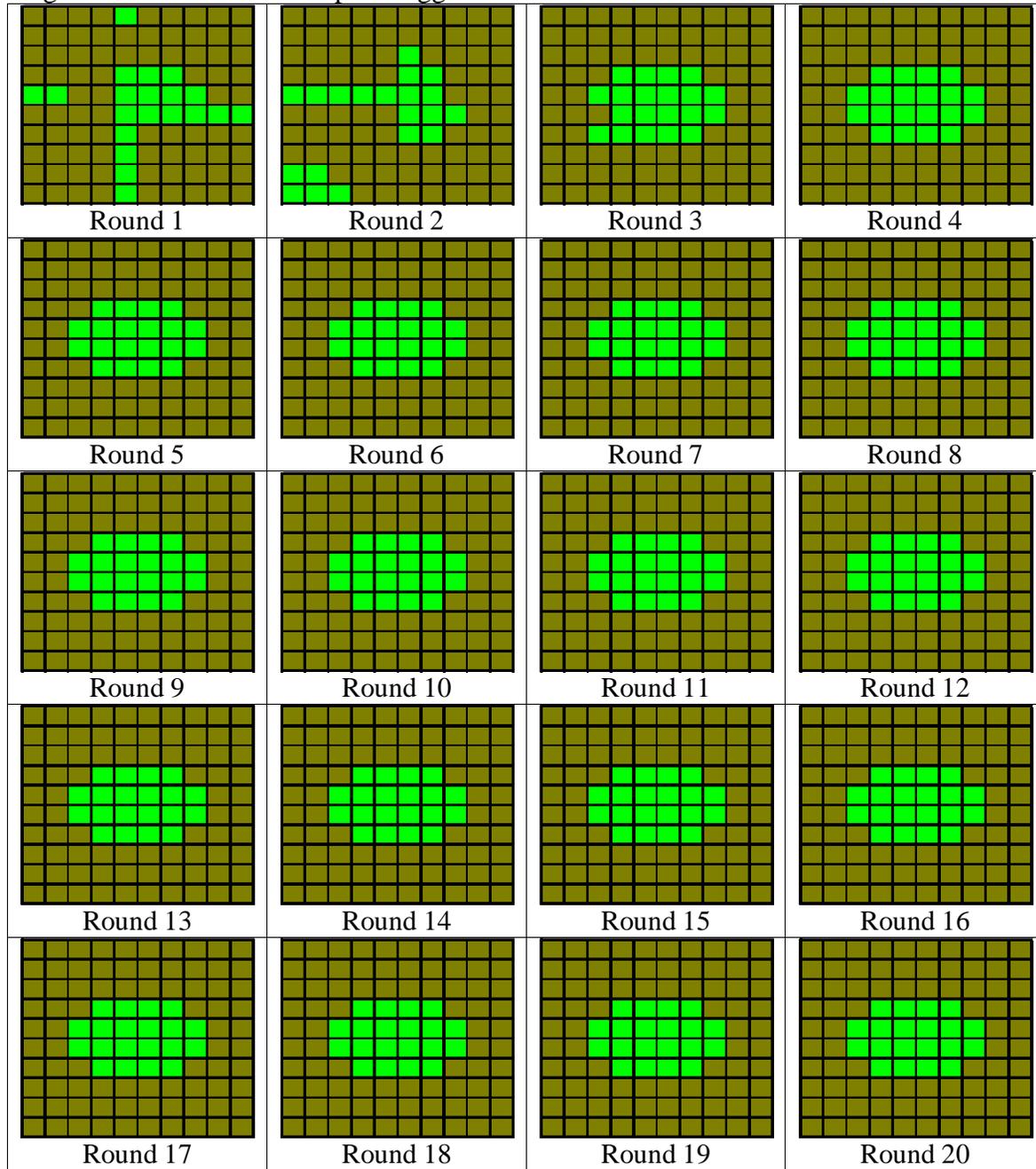
- Four subsidies within the subsidy menu mechanism:
  - Per conserved habitat acre subsidy;
  - Own shared border
  - Row shared border subsidy
  - Column shared border subsidy
- Subsidies = + or – (or 0)

# Coordination Game

Multiple Nash equilibria exist

- (“A Beautiful Mind”)
- Equilibrium I—High risk, high reward
- EQ II—Safest bet, low reward
- EQ III—all those between I and II

