Ecosystem services: science & policy considerations to improve resource management in arid environments

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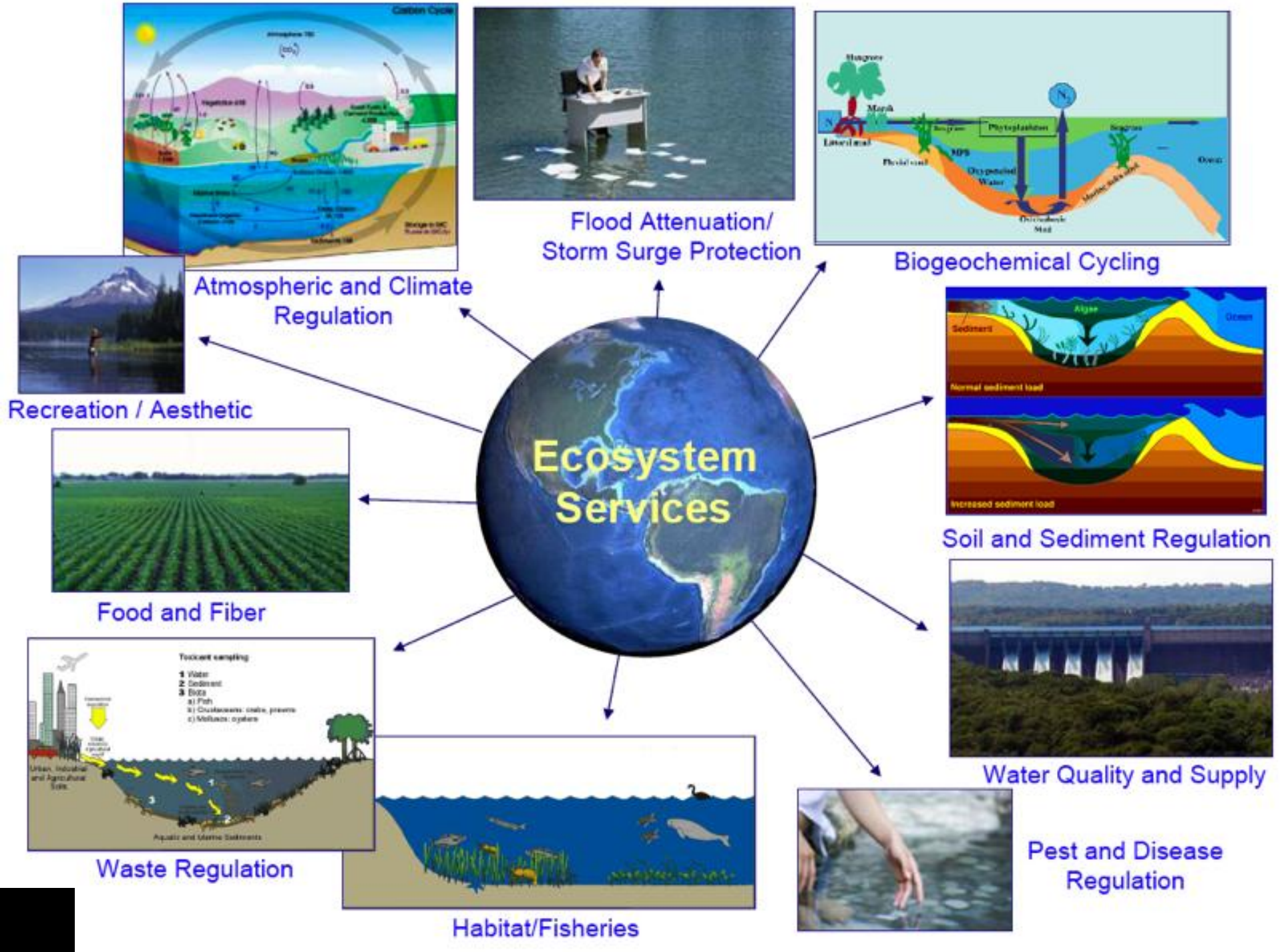
AGAVES

U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT

USGS science for a changing world


Ecosystem Services
Atmospheric and Climate Regulation
Flood Attenuation/ Storm Surge Protection
Biogeochemical Cycling
Recreation / Aesthetic
Soil and Sediment Regulation
Food and Fiber
Water Quality and Supply
Waste Regulation
Habitat/Fisheries
Pest and Disease Regulation

Why is it hard to value ecosystem services?

	Excludable	**Non-Excludable**
Rival	**Market Good**: cars, houses, land, oil, timber	**Open Access resource:** Oceanic fisheries, timber etc. from unprotected forests, waste absorption capacity
Non-rival	**Club or toll good** patented information, toll roads, country clubs	**Pure Public Good:** Information, most ecosystem services, e.g. climate stability, coastline protection, life support functions, etc.

Overview

- Key emerging concepts in ecosystem services
- Ecosystem services in arid/semiarid environments: a brief history
- Three key issues:
  1. Water as a driver of ES: relative scarcity of types of water
  2. The importance of watershed position
  3. Long-distance beneficiary flows & their consequences
- Applications to science and policy

Ecosystem service types

Supporting services Nutrient cycling Net primary production Pollination & seed dispersal Habitat Hydrologic cycle	**Regulating services** Gas regulation Climate regulation Disturbance regulation Biological regulation Water regulation Waste regulation Nutrient regulation Soil retention
Provisioning services Water supply Food Raw materials Genetic resources Medicinal resources Ornamental resources	**Cultural services** Recreation Aesthetic Science & education Spiritual & historic

A beneficiaries-based framework for ES

"Supporting services" or ecosystem processes

"Easy" for ecologists to study, impossible to value economically

Hydrologic cycle
Ecosystem water needs
Photosynthesis, net primary productivity
Rainfall interception & infiltration, evapotranspiration
Soil formation
Soil binding by vegetation
Viewsheds, topography

