Instream Value Considerations for Watershed Restoration Programs

Mark Buckley
ECONorthwest
Department of Ecology Instream Values Symposium
June 11, 2008
buckley@portland.econw.com

Axioms of Valuing Instream Flows

- Out-of-stream flow applications are readily valued
- Resource allocation decisions must be based on values
- Tradeoffs exist and must be defensible
- Instream flow benefits are not easily valued in comparable terms because of the types of benefits delivered
- Necessary characteristics:
  - Achievable implementation
  - Systematic approach
  - Comprehensive assessment of net benefits

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Searching Under the Streetlight

- Out-of-stream flows
  - market values

- Instream flows
  - existing market values
  - what are the important benefits?

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Markets: Function and Failure

	Excludable	Non-Excludable
Rival		
Non-Rival		

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Markets: Function and Failure

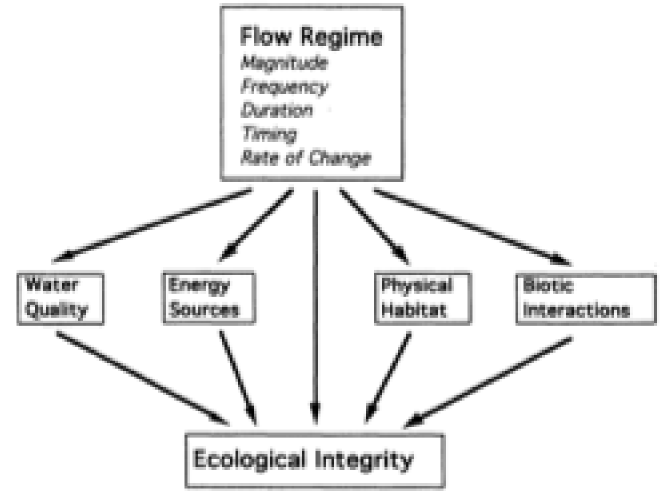
	Excludable	Non-Excludable
Rival	**Private Goods** •Land parcels •Buildings **Markets Work**	**Common-Property Resources** •Water supply (aquifer, streamflow) •Fisheries **Oversight Required**
Non-Rival	**Toll Goods** •Bridges •River Access	**Public Goods** •Water quality, scenery •Flood protection **Government Provision**

- **Externalities caused by consumption exist for limited goods only**
- **Efficient outcomes arise without intervention for private goods only**

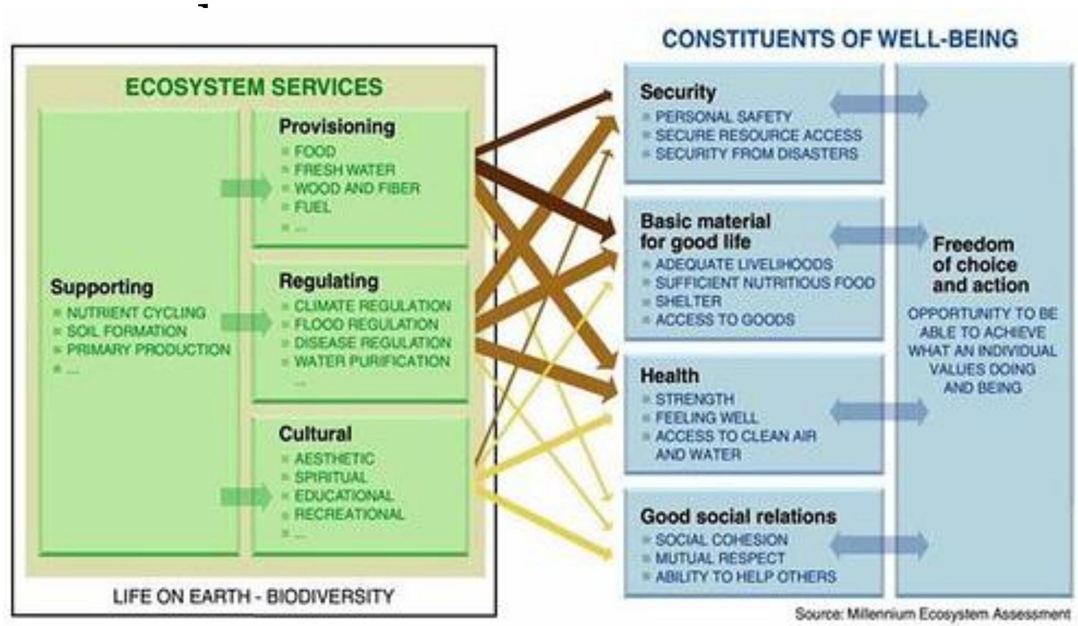
ECONorthwest
ECONOMICS • FINANCE • PLANNING

Starting at the Fundamentals

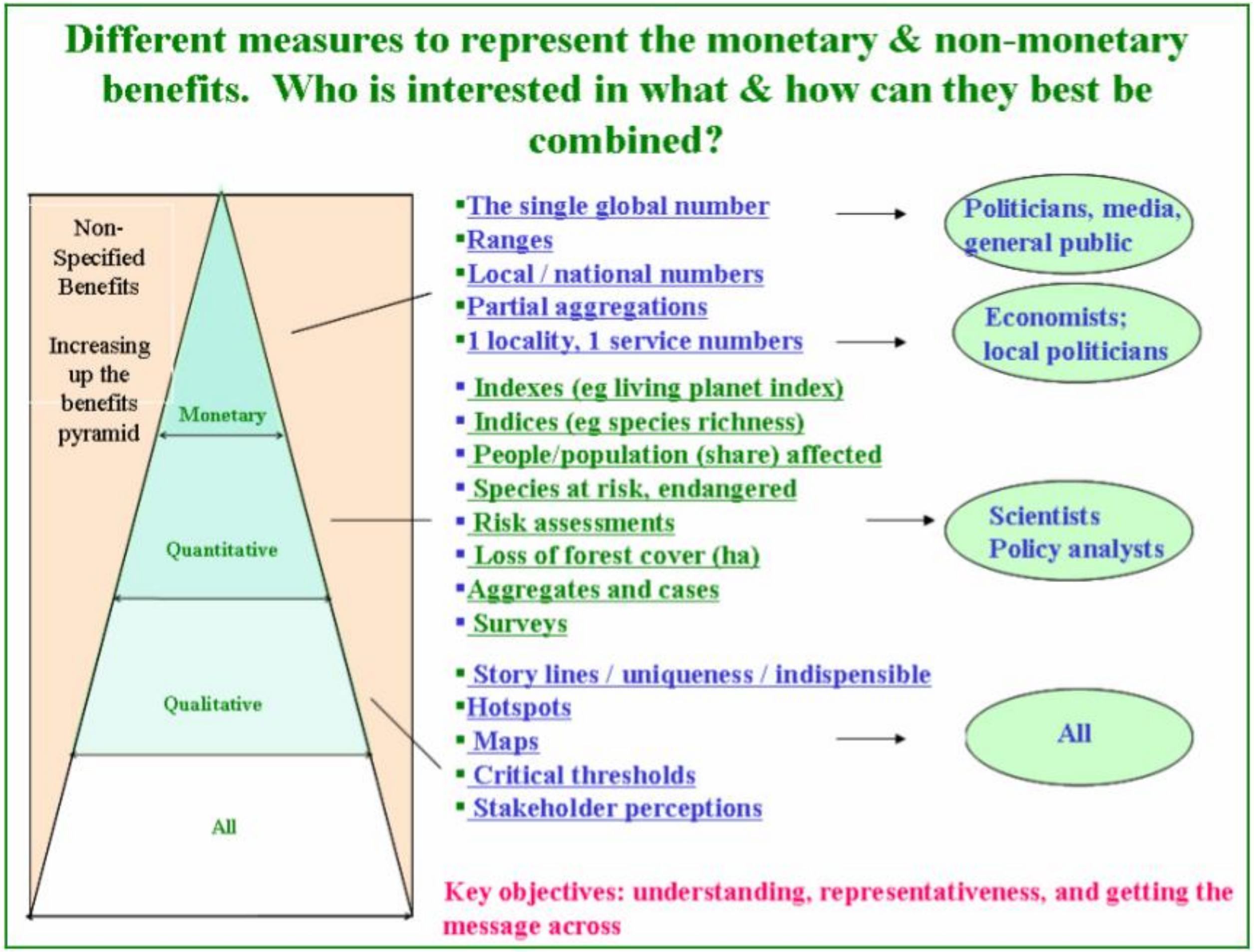
- Why do streams matter?
  - Ecosystem services
- What stream processes matter?
  - Natural Flow Regime
  - Environmental Flows
    - flood, base, pulse, extreme