Figure E. Illustrative Example—Agglomeration Bonus



# Trading Spaces

- Set up a market to trade invasive species control responsibility

Figure 3. Illustrative Example—TSARs

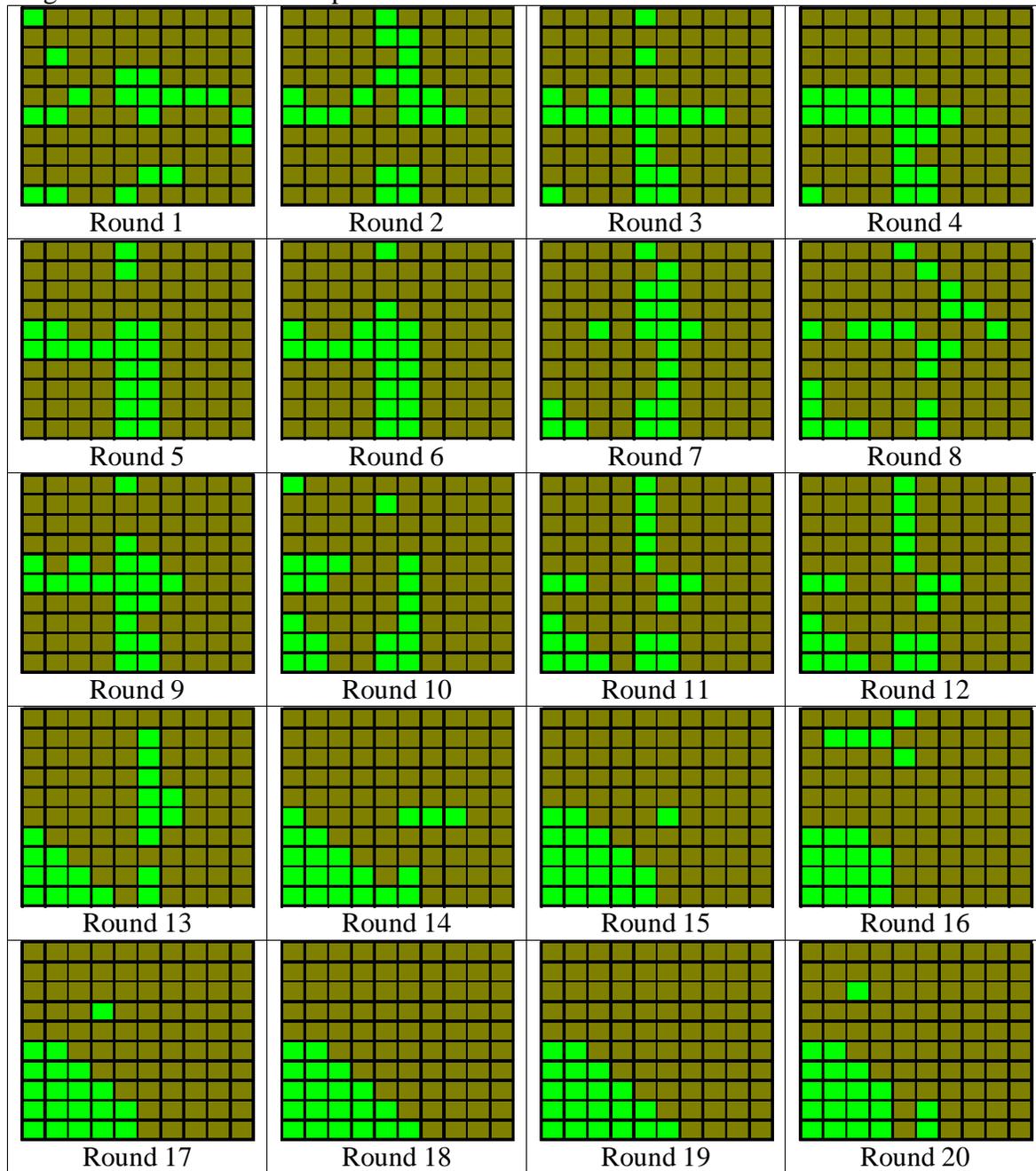
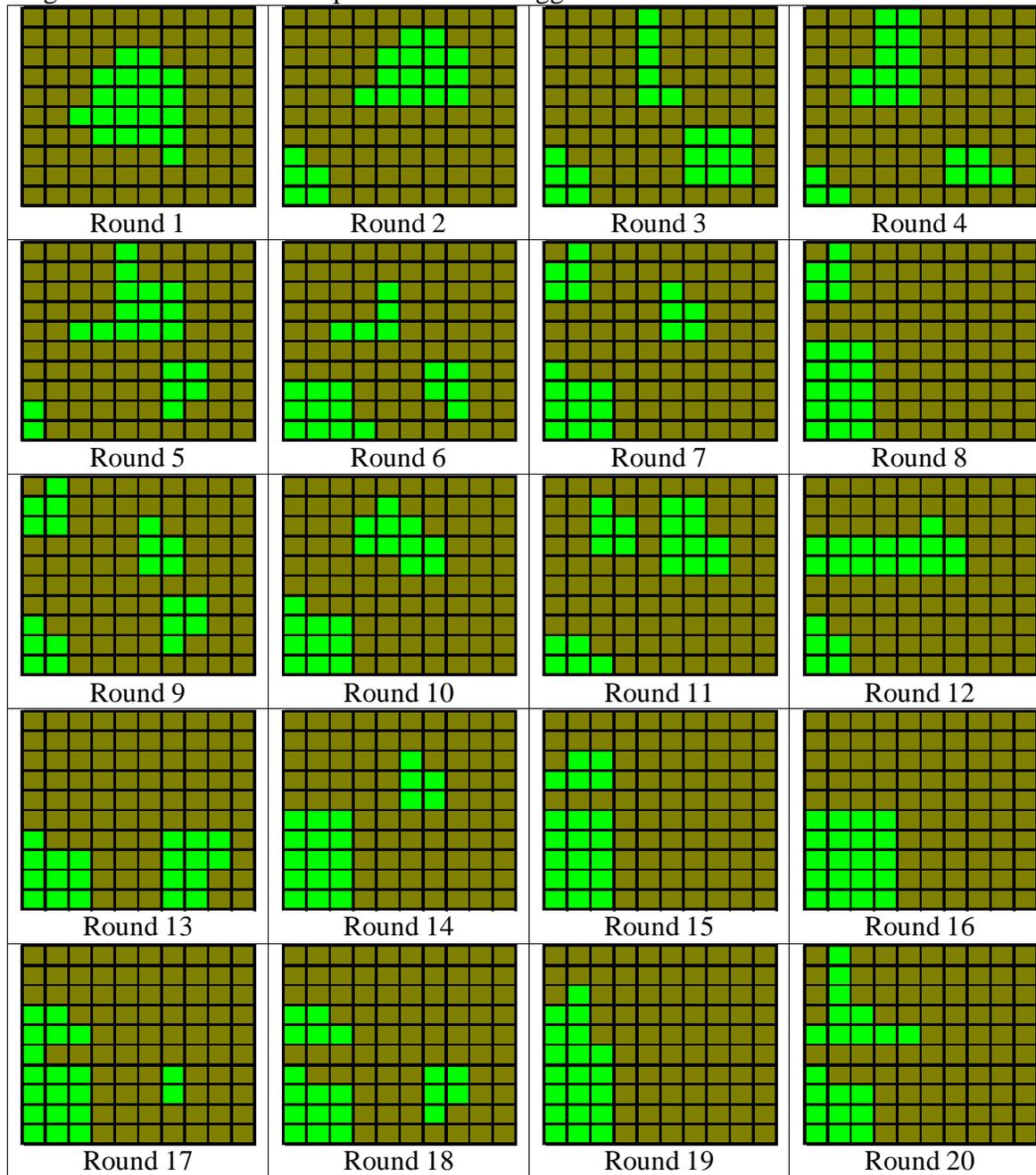


Figure 4. Illustrative Example—TSARs w/Agglomeration Bonus



# Valuation

- Half-full, half-empty
  - Value of protecting baseline biodiversity?
  - Value of delaying some inevitable change from the baseline
  - What is the baseline by the way?
  - What if regular folks like the invader?



# Definitions

- A water body is **Invaded** if a non-native species exists in a lake or river.
- A water body is **Harmfully Invaded** if that causes 'measurable' harm to some ecosystem attribute.
- A water body is **Not Invaded** if a lake or river is populated with only native species or **Not Harmfully Invaded** non-harmful invasive species.