Millennium Assessment ecosystem services, "intermediate services"

Traditionally viewed as ecosystem services, not always easy to conceptualize & value economically

Water supply
Water regulation
Carbon sequestration and storage
Disturbance regulation
Soil retention
Aesthetic value

Benefits for human beneficiaries

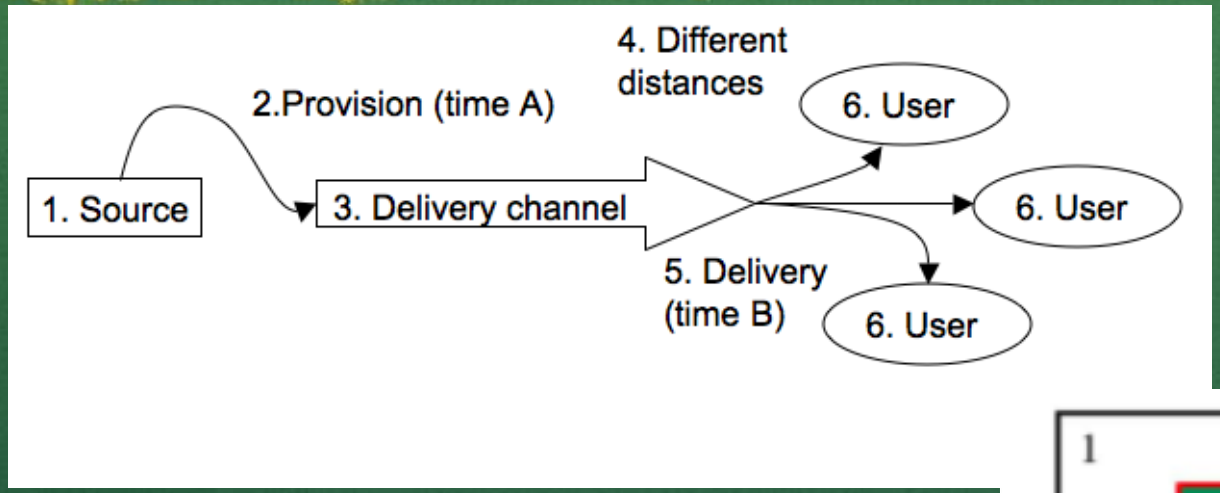
"Easy" for economists to value economically

Water for agriculture, electricity generation, households, industry, recreation
Climate stability
Avoided flood damage
Avoided landslide/mudslide/ avalanche damage
Avoided erosion
Avoided sedimentation
Sensory enjoyment

Explicit identification of beneficiaries

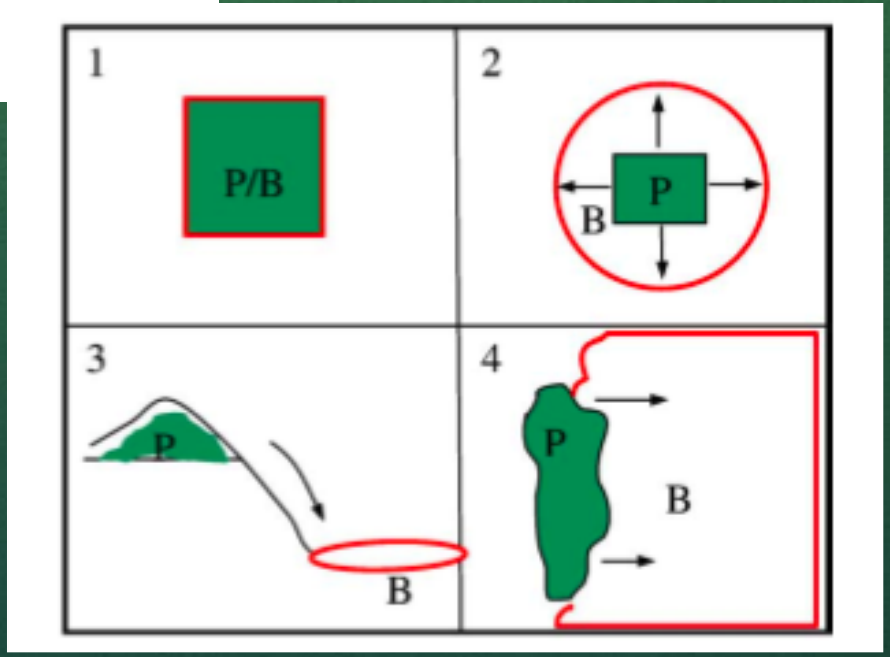
"Traditional" ES	General beneficiary class	Specific beneficiary group
Carbon sequestration & storage	Groups vulnerable to climate change	Coastal populations, snowmelt dependent populations, farmers, etc.
	Users of atmospheric CO_2 absorption	Greenhouse gas emitters
Aesthetic value	Scenic views	Homeowners with scenic views
	Proximity to open space	Homeowners near open space
Soil retention	Non-eroded systems	Farmers on erodible land
	Areas benefiting from sedimentation	Some floodplain farmers
	Non-sedimented systems	Some farmers, fishermen, hydro utilities, etc.
Disturbance regulation	Flood protection	Floodplain residents, farmers, public & private property owners
	Storm surge protection	Same groups as above
	Mudslide/avalanche protection	Same groups as above
Provision of adult salmon	Cultural icon	Native Americans, watershed residents, U.S. citizens
	Food source	Native Americans, subsistence fishermen, consumers
	Recreational amenity	Recreational fishermen, wildlife watchers

