Science Advisory Board Workshop Report: Science for Valuation of EPA's Ecological Protection Decisions and Programs; Workshop Held December 13-14, 2005, Washington D.C.

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1. Workshop Background and Objectives

The EPA Science Advisory Board (SAB) held a public workshop on December 13-14, 2005 in Washington D.C. on "Science for Valuation of EPA's Ecological Protection Decisions and Programs." The purpose of the workshop was to discuss the initial work of the SAB's Committee on Valuing the Protection of Ecological Systems and Services (C-VPESS); to provide an opportunity for members of the SAB, the Advisory Council on Clean Air Compliance Analysis (Council), and Clean Air Scientific Advisory Committee (CASAC) members to learn from each others' work relating to ecological valuation; and to feature feedback and insights from Agency clients and outside subject matter experts. The agenda included presentations and discussions with advisory committee members, Agency Staff, and invited experts (agenda and list of invited participants included on page 77 of this workshop report).

Background

Protecting human health and the environment is the core mission of EPA. EPA's Strategic Plan lists protecting "healthy communities and ecosystems" as one of EPA's five major goals. Several environmental statutes administered by the Agency mandate the assessment of ecological benefits. Cost-benefit analysis is required by Executive Order 12866 for economically significant regulations. EPA is required, by good management practice and by federal law, to assess the effectiveness of its programs. In addition, effective environmental protection requires communication about the value of ecological protection decisions at the regional and national levels.

Reflecting the need for science-based approaches for valuing ecological protection, the Science Advisory Board (SAB) and the Advisory Council on Clean Air Compliance Analysis (Council) have undertaken many projects in recent years. In some projects, advisory committees have advised the Agency in reporting on the environment. Other projects have focused on methods for identifying critical ecosystems at the regional level. Some have focused on benefit assessment issues in particular programs, such as the Clean Air Act programs or the Superfund program.

One SAB project, initiated in October 2003, led to the establishment of the C-VPESS. This multi-disciplinary committee was charged with conducting a broad assessment of Agency needs and the state of the art and science of valuing protection of ecological systems and services and identifying key areas for improving knowledge, methodologies, practice, and research. In addition to providing advice for the Agency on its draft *Ecological Benefits Assessment Strategic Plan*, the C-VPESS has also planned reports to help strengthen EPA's approaches for valuing the protection of ecological systems and services, use of such information by decision makers, and the key research areas needed to strengthen the science base.

Intended Audience for the Workshop

There were multiple audiences planned for the workshop: the members of the SAB, Council, and CASAC; EPA managers concerned with decision-making affecting ecological resources and documenting ecological benefits; EPA ecological scientists and risk assessors who support those decisions; EPA social and behavioral scientists supporting those decision; EPA economists responsible for regulatory impact analyses and other economic analyses supporting ecological protection; EPA regional staff concerned with demonstrating the benefits of protecting and restoring specific ecosystems and ecological resources; and scientists in other federal agencies concerned with characterizing ecological benefits.

2. Introductory Remarks at the Workshop

Dr. M. Granger Morgan, Chair of the SAB welcomed meeting participants and expressed his appreciation for the involvement of a wide range of experts from different SAB committees, the Clean Air Scientific Advisory Committee, and the Council, as well as invited experts from universities, consulting firms, EPA and other federal agencies. He recognized the efforts of the C-VPESS in preparing materials for the workshop and expressed his hopes for a lively intellectual interchange on the challenging topic of ecological valuation.

Dr. Dr. Barton H. (Buzz) Thompson, Jr., Chair, SAB C-VPESS, then briefly discussed the mission of C-VPESS and the goals of the workshop. He noted that the overall C-VPESS charge was "to assess Agency needs and the state of the art and science of valuing protection of ecological systems and services, and then to identify key areas for improving knowledge, methodologies, practice, and research." The workshop was designed as a peer involvement workshop to give committee members an opportunity to present some initial findings and conclusions and receive feedback from the Agency and other participants.

He described the format, which included presentations and question and answer periods in plenary sessions, breakout groups, and panel discussions.

3. Keynote Presentation - Global View from the Perspective of the Millennium Ecosystem Assessment

Dr. Walter Reid, Former Director of the Millennium Ecosystem Assessment, gave the keynote presentation at the workshop. In a slide presentation (attached below), he provided a global perspective on valuing the protection of ecosystems and their services, based on his work and that of over 1,300 scientists from 95 countries in the study, the largest assessment ever undertaken of the health of ecosystems. He noted that the Millennium Ecosystem Assessment project encountered many of the same issues encountered and reached many of the same conclusions about valuation approaches as the SAB C-VPESS. Both shared the goals of bringing the findings of science to bear on the needs of decision-makers

Dr. Reid noted that the assessment focused on the linkages between ecosystems and human well-being and, in particular, on "ecosystem Services." The Millennium Ecosystem Assessment dealt with the full range of ecosystems, from those relatively undisturbed to ecosystems intensively managed and modified by humans, such as agricultural land and urban areas. He defined ecosystem services are the benefits people obtain from ecosystems, which include provisioning services such as food, water, timber, and fiber); regulating services that affect climate, floods, disease, wastes and spiritual benefits; cultural services that provide recreational, aesthetic and spiritual benefits; and supporting services such as soil formation, photosynthesis and nutrient cycling.

The four main findings reached were that:

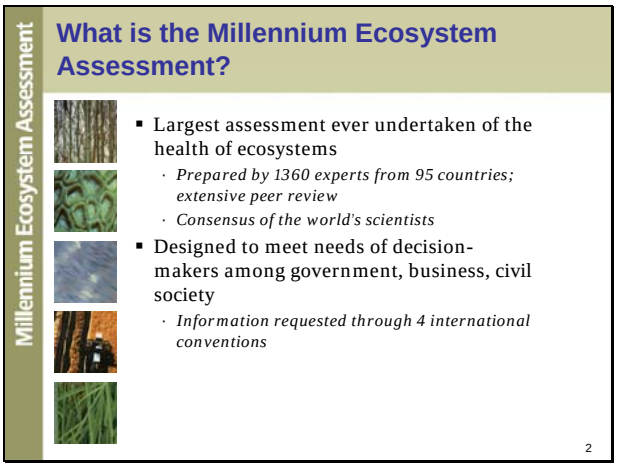
- humans have radically altered ecosystems in the last 50 years
- changes have brought gains but at growing costs that threaten achievement of development goals
- degradation of ecosystems could grow worse but can be reversed, and
- workable solutions will require significant changes in policy.

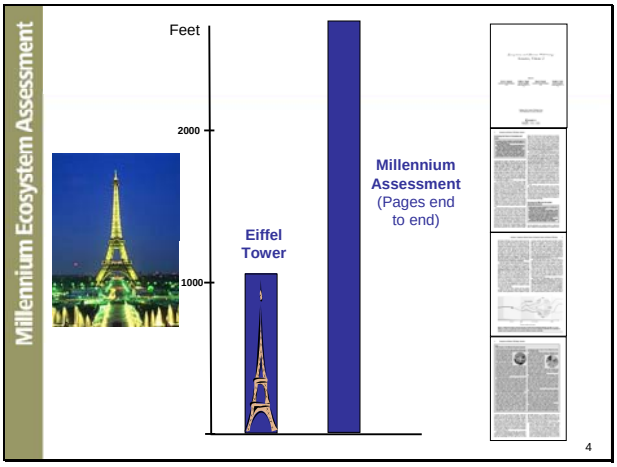
He noted that incorporation of nonmarket values of ecosystems in resource management and investment decisions was a change that needs to happen. The Millennium Ecosystem Assessment focused on utilitarian values but recognized that considerations of intrinsic value also influence the actions people affecting ecosystems. Analytical challenges are formidable, even in focusing on utilitarian approaches to valuation because many ecosystem services are not, and many cannot be internalized in markets. As a result, public goods are being excessively degraded. In addition, many trade-offs associated with ecosystem services are expressed in areas remote from the site of ecological degradation. As a result, economic values of non-marketed services are often substantial but rarely included in management decisions.

From the perspective of the Millennium Ecosystem Assessment, decisions can be enhanced if they are informed by more complete information on economic and non-economic values. Economic valuation can be most useful to policy in the context of

comparing alternative options. Economic valuation can also to enhance understanding of the importance of ecological services, to provide a basis for payments for ecosystem services and for establishing markets, and for national accounting. Dr. Reid also noted that the Millennium Assessment considered spiritual and cultural values of ecosystems as important as other services for many local communities. Deliberative decision making processes provide a mechanism enabling the articulation of these different types of value consideration.

In the short question-and-answer session that followed, Dr. Reid noted that the Millennium Ecosystem Assessment drew on existing peer reviewed studies. The Assessment conducted both global and sub-global studies. He also noted that the assessment focused on services with a biological nexus.

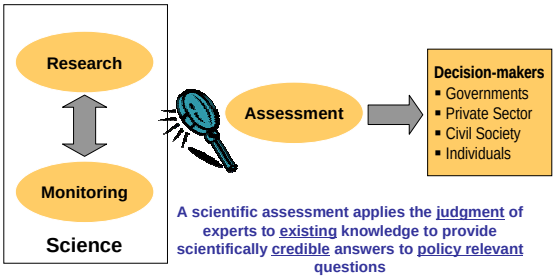




Millennium Ecosystem Assessment

Science Assessment

A social process designed to bring the findings of science to bear on the needs of decision-makers



A scientific assessment applies the judgment of experts to existing knowledge to provide scientifically credible answers to policy relevant questions

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Millennium Ecosystem Assessment

Core Questions

1. What is the rate and scale of ecosystem change?
2. What are the consequences of ecosystem change for human-well being?
3. How might ecosystems and their services change over the next 50 years?
4. What options exist to conserve ecosystems and enhance their contributions to human well-being?

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Millennium Ecosystem Assessment

What was unique?

Ecosystem services

Photo credits (left to right, top to bottom): Purdue University, WomensAid.org, LSUP, NASA, unknown, CEH Wallingford, unknown, W. Reid, Staffan Widstrand, E.A. Fitzpatrick, University of Wisconsin

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Millennium Ecosystem Assessment

Provisioning Services

Goods produced or provided by ecosystems

Food
- Crops
- Livestock
- Capture Fisheries
- Aquaculture
- Wild Foods

Fiber
- Timber
- Cotton, hemp, silk
- Wood Fuel

Genetic resources

Biochemicals

Freshwater

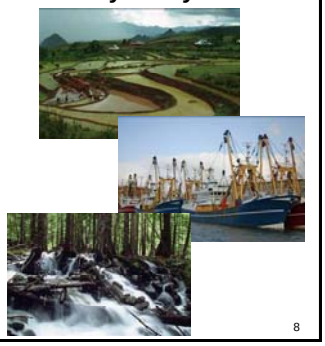

Photo credit (top): Tran Thi Hoa (World Bank).

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Millennium Ecosystem Assessment

Regulating Services

Benefits obtained from regulation of ecosystem processes

Air Quality Regulation

Climate Regulation
- Global (CO_2 sequestration)
- Regional and local

Erosion regulation

Water purification

Disease regulation

Pest regulation

Pollination

Natural Hazard regulation

9

Millennium Ecosystem Assessment

Cultural Services

Non-material benefits obtained from ecosystems

Spiritual and Religious Values

Knowledge Systems

Educational values

Inspiration

Aesthetic Values

Social Relations

Sense of Place

Recreation and Ecotourism

Photo credits (top to bottom): W. Reid, Mary Frost, Staffan Widstrand, unknown.

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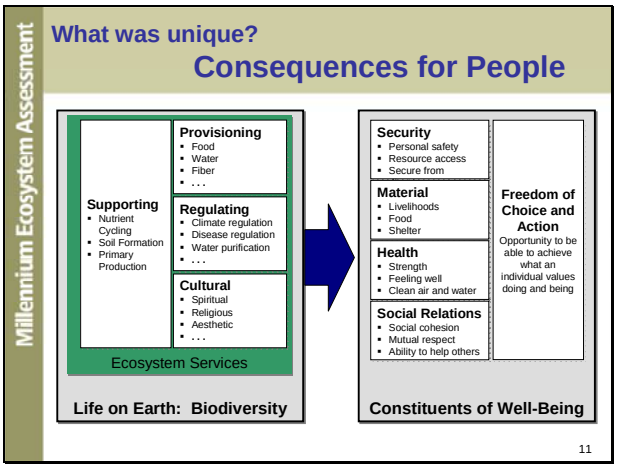
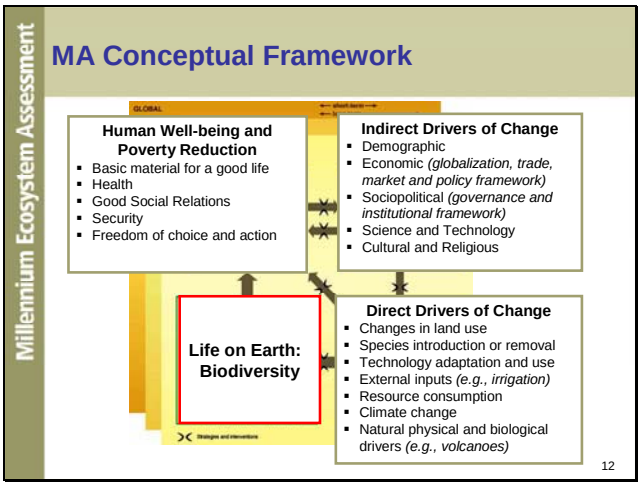
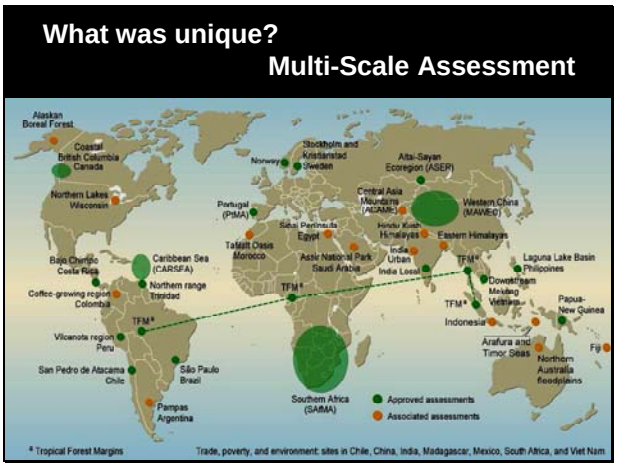
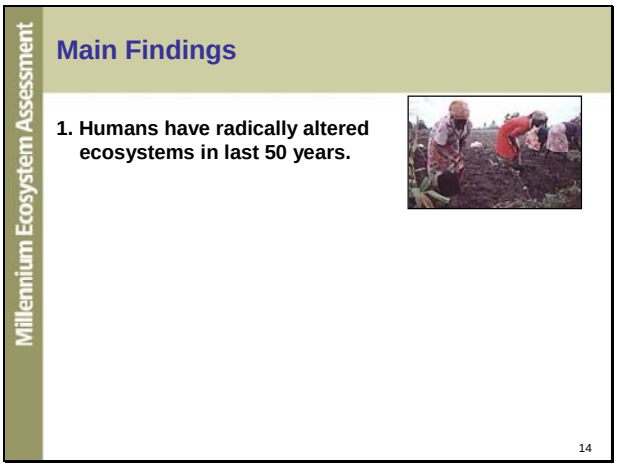

Millennium Ecosystem Assessment
What was unique?
Consequences for People
Supporting
Nutrient Cycling
Soil Formation
Primary Production
Provisioning
Food
Water
Fiber
. . .
Regulating
Climate regulation
Disease regulation
Water purification
. . .
Cultural
Spiritual
Religious
Aesthetic
. . .
Ecosystem Services
Life on Earth: Biodiversity
Security
Personal safety
Resource access
Secure from
Material
Livelihoods
Food
Shelter
Health
Strength
Feeling well
Clean air and water
Social Relations
Social cohesion
Mutual respect
Ability to help others
Freedom of Choice and Action
Opportunity to be able to achieve what an individual values doing and being
Constituents of Well-Being
11


Millennium Ecosystem Assessment
MA Conceptual Framework
Human Well-being and Poverty Reduction
Basic material for a good life
Health
Good Social Relations
Security
Freedom of choice and action
Indirect Drivers of Change
Demographic
Economic (globalization, trade, market and policy framework)
Sociopolitical (governance and institutional framework)
Science and Technology
Cultural and Religious
Life on Earth: Biodiversity
Direct Drivers of Change
Changes in land use
Species introduction or removal
Technology adaptation and use
External inputs (e.g., irrigation)
Resource consumption
Climate change
Natural physical and biological drivers (e.g., volcanoes)
12


What was unique?
Multi-Scale Assessment
Alaskan Boreal Forest
Coastal British Columbia Canada
Northern Lakes Wisconsin
Caribbean Sea (CARSFA)
Northern range Trinidad
Coffee-growing region Colombia
Vilcanota region Peru
San Pedro de Atacama Chile
São Paulo Brazil
Pampas Argentina
Southern Africa (SAfMA)
Approved assessments
Associated assessments
Laguna Lake Basin Philippines
Papua-New Guinea
Fiji
Trade, poverty, and environment: sites in Chile, China, India, Madagascar, Mexico, South Africa, and Viet Nam


Millennium Ecosystem Assessment
Main Findings
1. Humans have radically altered ecosystems in last 50 years.
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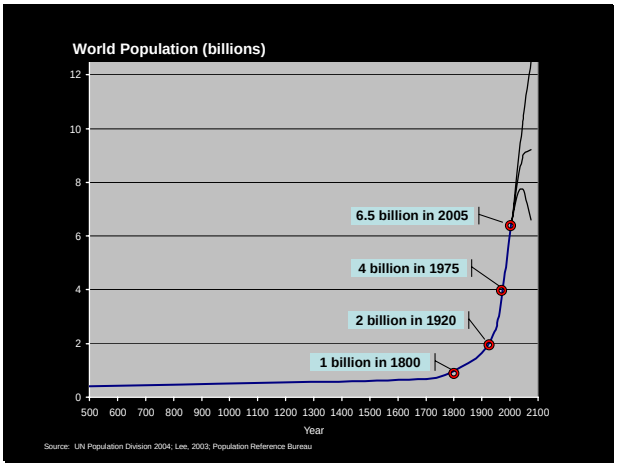
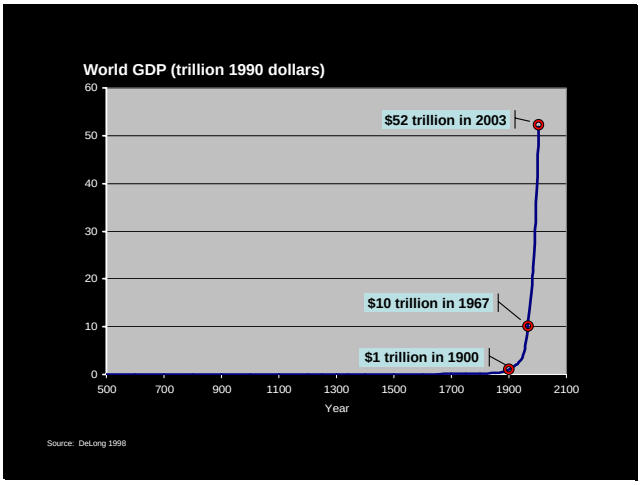
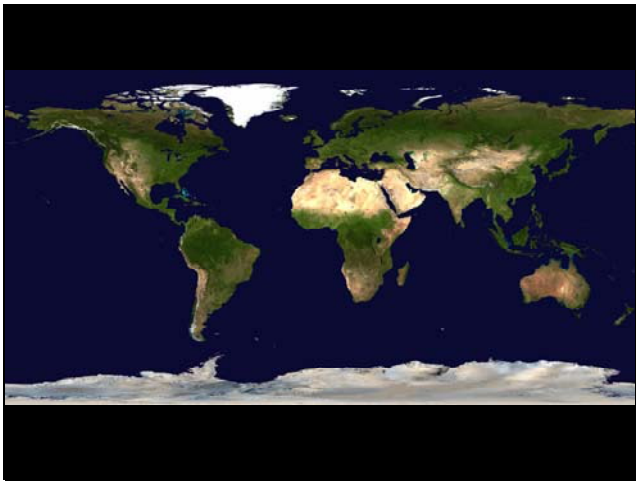
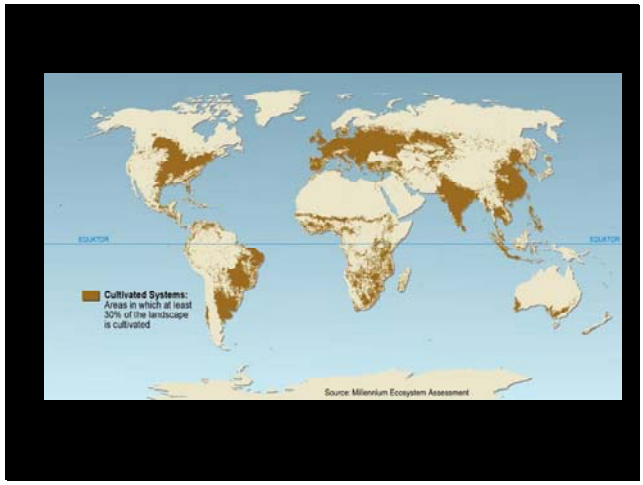
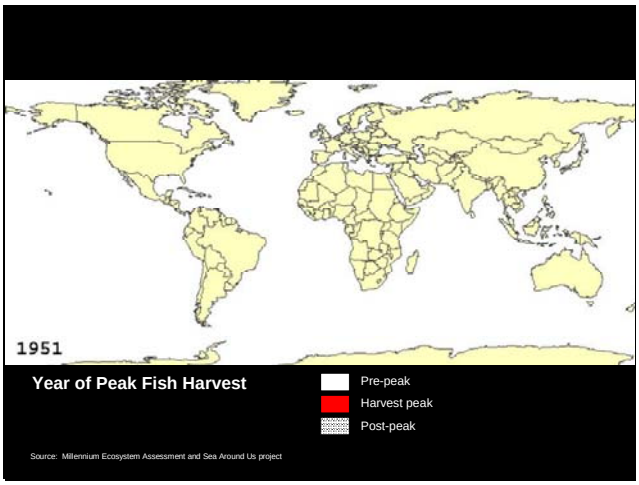
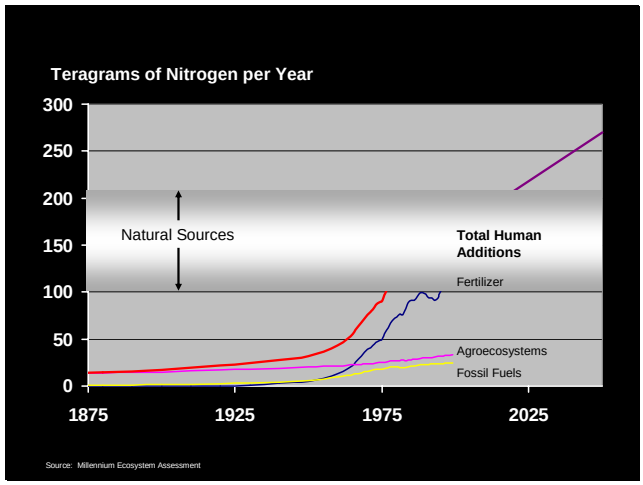

World Population (billions)
6.5 billion in 2005
4 billion in 1975
2 billion in 1920
1 billion in 1800
Year
Source: UN Population Division 2004; Lee, 2003; Population Reference Bureau


World GDP (trillion 1990 dollars)
$52 trillion in 2003
$10 trillion in 1967
$1 trillion in 1900
Year
Source: DeLong 1998




Cultivated Systems:
Areas in which at least 30% of the landscape is cultivated
Source: Millennium Ecosystem Assessment


1951
Year of Peak Fish Harvest
Pre-peak
Harvest peak
Post-peak
Source: Millennium Ecosystem Assessment and Sea Around Us project


Teragrams of Nitrogen per Year
300
250
200
150
100
50
0
1875
1925
1975
2025
Natural Sources
Total Human Additions
Fertilizer
Agroecosystems
Fossil Fuels
Source: Millennium Ecosystem Assessment

Millennium Ecosystem Assessment
Main Findings
1. Humans have radically altered ecosystems in last 50 years.
2. Changes have brought gains but at growing costs that threaten achievement of development goals.
▪ Degradation of many ecosystem services
▪ Increased risk of abrupt changes in ecosystems
▪ Growing harm to poor people
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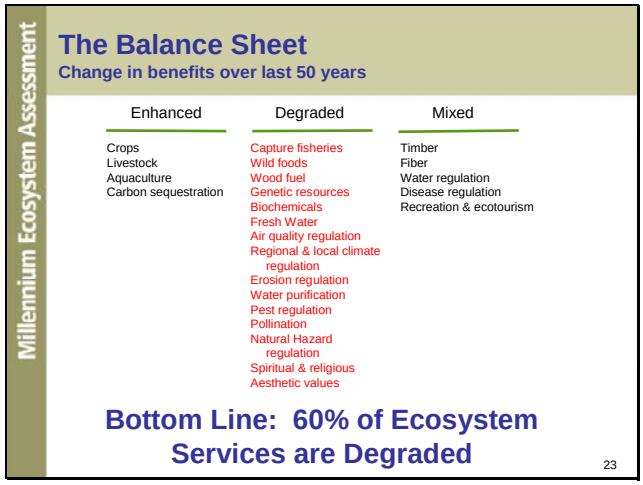
Millennium Ecosystem Assessment
The Balance Sheet
Change in benefits over last 50 years
Enhanced
Crops
Livestock
Aquaculture
Carbon sequestration
Degraded
Capture fisheries
Wild foods
Wood fuel
Genetic resources
Biochemicals
Fresh Water
Air quality regulation
Regional & local climate regulation
Erosion regulation
Water purification
Pest regulation
Pollination
Natural Hazard regulation
Spiritual & religious
Aesthetic values
Mixed
Timber
Fiber
Water regulation
Disease regulation
Recreation & ecotourism
Bottom Line: 60% of Ecosystem Services are Degraded
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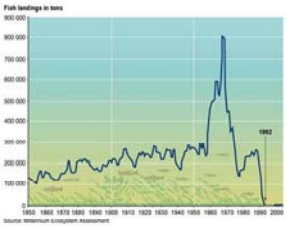
Millennium Ecosystem Assessment

Increased likelihood of abrupt changes

(established but incomplete evidence)

- **Fisheries collapse**
- **Eutrophication**
- **Coral reef regime shifts**
- **Disease emergence**
- **Species introductions**
- **Regional climate change**



Atlantic Cod off Newfoundland

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Impact on Poor People
Critical concern – drylands

- 40% of land surface and more than 2 billion inhabitants
- Lowest levels of human well-being
- 10-20% of drylands degraded
- Only 8% of renewable water supply
- Highest rate of population growth

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Millennium Ecosystem Assessment

Main Findings

1. Humans have radically altered ecosystems in last 50 years.
2. Changes have brought gains but at growing costs that threaten achievement of development goals.
3. **Degradation of ecosystems could grow worse but can be reversed.**

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MA Scenarios

		World Development	
		Globalization	Regionalization
Environmental Management	Reactive	**Global Orchestration**	**Order from Strength**
	Proactive	**TechnoGarden**	**Adapting Mosaic**

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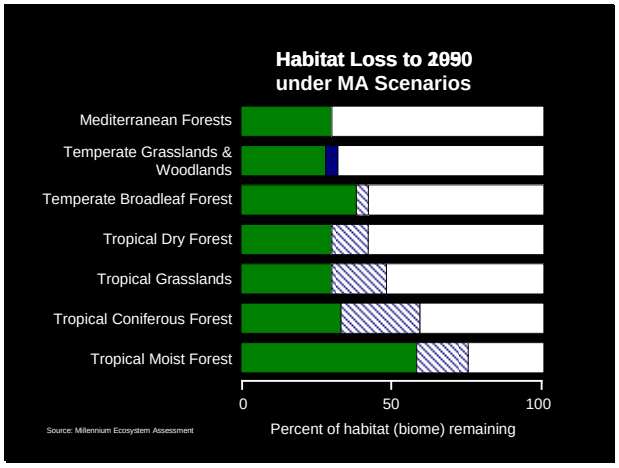

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Some services improved in one or more of the MA scenarios

Examples:

- Freshwater
- Water regulation
- Erosion control
- Water purification
- Storm protection
- Aesthetic values
- Recreation

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Main Findings

1. Humans have radically altered ecosystems in last 50 years.
2. Changes have brought gains but at growing costs that threaten achievement of development goals.
3. Degradation of ecosystems could grow worse but can be reversed.
4. **Workable solutions will require significant changes in policy**

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Responses

Economics and Incentives

Institutions and Governance

- Planning and Management

Technologies

- Greater efficiency of resource use
- Less harm to other services

Social and Behavioral

Knowledge

Incorporation of nonmarket values of ecosystems in resource management and investment decisions.