Poff et al. 1997



Valuing the Fundamentals



Patrick ten Brink, Institute for European Environmental Policy (2008)

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Ecosystem Services

- Value drivers:
  - the ecosystem processes present
  - the quality and supply of ecosystem processes, including regularity and extent
  - the community activities utilizing the ecosystem services
  - the value of activities utilizing the ecosystem services
  - the number of people using the ecosystem service
  - communities of concern using the ecosystem service
  - the cost and availability of substitutes for the ecosystem service

Changes in these factors change the values. Measuring, characterizing these factors is a step towards valuation.

Implemented in Practice

- California Department of Water Resources
  - Proposition 50 watershed restoration grants
- All costs and benefits
  - Identify
  - Characterize
  - Quantify
  - Monetize
- Comprehensive

Benefit	Measure
Avoided loss of ecosystem services due to invasive plant control.	Dollars of avoided costs per year.
Improved salmonid spawning and rearing habitat resulting from sediment reduction.	Increased number of adult salmonid population per year.
Increase in annual consumer surplus derived from improved recreational opportunities.	Increased consumer surplus per year.
Avoided road maintenance and reconstruction costs.	Dollars of road maintenance and reconstruction costs per year.
Increased carbon sequestration.	Additional U.S. tons of carbon sequestered per year.
Education of stakeholders of importance of water quality and salmonid population enhancement projects.	Number of people reached.
Education of land managers from monitoring results.	Number of people reached.
Water conservation education and planning.	Number of people participating.
Increased access for emergency vehicles.	Increase in homeowners ability to qualify and obtain insurance and liability coverage.

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Beneficial Use Categories - CA DWR/SWRCB

- Water Supply

–MUN Municipal and Domestic Supply
–AGR Agricultural Supply
–IND Industrial Service Supply
–PRO Industrial Process Supply
–GWR Groundwater Recharge
–FRSH Freshwater Replenishment
–NAV Navigation
–POW Hydropower Generation

- Recreation

–REC-1 Water Contact Recreation
–REC-2 Non-Contact Water Recreation

- Habitat

–Comm Commercial and Sport Fishing
–WARM WarmFreshwater Habitat
–COLD ColdFreshwater Habitat
–ASBS Preservation of Areas of Special Biological Significance
–SAL Inland Saline Water Habitat
–WILD Wildlife Habitat
–RARE Rare, Threatened, or Endangered Species
–MAR Marine Habitat
–MIGR Migration of Aquatic Organisms
–SPWN Spawning, Reproduction, and/or Early Development
–SHELL Shellfish Harvesting
–EST Estuarine Habitat
–AQUA Aquaculture

- Wetland

WET Wetland Habitat
–WQE Water Quality Enhancement
–FLD Flood Peak Attenuation/ Flood Water Storage

- Traditional and Cultural Uses of Water

–CUL Native American Culture
–FISH Subsistence Fishing

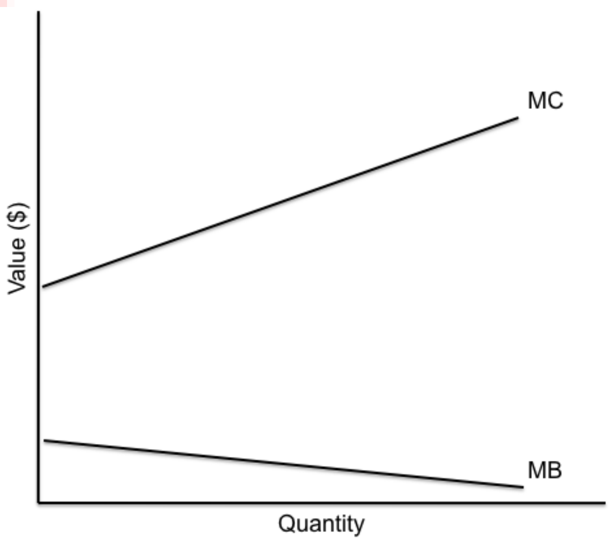
ECONorthwest
ECONOMICS • FINANCE • PLANNING

Transparent Valuation

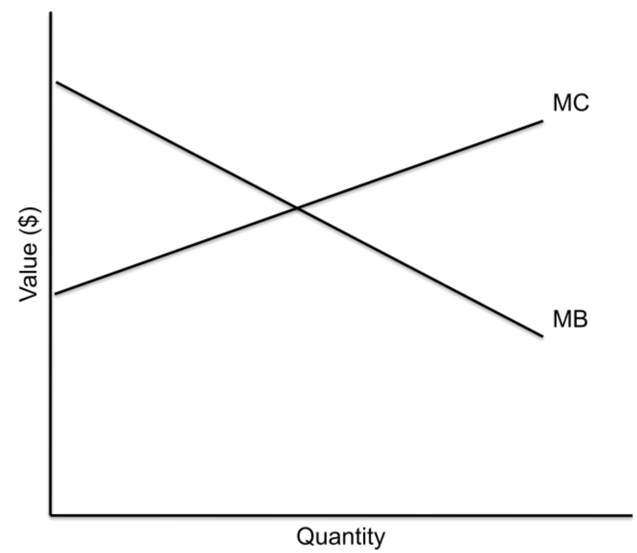
- Identify, characterize, and quantify first
- Provide monetized value as well, not exclusively
- Different monetary values have different levels of acceptance
- Market values and avoided costs are hard to refute

Avoided Costs

- Costs of services that would otherwise be required
- Depends on supply (marginal cost) AND demand (marginal benefit)
- Avoided cost requires demand drivers



•New information
•Change in tastes
•New regulatory requirements
•New regulatory framework
•Demographic/population shifts



ECONorthwest
ECONOMICS • FINANCE • PLANNING

Lake Tahoe Water Quality Trading

Table 6-10. Cost effectiveness by pollutant and Treatment Tier

	< 20 micron sediment reductions (Million $/10^18 Particles)	Phosphorus reductions (Million $/MT)	Nitrogen reductions (Million $/MT)
Atmospheric			
Tier 2	$0	$0	$0
Tier 3	$1.7	$17	$1.3
Urban & Groundwater			
Tier 1	$1.00	$25	$7.4
Tier 2	$1.30	$31	$5.6
P&T Tier	$0.96	$30	$9
Forested Uplands			
Tier 1	$3.4	$91	$110
Tier 2	$3.9	$300	$340
Tier 3	$4.8	$220	$84
Stream Channel			
Tier 1	$1.30	$39	N/A
Tier 2	$0.24	$6.9	N/A
Tier 3	$0.06	$1.7	N/A