More specifically, a water body is **Invaded** if the lake or river has a non-native species; and **Harmfully Invaded** if the species

- disrupts natural ecosystems and causes irreversible ecological harm
- gets rid of native plants, fish, and other aquatic life, or
- damages the economy

A water body is **Not Invaded** if the lake or river either does not have a non-native species or **Not Harmfully Invaded** if it has a non-invasive species that

- does not disrupt natural ecosystems and cause irreversible ecological harm
- does not get rid of native plants, fish, and other aquatic life, and
- does not damage the economy

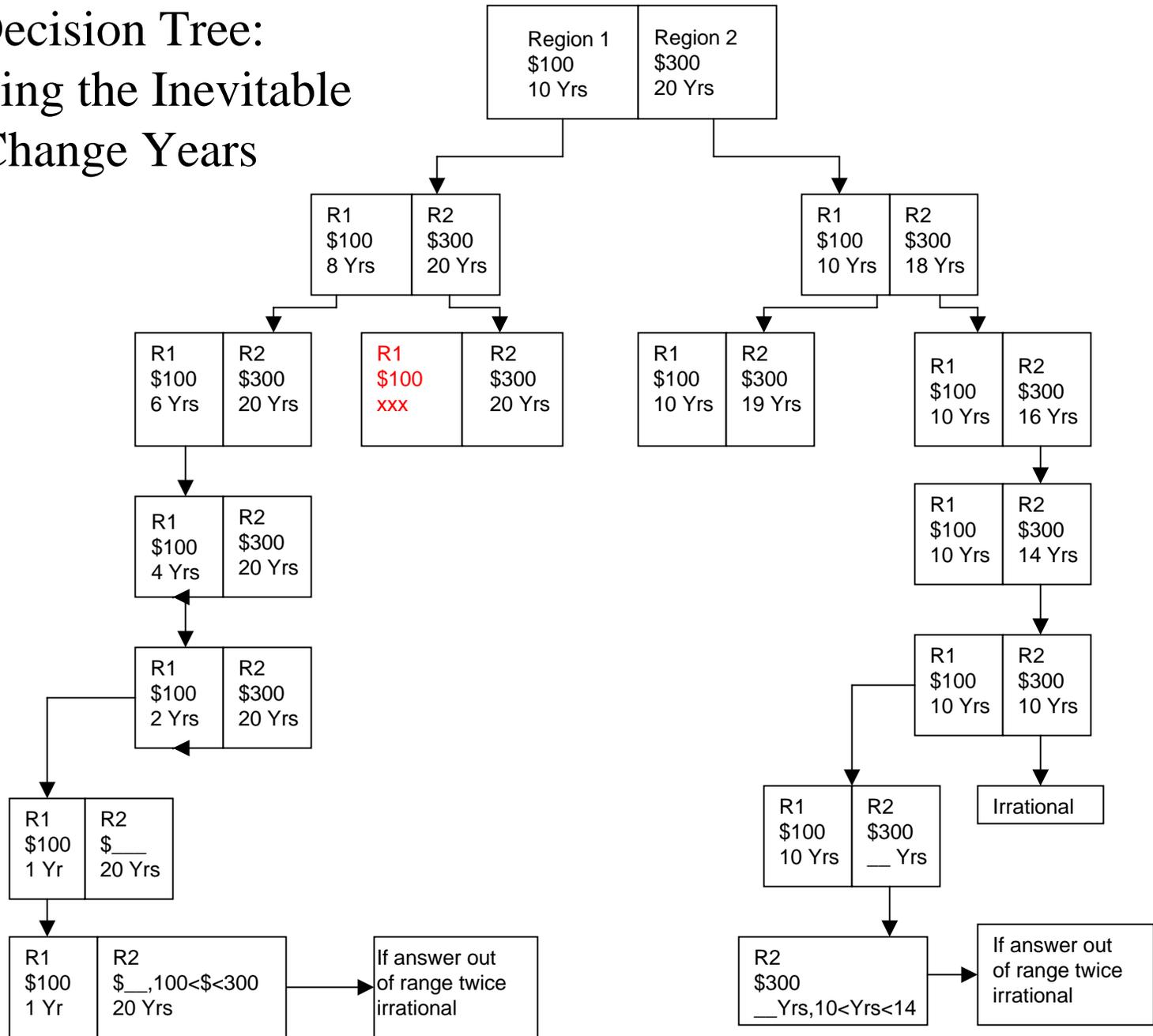
We would like to ask you some more questions like these. However, in these questions, one region will have a lower annual cost of living and the other will have higher percent of lakes and rivers that are not invaded. You must either choose between the two options or that you have no preference. No preference indicates that you are indifferent between the two options not that you dislike both options.

	Region1	Region2	
Increase in annual cost of living:	\$100 More Expensive	\$300 More Expensive	
Percent of lake acres and river miles that are not invaded in given amount of time from today:	40% Not Invaded Today	60% Not Invaded Today	
Which region do you prefer?	Region1	Region2	No Preference

# Delaying the Inevitable

	Region1	Region2	
Increase in annual cost of living	\$100 More Expensive	\$300 More Expensive	
Percent of lake acres and river miles that are not invaded in given amount of time from today:	100% Invaded in 10 years	100% Invaded in 20 years	
Which region do you prefer?	Region1	Region2	No Preference

# Decision Tree: Delaying the Inevitable Change Years



# Ambiguity

How do we or should we assign value to invasive species we find aesthetically attractive?

What if the species has some good points and bad points?