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MA perspectives on valuation

1. **MA focused on utilitarian values but recognized that the actions people take that influence ecosystems result also from considerations of intrinsic value.**
2. **Many of the values associated with ecosystems are not (and many can not be) internalized in markets – problem of public goods. This is leading to excessive degradation.**
   - Services are treated as 'free' and limitless
   - Significant externalities
   - Trade-off of provisioning services against others

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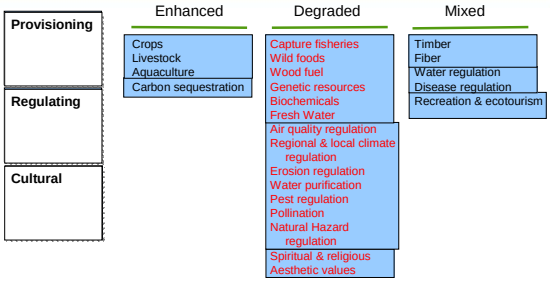
Trade-offs Among Services



Provisioning services are being enhanced at the cost of regulating & cultural services

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Millennium Ecosystem Assessment

MA perspectives on valuation

3. **Economic values of non-marketed services are often substantial but rarely included in management decisions**
   - Annual recreation value of Hawaii marine protected areas: **$300,000** to **$35 million** ea.
   - Increased income from forest-based pollinators on one coffee farm in Costa Rica: **$60,000/yr**
   - Value of marsh in Sri Lanka for flood control: **$1,750/ha**
   - Benefits per household of preserving neighboring open space in Maryland: **$1,000 - 3,300/ha**

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MA perspectives on valuation

4. **Economic (and health costs) of degradation of services can be substantial**
   - Cost of damage of UK agriculture to other ecosystem services: **$2.6 billion** (10% of farm receipts)
   - Introduction of Zebra mussels into aquatic ecosystems in the US: **$100 million** annual costs to power industry
   - Annual cost to fisheries of mangrove deforestation in Campeche Mexico: **$279,000**

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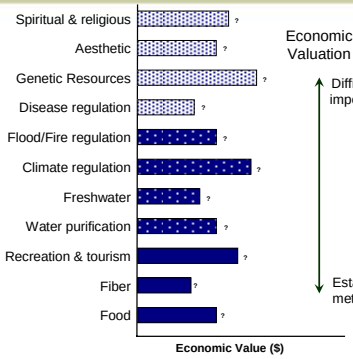
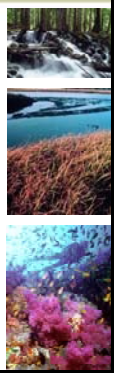
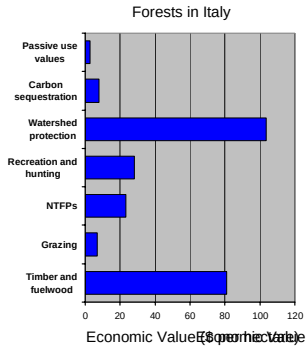
Significant scope for greater estimation of economic value

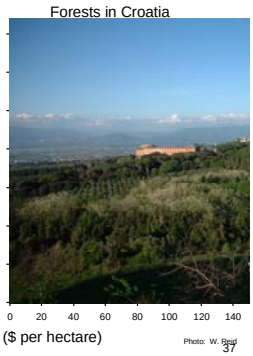




Millennium Ecosystem Assessment

Economic value of non-marketed services can be high





Source: Millennium Ecosystem Assessment

Photo: W. Reid

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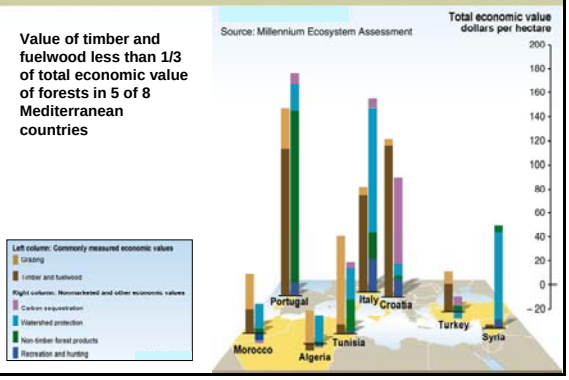
Millennium Ecosystem Assessment

Marketed and non-marketed values

Value of timber and fuelwood less than 1/3 of total economic value of forests in 5 of 8 Mediterranean countries



Millennium Ecosystem Assessment

MA perspectives on valuation

5. **Decisions can be enhanced if they are informed by more complete information on economic and non-economic values.**
   - Greatest policy relevance of valuation is in the context of comparing alternative policy or management options

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Millennium Ecosystem Assessment

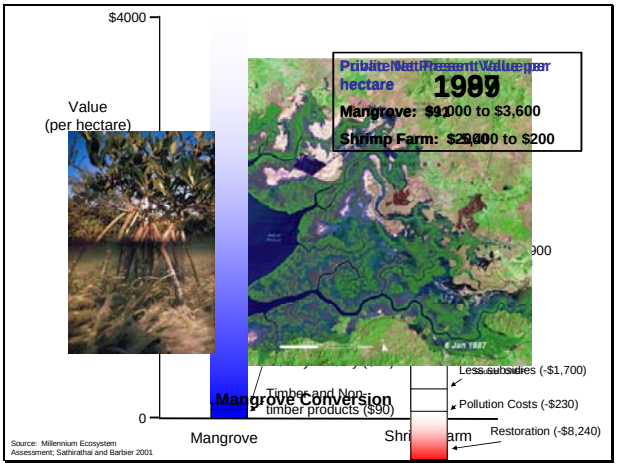
Trade-offs among ecosystem services

Mangrove Services:
- nursery and adult fishery habitat
- fuelwood & timber
- carbon sequestration
- traps sediment
- detoxifies pollutants
- protection from erosion & disaster

Mangrove ecosystem

crops

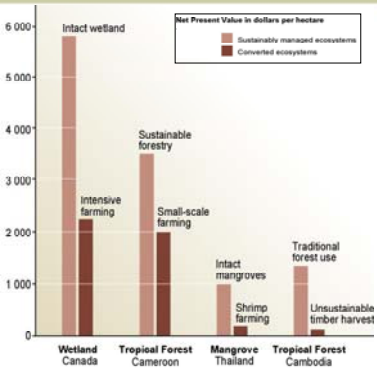
40



Millennium Ecosystem Assessment

Economic case for conservation

The total economic value associated with managing ecosystems more sustainably is often higher than the value associated with conversion



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MA perspectives on valuation

6. Economic valuation uses:

- Choices among different management or policy options
- Public understanding
- Basis of Payments for Ecosystem Services
- Basis for establishing markets (if value can be captured).
- National accounting

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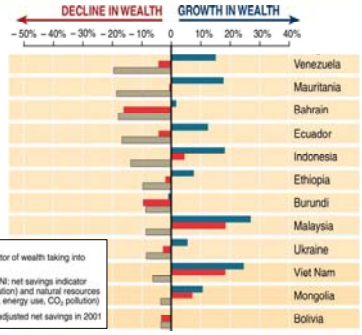
Millennium Ecosystem Assessment

National Accounting

Net National Savings in 2001 Adjusted for changes in Human and Natural Capital

For countries shown here, resource depletion (minerals, oil, forests) and damage from CO_2 emissions accounted for 10-25% decline in savings



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MA perspectives on valuation

7. Serious shortcomings in availability of economic information

- Most studies focus on only one or two services and most studies are not in peer reviewed literature
- Major gap:
  - *Landscape scale studies providing valuation of multiple ecosystem services (full 'bundle' of services)*
- Availability of ecological production functions often is the limiting factor

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MA perspectives on valuation

8. Spiritual and cultural values of ecosystems are as important as other services for many local communities

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MA perspectives on valuation

9. Need for deliberative decision-making processes

- Additional information on economic values of ecosystem services could improve decision-making
- But, not all ecosystem services that matter to people can be valued in economic terms (esp. cultural services and considerations of intrinsic value)
- And, different stakeholders will place different weights on different attributes of ecosystems
- Deliberative decision-making processes provide a mechanism enabling the articulation of these different types of value considerations.

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MA perspectives on valuation

10. Scale dependence and stakeholder dependence of value considerations

Carbon sequestration
Bioprospecting
Genetic resources

Spiritual values
Food
Water

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Findings and data: MAweb.org & Island Press

Publications

Synthesis Reports

- Synthesis
- Board Statement
- Biodiversity Synthesis
- Wetlands Synthesis
- Health Synthesis
- Desertification Synthesis
- Business Synthesis

Technical Volumes and MA Conceptual Framework (Island Press)

- Ecosystems and Human Well-being: A Framework for Assessment
- State and Trends
- Scenarios
- Multi-Scale Assessments
- Responses

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Financial and in-kind support

(full list available at www.MAweb.org)

Global Environment Facility
United Nations Foundation
David and Lucile Packard Foundation
World Bank
Consultative Group on International Agricultural Research
United Nations Environment Programme
Government of China
Government of Norway
Kingdom of Saudi Arabia
Swedish International Biodiversity Programme
Asia Pacific Network for Global Change Research
Association of Caribbean States
British High Commission, Trinidad & Tobago
Caixa Geral de Depósitos, Portugal
Canadian International Development Agency
Christensen Fund
Cropper Foundation
Environmental Management Authority of Trinidad and Tobago
Ford Foundation
Government of India
International Council for Science
International Development Research Centre
Island Resources Foundation
Japan Ministry of Environment
Laguna Lake Development Authority
Philippine Department of Environment and Natural Resources
Rockefeller Foundation
U.N. Educational, Scientific and Cultural Organization;
UNEP Division of Early Warning and Assessment
United Kingdom Department for Environment, Food and Rural Affairs
United States National Aeronautic and Space Administration
Universidade de Coimbra, Portugal

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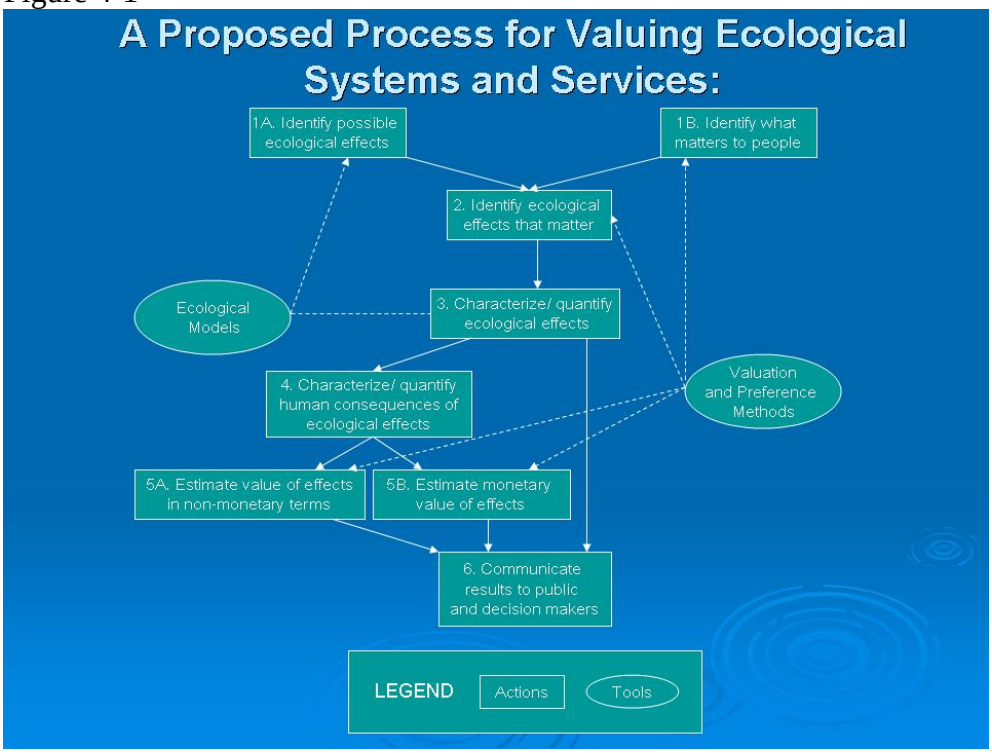
4. Introduction to C-VPESS Work on an "Expanded and Integrated Approach" for Valuing Ecological Protection

Dr. Kathleen Segerson gave a short overview presentation of the conceptual approach developed by the committee to date (presentation slides found at the conclusion of this section of the workshop report). She described the committee's goal: to assess EPA's needs and the state of the science used for valuing ecological protection and to identify key areas for improvement. The committee to date has focused on EPA's needs in three areas: national rulemaking, regional decision-making, and program evaluation and assessment.

A key issue for the committee was the use of terms "value" and "valuation." "Value" is understood by the committee as a broad concept including both instrumental and (non-anthropocentric) values and thus emphasizes utility-based, moral, religious, and spiritual values. The committee's approach was to recognize the many possible sources of value and seek methods for characterizing or measuring them. "Valuation" methods therefore include methodologies, based on theory and data, for doing these different kinds of valuation. The methods can differ in their focus and in some cases in their underlying premises.

She summarized the key features of an integrated and expanded approach as: a focus on impacts of most concern to people, an integration of ecological analysis and valuation, and the use of an expanded set of valuation approaches. To implement such an approach, she described a proposed process for valuing ecological systems and services under consideration by the committee (See Figure 1).

Figure 4-1



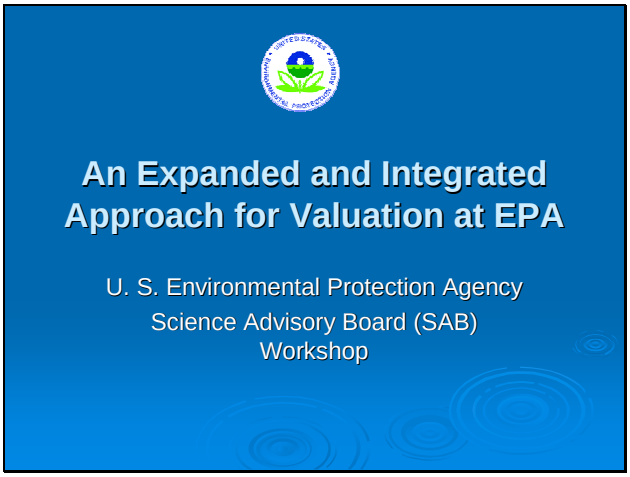
The approach would use ecological models and valuation and preference methods to identify and then characterize and measure the ecological effects that matter in ways appropriate to each type of decision context faced by EPA. The preliminary conclusions and recommendations emerging from the committee encourage EPA to move toward an expanded range of important ecological effects and human considerations by:

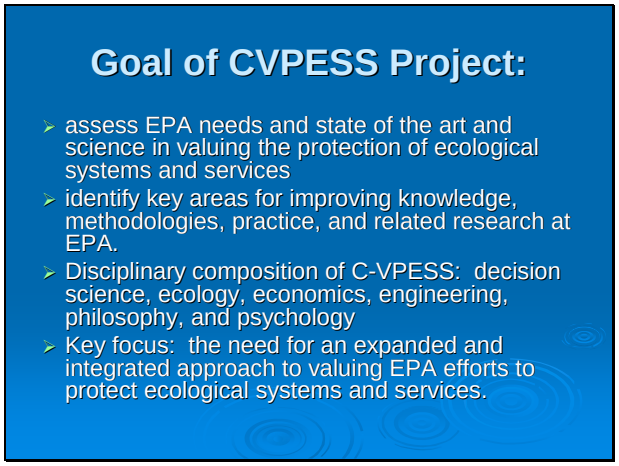
- recognizing many types and sources of value;
- thinking about ecosystem "services" and mapping from and mapping from ecological endpoints to services;
- expanding the range of services;
- focusing on the services that are most likely to be important to people
- exploring the use of different methods;
- ensuring interdisciplinary collaboration throughout the process throughout the process; and
- soliciting public input early in process.

In the question and answer period that followed the presentation, a participant asked whether the committee viewed the value of ecological systems as the sum of the ecological services they provide. Dr. Segerson responded that for some committee members, the term "ecological services" was sufficiently broad to encompass spiritual values and non-utilitarian values. For other members, the term "services" did not capture all the different types of values associated with ecological systems and their components. Participants emphasized the importance of providing advice to improve estimates of uncertainty and providing a way to address ecological effects from a long-term perspective, even if such a view increases uncertainties in ecological modeling and valuation, as the values people hold change over time.

One participant raised a question about the appropriate spatial scale for analysis. Dr. Segerson noted that ecological effects can be viewed very differently at the national scale, as opposed to local scale. She noted that the committee was focusing on a variety of decision contexts and not solely on national-level values.

A participant asked how the committee advice could help EPA work within its limited constraints of time and funding for analysis. Dr. Segerson responded that the committee was concerned with providing practical advice and how to qualify benefit transfer information so it can be used in the best ways. It was also considering alternatives to traditional economic methods, to see if other approaches might also offer useful information for decision makers.





EPA's Mission Regarding Ecosystem Protection

- EPA's mission is to "protect human health and the environment."
- EPA has historically focused decision making and much of its expertise on human health from environmental stressors, with relatively little attention given to ecosystems effects not directly linked to human health.
- "Healthy Communities and Ecosystems" - One of the Five Goals in EPA's Strategic Plan
- Basic premise of C-VPESS work: EPA has a mission to protect ecological systems because of the services they provide and the collective responsibility to protect the environment.

Concept of Ecosystem Services

- EPA's ecological risk assessment paradigm focuses on identification of ecological assessment endpoints, not ecological services.
- Central theme of C-VPESS: the need to move beyond consideration of ecological endpoints to the consideration of "ecosystem services," which reflect the direct or indirect contributions of ecosystems to human well-being.
- Ecosystem services can be defined very broadly, but in the context of valuation, it is important to distinguish between intermediate services and final services to avoid double counting.

Concept of Value

- The term "value" means different things to different people, and has different meanings within different disciplines.
- A fundamental distinction exists between instrumental values (means) and intrinsic values (ends).
- While all values are anthropogenic, there is disagreement over whether all values are anthropocentric.
- C-VPESS recognizes that there are many possible sources of value derived from ecosystems and the services they provide, and seeks methods for characterizing these various sources of value.

Use of Terms

- "Value" is used broadly to include values that stem from contributions to human well-being as well as values that reflect other considerations, such as social and civil norms (including rights) and moral, religious, and spiritual beliefs and commitments.
- "Benefit" is used to refer more narrowly to the contribution of ecosystems and their services to human well-being.
- "Valuation" is used to refer to the process of characterizing, estimating, or measuring either the value of, or the value of a change in, an ecosystem, its components, or the services it provides. Includes both monetary and non-monetary valuation.
- There are a number of methods that can be used for valuation, which differ in their focus and, in some cases, in their underlying premises.
- C-VPESS is exploring a range of possible valuation methods.

Major challenges in Ecological Valuation of EPA policies or programs

- understanding the many sources of value that ecosystems generate
- predicting the ecological effects of alternative EPA actions
- linking those effects to changes in the dimensions of ecosystems or the service flows that people value
- developing methods that can be used to characterize and/or measure the value of protecting ecological systems and services
- aggregating to a national level using local or regional studies
- finding measures or means of representing ecological values that are commensurable with values of non-ecological changes, such as human health

Ecological Valuation at EPA

Valuation Contexts:

- **National rule making**
- **Regional programs and decisions**
- **Program evaluation and assessment (GPRA)**

- The specific information needs and institutional constraints differ in these different contexts.
- Ecological valuation at EPA must be conducted within a set of institutional, legal, organizational, and practical constraints.

Observations regarding the current state of ecological valuation at EPA

Observations from interviews with EPA staff (focusing on rule making):

- Ecological valuation practices vary considerably across program offices, reflecting differences in mission, in-house expertise, etc.
- The timing of the process largely determines the kinds of analytical techniques that are employed (e.g., court-imposed deadlines and need for OMB review).
- There is a tendency to use methods that have passed review in the past and a disincentive to explore new or innovative approaches.
- Extent and nature of the integration between social scientists and biophysical scientists at EPA is unclear.

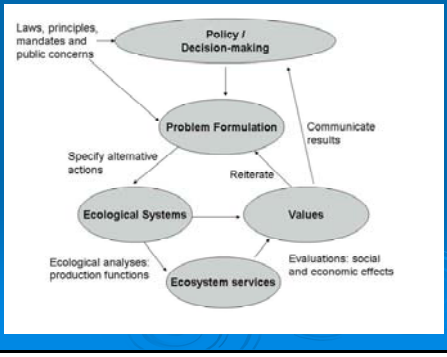
Observations regarding the current state of ecological valuation at EPA (continued)

Observations from an illustrative example: New CAFO regulations

- Focus on a limited set of environmental benefits, driven primarily by the ability to monetize these benefits using generally accepted models and existing value measures (due to time and resource constraints).
- Sole focus on the use of economic valuation methods.
- Mention of non-monetized benefits, but no attempt to characterize or quantify them in any way.
- Use of highly leveraged benefit transfers.
- Little attempt to model systematically and in detail rule's ecological impact early in the assessment.
- Little, if any, consultation with public, especially early in process, to help identify effects that are likely to be most important to them.
- Limited use of peer review, especially early in the process, to provide feedback and advice.

An Integrated and Expanded Approach

Components of Valuation: A General Framework



Key features of an integrated and expanded approach:

1. Focus on impacts of most concern to people.

Key issues:

- Recognition of the many possible sources of value from ecosystem protection
- Need for information about values early in the process
- Requires an expansion of the types of services to be characterized, quantified or valued

Key features of an integrated and expanded approach (continued):

2. Integrate ecological analysis and valuation.

Key issues:

- Need for collaboration throughout process, beginning at early stages.
- Identification of relevant ecosystem services and mapping of effects on ecological assessment endpoints to effects on services
- Design of ecological analysis so that outputs provide usable inputs for value assessments
- Design of valuation techniques that address important ecological/biophysical considerations

Key features of an integrated and expanded approach (continued):

3. Use of an expanded set of valuation approaches.

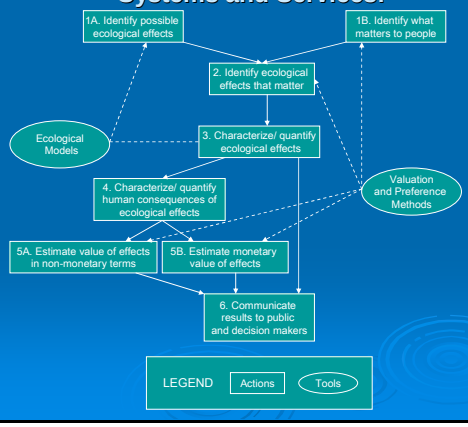
Key issues:

- Recognition that different approaches provide different ways of characterizing or providing information about values
- Different approaches could be used at different stages of valuation process (e.g., providing information to guide focus of study vs. characterizing benefits specific to the EPA action)
- Approaches to be used could vary with the specific policy context, reflecting differences in information needs, the underlying sources of value, data availability, and methodological limitations.

Key question:

How to implement such an approach?

A Proposed Process for Valuing Ecological Systems and Services:



Preliminary Conclusions and Recommendations

The Committee encourages EPA to move towards covering an expanded range of important ecological effects and human considerations by:

- Recognizing many sources of value, both instrumental and intrinsic
- Thinking about instrumental values in terms of ecosystem "services" and mapping from ecological assessment endpoints to services (using concept of an ecological production function)
- Expanding the range of services to which valuation is applied, focusing on the services that are most likely to be important to people

Preliminary Conclusions and Recommendations (continued):

- Exploring and expanding the use of different methods for characterizing or measuring both intrinsic and instrumental values
- Involving, from the beginning of the process, an interdisciplinary collaboration among of physical/biological and social scientists
- Soliciting, from the beginning of the process, input from the public or representatives of individuals affected by ecological changes

5. Panel Discussion with EPA Senior Managers

A member of the C-VPESS, Dr. James Boyd, introduced the panel of five senior Agency managers who had been asked to respond to three questions:

- The C-VPESS observes that EPA has only been able to conduct valuations for a narrow range of ecological effects, compared to the wide range of ecosystems and ecological resources affected by EPA decisions and polices. In your own experience, have EPA decisions and programs been affected by limits on the ability to appropriately measure and value ecological effects?

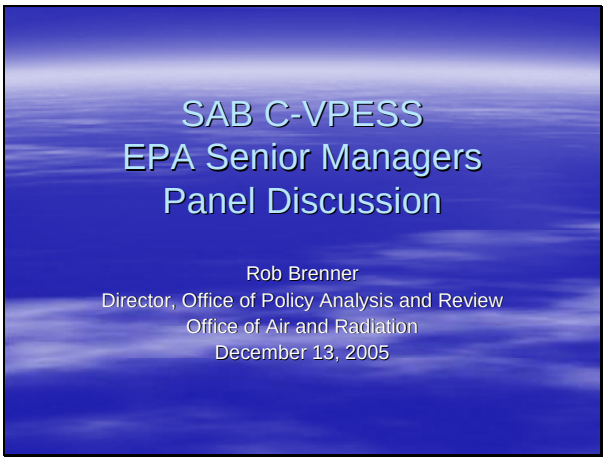
- C-VPESS recommends that EPA expand valuation efforts to reflect more different types of values than the commercial and recreational values captured by most kinds of traditional economic analyses. The Committee advises EPA to explore supplementing economic methods with other kinds of methods to reflect a fuller range of values. What do you see as the potential for such efforts? What do you see as the barriers to exploring these options?

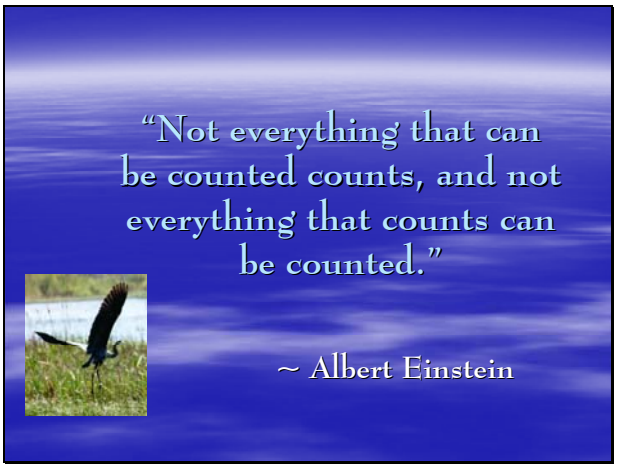
- C-VPESS intends to use case examples to illustrate the integration of multiple methods as a way to describe and measure a broader range of values related to protection of ecological systems and services. From your vantage point, what would make such examination of case examples most useful?

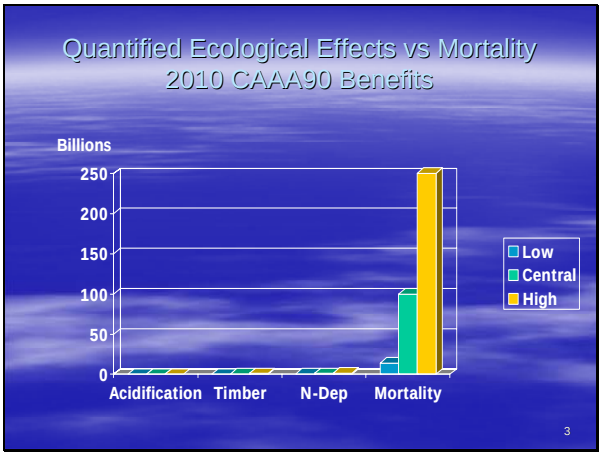
Mr. Robert Brenner from EPA's Office of Air and Radiation began the panel discussion with a short presentation (slides attached below) and a quote from Albert Einstein: "Not everything that can be counted counts, and not everything that counts can be counted." He noted that EPA's air program has succeeded at documenting health effects for pollutants, but that often they do not motivate local efforts for environmental protection. He noted that near environmental protection near Denver and in the Smoky mountains were driven by public desire to see important landmarks. Ecological concerns drove those decisions.

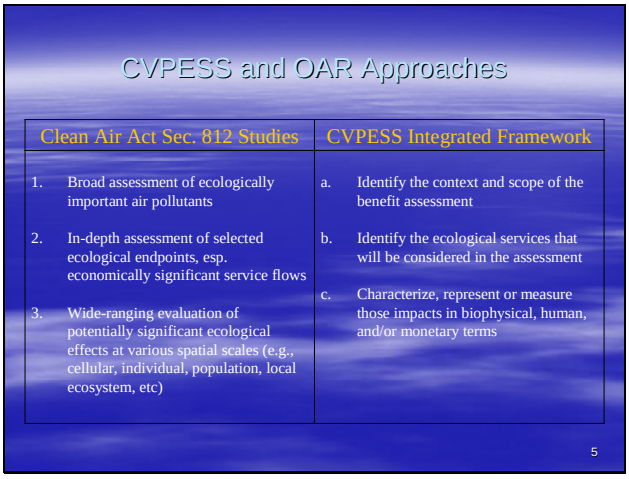
He viewed the C-VPESS integrated framework presented by Dr. Segerson as consistent with the approach being taken by OAR in its Section 812 study of the costs and benefits of implementing the Clean Air Act. His office is interested in strengthening economic data and approaches for valuation through benefit-cost or cost-effectiveness analyses, as well as exploring other assessment methods. In his view, however, serious impediments to the success of the integrated, expanded approach to ecological valuation remain. Given EPA's regulatory needs, there is competition for limited analytical resources. There appears to be ongoing resistance to using currently available approaches, such as the recent contingent valuation study of natural resource improvements in the Adirondacks. He concluded by calling for help defining "best

practices" for a full range of quantifiable effects, including effects that can only be only characterized qualitatively. He suggested that the committee look at an upcoming rule and identify current best practices, so the Agency can take advantage of them.









Dr. Albert McGartland, Director of EPA's National Center for Environmental Economics, was the next speaker. He acknowledged that EPA sometimes appears as the "cancer protection agency," rather than an environmental protection agency because it rarely takes action to address ecological issues. He noted that analyses supporting a recent mercury decision were framed nearly entirely in terms of human health effects, while the impacts of the chemical had a broad range of ecological impacts. He acknowledged the need for increased cooperation across agencies and across disciplines to improve valuation of ecological endpoints. He also cautioned against "letting the perfect be the enemy of the good" and noted that his entire extramural budget would be exhausted by a single high-quality contingent valuation study. He suggested that the committee focus its attention on issues of marginal benefits related to specific decisions, rather than total benefits of ecosystems. He pointed out the Agency's need for cheaper and more efficient ways to conduct valuations. He noted that valuation of human health benefits was successful because dose-response information could be linked to epidemiology and to the economic analysis of marginal changes needed by rulemaking. Without those kinds of links, ecological valuation will always be difficult. Given those missing links, he asked the committee to focus on benefit transfer or other kinds of best practices to follow.

Ms. Kathleen Callahan, Deputy Regional Administrator from EPA Region 2, presented a different perspective. She noted that the regions are intensely interested in ecological valuation issues because they reflect day-to-day decisions encountered in implementing national rules and policies and working with state and governments. Staff in her region face tight deadlines for decision-making. They encounter ecological values that differ across their region (which includes New York, New Jersey, the Virgin Islands, and Puerto Rico) and sometimes also differ from national values. Public health concerns drive many decisions, but ecological health also "plays in." She described a Superfund site, where the region faced a decision about whether to protect an old stand of trees or remove them so children would not be attracted to play on contaminated soil. Another example was Long Island Sound, where the region attempted an ecological valuation

study in 1990. Because that study was not peer reviewed and was challenged, the regional office did not attempt an update needed in 2000. The region could benefit generally from understanding the value of its ecological resources, especially estuaries, but the unsuccessful effort in 1990 time in Region 2 where such an effort was tried.

Ecological values also appear as issues when the Agency works with other tribal, state, and federal partners. In a clean-up decision for Onondaga Lake, contaminated with mercury and other hazardous waste residues, the Onondaga Indian Nation objected to the fairly expensive (approximately half-million-dollar) remedy selected by the region. The tribe objected because the lake was sacred; any remedy that left the lake less contaminated than when the Onondaga's Peacekeeper sanctified it was unacceptable. A different issue arose when the region worked with the State of New Jersey and other federal agencies on the Special Area Management Plan for the Hackensack wetlands. In discussing aims for the plan, colleagues in other federal agencies raised issues in landscape ecology. EPA Region 2 had no landscape ecologist and no framework for factoring such values and science into a decision where the region traditionally relied on wetland characterization guidance and information about property values.

Ms. Callahan expressed a hope for an "iterative process" that would gradually improve the information about ecological values supporting regional decisions. She also called for a clearer understanding of how to conduct public dialogue about ecological values in a manner consistent with all partners' roles in governance and how to translate that dialogue into effective planning for environmental protection.

Dr. Michael Shapiro, Principal Deputy Administrator of EPA's Office of Water, began his comments by acknowledging that his office has a "very high stake" in ecological values. Within his office, policies and rules under the Safe Drinking Water Act are driven by public health concerns, but ecological values are the driving concern for the Clean Water Act.

He echoed his colleagues' views that information about ecological values play into Agency decisions at different levels in different ways. At the national level, lack of valuation information affects strategy and priority setting. In the Agency's five-year planning cycle, the Agency determines investments in programs and rulemaking efforts that offer the greatest benefits. When ecological programs are unable to project ecological benefits, they can get short-changed in the planning and budgeting process.

Dr. Shapiro noted the value of teamwork and a holistic approach described in the C-VPESS integrated and expanded approach, but emphasized that for the most part, at the national level, dollar values are critical when hard, difficult decisions on major rules must be made. As much as the committee may wish for the Agency to adopt an analysis that factors multiple concerns through multiple metrics, dollars will dominate, because most analyses quickly are dominated by monetized metrics. Given the Agency's time constraints, it needs to rely on benefit transfer and has only limited opportunities to conduct studies to "add to the bookshelf." If there is no agreement on contingent valuation, then key tools for analysis are removed.

Dr. Shapiro observed that under the Clean Water Act, many technology-based rulemakings were completed and that regulatory efforts were shifting to the regions for implementation. Regional and local-level decisions offer more significant opportunities for long-term studies of particular ecosystems and extended dialogue on ecological values. Such a context can provide more opportunities for a holistic approach that can address aesthetic and spiritual values that cannot be easily aggregated or analyzed at a national level.

Dr. George Gray, Assistant Administrator for EPA's Office of Research and Development, began his remarks with recognition of the challenge before the committee, as well as appreciation of the difficulties as well as the challenges of working across disciplines. He noted that the SAB plays a useful role in motivating the Agency to innovate, to try new methods, and to overcome the inertia associated with reliance methods that have "passed review" in the past.

He saw merit in the expanded and integrated approach proposed by the committee. In his view, it offered a challenge to biophysical sciences and even to human health metrics and not just to economics. He then briefly reviewed the role of the Office of Research and Development in ecological valuation. He noted that his office has supported Agency efforts in ecological risk assessment. As part of the Agency's extramural grant program, Science to Achieve Results (STAR) program, the Office of Research and Development has focused a part of its Economics and Decision Science efforts on ecological valuation. That program has called for inter-disciplinary collaboration, and has encouraged studies at different geographic scales; studies using different methodologies; and studies examining the appropriate use of benefit transfer.