- Water quality improvement opportunities vary in cost-effectiveness
- Achieving 2020 goals under existing allocations would cost $2.4 billion; could cost $1.7 billion with offsite stream channel restoration
- For a $500 million budget, 50% greater water quality improvement
- Allowing municipalities to meet water quality requirements with stream channel restoration for Lake Tahoe provides substantial avoided costs

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Cost/Benefit Concentration

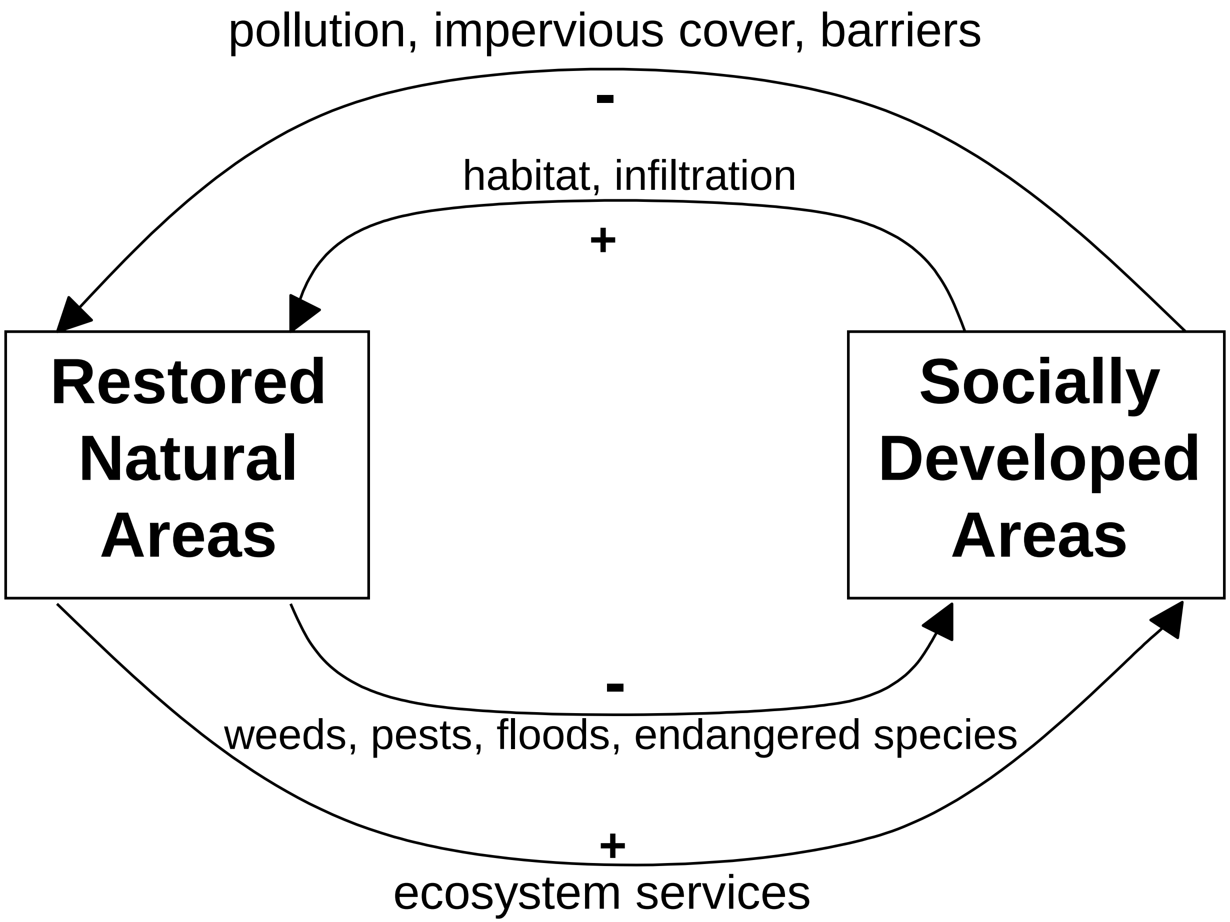
- Concentrated Costs/Benefits
  - strong incentives exist to motivate action
  - markets/individual self-interested behavior can lead to socially-optimal outcomes
- Diffuse Costs/Benefits
  - weak incentives exist
  - coordination/information/transaction costs can overwhelm cooperative efforts

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Total Costs, Total Benefits

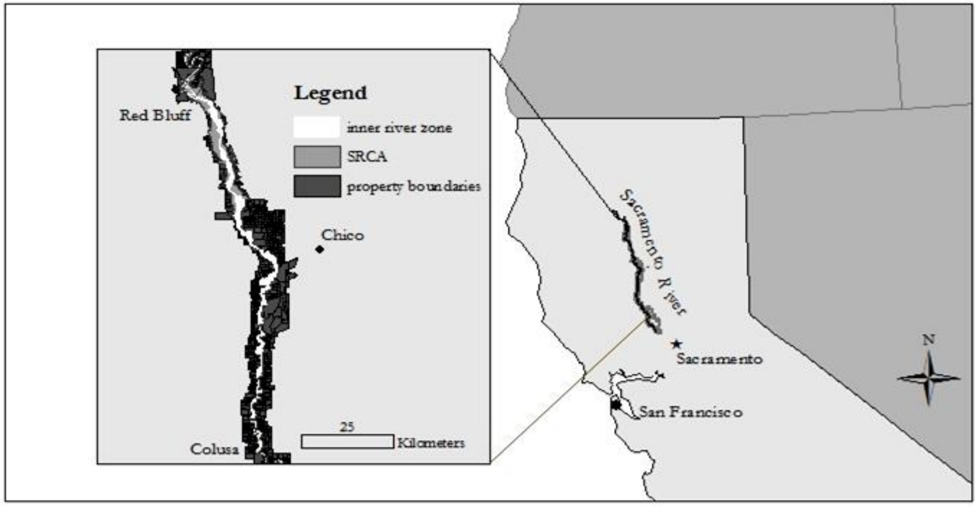
- Cost-benefit analysis should include all costs and benefits.
- Categories include:
  - Public and private costs
  - Internal and external costs
  - Current and future costs
  - Risk and uncertainty adjustments
- Wide range of benefits to potentially be included
  - use and non-use
  - market and non-market
- Distribution
- Expectations – even when they differ from experts

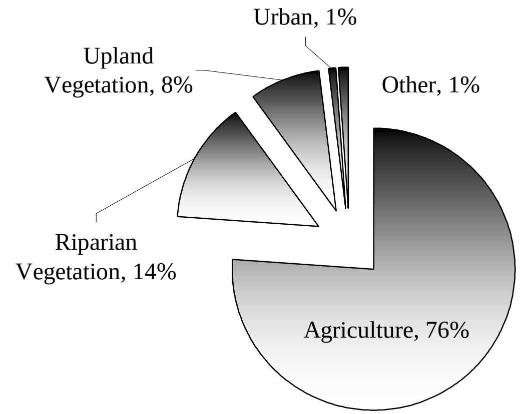
Interdependence of Restored and Developed Areas



ECONorthwest
ECONOMICS • FINANCE • PLANNING

Sacramento River Conservation Area





- Inner River Zone and Conservation Area

(pre-restoration)

- Senate Bill 1086 Sacramento River Conservation Area
- 160 km, 2.5 year floodplain
- Goal: protect, restore and enhance native fisheries and riparian habitat in the corridor
- The Nature Conservancy, River Partners, and other restoration groups have goals related to the SRCA objectives

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Impacts of Native Riparian Restoration on Agriculture

- Weeds and pests (vertebrate and invertebrate)
- Disturbances
  - fires
  - out of channel flood flows
- Endangered species
- Trespassing
- Pollinators and pest control
- Cultural
- Financial
  - tax revenues
  - economies of scale for production

Buckley

Buckley

SF Chronicle

- “How could you so bullishly run over the citizenry by **risking broken levees** with plugging the river channel?”

