

Integrating cultural and biophysical ecosystem service assessment and exploring their incorporation into Federal planning efforts

Darius J. Semmens
Geosciences and Environmental Change Science Center

Presented at **Open Knowledge: Bridging Perspectives
To Address Water Challenges**

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**U.S. Department of the Interior
U.S. Geological Survey**

...what I'm really going to talk about

- **Ecosystem services as a bridge between disciplines**
 - Context for transdisciplinary research
- **Spatial modeling of cultural ecosystem services**
 - Social Values for Ecosystem Services (SoLVES)
 - Scenario analysis
 - Integrating cultural and biophysical ES
- **Ecosystem services & migratory species**
 - Spatial subsidy concept
 - Example application – monarch butterflies



Now a component of Federal Policy

- More than just a convenient framework for transdisciplinary research
- Agencies directed to develop and institutionalize policies to promote consideration of ES in planning, investment, and regulation



October 7, 2015

M-16-01

MEMORANDUM FOR EXECUTIVE DEPARTMENTS AND AGENCIES

FROM: Shaun Donovan, Director
Office of Management and Budget
Christina Goldfuss, Managing Director
Council on Environmental Quality
John Holdren, Director
Office of Science and Technology Policy

SUBJECT: Incorporating Ecosystem Services into Federal Decision Making

Overview. Nature provides vital contributions to economic and social well-being that are often not traded in markets or fully considered in decisions. This memorandum provides direction to agencies on incorporating ecosystem services into Federal planning and decision making. (Broadly defined, ecosystem services are the benefits that flow from nature to people, e.g., nature's contributions to the production of food and timber; life-support processes, such as water purification and coastal protection; and life-fulfilling benefits, such as places to recreate.)

Specifically, this memorandum:

- (1) Directs agencies to develop and institutionalize policies to promote consideration of ecosystem services, where appropriate and practicable, in planning, investments, and regulatory contexts. (Consideration of ecosystem services may be accomplished through a range of qualitative and quantitative methods to identify and characterize ecosystem services, affected communities' needs for those services, metrics for changes to those services and, where appropriate, monetary or nonmonetary values for those services.)
- (2) Sets forth the process for development of implementation guidance and directs agencies to implement aforementioned policies and integrate assessments of ecosystem services, at the



Ecological Endpoints

- Biophysical characteristics or qualities; concrete, tangible, and measurable; and directly, intuitively connected to human well being (Boyd, 2007)
- Natural science: develop management and models to predict changes in ecological endpoints
- Social science: weight or place value on ecological endpoints to prioritize management and protection actions



Consider a desert spring...

- **Physical science**
 - How will nearby groundwater withdrawal impact spring discharge?
- **Life science**
 - What are the ecological impacts of reduced or curtailed spring discharge?
- **Social science**
 - How will these changes impact human well being?
 - (Who cares? So what?)



Consider a desert spring...

- Provisioning services
 - Water for stock animals
 - Water for irrigation
 - Water for domestic/personal use
- Cultural services
 - Historical/religious significance
 - Recreation
 - Wildlife viewing
 - Hunting/fishing
 - Swimming
 - Aesthetic enjoyment
 - Others



Spatial modeling of cultural ES



Darius Semmens, Ben Sherrouse, Ken Bagstad, and Zach Anchona
USGS Geosciences and Environmental Change Science Center

<http://solves.cr.usgs.gov>



Social Values for Ecosystem Services

- Social values = nonmarket values perceived by stakeholders for ecosystems
- Close correspondence with cultural ecosystem services
- Consideration of social values is lacking relative to ecological and economic values
- SoIVES = GIS tool allowing users to assess, map, and quantify social values
 - Developed as an ArcGIS 10 Add-In toolbar for ArcMap
- Goal to augment ecosystem service assessments with social value information



Social Values and Cultural ES



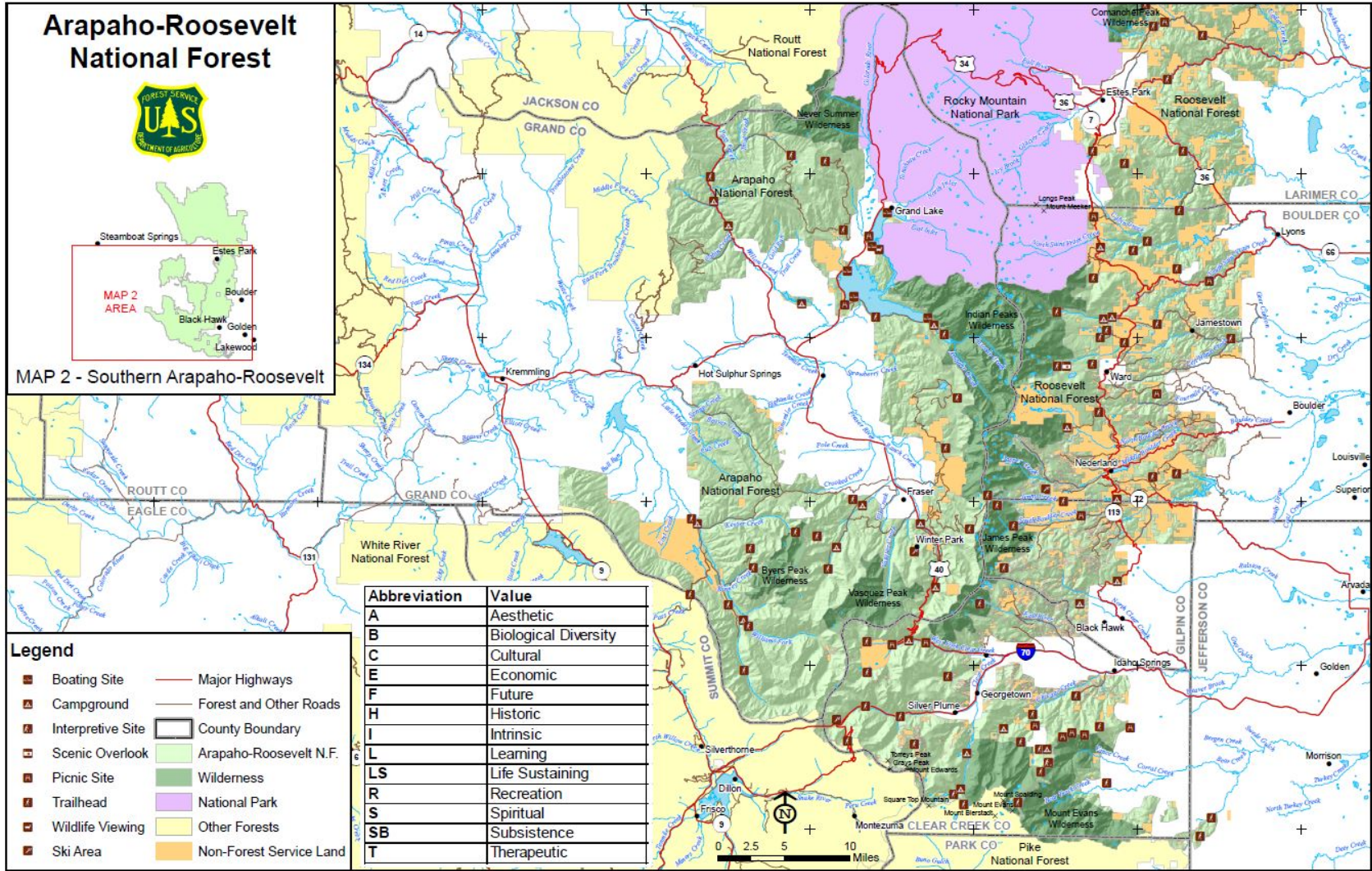
Aesthetic
Biodiversity
Cultural
Economic
Future
Historic
Intrinsic
Learning
Life-Sustaining
Recreation
Spiritual
Subsistence
Therapeutic



Imagine that you could allocate 100 points toward what you value in the Arapaho-Roosevelt National Forest. For example, you might assign 100 points to one value and zero to all the others, or you might assign 50 to one, 25 to another, and 25 to another.