He encouraged the SAB Committee to identify both long- and short-term research priorities that ORD could consider for funding. He also suggested that the committee explore case studies at different scales (e.g., local, regional, and national) and in the process take advantage of the ecological case studies completed by an inter-disciplinary research team in the Office of Research and Development.

The panel then took questions from the audience. The first question acknowledged Dr. Shapiro's comment that increasingly benefits that cannot be monetized aren't considered by decision-makers. The questioner asked about the "pressures" and reasons behind this development, which appears in the environmental arena more prominently than in the defense, security, and public health areas. Mr. Brenner responded that over time decision-makers are asked to consider many different factors in rulemaking, such as small business impacts and other effects. Monetizing benefits reduces the complexity for decision makers. Non-monetized effects are listed, but until there is a framework for addressing them, they are unlikely to be explicitly addressed in rule making. Dr. McGartland made a different point. He noted that despite the inability of the Agency to characterize ecological benefits fully, all rules from the Office of Water that were finalized in the last three to five years had monetized costs that exceeded benefits. He observed that the Agency should be more systemic in its analysis of non-

monetized benefits and that decision makers could better trained in the use of such analysis.

Ms. Callahan observed that reliance on quantifying values is a "trap our society falls into." In the face of competing values, there is no good process for dialogue and decision-making. Decision-makers easily favor quantitative justifications for their decisions. In a litigious society, quantitative evidence overwhelms qualitative evidence, unless qualitative evidence can be communicated in an extraordinary way.

Another question concerned whether issues similar to eco-valuation arise when human health values are monetized. Mr. Brenner responded that at times it is difficult to know if human health values are monetized fully. In the acid rain program, for example, EPA is finding human health benefits previously unsuspected. Dr. Shapiro responded that the public generally shared an intuitive sense of the metric of live saved or health events averted, but lacked such consensus in the ecological arena. Dr. Gray noted that EPA has a history of decision-making related to un-quantified, un-monetized health effects, where non-cancer health events are at issue and data principally involve reference doses or reference concentrations related to hazardous effects. In his view, such history shows a willingness to take different approaches.

Mr. James Laity, a member of the workshop's expert panel on December 14, 2006, spoke from the audience and identified himself as an examiner of Office of Water rulemakings at the Office of Management and Budget. He characterized the non-monetized benefits he reviewed as generally presented in the format of a "laundry list" where it is difficult to distinguish important effects from those less important. He encouraged the Science Advisory Board to stimulate work on meaningful, objective, possibly quantified ways to evaluate non-monetized benefits.

A final questioner asked about the merits of a tiered approach to analysis of ecosystem services and, in a separate question, about the possibility of an ecological equivalent to the "statistical value of a human life" used in the 812 Study. Mr. Brenner agreed that the Agency did need a less resource-intensive way to identify major benefits. Other panelists were intrigued by the notion of a "statistical value of an ecosystem" but couldn't envision what that would be.

6. Overview of Methods Being Considered by C-VPESS

Dr. Gregory Biddinger introduced this joint presentation with Drs. Terry Daniel and Stephen Polasky to provide an overview of the total suite of methods related to valuation being considered by the C-VPESS (see presentation slides at the end of this section of the workshop report). He noted that the workshop agenda planned for workshop participants to focus on five selected sets of approaches from that suite of methods in the afternoon breakout sessions. In the short presentation, Dr. Biddinger summarized eco-centric approaches; Dr. Terry Daniel summarized socio-psychological methods; and Dr. Stephen Polasky summarized methods designed to obtain group determination of values and economic methods. They each related methods to the process diagram introduced by Dr. Segerson and provided some brief detail about several of the methods discussed.

Workshop participants then had the opportunity for several questions. One participant asked whether the committee had considered research on the information needs of decision-makers and legislators. He asked whether there was a possible need for tools to help decision makers with their own value clarification and tools to help them communicate to the public and with each other. Dr. Daniel responded that he understood that analysis of decision-making in Congress was outside the scope of the committee's charge. Other committee members seconded the view that the committee was focusing on public values, not the values of leaders, which would add to the complexity of analysis and raise issues of amplification feedback.

Another workshop participant asked about issues of feasibility in selection and use of methods and how the Agency could be advised to use its resources to do a better, if not perfect, job of valuation. He asked whether the "80/20 percent" rule could apply to help the Agency gain practical benefits. The panel noted that such an approach was important.

A participant questioned how the use of surveys or "polls," described by Dr. Daniel as part of the "socio-psychological methods" might be used to measure values discussed in the morning's keynote presentation, which called for increased sustainability and stewardship of natural resources. The participant expressed concern that results of polls could be trivial because they would express little understanding of ecological effects. Dr. Daniel responded that surveys that express public opinion do not make decisions; they provide one source of information for decision makers. If results of surveys show a divergence between public views and values and those of experts, then there may be an education or information lag that decision-makers might choose to address. Dr. Polasky responded that effective valuation is multi-disciplinary. Valuation runs a risk if decisions are made on the basis of a single type of valuation study in isolation. Dr. Biddinger also commented that it was important to find new ways to communicate ecological values effectively.

A question was then posed about the time preferences associated with public

values. Dr. Polasky responded that considerations of long-term ecological effects raise issues of dynamics and sustainability. He noted that the committee has plans to address this issue. Dr. Daniel noted that social-psychological research shows that people do consider future environmental impacts in how they express values. Another committee member spoke from the floor about the importance of recent research on discounting. If discounting rates are uncertain, people give future conditions more weight. He considered this result important if the goal is sustainable human welfare.

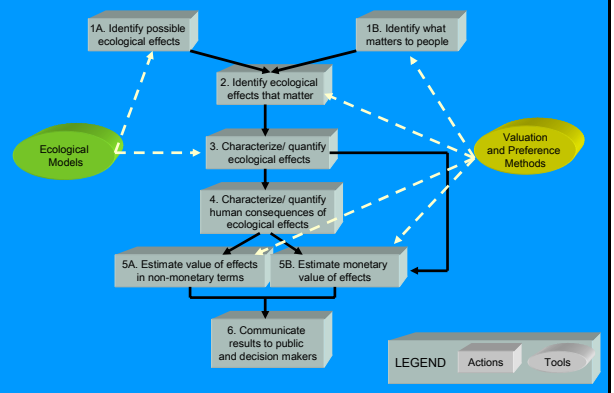
Another question pertained to the implementation of multiple approaches and whether they might be tested against each other, how they might be used at different scales of decision-making, and whether it was appropriate to take a tiered approach that included a screening step to allow for budgeting of resources. A committee member responded that the committee's view of the valuation process was designed to link appropriate tools to the specific decision context faced by the Agency.

The next question concerned how to value possibly irreversible ecological effects, such as introduction of exotic species, where there are many unknowns. Dr. Polasky responded that there is a need for valuation methods that are appropriate for dynamic ecological systems where there are major uncertainties and possible long-term impacts. He noted that decision-making approaches exist for such situations. Analysts would estimate the rate of introduction, the likelihood of harmful effects, and the relative outcome of continuing an existing vs. alternatives proposed. Dr. Biddinger and Dr. Daniel responded that early collaboration between economists, ecologists and social scientists to identify significant ecological effects and early screening of possible benefits against costs were important first steps to take to screen for such cases.

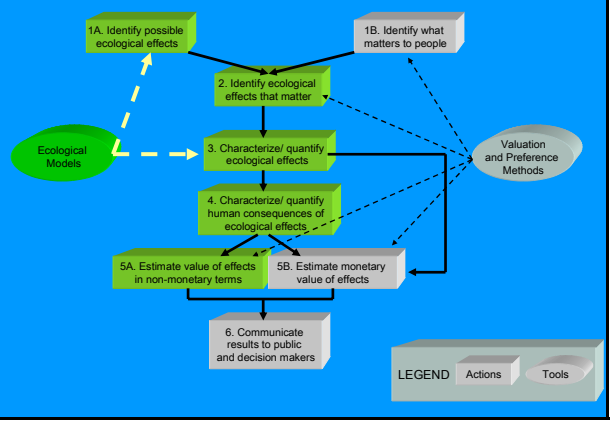
Overview of Methods Being Considered by C-VPESS

SAB Workshop: Science for Valuation of EPA's Ecological Protection Decisions and Programs

Valuation Process Diagram



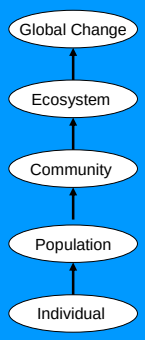
Valuation Process Diagram – Eco-Centric Approaches



Categories of Eco-centric Approaches

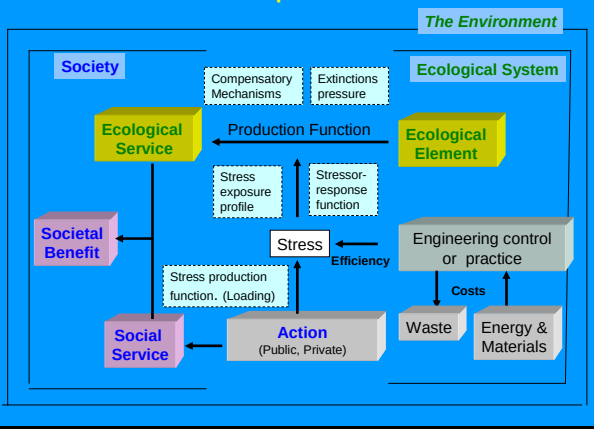
- **Ecological Models**
  - Production Functions
- **Energy and Materials Flow**
  - Embodied Energy Value
  - Emergy
  - Ecological Footprint Analysis
- **Spatial Representation**
  - Spatial Representation of Biodiversity and Conservation Value
- **Indicators Approach**
  - Ecosystem Benefit Indicators
- **Habitat Approaches**
  - Habitat Equivalency Analysis (NEA)
- **Decision Frameworks**
  - Net Environmental Benefit Analysis (NEBA)

Ecological Models – Production Function



- Ecological science can deliver predictions of ecological change (or prevention of change) associated with effects of agency actions
- Numerous Ecological production models developed and primers exist (e.g. Primer of Ecological Theory - Roughgarden 1998)
- Can connect material outputs to stocks and services if services are well defined. (Research focus area)
- Ecologists may not have data available on shelf to parameratize every ecological system for EPA's use. (Research focus area)

Ecological Protection linked to Ecological Services Conceptual Model



Research Proposal

- **Identify ecosystem service provider**
- **Determine aspects of community structure that influence function**
  - **Compensatory Response Mechanism**
  - **Non-random extinction sequences**
- **Assess key environmental factors influencing provisions of services**
- **Measure the spatial-temporal scales at which services operate**

Claire Kremen - Ecological Letters (2005) 8:468-479 – *Managing Ecosystem Services: What do we need to know about their ecology?*

Energy and Material Flow Analysis

- **Quantifies energy and material flow through complex ecological and economic systems**
- **Input-Output Analysis or flow accounting methods**
- **Produce estimates of the *cost of goods* in energy terms**
- **Embodied Energy Value** – Solar energy is the only *Primary* input to global ecosystems. Focus on estimating total (Direct and indirect) energy consumption for an economy (Costanza, 1980)
- **Emergy – C**onsiders all systems to be networks of energy flow and presents an energetic basis for quantification or valuation of ecosystem goods and service Odum et. El. (2000).
- Ecological Footprint Analysis – A variation of energy and material flow that converts impacts to units of land. Total area of productive land to … (support population) – [Costanza. R (ed.) 2000]

Spatial Representation

- Focus on Biodiversity and Conservation value
- Numeric representations of uniqueness, irreplaceability and level of imperilment
- Scale linked ecological target(s)
- Cumulative biological, ecological and conservation value

Stoms et.al. 2005 – Choosing surrogates for biodiversity conservation in complex planning environment. Journal of Conservation Planning. 1: 44-63

Ecosystem Benefits Indicators

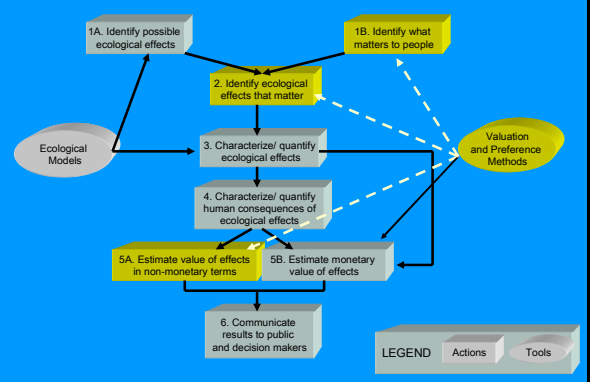
- **Quantitative and visual Approaches to assessments and Land Use**
- **Summarize and quantify complex information and employ economic principles**
- **Benefits are expressed as bundles of indicators, both biophysical and socio-economic**
- **Indicators mapped in Geographic Information System (GIS) context**
- **Indicators can be utilized as input to Trade-off Analysis**
- **Scale of assessment application can range from regional to national.**

James Boyd – What's nature Worth? Using Indicators to open the Black Box of Ecological Valuation. 2004. Resources. pp. 18-22

Habitat Analysis

- **Habitat Equivalency Analysis** was developed for use in Natural Resource Damage compensation assessments
- Quantifies units of habitat needed to provide same level of service over time that was lost due to an injury
- Simultaneously quantifies injury and scales the size of restoration
- Calculates Net Present Value (NPV) measure of service in Discounted Service Acre Years (DSAYs)
- HEA has mostly been applied at the local or watershed levels
- **Net Environmental Benefits Analysis** is a management framework and some advocate NEBA and HEA be linked in remediation / restoration activities.

Social-Psychological Methods



Background Issues

- Human judgments as basis for ecosystem values
  - Publics and stakeholders are relevant for EPA
  - May include biocentric, moral and other values
- Whose judgments?
  - Experts, stakeholders, general publics, citizens
  - Well-informed to ill-informed, rational to emotional
- Context matters
  - Values uncovered versus values constructed
- Value metrics
  - Multiple value dimensions: *preference, importance …*
  - Relative, incommensurate
- Resolving value conflicts and tradeoffs
  - Negotiation versus calculation

Socio-Psychological Methods - 1

- Surveys
  - Standardized formal questionnaires
  - Large representative samples
  - Mail, phone, face-to-face, inter
  - Closed responses (choice, r ate)
- Focus Groups
  - Facilitated discuss deliberation
  - Small relevant group cused topics
  - Open respor (comments)
- Narrative i vs
  - Loosely st ed conversations
  - Selected inf mants
  - Emphasis on depth over breadth

Talk Talk Talk

Socio-Psychological Methods - 2

- Behavior Observation / Behavior Trace
  - Visitor/user behavior in the environment
  - Direct, cameras, counters / trail erosion
  - Correlate Δ behavior, Δ environment
- Interactive Games
  - Computer simulations, visualizations, VR
  - Δ behavior ⇔ Δ environment models
- Referenda and Juries
  - Sanctioned decisions/verdi alues
  - Social/civil context
- Deliberative Gr
  - Facilitate ned tradeoff analysis
  - Value tation/construction
  - Consensus (?)

Steve and Breakout Sessions

Identify What Matters to People

1B. Identify what matters to people

Valuation and Preference Methods

S-P methods provide tested means for systematically identifying and articulating public desires and concerns relevant to public environmental policy

USDA Forest Service Survey

19. The most important role for the public lands is providing jobs and income for local people.

Strongly disagree	1	2	3	4	5	Strongly agree

15. Forests have a right to exist for their own sake, regardless of human concerns and uses.

Shields et al 2002

Identify What Matters to People

1B. Identify what matters to people

Valuation and Preference Methods

S-P methods provide tested means for systematically identifying and articulating public desires and concerns relevant to public environmental policy

Pending NOAA Fisheries Survey (draft)

State and federal marine waters are managed for the benefit of current and future generations. Which of the following should be emphasized in the management of our marine waters?

- ❒ Improving their natural conditions, such as wildlife, water and scenery
- ❒ Developing commercial opportunities such as commercial fishing, energy development and shipping
- ❒ Balancing natural conditions and commercial opportunities about equally
- ❒ I am unsure

Identify Ecological Effects That Matter to People

2. Identify ecological effects that matter

Valuation and Preference Methods

7. Conserving and protecting forests and grasslands that are the source of our water resources, such as streams, lakes, and watershed areas.

Not at all important	1	2	3	4	5	Very important

9. Protecting ecosystems and wildlife habitats.

Shields et al 2002

Estimate value of effects in non-monetary terms

Valuation and Preference Methods

5A. Estimate value of effects in non-monetary terms

5. Developing new paved roads on forests and grasslands for access for cars and recreational vehicles.

Very unfavorable	1	2	3	4	5	Very favorable

1. Expanding access for motorized off-highway vehicles on forests and grasslands (for example, snowmobiling or 4-wheel driving).

6. Designating more wilderness areas on public land that stops access for development and motorized uses.

Shields et al 2002

Group Determination of Values

- **Referenda and Juries**
  - **Sanctioned decisions/verdicts => values**
  - **Social/civil context**
- **Deliberative Groups**
  - **Facilitated, informed tradeoff analysis**
  - **Value elicitation/construction**
  - **Consensus (?)**

Group Determination of Values

- Decision processes where outcome is determined by groups (not individuals)
- Economic approaches to valuation typically aim to ascertain the values of individuals
- People acting as citizens in group decisions may respond differently than people acting as consumers in individual decisions

Group Determination of Values

- Examples of group decision processes from which one might ascertain information about the value of ecosystem services
  - Voting on referenda
  - Deliberative value elicitation/citizen juries
  - Civil court jury awards

Voting on Referenda

- Referenda are formal solicitations to the public to determine the public's willingness to pay
- Example: ballot initiative to purchase open space
  - 1,373 votes on community funding for parks and open space, 1996-2004
  - 1,062 passed; $26.4 billion funding committed
  - Source: Trust for Public Land

Voting on Referenda

- Advantages
  - Direct expression of public preferences
  - Evidence about median voter preferences
  - Responses as citizens about a public good
- Disadvantages
  - Votes may reflect views on multiple subjects (e.g., views on taxes)
  - Can't directly infer aggregate valuation

Voting on Referenda

- Aggregation issue example
  - 3 person community
  - Each has a value of the public good
  - Each faces a property tax (tax price)
- Total value of public good: 220
- Total cost: 300
- Referendum passes 2-1

Voter	Value	Tax Price
A	100	200
B	60	50
C	60	50

Voting on Referenda

- Reverse example
- Total value of public good: 300
- Total cost: 220
- Referendum fails 2-1

Voter	Value	Tax Price
A	200	100
B	50	60
C	50	60

Deliberative Value Elicitation & Citizen Juries

- A problem with asking people their views on the value of ecosystem services:
  - Many people are not well informed: complex issues that are largely ignored by the general public
  - Many people will not have thought carefully about values or have well formed views

Deliberative Value Elicitation & Citizen Juries

- Deliberative approaches
  - Form a small group (voluntary participation)
  - Provide group with technical information
  - In-depth discussion
  - Structured decision-making

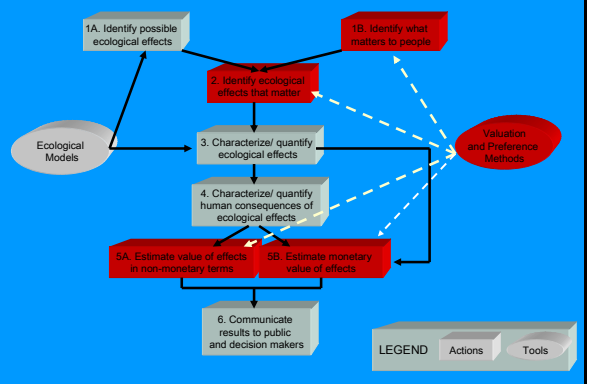
Deliberative Value Elicitation & Citizen Juries

- Advantages
  - Thoughtful valuation based on information and careful deliberation
- Disadvantages
  - Self-selection bias: is group representative of general public
  - Dominant individual effect
  - Effect of how process is structured may affect the results

Civil Court Jury Awards

- Liability rules: require an entity that damages ecosystems to
  - restore
  - replace with a functional equivalent
  - pay monetary damages equivalent to lost value
- Example: Natural Resource Damage Assessment (NRDA)
  - CERCLA (Superfund)
  - Oil Pollution Act
- Concern: high cost of litigation

Economic Methods



Economic Approaches to Valuation

- Dominant methodology for quantitative assessment of valuation of ecosystem services
- Built on microeconomic theory that has been well developed
- Translates values into a common currency (monetized value) that makes comparisons easy to comprehend
- Some object to converting "priceless" environmental attributes into money equivalents

Conceptual Foundation: Utility Theory and Welfare Economics

- Key concept: what tradeoffs makes an individual equally well off?
- Willingness-to-pay: how much money would an individual give up to buy an ecosystem service?
- Willingness-to-accept: how much money would an individual need to receive in exchange for taking away an ecosystem service?

Market-based Valuation

- Some ecosystem services provide marketed commodities, directly or indirectly
- Examples:
  - Value of increased fish harvest from improved water quality or protection of coastal wetlands
  - Value of increased crop production from pollinators

Non-Market Valuation

- Revealed Preference
  - Travel Cost Method
  - Hedonic Approach
  - Averting Behavior
- Stated Preference
  - Choice Experiments
    - Contingent Valuation,
    - Conjoint Analysis

Travel Cost Method

- Opportunity cost for participating in outdoor recreation: travel time and out-of-pocket expenses
- Opportunity costs provide an implicit price for recreational trips
- Estimate how trip choices change on the basis of trip costs and other variables (e.g. site qualities…)
- Derive a willingness-to-pay (demand) for trips

Hedonic Approach

- Some purchased goods as composite goods whose values depends on many characteristics
- Example: value of a house depends upon
  - Structural characteristics (e.g., sq feet, age, # of bedrooms…)
  - Environmental characteristics (e.g., air quality, access to open space…)
- Controlling for other characteristics, how does willingness-to-pay vary with environmental characteristic of interest

Revealed Preference Methods

- Advantages:
  - Based on observable behavior for decisions with real consequences
- Disadvantages:
  - May only apply to a small set of ecosystem services (e.g., travel cost - recreation)
  - Questions about specification of empirical equation (explanatory variables, functional form…)
  - Are individuals fully informed about choices?

Stated Preference Approaches

- Choice experiments: survey asking individual to make choices
  - Contingent valuation: offer a choice about whether individual would pay a specified price for a specified increase is an ecosystem service
  - Conjoint analysis: offer bundles of services and price and ask which is preferred

Stated Preference Approaches

- Advantages
  - Direct question about values
  - Applicable to ecosystem services for which there is no direct observable behavior ("non-use" values)
- Disadvantages
  - Hypothetical – would people really pay what they say they will?
  - How well informed are respondents?
  - How much are responses influences by question format?

Other Approaches

- Rather than try to estimates value directly, use evidence on cost to infer something about value (similar to averting behavior)
- Replacement Cost
- Marketable Permit Prices

Replacement Costs

- What would it cost to replace an ecosystem service with human engineered solution?
- Example: Catskills/New York City water supply
- To be valid, must meet three conditions:
  - Human engineered solution provides equivalent quality/quantity of service
  - Solution is least cost alternative of providing the service
  - Individuals in aggregate would be willing to incur the cost if ecosystem service were not available

Marketable Permit Prices

- Cap-and-trade systems
  - Tradable emissions permits (pollution)
  - Individually transferable quotas (fishing)
- Observable price for permit/quota
- Examples: SO_2 and CO_2 markets

Marketable Permit Prices

- Can the price of a permit/quota be used to infer the value of an ecosystem service?
- Price of emissions permit reflects the *marginal cost* of meeting the cap
- Price will depend on stringency of cap
  - European Exchange: 21.18 €/metric ton
  - Chicago Climate Exchange: $1.65/metric ton (Prices as of Dec 9, 2005)

Cross-Cutting Issues

- Benefits Transfer
- Dynamics
- Uncertainty

7. Addressing Uncertainty in Ecological Valuation and Expert Elicitation

Dr. William Ascher provided a short presentation (see slides at the end of this section of the workshop report) focused on the analysis of uncertainty in ecological valuation and how to convey uncertainty to policy makers. He noted different kinds of uncertainty and then discussed how uncertainty analysis might proceed and be communicated to policy makers, given their use of uncertainty (e.g., for edging, contingency planning, and communication with the public and other policy makers) and their preference for greater certainty and tendency to equate uncertainty with weak analysis.

He suggested that analysts need to keep the range of uncertainty prominent. He provided some initial conclusions, under discussion by the C-VPESS, about how ecological analyses can convey uncertainty effectively to policymakers through appropriate formats, methods, building on existing models, and processes for working with policymakers or "gatekeepers" such as the Office of Regulatory and Information Affairs at the Office of Management and Budget.

He then turned to a short discussion of expert elicitation as one method to determine degrees of uncertainty and disagreement, understand their bases, and reduce uncertainty and disagreement. He defined expert elicitation broadly as the "use of expert judgment in an analysis" that entails "second-hand" analysis of available data. He described four different kinds of expert elicitation [compilations of existing judgments; individual-expert syntheses; expert-interaction approaches, such as the Delphi approach; and the Technical Facilitator/Integrator (TFI) approach]. He described these approaches as differing in their cost, formality, extent and nature of any interactions among experts, and the form of the final information provided to policy-makers from the elicitation.

After Dr. Ascher concluded the presentation (presentation slides attached at the conclusion of this section of the workshop report), Dr. Robert Costanza provided brief remarks. He noted that ecological risk assessment has many different kinds of uncertainties, that only some of them are adequately captured through quantitative methods such as Monte Carlo analysis, and that analysts need to "bracket" other kinds of uncertainties for decision-makers. The goal of uncertainty analysis, in his view, was not to reduce uncertainties (because additional research might paradoxically increase uncertainty about ecological effects). Instead the goal is to represent uncertainties in ways that allow better decision-making in the face of uncertainty. In his view, this issue was linked to the question "who bears the burden for uncertainty?" If there is no full discussion of uncertainty, the public typically bears the burden of adverse effects. He suggested that the burden might better be place on parties standing to benefit from creating uncertainties. Assurance bonds might be one mechanism where uncertainty analysis could be used to foster better decision making. If polluters were required to purchase and hold bonds until potential damages identified as possible in a worst-case analysis were not demonstrated, the public might be better protected against high-impact, highly uncertain risks.

A workshop participant noted that the SAB might consider this idea in its review of EPA's annual research budget and research planning efforts. There is a science component to adaptive management that can help foster learning from policy experiments, if decisions are structured appropriately and their impacts studied.

Another workshop participant spoke of the importance of uncertainty analysis in ecological valuation and recounted his experience providing advice to the Agency for its 812 Study. He noted that the Agency had a high threshold for committing a Type 1 (false positive) error in monetizing ecological benefits associated with ecological protection resulting from implementing the Clean Air Act. When EPA does not include those highly uncertain ecological benefits in its monetary estimates, the Agency may commit, in his view, a Type 2 (false negative) error.

Another participant asked if there are points in the valuation process where expert elicitation may best be involved. Dr. Ascher responded that the C-VPESS is wrestling with this issue. Expert elicitation is probably more useful in the production function part of an analysis and less useful in expressing how the general public values some ecological change. Dr. Costanza also commented that often there are differences in knowledge of experts and the public about the connections between ecological impacts and human welfare. He suggested that it would be useful to find a role for expert opinions, a role especially important until the public is better educated about ecological processes. The committee's emphasis on "methodological pluralism," where results are triangulated across several methods to assess ecological value, can provide better analyses to support decisions.

A final questioner asked whether there was a role for fuzzy logic and sensitivity analysis in the committee's exploration of uncertainty methods to support ecological valuation. Dr. Costanza responded that the committee should mention and explore those ideas.

Addressing Uncertainty in Ecological Valuation; Expert Elicitation

SAB Workshop: Science for Valuation of EPA's Ecological Protection Decisions and Programs

How to conduct valuation, given uncertainty

1. Different valuation approaches for different types of uncertainty?
   - Stochastic uncertainty
   - Theory uncertainty
   - Data limitations
2. Probability-estimating techniques within the valuation (e.g., Monte Carlo, expert elicitation)

How to conduct valuation, given uncertainty

3. How to most efficiently reduce uncertainty?
   - Maybe requires a diagnosis of types & sources of uncertainty
     - Budnitz et al. on earthquake prediction

How to convey uncertainty to policymakers

- Requires knowing how policymakers do & should use understandings of uncertainty
  - For hedging
  - For contingency planning
  - For communication with public & other policymakers

How to convey uncertainty to policymakers

- Requires knowing how policymakers do & should use understandings of uncertainty
  - Tendency to prefer greater certainty
  - Tendency to fold estimate & uncertainty indications into prior assessment
  - Tendency to equate uncertainty with weak analysis

How to convey uncertainty to policymakers

Implications:

1. Need to keep range of uncertainty prominent
2. Need to convey assumptions so that policymakers can judge credibility & convey to audiences
3. Need to provide enough information so that bca & other decision aids can incorporate the uncertainty

How to convey uncertainty to policymakers

1. Appropriate formats (e.g., confidence intervals, probabilities, etc.)?
2. Uncertainty tests (e.g., Monte Carlo, expert elicitation)
3. Useful models adaptable from other applications (e.g., "risk characterization" for health risks)?
4. How much information to be conveyed?

How to convey uncertainty to policymakers

5. What processes of interaction between analysts & policymakers?
6. How to overcome institutional or other obstacles to conveying uncertainty?
7. Choice of models & visual aids
8. Should policymakers (or gatekeepers such as OIRA) insist on protocols for expressing uncertainty?

Expert Elicitation: Defining Expert Elicitation

- Use of expert judgment in an analysis
- Also called "multi-expert opinion" methods
- Entails "second-hand" analysis
- Wide range of different methods

Purposes of Expert Elicitation

1. Undertake analysis using others' expertise
   - Typically less costly in time & money
   - Potential to incorporate broad range of wisdom & insights
2. Determine degree of uncertainty & disagreement
3. Understand the bases of uncertainty & disagreement
4. Reduce uncertainty & disagreement

Dimensions of Differences

1. breadth of expertise of the individuals involved in the exercise
2. degree and nature (if any) of interaction between the experts and those conducting the expert elicitation
3. degree and nature (if any) of interaction among the experts
   - e.g., face-to-face vs. mail responses

Dimensions of Differences

4. formality
   - from brain-storming to highly-structured, often computer-aided
5. degree of synthesis and interpretation by study conductors
6. [for multi-round methods]: nature of feedback that the experts are provided from one round to the next

Dimensions of Differences

7. how judgments are aggregated & presented
   - from simple means or medians, to full probability distributions, confidence intervals, & explanations for the differences
   - some use Bayesian methods to incorporate quantitative probability estimates

Specific Elicitation Methods: 1. Compilations of existing judgments

- E.g., "consensus economic forecasts"; biodiversity hotspots
  - Can present means, medians & ranges
  - Very inexpensive & fairly quick

Specific Elicitation Methods: 1. Compilations of existing judgments

- E.g., "consensus economic forecasts"; biodiversity hotspots
  - Can present means, medians & ranges
  - Very inexpensive & fairly quick

Specific Elicitation Methods: 1. Compilations of existing judgments

- Risk of including obsolete judgments
  - Recency is highly correlated with accuracy, at least for forecasts
- Risk of mixing different concepts
- No interaction among experts
- No direct gauge of uncertainty
  - Spread only partially revealing

Specific Elicitation Methods: 2. Individual-Expert Synthesis

- Granger Morgan
- Individual interviews (no interactions among experts) synthesized by study conductors
- Experts of similar expertise
  - Therefore gauging degrees of disagreement
- Presents reasons for judgments

Specific Elicitation Methods: 3. Expert-interaction approaches

Brainstorming:
- Unstructured
- Potentially rich interactions
- Vulnerable to intimidation, groupthink, etc.

Specific Elicitation Methods: 3. Expert-interaction approaches

Delphi

- Multiple rounds of requests for judgments, feedback on medians & ranges, opportunities for revisions
- No direct, face-to-face interactions among experts
  - Avoids groupthink, etc.