Spatial context in mapping

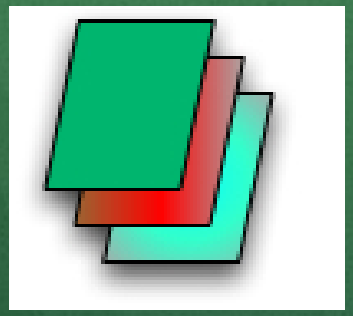


Fisher et al. 2009

Ruhl et al. 2007

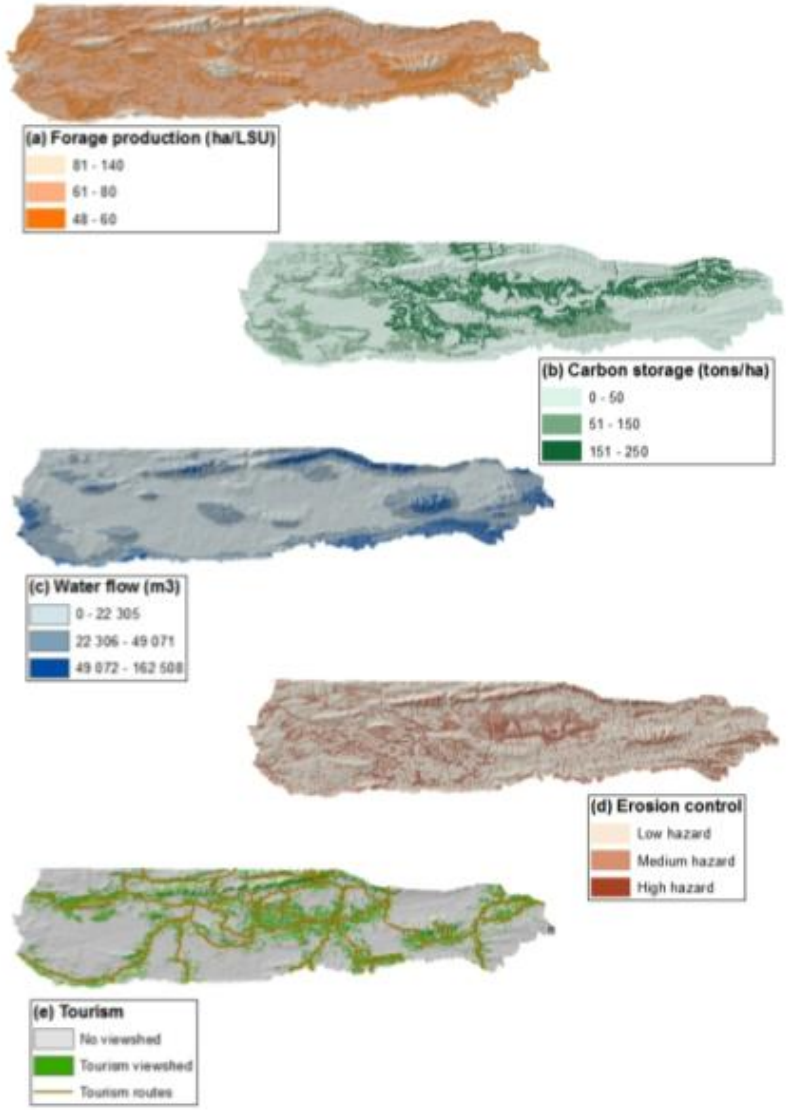


Today's state of the practice



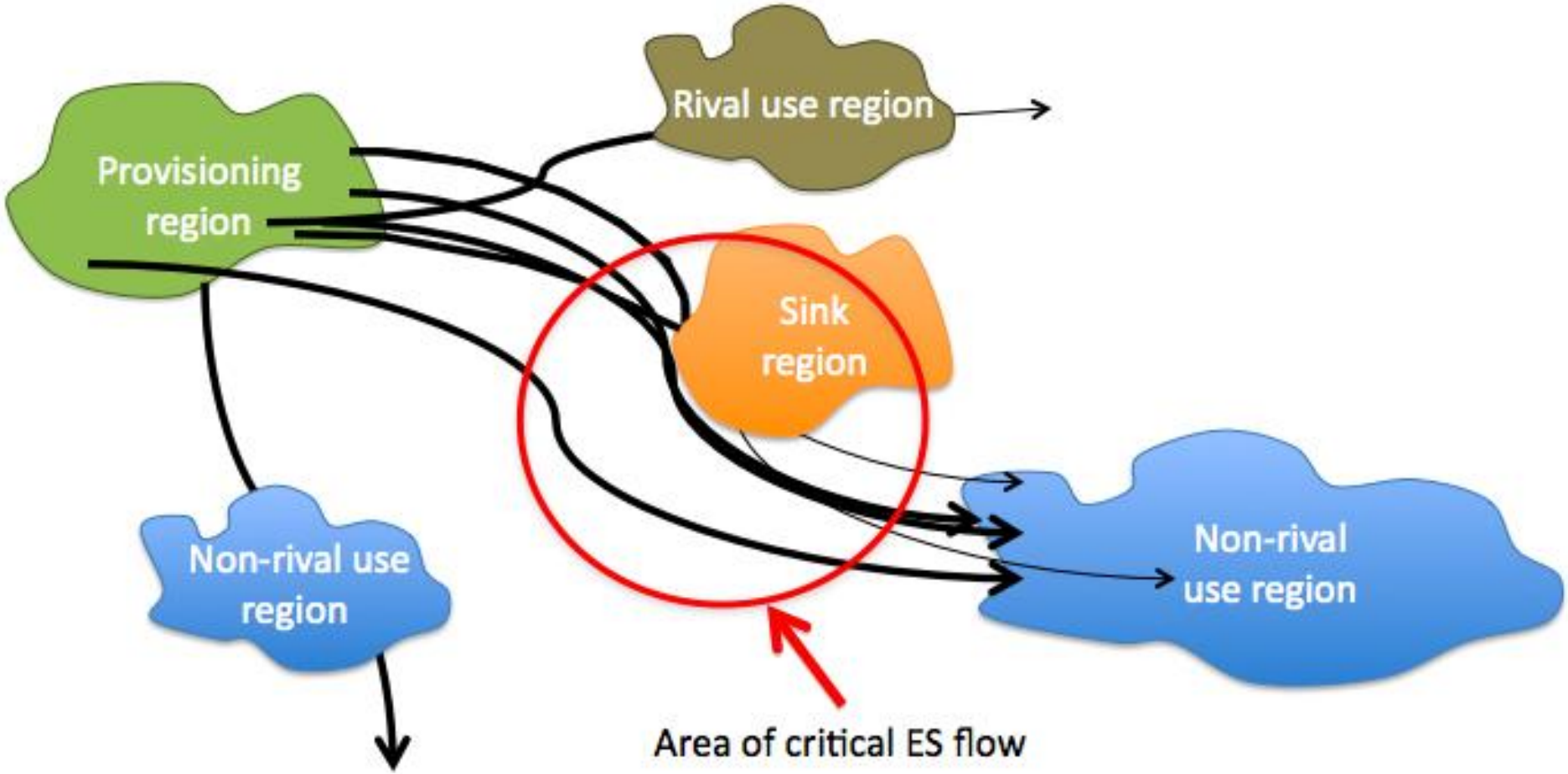
GIS database

Reyers et al. 2009



Soil erosion = f (rainfall, soil depth, soil texture, vegetation type)

Spatial context & ES flow analysis



History of ES in arid & semiarid systems

- Fewer, smaller universities in Intermountain West = fewer economists working on the issue?
- Costanza et al. 1997
  - Value of $0 for deserts
- Dodds et al. 2008
  - Lowest value for deserts of 6 North American ecoregions
  - 1-2 orders of magnitude lower value ($/ha) than any other ecoregion (with exception of western forested mountains)

Links between ES & NPP?

- MA (2005), Costanza et al. (2007), Richmond et al. (2007)
- High productivity alone ≠ more ES/ES value
  - Likely to differ service by service
  - More production of ecosystem goods, faster cycling of matter & nutrients, greater throughput of energy
  - All else being equal, still have to have demand to have value for ES
  - Higher marginal value for scarce resources in resource limited environments

Growing momentum for aridlands ES research & policy