Please read through the list below and distribute 100 points any way you would like


- _____ Aesth
smell:
- _____ Biolog
variet
- _____ Cultur
contir
- _____ Econo
oppo
- _____ Futur
know
- _____ Histor
natur
- _____ Intrin
matte



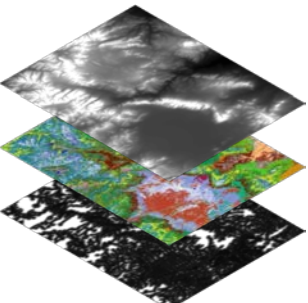
Social Values for Ecosystem Services (SoIVES)

Geodatabase Contents

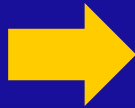
Point Data



Environmental Data

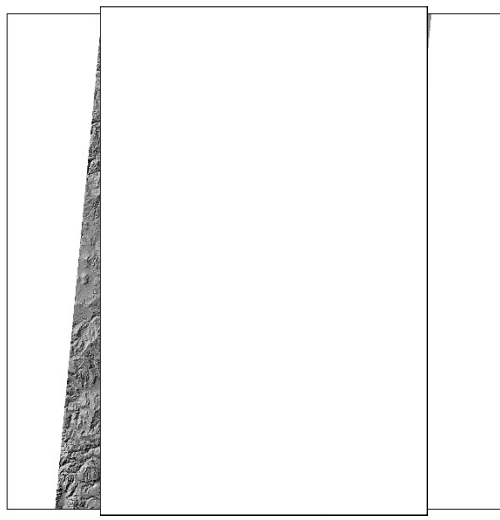


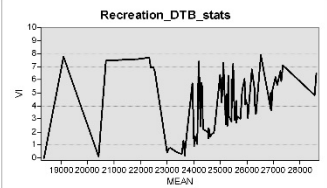
Nonspatial Data	
•	Attitudes and Preferences
•	Value Allocations
•	Other Tabular Data

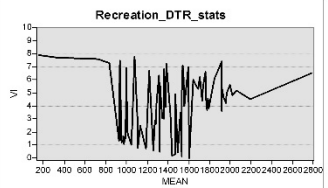


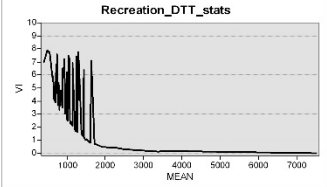
Pike San Isabel National Forest

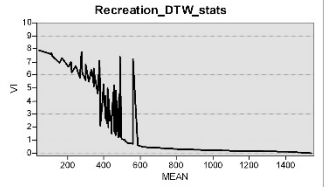
All Surveys
Recreation

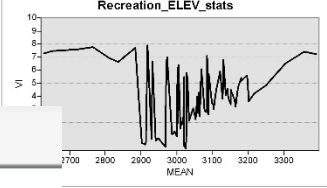


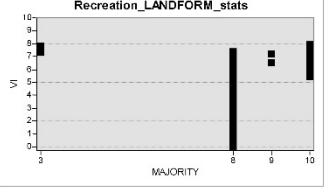












SoIVES

- Project Setup
- Analyze Survey Data
- Transfer Values
- View Results

Analyze Survey Data

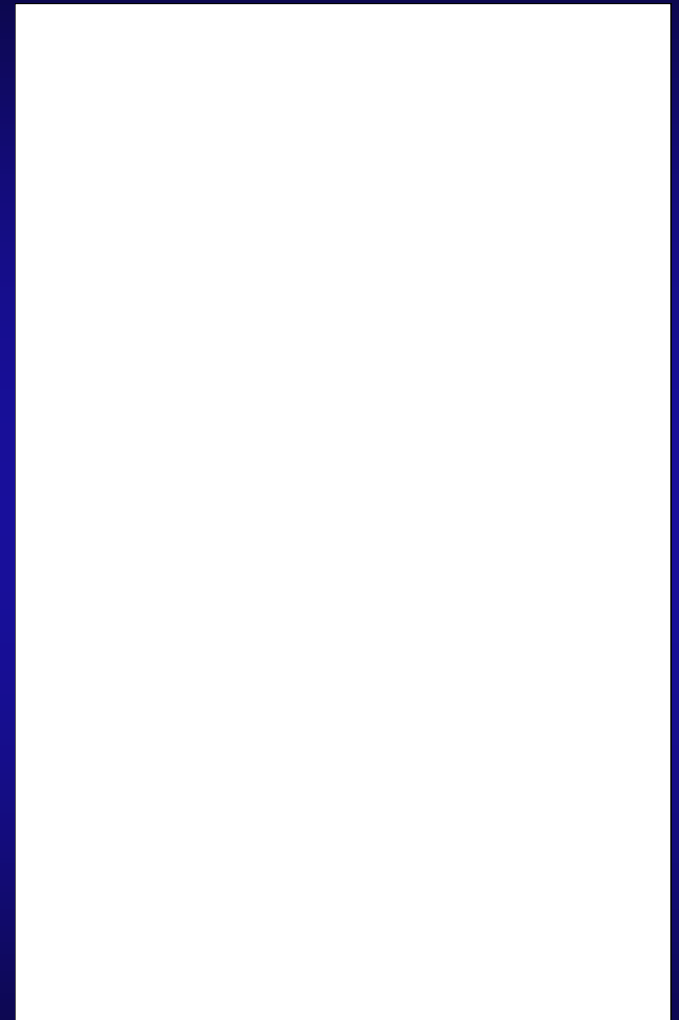
ion
AUC = 0.8765
ble model for study area
C = 0.8208
nternal model for value transfer

Refer to the relevant environmental dataset for a description of the categories indicated by the numeric values displayed on the x-axis of any categorical data graphs



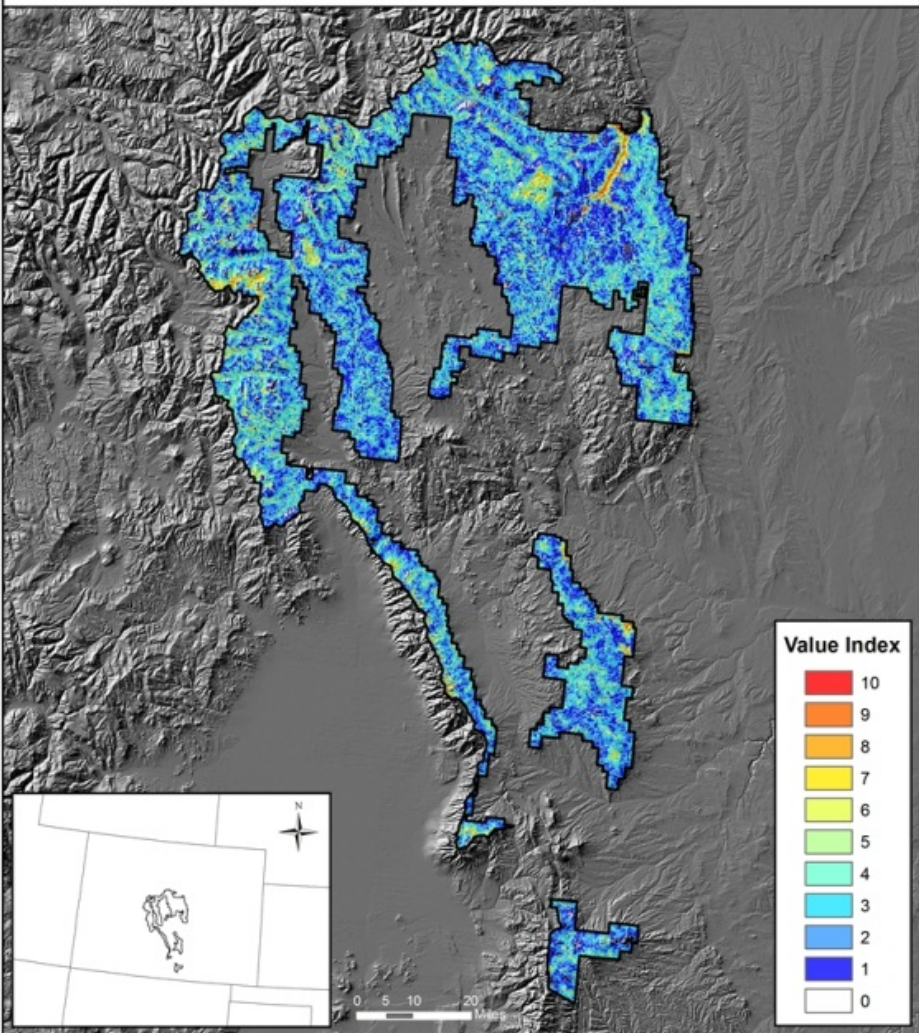
SoLVES Methodology

- Calculates and maps a 10-point (0-10) “value index”, a nonmonetary, spatially explicit metric of social values
- Derives value index from a combination of spatial and nonspatial public value and preference survey responses
- Uses MaxEnt to model the spatial correspondence between the value index points and environmental variables