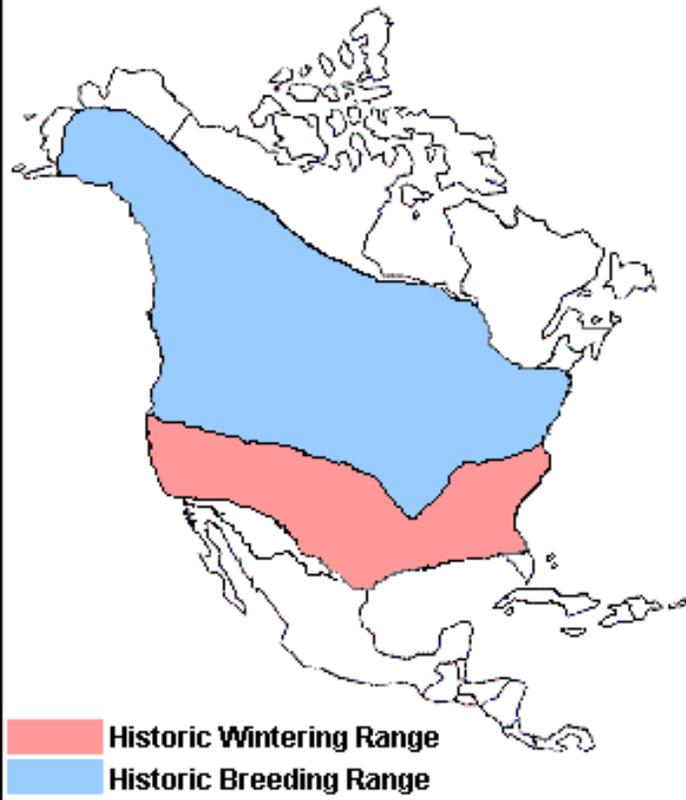
How much are you willing to pay to let  
this bird live?