Specific Elicitation Methods: 3. Expert-interaction approaches

Delphi

- Premium on wide range of expertise
- Typically, some degree of convergence
  - Therefore not a measure of pre-existing agreement/disagreement but rather of agreement potential with multi-disciplinary interactions

Specific Elicitation Methods: 3. Expert-interaction approaches

Delphi

- Sacrifices richness of direct interaction
- Risk that different understanding of terms will lead to false indications of differences in judgments

Specific Elicitation Methods: 3. Expert-interaction approaches:

Technical Facilitator/Integrator (TFI):

4 stages:

1. Literature review & assessment + own integrator's expertise
2. Integrator interacts with experts to assess judgments, issues, distribution of judgments
3. Integrator facilitates expert interactions
4. Expert panel assesses overall record & distribution of judgments

Specific Elicitation Methods: 3. Expert-interaction approaches:

Technical Facilitator/Integrator (TFI):

- Number of stages depends on resources
- Obvious parallels to other methods
- Huge burden on integrator/facilitator

8. Discussion of Specific Methods Featured in Workshop Breakout Groups

Dr. Buzz Thompson introduced the topics of the five breakout groups (Economic Analysis and Ecological Production Functions; Group Expressions of Value: Referenda and Citizen Juries; Deliberative Approaches for Modeling, Valuation, and Decision Making; Social/Psychological Methods for Ecosystem Values Assessments; Spatial Representation of Biodiversity and Conservation Values and Ecological Services. He emphasized that the purpose of the breakout sessions was for the C-VPESS to receive input and feedback from meeting participants. He pointed meeting participants to the suggested questions for breakout sessions included in their meeting materials[1] and the background materials from breakout sessions provided for them (see section beginning on page 86 of this report).

Breakout sessions met from 3:30-5:30 p.m. on December 13, 2005. Meeting participants reconvened in plenary session at 8:30 a.m. on December 14, 2005 to hear brief reports about the previous day's five breakout sessions and to participate in brief question and answer sessions for each. Dr. A. Myrick Freeman, a C-VPESS member, introduced the speakers and moderated the session.

8.1. Break-out Report: Economic Analysis and Ecological Production Functions

Dr. Joan Roughgarden and Dr. Stephen Polasky reported on the breakout session on economic analysis and ecological production functions (materials for this breakout session may be found on page 86). Dr. Roughgarden noted that ecological science has advanced to the stage where EPA could take greater advantage of linking outputs of ecological models to economic valuation. They noted the need for "quick and cheap" methods but Dr. Roughgarden observed that ecological studies cannot be "second rate" and encouraged EPA to "aim high, despite constraints." They noted that often there is a mismatch between the research efforts of academic ecologists and EPA's needs. There could be great benefits if models known to work for specific ecosystems and parameterize were paramaterized for other places of regulatory concern.

A workshop participant asked whether there are well-articulated criteria for quality of ecological studies and data in the regulatory arena and whether practical short-cuts, given constrained resources, might critically compromise the quality of studies. The breakout presenters did not respond with specific criteria. They did discuss, however, strategies for targeting ecological research. They discussed taking advantage of the

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[1]- What methods or aspects of methods seem most promising for EPA to adopt or explore? In what kinds of decision contexts would EPA use those methods? Where would they fit in a valuation process?
-What should be added to or changed in the methods discussed to make them more credible and more useful?
-What are the barriers to adoption of promising new methods and how might they be best overcome?
-Which issues would benefit from additional exploration and research? How could the SAB, CASAC, and Council be helpful in providing such advice?
-Given whatever approaches to valuation you are considering, how should be degree of uncertainty be a) gauged and b) conveyed?

research surveyed for thee *Millennium Assessment.* They discussed the need to consider investments in peer review in light of the overall need for ecological-economic modeling, with a balanced allocation of effort in both dimensions. Dr. Roughgarden noted that breakout participants had observed that advances in computing technology for economic analyses might provide needed resources for extending ecological analysis.

A questioner responded with a question about the appropriateness of using "Knowledge Networks" to identify survey respondents. This web-enabled strategy results in high response rates, in his view a pre-requisite of a "good study," but he expressed concern that the survey groups identified by "Knowledge Networks" might not reflect the population as a whole. He asked about the availability of guidance that might help EPA manage the tension between "doing a study that meets technical requirements" and taking "shortcuts that make science practical in the real world."

Dr. Polasky responded that the 80/20% rule might apply. He noted that the C-VPESS must wrestle with ways EPA can get most of the information needed for a limited set of benefits and avoid emphasizing "the perfect over the practical." Dr. Roughgarden agreed that there is a difference between "getting it right" and "getting it perfect." She noted a need for a "systematic push" to minimize type 1 errors and avoid egregious type 2 errors. Nevertheless, in her experience, ecological studies generally take five years to complete. Dr. Roughgarden suggested that the Agency pursue quality research and that the Agency should adopt "stopgap" policy options until ecological data is available.

A participant asked whether there was also a shortage of technically competent people willing and able to engage in applied work. Dr. Roughgarden responded that there is a large pool of young Ph.D. ecologists now untapped. Graduate ecologists in her experience never think of EPA as a potential employer. She suggested that better outreach by EPA would tap this enormous potential. Dr. Polasky similarly acknowledged the capability within EPA's National Center for Environmental Economics and also noted that many economists outside EPA wanted to work with ecologists. He believed that the tradition of multi-disciplinary collaboration was stronger outside the Agency than within.

The last question concerned the importance of an accessible platform to make research data available to outside academic researchers, as well as to the Agency. A workshop participant noted that if a common platform were conveniently designed with good spatial data information, a wide variety of social, economic, and ecological data could be used to enhance the science supporting ecological valuation. Data developed for local or special purposes could be cross checked, studied for their alignment with other data, and appropriate standards developed. He noted that such platforms were routine in labor and health economics. Dr. Roughgarden responded that such a platform could be linked to the well-established Long Term Ecological Research network of data stations. This existing network has a 20-year tradition of data-sharing and standards that might accommodate research on ecological production functions and other needed ecological valuation research.

8.2. Group Expressions of Value: Referenda and Citizen Juries

Dr. William Ascher reported on the breakout group focused on referenda, initiatives, and citizen juries (background materials and presentations used in this breakout session may be found on page 88 below). He noted that while these approaches may be considered "unorthodox," they have the potential to capture values not reflected in actual markets and reflect group expressions of value. In addition, referenda and initiatives involve actual, not hypothetical, decisions, reached on particular issues. He reported that the break-out group criticized the use of analyses of referenda and initiatives due to concerns about the politics associated with voting and the complications associated with interpreting results and using them in benefit transfer. The breakout group, however, did discuss their use in validating more conventional methods.

Dr. Ascher reported on the breakout group's discussion of citizen juries. Despite concern about the novelty of this approach, lack of possible representativeness of membership in juries, and standards for legitimating the approach, the group saw some potential in capturing types of values that elude other methods. The group shared a strong sentiment for multiple methods and a concern for the problem of under-estimation of hard-to quantify ecosystem components.

Dr. Ascher's presentation slides are included at the end of this section of the workshop report.

In the question and answer period, a meeting participant asked about the use of the term "jury," since American society gives legitimacy to jury decisions, which usually make decisions in an adversarial context. The participant observed that the juries described operated more like grand juries in the American system and suggested that the literature on grand juries might be helpful.

Another meeting participant suggested that group values relating to ecological protection might be very well captured through the approach developed by Henry Willis and Michael DeKay of Carnegie Mellon, who have developed a framework for ecological risk ranking, which has proven robust through many applications.

A final participant expressed concern over the target audience intended for the group approaches described. She saw problems associated with limiting involvement to the middle-class individualslikely to participate.

Inferring Values from Public Choices

W. Ascher
VPESS
December 2005

Vehicles of Public Input Reflecting Values

- Individual-response valuation
- public opinion polls
- non-governmental fora
- public hearings
- public notice and comment
- concertation
- quasi-governmental commissions
- direct community decision-making through town halls, etc
- elected representation
- public opinion polls
- letter writing, emailing or calling an elected representative
- taking existing public policies as the revealed preferences of society
- contributions to non-governmental efforts
- **willingness to accept negotiations**
- **referenda/initiatives**

Revealed Preferences from "Public Choices"

1. Referenda/initiatives
   - Referendum: legislature calls for a public vote
   - Initiative: citizen petition
   - Usually for eco-system improvements
2. Willingness-to-accept negotiation outcomes
   - Best if voted; but could have other indications of "close call"

Different conception of what value is:

- Intensity
- Median: the majority (or close to majority) of sufficiently engaged people believe that the expense is worth it
  - Closer to 50-50, the better, though floors or ceilings can be estimated regardless

Different conceptions:

- Intrinsic validity
  - IF one accepts that society's decisions have standing as expressions of value
  - Whether private utility or public regardedness

Different conceptions:

- Conception of democracy & representation
  - Anti-Burkean, non-Benthamite
    - Burke: representatives, not citizens, choose what is good for the people
    - Bentham: greatest [private] good for the greatest number
  - Government should do what the public wish government to do

Criticisms

1. Referenda & initiatives are subject to intense politicking
   - But politicking is pervasive & democratic
2. Perceptions of benefits & costs may diverge from actual stakes
   - But it is possible to follow up with surveys to determine how the stakes are perceived

Criticisms

3. Other issues determine the vote
   - Popularity of backers; partisan maneuvering
   - For willingness-to-pay: restrict to simple-issue referenda or initiatives
   - For willingness-to-accept: simple-issue Coasean negotiations

Criticisms

- Not capable of determining the option of greatest aggregate utility
  - 60% favor because their net gain is +$100
  - 40% against because their net gain is -$200
  - Usually true, but logic is simply different
  - Assuming 0 value for opponents, a floor on mean value is possible

Complications:

- Different benefits transfer complications
  - Disentangling objectives if multiple issues
    - Or, contingent valuation keyed to actual cases of pending decisions

Complications:

- More than 50% vote margin will underestimate the community's collective valuation
  - Result is therefore a floor
- Multiple issues obscure the willingness to pay for any single benefit
  - Go for simple-issue referenda or initiatives
- Different benefits transfer complications

Validation of More Conventional Valuation Methods

- Several studies predict referendum votes from contingent valuation estimates; check whether the predictions are borne out

Validation of More Conventional Valuation Methods

NOAA Panel:

[E]xternal validation of elicited lost passive use values is usually impossible. There are however real-life referenda. Some of them, at least, are decisions to purchase specific public goods with defined payment mechanisms, e.g., an increase in property taxes. The analogy with willingness to pay for avoidance or repair of environmental damage is far from perfect but close enough that the ability of CV-like studies to predict the outcomes of real-world referenda would be useful evidence on the validity of the CV method in general.

Validation of More Conventional Valuation Methods

The test we envision is not an election poll of the usual type. Instead, using the referendum format and providing the usual information to the respondents, a study should ask whether they are willing to pay the average amount implied by the actual referendum. The outcome of the CV-like study should be compared with that of the actual referendum. The Panel thinks that studies of this kind should be pursued as a method of validating and perhaps even calibrating applications of the CV method

8.3. Deliberative Approaches for Modeling, Valuation, and Decision Making

Dr. Harold Mooney reported on the breakout-group focused on decision-aiding approaches and mediated modeling (breakout materials and a related presentation may be found on page 102 of this workshop report). He presented a short overview of the approaches featured by Drs. Joseph Arvai and Robert Costanza and quickly summarized the discussions of the breakout group. The group discussed the issue of identifying and engaging representative stakeholders, gaming and bias issues, and noted that the SAB published a science and stakeholder involvement study in 2001. Other questions concerned:

- How can these techniques be used at the national level?
- How do we get more social science involved in EPA in order to do these activities meaningfully? How to get EPA to take non economic valuation more seriously?
- Who is going to own and rerun the models through time?
- How complex can the models be and still be transparent?
- How are uncertainty, non-linearities, dealt with?
- Limitations of costs and available talent
- Value measures are relative (no common metric)

Dr. Mooney reported that the breakout group saw many benefits associated with the methods:

- Emergent values result
- Local focus makes it easier for decision-making
- Social learning an important by-product of process
- Benefits in relation to cost are high
- Transparency
- Procedural equity

- Collaborative

Dr. Mooney's presentation slides are included at the end of this section of the workshop report.

Dr. Mooney invited Bruce Hull to provide some additional commentary. Dr. Hull noted that the approaches described can work well but may feel difficult at first for experts. He saw these deliberated and mediated processes offering benefits when working with local stakeholders in specific places. The social learning that results through these processes builds the capacity of local groups to solve environmental problems.

A workshop participant added that mediated modeling approaches have been used by the Army Corps of Engineers in collaboration with Sandia National Laboratories. Although the process is expensive, it can help obtain full buy-in and support for decision options.

A different point was made by another workshop participant. She noted that almost all the information needed for mediated modeling is required for expert valuation. She viewed mediated modeling as an alternative decision process, not an alternative form of valuation. Yet another participant took issue with this view. He noted that group processes entail substantial value synthesis and is different in nature from expert valuation and decision making.

Dr. Mooney invited Dr. Arvai to make several remarks. Dr. Arvai commented that values need to be considered across several alternatives and are only meaningful in a comparative context, where there are consideration of the multiple attributes relevant to a decision. Decision-aiding approaches are ways to synthesize information across several valuation methods to infer value from their results.

A workshop participant noted that EPA has experience with such methods through negotiated rulemakings and pointed to the Agency's experience with the Phase Two Microbial Disinfectant Byproduct (MDB) Rule. He acknowledged the merit of such a process, but offered two cautions. Stakeholders involved in such processes have difficulty balancing their genuine desire to arrive at a socially acceptable outcome against representing their constituency. Therefore, the outcome of such efforts depends greatly on the negotiating skills of individuals representing their constituencies. He also noted that stakeholder identification is critically important. He also noted that such processes are lengthy and expensive. The MDB Rule developed a near-consensus regulation that opened up only slight relief to small drinking water systems that were the focus of the rule-making and who were not directly involved in the negotiation.

Dr. Arvai acknowledged that stakeholder identification is always critical. He noted, however, that decision-aiding approaches are not aimed at negotiation, but at identifying the relevant components of values and describing the range of relevant values

and their components to decision-makers.

Deliberative Approaches for Modeling, Valuation and Decision Making

Joseph Arvai
Robert Costanza

Discussion leaders and early departers

The essence of Arvai

- The value of ecological systems and services emerges from *stakeholder deliberation*
- The overall value of ecological systems and services is *multiattribute in nature*.
- The value of systems or services is established through an analysis of *management alternatives*; thus, the value of ecological systems and services is relative and reflects the *tradeoffs* that people are willing to make.

Joe's Procedure

- Analyses of people's (stakeholders, public, experts, etc.) objectives identifies the attributes of systems and services that deserve attention in "valuation".
- Consultation with technical experts (economists, ecologists, etc.) identifies appropriate measures for these attributes including:

  natural measures (eg value of electricity); **proxy measures** (habitat quality for fish); **constructed measures** (indexes of accessibilitiy for cultural and spiritual purposes)

OBJECTIVES, ATTRIBUTES, MEASURES

Objectives	Attributes; Measures
Recreation	*Access to recreation opportunities; Weighted User Days*
Environmental Health	*Erosion levels; Weighted Erosion Days*
Environmental Health	*Flow levels; Weighted Flood Days*
Environmental Health	*Habitat quality; % Available Habitat, IBI*
Environmental Health	*Water quality; Multiattribute Index (particulates, PCBs, etc.)*
Cultural	*Regular access to sites; Consistency Index*
Economic	*Revenues; Annual Revenues M$ / Year*

ESTABLISHING VALUE

Objectives	Attributes/ Measures	Mimic Natural Hydrograph	Enhanced Summer Releases	Enhanced Winter Releases
Enhance recreation opportunities	Access/ Weighted user days	1400	1200	1500
Enhance environmental health	Habitat Quality/ % Available	50%	20%	30%
Maximize economic returns	Revenues/ $Mil/Yr	$60	$80	$65

ESTABLISHING VALUE

Objectives	Attributes/ Measures	Mimic Natural Hydrograph	Enhanced Summer Releases	Enhanced Winter Releases
Enhance recreation opportunities	Access/ Weighted user days	1400	1200	1500
Enhance environmental health	Habitat Quality/ % Available			
Maximize economic returns	Revenues/ $Mil/Yr	$60	$80	$65

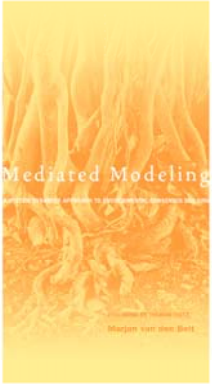
Instead, the value of a given option exists in the tradeoffs that people are willing to make across not just their objectives, but also the level of achievement with respect to them.

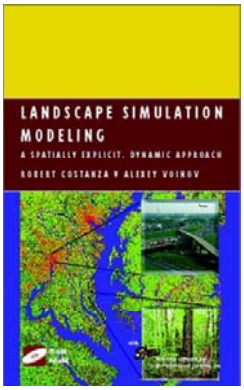
ADVANTAGES

- Provides both preference orders for management options.
- Multiattribute, inclusive, and transparent.
- Useful for both decision making and retrospective evaluation.

CHALLENGES

- Big effort and potentially time consuming.
- Decision makers may wish to protect their autonomy.
- Not explicitly geared towards current OMB requirements for regulatory evaluation.





Three Step Modeling Process*

1. Scoping Models
high generality, low resolution models produced with broad participation by all the stakeholder groups affected by the problem.

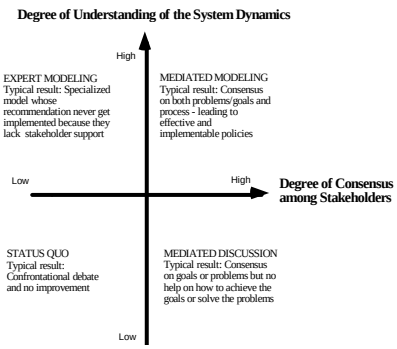
2. Research Models
more detailed and realistic attempts to replicate the dynamics of the particular system of interest with the emphasis on calibration and testing.

3. Management Models
medium to high resolution models based on the previous two stages with the emphasis on producing future management scenarios - can be simply exercising the scoping or research models or may require further elaboration to allow application to management questions

Increasing Complexity, Cost, Realism, and Precision

*from Costanza, R. and M. Ruth. 1998. Using dynamic modeling to scope environmental pr and build consensus. *Environmental Management* 22:183-195.

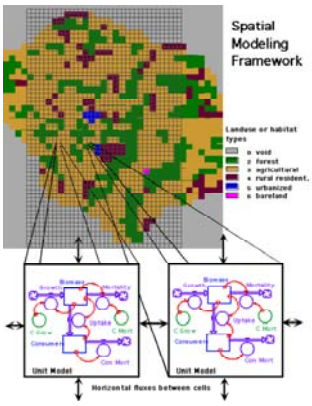
Gund Institute for Ecological Economics, University of Vermont



Patuxent Watershed Scenarios*

	Land Use				Nitrogen Loading				Nitrogen to Estuary			Hydrology		N in GW	NPP
	Forest	Resid	Urban	Agro	Atmos	Fertil.	Decomp.	Septic	N aver.	N max	N min	Wmax	Wmin	N gw c.	NPP
Scenario	number of cells				kg/ha/year				mg/l			m/year		mg/l	kg/m2/y
1	1650	2386	0	0	56	3.00	0.00	162.00	0.00	3.14	11.97	0.05	101.059	34.557	0.023	2.185
2	1850	348	7	0	2087	5.00	106.00	63.00	0.00	7.17	46.61	0.22	147.979	22.227	0.25	0.333
3	1950	911	111	28	1391	96.00	110.00	99.00	7.00	11.79	42.34	0.70	128.076	18.976	0.284	1.119
4	1972	1252	223	83	884	86.00	145.00	119.00	7.00	13.68	60.63	0.76	126.974	19.947	0.281	1.72
5	1990	1315	311	92	724	86.00	101.00	113.00	13.00	10.18	40.42	1.09	138.486	18.473	0.263	1.654
6	1997	1195	460	115	672	91.00	94.00	105.00	18.00	11.09	55.73	0.34	147.909	18.312	0.289	1.569
7	BuildOut	312	729	216	1185	96.00	155.00	61.00	21.00	12.89	83.03	2.42	174.890	11.066	0.447	0.558
8	BMP	1195	460	115	672	80.00	41.00	103.00	18.00	5.68	16.41	0.06	148.154	16.730	0.23	1.523
9	LUB1	1129	575	134	604	86.00	73.00	98.00	8.00	8.05	39.71	0.11	150.524	17.623	0.266	1.494
10	LUB2	1147	538	134	623	86.00	76.00	100.00	11.00	7.89	29.95	0.07	148.353	16.575	0.269	1.512
11	LUB3	1129	577	134	602	86.00	73.00	99.00	24.00	7.89	29.73	0.10	148.479	16.750	0.289	1.5
12	LUB4	1133	564	135	610	86.00	74.00	100.00	12.00	8.05	29.83	0.07	148.444	16.633	0.271	1.501
13	agro2res	1195	1132	115	0	86.00	0.00	96.00	39.00	5.62	15.13	0.11	169.960	17.586	0.292	1.702
14	agro2frst	1867	460	115	0	86.00	0.00	134.00	18.00	4.89	12.32	0.06	138.622	21.590	0.142	2.258
15	res2frst	1655	0	115	672	86.00	82.00	130.00	7.00	7.58	23.50	0.10	120.771	20.276	0.18	1.95
16	frst2res	0	1655	115	672	86.00	82.00	36.00	54.00	9.27	39.40	1.89	183.565	9.586	0.497	0.437
17	cluster	1528	0	276	638	86.00	78.00	121.00	17.00	7.64	25.32	0.09	166.724	17.484	0.216	1.792
18	sprawl	1127	652	0	663	86.00	78.00	83.00	27.00	8.48	25.43	0.11	140.467	17.556	0.349	1.222

* From: Costanza, R., A. Voinov, R. Boumans, T. Maxwell, F. Villa, L. Wainger, and H. Voinov. 2002. Integrated ecological economic modeling of the Patuxent River watershed, Maryland. *Ecological Monographs* 72:203-231.



So what were the group issues??

- The issue of identifying and engaging representative stakeholders, gaming and bias issues,etc. SAB did a stakeholder involvement study in the past.
- How can these techniques be used at the national level?
- How do we get more social science involved in EPA in order to do these activities meaningfully? How to get EPA to take non economic valuation more seriously?

More issues

- Who is going to own and rerun the models through time?
- How complex can the models be and still be transparent?
- How are uncertainty, non-linearities, dealt with?
- Limitations of costs and available talent
- Value measures are relative (not common metric)

Benefits

•Emergent values result

•Local focus makes it easier for decision-making

•Social learning an important by-product of process

•Benefits in relation to cost are high

•Transparent

•Procedural equity

•Collaborative

8.4. Social/Psychological Methods for Ecosystem Values Assessments

Dr. Ann Fisher reported on the breakout-group focused on social and psychological methods for ecosystem values assessments (breakout materials and a related presentation may be found on page 115 of this workshop report). The scope of methods included surveys, focus groups, narrative interviews, behavioral observations/behavioral traces, and interactive games. The group identified possible EPA applications of methods that have potential for characterizing elusive non-market values, especially important values that people resist expressing in terms of trade-offs. They alsosuggested several additional ways social and psychological data could be linked to eco-valuation. One breakout member described how the British government was using standard multi-attribute approaches to risk for classifying reactions to a wide variety of potential risks, including ecological risks. The group discussed barriers to EPA's exploring such approaches, including overcoming the hurdles involved in collecting data from more than 10 people. The discussed how the Agency might partner with the US Forest Service and the National oceanic and Atmospheric Administration, which uses

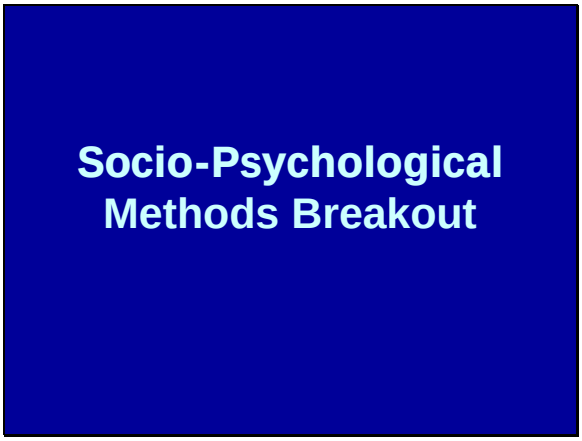
social surveys to understand the value of different ecological protection options. Dr. Fisher's presentation slides are included at the end of this section of the workshop report.

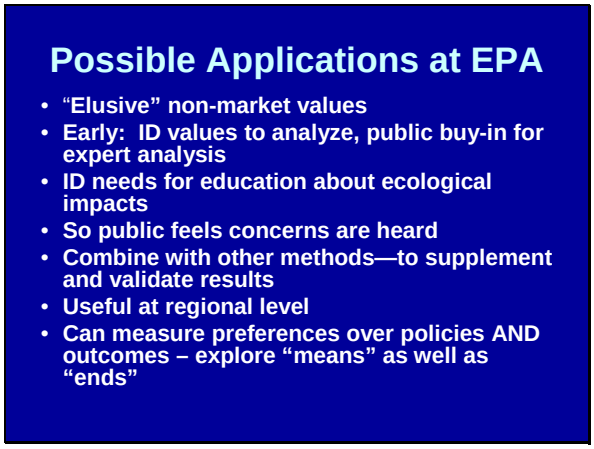
In the question-and-answer-period that followed, a workshop participant noted that it was important to decide when information about trade-offs are need, and when other kinds of information about values can be helpful to decision makers. Another workshop participant suggested that it would be useful for an SAB panel to look at the scientific issues associated with data collection and offer advice regarding several questions, including: when and how web panels might be appropriate; alternatives to "Knowledge Networks;" criteria for good surveys, including the role of high response; and formats for providing non-economic information to the Agency.

A workshop participant commented that at the local level, decisions regarding values are not expressed in an economic framework. Social-psychological approaches are needed to characterize ecological values in that domain.

A federal expert invited to the workshop noted that the U.S. Forest Service uses social-psychological approaches as part of a major effort to understand communities. He expressed the view that it would be useful for the Forest Service to share both "success and horror stories."

Dr. Terry Daniel, one of the breakout leaders, made special note that social-psychological methods are useful to discriminate responses by groups. They can show where there are differences and convergence in values across groups so that decision-makers can develop effective policies.





Additional Soc/Psych Methods

- Research documenting public health, psychological, and public safety benefits of ecological amenities
- Complex systems analysis for emergent behavior
- Recent British "Orange Book" – Standard Multi-Attribute Model for Managing Risks to the Public
- Cultural risk metrics adapted from USFS
- Monitoring news coverage of ecological resources

Barriers/Possible Strategies

- Representative results?
  - Use techniques that ensure representative samples
- EPA's lack of non-economist social scientists
  - Possible strategy: ?
- OMB review a major hurdle
  - Plan ahead for survey needs
  - Partner with other agencies (NOAA, USFS)

Issues

- What Soc/Psych methods offer that economic methods don't
  - People resist thinking about tradeoffs for some values
  - Preference ratings can express information that trade-offs can't (e.g., rationale for values) or gather information in more understandable ways

Issues-2

- How can Soc/Psych methods establish the importance of bio-physical impacts that can't be monetized? Metrics?
- Use value-of-information approach to identify when additional ecological valuation is needed for a decision?
- Useful to identify when a decision needs public value info vs. when expert input is enough
- Key: learn the mental models of populations to be studied

8.5. Spatial Representation of Biodiversity and Conservation Values and Ecological Services

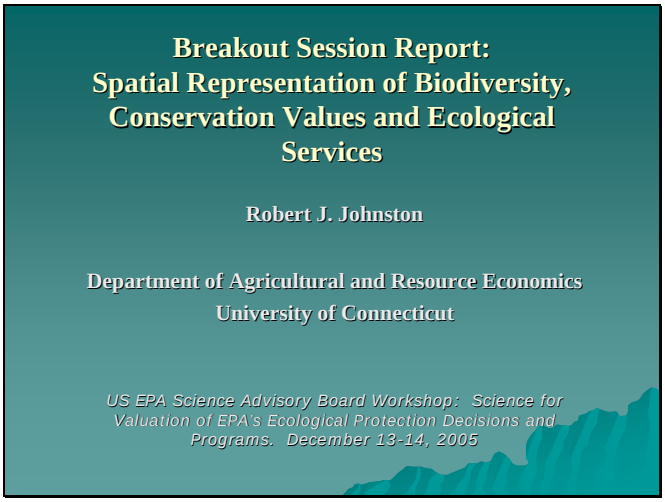
Dr. Robert Johnston reported on the breakout-group focused on spatial representation of biodiversity and conservation values and ecological services (breakout materials and a related presentation may be found on page 119 of this workshop report). He quickly summarized the presentations made by Drs. James Boyd and Dennis Grossman. He noted common presentation themes emphasizing standardized, transparent, spatially explicit information and models for use by policy makers. He reported that breakout discussions touched on issues of simplicity vs. richness; making assumptions underlying models clear; the importance and difficulty of communicating effectively across disciplines; and making appropriate scientific use of existing spatial data. He noted that workshop participants agreed on priorities and the importance of multi-disciplinary collaboration. In his view, the most important keys to successful use of such spatial approaches were transparency, consistency, standardization, and clarity. Dr. Johnston's presentation slides are included at the end of this section of the workshop

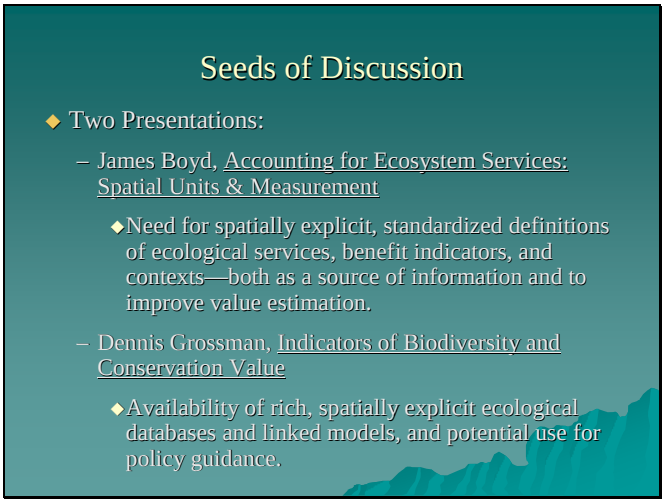
report.

A brief question and answer session followed. The first question concerned whether the breakout group discussed whether the data presented were normative or positive and the appropriate use of those different kinds of spatial data in Agency decision-making. Dr. Johnston responded that there was no explicit discussion related to this question. A workshop participant asked whether issues of confidentiality arose in discussion, because the issue of confidentiality of data does arisen when he attempted to link models. Dr. Grossman responded that the NatureServe model does contain confidential information about the specific location of some endangered species.

Another workshop participant noted recent research by Robert Dodds that surprisingly suggests that weights are not as important as previously thought in technical assessment schemes.

Dr. Boyd concluded the discussion with a comment that increased clarity about the nature of ecosystem services was necessary, so that both ecologists and economists can more transparently identify and count ecosystem services.





Common Presentation Themes

- Standardized, transparent and spatially explicit information and models that can:
  - Offer a source of information to policymakers, independent of any subsequent valuation efforts.
  - Serve as a standardized starting point for more defensible and transparent valuation efforts.
  - Promote more rigorous, standardized economic and non-economic valuation efforts.
  - Promote more defensible benefits transfer of existing work—identify systematic elements of value.
  - Primarily economic – ecological themes.

Challenge #1: Simplicity vs. Richness

- Despite shortcomings, reducing benefits to a single metric (monetary valuation) has advantage of formality, simplicity, and clear acceptance in the policy process.
- Were presentations suggesting *alternatives* to economic valuation or *ways of improving* economic valuation?
  - Universal consensus on the latter issue; less consensus on the former.

Challenge #2: What are the Black Boxes?

- Issues taken for granted or suppressed by some disciplinary approaches are exactly those considered most important by others.
- Examples:
  - How are weights defined when comparing/aggregating ecological services or prioritizing policies?
  - What are intermediate inputs versus final valued services?
  - What are the spatial units and assumptions of analysis?