- “This [restoration project] is only a **water grab for the south state**. Environmentalists are just too naïve to realize they are being duped by the large Southern California developers.”

- “The contractors doing the planting care only about spending and making thousands of dollars of tax payers money per acre… **Let God do the job, he is cheaper**”.

Comments by farmers concerning the Sacramento River restoration efforts

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Impacts of Farmers on SRCA Restoration and Conservation

- Increased usage of chemicals
- Removal of native and endangered species
- Increased fencing, riparian vegetation removal, and rip-rapping
- Political activity to reduce the full project area from 217,000 acres to 80,000 acres (2002)
- 4 of 7 counties have opted out of outer zone participation (2002)
- Colusa City and county enacted more stringent limitations on restoration projects (2006)


Buckley


Buckley

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Ecological and Social Compatibility by Land Type Pairing

	Socially Compatible	Socially Incompatible
Ecologically Compatible		
Ecologically Incompatible		

Ecological and Social Compatibility by Land Type Pairing

	Socially Compatible	Socially Incompatible
Ecologically Compatible	**Mutually Beneficial** •Year around flows (Agriculture) •Water purification (Suburban) •Avian habitat (Residential)	**Conflict** •Endangered species (Forestry) •All Instream flow (Agriculture) •Natural flood/fire regimes (Suburban)
Ecologically Incompatible	**Inefficient/Infeasible** •Native vegetation (Brownfields) •Spawning habitat (Urban channels)	**Mutually Undesirable** •Stock collapse (Fisheries) •Exotic weeds (Agriculture) •Ecological disequilibria (Forestry, Ag)

•Positive externalities are generated under social compatibility

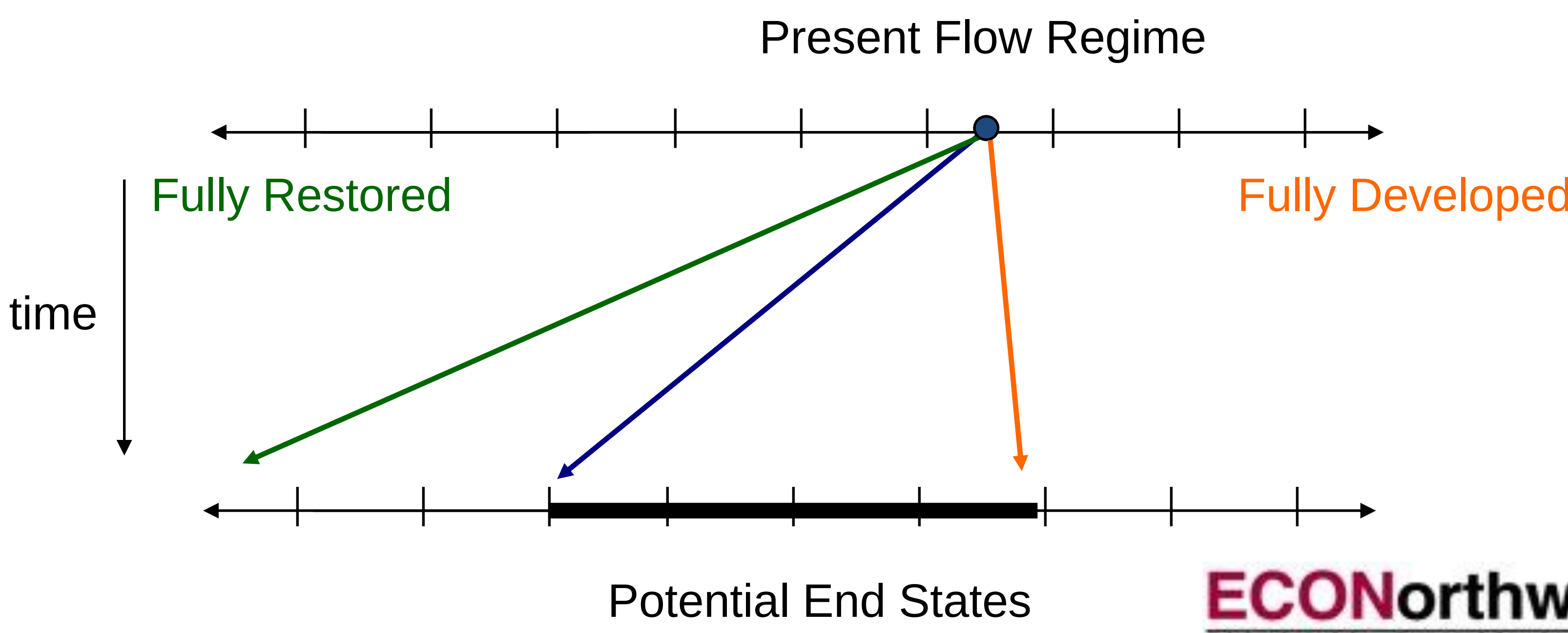
•Negative externalities are generated under social incompatibility

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Cooperative Outcome

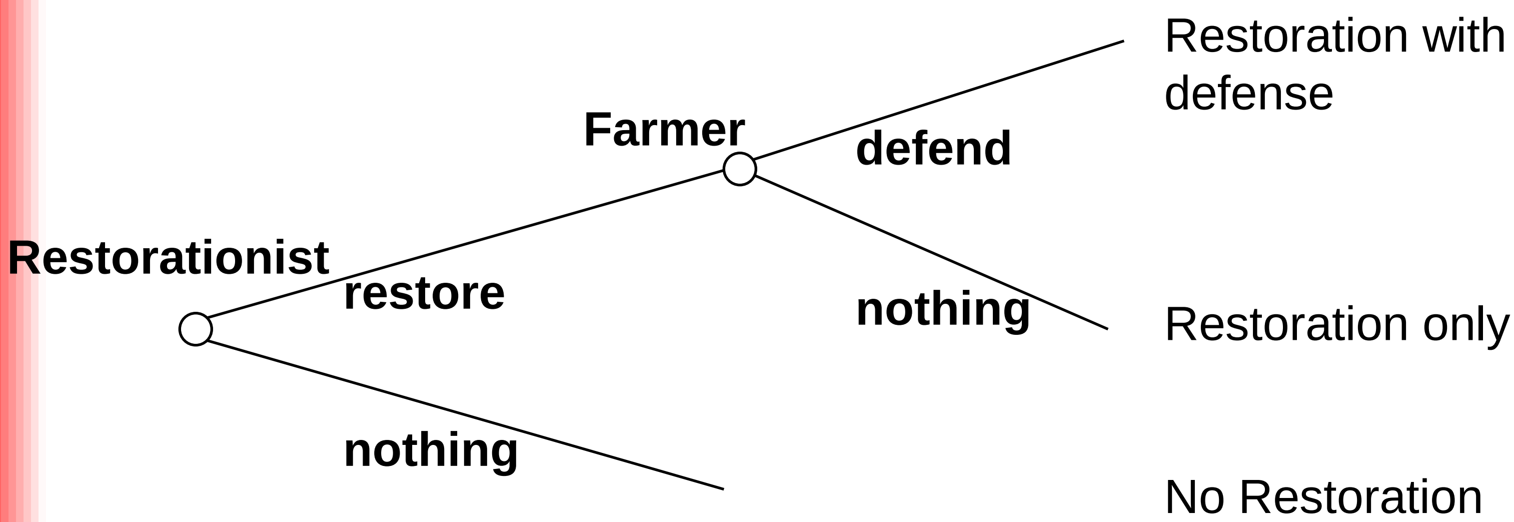
- Extreme goals unlikely (fully restored)
- Universally acceptable