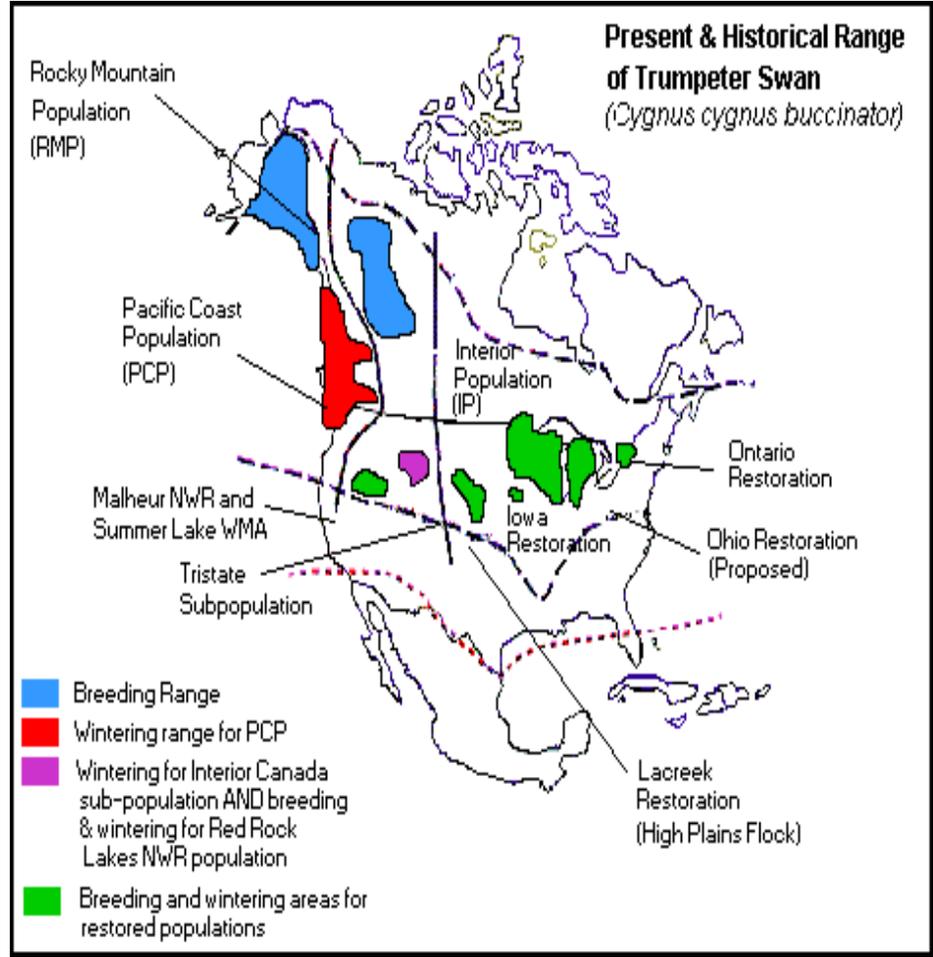
Trumpeter Swan © Andrew Spencer

Surfbirds.com

**Historical Range of Trumpeter Swan  
(*Cygnus cygnus buccinator*)**



**Present & Historical Range  
of Trumpeter Swan  
(*Cygnus cygnus buccinator*)**



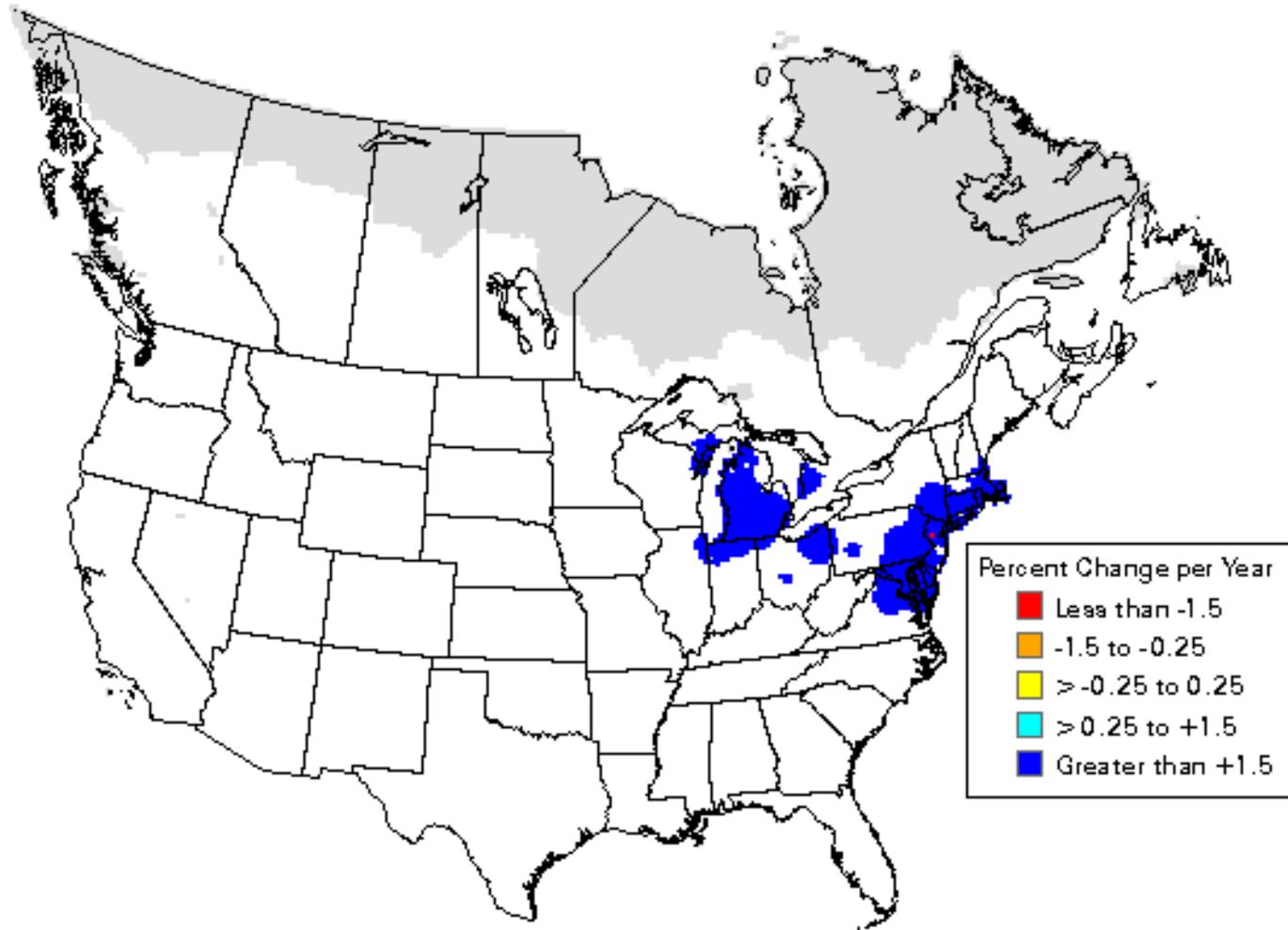
From the Defenders of Wildlife

How much are you will to pay to kill  
this bird dead?



# Mute swan

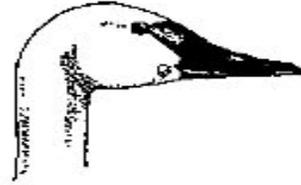
In 2002, the Maryland General Assembly urged the USFWS to act with expedience to craft and conduct appropriate regulatory processes to let Maryland establish a method to control the mute swan population and to mitigate the its impact permanently and statewide.



**Mute Swan BBS Trend Map, 1966 – 2003**  
**USGS Breeding Bird Survey**



**Trumpeter**



**Tundra  
(Whistling)**



**Mute**

<p>Native to the northern U.S. Endangered Species</p>	<p>Native to the U.S. Population exceeds 10,000 Protected Species</p>	<p>Not native to the U.S. Population exceeds 6,000.</p>
<p><b>Wingspan:</b> 7-8 feet <b>Weight:</b> 21-30 pounds <b>Height:</b> 4 feet</p>	<p><b>Wingspan:</b> 6-7 feet <b>Weight:</b> 13-20 pounds <b>Height:</b> 3 feet</p>	<p><b>Wingspan:</b> 7-8 feet <b>Weight:</b> 25-30 pounds <b>Height:</b> 4 feet</p>
<p>Often has a red border on lower mandible. Eye indistinct from bill.</p>	<p>Often has a yellow spot in front of eye. Eye distinct from bill.</p>	<p>Distinct black knob</p>
<p><b>Bill:</b> broad, flat black bill with fine tooth-like serrations along the edges.</p>	<p><b>Bill:</b> black in color</p>	<p><b>Bill:</b> orange in color</p>
<p><b>Profile/Posture:</b> Straight, sloping profile with bill is heavy and somewhat wedge-shaped in proportion to its large angular head. Holds neck erect.</p>	<p><b>Profile/Posture:</b> Curving profile with bill is slightly dish-shaped or conclave and is small in proportion to its smoothly rounded head. Holds neck erect.</p>	<p><b>Profile/Posture:</b> Arches wings over their backs and position their necks in a graceful "S" curve with the bill pointed downward.</p>
<p><b>Voice:</b> resonant, deep and loud, sonorous and trumpetlike.</p>	<p><b>Voice:</b> high pitched, often quavering OO-OO-OO, WHO-HO, or variations.</p>	<p><b>Voice:</b> often silent, but may hiss, grunt, or snort at low volume.</p>
	<p><b>Behavior:</b> congregate in large flocks during migration.</p>	<p><b>Behavior:</b> often carry their young on their backs.</p>

# Ambiguity

- Currently, it is unknown exactly what percentage of lakes are not invaded in Region 2 so an estimate was made. The actual percentage could be anywhere in the range given with equal probability for each percent. That is, if you are given a range of 1-10% there is a 10% chance that each percent is the actual percent.

# Ambiguity (Aversion)

	Region1	Region2	
Increase in annual cost of living:	\$100 More Expensive	\$300 More Expensive	
Percent of lake acres and river miles that are not invaded in given amount of time from today:	40% Not Invaded Today	50-70% Not Invaded Today Equal Chance of each Probability	
Which region do you prefer?	Region1	Region2	No Preference