- USEPA Southwest place-based research
- Agency-Academic research partnerships (e.g., AGAVES)
- Abundance of public land & interest from Federal agencies (Departments of Interior, Defense, USDA & Forest Service, EPA...)

Key issues in semiarid ecosystem services research/policy

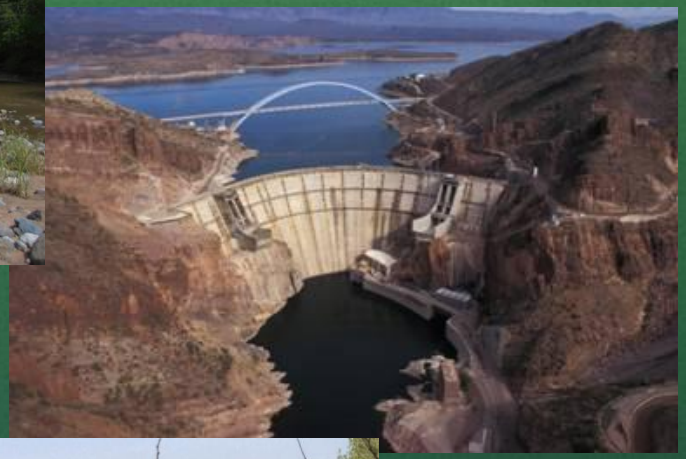
1. Water as a driver of ecosystem services: Relative scarcity

   Unregulated and/or perennial surface water < Regulated and/or intermittent surface water < Shallow groundwater < Deep groundwater

2. Watershed position as related to ecosystem service provision & use

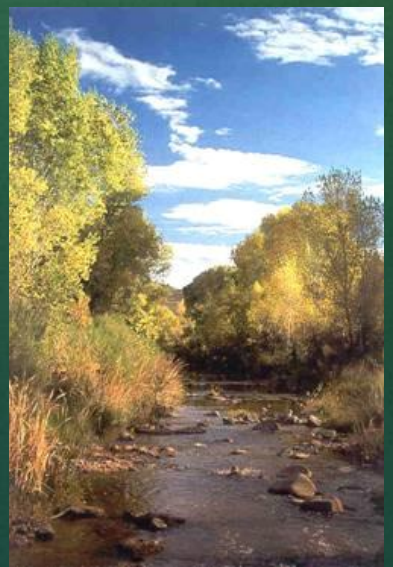
3. Low population densities = dispersed beneficiaries, long-distance spatial flows of ecosystem services

1. Relative scarcity of water



Surface-water derived ecosystem services: unregulated streams

- Water supply
- Recreation (certain types)
- Support to surface-flow & riparian vegetation derived ecosystem services
  - Carbon sequestration/storage
  - Cooler microclimates
  - Sediment & nutrient regulation
  - Aesthetic value
  - Some habitat-derived values (presumably greatest levels)
- Non-use value (existence, option, bequest), given its rarity?