Challenge #3: Playing Nicely with Others

- Communication and convergence between disciplines is critical and sometimes lacking.
- Examples:
  - What assumptions are implicit in maps of "ecological values," and are these values?
  - To what extent are certain types of ecological services captured by appropriately conducted economic valuation?
  - What is a "value"? An ecological "service"?
  - What limitations and assumptions are implied or not implied by anthropocentric valuation? By non-anthropocentric valuation?

Challenge #4: Using What is Out There

- Lack of awareness of spatially explicit databases that can, at the very least, serve as an input to valuation.
  - These data can be better utilized by ecologists, economists and others.
  - Availability of data does not imply availability of models.
  - Even with these databases, is the ecological predictive capacity there on place-specific basis to support valuation? Lack of consensus…

Challenge #5: The Usual Suspects

- Anthropocentric versus non-anthropocentric approaches to ecological value.
- What ecological services are subject to economic tradeoffs, substitution and prioritization?
- Expert opinion versus public preferences.

Significant Convergence

- Benefits of collaborative, multidisciplinary work have not been sufficiently realized or explored—this is an area of substantial promise.
- Need to standardize communication, units of measurement, and reporting.
- Locality and spatial aspects of value are not simple issues, and have not been addressed sufficiently.
- Need to clearly communicate what is providing services, how services are defined, and who is realizing benefits.

Significant Convergence

- More promising to focus on *complementary* approaches to ecological value rather than *substitute* approaches.
- Estimated values should provide a *basis* for subsequent deliberations—not a *replacement*.
- We can't do a "core dump" on policymakers—there is virtue in simplicity.
- *Sine qua non*: Need for transparency, consistency, standardization and clarity from all disciplines.

9. Panel Discussion: Experts' Feedback on Valuation Methods

A member of the C-VPESS, Dr. Harold Mooney, introduced the panel of four experts who had been asked to respond to three questions:

1. Given the C-VPESS call for EPA to expand valuation to include a wide suite of ecological values, how well do the methods discussed at this workshop capture the range of methods currently available and in development?

2. What methods seem most practical and implementable for use by EPA in characterizing or measuring values not reflected in traditional markets?

3. If you were to choose two topics for specific attention by the C-VPESS and the SAB to provide advice to help EPA expand valuation efforts, what would they be?

Dr. Trudy Cameron, Raymond F. Mikesell Professor of Environmental and Resource Economics at the University of Oregon, was the first to present remarks. She addressed the three questions above in a slide presentation, captured in the three points immediately below:

1. How well do the methods discussed here capture the range of methods currently available and in development?

Pretty well

2. Which seem most practical and implementable for non-market ecosystem services?

Available data will determine preferred methods within economic toolkit (prefer observed choices; make do with stated preferences)
Deliberative processes: very helpful for scoping out feasible and potentially attractive policy options, and for "first cuts" concerning relevant versus irrelevant attributes of options for affected populations; will not yield info on average tradeoffs in population as a whole (non-representative)
Energy and materials flow analysis: helpful in capturing the constraints faced by society, but not preferences (demand; benefits)
To a certain extent, you get what you pay for…
Different alternatives for valuation have different attributes: cost, quality of information.
Agency will have to make tradeoffs. "Best" method for a particular context maximizes net benefits (total benefits from the valuation information obtained—i.e. "better policy decisions"—minus the total costs of arriving at it).

3. Two topics for specific attention?

Ecological production functions – how ecosystem properties contribute to ecosystem

services that we, as a society, perceive and care about (either for our own instrumental uses, or for their "intrinsic" value)
Misinformation produces bad choices which imply incorrect valuations. Perfectly informed constituency is an impossible goal. Elicit subjective information sets, even if "wrong," so that it is possible to use models to "back out" repaired valuations under simulated "correct" information.

Dr. Cameron then made eight additional points, clarifications about "valuation" that she did not see mentioned in C-VPESS draft reports. Text from her presentation slides appears below.

1. Non-economists often use: "economic" versus "non-economic" ecosystem services to describe what economists consider to be: "commercially exploited" versus "non-commercial" ecosystem services

…Any problem about how to allocate scarce resources (here, ecosystems) to different uses (commercial exploitation, development, preservation, etc.) is an "economic problem." The economics tent is huge. Economic is not just Alan Greenspan (or Ben Bernanke). It is the "study of how to allocate scarce resources across competing end uses" (SOHTASRACEU?) "Resources" can be anything, not simply money.

Beyond the term "economics," there are many other common words that economists recycle and use as technical terms. We should have invented new jargon, as other disciplines sometimes do, but we haven't. Makes things very confusing for outsiders who think they know what we mean when we use words like "cost" or "capital," for example.

2. Beyond valuation? i.e., The case of an ecosystem service that it is "impossible to put a dollar value upon"?

Property rights and refusal to contemplate WTP:

Some people may be unwilling to think about willingness to pay to preserve or enhance an ecosystem service because this implies that they do not have an inalienable "property right" to those services. Need to get people to imagine "IF you did not have a right to this ecosystem service, how much would you be willing to give up to preserve or enhance it?" A very practical question, but some people won't play this game.

May refuse to contemplate tradeoffs because it is "not fair" that they should be asked to make such a tradeoff, perhaps because they have never had to do it before and it makes them uncomfortable to think about it. The "invaluable 41-year marriage." May have the luxury of viewing a marriage as beyond valuing until you have had to trade off against it—as in "your career versus your marriage."

Social stigma and refusal to contemplate WTA:

If someone does have a property right to something (e.g. a clean river), then the correct

measure of social value is "compensation demanded" or "willingness to accept (compensation to give up that right)". But some people will refuse to play that hypothetical game as well, even if they would (privately and anonymously) be willing to take some finite amount of compensation. Reason? They do not wish to incur the social stigma associated with "selling out" (a term that is pejorative in itself). The amount of compensation you would have to give them would need to be enough to make up for not only for the loss of the clean water, but also for the loss of their reputation for solidarity with their community. The value of a good depends upon the availability of substitutes, among other things. There may be substitutes for a clean river, but no substitute for their community standing and reputation (their "good name").

Empirical problem: can't distinguish between the amounts of compensation needed for each thing—the resource and their good name.

3. Economists don't usually question the reasons why people are willing to give up other things to preserve or enhance ecosystem services. All that matters: the fact that they ARE willing, and the extent to which they are.

This doesn't mean we are not curious about things that might seem to explain variations in WTP. We often explore how our WTP estimates seem to vary systematically with observable individual attributes (gender, age, ethnicity), or with measures of attitudes or reported behaviors from the same people ("How well-informed are you about environmental issues?" "How often do you go fishing for sport?") When we do this, we are looking for logical consistency between estimated WTP and things that intuition suggests should be correlated with it. Or, we are seeking to forecast how average WTP might differ across sub-populations with different characteristics.

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4. There is a difference between what is (a "positive" question) and what should be (a "normative" question). Economists study the tradeoff decisions that people do make, conditional on their characteristics and the attributes they perceive for the alternatives they are considering.

Rich enough empirically estimated economic models of choice can be used to simulate, counterfactually, what choices people would probably make if their characteristics were different along the same dimensions (e.g. age) or if the alternatives they face had different levels of the same attributes (= positive analysis).

Without data on the choices people make, no theoretical economic model will tell you

what choices society should make.

Best we can do: Conditional on knowledge of preferences, we can point to the alternative that is likely to be considered most desirable,

But: economic models cannot tell us what preferences should be.

5. Important role for environmental advocacy: to help people's perceptions match the scientific facts about ecosystems services.

6. An unfortunate but common misconception about economists' motives:

18th century definition of "wealth" = well-being (e.g. the commonweal)
…the opposite of "illth" (mentioned even in a 1915 intro textbook)
i.e. Adam Smith's (1776) "The Wealth of Nations" was concerned with the "well-being of nations"…

21st century definition of "wealth" = stock of financial assets
…may or may not be an indicator of "wealth" in the 18th century sense

Due to this evolution in common usage, the idea of "maximizing wealth" now sounds money-oriented and just plain greedy. That's why economists now call it "maximizing social welfare."

7. Misconceptions about economists' notions of "value"—particularly when it is characterized as "monetization" (as an epithet). After all, moneychangers have had a bad reputation for a couple of thousand years.

"Value" is another common word recycled by economists to serve as a technical term. Here, it refers to a particular "marginal rate of substitution": i.e. how much of "all other goods" would you be willing to give up, to get one more unit of the environmental good in question?

The composite commodity we call "all other goods" (AOG) is measured in *convenient units such* that *one unit costs $1*. <u>This is where the "monetization" step occurs.</u> We can then use dollars as a measure of the *quantity* of "all other goods."

If you had to pay for the environmental good, but you chose *none* of it, you could afford a number of units of "all other goods" equal to your number of dollars of income. In consumer theory, we view money income simply as a measure of the quantity of other (market) goods you can consume, given your budget constraint.

"Value" of the environmental good is derived from tradeoffs willingly made between quantities of the environmental good ("*envgood*") and quantities of all other goods ("*AOG*")

Suppose utility depends on the *marginal utility* of each thing, times the quantity of that

thing (in the case of a simple linear utility function):

$$Utility = \frac{\Delta Utility}{\Delta \$AOG} \cdot \$AOG + \frac{\Delta Utility}{\Delta envgood} \cdot envgood + \ldots \text{(other terms?)}$$

To hold utility constant ($\Delta Utility = 0$) when we increase the environmental good by one unit, by how much could we decrease consumption of all other goods (income)? Solve this equation for $\Delta \$AOG$:

$$0 = \Delta Utility = \underbrace{\frac{\Delta Utility}{\Delta \$AOG}}_{\substack{\text{marginal} \\ \text{utility of} \\ \text{AOG (=income)}}} \cdot \underbrace{[\Delta \$AOG]}_{[\ ?\ ]} + \underbrace{\frac{\Delta Utility}{\Delta envgood}}_{\substack{\text{marginal} \\ \text{utility of} \\ envgood}} \cdot \underbrace{[\Delta envgood]}_{[\ +1\ ]} + 0$$

Economists don't dictate the sizes of these marginal utilities—they have to attempt to measure them by studying the tradeoffs people are willing to make. Here, linear utility function implies that marginal utilities are constant (an oversimplification in most cases). This model implies that "value"= "willingness to pay" is also a constant, given by:

$$\frac{\Delta \$AOG}{[1]} = -\frac{\left(\dfrac{\Delta Utility}{\Delta envgood}\right)}{\left(\dfrac{\Delta Utility}{\Delta \$AOG}\right)} = \text{"- ratio of marginal utilities"}$$

Note that units of Utility cancel (fortunately) and result is in
"dollars-worth of AOG willingly given up, for one more unit of envgood"

Note that this is a quantity of AOG, given current prices. Money is just a convenient metric for the quantity of this composite good. Economic "values" are about tradeoffs (substitutions) people are willing to make.

or (more tersely) "willingness to pay, in dollars per unit of envgood
or (even more tersely) "value of envgood"

Note that units of *Utility* cancel (fortunately) and result is in
"dollars-worth of *AOG* willingly given up, for one more unit of *envgood*"

Generalizing valuation approach:
The ratio of marginal utilities is called the "marginal rate of substitution" between the environmental good and all other goods (income).

$$\Delta\$AOG = -\left(\frac{\text{"Marginal utility of } envgood\text{"}}{\text{"Marginal utility of income"}}\right)$$

More-interesting and more-realistic utility functions are not simply linear in their arguments (the quantities of each good). They are likely to display

- diminishing marginal utility (DMU), such that the extra utility from and extra unit declines with additional units, and
- diminishing marginal rates of substitution, such that the amount of another good that you are willing to give up to get one more unit of good X declines, the more you already have of good X.

Implication: "value" of one unit of envgood will depend on how much you are currently consuming of this good and other goods (income). It is also likely to differ across people, because preferences differ.

8. Energy Theory of Value

The "energy requirements" per unit of output is a dimension of the constraints faced by society.

The "production opportunity set" describes all the possible combinations of goods and services we can enjoy. It is defined by the quantities of each available resource, and the technologies available to convert these resources into things that we want or need.

If "resources" are heterogeneous, it is easy to argue that the production possibility frontier is "bowed outwards" (has an increasingly negative slope from left to right) -- the more of any one good you try to produce, the more costly each unit becomes in terms of other things you can no longer produce.

If we can reduce all resources to equivalent and homogeneous units of "emergy" (solar radiation), then the production possibility frontier has a constant (negative) slope. Relative emergy requirements per unit of each possible good we could produce define the cost of good A in terms of the units of other goods that would need to be foregone in order for us to produce that one unit of good A.

Relative emergy requirements for production define "What we HAVE to give up in terms of other goods to produce another unit of A."

- This is called a marginal rate of transformation in production.

Relevant concept for valuation is "What we ARE WILLING to give up in terms of other goods to consume another unit of A."

- This is defined by preferences over the different possible goods we could produce (the marginal rate of substitution in consumption).

Only at the "optimal" allocation are these two amounts equal. For non-marketed goods

such as ecosystem services, we do not observe competitive equilibrium. Instead, it is our task to try to figure out where it might be, so we get some idea of how much to provide.

We need to know BOTH
a. marginal rates of transformation (which the idea of emergy might be helpful in identifying), and
b. marginal rates of substitution (based on some type of aggregation of individual preferences…a social welfare function)

In the question-and-answer session that followed her presentation, a workshop participant asked whether framing questions in terms of dollars distorts respondents' answers. Dr. Cameron responded that economists can use other metrics as a numeraire. Any pair-wise trade-off can be used. Monetary estimates can be "backed in" at a later time. In response to another question, she affirmed that economics is the study of choices among competing uses. Another participant asked whether questions about ecological value should be framed "absent reference to rights." Dr. Cameron suggested that researchers can reframe questions when people refuse to indicate choices. She was asked whether there were some domains where it may be inappropriate as a society to build utility functions. Another workshop participant commented that any time society makes a choice, society has revealed values about alternatives. Dr. Cameron concluded the discussion with the comment that the task of economists are to reveal people's choices. Once that's done, it is possible to study whether those choices relate to government's choices.

Dr. Jonathan Krosnick, Frederic O. Glover Professor in Humanities & Social Sciences & Professor of Communication & Political Science, Stanford University, was the second panelist to speak and expressed his appreciation for the workshop and work of the C-VPESS. He presented several slides to demonstrate that response rates are not a valid indicator of survey accuracy. He emphasized that reliability depends on surveys being administered to a representative sample and designed well (so that they controlled for recall errors, comprehension errors, reporting errors, intentional omission/addition, and nonresponse).

Internet surveys can be as reliable as telephone surveys and can be less costly to conduct. He emphasized that the general public informs policy-making via social science measurement and cited numerous examples of continuing surveys conducted by other federal agencies. He then provided a variety of examples showing the accuracy of social science measurements that are well conducted. He noted that contingent valuation surveys can also have high validity and reliability. Among social science methods, he cautioned against data collection in groups, as opposed to collecting data from individuals, and cautioned also against collection technique that emphasize introspection. He characterized all methods as having value and urged EPA to explore and evaluate them all. Dr. Krosnick was only able to take one question. It concerned whether response to surveys differ by the degree to which related questions involve controversy. Dr. Krosnick responded that surveys can be framed well to deal with controversial issues. Dr. Krosnick's slides appear below.

Me 20 years ago:

- Deeply skeptical
  - About survey measurement of values
  - About CV

1

Me today:

- Deeply skeptical but …
  - Impressed by how well surveys work.
    (if designed and implemented well)
  - Impressed by how well CV works.

2

EPA is not Alone

The general public
informs policy-making
via social science measurement

3

Examples of Continuing Federal Surveys

- Survey of Income and Program Participation (Census Bureau) 1984 -
- Consumer Expenditure Surveys (Census Bureau) 1968 -
- Annual Housing Surveys (Census Bureau) 1973 -
- Survey of Consumer Attitudes (NSF) 1953 –
- Health and Nutrition Examination Surveys (NCHS) 1959 -
- National Health Interview Surveys (NCHS) 1970 -
- American National Election Studies (NSF) 1948 -
- Panel Study of Income Dynamics (NSF) 1968 –
- National Longitudinal Surveys (BLS) 1964 -
- Behavioral Risk Factor Surveillance System (CDC) 1984 –
- Monitoring the Future (NIDA) 1975 –
- American national Election Studies (NSF) 1948-
- General Social Survey (NSF) 1972-
- National Crime Victimization Survey (DOJ) 1973-
- Continuing Survey of Food Intake by Individuals (USDA) 1965-
- National Survey of Distracted and Drowsy Driving (NHTSA)

4

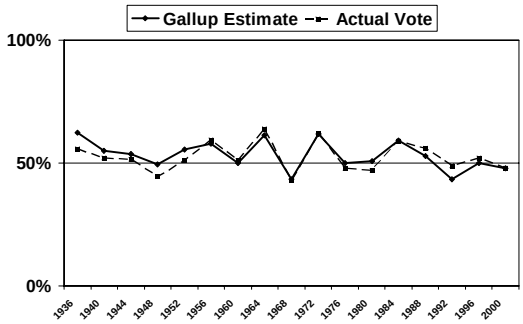
Potential Threats to Accuracy

- Recall errors
- Comprehension errors
- Reporting errors
- Intentional omission/addition
- Nonresponse

5

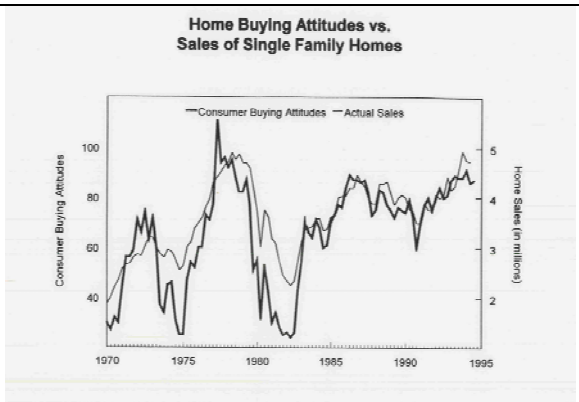
How Accurate is Social Science Measurement?

6



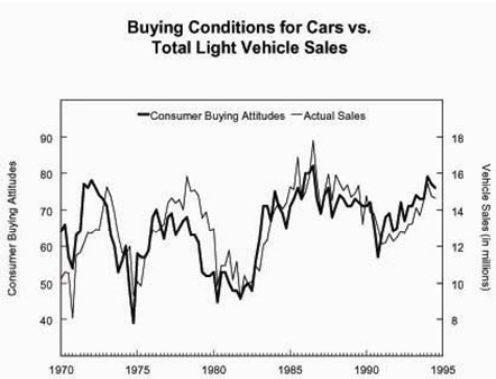
Gallup final survey estimates of support for winning presidential candidate correlated with actual election outcome, r = .85.

7



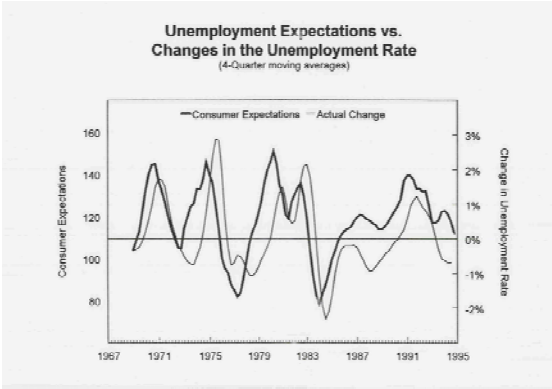
Survey estimates of home buying attitudes correlated with actual home sales, time series correlation = .77.

8



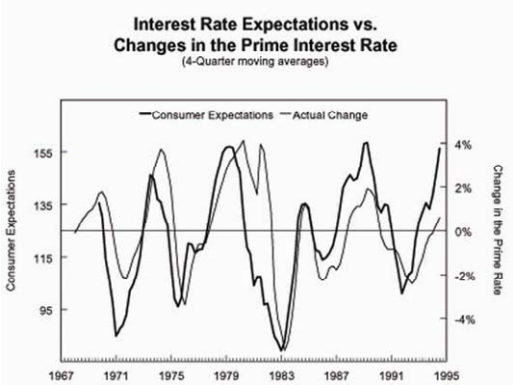
Survey estimates of car buying attitudes correlated with actual car sales, time series correlation = .73.

9



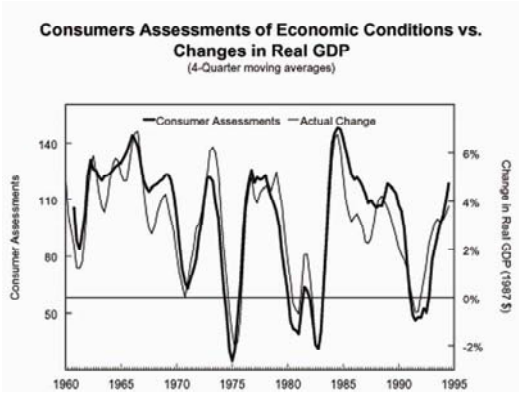
Survey estimates of unemployment expectations correlated with actual changes in unemployment rate, time series correlation = .80.

10



Survey estimates of interest rate expectations correlated with actual changes in prime interest rate, time series correlation = .74.

11



Survey estimates of consumer perceptions of the national economy correlated with actual changes in real GDP, time series correlation = .90.

12

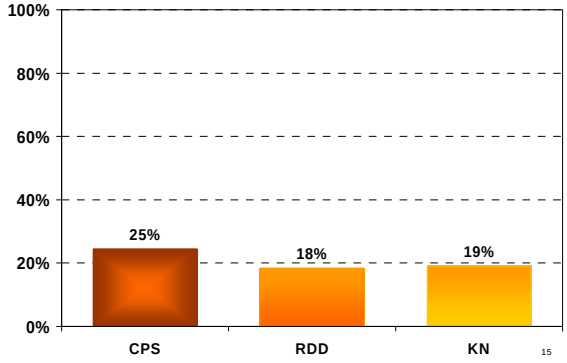
Survey estimates of inflation expectations correlated with actual changes in the Consumer Price Index, time series correlation = .90.

13

Accuracy of Face-to-Face, Telephone, and Internet Surveys?

14

Never Married



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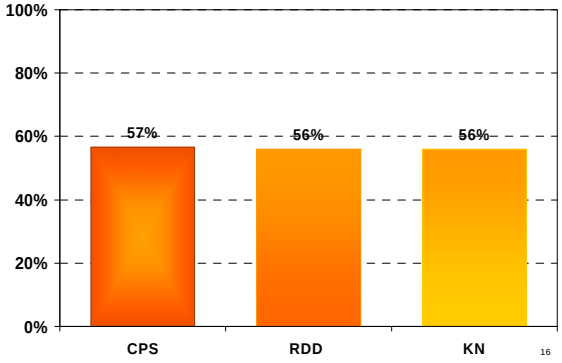
Married



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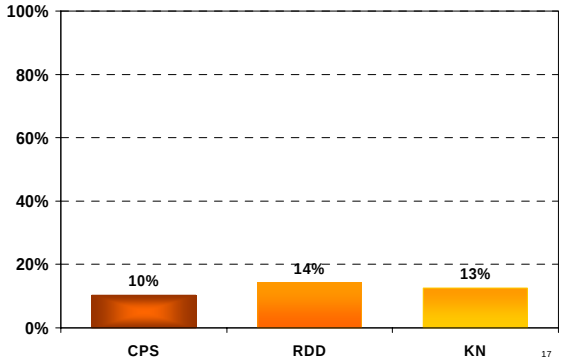
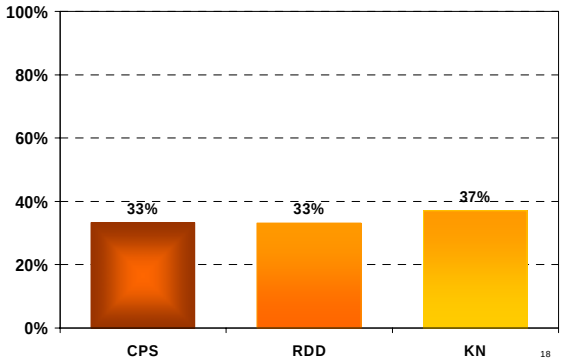
Divorced



17

Two People in Household



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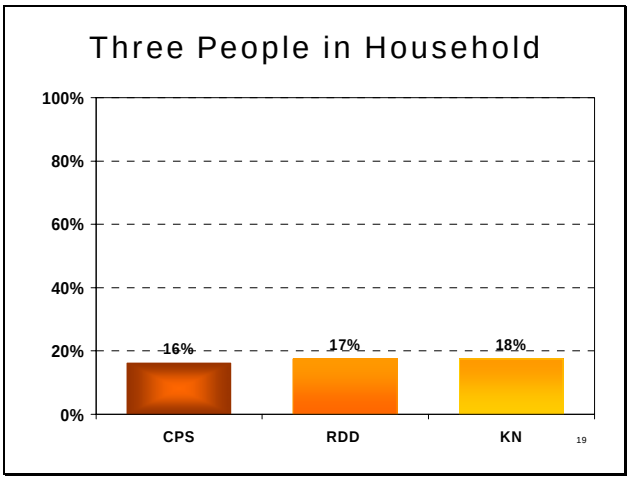
Three People in Household
100%
80%
60%
40%
20%
0%
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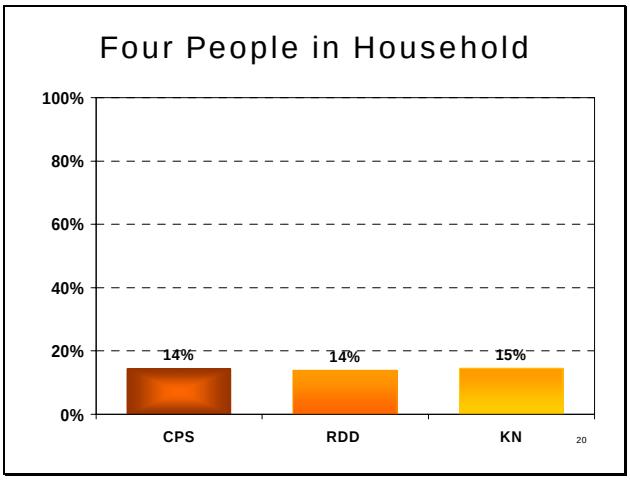
CPS
RDD
KN
19


Four People in Household
100%
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RDD
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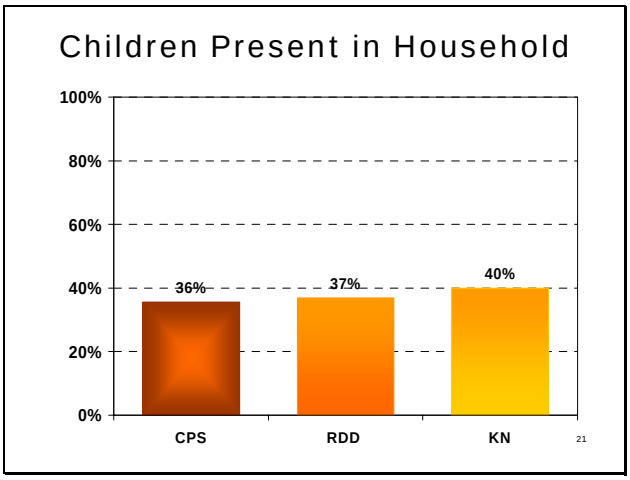
20


Children Present in Household
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40%
CPS
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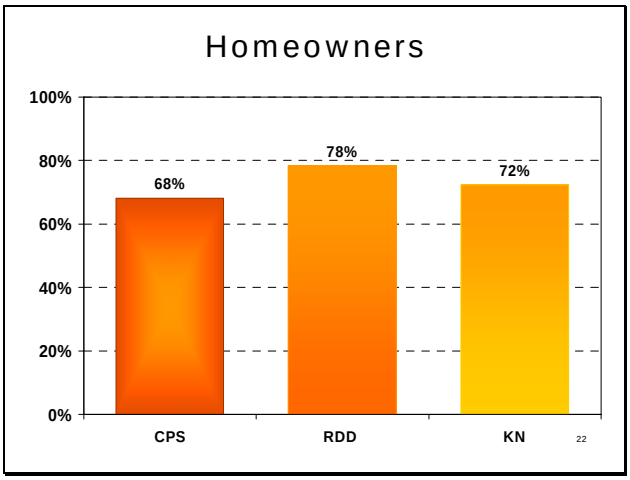
21


Homeowners
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40%
20%
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68%
78%
72%
CPS
RDD
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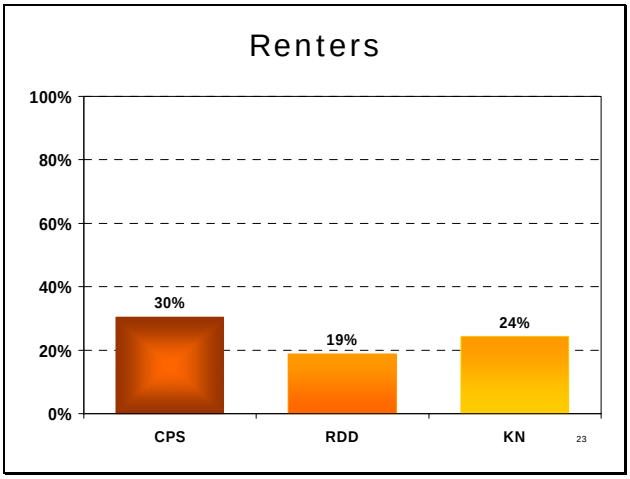
22


Renters
100%
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24%
CPS
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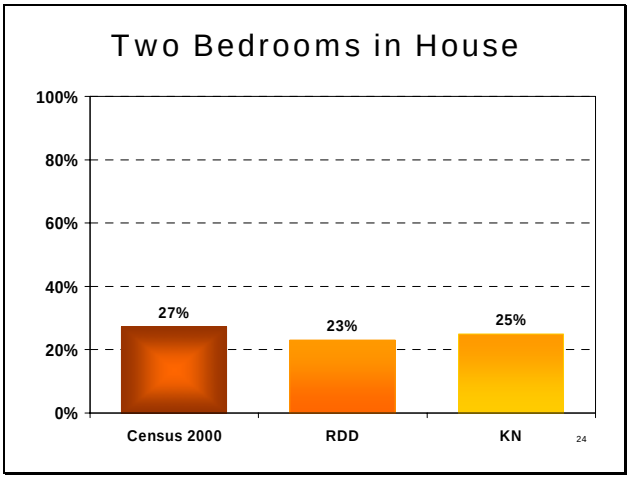
KN
23