  Most stable = most individual gains = most equitable
- Net welfare gains possible when non-zero sum



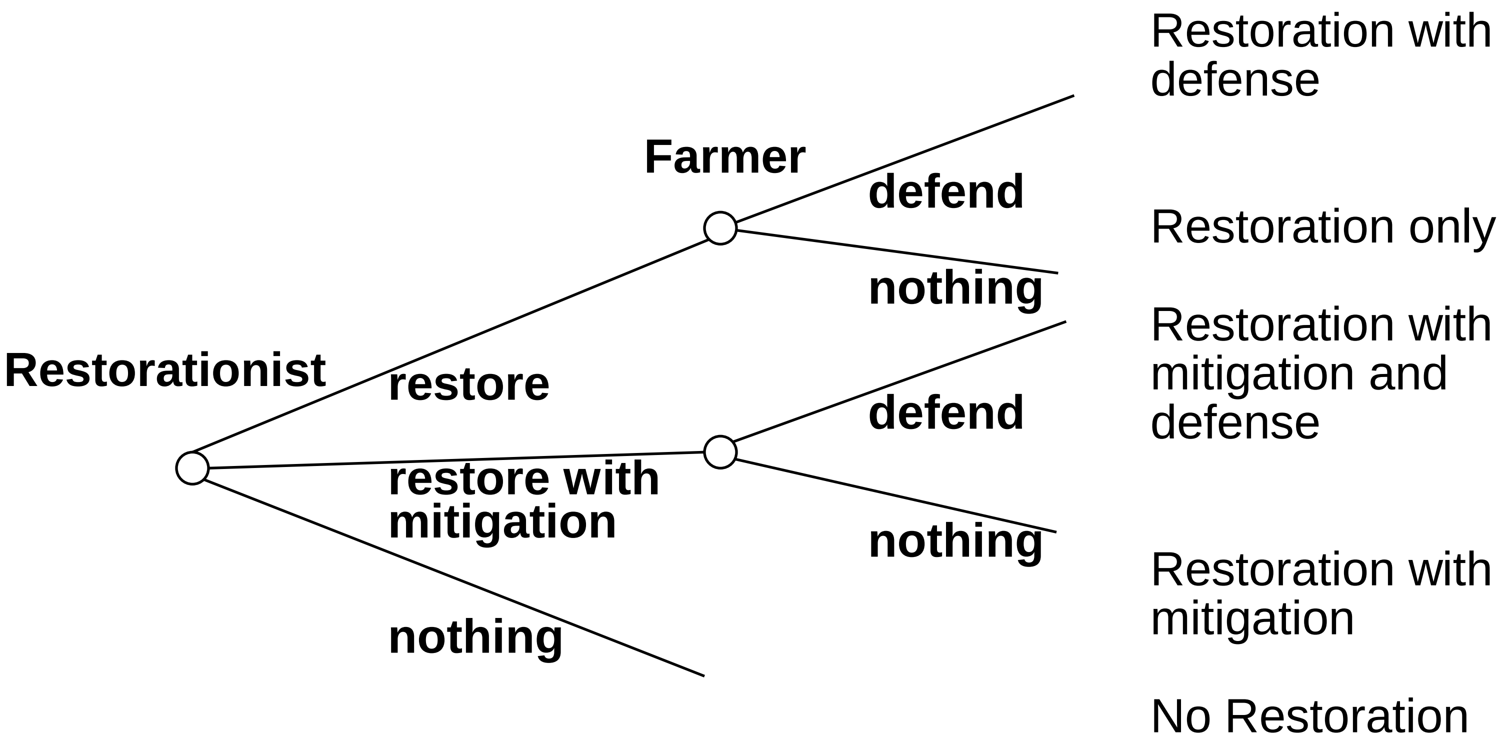
ECONorthwest
ECONOMICS • FINANCE • PLANNING