# Mindsets



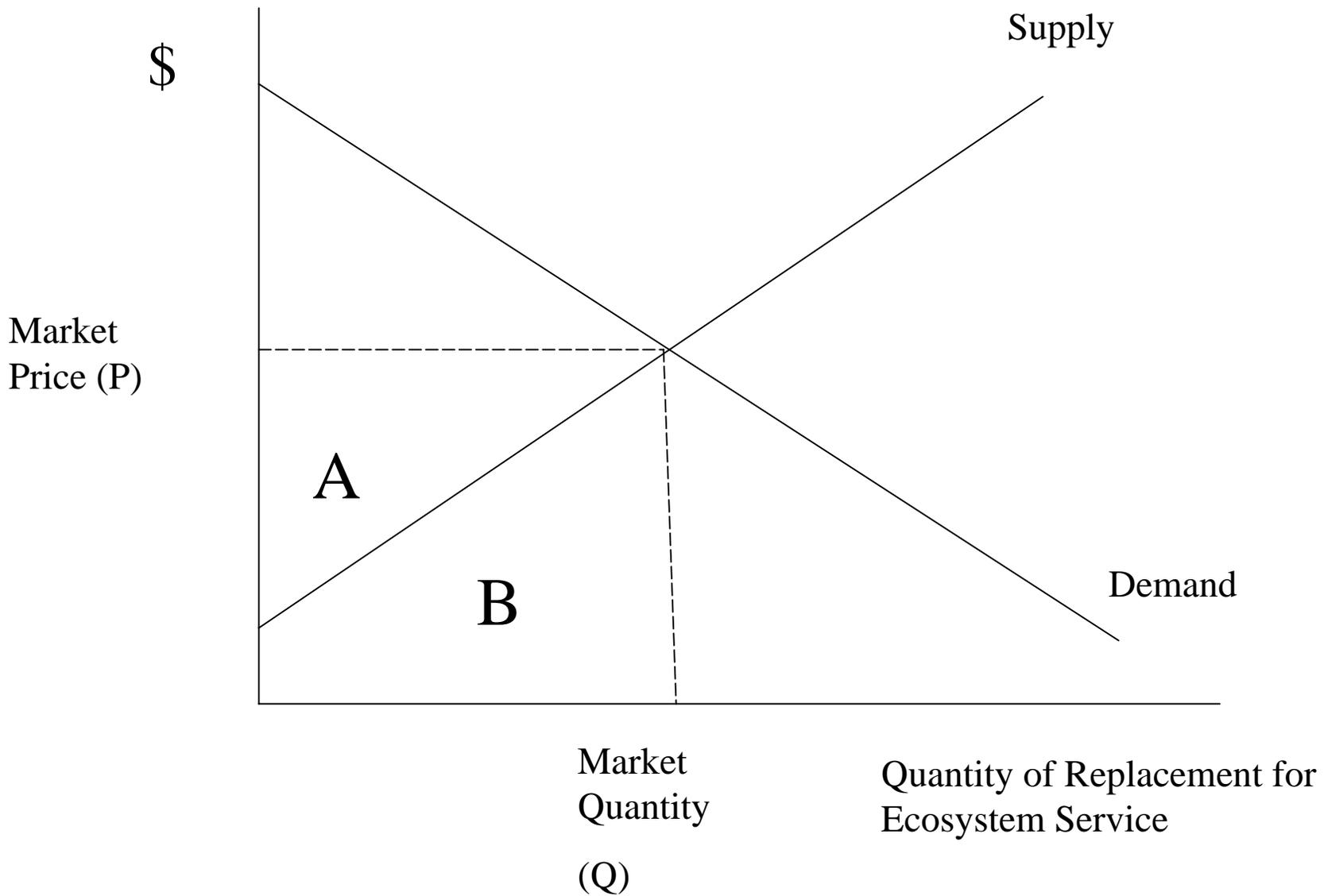
# J Roughgarden's Guide to Diplomatic Relations with Economists

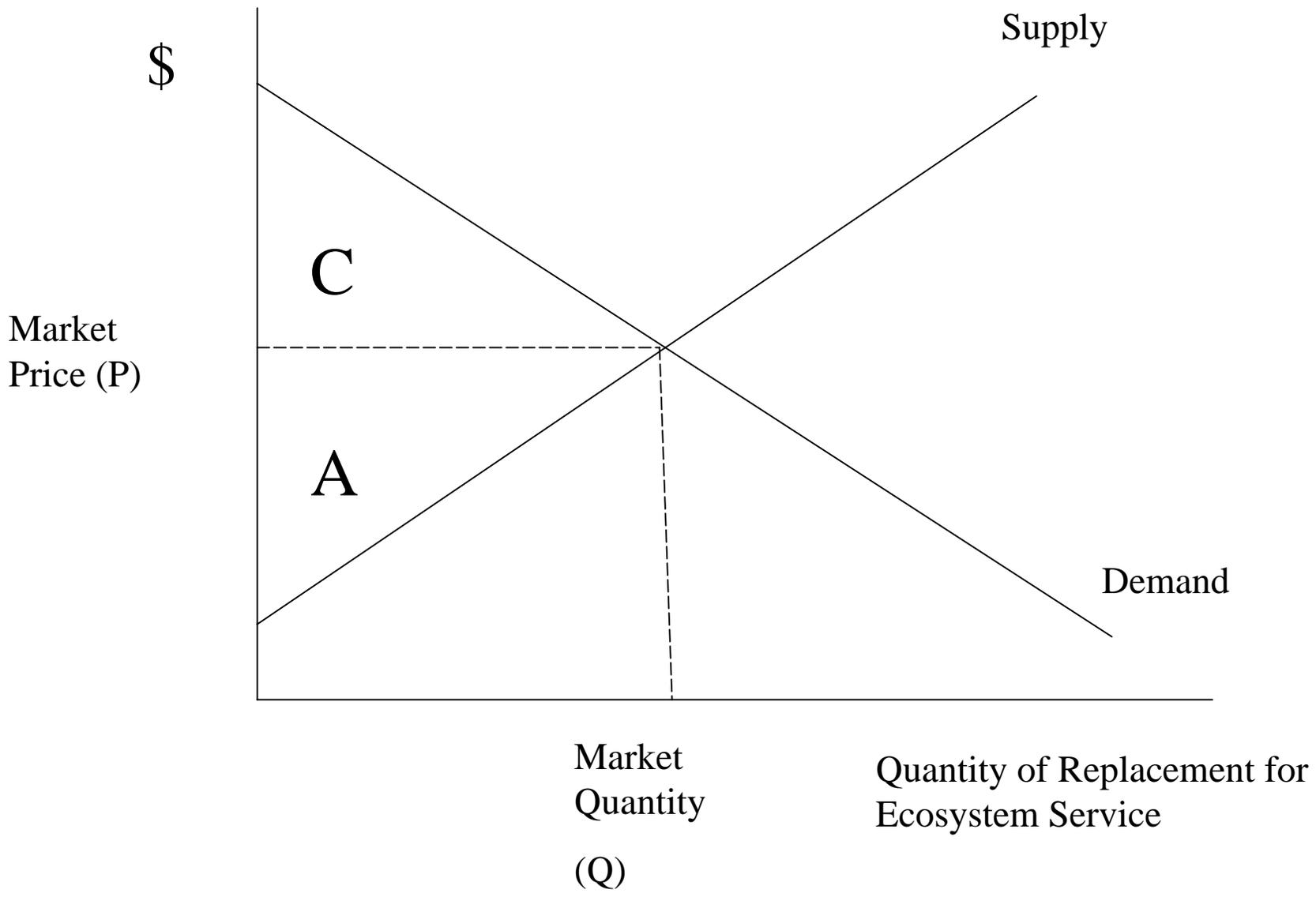
Joan's rules of engagement:

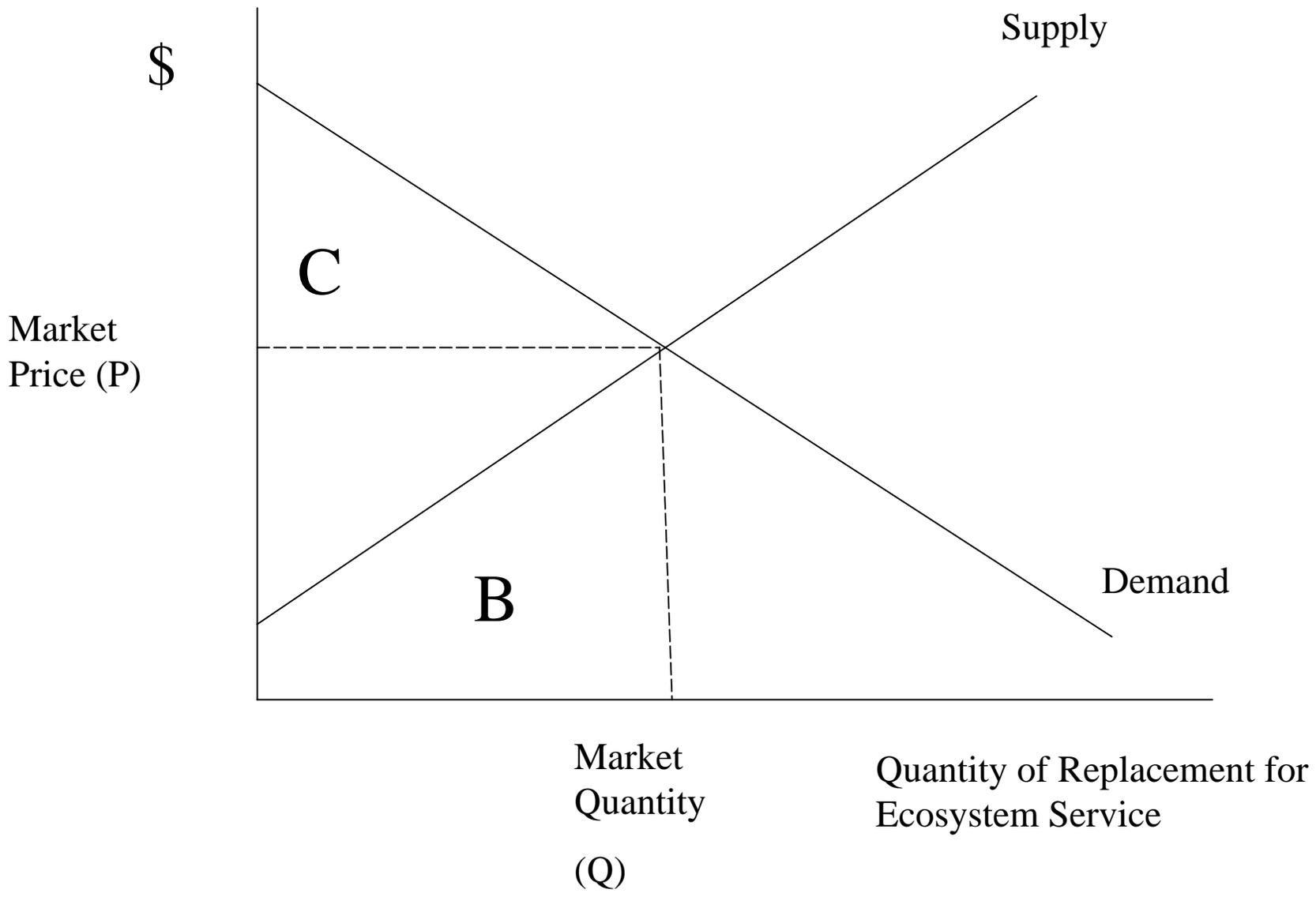
- Know who economists are
- Don't assume the higher moral ground
- Don't underestimate them
- Explain how ecology promotes economic growth
- Get used to their idea of valuation

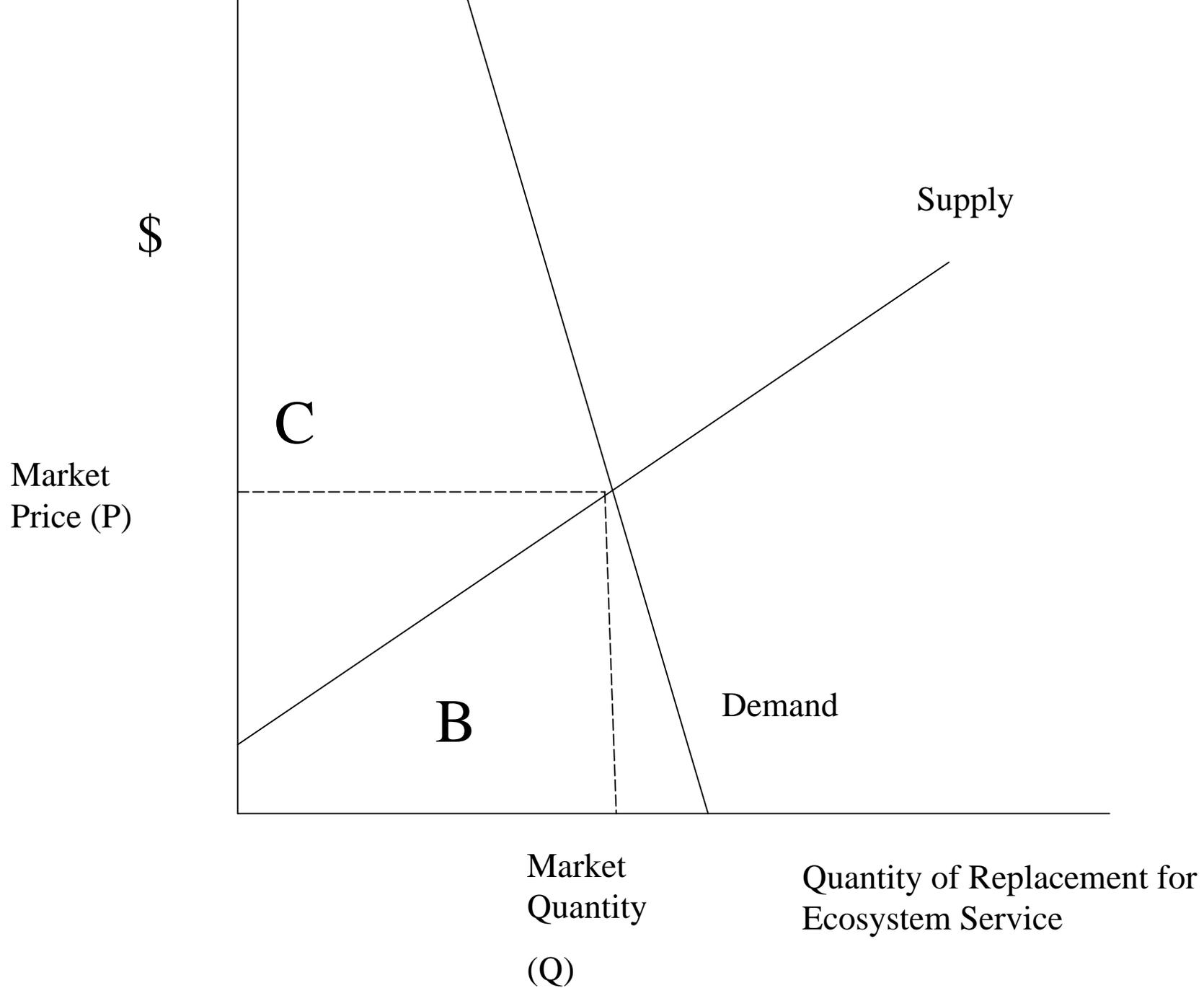
## Example—Pimentel et al. #s on invasive species