Two Bedrooms in House
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80%
60%
40%
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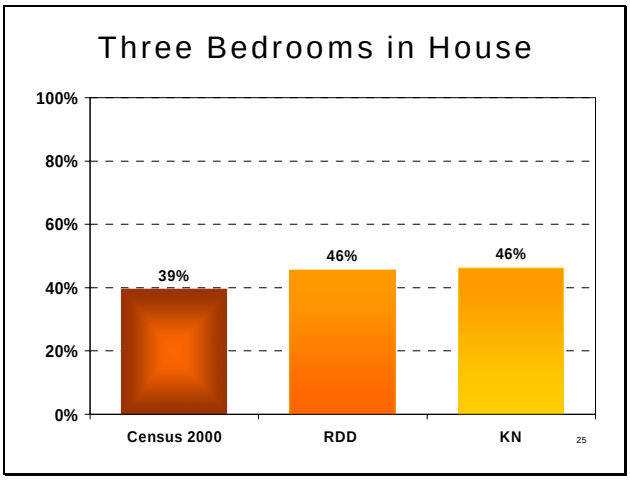
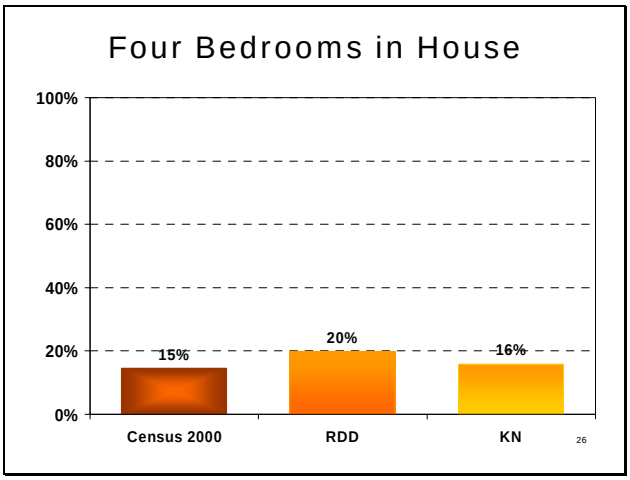
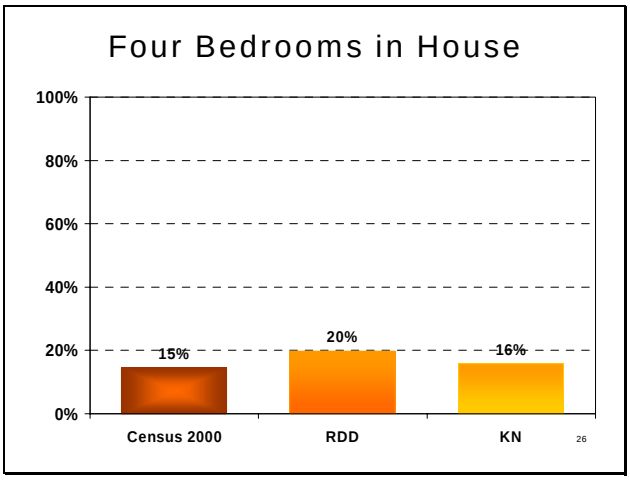
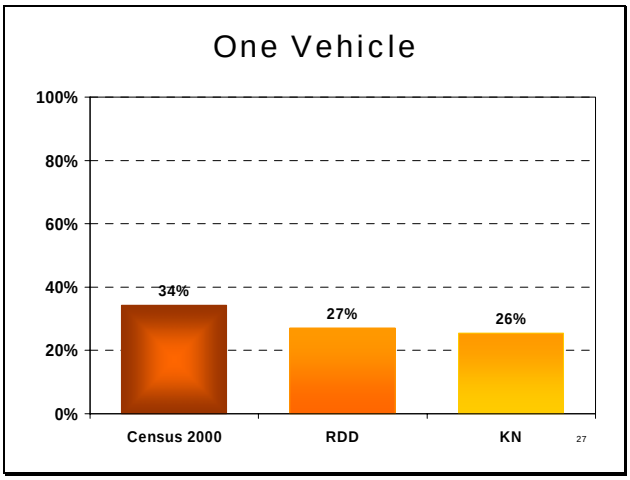
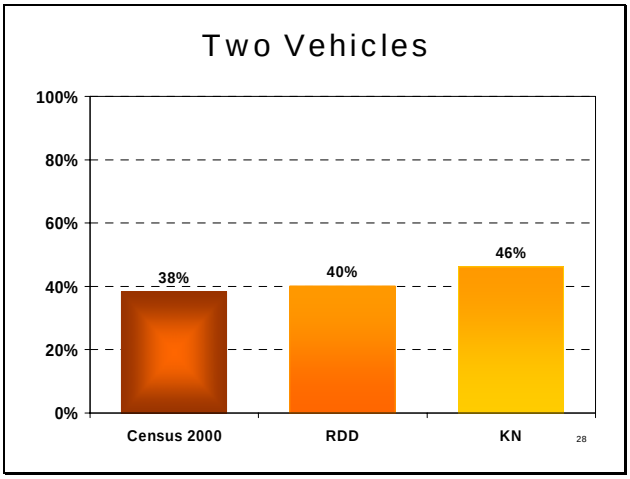
0%
27%
23%
25%
Census 2000
RDD
KN
24







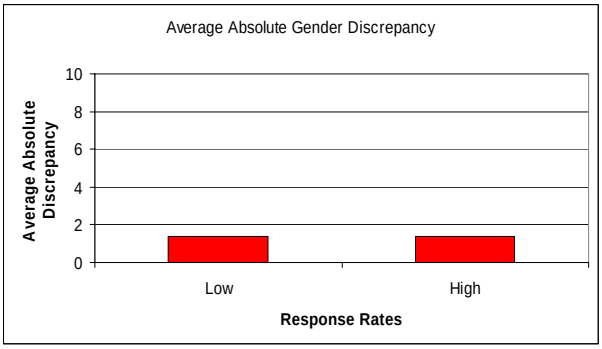




Impact of Response Rates on Accuracy:

7% vs. 70%

29



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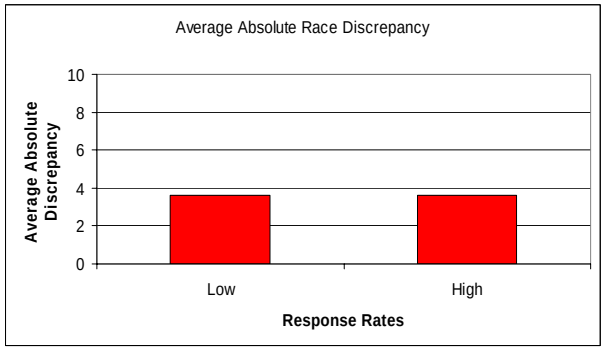

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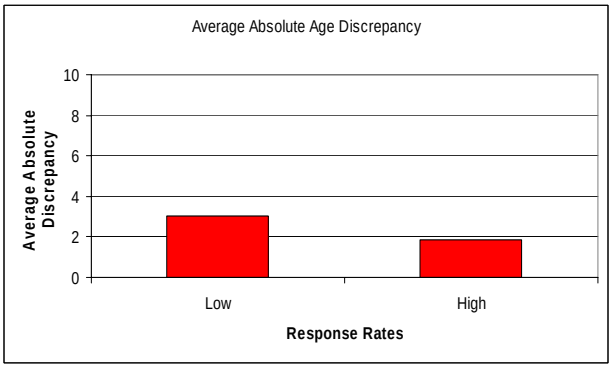

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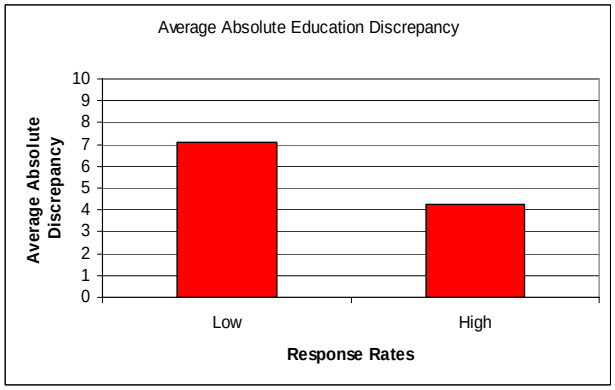

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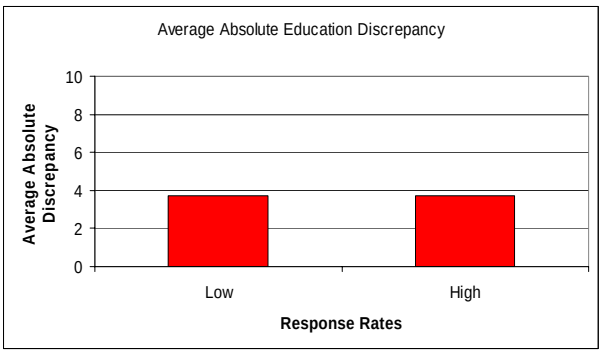

34

Validity of CV Measurements

35

Results: 4 vs. 2 Species

Price	4 Species	2 Species
$10	50.3%	35.6%
$25	39.8%	24.7%
$80	29.9%	17.9%
$140	23.6%	14.9%
$215	18.6%	10.7%
Mean	$63	$34
% Yes	37%	21%

36

Regression Predicting WTP

- Price (log) -.40**
- Income (if <$35,173; log) .17**
- Income (if > $35K, < $150K; log) .15**
- Income (if > $150K; log) .11*

(continued …)

+p<.10 *p<.05 **p<.01

37

Regression Predicting WTP

- Extremely important to protect coastal areas .15*
- Decrease government spending on endangered wildlife -.27*
- Strong environmentalist .24**

(continued …)

38

Regression Predicting WTP

- Natural recovery will take longer .53**
- Natural recovery will be quicker -.29**
- Program will be completely or mostly effective .60**
- Program will not be effective -1.26**

(continued …)

39

Regression Predicting WTP

- Thinks special tax will be for more than one year -.28**
- No confidence in the State of California -.21*
- Opposes increased spending on government programs -.32**

(continued …)

40

Regression Predicting WTP

- Participates in salt water boating or fishing or goes to the beach .22**
- Birdwatcher .18*
- Often watches TV shows about animals .19**
- Household often eats fish .18*
- Lives in Los Angeles or Orange Co. .17*
- Lives North of San Francisco -.25*

41

Reliability of CV Measurement

52% yes in 1991

53% yes in 1993

42

Interim Conclusions

- Social science measurements appear to be reliable.
- Social science measurements appear to be valid.
- Methodological mistakes can easily be made to compromise the reliability and validity.

43

EPA (finally)

44

Organization of Measurement Techniques

- Surveys
- Focus Groups
- Narrative discussions
- Observation of behavior
- Games

45

Distinctions in Data Collection Methods

- Sampling
  - Representative
  - Non-representative
- Measurement vs. Experimentation
  - Experiment within subjects
  - Experiment between subjects
- React to goods vs. Introspection
  - Lots of work cautions about introspection
- Respondents alone vs. in groups

46

Distinctions in Data Collection Methods

- Provide information?
  - Provide information about the good only
  - Provide other background info as well
- Choices between …
  - Problems to solve
  - Solution options for a single problem
- Evaluations of …
  - Problem seriousness
  - Solution options

47

Distinctions in Data Collection Methods

- Measurement metric
  - Money
  - Non-monetary
- Mode of presentation
  - Verbal
  - Visual

48

All methods have value

Choice:

–An empirical issue

–Not intuitive prejudices

49

Be careful when interpreting past work on measurement validity

- Poor design undermines a study's value
- EPA is lucky
  - Can tell respondents it is a federal agency seeking public guidance.
- A half-page questionnaire handed to people walking into a science museum will not elicit the same respondent motivation and decision quality.

50

What should EPA do?

- Be brave!
  - Don't choose among methods now.
  - Commission an ambitious and thorough methodological review.
    - New empirical comparison of methods in EPA contexts.
  - Work with other federal agencies.

51

Dr. Mark Schwartz, Associate Professor in the Department of Civil and Environmental Engineering at the University of California-Berkeley, acknowledged the important charge of understanding more fully the value of protection ecological systems and services. He linked the advisory effort to EPA's interest in broadening its mission to think about ecosystem protection. He noted that the C-VPESS membership contained the appropriate multi-disciplinary mix and range of ecological expertise to address the issue of ecological valuation seriously. He agreed with Dr. Roughgarden on that ecological science can provide meaningful production functions to help the Agency make ecological protection decisions.

He suggested that an important priority would be to explore the potential of the Long-Term Ecological Research Program and National Ecological Observatory Networks (NEON) for predicting ecological outcomes. He also noted that from his perspective the number and range of methods presented is almost "dizzy-ing." The challenge will be to distill methods into a clear, coherent picture that the Agency can understand and use. He suggested that the Sokal and Rohlf publication *Biometry* includes a diagram that provides

one way to represent data or methods for different types of applications that might be a model for the C-VPESS. He also noted that priority attention should be given to linking ecological data and methods appropriate to different levels and types of decisions and to increasing model integration.

Mr. Jim Laity, Policy Analyst, Office of Information and Regulatory Affairs, Office of Management and Budget, was the final speaker on the expert panel. He thanked the SAB and EPA for taking on the issues discussed at the workshop and for bringing them to the attention of the Office of Management and Budget. He noted that he was speaking as an individual and not for the Office of Management and Budget.

The starting point of his remarks was his assumption that the goal of an eco-valuation exercise was to provide useful, objective information for decision-making. Therefore, in his view, valuation should be a descriptive, not normative process. He identified himself as explicitly anthropocentric in orientation and posited that those who advocate a different position were "jockeying for advantage."

In the context of monetized valuation, he personally advocated use of revealed preference approaches, but he noted that OMB officially had endorsed the use of stated preference approaches.

He urged the C-VPESS to look at best practices related to cost-effectiveness metrics that would be useful for eco-valuation. He called for standards for non-monetized metrics that could be used when it is difficult to monetize values. He emphasized the need for standardization in this area that could make bio-physical metrics objective, measurable and verifiable.

Where values can neither be monetized nor quantified, he emphasized that the qualitative information provided be descriptive, not normative, to express society's preferences, so that policy makers can make risk management decisions. He noted that most environmental protection decisions are incremental in nature and do not raise issues of absolute rights.

He noted that such terms as "educating the public, "conservative assessments." (rather than use of central tendencies), and the "precautionary principle" do not have a role in the debate over eco-valuation.

As scientists discuss and clarify the nature of ecological services, he wondered if the benefits associated with some EPA programs may not be as high as some might argue. He suggested that the Office of Water's technology-driven statutes, such as effluent guidelines, might not be associated with significant ecological benefits.

He provided a few comments related to his own critical view of stated preference studies. In his view, the budget constraint intended as part of stated preference surveys is not perceived as real by respondents. In addition, respondents don't have a "mental universe" of the other possible environmental amenities that could be met by the investment of interest in the stated preference surveys. He also expressed a strong view

that efforts to educate people as part of the stated preference survey effort distort the results of such surveys.

At the conclusion of his remarks he addressed the issue of data gaps and uncertainty in eco-valuation. He identified the need for criteria and standards for benefit transfer for eco-valuation as an important priority area for the committee to address. He suggested that approaches minimize expert elicitation and strike a balance between complexity and simplicity to make the results of an eco-valuation comprehensible to decision makers. Standardization is needed. If dollars are not the universal metric, then some other measure is needed that can bridge the gap between increasingly rich data and theory in ecological sciences and the type of monetized information preferred by decision makers. He suggested that some mechanism like the Bureau of Environmental Statistics could provide standardization, strike the balance between complexity and simplicity, be independent of EPA, and provide transparent scientific information could be useful for regulatory support and for program evaluation needs under the Government Performance and Results Act and for the Program Assessment Rating Tool.

In the question and answer period following his remarks a workshop participant noted that the National Academy of Sciences has also called for a separate agency for environmental statistics. Another participant challenged Mr. Laity's conjecture that the value of ecological services might be low; she suggested that "existence values" might be so high that they might be difficult to accommodate within existing regulatory assumptions. Mr. Laity responded that there is a need to look at empirical evidence, not hypotheticals.

Another workshop participant asked about how regulatory decision making can accommodate and adjust to changes in environmental values. He suggested that the C-VPESS should keep in mind that environmental values in American society have changed historically and can change in major ways in the future. The final comment from a workshop participant concerned the proper role of education as linked to eco-valuation and suggested that this topic deserved additional attention.

10. Summary and Next Steps

Dr. Buzz Thompson concluded the workshop with brief remarks thanking workshop participants for the valuable, constructive discussions. He noted that the workshop generally endorsed the integrated, expanded approach proposed by the C-VPESS. He expressed his sense that the plenary and breakout discussions had emphasized that C-VPESS advice be practical and consider the budget and resource limitations of the Agency when making recommendations about valuation methods and processes. He also noted workshop participants' suggestions for the committee to balance complexity and simplicity in its recommendations and to include suggestions for possible institutional reforms in its advice. The next steps for the C-VPESS are to focus on reports focusing on methods and applications. The workshop discussions will provide valuable insights to help guide those efforts.

11. Agenda and List of Invited Participants

U. S. Environmental Protection Agency Science Advisory Board (SAB) Workshop
December 13-14, 2005
Science for Valuation of EPA's Ecological Protection Decisions and Programs
Horizon Ballroom, Ronald Reagan Building, Washington, DC

Purpose: The SAB Committee on Valuing the Protection of Ecological Systems and Services (C-VPESS) was charged to assess Agency needs and the state of the art and science of valuing protection of ecological systems and services and then to identify key areas for improving knowledge, methodologies, practice, and research.

The purpose of the workshop is to discuss the initial work of the C-VPESS; to provide an opportunity for advisors across the SAB, Advisory Council on Clean Air Compliance Analysis (Council) and Clean Air Scientific Advisory Committee (CASAC) to learn from each others' work related to ecological valuation; and to feature feedback from the Agency and outside experts.

December 13, 2005

9:00-9:20	Welcome Purpose of Workshop and Agenda Overview	Dr. M. Granger Morgan, Chair, SAB Dr. Barton H. (Buzz) Thompson, Jr., Chair, SAB C-VPESS
9:20-9:30	Introductory Remarks	Mr. Marcus Peacock, EPA Deputy Administrator
9:30-10:10	Global View from the Perspective of the Millennium Ecosystem Assessment	Dr. Walter V. Reid, Stanford University
10:10-11:00	Introduction to C-VPESS Work on an "Expanded and Integrated Approach" for Valuing Ecological Protection	Dr. Kathleen Segerson, C-VPESS Vice-Chair
11:00-12:00	Panel Discussion with EPA Senior Managers	Dr. James Boyd, Moderator Panelists: Mr. Robert Brenner Office of Air and Radiation Ms. Kathleen Callahan EPA Region 2 Dr. George Gray Office of Research and Development

		Dr. Albert McGartland Office of Policy, Economics and Innovation Dr. Michael Shapiro Office of Water
12:00-1:30	Lunch	
1:30-2:30	Overview of Methods Being Considered by C-VPESS	Dr. Gregory Biddinger, Moderator Dr. Terry Daniel Dr. Stephen Polasky
2:30-3:10	Addressing Uncertainty in Ecological Valuation and Expert Elicitation	Dr. William Ascher Dr. Robert Costanza
3:10-3:15	Charge to Breakout Sessions	Dr. Barton H. (Buzz) Thompson, Jr
3:15-3:30	Break	
3:30-5:30	Break-out Sessions on Specific Methods	Session Leaders
	A. Economic Analysis and Ecological Production Functions (Concourse Level: Hemisphere A)	Dr. Joan Roughgarden Dr. Stephen Polasky
	B. Group Expressions of Value: Referenda; Citizen Juries (Concourse Level: Meridian C)	Dr. William Louis Ascher Dr. Barton H. (Buzz) Thompson, Jr.
	C. Deliberative Approaches for Modeling, Valuation, and Decision Making (Concourse Level: Hemisphere B)	Dr. Robert Costanza Dr. Joseph Arvai
	D. Social/Psychological Methods for Ecosystem Values Assessments (Concourse Level: Meridian E)	Dr. Terry Daniel Dr. Kathleen Segerson
	E. Spatial Representation of Biodiversity and Conservation Values and Ecological Services (Concourse Level: Meridian D)	Dr. Dennis Grossman Dr. James Boyd
5:30	Adjourn	

December 14, 2005

8:30	Opening of Second Day of Workshop	
8:30-10:30	Reports from Break out Sessions	Dr. A. Myrick Freeman, Moderator
10:30-10:45	Break	
10:45-11:45	Panel Discussion: Experts' Feedback on Valuation Methods	Dr. Harold A. Mooney, Moderator
11:45-12:00	Summary of Workshop	Dr. Barton H. (Buzz) Thompson, Jr.
12:00	Adjourn	

U. S. Environmental Protection Agency Science Advisory Board (SAB) Workshop
December 13-14, 2005
Science for Valuation of EPA's Ecological Protection Decisions and Programs
Ronald Reagan Building, Washington, DC
List of Participants

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12. Background Material and Presentations for Breakout Groups

12.1. Economic analysis and ecological production functions

Session Leaders:
Dr. Joan Roughgarden, Professor, Biological Sciences and Evolutionary Biology, Stanford University, Herrin Laboratory, Stanford, CA
Dr. Stephen Polasky, Fesler-Lampert Professor of Ecological Economics, Department of Applied Economics, University of Minnesota

Contents:

- Bibliography in Ecological Economics developed by Joan Roughgarden
- Citations related to breakout topic (copies available at breakout session)
  - 1998, Roughgarden, J., Production functions from ecological populations: a survey with emphasis on spatially explicit models. In: Tilman, D. and P. Kareiva, (Eds.) Spatial Ecology: The Role of Space in Population Dynamics and Interspecific Interactions, Princeton University Press, pp. 296--317.
  - 2003, Armsworth, P. and J. Roughgarden. The economic value of ecological stability. Proc. Nat. Acad. (USA) 100:7147--7151.
  - 2004, Taylor H., Gretchen C. Daily, Paul R. Ehrlich, and Charles D. Michener. 2004. Economic value of tropical forest to coffee production. *PNAS* (34):12579–12582.
  - 2005, Polasky, Stephen, Erik Nelson, Eric Lonsdorf, Paul Fackler, and Anthony Starfield. 2005. Conserving species in a working landscape: land use with biological and economic objectives. Ecological Applications 15:1387–1401.
- Diagram (see diagram below depicting ecological models, outputs, services, valuation tools and decision approaches)

Diagram (see diagram below depicting ecological models, outputs, services,

Bibliography in Ecological Economics developed by Joan Roughgarden

2003, Armsworth, P. and J. Roughgarden. The economic value of ecological stability. Proc. Nat. Acad. (USA) 100:7147--7151.

2001, Roughgarden, J. and P. Armsworth. Managing ecosystem services. In: Press, M., N. Huntly, and S. Levin, eds. Ecology: Achievement and Challenge, Blackwell Science, pp. 337--356.

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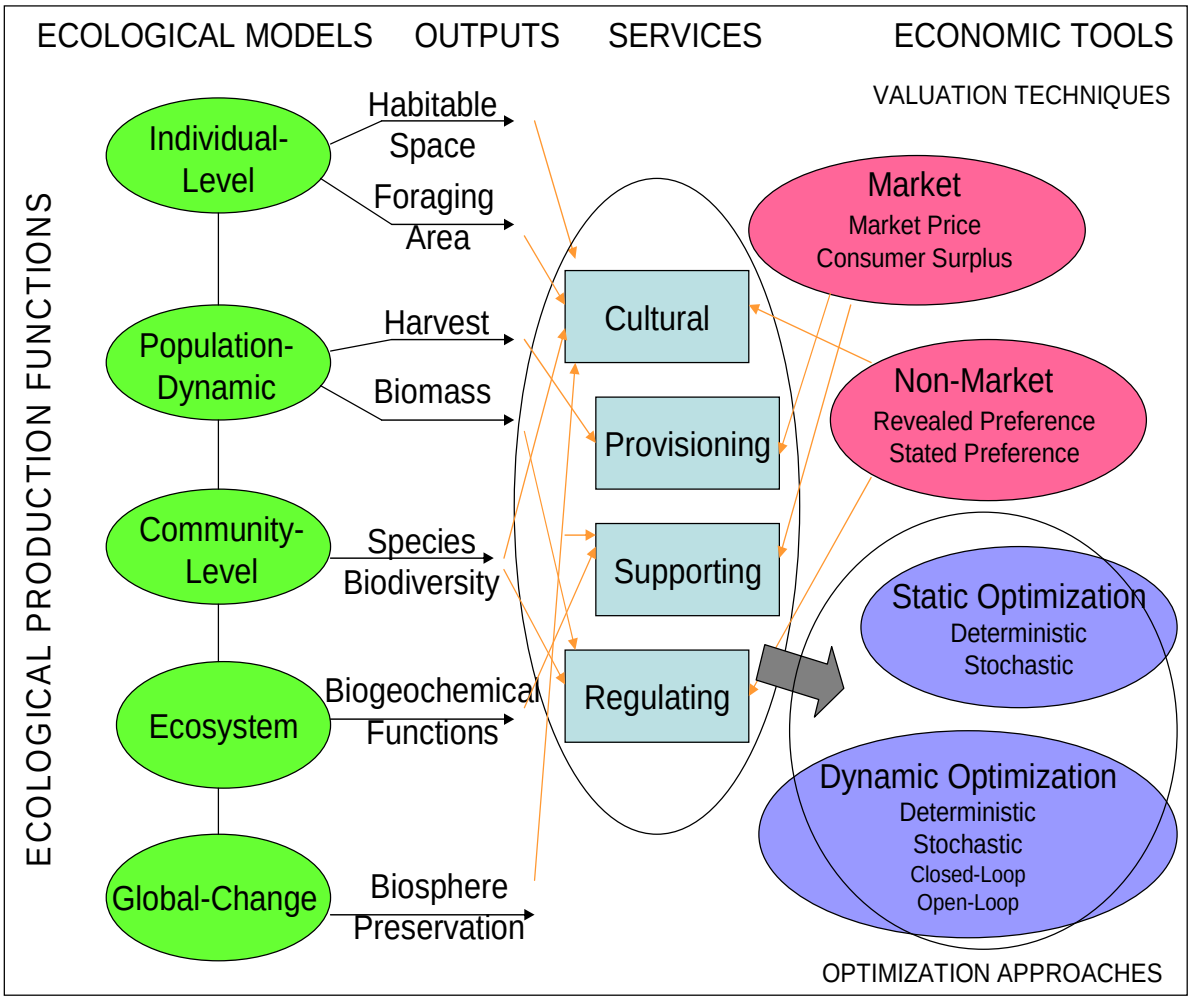
1995, Brown, G. and J. Roughgarden, An ecological economy: notes on harvest and growth. In: Perrings, C., K.G. Maler, C. Folke, C.S. Holling and B.O. Jansson (Eds.), Biodiversity Loss: Ecological and Economic Issues, Cambridge, Cambridge University Press, pp. 150-189.



12.2. Group Expressions of Value: Referenda; Citizen Juries

Session Leaders:
Dr. William Louis Ascher, Donald C. McKenna Professor of Government and Economics, Claremont McKenna College
Dr. Barton H. (Buzz) Thompson, Jr., Robert E. Paradise Professor of Natural Resources Law and Vice Dean , Stanford Law School, Stanford University

Contents:

- Valuation Methods Based on Referenda and Other Public Decisions
- Citations Related to Referenda and Citizen Juries (copies available at breakout session)

Kahn, M.E., and J.G. Matsusaka. 1997. Demand for environmental goods: Evidence from voting patterns on California initiatives. Journal of Law and Economics 40:137-173.

RK Blamey, RF James, R Smith and S Niemeyer. 2000. Citizens' Juries and Environmental Value Assessment. http://cjp.anu.edu.au/docs/CJ1.pdf.: The first in a series of reports to be published containing the results of the research project Citizens' Juries for Environmental Management.

Valuation Methods Based on Referenda and Other Public Decisions

Referendum votes and other formal public decisions provide the basis for a set of valuation approaches that can provide monetized values, but use somewhat different logic than that of the conventional individually based revealed-preference and stated-preference methods. The outcomes of referenda (measures placed on the ballot by a legislative body), initiatives (ballot measures proposed by citizens), or other official public decisions directly express what the body politic as a collectivity values in terms of policy outcomes. These expressions may or may not correspond closely to the aggregated values of the individuals in the community in terms of outcomes. Referenda approaches (not to be confused with the "referendum format" often used for posing questions to solicit contingent valuation responses) provide information about the policy preferences of the median voter; under certain circumstances this information can tell us about the median voter's valuation of specific environmental amenities, and can even provide information, albeit weaker, about mean valuations of those who participate in the voting process.

Referenda and initiatives are formal solicitations to the public to determine the public's *willingness to pay*. In a referendum or initiative, officials or policy activists present voting choices that formally specify environmental *objectives*, such as reducing air pollution, establishing a wildlife preserve, or building a storm run-off system. In some cases, these objectives are clearly specified in quantitative terms: number of tons of sulfur dioxide expected to be removed, number of acres of reserve, or reduction of the area subject to flooding. The *costs* of achieving these objectives are specified in various ways, ranging from the financial costs in taxes or bonds, to the restrictions that would be expected to impose opportunity costs such as reduced employment opportunities or

restricted resource extraction.

The logic of using formal public outcomes to infer how much "society values" particular outcomes has been used primarily in the literature on health and safety. For example, the value of a "statistical life" has been estimated by calculating how much public policies commit to spend in order to reduce mortality rates from health or safety risks, or, conversely, how much economic gain is associated with public decisions that reduce safety (e.g., by examining official decisions of U.S. states to raise or lower speed limits, Ashenfelter & Greenstone [2004] estimated the market value of the time saved by getting to the destination more quickly, and from that estimated the value of the additional expected traffic fatalities). The logic of making valuation inferences from referenda and initiatives has been addressed in a few publications, most directly in Deacon & Shapiro, 1975; and Shabman & Stephenson, 1996.

In addition to taking the valuation derived from the analysis of public decisions as an input in itself, the analysis of public decisions, particularly referenda and initiatives, can be used to validate the results of other valuation methods. Several studies have compiled the results of initiatives and/or referenda in order to try to validate more conventional valuation techniques, especially contingent valuation (Kahn & Matsusaka (1997), List & Shogren (2001; 2002), Murphy et al. (2003), Polasky, Gainutdinova & Kerkvliet. (1996), Schläpfer, Roschewitz, & Hanley (2004). Vossler & Kerkvliet (2003)). As Arrow et al. (1993) recommend:

The referendum format offers one further advantage for CV. As we have argued, external validation of elicited lost passive use values is usually impossible. There are however real-life referenda. Some of them, at least, are decisions to purchase specific public goods with defined payment mechanisms, e.g., an increase in property taxes. *The analogy with willingness to pay for avoidance or repair of environmental damage is far from perfect but close enough that the ability of CV-like studies to predict the outcomes of real-world referenda would be useful evidence on the validity of the CV method in general. The test we envision is not an election poll of the usual type. Instead, using the referendum format and providing the usual information to the respondents, a study should ask whether they are willing to pay the average amount implied by the actual referendum. The outcome of the CV-like study should be compared with that of the actual referendum. The Panel thinks that studies of this kind should be pursued as a method of validating and perhaps even calibrating applications of the CV method…*(emphasis added)

In comparing the valuations yielded by stated-preference approaches with those derived from public decisions, the studies typically show the inferences from public decisions to yield lower values—not surprising in light of the absence of the hypothetical element in the public-decision results. Although systematic comparisons with conventional revealed preference approaches are lacking, it is likely that the valuations of eco-system components calculated from public decisions would be higher, because public decisions do capture whatever elements of public-regardedness are present among the voters. The valuations based on public decisions have intrinsic validity within the paradigm that gives standing to the community votes as reflecting the policies that the public prefers.

Direct Referendum/Initiative Analysis

The valuation analyst can chose to take the referendum choices as they are formally specified, in which case a winning proposal can be interpreted as having standing as the electorate's choice. For example, a municipal government may propose a referendum measure to purchase and maintain 500 acres of currently unused land as a forest reserve costing $1,000,000 annually for a community of 10,000 households. Assume that the measure is not significantly entangled in controversies over how it will be financed (e.g., there is no opposition that a bond measure would simply saddle future generations). The measure passes by 51%. The value can be metricized in various ways; e.g., as

- $1,000,000 per annum for the 500 acres for the community
- $2,000 per annum per acre for the community
- $100 per annum for the 500 acres per household
- $.20 per annum per acre per household.

If the initiative or referendum passes by a slim majority, this valuation can be considered to be quite close to the "community's" valuation. If the vote is more strongly in favor, then the valuation represents a floor on the community's value of the eco-system benefits. If the initiative or referendum loses by a slim majority, then (more arguably) one could assert that the community's valuation is also close to the value implied by the proposed measure.

If the outcome is not close (e.g., the initiative or referendum passes by 70%), the inferred value is a floor on the community's value. This is because a higher cost may have still gained a majority, albeit probably a narrower one.

However, the fact that a referendum or initiative fails to pass does not necessarily mean that the inferred value is a ceiling on the community's value, because other issues, such as how the measure is to be financed, may lead to the rejection of a measure that otherwise would have been accepted. The results will be most easily interpreted if the initiatives or referenda are: a) as focused as possible on a single dimension of environmental protection or amenity; b) free of ideological debate; c) confined to easily identifiable government costs rather than diffused and uncertain costs such as job losses.