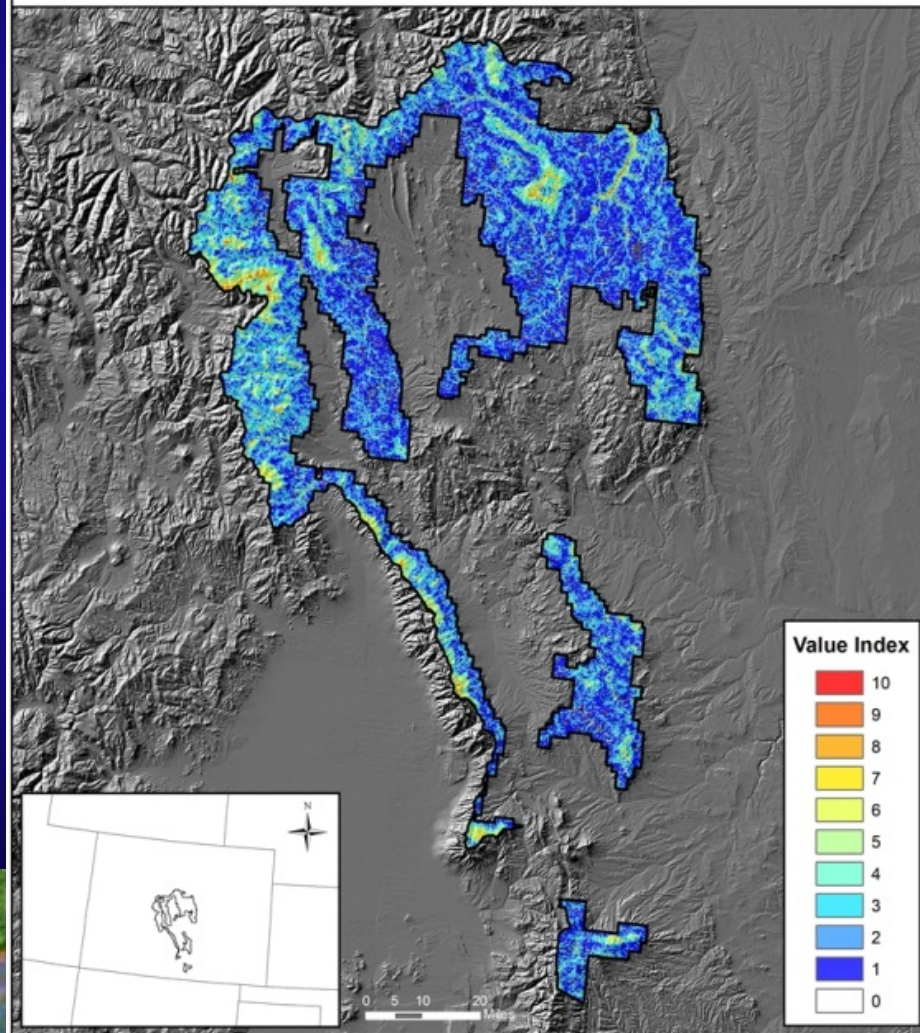
Pike and San Isabel National Forests, Colorado

Recreation Value for Survey Respondents
Favoring Motorized Recreation



Pike and San Isabel National Forests, Colorado

Aesthetic Value for Survey Respondents
Opposing Motorized Recreation



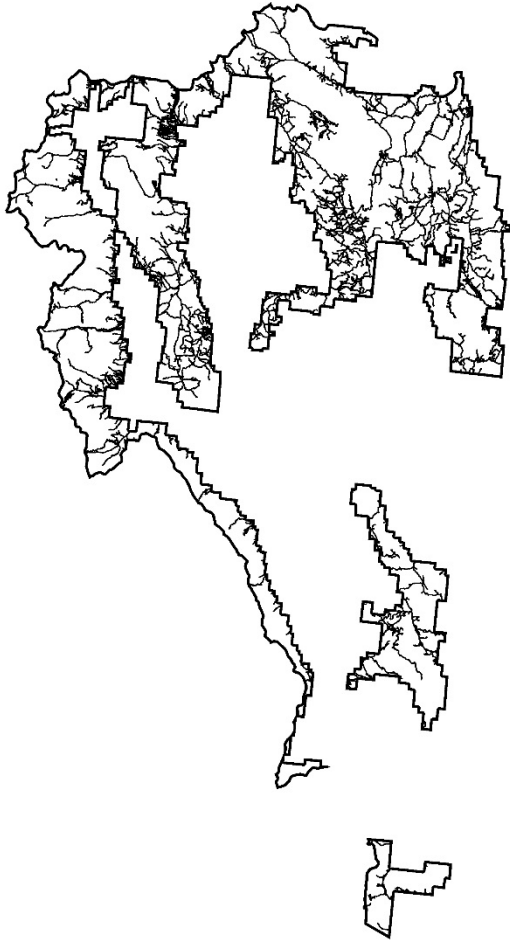
Scenario Analysis with SoLVES

- SoLVES can also be used to anticipate endpoint change associated with future scenarios – a common component of planning activities
 - Increased visitation associated with population growth
 - Designation of new wilderness areas
 - Construction of new roads

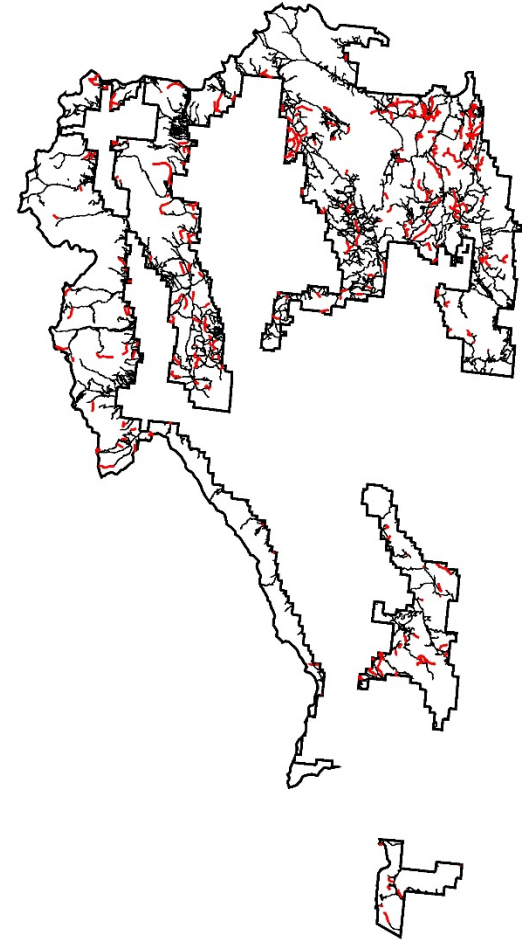


Road Network Modification

Original



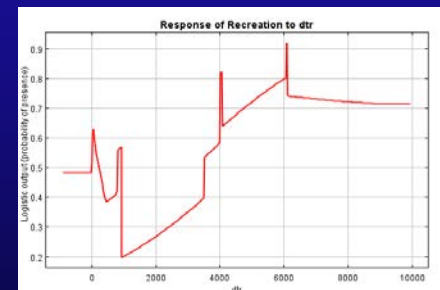
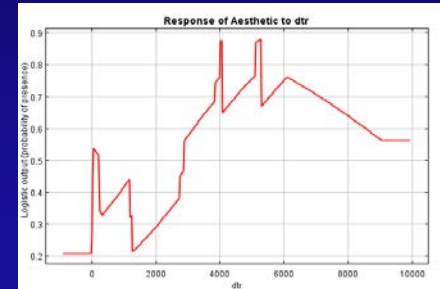
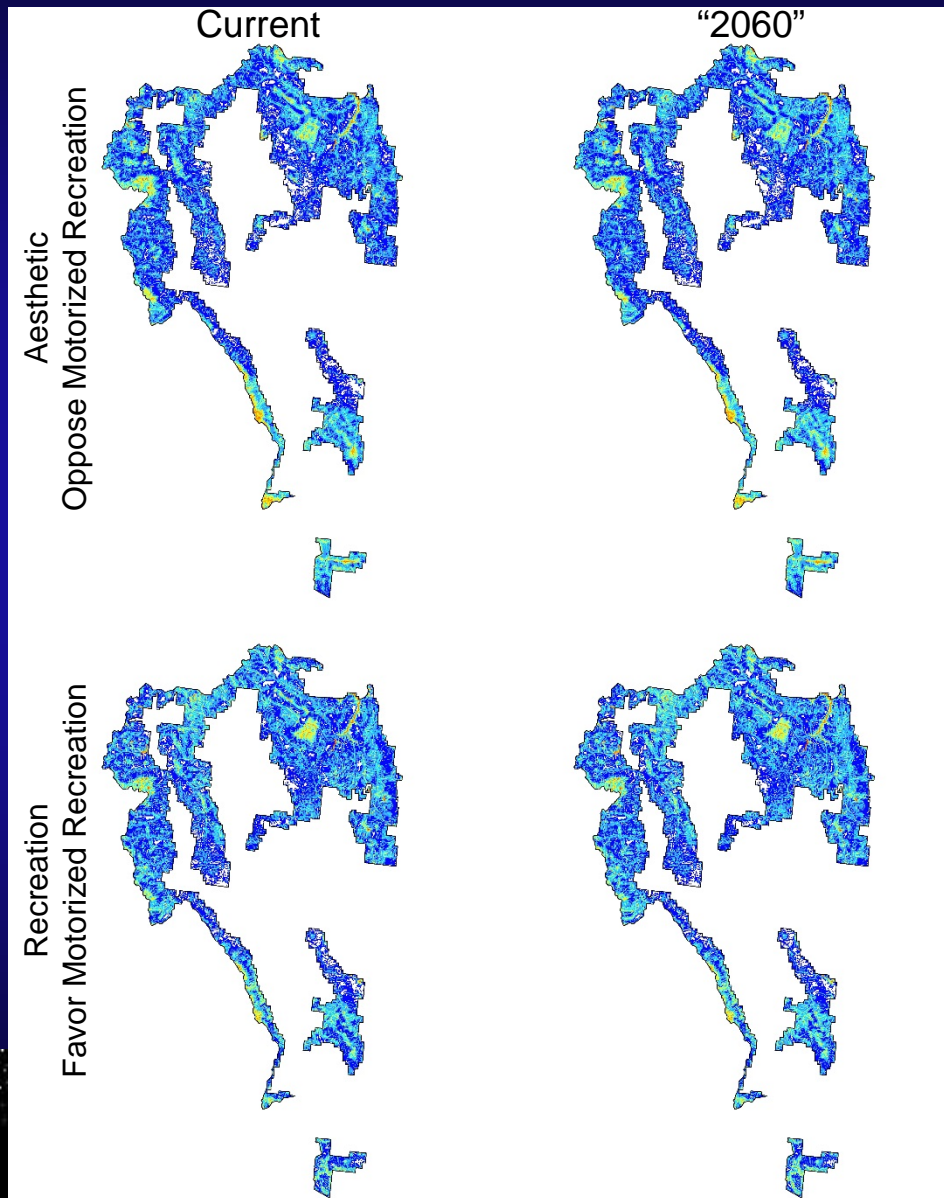
Modified