Basic Restoration and Defense Decisions



ECONorthwest
ECONOMICS • FINANCE • PLANNING

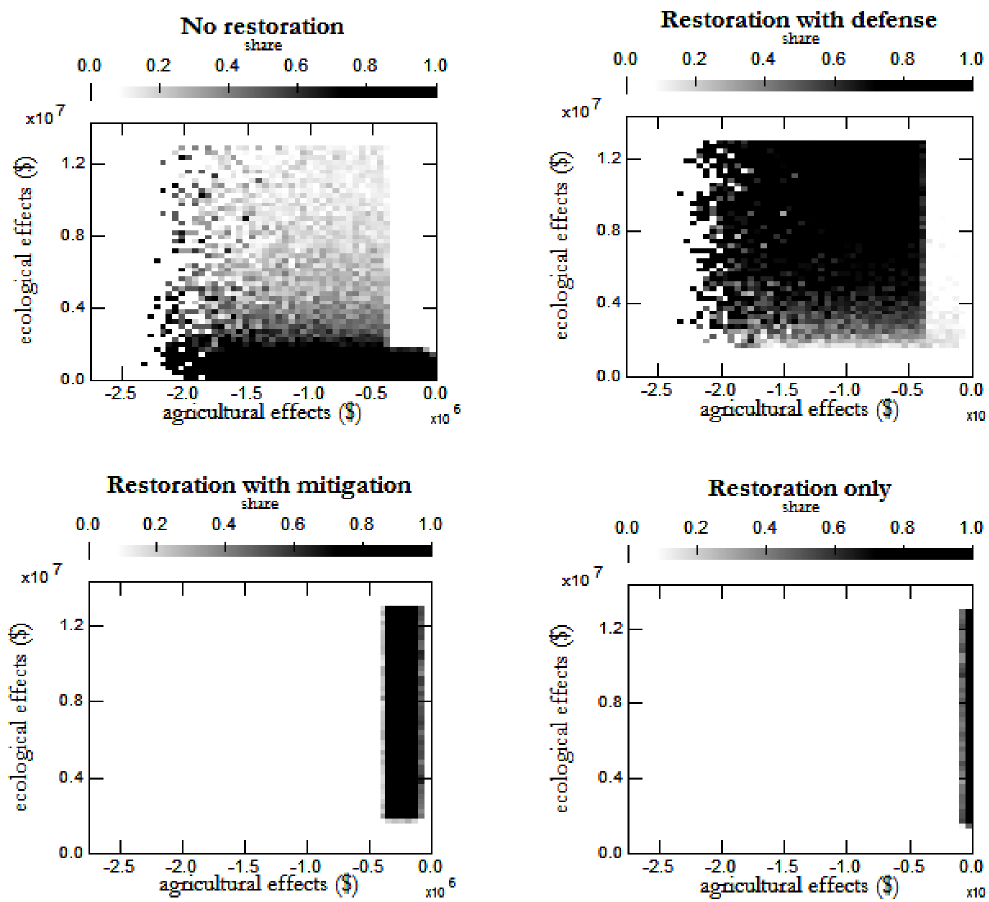
Restoration Decisions with Mitigation



Assume perfect information and solve for SPNE via backward induction

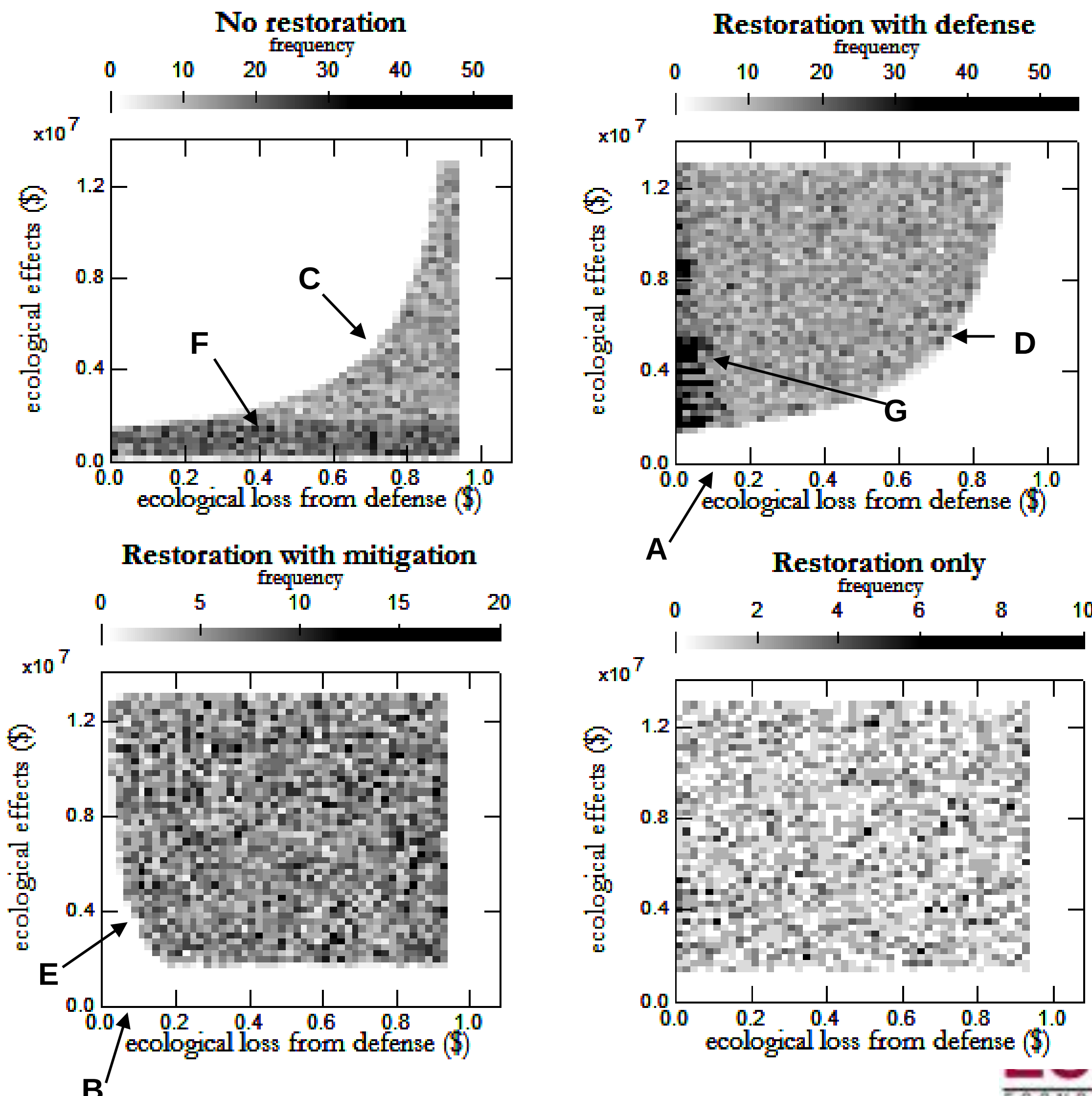
ECONorthwest
ECONOMICS • FINANCE • PLANNING

10 Year, 1 Farmer Weed Simulations, Adjusted for Sampling Distribution



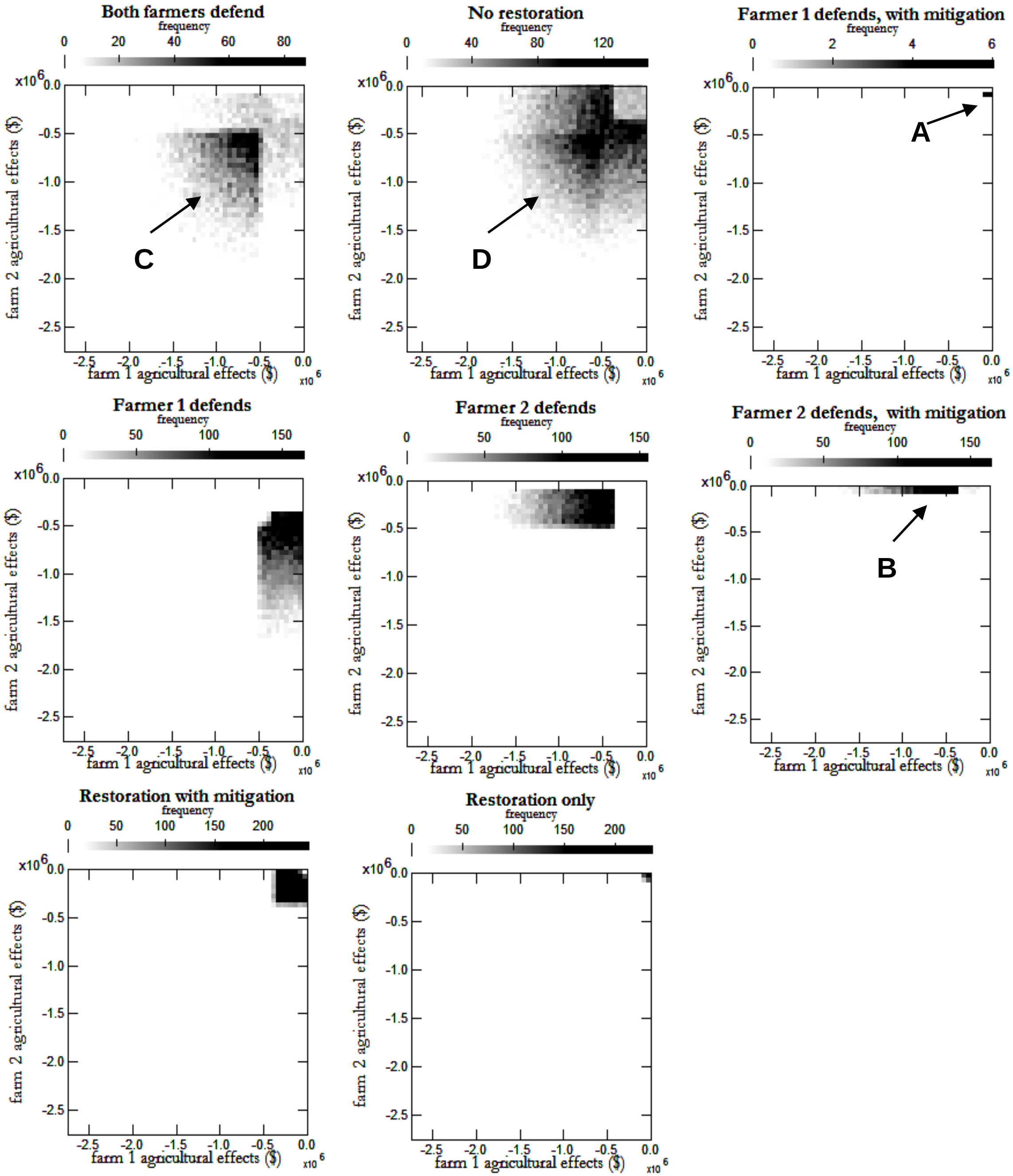
ECONorthwest
ECONOMICS • FINANCE • PLANNING