Note that the approach does not primarily address the *mean* value of the ecosystem improvement or protection. This is because the electorate's choice is not the conventional utilitarian notion of the total value summed across all individuals who vote. It is possible to determine a very modest floor on this aggregate value (and therefore on the mean value) by attributing to the "yes" voters the value of the benefit-cost ratio specified by the proposal, and a value of zero to all voters who opposed the proposal. For example, in the case of the forest reserve proposal described above, if the proposal had received a 70% "yes" vote, the minimum mean value would be $1,400 per annum per acre for the community (i.e., .7 x $2,000 + .3 x 0).

Making valuation estimates directly from referendum or initiative outcomes has two advantages over conventional valuation methods. Unlike the standard revealed-

preference approaches, such as hedonic pricing or the travel-cost method, voting on referenda or initiatives will reflect as much (or as little) public-regardedness as the voters actually hold toward the objectives involved. Standard revealed-preference approaches reflect the private-utility-maximizing decisions of individuals who purchase homes, spend money to visit parks, etc.; these decisions do not reflect what individuals want for their communities. Voting affirmatively for referendum- or initiative-proposed public expenditures do elicit valuing on behalf of the community, insofar as the voters are so disposed. Of course, a voter may vote for or against a referendum or initiative proposal strictly out of concerns for herself and/or her family, but the outcome does not exclude the existence value component if it exists.

Unlike the conventional stated preference approaches such as contingent valuation, the analysis based on referendum or initiative outcomes is not subject to the possible distortions of hypothetically-posed choices. If a voter supports the referendum or initiative proposal, the vote contributes to the likelihood that the expenditures will actually occur and the costs will actually be borne. Some might argue that the chance that any one vote will decide the outcome of the referendum or initiative is remote, and therefore the vote is more of a symbolic act than a tradeoff choice. However, there are two important responses to this point. First, whatever the mix of motives of the voters, the outcome *is* the community's decision, and therefore has standing in and of itself. This is the same logic by which we accept elected officials as legitimate even if we are dubious about the motives or rationality of the voters. Second, even if a voter believes that the chances that his or her vote will make the difference are negligible, the vote is still an expression of support or opposition to the proposal. There is little reason to believe that a "yes" vote would reflect just the gratification of voting "yes" (especially in secret balloting) rather than a belief that the proposal merits support.

The most useful referenda or initiatives would propose direct costs to the voters, typically in the form of taxes, fees, or bonds to finance actions designed to improve or protect eco-systems. Referenda or initiatives that entail restrictions on development (such as more stringent emissions or effluent standards) are less useful, because of the uncertainty of the level and incidence of the economic impacts. Similarly, in order to isolate the values attributed to particular ecosystem benefits, referenda and initiatives that address only one objective, such as preserving habitats or reducing air pollution. With multiple objectives, the analysis cannot assign the willingness to pay to each component. Similarly, if it is clear that a referendum or initiative entails additional partisan political stakes (e.g., if it is widely viewed as a political test of a government official), the results are less illuminating in terms of the ecosystem values that the voters hold.

Another concern that some would level against inferences based on referenda or initiatives is that these votes are often subject to intense efforts by interest groups, advocacy groups, and even governments to manipulate public perceptions. This concern has two aspects: whether the information on which voters base their decisions has been distorted, and whether the votes are swayed by appeals on one side or the other. The first aspect is more compelling: we certainly would be less willing to accept the validity of an estimate derived from voting decisions driven by serious misconceptions of the proposed benefits and/or costs. The outcome is still the official decision of that community, but the justification for using the result as the basis of benefits transfer to other communities

would be very weak. On the other hand, the fact that referenda and initiatives are often subject to intensive campaigns of persuasion may be considered a virtue rather than a drawback, insofar as it would provide more information on both sides. In addition, the fact that individuals are exposed to efforts at persuasion is by no means confined to referenda and initiative contests: respondents to contingent valuation surveys have of course been subjected to many years of promotional activities by environmental groups; people who travel farther to a particularly popular national park such as Yosemite have been influenced by all sorts of communications extolling its virtues. In short, efforts at value persuasion are pervasive, and in any event should not be a basis for rejecting the significance of decisions of individuals exposed to those efforts. The philosophical basis underlying the use of referenda or initiatives, namely that the public's preferences are legitimately shaped by the political process, and that the public's policy preferences are important beyond how the public values the outcomes that these policies may produce, is quite different from the so-called "progressivist" position that individuals' values should be determined in isolation of "politics" (Sagoff 2004: 177-178).

Another difference in philosophical basis is that the referendum and initiative results reflect intensity of attention to the issue, at least insofar as those who do not care enough to vote are excluded from the analysis. From the progressivist, technocratic perspective, everyone's values ought to be incorporated, because the policies ought to maximize utility (i.e., the consequences of public decisions) regardless of whether specific individuals are mobilized to take action. On the other hand, prominent strains of pluralist democratic theory regard intensity as a fully legitimate factor in determining policy outcomes (Lowi 1964).

One limitation of estimating values from referendum or initiative outcomes is that it is sometimes difficult for voters to assess the actual stakes involved. The benefits will often have to be predicted (e.g., how much biodiversity will be reserve really safeguard; how much less flooding will the flood-control system actually prevent?), entailing a certain amount of uncertainty. The benefits that do occur will often be community-wide, with some uncertainty as to how much an individual or particular household can take advantage of the benefits. On the cost side, the burden of a tax increase or bond measure on household expenditures may be very difficult for the typical voter to estimate, and the impacts of development restrictions may be even more difficult in light of the uncertainty as to which families would ultimately be affected. Insofar as the costs specified by the referendum or initiative are not easily translatable into household budget terms, the outcome, though it is still "the community's decision," is less revealing about the values held by the voters.

Referendum/Initiative Analysis Followed by a Survey

Therefore another variant that relies on referendum and initiative outcomes to make willingness-to-pay estimates consists of combining the voting outcome with a follow-up survey to determine the perceptions of the stakes. This variant amounts to a hybrid of the first variant and the "referendum format" contingent valuation approach. The floor of the willingness-to-pay value of the proposed eco-system improvements is estimated by determining the voters' *perceptions* of the eco-system improvements and costs proposed by a recent referendum or initiative. The respondents are asked whether

they voted, how they voted, and what they believed the benefits and costs of the proposal were. As with Variant 1, if the initiative or referendum passes by a slim majority, this valuation can be considered to be quite close to the median voter's valuation. If the initiative or referendum loses by a slim majority, then (more arguably) one could assert that the median voter's valuation is also close to the value implied by the proposed measure. (Note: again, a losing initiative or referendum does not necessarily mean that the inferred value is a ceiling on the median voter's value, because other issues may lead to the rejection of a measure that otherwise would have been accepted.) As with Variant 1, the results will be most easily interpreted if the initiatives or referenda are: a) as focused as possible on a single dimension of environmental protection or amenity; b) free of ideological debate; c) confined to easily identifiable government costs rather than diffused and uncertain costs such as job losses.

If, in addition to asking how respondents voted and their perceptions of the benefits and costs of the proposal, the randomly-sampled respondents who opposed the proposal are asked what (lower) cost would have induced them to vote for the proposal, and those who supported the proposal are asked how much more they would have been willing to pay, this approach also permits an estimate of aggregate and mean values, just as a standard contingent valuation study would, with less potential distortion arising from respondents' desire to be regarded in a favorable light. Thus the survey following a referendum or initiative can provide an internal cross-check of how much correspondence there is between the stated-preference approaches and the referendum or initiative findings.

It should be noted that in focusing on the benefits and costs that respondents report, rather than the actual benefits and costs that the referendum or initiative proposal specifies, the results do not reflect the community's formal decision. This is a significant difference in the philosophy underlying the standing of the results. That is, the first variant, even if it does not necessarily reflect the values that voters perceive, it does represent what the voters have chosen. Different logics underlie their standing.

Direct Analysis of Public Decisions to Accept Pollution or Resource Depletion

While the approaches outlined above provide information about willingness to pay, there are some public decisions that can provide inferences for willingness-to-accept decisions. These decisions involve a community's vote as to whether to permit the entry of a new firm or a new (or increased) economic activity despite the expectation that such permission will degrade the eco-system. Assuming that a) the vote is explicit; b) the expected damage is well specified, c) property rights are clearly held by the community (i.e., the community has the right to refuse entry), d) the community's gains can be easily estimated, and e) the transactions costs are low, the payment represents the ceiling on the community's valuation of the environmental amenities that are being relinquished. It is a ceiling because of the possibility that the community would have accepted a lower level of compensation, and if the community valued the forgone eco-system services more than the compensation, then presumably it would not have accepted the compensation. However, if there is a vote and the outcome is close, the calculated valuation can be considered to be close to the community's valuation.

The estimation task involves assessing the amount of environmental damage in physical terms and the amount of compensation in monetary terms. Typically this compensation will come in the form of additional sources of taxes, the value of infrastructure that the new entrants provide for the community, additional income earned by community members, etc. The per-household as well as per-community compensation would be relevant. For example, the entry of an air-polluting factory may be accepted only after the factory's owner commits to a certain number of jobs for the community, building a park, upgrading roads, contributing to the community's vocational program.

Obviously many "community decisions" to permit the entry of polluters or other activities that degrade the ecosystem are not amenable to this approach, because community leaders negotiate the level of benefits that the community will receive without a vote being taken, or the benefits or costs are difficult to estimate.

Public Decisions to Accept Pollution or Resource Depletion Followed by a Survey

Just as the analysis of referendum and initiative outcomes can be augmented by determining voters' perceptions of the stakes, the ceiling of the willingness-to-accept value of eco-system deterioration can be estimated by determining the benefits perceived by voters who supported the arrangement accepting the entry of a polluting or depleting operation into the community, and their perceptions of the damage that would be done. Like the direct analysis of willingness-to-accept votes, if the arrangement was approved by the electorate, and the property rights clear and transactions are low, the ratio of the perceived benefits and costs represents the ceiling of the median voter's valuation. The survey, best administered as soon as possible after the actual vote, would reveal what the community members interpreted the benefits and costs to be, thus bringing the valuation closer to individual values; but again with the tradeoff that the results would not have standing as the "community's choice." If the survey includes the questions of the conventional contingent valuation survey questions regarding how much each respondent would have been willing to accept, then the results would be even more robust in finding mean and aggregate valuations as well as median valuations.

Uses and Limitations of All Four Variants

All of these approaches attempt to measure the sum total of values of improving or protecting eco-systems and eco-system services; therefore both means and ends (instrumental and intrinsic) values can be involved. All variants in principle could measure the values attributed to all types of services, expressed in terms of monetary values per unit of eco-system improvement or protection. The variants are flexible in terms of levels of data, detail and scope, inasmuch as initiatives, referenda and other public decisions have been made at all sub-national levels. The valuations can be aggregated across benefits and with other methods, as long as the scale and magnitude of benefits are roughly the same. While highly complex initiatives, referenda, and other public decisions are not good candidates for estimating value, the valuations generated from simpler cases can be used as inputs for complex applications.

Any EPA decision context calling for monetized valuation could employ any of

these variants, either singly or as cross-checks with conventional revealed preference or sated preference approaches. Benefit transfer applications will be limited to cases of similar magnitudes of benefits, because of the likelihood that community decisions are highly sensitive to such magnitudes.

The first two variants, in analyzing referenda and initiatives, can evaluate tradeoffs between community and/or household costs (higher taxes, possibly job losses) and eco-system improvements (establishment or improvement of air, water, biodiversity protection, etc.). The third and fourth variants can evaluate tradeoffs between community and/or household benefits (increase in tax base, job creation, infrastructure improvements, etc.) and eco-system deterioration (greater pollution, amenity reductions).

In uses that apply valuations directly to the jurisdiction previously experiencing the initiative, referendum or negotiation, the scale would be the same municipality, country or state. For benefits transfer, the scale should also be the same, given the need for similar magnitude of benefits and costs mentioned above.

The outputs of these approaches should be easy to understand and to communicate to the public. It is a significant advantage to be able to say that the valuation of an eco-system component has been estimated on the basis of how community's have decided what these components are worth.

These approaches would work best when:

- applied to the same jurisdiction (e.g., if Portland is considering another storm control issue, the analysis of the Portland referendum would be most appropriate), but can still be used via benefits transfer;
- a unitary conservation or environmental benefit is involved;
- the initiative or referendum outcome was a close vote (this yields stronger inferences about the actual valuation, rather than floors or ceilings);
- extraneous issues (such as whether the vote is a "political test" on particular politicians, or the mode of financing is controversial) are unimportant;
- surveys can be accomplished soon after the actual vote.

The resources needed to implement the variants would depend on the applications. If the purpose is to compile a set of initiative and referendum results, this could be done for the first approach by a) assigning an EPA economist to oversee the effort (perhaps 10% effort over a year); b) assigning an intern to compile as many U.S. municipal, county and state initiatives and referenda related to environmental and conservation held over the past half-decade. (perhaps 50% effort over a year). The analysis to generate valuations would require 10% of the time of a two-person team of EPA economists, perhaps one being a consultant. For the second variant, more effort is required for each survey: two EPA analysts (or consultants) each devoting one month to develop, administer, and analyze the survey results.

The major obstacle to the effective use of these approaches may be the lack of familiarity within government of the approach of drawing inferences from public decisions, although the method has had a respectable history of use in estimating the value of a "statistical life." It is striking that despite the multiple studies of how

conventional valuation methods such as contingent valuation compare to initiatives or referenda outcomes, there is apparently no literature that takes the outcomes of the initiatives or referenda *per se* as valuations, except to study why different subunits (e.g., counties within California [Kahn & Matsusaka, 1997]) yield different outcomes. Perhaps it is just too simple a finding—that a particular initiative or referendum that devotes X dollars to gain Y enhancement or protection of the eco-system—to warrant publication. Nevertheless, the paucity of literature may be an obstacle to adopting this approach.

Addressing the Uncertainty Entailed in these Approaches

The uncertainties involved in the variants (first and third) that focus on benefits and costs specified in the proposals lie in the estimates of actual benefits and costs entailed in the proposals. They should be analyzed with the standard methods of projecting consequences, and conveyed through probability distributions and confidence intervals. The uncertainties involved in the approaches that rely on surveys lie in the potential for biased sampling in the selection of survey respondents, as well as poor memory and response set (e.g., respondents may report that they voted). These can be reduced through careful random sampling and cross-checks within the questionnaires.

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Inferring Values from Public Choices

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December 2005

Vehicles of Public Input Reflecting Values

- Individual-response valuation
- public opinion polls
- non-governmental fora
- public hearings
- public notice and comment
- concertation
- quasi-governmental commissions
- direct community decision-making through town halls, etc
- elected representation
- public opinion polls
- letter writing, emailing or calling an elected representative
- taking existing public policies as the revealed preferences of society
- contributions to non-governmental efforts
- **willingness to accept negotiations**
- **referenda/initiatives**

Revealed Preferences from "Public Choices"

1. Referenda/initiatives
   - Referendum: legislature calls for a public vote
   - Initiative: citizen petition
   - Usually for eco-system improvements
2. Willingness-to-accept negotiation outcomes
   - Best if voted; but could have other indications of "close call"

Different conception of what value is:

- Intensity
- Median: the majority (or close to majority) of sufficiently engaged people believe that the expense is worth it
  - Closer to 50-50, the better, though floors or ceilings can be estimated regardless

Different conceptions:

- Intrinsic validity
  - IF one accepts that society's decisions have standing as expressions of value
  - Whether private utility or public regardedness

Different conceptions:

- Conception of democracy & representation
  - Anti-Burkean, non-Benthamite
    - Burke: representatives, not citizens, choose what is good for the people
    - Bentham: greatest [private] good for the greatest number
  - Government should do what the public wish government to do

Criticisms

1. Referenda & initiatives are subject to intense politicking
   - But politicking is pervasive & democratic
2. Perceptions of benefits & costs may diverge from actual stakes
   - But it is possible to follow up with surveys to determine how the stakes are perceived

Criticisms

3. Other issues determine the vote
   - Popularity of backers; partisan maneuvering
   - For willingness-to-pay: restrict to simple-issue referenda or initiatives
   - For willingness-to-accept: simple-issue Coasean negotiations

Criticisms

- Not capable of determining the option of greatest aggregate utility
  - 60% favor because their net gain is +$100
  - 40% against because their net gain is -$200
  - Usually true, but logic is simply different
  - Assuming 0 value for opponents, a floor on mean value is possible

Complications:

- Different benefits transfer complications
  - Disentangling objectives if multiple issues
    - Or, contingent valuation keyed to actual cases of pending decisions

Complications:

- More than 50% vote margin will underestimate the community's collective valuation
  - Result is therefore a floor
- Multiple issues obscure the willingness to pay for any single benefit
  - Go for simple-issue referenda or initiatives
- Different benefits transfer complications

Validation of More Conventional Valuation Methods

- Several studies predict referendum votes from contingent valuation estimates; check whether the predictions are borne out

Validation of More Conventional Valuation Methods

NOAA Panel:

[E]xternal validation of elicited lost passive use values is usually impossible. There are however real-life referenda. Some of them, at least, are decisions to purchase specific public goods with defined payment mechanisms, e.g., an increase in property taxes. The analogy with willingness to pay for avoidance or repair of environmental damage is far from perfect but close enough that the ability of CV-like studies to predict the outcomes of real-world referenda would be useful evidence on the validity of the CV method in general.

Validation of More Conventional Valuation Methods

The test we envision is not an election poll of the usual type. Instead, using the referendum format and providing the usual information to the respondents, a study should ask whether they are willing to pay the average amount implied by the actual referendum. The outcome of the CV-like study should be compared with that of the actual referendum. The Panel thinks that studies of this kind should be pursued as a method of validating and perhaps even calibrating applications of the CV method

Juries

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Relevance of Initiatives/Public Negotiations

- Sources of Revealed Preferences
  - Legislative decisions
    - Conservation investments
  - NGO acquisitions & investments
    - E.g., conservation easements
  - Jury awards
    - E.g., NRD actions
  - Judge-ordered awards
- Public Valuations
  - Citizen valuation juries
  - Consensus conferences
  - Public-regarded surveys

Potential Advantages of Jury Awards over Referenda/Initiatives

- More complete information
- More deliberative
  - Also reflective & evolutionary
- Often more focused issue
- Continuum of choices
- "Due process" protections
  - Politicking expressly excluded
- More likely to generate "public valuation"??
  - Implicit role
  - Judicial instructions
  - Responsibility and impact

Potential Problems with Jury Awards (shared with referenda/initiatives)

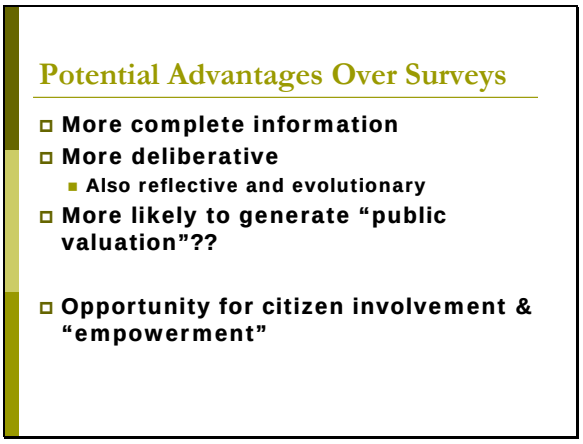
- Limited availability
- Legitimacy of valuation transfer
  - Public benefits ←→ private costs
  - Context: legal violation
- Voting rule
  - Majority voting
  - Super-majority voting
  - Consensus

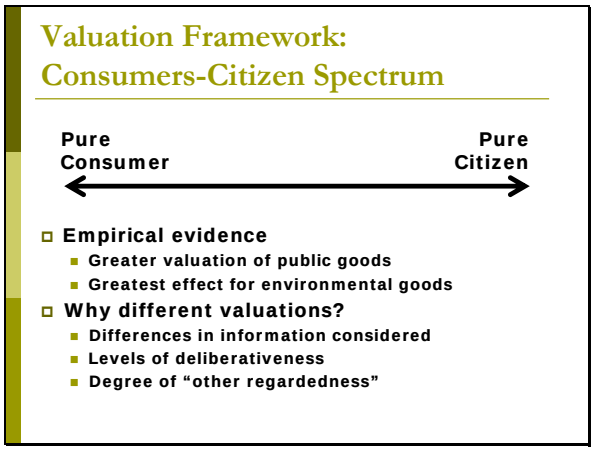
Potential Problems with Jury Awards (unique)

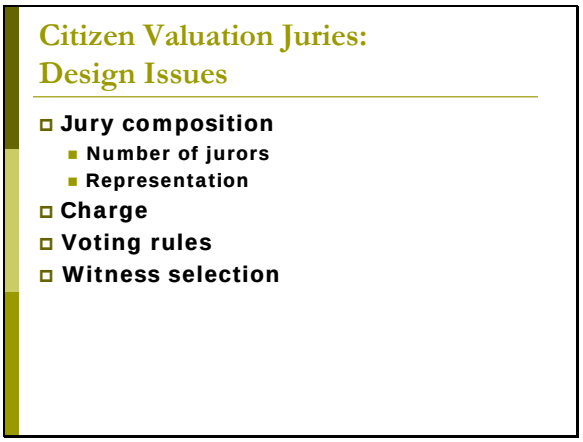
- High variance
  - Small number of jurors
- Jury representativeness
  - Bias toward old and poor
  - Do instructions help overcome?
- Potential circularity
  - Two models of jury process:
    - Informed jury valuation
    - Judging expert credibility

Citizen Valuation Juries

- Can organize around any valuation question
- Can specify decision-making rule & model
- Better control over representation
- Valuation transfer less problematic
- But still issues re:
  - Small size
  - Variance in results







12.3. Deliberative Approaches for Modeling, Valuation, and Decision Making

Session Leaders:
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Contents:

- Conceptual Framework for the Decision Science Approach to Values
- Deliberative Approaches
- Mediated Modeling

Conceptual Framework for the Decision Science Approach to Values

The decision science perspective on valuing the protection of ecological systems and services is, at its core, relativist. Form this perspective, the "value" surrounding ecological systems and services is not an absolute concept, despite the fact that numerical and narrative descriptions of individual components of it (absent a comparison) may be obtained using a variety of economic and non-economic (e.g., psychological, biophysical, etc.) methods. Instead, the decision sciences take the view that that the overall value that is ascribed to the environment and its services can only be fully understood in a comparative context; in other words, we can only say that a system—or indeed the suite of services provided by that system—has a high or low value in the context of:

(a) retrospective evaluations undertaken by analyzing the degree of change experienced by the system relative to some previous or unaltered state (i.e., a system is either more or less valuable because it performs either better or worse than it did before), or
(b) decision making for management undertaken by comparing predictions about how a system or its suite of services might behave—again better or worse relative to its current condition—after it has been subjected to one or more possible management or regulatory options.

The attributes across which these changes—and hence, values—are accounted for are defined by the objectives of a given decision context. These objectives tend to be diverse and simultaneously incorporate inputs from a wide variety of disciplines. It is not atypical, for example, to ascribe an overall relative value to an ecological system or service based on the extent to which it maintains some requisite level of ecological function and productivity, provides security for endangered or threatened species, facilitates the maintenance of key services such as nutrient cycling or decomposition, yields economic outputs in the form of resource extraction and tourism, lends itself to desired recreation opportunities, and supplies a sense of pride or awe (Gregory et al. 2001). In this sense, the decision sciences straddle the line between economic and non-economic approaches to valuation in that inputs for a formal comparison of options in the case of management decisions, and current and previous conditions in the case of evaluation, are required from fields such as economics, ecology, psychology, and sociology. However, absent an explicit framework for comparison across attributes, and options or alternative states, individual inputs from these sources have very little meaning—from an overall "value" standpoint—in their own right.

Thus, a decision science approach to valuing the protection of ecological systems and services is explicitly multiattribute in nature. Absent this multiattribute view of value—with the various attributes of value tied to the concerns stated by stated by technical experts and other key stakeholders—the relative values obtained often fall short of providing the requisite guidance for decision making and evaluation, and run the risk of not meeting or surpassing the threshold of relevancy (Keeney & Raiffa 1993)—defined chiefly by those who will hold decision makers and agencies accountable. Of

course, a multiattribute and comparative view of value presents challenges to decision makers and evaluators. For example, those who undertake valuations geared toward the decision sciences must be prepared to work with multiple and diverse stakeholders sometimes over extended temporal periods, conduct additional decision-specific technical analyses that are linked to stated objectives, and address complex and often contentious tradeoffs (Arvai et al. 2001; Gregory et al. 2001; Hammond et al. 1999; Keeney & Gregory 2005).

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Deliberative Approaches

Significant interest has been devoted to multi-stakeholder, deliberative processes for environmental decision making both at EPA (e.g., EPA 2000) and elsewhere (e.g., Beierle and Cayford 2002; Beierle 2002). Much of this interest has focused on deliberative processes as a means of legitimizing resulting policy decisions. To this end, there have been several examples of both research and practice where deliberative approaches to decision making have resulted in a high degree of participant satisfaction in a variety of different management contexts (McDaniels, Gregory, and Fields 1999; Arvai 2003). Results from these studies, and others (e.g., Heiman 1990; Kraft 1988; Vari, Mumpower, and Reagan-Ciricione 1993; National Research Council 1989), argue that people are more likely to accept outcomes that result from decision making processes that seem fair, reasonable, and amenable to allowing the public and other stakeholders an opportunity to voice their feelings and concerns.

This argument is also in line with writing on “procedural justice”, which suggests that a higher degree of acceptance is be expected for decisions that seem fair to the affected parties from the point of view of both the decision outcome and the process that resulted in it (Kraft and Scheberle 1995; Lind and Tyler 1988). In other words, people whose individual interests are adversely affected by an outcome may be more willing to accept decisions because they perceive that they have been dealt with fairly, they

understand the other participants' positions, and they have had the opportunity—even if comes indirectly—to contribute to the debate (Hillier 1998; Syme, Macpherson, and Seligman 1991).

Why does this positive relationship between deliberative processes and support for resulting decisions exist? Some have suggested greater stakeholder satisfaction results from a frame shift during decision making from one that is imposed to one that is voluntary (Slovic 1987). Others have suggested that greater stakeholder satisfaction with decisions that are the product of deliberative approaches is simply the manifestation of a halo effect (Thorndike 1920). In this latter case, people tend to judge multiple dimensions of a stimulus in much the same was as they judge the most salient dimension. In other words, when one judges a decision to be "good" in one dimension (i.e., because it was made in a deliberative fashion), they are also likely to judge the same decision to be good in other dimensions (i.e., the outcomes of that decision).

Beyond these "stakeholder relations" benefits, there are other reasons—reasons that are of greater interest to this committee—for advocating the use of deliberative approaches for valuation and decision making. Foremost among these is the fact that these approaches work to foster the inclusion of differently formulated objectives, concerns, and arguments in the valuation and decision making process (Renn 1999; NRC 1996; Gregory 2000; Chess and Purcell 1999).

Indeed, EPA itself has acknowledged this point, stating in the past that the American people are the agency's primary "customer" and to this end issued the following policy statement (EPA 2000, p. 1): "We are committed to providing the best customer service possible. We aim to achieve this through increased public participation, increased access to information, and more effectively responding to customer needs." This is a sweeping statement that applies to a wide variety of valuation contexts, including both those that involve single valuation metrics (e.g., dollar responses obtained via contingent valuation) and multiattribute inputs obtained via multi-stakeholder approaches (e.g., such as mediated modeling and structured decision approaches).

For example, in the context of contingent valuation, a commitment to deliberative approaches implies that EPA will seek input from stakeholders regarding such things as: the ecological systems or services that will be the subject of valuations, the aspects of these ecological systems or services to be valued (e.g., the attributes by which an object such as aesthetic quality might be defined), appropriate measures (e.g., dollars for economic valuations; indices of quality for environmental attributes) for valuation outputs, and appropriate ways to frame and implement valuation questions.

Likewise, in the context of multiattribute approaches, this commitment guides EPA to seek input regarding: problem identification and framing, stakeholders' objectives as they relate to a given decision or evaluation context, the range of options that may be considered as part of a management decision, valuation inputs to consider during decision making or evaluation; these include results from valuation processes that include, but are not limited to CV, deliberative value elicitations, and the results from

(non-monetized) surveys, and information about the tradeoffs that must be addressed when selecting one option over another.

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A Decision Science Perspective on Valuing the Protection of Ecological Systems and Services

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OUTLINE

- The value of ecological systems and services is driven by people's *objectives*.
- The overall value of ecological systems and services is *multiattribute in nature*.
- The value of systems or services is established through an analysis of *management alternatives*; thus, the value of ecological systems and services is relative and reflects the *tradeoffs* that people are willing to make.

OBJECTIVES

- Analyses of people's (stakeholders, public, experts, etc.) objectives identifies the attributes of systems and services that deserve attention in "valuation".
- Consultation with technical experts (economists, ecologists, etc.) identifies appropriate measures for these attributes.

ATTRIBUTES AND MEAUSURES

In response to the desire/need for quantification…

Natural Measures - Direct measures of an attribute
e.g., monetary value of electricity generated ($)

Proxy Measures - Indirect measures of an attribute
e.g., habitat quality as a measure of the health of fish communities

Constructed Measures - Measures created for an attribute
e.g., index of accessibility for cultural or spiritual purposes

OBJECTIVES, ATTRIBUTES, MEASURES

Objectives	**Attributes; Measures**
Recreation	*Access to recreation opportunities; Weighted User Days*
Environmental Health	*Erosion levels; Weighted Erosion Days*
Environmental Health	*Flow levels; Weighted Flood Days*
Environmental Health	*Habitat quality; % Available Habitat, IBI*
Environmental Health	*Water quality; Multiattribute Index (particulates, PCBs, etc.)*
Cultural	*Regular access to sites; Consistency Index*
Economic	*Revenues; Annual Revenues M$ / Year*

MULTIATTRIBUTE VALUATION

Objectives	Attributes/ Measures	Option A
Enhance recreation opportunities	Access/ Weighted user days	*X DAYS*
Enhance environmental health	Habitat Quality/ % Available	*Y%*
Maximize economic returns	Revenues/ $Mil/Yr	*$Z Mil/Yr*

ESTABLISHING VALUE

Objectives	Attributes/ Measures	Mimic Natural Hydrograph	Enhanced Summer Releases	Enhanced Winter Releases
Enhance recreation opportunities	Access/ Weighted user days	1400	1200	1500
Enhance environmental health	Habitat Quality/ % Available	50%	20%	30%
Maximize economic returns	Revenues/ $Mil/Yr	$60	$80	$65

ESTABLISHING VALUE

Objectives	Attributes/ Measures	Mimic Natural Hydrograph	Enhanced Summer Releases	Enhanced Winter Releases
Enhance recreation opportunities	Access/ Weighted user days	1400	1200	1500
Enhance environmental health	Habitat Quality/ % Available	50%	[illegible]	[illegible]0%
Maximize economic returns	Revenues/ $Mil/Yr	$60	$80	$65

"Value" is not a function of a single measure

ESTABLISHING VALUE

Objectives	Attributes/ Measures	Mimic Natural Hydrograph	Enhanced Summer Releases	Enhanced Winter Releases
Enhance recreation opportunities	Access/ Weighted user days	1400	1200	1500
Enhance environmental health	Habitat Quality/ % Available	50%	[illegible]	[illegible]
Maximize economic returns	Revenues/ $Mil/Yr	$60	$80	$65

Nor is it simply the function of a composite score

ESTABLISHING VALUE

Objectives	Attributes/ Measures	Mimic Natural Hydrograph	Enhanced Summer Releases	Enhanced Winter Releases
Enhance recreation opportunities	Access/ Weighted user days	1400	1200	1500
Enhance environmental health	Habitat Quality/ % Available	[illegible]	[illegible]	[illegible]
Maximize economic returns	Revenues/ $Mil/Yr	$60	$80	$65

Instead, the value of a given option exists in the tradeoffs that people are willing to make across not just their objectives, but also the level of achievement with respect to them.