Oppose vs. Favor Motorized Recreation

Variable	Contribution
ELEV	34.0%
DTR	22.2%
DTB	14.5%
LULC	14.4%
DTT	8.2%
DTW	5.2%
LANDFORM	1.6%

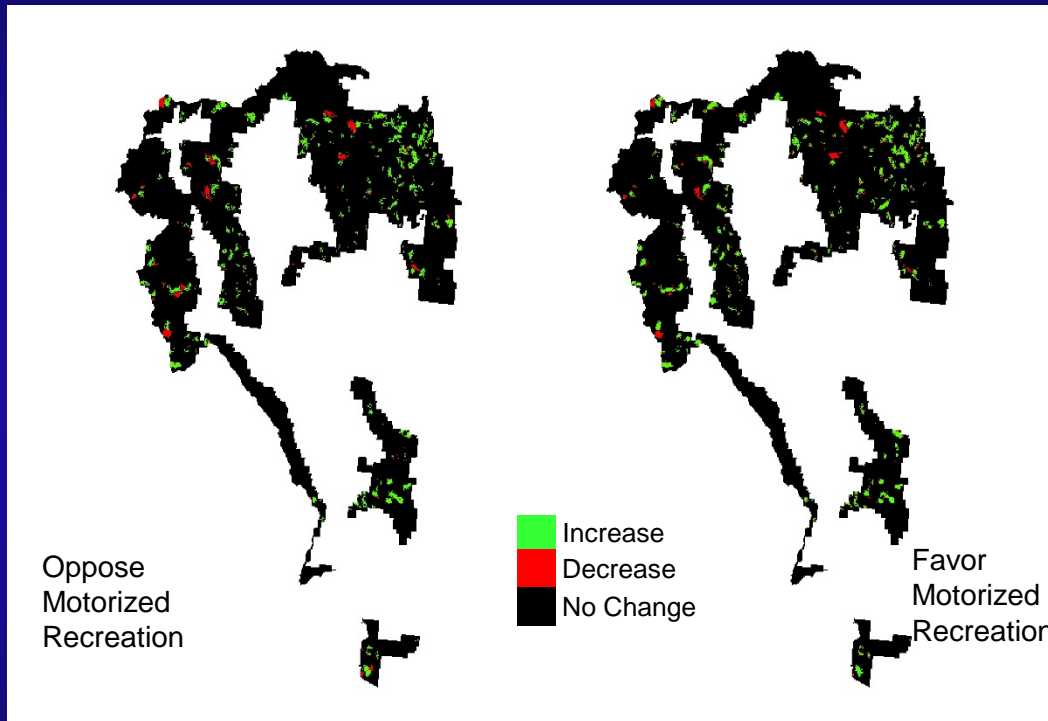
Variable	Contribution
LULC	26.1%
ELEV	22.0%
DTR	18.8%
DTW	15.0%
DTT	11.6%
DTB	5.3%
LANDFORM	1.2%



Oppose vs. Favor Motorized Recreation

Aesthetic Change

Recreation Change



Trade-off Matrix

		Recreation		
		Decrease	No Change	Increase
Aesthetic	Decrease	4%	5%	1%
	No Change	6%	42%	9%
	Increase	1%	8%	26%

2.0% increase in mean aesthetic value

2.3% increase in mean recreation value



Combining Cultural & Biophysical ES

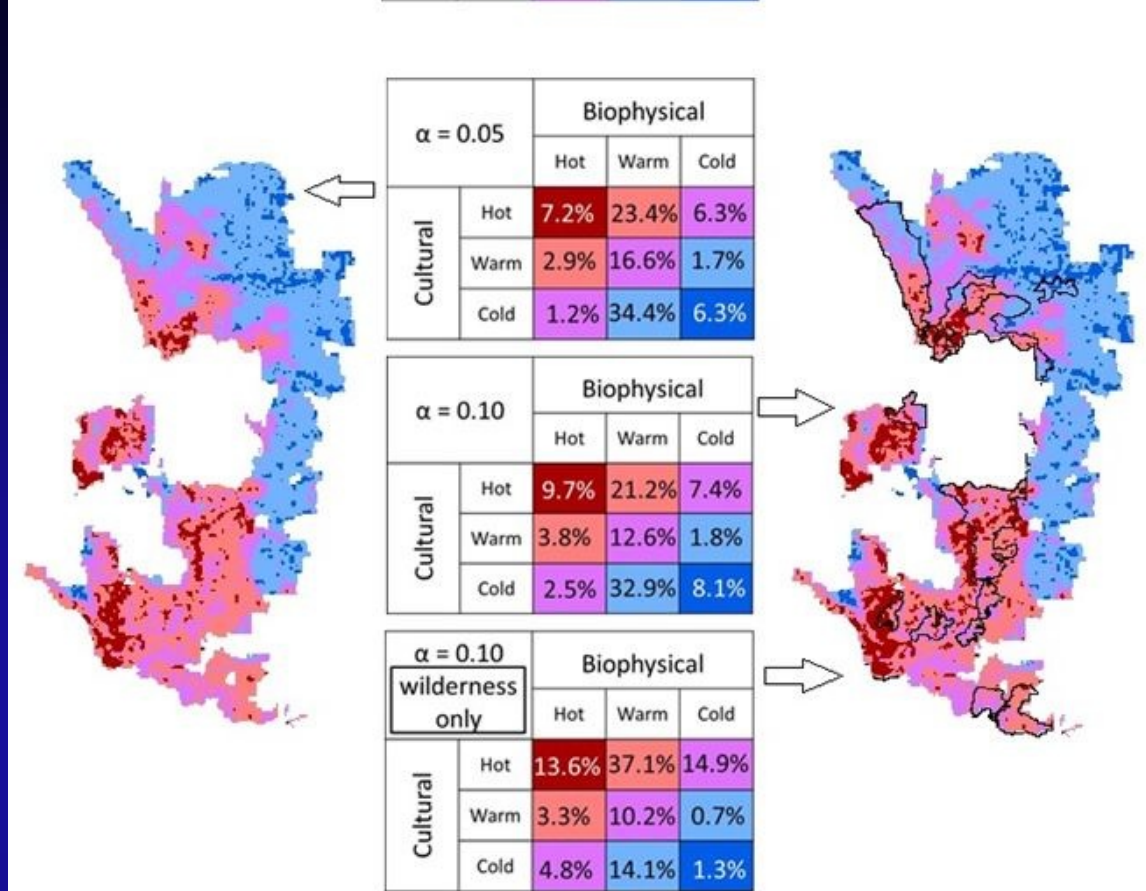
- If we forego monetary valuation, cultural and biophysical service production can be combined in space to map correspondence or divergence across the landscape

		Biophysically modeled ecosystem services (mapped using ARIES)		
		Hot	Warm	Cold
Cultural ecosystem services (mapped using SoIVES)	Hot	High management support (if cultural & biophysical services are synergistic) OR potential conflict between management and traditional uses (if tradeoffs exist between cultural & biophysical services)	High support for traditional uses; cases where biophysical modeling alone is inadequate to map value	
	Warm		Areas suitable for development or resource extraction, assuming other important natural or cultural resources are absent (e.g., high biodiversity, threatened & endangered species, indigenous cultural significance)	
	Cold	Public outreach needed to build support for management (e.g., for watershed protection programs)		



Hot Spot Results

Hot/warm/cold spot maps for the Arapahoe-Roosevelt National Forest for two different levels of statistical significance.