Surface-water derived ecosystem services: flow-regulated streams

- Water supply
- Hydroelectric generation/flood control/recreation (certain types)
- Support to surface-flow & riparian vegetation derived ecosystem services
  - Carbon sequestration/storage
  - Cooler microclimates
  - Sediment & nutrient regulation
  - Aesthetic value
  - Some habitat-derived values (presumably intermediate levels)

Shallow groundwater-derived ecosystem services

- Water supply
- Support to deep phreatophyte-supported ecosystem services
  - Carbon sequestration/storage
  - Sediment regulation
  - Some habitat-derived values (presumably lowest levels)

Deep groundwater-derived ecosystem services

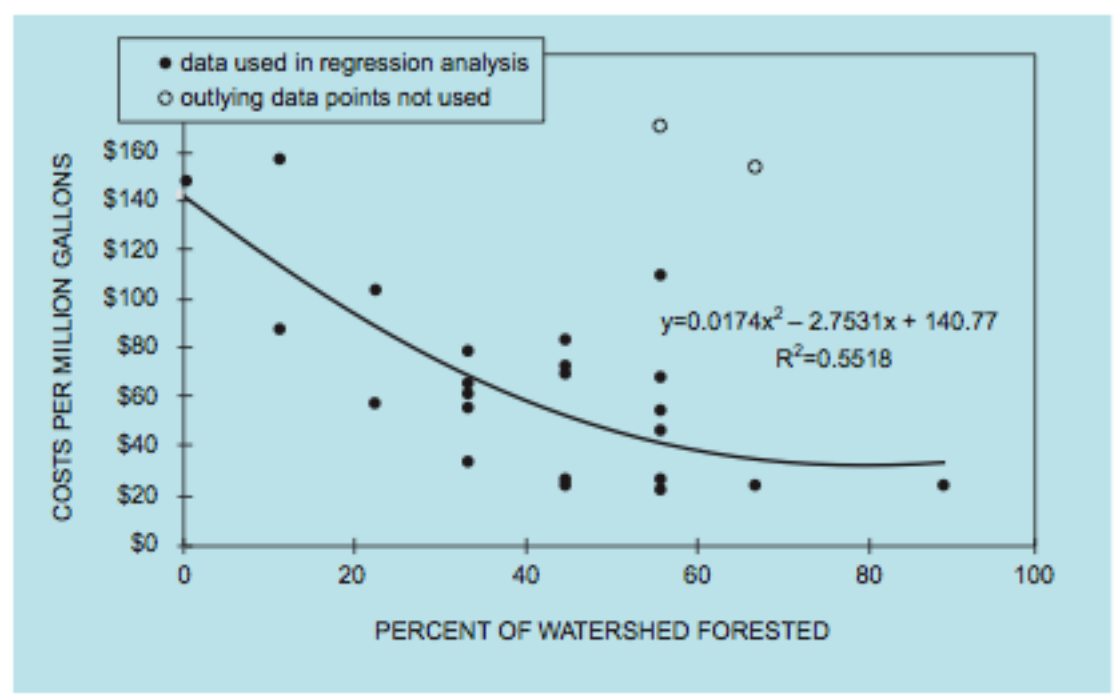
- Water supply
- Subsidence prevention

Summary

Ecosystem service	Unregulated streams	Flow-regulated streams	Shallow groundwater	Deep groundwater
Water supply	X	X	X	X
Recreation	X	X		
Carbon sequestration/storage	**X**	**X**	x	
Cooler microclimates	X	X		
Sediment/nutrient regulation	**X**	**X**	x	
Aesthetic value	**X**	**X**	x	x
Other habitat-derived ES (incl. migration support)	**X**	X	x	
Non-use value	**X**	X		
Hydroelectric generation		X		
Flood control		X		
Subsidence regulation	X	X	X	x

2. Hydrologic position

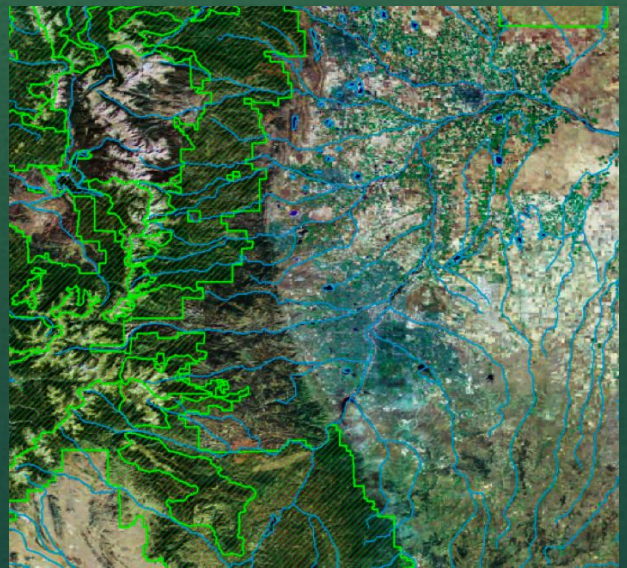
- New York City, Seattle, Portland, San Francisco, Quito…
- Does ES-based management "just happen" when cases are obvious enough?
- If that's the case, do we move cases that obvious?"

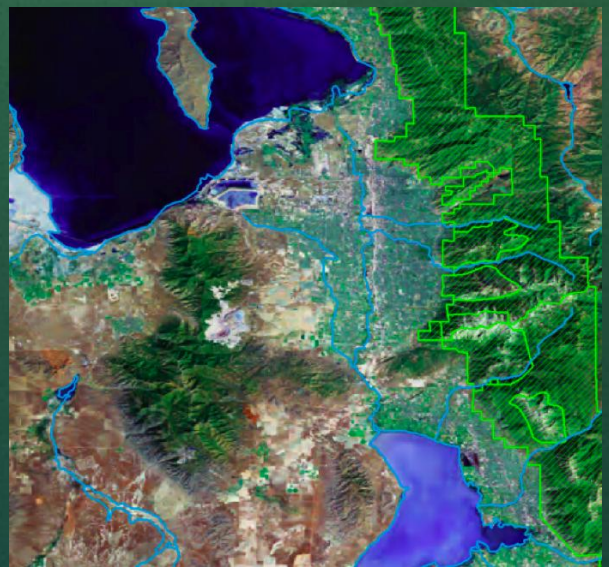


Trust for Public Land 2002

“Obvious cases” in the Southwest

- Phoenix (Tonto NF)
- Denver & Front Range (Roosevelt-Arapaho-Pike-San Isabel NFs)
- Salt Lake City (Uinta-Wasatch-Cache NF)