- \$139 billion in “economic” damages done to US due to invasive species
- This \$# is the #
- Economists cringe
- Why?

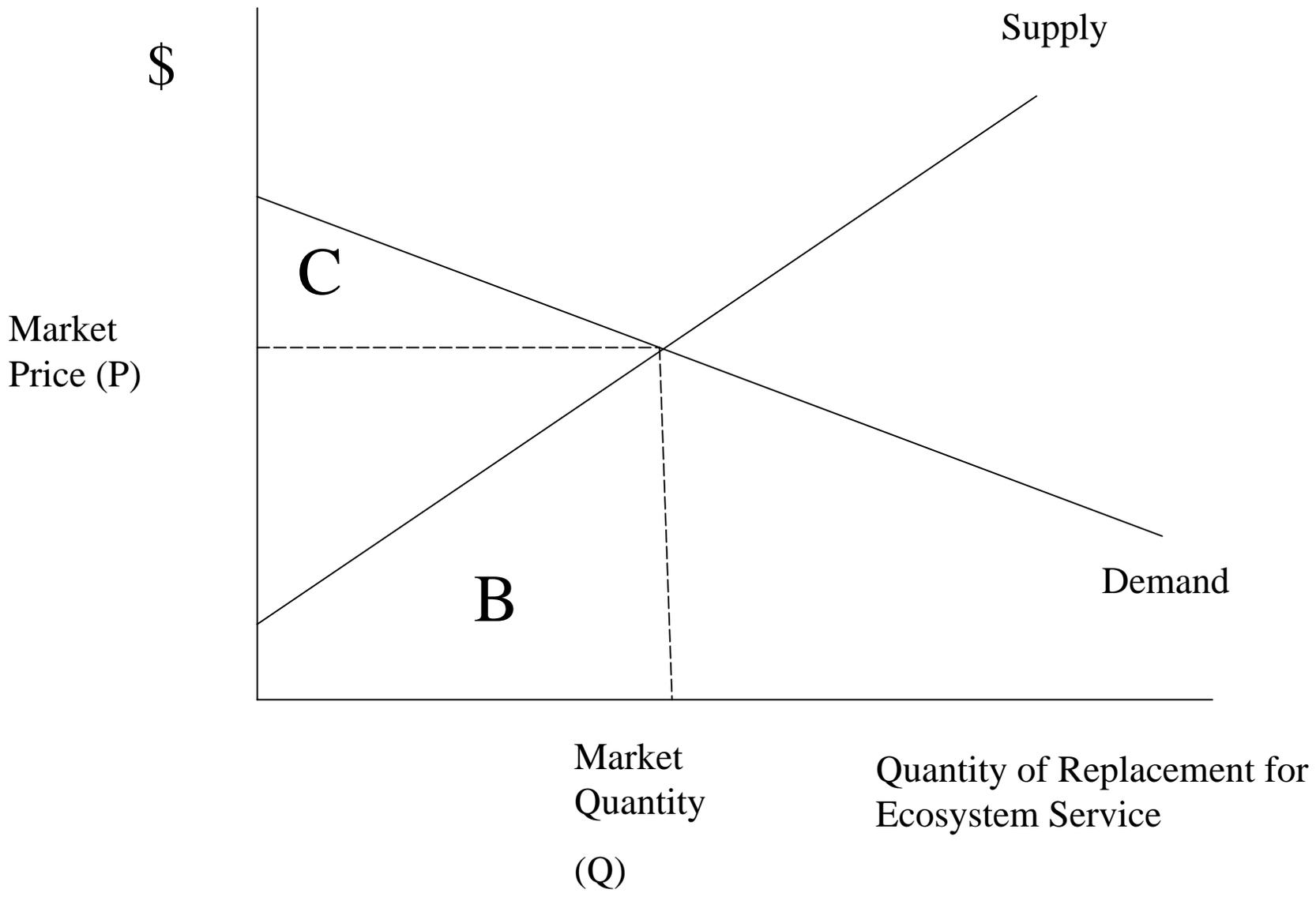








- “A serious underestimate of infinity”  
– Michael Toman



- So who will be the economist(s) willing to put another national number on the table based on welfare theory?
- Food safety—driven by COI estimates
- Invasive species—driven by COD estimates

# Review

- Risk
  - Prevention and control
  - Joint determination
- Incentives
  - Markets
  - Coordination
- Valuation
  - Delay the inevitable
  - ambiguity
- Prosperity
  - Trade
  - Growth
- Mindsets
  - More protection at lower costs
  - Defining the target baseline