Bottom table shows results just for designated wilderness areas, which have relatively more hot and less cold spots than the forest as a whole.



Consider a desert spring... again

■ Supporting services

- Water for wildlife – javelina, desert bighorn sheep, mule deer, etc.
- Core habitat for aquatic and riparian species
- Breeding habitat for invertebrate & amphibian species
- Food sources for reptiles
- Roosting habitat for resident bird species
- Stopover habitat for migratory species

■ All of these feed back into cultural services



Ecosystem Services & Migratory Species: Quantifying spatial subsidies

**Darius Semmens¹, Jay Diffendorfer¹, Laura López-Hoffman², and
Ruscena Wiederholt²**

¹USGS Geosciences and Environmental Change Science Center, Denver CO

²School of Natural Resources, University of Arizona, Tucson AZ

USGS Powell Center for Analysis and Synthesis – Working Group

Economics & Markets - Ken Bagstad, Josh Goldstein, John Loomis

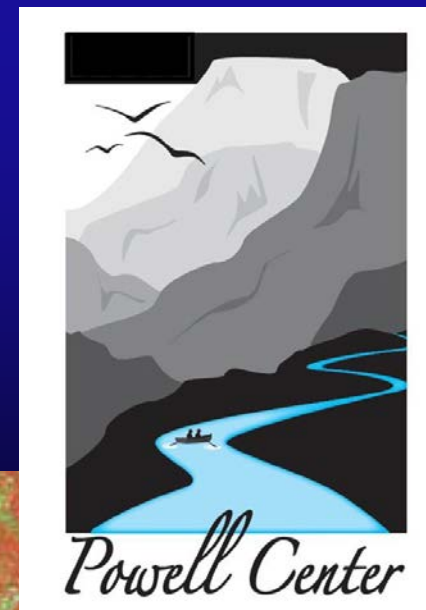
Northern Pintail Ducks – Jim Dubovsky, Brady Mattsson,

Wayne Thogmartin

Mexican Free-Tailed Bats – Paul Cryan, Gary McCracken, Rodrigo

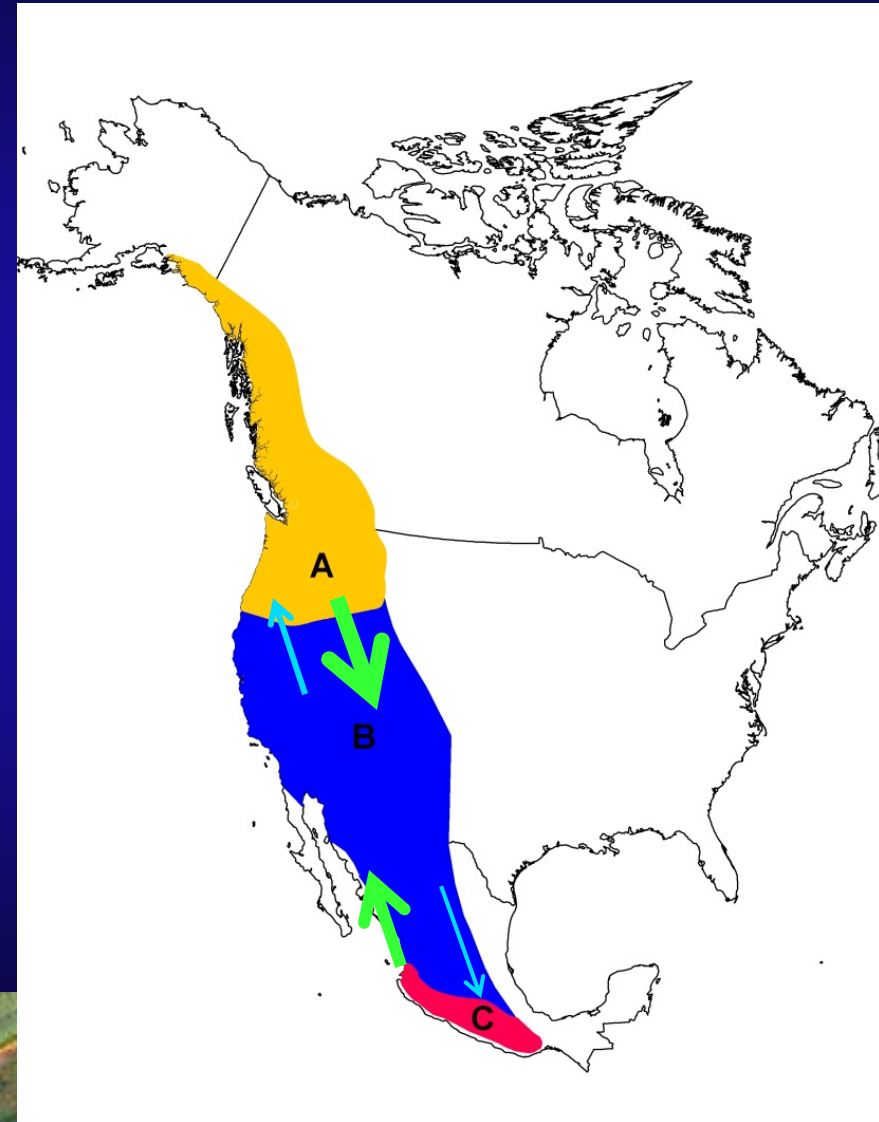
Medellin, Amy Russel

Monarch Butterflies – Karen Oberhauser, Leslie Ries, Brice Semmens



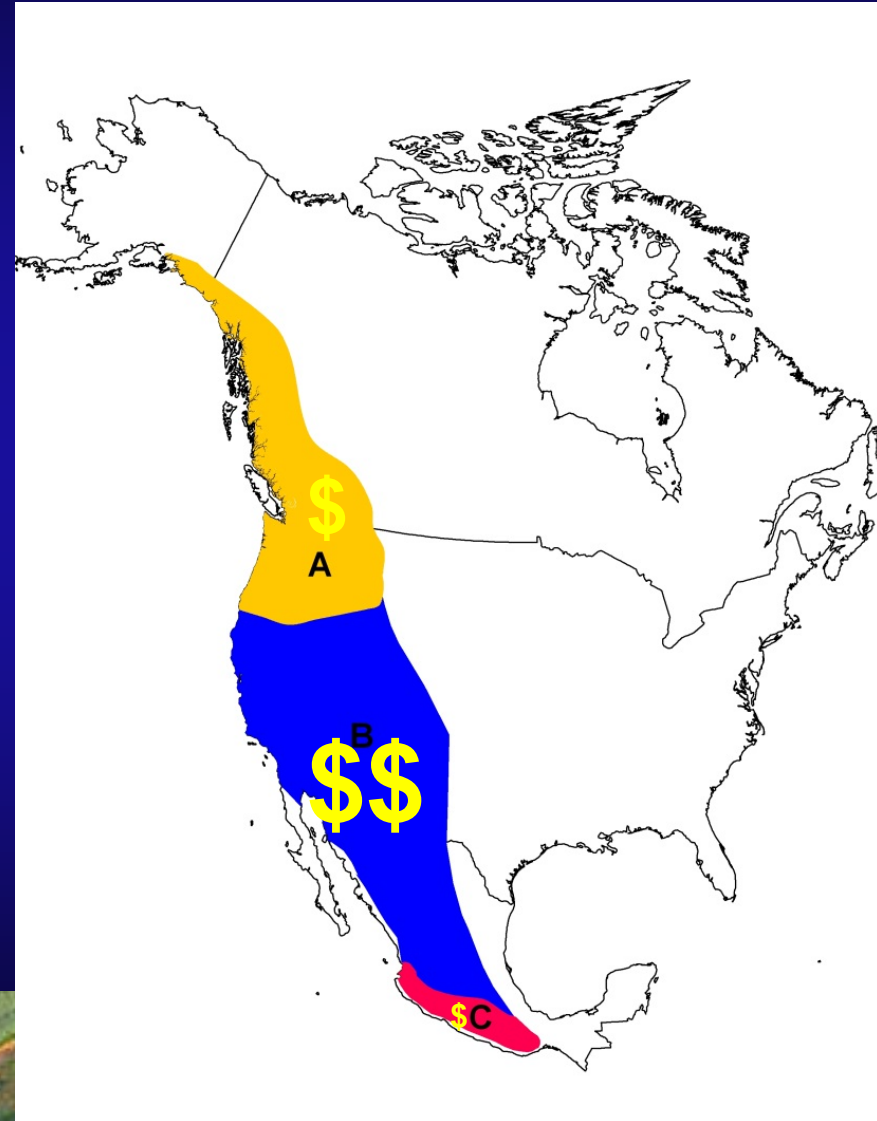
Spatial Subsidies Concept - Ecology

- Ecological support received by area from rest of range
 - Population maintained during time spent elsewhere
- Ecological support provided to rest of range via role of area in maintaining population
 - Habitat for survival & breeding