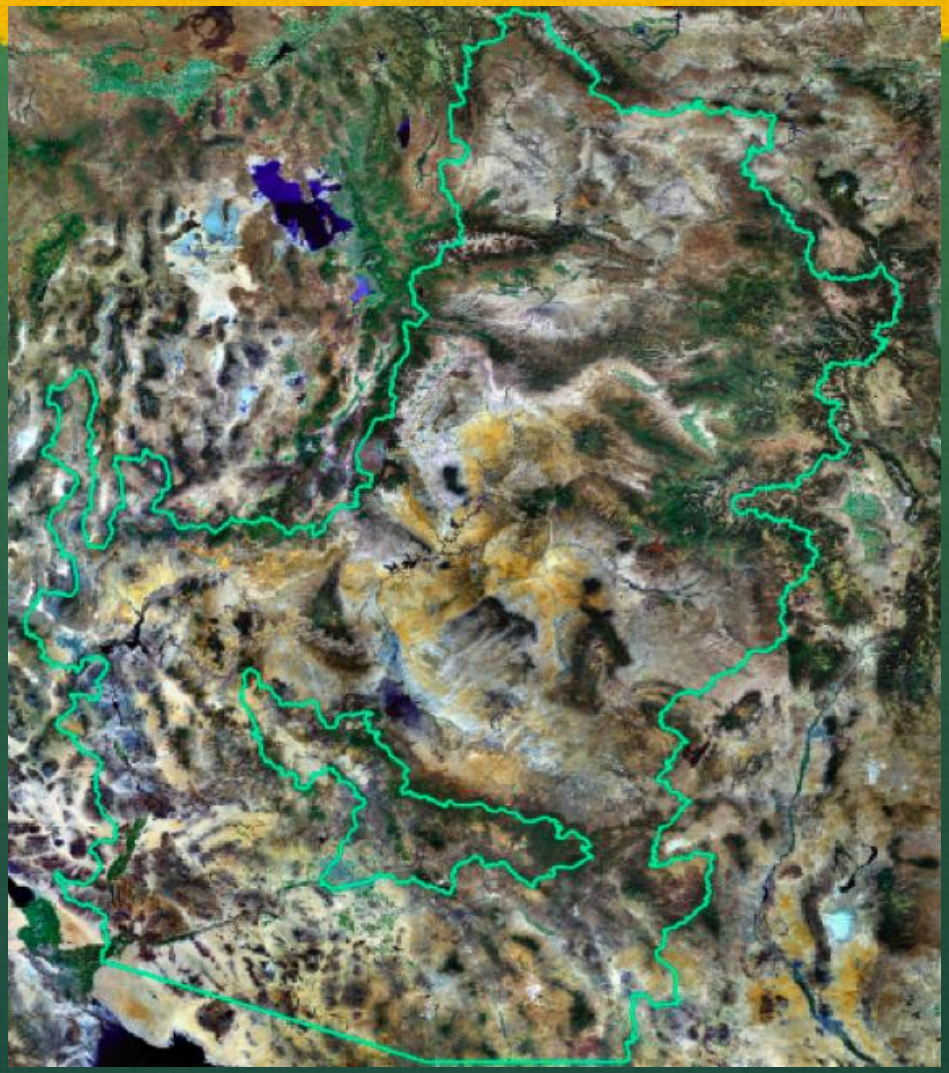




A “less obvious case:” San Pedro River

Other “less obvious cases?”

- Small population centers
- Population centers in headwaters, versus downstream
- Large river systems
- “Less obvious cases” make it harder to demonstrate large value for a key western ES: water

