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

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Geosciences and Environmental Change Science Center

Presented at Open Knowledge: Bridging Perspectives
To Address Water Challenges

Tucson, Arizona
February 17, 2016
...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

MEMORANDUM FOR EXECUTIVE DEPARTMENTS AND AGENCIES

FROM: Shaun Donovan, Director
Office of Management and Budget
Christina Goldfuss, Managing Director
Council on Environmental Quality
John P. 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
- SolVES = 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:

____ Aesthetic

____ Biological

____ Cultural

____ Economic

____ Future

____ Historical

____ Intrinsic

---

**Legend**

- Boating Site
- Campground
- Interpretive Site
- Scenic Overlook
- Picnic Site
- Trailhead
- Wildlife Viewing
- Ski Area
- Major Highways
- Forest and Other Roads
- County Boundary
- Arapaho-Roosevelt N.F.
- Wilderness
- National Park
- Other Forests
- Non-Forest Service Land

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Value</th>
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<tr>
<td>A</td>
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<tr>
<td>B</td>
<td>Biological</td>
</tr>
<tr>
<td>C</td>
<td>Cultural</td>
</tr>
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<td>E</td>
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<tr>
<td>L</td>
<td>Learning</td>
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<tr>
<td>LS</td>
<td>Life Sustaining</td>
</tr>
<tr>
<td>R</td>
<td>Recreation</td>
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<td>S</td>
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<td>T</td>
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Social Values for Ecosystem Services (SoLVES)

Geodatabase Contents

Point Data

Environmental Data

<table>
<thead>
<tr>
<th>Nonspatial Data</th>
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<tbody>
<tr>
<td>• Attitudes and Preferences</td>
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<tr>
<td>• Value Allocations</td>
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<tr>
<td>• Other Tabular Data</td>
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</table>

Pike San Isabel National Forest

All Surveys
Recreation

Recreation_DTB_stats
Recreation_DTT_stats
Recreation_DTW_stats
Recreation_ELEV_stats
Recreation_JMIFORM_stats

SoLVES

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

AUC = 0.8708

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.
SoIVES 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
Scenario Analysis with SoIVES

- SoIVES 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

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<th>Contribution</th>
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<tr>
<td>DTR</td>
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<tr>
<td>DTB</td>
<td>14.5%</td>
</tr>
<tr>
<td>LULC</td>
<td>14.4%</td>
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<tr>
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<tr>
<td>DTW</td>
<td>5.2%</td>
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<tr>
<td>LANDFORM</td>
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Variable Contribution

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<tr>
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<tr>
<td>LANDFORM</td>
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Response of Aesthetic to dU

Response of Recreation to dU
## Oppose vs. Favor Motorized Recreation

### Trade-off Matrix

<table>
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<tr>
<th>Aesthetic</th>
<th>Recreation</th>
<th>Mean Value Increase</th>
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<tbody>
<tr>
<td>Decrease</td>
<td>4%</td>
<td>2.0%</td>
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<tr>
<td>No Change</td>
<td>6%</td>
<td>2.3%</td>
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<tr>
<td>Increase</td>
<td>1%</td>
<td></td>
</tr>
</tbody>
</table>

*2.0% increase in mean aesthetic value*

*2.3% increase in mean recreation value*
If we forego monetary valuation, cultural and biophysical service production can be combined in space to map correspondence or divergence across the landscape.

<table>
<thead>
<tr>
<th>Cultural ecosystem services (mapped using SolVES)</th>
<th>Biophysically modeled ecosystem services (mapped using ARIES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot</td>
<td><strong>Hot</strong>&lt;br&gt;High management support (if cultural &amp; biophysical services are synergistic) OR potential conflict between management and traditional uses (if tradeoffs exist between cultural &amp; biophysical services)</td>
</tr>
<tr>
<td>Warm</td>
<td><strong>Cold</strong>&lt;br&gt;PUBLIC outreach needed to build support for management (e.g., for watershed protection programs)</td>
</tr>
</tbody>
</table>
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

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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 Mattson, 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 (DS)
  - 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

<table>
<thead>
<tr>
<th></th>
<th>$D_s$</th>
<th>WT Donate</th>
<th>Tourism</th>
<th>Volunteer</th>
<th>$V_s$</th>
<th>$Y_s$</th>
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<tbody>
<tr>
<td>Mexico wintering</td>
<td>0.08</td>
<td>$79,089</td>
<td>$2,198,992</td>
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<td>$2,278,087</td>
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<td>Sums</td>
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<td></td>
<td>$110,684,131</td>
<td>$0.00</td>
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Subsidy Calculation: Results

- Rural portions of range subsidizing the provision of cultural services in urban areas.
- 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.

<table>
<thead>
<tr>
<th>Region</th>
<th>$D_s$</th>
<th>WT Donate</th>
<th>Tourism</th>
<th>Volunteer</th>
<th>Vs</th>
<th>Ys</th>
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<tr>
<td>Mexico OW</td>
<td>0.08</td>
<td>$79,089</td>
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Questions?

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