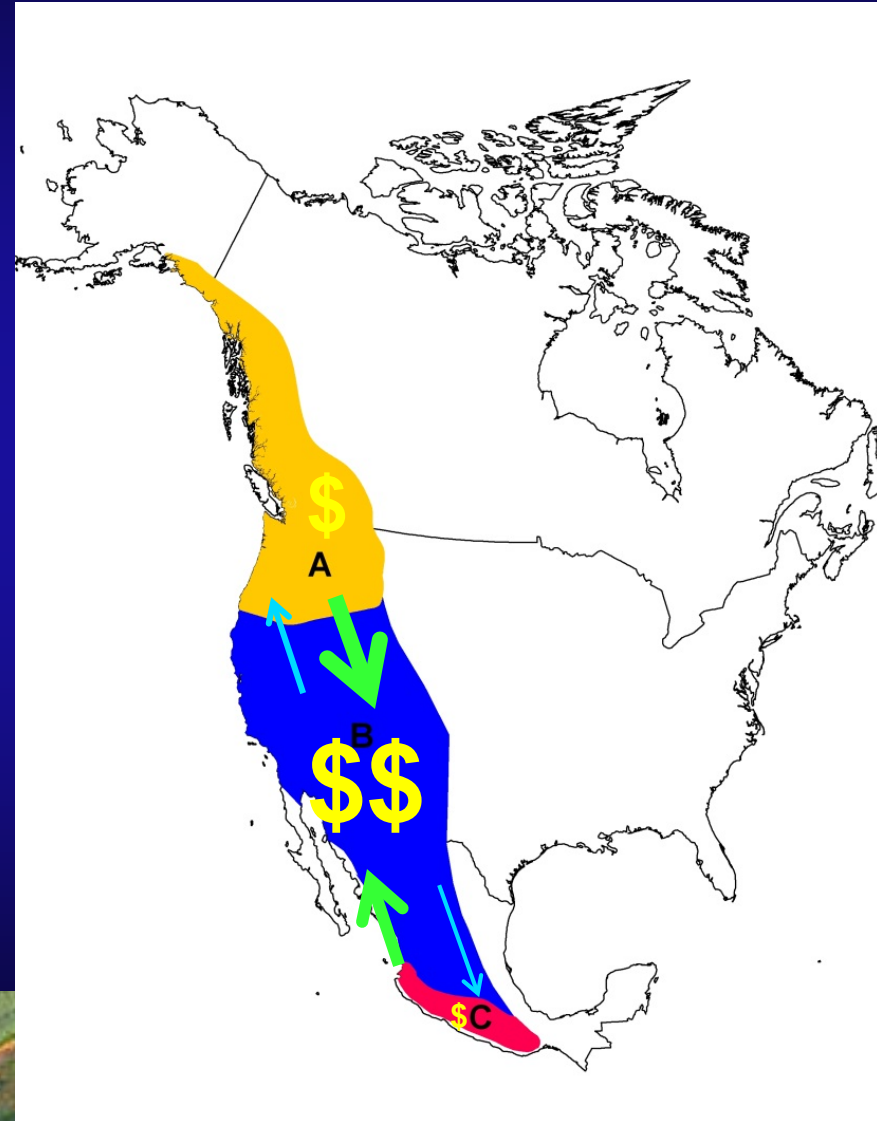
Spatial Subsidies Concept – Socioeconomics

- Species provides benefits to humans within area
 - Food, recreation, pest control, pollination, seed dispersal, etc.
- Species also provide benefits across migratory range



Spatial Subsidies Concept – Mismatches

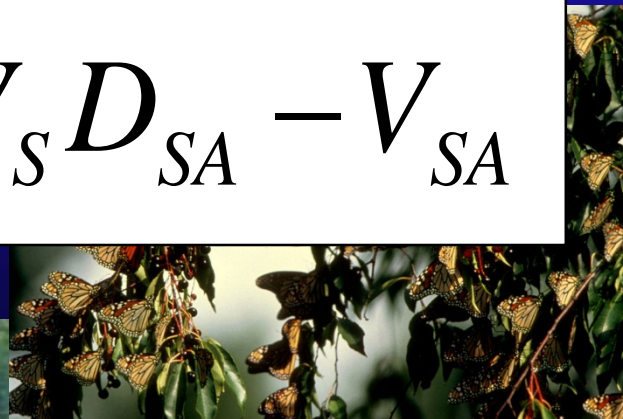
- Place(s) where species provides most benefits to humans may not correspond with place(s) providing most support to species
 - Mismatch between ecologically and economically important areas
 - Subsidy is the net balance between them



Key Parameters – Biophysical and Socioeconomic

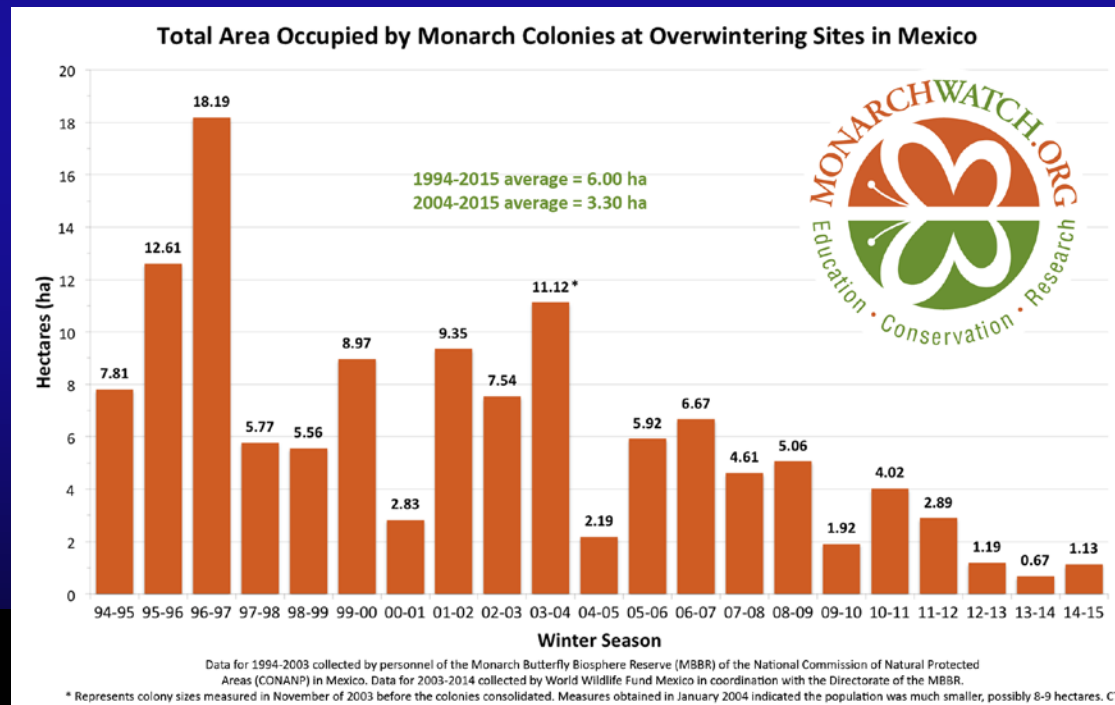
- To quantify spatial subsidies 2 key parameters must be estimated over a species' entire range
 - V_S - value of services provided by species in each part of its range
 - D_S – proportional dependence of species on each of the same parts of its range