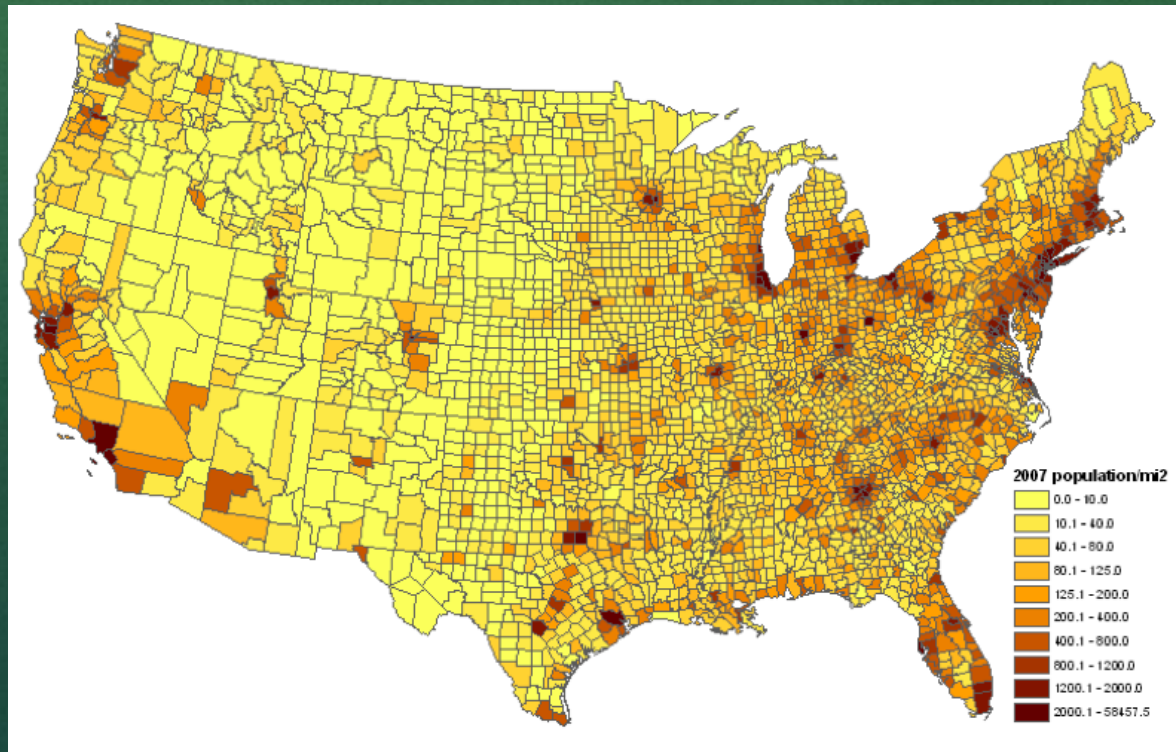


Expressing value without beneficiaries: Regulatory standards vs. WTP

- Society's choice about the level of degradation that's acceptable and the costs to clean up, regardless of beneficiaries, and based on governmental regulation
- Clean Water Act, Endangered Species Act
- Avoided/replacement cost, NOT a direct expression of preferences, i.e., contingent valuation/choice experiments

3. Geographic dispersion of beneficiaries

- All else being equal, does low population density = low ES demand = low ES value?
- If that's the case, how to account for value in rare ecosystems?
- Long-distance beneficiary flows may be unrecognized or underappreciated



Problem with long-distance beneficiary flows

- Are surveys accounting for the whole beneficiary population?
  - If not, underestimates value!
- Are survey respondents & decision makers aware of spatial dependencies (i.e., imperfect information)?
  - If not, key players may lose out in decision making

Long-distance beneficiary flows

- Water: LA/NV/PHX-Colorado snowpack connections
  - Land use (urbanization-grazing) impacts on reservoir condition & lifespan)

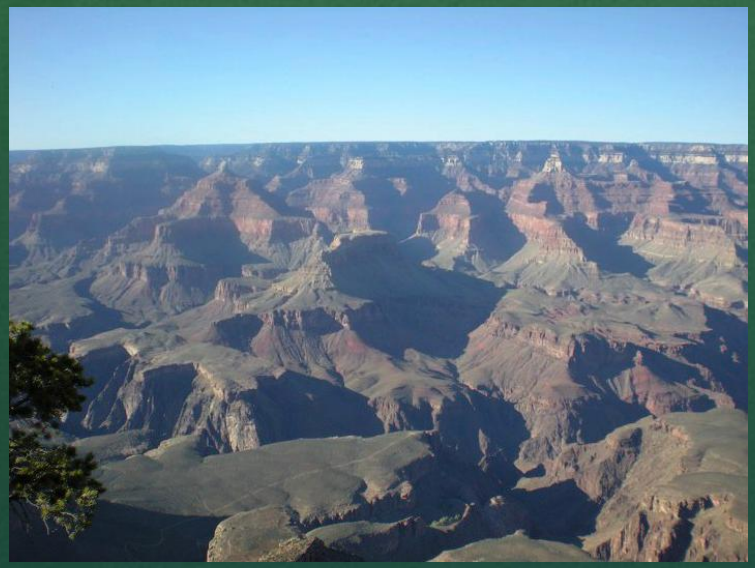
Long-distance beneficiary flows

- Migratory birds: recreation, migration support (Semmens et al.)

Brookshire et al.

Long-distance beneficiary flows

- Fires, climate change impacts, forest disease & insects and carbon, recreation in charismatic sites (e.g., National Parks)



Long-distance beneficiary flows

- WTP & distance decay, especially in charismatic systems & for non-use value (Pate and Loomis 1997, Loomis 2000, Bateman et al. 2006)
- San Pedro : Brookshire (in prep) find steep decay -> San Pedro of its kind but outside