Restorationist Expectations of Ecological Benefits From Restoration and Losses From Farmer Defense



ECONorthwest
ECONOMICS • FINANCE • PLANNING

Three Player Game, Weed Effects, 10 Year Planning



ECONorthwest
ECONOMICS • FINANCE • PLANNING

Conclusions

- Identify ALL costs and benefits
  - all stakeholders
  - systematic, collectively exhaustive, achievable
- Characterize, quantify ecosystem services and demand drivers before monetizing
- Characterize, monetize ecosystem service avoided costs
- Consider compromises for mutual gains and to avoid unintended consequences

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Overflow slides

ECONorthwest
ECONOMICS • FINANCE • PLANNING

The Problem Of Restoring Natural Systems Among Social Systems: Strategic Considerations and the Sacramento River

1. Theoretical Models
   i. Simultaneous, repeated, Bayesian, and cooperative games
2. **Dynamic Game Simulation Models**
   i. Two and three player games with empirical data
3. Agent-Based Models
   i. Spatially-varied farmer types and sensitivity to ecological restoration
4. Externalities From Ecological Restoration
   i. Discussion of types of externalities generated by restoration and their implications for social feedbacks and cooperation by class

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Farmer Survey Responses on Externality Expectations From Restoration

	Agree	Somewhat Agree	Unsure	Somewhat Disagree	Disagree
Benefits Provided					
Pollinators	8%	12%	46%	19%	15%
Pest predators	22%	37%	19%	22%	0%
Fish and game	22%	37%	30%	7%	4%
Scenery	11%	19%	22%	26%	22%
Costs Generated					
Insect pests	37%	30%	26%	7%	0%
Weeds	48%	22%	22%	7%	0%
Endangered species	44%	26%	22%	4%	4%
Flooding	44%	26%	19%	7%	4%
Mammal pests	52%	33%	15%	0%	0%

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Payoff Functions

- Restorationist - R

  $V_R = \partial(U_R) / \partial(L_A) - (c_A + p_A)L_A - c_m L_A - \partial(U_R) / \partial(L_D)$

  {expected utility of marginal ecological gains} – {cost of restoration activities} –{cost of any externality mitigation activities} – {expected utility loss via ecological impacts of farmer defensive responses}

- Farmers – F_1, F_2

  $V_{Fi} = \partial(U_{Fi}) / \partial(L_A) - c_D L_D + \partial(U_{Fi}) / \partial(L_D)$

  {expected value of production loss from restoration activities} – {cost of defensive activities} + {expected value of production gain from defensive activities}

ECONorthwest
ECONOMICS • FINANCE • PLANNING

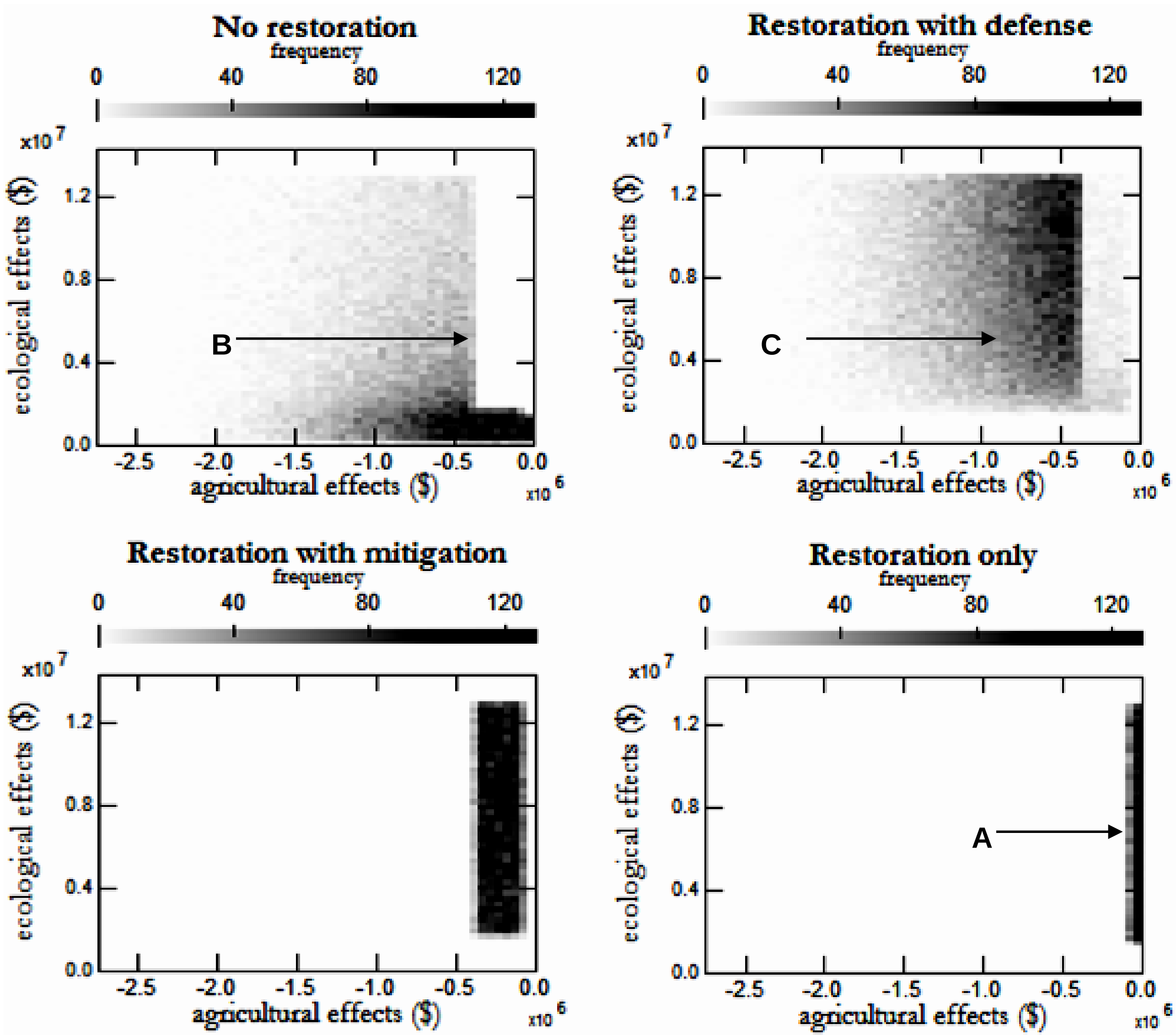
Payoff Considerations

- Scenarios for weed effects, vertebrate pest effects, and both
- Calculated for 1, 10, and 20 year planning horizons (5% discount rate)
- Costs from local UC-Davis Ag. Extension reports
- Other costs reported by local restorationists, farmers, literature
- Benefit/damage ranges determined by values from biological/economic literature
- Farmer-farmer externality effects tested at 25%, 50%
- Simplifying assumptions for mitigation expected effectiveness of 80%, farmer defensive mitigation expected effectiveness of 90%