$$Y_A = V_S D_{SA} - V_{SA}$$



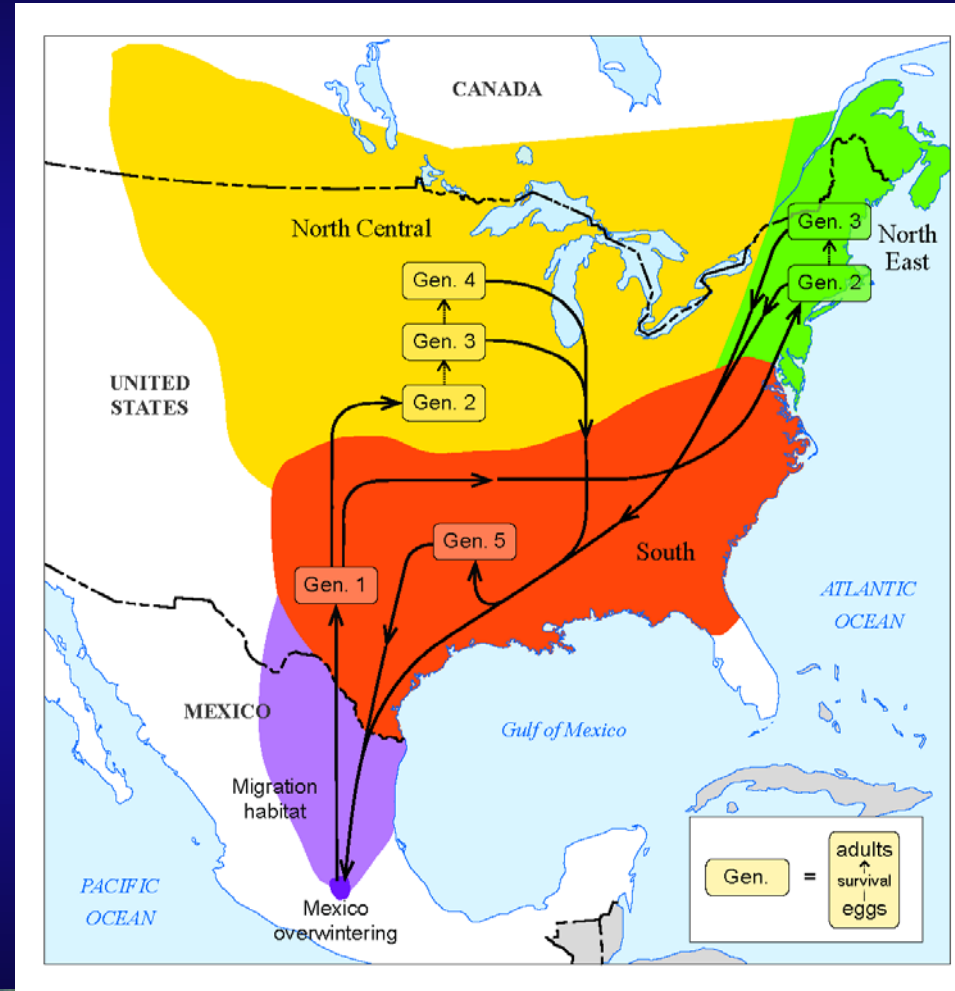
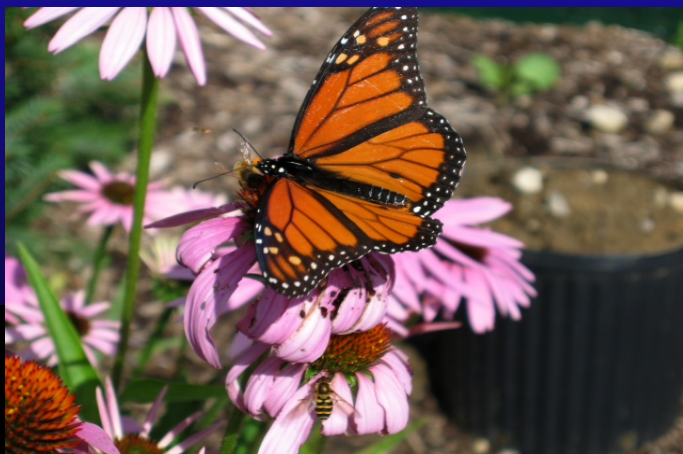
Monarch Butterfly: Problem

- Pronounced population decline over last 20 years
- Leaders of Mexico, U.S., and Canada pledged to reverse
- ESA listing petition in U.S.
- Tri-national collaboration to restore population to 6 ha



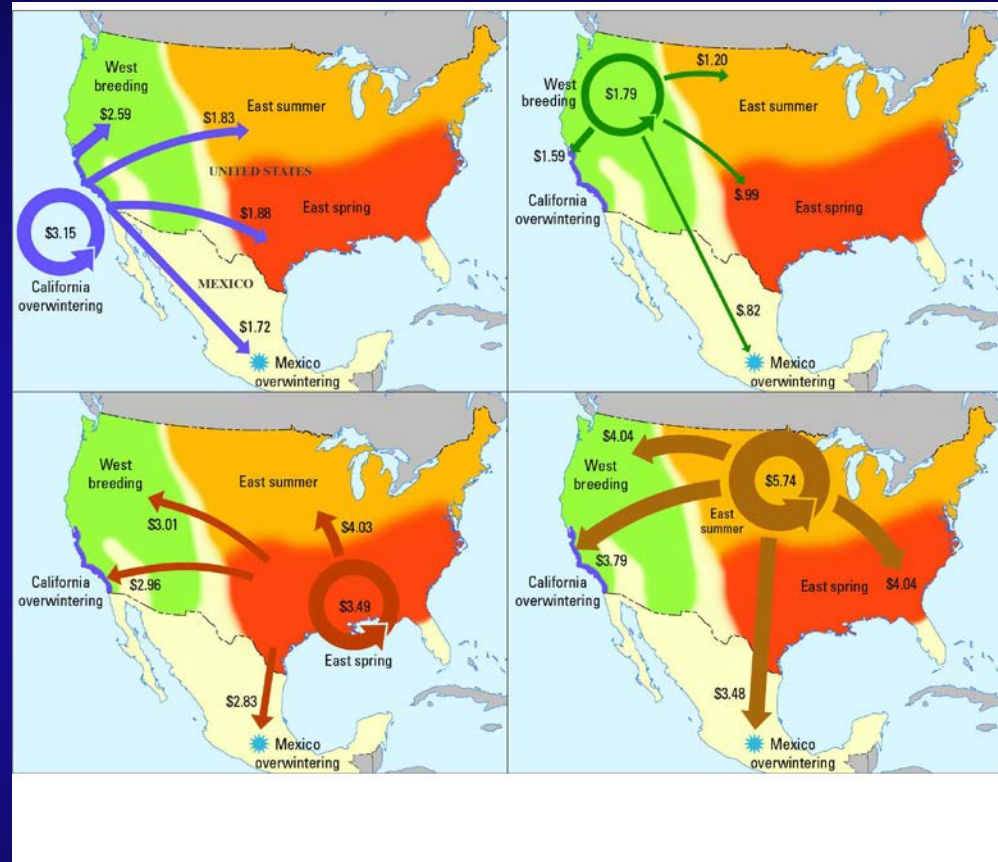
Subsidy Calculation: Monarch Butterflies

- Economic values - V_s
 - Willingness to pay/donate for monarch conservation
 - Tourism – Biosphere Reserve
 - Volunteer time
- Proportional dependence - D_s
 - Sensitivities from a demographic model
 - Oberhauser et al. In review.