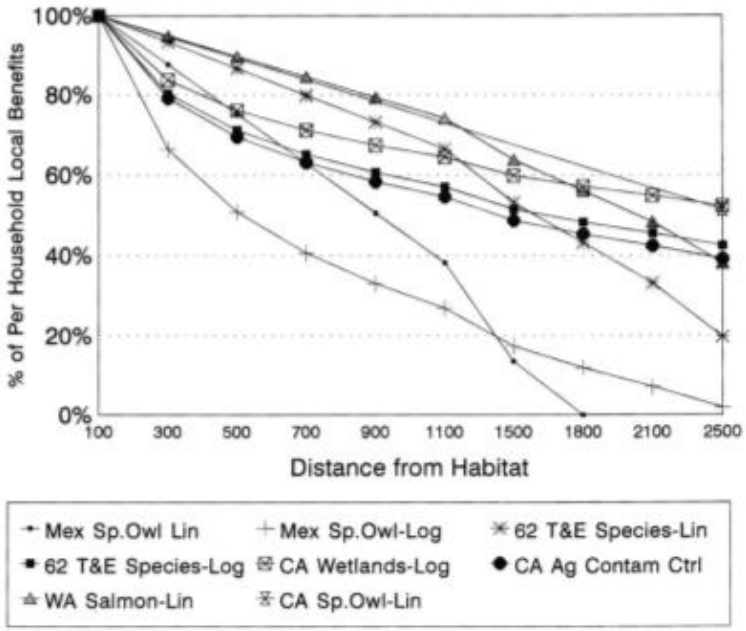


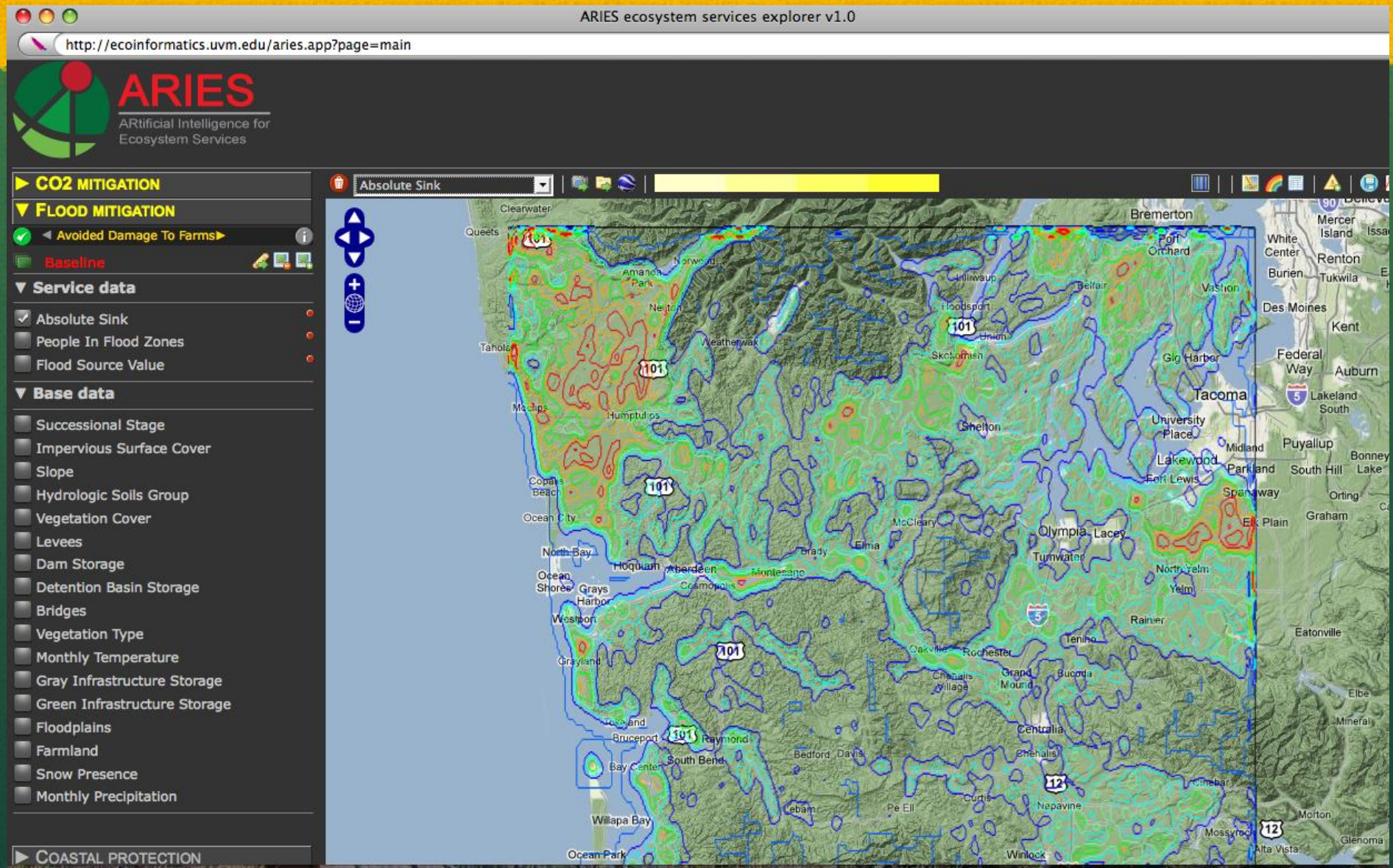
FIGURE 1
PER HOUSEHOLD BENEFIT GRADIENTS FOR PUBLIC GOOD VALUES OF WILDLIFE: PERCENT OF LOCAL WTP AS A FUNCTION OF DISTANCE FROM HABITAT

Loomis 2000

Scientific implications

- Map not just potential ES provision, but use & flows, across wide distances
  - Scientifically challenging!
  - Potential to inform survey work and get fuller, more accurate valuation estimates
  - Gives insight into siting conservation & development choices, polluter pays vs. beneficiary pays approaches to PES
  - As land managers, you: 1) may know many of your constituents but 2) helps to have as many of them on your side as possible!
- Better accounting for ES to align economic theory, mapping & valuation

Mapping spatial dynamics



BLM-USGS Ecosystem Services Valuation Pilot

- Determine which, if any, methods for valuing ecosystems are ripe for operational use at the BLM
- Explore the usefulness of an ecosystem services valuation framework to BLM's land use decision-making process
- Start at a site that is:
  - Data-rich
  - Faces multiple management issues related to multiple ecosystem services
  - Includes native/cultural heritage issues requiring nonmonetary valuation

Study site: San Pedro River, AZ

- Testing alternative methods & tools
- Multiple ES
  - Water
  - Biodiversity-based ES
  - Carbon
  - Cultural
- Multi-stakeholder context

Policy implications: summary

- Problems 1-3 partly explain why ES to date are not part of standard policy decisions
- Need to reframe tradeoffs as more than just recreation/wilderness/preservation vs. extractive use
- Institutions: in the West, historically facilitated settlement, extractive resource use (homesteading, mining law, water law, state trust lands to fund education)
- Land ownership patterns aren't always sensible for sound resource management (e.g., checkerboard)

Policy implications: adding it up

- When dollars are used:
  - Carefully consider discounting & intergenerational (Layton and Levine 2003)
  - Correctly account for WTP-WTA disparity
  - Be careful around ecological thresholds and uncertainty
- Dollars don't always need to be used:
  - Often inappropriate/controversial (e.g., Native American cultural values, endangered species)
  - Nonmonetary preference surveys useful, well established in some fields (e.g., recreation management)

Conclusion

"Markets measure the relative marginal benefits of different economic products but fail to measure the marginal costs of ecological degradation.

As a result, *our economy fails to solve the macroallocation problem: How much ecosystem structure should be apportioned toward the production of human-made goods and services and how much should be left intact to provide ecosystem services?"* (Farley 2008)