ESTABLISHING VALUE

Objectives	Attributes/ Measures	Mimic Natural Hydrograph	Enhanced Summer Releases	Enhanced Winter Releases
Enhance recreation opportunities	Access/ Weighted user days	1400	1200	1500
Enhance environmental health	Habitat Quality/ % Available	50%	20%	30%
Maximize economic returns	Revenues/ $Mil/Yr	$60	$80	$65

ADVANTAGES

- Provides both preference orders (A>B>C) and relative values (A=2B=3C) for management options.
- Multiattribute, inclusive, and transparent.
- Useful for both decision making and retrospective evaluation.
- High level of methodological precision.

CHALLENGES

- Effortful and potentially time consuming.
- Overly formal for many EPA decisions; decision makers may wish to protect their autonomy.
- Not explicitly geared towards current OMB requirements for regulatory evaluation.

Mediated Modeling

Brief Description of Method. Computer models of complex systems are frequently used to support decisions concerning environmental problems. To effectively use these models, (i.e. to foster consensus about the appropriateness of their assumptions and results and thus to promote a high degree of compliance with the policies derived from the models) it is not enough for groups of academic "experts" to build and run the models. What is required is a different role for modeling - as a tool in building a broad consensus not only across academic disciplines, but also between science and policy. Mediated modeling is the involvement of stakeholders (parties interested in or affected by the decisions the model addresses) as active participants in all stages of the modeling process, from initial problem scoping to model development, implementation and use (Costanza and Matthias 1998; van den Belt 2004). Integrated modeling of large systems, from individual companies to industries to entire economies or from watersheds to continental scale systems and ultimately to the global scale, requires input from a very broad range of people. We need to see the modeling process as one that involves not only the technical aspects, but also the sociological aspects involved with using the process to help build consensus about the way the system works and which management options are most effective. This consensus needs to extend both across the gulf separating the relevant academic disciplines and across the even broader gulf separating the science and policy communities, and the public. Appropriately designed and appropriately used mediated modeling exercises can help to bridge these gulfs. The process of mediated modeling can help to build mutual understanding, solicit input from a broad range of stakeholder groups, and maintain a substantive dialogue between members of these groups. Mediated modeling and consensus building are also essential components in the process of adaptive management (Gunderson, Holling, and Light 1995). An extended description of this method can be found in Appendix. B.

Mediated Modeling and Value. Mediated models can contain explicit valuation components. In fact, if the goal of the modeling exercise is to consider trade-offs, then valuation of some kind becomes an essential ingredient. How these trade-offs and valuations get incorporated into the model, varies, of course, from exercise to exercise.

Perhaps the best way to describe this process is with an example. The South African fynbos ecological economic model described by Higgins et al. (1997) is an illustrative example.

The area of study for this example was the Cape Floristic Region—one of the world's smallest and, for its size, richest floral kingdoms. This tiny area, occupying a mere 90,000 km2, supports 8,500 plant species of which 68% are endemic, 193 endemic genera and six endemic families (Bond and Goldblatt 1984). Because of the many threats to this region's spectacular flora, it has earned the distinction of being the world's "hottest" hot-spot of biodiversity (Myers 1990).

The predominant vegetation in the Cape Floristic Region is fynbos, a hard-leafed and fire-prone shrubland which grows on the highly infertile soils associated with the ancient, quartzitic mountains (mountain fynbos) and the wind-blown sands of the coastal margin (lowland fynbos) (Cowling 1992). Owing to the prevalent climate of cool, wet winters and warm, dry summers, fynbos is superficially similar to California chaparral and other Mediterranean climate shrublands of the world (Hobbs, Richardson, and Davis 1995). Fynbos landscapes are extremely rich in plant species (the Cape Peninsula has 2,554 species in 470 km2) and plant species endemism ranks amongst the highest in the world (Cowling 1992).

In order to adequately manage these ecosystems several questions had to be answered, including, what services do these species-rich fynbos ecosystems provide and what is their value to society? A two-week workshop was held at the University of Cape Town (UCT) with a group of faculty and students from different disciplines along with parks managers, business people, and environmentalists. The primary goal of the workshop was to produce a series of consensus-based research papers which critically assessed the practical and theoretical issues surrounding ecosystem valuation as well as assessing the value of services derived by local and regional communities from fynbos systems.

To achieve the goals, an 'atelier' approach was used to form multidisciplinary, multicultural teams, breaking down the traditional hierarchical approach to problem-solving. Open space (Rao 1994) techniques were used to identify critical questions and allow participants to form working groups to tackle those questions. Open space meetings are loosely-organized affairs which give all participants an opportunity to raise issues and participate in finding solutions.

The working groups of this workshop met several times during the first week of the course and almost continuously during the second week. The groups convened together periodically to hear updates of group projects and to offer feedback to other groups. Some group members floated to other groups at times to offer specific knowledge or technical advice.

Despite some initial misgivings on the part of the group, the structure of the course was remarkably successful, and by the end of the two weeks, seven working

groups had worked feverishly to draft papers. These papers were eventually published as a special issue of *Ecological Economics* (Cowling and Costanza 1997). One group focused on producing an initial scoping (or mediated) model of the fynbos. This modeling group produced perhaps the most developed and implementable product from the workshop: a general dynamic model integrating ecological and economic processes in fynbos ecosystems (Higgins et al. 1997). The model was developed in STELLA and designed to assess potential values of ecosystem services given ecosystem controls, management options, and feedbacks within and between the ecosystem and human sectors. The model helped to address questions about how the ecosystem services provided by the fynbos ecosystem at both a local and international scale are influenced by alien invasion and management strategies. The model consists of five interactive sub-models: a) hydrology; b) fire; c) plant; d) management; and (e) economic valuation. Parameter estimates for each sub-model were either derived from the published literature or established by workshop participants and consultants (they are described in detail in Higgins et al. 1997). The plant sub-model included both native and alien plants. Simulation of the model produced a realistic description of alien plant invasions and their impacts on river flow and runoff.

This model drew in part on the findings of the other working groups, and incorporates a broad range of research by workshop participants. Benefits and costs of management scenarios were addressed by estimating values for harvested products, tourism, water yield and biodiversity. Costs included direct management costs and indirect costs. The model showed that the ecosystem services derived from the Western Cape mountains are far more valuable when vegetated by fynbos than by alien trees (a result consistent with other studies in North America and the Canary Islands). The difference in water production alone was sufficient to favor spending significant amounts of money to maintain fynbos in mountain catchments.

The model was designed to be user-friendly and interactive, allowing the user to set such features as area of alien clearing, fire management strategy, levels of wildflower harvesting, and park visitation rates. The model has proven to be a valuable tool in demonstrating to decision makers the benefits of investing now in tackling the alien plant problem, since delays have serious cost implications. Parks managers have implemented many of the recommendations flowing from the model.

There are several other case studies in the literature of various applications of mediated modeling to environmental decision-making, including valuation. Van den Belt (2004) is the best recent summary and synthesis.

Decision contexts where this method can be used. As described above, the method is fairly general and could be used to assess any value (means toward and ends) that a group of stakeholders could identify and build into a model. Any decision context that requires the estimation of the values of ecosystem goods or services could employ this method, although to the committee's knowledge no EPA decisions have as yet employed this technique. The method covers all elements of the diagram after the initial identification of EPA needs, and could be used in conjunction with the full range of

decision models. Prior applications have been at a broad range of scales, from watersheds or specific ecosystems to large regions and the global scale. The method is in principle broadly applicable to the full range of time and space scales.

Resource Inputs/Limitations. Resources needed to implement the method vary from application to application. The method can deal with a broad range of available data and resources, probably better that most other methods, since the model can adapt to the resources available across different levels of data, detail, scope and complexity. As a rule of thumb, one can produce a credible mediated model in 30-40 hours of workshops; about 300-400 hours of organizing/modeling. Cost: about $40,000 - $100,000 depending on side activities. The most serious obstacle seems to be the fact that this method is very different from the top-down approach most frequently used in government. It requires that consensus building be put at the center of the process, which can be very scary for institutions accustomed to controlling the outcome of decision processes. The final outcome of this process cannot be predetermined.

Uncertainty: In terms of uncertainty, there are all the usual sources, but the difference is that the stakeholders are exposed to these sources as they go, and learn to understand and accommodate them as part of the process. The method is compatible with formal or informal characterizing of uncertainty, producing probability distributions in addition to point estimates.

Other important dimensions:

- The method is inherently dynamic – that is what it does best
- The results can be aggregated to get a single benefits number as needed.
- Participants in the mediated modeling process gain deep understanding of the process and products. Those who have not participated can easily view and understand the results if they invest the effort. Usually the results can (with some additional effort) be made accessible to a broad audience.
- Since the method explicitly discusses and incorporates subjective or "framing" issues, it is at least open and transparent to users. No research has yet been done on whether application of the process to exactly the same problem by two independent groups would yield "consistent and invariant" results. One would expect general consistency, but some variation between applications. This is an area for further research.

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12.4. Social/Psychological Methods for Ecosystem Values Assessments

Session Leaders:
Dr. Terry Daniel, Professor of Psychology and Natural Resources, Department of Psychology, Environmental Perception Laboratory, University of Arizona
Dr. Kathleen Segerson, Professor, Department of Economics, University of Connecticut

Contents:

- Brief overview of social-psychological methods prepared by a sub-group of the C-VPESS that represents initial ideas about what roles these methods might play in ecosystem values assessments. Material is intended to stimulate discussion among members of the Committee and participants at the workshop.

Outline of session contents

For the purposes of EPA policy and decision making the values of ecosystems and ecosystem services are based at least in part on the judgments of stakeholders and citizens. Social/psychological methods are proven scientific means for determining people's value-relevant perceptions and judgments about a wide array of objects, events

and conditions. Valuations and benefit assessments based on judgments by relevant samples of stakeholders and/or citizens provide an appropriate basis for EPA policy and decision making, along with economic (monetary) and bio-ecological assessments.

Social/psychological methods are characterized by:

- An emphasis on descriptive rather than prescriptive models and reliance on empirically based theories of human values, judgments and decision making;
- Acknowledgment of the important effects of the assessment contexts (e.g., representation/framing of assessment targets, mode of preference expression, perceived intentions/goals of the assessors) and the associated constraints on validity and generalizability of any assessment results;
- Recognition of the effects of human predispositions, interpretations and cognitive limitations (e.g., bounded rationality, mental models, emotional/affective responses) on the outcome of any value assessment;
- Use of a wide range of overt expressions of value (narratives, lexicographic scales, ratings, choices, actions);
- Assessments over multiple value dimensions (e.g., biocentric, utilitarian, aesthetic, ethical) expressed in qualitative (lexical) or quantitative metrics that need not be commensurate;
- Segregation of different value proponents into coherent sub-sets based on a priori social-demographic characteristics (e.g., young-old, rural-urban, eastern-western) or on observed patterns of expressed values (e.g., current versus future, utilization versus preservation, biocentric versus anthropocentric orientations);
- Resolution of conflicts between different value dimensions and/or value proponents by explicit communication and negotiation among decision makers and stakeholders.

Candidate methods for ecosystem values assessments

Surveys: Standardized, formal questionnaires may be conducted by mail, telephone, internet or face-to-face interview. Assessment targets are most often represented by verbal descriptions or labels, but photographs, videos or computer visualizations can be used where appropriate. Questions may be presented as multiple distinct items each focused on one aspect of an assessment target or as multi-dimensional scenarios conjoining several aspects. Response formats range from binary choices to rankings or ratings on various value scales to open-ended narratives.
Example: Sheilds et al (2002): multi-item questionnaire, USDA Forest Service, GPRA
Example: Kneeshaw et al (2004): conjoint survey, wildfire risk management options
Example: Ribe et al (2002): perceptual survey, forest management options

Focus groups: Small groups of relevant stakeholders are engaged in facilitated discussion and deliberation on selected/focused topics relevant to the assessment target. Typically open-ended narratives are collected and subjected to qualitative analyses to

identify and possibly to ascertain levels of consensus on relevant issues, perspectives and positions represented by the participants.
Example: Winter et al (2002): wildfire risk management options

Narrative interviews: Individuals nominally representing possible stakeholder perspectives are asked to comment on broadly defined topics with little direction from the interviewer/assessor. Open-ended narratives are collected and subjected to qualitative analyses to explore and articulate the breadth and depth of expressed understandings and concerns relevant to the assessment target. Included in this category are various ethnographic methods.
Example: Brandenburg & Carroll (1995): forest management in a local watershed

Behavioral observation/behavior trace: Changes in the patterns of movements and activities of users or visitors are observed and correlated with changes in aspects of an environmental setting that are relevant to the assessment target. Behavior may be observed directly or recorded by cameras, counters or other automated surveillance technology. Alternatively, persisting traces of visitation or use, such as written registration lists, vegetation disturbance, soil compaction or erosion, or campfire rings may be inventoried and analyzed to indicate patterns of behavior.
Example: Daniel & Gimblett (2000): travel patterns in a National Park

Interactive games: Patterns of responses are observed in interactions with simulated (hypothetical) environments and analyzed to infer preferences and values relevant to changing features of the environments. Environmental changes may be programmed by the investigator and/or selected or initiated by the respondent. Applications of interactive games to environmental values assessment are still in the experimental stage.
Example: Bishop & Rohrmann (2003): responses sub-urban park designs

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12.5. Spatial Representation of Biodiversity and Conservation Values and Ecological Services

Session Leaders:
Dr. Dennis Grossman, Vice President for Science, Science Division, NatureServe
Dr. James Boyd, Senior Fellow, Director, Energy & Natural Resources Division, Resources for the Future

Contents:

- Spatial Representation of Biodiversity and Conservation Value
- Ecosystem Benefit Indicators

Spatial Representation of Biodiversity and Conservation Value

Description of method: This method results in the spatial representation of the uniqueness and irreplaceability of biological and ecological diversity in a regional context. This is a scientifically based approach to assign a conservation value to select species and ecological systems that are representative of an ecological region.

The values are represented as a numeric representation of the uniqueness, irreplaceability and level of imperilment for plant and animal species, vegetation, habitats and ecological systems.

Key assumptions:

- Representative biological and ecological diversity can be elaborated spatially across any region.
- The conservation value (status and quality) of each occurrence can be ascribed to each element of biodiversity as a repeatable and consistent procedure.
- The cumulative biological and ecological diversity and conservation values can be practically applied to inform and direct critical resource management and conservation decisions.

Key steps in the method include:

a) Define the biological and ecological targets for valuation
b) Define occurrence standards for each target
c) Define standards for valuing the quality of each occurrence
d) Define standards for measuring range wide status of each target
e) Create a 'conservation value layer' for each target that represents values and goals of the stakeholder
f) Create 'conservation value summary' of all targets that represents values and goals of the stakeholder
g) Modify the conservation value through incorporation of threats and opportunities.

Decision contexts where this method could be used:

- Enumeration of biodiversity protection implications that result from policy changes (i.e., change of protection status for isolated wetlands).
- Identification of critical riparian habitat
- Prioritization of remediation action on superfund sites
- Due diligence reviews and EIS as a prerequisite for permitting.
- Identification of reference conditions for establishment of baseline quality metrics for wetland and aquatic habitats.
- Assessment of the status of target species and ecosystems.

The method can be applied to a broad range of local to regional to national scales. The types of data and the spatial representation of this data change relative to the questions that are being addressed.

Resource inputs and limitations:

- The assumption is that there is a sufficient coverage of standardized biodiversity data required to run these models. The standards have been developed, and the data required changes associated with the application questions. Where there is a paucity of required data, it is readily 'developable', but can require the resources complete the required databases to run the models. The method is useless without good appropriate data.
- This method requires local scientific data, knowledgeable scientific interpretation and conservation planning expertise. The magnitude of the need is contingent upon the application and the current state of data and knowledge.
- Lack of data, currency and confidence of data, and data sharing issues associated with 'sensitive' data, training, and tools are the most important obstacles to the use of this method. However, there are many ways to create surrogate datasets that will allow users to adapt to different types of 'barriers'.

Uncertainty. There are confidence measures built into the methodology that can

be brought into the decision making process or displayed separately for analysis. The most significant sources of uncertainty in the use of this method include:
The variability in the quantity and quality of the data.
The limitations of scientific understanding of distribution and quality criteria for some elements of biodiversity.

Other important dimensions:

- The method is adaptable: it can be run repeatedly to represent temporal change or different landscape scenarios.
- Results are commonly aggregated to derive a single benefits number, but all of the native data is constantly maintained in the system and can be presented separately.
- The output is both understandable and communicable to the interested audience.
- The results are repeatable, and the process and algorithms are very transparent.

Detailed Description of Method

1. Define the biological and ecological targets for valuation

Biological diversity is often characterized by different levels of biological and ecological organization, from genes to populations to species to natural communities to ecosystems and sometimes to ecoregions and biogeographic provinces. All of these levels can be used for characterization and valuation, but certain levels are most appropriate to address specific types of assessments. For regional scale valuation, species, natural communities and ecosystems are generally used for purposes of conservation assessment and biodiversity valuation.

Within these categories, it is helpful to use the concept of coarse filter and fine filter conservation elements. The fine filter elements are important biodiversity resources that often are sparsely distributed across the landscape. These would include imperiled, declining, endemic, vulnerable, “umbrella” species and subspecies, as well as Focal Communities such as unique environments, rare plant communities, rare aquatic habitats, vulnerable species aggregations, migratory stopover points, and others. These fine filter elements represent those components of biodiversity that can become extinct due to lack of knowledge or attention. The coarse filter elements are comprised of the broad vegetation types, habitats and ecological systems that represent aggregations of communities and natural landscape patterns and processes at scales useful for management and monitoring. It is by looking at the combination of these fine and coarse filter element that one can portray the biological and ecological valuation of the landscape based on well developed and applied standards.

The valuation of fine and coarse filter elements across the landscape required a defined level for the currency and level of standardization of the knowledge. For example, there needs to be a defined taxonomy for all species and standard classification

approach for all ecological units. NatureServe and the network of state Heritage Program currently maintain this level of currency and standardization for over 30,000 animal taxa, 56,000 plant taxa, 7,000 vegetation types and 1,500 ecological systems.

2. Define occurrence standards for each target

This methodology then applies the concept of recognizing an area of land and/or water in which a species or natural community is, or was present. These Element Occurrences (EOs) have practical conservation value for the Element as evidenced by potential continued presence and/or regular recurrence at a given location. Biologists and ecologists have developed criteria and have been conducting inventories for many decades to document the best occurrences of these elements of conservation across the landscape. NatureServe databases alone manage and distribute information on the occurrences of over 500,000 imperiled species across the United States. This number grows dramatically when adding freshwater and coastal habitats, vegetation types and ecological systems.

3. Define standards for valuing the quality of each occurrence

Each of the element occurrences defined above must be given a relative quality rank to allow planners, managers and conservations to prioritize their actions relative to management of the landscape. Biologists and ecologists have developed an approach to designate A, B, C, and D quality ranks to these fine and coarse filter occurrences of conservation elements.

These methods incorporate factors of occurrence size, condition and landscape integrity. Size factors that are used in this assessment include a quantitative measure of area of occupancy, population abundance, population density, and population fluctuation. Condition looks at biotic/abiotic factors, structures, processes within the occurrence as measured by population reproduction and health, development and maturity, ecological processes, species composition and biological structure, along with abiotic physical and chemical factors. Landscape integrity compiles a qualitative measure of biotic factors, abiotic factors, and processes surrounding the EO. These factors include landscape structure and extent, community development and maturity, intactness of ecological processes, species composition and biological structure, and additional abiotic physical and chemical factors.

Many of coarse and fine filter occurrence quality metrics have been developed and used to provide a quality/integrity attribute to all occurrences. The quality ranks portray what experts determine to be within acceptable ranges of variation. These ranges are developed through the characterization of multiple, apparently undisturbed examples, examination of impact and response to human-induced alterations, review of literature and historical records, and the development and testing of ecological simulation models. “A” ranked occurrences are within the preferred ecological integrity threshold. “B” ranked occurrences have one key factor within its acceptable range of variation. “C” ranked occurrences do not have any key factors with their acceptable range of variation,

but they are still considered to be 'restorable'. "D" ranked occurrences are no longer restorable. In some cases these factors can be directly measured, while in other they may be inferred/estimated indirectly.

4. Define standards for measuring range-wide status of each target

The next step in this approach is to assign a range-wide conservation status rank to each of the conservation elements. This is primarily completed and is most useful as an element attribute at the global scale, but the standards can also be applied at the national, sub-national and local scales. The conservation rank factors differ as they are applied to species as compared to ecological communities and habitats.

For **species**, the factors that are considered in assessing conservation status include total number and condition of occurrences (e.g., populations); population size; range extent and area of occupancy; short- and long-term trends in the above factors; scope, severity, and immediacy of threats; number of protected and managed occurrences; intrinsic vulnerability and environmental specificity.

For **ecological communities**, there are primary and secondary factors used in assessing conservation status. The primary factors for assessing community status are the total number of occurrences (e.g., forest stands) and the total acreage occupied by the community. The secondary factors for assessing community status are the geographic range over which the community occurs, long-term trends across this range, short-term trend (i.e., threats), degree of site/environmental specificity exhibited by the community, and the imperilment or rarity across the range as indicated by sub-national ranks assigned by local natural heritage programs.

The definitions for each of the Global (G) Ranks are:

- **G1 – Critically imperiled:** At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.
- **G2 – Imperiled:** At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors
- **G3 – Vulnerable:** At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors
- **G4 – Uncommon but apparently secure:** Uncommon but not rare; some cause for long-term concern due to declines or other factors
- G5 – Widespread, abundant and secure: Common; widespread and abundant

All fine and coarse filter conservation elements across North America have been evaluated and given a conservation status rank.

5. Create a 'conservation value layer' for each target that represents values and goals of the stakeholder

The biodiversity value attributes that have been created for the global range-wide conservation status and the quality of viable occurrences now allows the development of a conservation value surface layer for each individual conservation element. The creation of this layer requires the ability to spatially portray each of the occurrences as well as the quality and confidence of each occurrence. The spatial portrayal of element occurrences is derived from imagery, maps and field points, along with modeled distributions of specific elements. The element quality attributes are imported directly as available, and generated from landscape integrity models when necessary.

6. Create 'conservation value summary' of all targets that represents values and goals of the stakeholder

The combination of 'conservation value layers' for selected elements across a planning or assessment jurisdiction creates an aggregated 'conservation value summary' that provides a spatially explicit representation of the biodiversity and conservation values that are important to the conservation and resource management community. Different user groups can select the types of elements that there need to assess across the jurisdiction, and they can also modify the relative conservation weight of each fine and coarse filter conservation element. This will provide a customized conservation surface that portrays the values that they will need to incorporate into their planning and assessment work. This also becomes a baseline for monitoring the effects of their programs to manage for biodiversity value over time.

7. Modify the conservation value through incorporation of threats and opportunities in order to prioritize conservation and resource management activities.

The conservation values that are generated through processes 1-6 can be modified to reflect values that are relevant to a specific assessment. Zoning policies, growth models, economic values, ecological services and other values help to identify the effect of different or future scenarios relative to the current or desired future condition of the landscape.

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Ecosystem Benefit Indicators (Boyd And Banzhaf, 2005, Banzhaf and Boyd, 2005, Boyd and Wainger 2002; Boyd 2004)

Because many ecosystem services are public goods, markets are not available to provide clear units of account. Cost-benefit analysis and national accounting for marketed goods is made easier by clear units of account: namely, the end-products consumers enjoy. While environmental economics has grappled for decades with the challenge of missing prices for environmental goods and services, it has neglected another central issue: the consistent definition of the environmental units to which prices are attached. An argument for standard units of account is that they can facilitate the transfer of valuations across the landscape and across time.

Possible use by EPA

Clear units of account are also desirable from the standpoint of environmental programs that police gains and losses in environmental quality or economic value. Consider wetland banking, water permit trading, land swaps, and natural resource damage assessment. All such activities trade compound, bundled environmental goods. Ideally, however, what should be traded – and accounted for – are the individual environmental goods and services provided by the bundle. In practice, however, trade and compensation programs use blunter proxies, such as "acres of wetland" or "pounds of nitrogen." What is lost in this kind of accounting system is gains and losses in individual ecosystem services.

Standardized units of account are also important to the measurement of performance. If the nation's environmental status is to be characterized and tracked over time units must be clearly defined, defensible ecologically and economically, and consistently measured. At present, the government and the public are presented with an over-abundance of units of measurement and often those units are poorly defined, unclear in their origin, and exacerbate the divide between economic and ecological analysis. Often within a single agency there are multiple competing paradigms for what should be measured.

At the national level, in the evaluation of new rules as part of the RIA process, government performance reviews, strategic planning, budget justification, and priority setting. They are also applicable at more local scales as a tool to improve regional and local planning, such as watershed planning in the context of TMDLs.

Description of the Method: Units of Account

There are two principle activities associated with the method. First, the definition and measurement of ecosystem service *units* (quantity measures of services). Second, the use of benefit indicators (or "willingness to pay indicators" to facilitate transfer of benefit estimates across the landscape or to empower tradeoff analysis by regulators, planners, and conservancies.

Analysis of the benefits of natural resources requires a distinction between ecosystem components, processes, functions and *services*. The term services originates in economics, but has been adopted within ecology as well to signify the connection between ecosystems and human wellbeing.[2] Ecosystem components include resources such as surface water, oceans, vegetation types, and species. Ecosystem processes and functions are the biological, chemical, and physical interactions associated with ecosystems. These functions are the things described by biology, atmospheric science, hydrology, and so on.

Ecosystem services arise from these components and functions but are different: *Ecosystem services are the end products of nature that yield human wellbeing.* Part of this definition is particularly important: namely, that ecosystem services are "end products." End products are the environmental components about which people make choices. It is important to emphasize that many aspects of nature are *valuable*, but are not capable of being valued in an economic sense – because they are not associated with social or individual choices.[3]

This definition restricts the units of account, relative to many ways in which ecosystem services are commonly used. For example, nutrient cycling is often termed n ecosystem service. This is not a service, however, but rather an ecological function. To be sure, it is a valuable function, but it an intermediate aspect of the ecosystem and not an end product. Being valuable is not the same thing as being a service.

Consider another example. Reference is often made to recreation being an ecosystem service. It is not. Recreation is a benefit that relies on ecosystem services as inputs. Recreation is the joint product of ecosystem services including surface waters and fish populations and *other goods and services* including tackle, boats, time allocation, and access. From an economic standpoint, units of ecosystem account will exclude many things that are called ecosystem services.

Note that the above examples of economically defined units of account lead to units that are in fact biophysical, rather than "economic" in nature. An economic definition therefore leads naturally and necessarily to a bridge between economic and biophysical analysis. No ecologist should think that the economic definition of services

[2] See Gretchen Daily, *Nature's Services.*
[3] Many components of an ecosystem can be thought of as "intermediate products" in that they are necessary to the production of services, but are not services themselves.

leads away from biophysical analysis. In fact, the opposite is true.

The relationship of units of account to "environmental indicators" is as follows. First, the units of account described above are themselves indicators of performance or environmental conditions. These units are countable, spatially explicit indicators of certain biophysical characteristics. They can be expressed both numerically and spatially via geospatial information systems. Thus, our units of account, or ecosystem service indicators, are related to certain "ecological indicators" emanating from the biophysical sciences.

Description of the Method: Willingness to Pay Indicators

However, we will also relate units of account to a different type of indicator: indicators of willingness to pay. In accounting for conventional, market goods, market prices are used to "weight" units of account. Because many ecosystem services lack these prices, how are units of account to be weighted? This question is central to benefit-cost analysis and welfare accounting. It should also, arguably, be central to government performance assessment and the evaluation of environmental trades, though preservation or enhancement of economic value is not always the aim of such programs. The aspiration of economic analysis is willingness to pay-based weights. For this reason, the workshop will also address the derivation of weights that can be assigned to ecosystem units of account.

The principal observation here is that the value of ecosystem services is highly dependent upon location in the biophysical and social landscape. In conventional accounting, arbitrage allows us to assume a single market price. For many ecosystem services there is no arbitrage. Also, many ecological services are best thought of as differentiated goods with important place-based quality differences. Ecosystem services' scarcity, substitutes, and complements are likewise spatially differentiated.

There are several implications. First, units of account should be spatially explicit. Second, the weights assigned to units – if units are to be aggregated into summary measures – should be spatially explicit. This can mean several things, depending upon the valuation method being applied. For example, stated preference techniques can be used to place value on units of account using place-specific scenarios. In other words, the scenarios presented in stated preference surveys could rely on standardized units and ways of measuring place-based quality, substitution, and complementary asset landscape factors. Alternatively, meta-analysis of existing value estimates can be used to calibrate benefit transfers. Standardized service units and location-specific factors affecting willingness to pay would provide a consistent architecture for such an exercise.[4] An alternative approach is a reduced-form regression of willingness to pay on various factors, including landscape-dependent indicators of the contribution of ecosystems to final goods and services and landscape-dependent indicators of substitutes and

[4] This topic was raised at NCEE's workshop on benefit transfer in Spring, 2005.

complements, population, and other socio-demographic characteristics.[5]

Finally, there is relevance to less econometrically formal weighting procedures. Examples here include stakeholder-driven decisions, citizen juries, and mediated modeling exercises. In these examples weights are not derived by economic analysis, but rather are debated and concluded via some kind of institutional process. Here too, standardized units of account and landscape willingness to pay indicators could help educate and discipline benefit assessment.

Strengths and Weaknesses

Both ecosystem service measurements (indicators) and benefit indicators are a quantitative and visual, but not monetary, approach to the assessment of services. Unless married to an econometric benefit transfer exercise, conjoint analysis, citizen jury, or other weighting approach, the indicators will not themselves yield a single dollar-based "answer." Rather, they should be though of as an accounting tool to measure and track over time, in a consistent manner, changes in service levels and factors related to willingness to pay for those services. The monetization of benefits, which is clearly important in certain regulatory applications, demands additional methods.

Service and benefit indicators are simple, countable aspects of the biophysical and social environment. They are transparent and easily replicable. Because indicators are cheaper to generate than econometric value estimates they better allow for landscape assessment of multiple services at large scales.

EBIs are drawn mainly from geospatial data, including satellite imagery. Data can come from state, county, and regional growth, land-use, or transportation plans; federal and state environmental agencies; private conservancies and nonprofits; and the U.S. Census. Benefit indicators can capture the landscape, or spatial, factors that contribute to social well-being. This is in fact a virtue of indicator methods. Indicators can be derived from and mapped within a GIS context. Spatial analysis is important because the ecological production function is a function of spatial interdependencies. From an economic standpoint, the social determinants of service benefits depend upon the landscape context in which those services arise. The consumption of services often occurs over a wide scale. Habitat support for recreational and commercial species, water purification, flood damage reduction, crop pollination, and aesthetic enjoyment are all services typically enjoyed in a larger area surrounding the ecosystem in question.

The method is applicable to the full range of ecological services. In practice, applicability may be limited by data gaps.

[5] Willingness to pay, while not directly observable, is a function of various characteristics that are observable. WTP weights p_i can be thought of as a function of landscape indicators I. In principle, this function, on a service-by-service basis, can be calibrated by relating observable indicators I to existing WTP estimates of service value. Were this possible in practice, location and ecosystem-specific indicators I could be used to transfer monetary WTP estimates to locations where they are not available.

The principle disadvantage of indicators alone, is that they do not directly yield dollar-based ecological benefit estimates. They also do not in themselves weight or estimate the tradeoffs associated with different factors relating to benefits (though as noted above they can be married to more formal methods designed to do such weighting). This is not really a weakness to indicators themselves, but rather an acknowledgement that more must occur than simple indicator measurement if the goal is dollar-based end-results.

Uncertainties associated with the method and how they would be addressed: A core rationale for the use of a benefit indicator approach is to explicitly convey the sources of complexity – and hence uncertainty – characterizing biophysical systems and the service flows arising from them. The visual depiction of willingness to pay indicators, for example, can mimic sensitivity analysis by presenting a range of benefit scenarios in GIS form. However, the visual depiction of quantitative information introduces uncertainties of its own. In particular, visual depictions can strongly influence perceptions. Uncertainty with regard to how indicators are perceived, particularly when presented visually should be acknowledged.

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