Subsidy Calculation: WTP

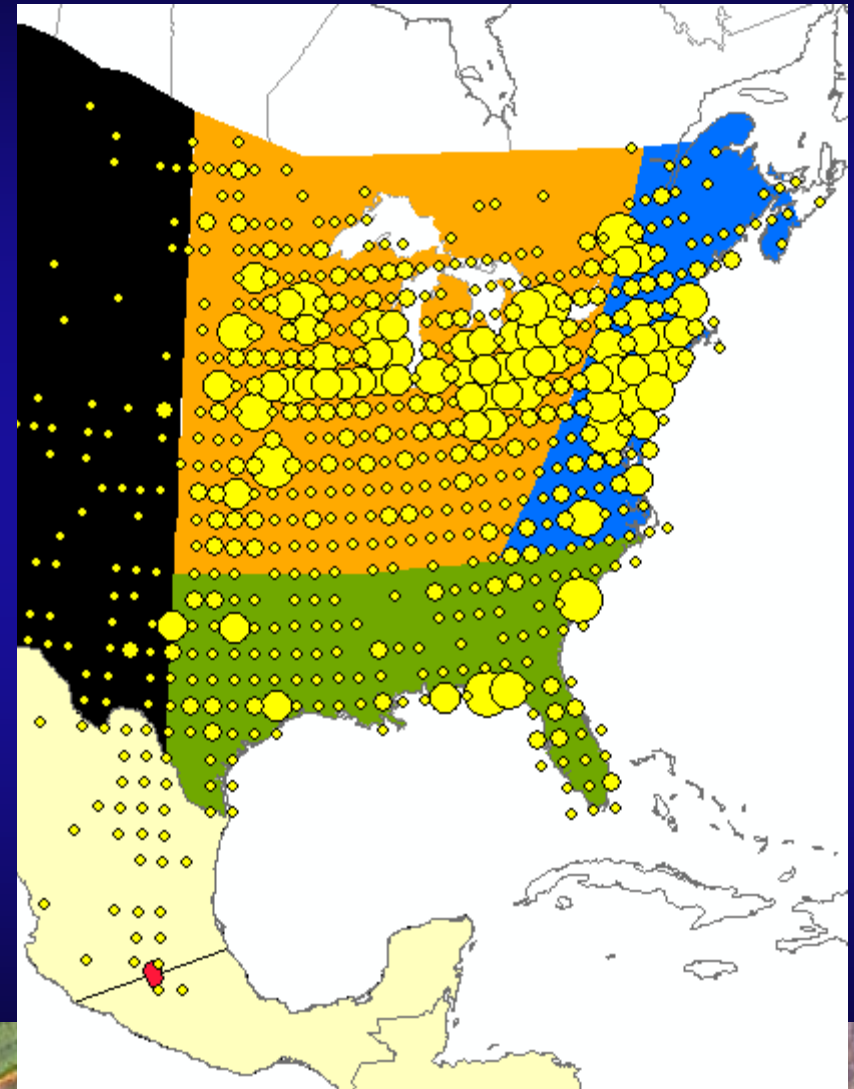
- National on-line survey of willingness to pay/donate for monarch conservation
 - WTP within and outside of region of residence
 - Regions coordinated with demographic model (D_S)
 - Unfortunately only for U.S.
 - Diffendorfer et al. (2014)
- WTP for Canada and Mexico extrapolated based on population and income for each state/province in monarch range
- Total WTP annualized by dividing by 33 yrs



- Only considered values within monarch range

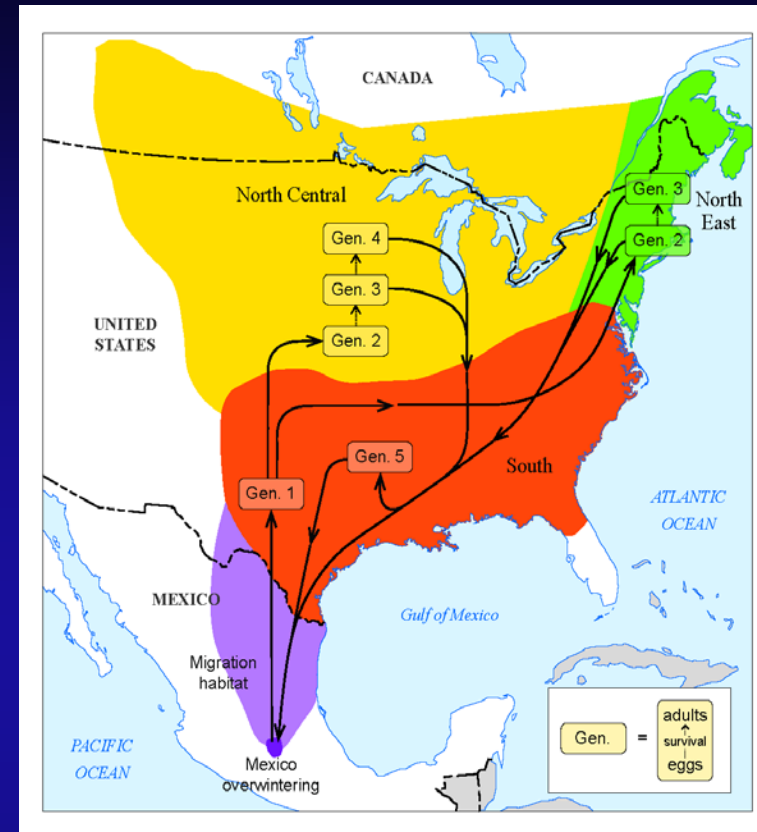
Subsidy Calculation: Volunteer

- Spatial compilation of all North American volunteer time for monarch-centric citizen science in 2012
 - Reflection of cultural value for monarchs
 - Ries & Oberhauser, 2015
- Data intersected with model regions to get total volunteer hours per region
- Multiplied by state/province-specific value of a volunteer hour to derive the total value by region



Subsidy Calculation: Results

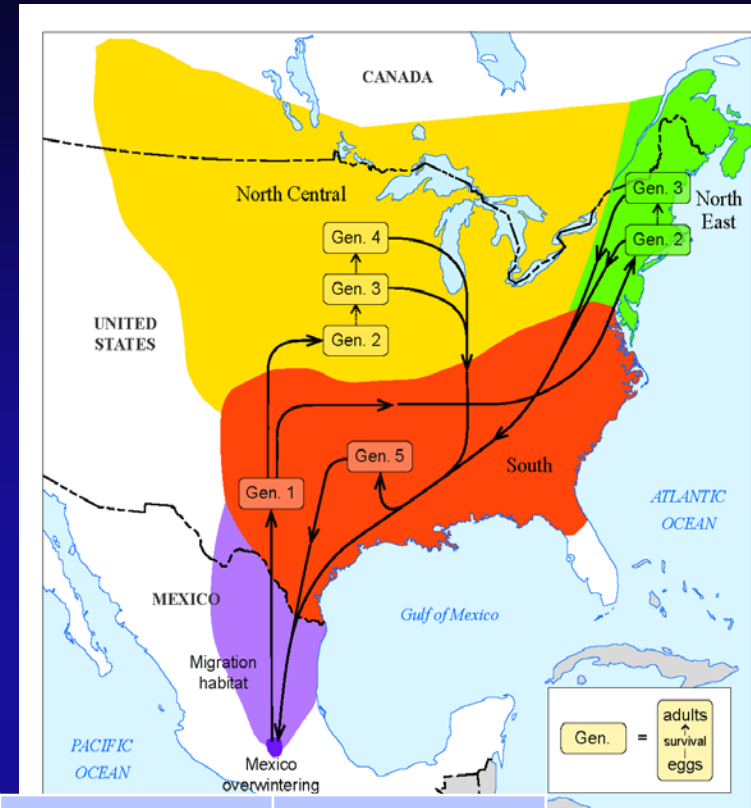
- Mexican portions of range subsidizing the provision of cultural services in the U.S. and Canada
- Subsidy driven primarily by the larger number of people (95%) living in Canadian/U.S. portion of range and in spite of its biological importance
- Important implications for cross-jurisdictional cooperative management



	D_s	WT Donate	Tourism	Volunteer	V_s	Y_s
Mexico wintering	0.08	\$79,089	\$2,198,992	\$6	\$2,278,087	\$6,576,643
Mexico migration	0.08	\$2,412,026	\$0	\$371	\$2,412,397	\$6,442,333
South	0.354	\$42,593,493	\$0	\$168,697	\$42,762,190	-\$3,580,007
North Central	0.282	\$36,995,519	\$0	\$391,425	\$37,386,944	-\$6,174,019
Northeast	0.204	\$25,676,887	\$0	\$167,626	\$25,844,513	-\$3,264,950
Sums	1				\$110,684,131	\$0.00

Subsidy Calculation: Results

- Rural portions of range subsidizing the provision of cultural services in urban
- Subsidy driven primarily by 80% of people living in urban areas that provide <0.2% of monarch habitat
- Important implications for incentivizing monarch habitat conservation/restoration



	D_S	WT Donate	Tourism	Volunteer	Vs	Ys
Mexico OW	0.08	\$79,089	\$2,198,992	\$6	\$2,278,087	\$6,576,643.42
Mex. Mig. rural	0.08	\$482,405	\$0	\$371	\$482,776	\$8,371,954.28
Mex. Mig. urban	0	\$1,929,621	\$0	\$0	\$1,929,621	-\$1,929,620.80
South rural	0.354	\$8,518,699	\$0	\$168,697	\$8,687,396	\$30,494,786.80
South urban	0	\$34,074,794	\$0	\$0	\$34,074,794	-\$34,074,794.40
NC rural	0.282	\$7,399,104	\$0	\$391,425	\$7,790,529	\$23,422,396.16
NC urban	0	\$29,596,415	\$0	\$0	\$29,596,415	-\$29,596,415.20
NE rural	0.204	\$5,135,377	\$0	\$167,626	\$5,303,003	\$17,276,559.34
NE urban	0	\$20,541,510	\$0	\$0	\$20,541,510	-\$20,541,509.60
Sums	1	\$107,757,014	\$2,198,992	\$728,125	\$110,684,131	\$0



Questions?

Darius Semmens

dsemmens@usgs.gov