Parameter	Value (for 100 acres)	Source
discount rate	5 percent	
Farmers		
weed control costs (chemicals and labor)	1 yr - $9150 10 yrs - $74,000 20 yrs - $120,000	UC Ag Extension guidance, 2003
vertebrate pest control costs	1 yr - $41,500 10 yrs - $105,000 20 yrs - $150,000	Pierce and Wiggers, 1997; UC, 2003
walnut prices	$0.47 to $0.77 per pound	UC Ag Ext., 2003
walnut yields	2400 to 8400 lbs./acre	UC Ag Ext., 2003
expected damage	0 to 50 percent of yield	Falta, 2003
restoration mitigation effect	80 percent	
neighboring farmer externality	25, 50 percent	
Revenues	1 yr - Y=-808.8-(O*0.078)+P*O net returns above operating costs: $13,000 to $500,000 10, 20 yrs - Y=-2038.8-(O*0.078)+P*O net returns above total costs: 10 yrs: -$890,000 to $3,000,000 20 yrs: -$1,400,000 to $4,900,000	UC Ag Ext., 2003
Restorationist		
cost of land	$10,000/acre	UC Ag Ext., 2003, Efseaff, 2005
cost of restoration	$4500/acre, over 3 years=$429,000	Efseaff, 2005
cost of weed control	1 yr - $40,000 10 yrs - $324,000 20 yrs - $523,000	Efseaff, 2005
cost of vertebrate pest control	1 yr - $40,500 10 yrs - $97,000 20 yrs - $137,000	Pierce and Wiggers, 1997; UC Ag Ext., 2003
ecological benefit	1 yr - $23,700 to $160,000 10 yrs - $193,000 to $13,000,000 20 yrs - $295,000 to $19,000,000	Loomis et al., 2000
loss from defense	0 to 100 percent	
loss from 2nd defense	additional 75% of first damage	

ECONorthwest
ECONOMICS • FINANCE • PLANNING

10 Year, 1 Farmer Weed Simulations



ecological effects (+)

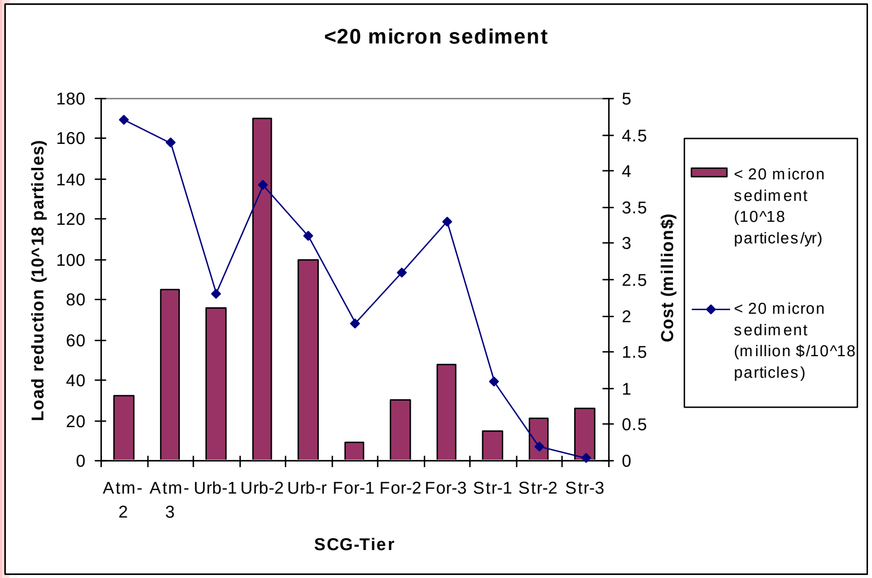
agricultural effects (-)

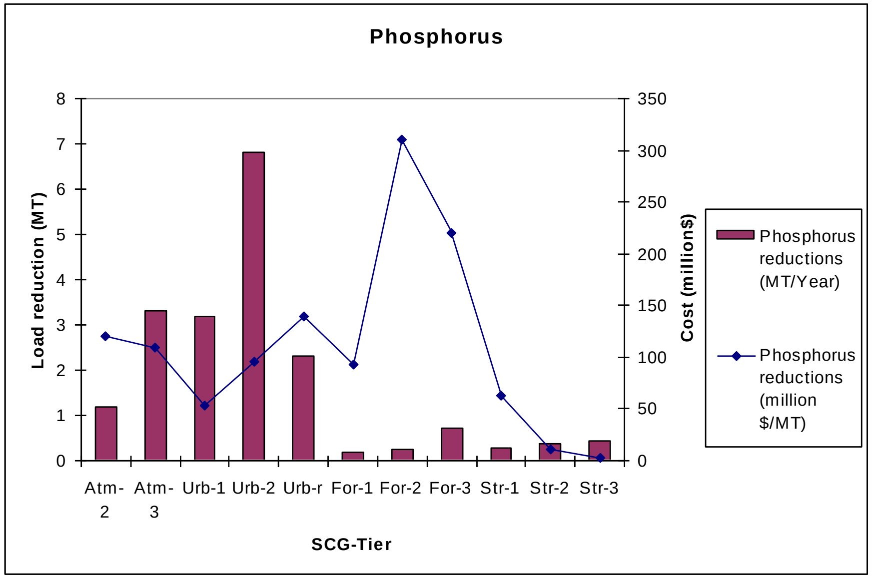
ECONorthwest
ECONOMICS • FINANCE • PLANNING

Two and Three Player Game Outcomes

	Vertebrates			Weeds		
Game Outcome	1 year	10 years	20 years	1 year	10 years	20 years
One farmer						
no restoration	10%	22%	17%	25%	26%	19%
restoration with defense	2%	33%	41%	42%	44%	49%
restoration with mitigation	59%	36%	33%	26%	24%	25%
restoration only	30%	9%	9%	7%	7%	7%
Two farmers						
no restoration	10.9%	38.2%	35.2%	29.8%	41.5%	31.7%
both defend	0.4%	13.9%	18.0%	5.5%	14.2%	7.4%
farmer 1 defends, with mitigation	0.9%	12.1%	13.7%	9.3%	15.6%	15.1%
farmer 2 defends, with mitigation	0.7%	9.7%	10.9%	7.7%	13.2%	12.8%
farmer 1 defends	0%	0%	0%	0.18%	0.01%	0.02%
farmer 2 defends	0.4%	2.6%	2.9%	2.5%	4.2%	4.6%
no defense, mitigation	76.8%	22.4%	18.5%	24.3%	10.9%	27.1%
restoration only	10.0%	1.0%	0.8%	20.8%	0.5%	1.3%

Annual Reductions and Equivalent Annual Cost





Differences in pollutant reduction costs exist between source categories and within source categories

ECONorthwest
ECONOMICS • FINANCE • PLANNING

Trading Benefits

Share of Total Lake Pollutant Budget Potentially Reduced

	Fine sediment particle reductions	Phosphorus reductions	Total 20 year cost (Million $)
Atmospheric	8%	8%	$7,300
Urban & Groundwater	44%	16%	$2,800
Forested Uplands	7%	2%	$3,200
Stream Channel	3%	1%	$15

Trading can allow pollutant reductions to happen at the lowest possible price

Trading can maximize the total pollutant reduction for a particular budget constraint

Example 3 percent reduction from each source category (20 years)

No trading = $4.5 billion

Trading = $580 million

Potential savings: $3.9 billion

(assuming these numbers and no transaction costs)

ECONorthwest
ECONOMICS • FINANCE • PLANNING