A Classification System for Final Ecosystem Goods and Services

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We started looking at ecosystems services using the MA approach, but we found the standard wanting, therefore we developed the Final Ecosystem Goods and Services Classification System, that seems to be an important improvement.
Where it all started...

Millennium Ecosystem Assessment (MEA) sparked the vision of using ecosystem services as a tool.

“Ecosystem services are the benefits people obtain from ecosystems.” (MEA 2005)
Key Elements of an ecosystem services Classification System

• Avoid Double Counting
• Comprehensive
• Links environmental production sectors directly to uses/users/Beneficiaries
• Facilitates identification of metrics and indicators
SEEA “desires” for a ecosystem services classification system and its metrics and indicators

- Integrated classification system (linking production and use)
- Defined approach and clarity to determine “what to measure” and why
How do you identify FEGS?

“components of nature, directly enjoyed, consumed, or used to yield human well-being” (Boyd & Banzhaf 2007)

Environmental Class + Beneficiary → FEGS

- Three Key Steps:
  1. Clearly define the Environmental Class boundary
  2. Identify Categories of Beneficiaries
  3. For any Beneficiary and Environmental Class, hypothesize FEGS received
“components of nature, directly enjoyed, consumed, or used to yield human well-being” (Boyd & Banzhaf 2007)

FEGS

Environmental Class + Beneficiary → FEGS

Estuaries and Near Shore Marine
Recreational Food Pickers and Gatherers
Flora and fauna, such as mussels, seaweed, crabs, etc.
Example 1: **Recreational Fishing**

- **Environment**
- **Processes/Functions**
- **Ecological Production Function**
- **Input of Labor & Capital**
- **Economic Production Function**
- **FEGS Beneficiary**
- **Total Economic Value**

**Intermediate Goods and Services**

Example 1: Recreational Fishing
Our Classification Scheme

<table>
<thead>
<tr>
<th>FEGS Classification Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
</tr>
<tr>
<td>XX.</td>
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<tr>
<td>XX.XX</td>
</tr>
<tr>
<td>XX.XXX</td>
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</tbody>
</table>

Diagram showing the classification structure with example codes: XX.XXXX and 21.0604.
Identifying FEGS

• By using the FEGS approach, an infinite list of ecosystem services was pared down to 338 FEGS

• FEGS-CS is an operational framework that standardizes identification of ecosystem services at multiple spatial scales

• Published EPA Report
  – Available at cfpub.epa.gov/si/
  – EPA/600/R-13/ORD-004914

• Interactive FEGS-CS website (developing...)
  – Create and download custom checklists of potential FEGS
  – Link with EnviroAtlas, mapping and models
  – Provide comments to the authors
  – Participate in forum discussions
  – WEB SITE OPERATIONAL
Relationships Among Nature and Economic Systems

NESCS-S (linking FEGS with Economic Benefit and Cost Analysis)
REVISED Figure 1: General model of flows related to ecosystem services

Individual and societal well-being  
(to specific beneficiaries)

Material and non-Material Benefits

Human inputs (e.g. labour and capital)

Final Ecosystem Goods and Services (FEGS)

Ecosystem processes, functions and structure
- Ecosystem characteristics
- Intra-ecosystem flows
- Inter-ecosystem flows

Ecosystem asset

Other ecosystem assets

Modified from: System of Environmental –Economic Accounting 2012 Experimental Ecosystem Accounting
FEGS could well function as the currency of the Ecosystem component of sustainability.
Beneficiaries (utility functions) lead to Valuation

1º Primary Beneficiaries

2º Secondary Beneficiaries

3º Tertiary Beneficiaries
In the 1930s Boxcars moving from Chicago to NYC were counted as one of the first metrics for Gross Domestic Product (80 years ago)
Incorporation of FEGS to USEPA Decision Making

• Adopt some NARS (probability based - National Aquatic Resources Survey) metrics and indicators (low hanging fruit); augment NARS with some additional metrics and indicators for FEGS

• Collaboration on developing NESCS with Office of Water and Office of Air and Radiation to incorporate FEGS into Benefit/Cost Analyses

• Key component of ORDs Sustainable and Healthy Community national research program: demonstration and proof of concept applications
END
Metrics and Indicators for FEGS
Humans Define and Classify Items of Importance in Order to Communicate

Chauvet Cave in the valley of the Ardèche River in France, 30,000-32,000 BP
What is the problem?

• Many definitions and disparate “lists,” “frameworks,” and “perceptions” of ecosystem services
• Miscommunication and discord among disciplines
• Disconnect between environment and human well-being
• Lack of consistency, rigor and a systematic approach; need typology and classification for “framework”

What do people care about?

- soil microbes
- clean water
- habitat
- fauna
What ecosystem services do scientists measure from this seemingly endless list?

The services quantified by ecologists are not necessarily those directly valued by the public.

Connecting ecosystem services to benefits requires interdisciplinary approaches.
How do we connect ecosystem services to human well-being?
Final Ecosystem Goods and Services (FEGS)

“components of nature, directly enjoyed, consumed, or used to yield human well-being” (Boyd & Banzhaf 2007)

- A focused definition
  - Centers on the ecosystems
  - Tied to measures of biophysical features
  - Counts only direct interactions, critical for economic valuation
  - Relates clearly to human beneficiaries and human well-being
The Importance of Beneficiary Linkages

Water is often considered an ecosystem service or “Benefit.”

To quantify ecosystem services on the ground, ecologists have to know what to measure.

What to measure depends on the beneficiary and what they directly utilize, consume, or enjoy from the environment.

FEGS
CURRENT GOAL

Identify, measure, and quantify FEGS in a scientific, rigorous, and systematic way that can be aggregated from local to regional and national scales.
Ecological Production Function

Economic Production Function

FEGS

Human Well-Being
Example 2: Carrot Farming

- Ecological Production Function
- Processes/Functions
- Input of Labor & Capital
- Total Economic Value

Intermediate Goods and Services

FEGS Beneficiary
Environmental Classes

“components of nature, directly enjoyed, consumed, or used to yield human well-being” (Boyd & Banzhaf 2007)

- 15 Environmental Sub-Classes
- Facilitate classification of any area in the world
- Boundaries can be identified and mapped using satellite
Environmental Classes

1. **AQUATIC**
   - 11. Rivers and Streams
   - 12. Wetlands
   - 13. Lakes and Ponds
   - 14. Estuaries and Near Coastal and Marine
   - 15. Open Oceans and Seas
   - 16. Groundwater
   
   ...include (but are not limited to)
   - saline lakes
   - reservoirs
   - quarries

2. **TERRESTRIAL**
   - 21. Forests
   - 22. Agroecosystems
   - 23. Created Greenspace
   - 24. Grasslands
   - 25. Scrubland / Shrubland
   - 26. Barren / Rock and Sand
   - 27. Tundra
   - 28. Ice and Snow
   
   ...include (but are not limited to)
   - uncut and wilderness area forests
   - parks, parkways, trees
   - cemeteries and airfields
   - beaches, unvegetated dunes

3. **ATMOSPHERIC**
   - 31. Atmosphere
“components of nature, directly enjoyed, consumed, or used to yield human well-being” (Boyd & Banzhaf 2007)

- Beneficiaries are the interests of an individual
- Synonymous with uses, households, or firms
- People are made up of multiple beneficiaries
- Identified 37 Beneficiary Sub-Categories
Beneficiary Categories

- 00.01. AGRICULTURAL
- 00.02. COMMERCIAL / INDUSTRIAL
- 00.03. GOVERNMENT, MUNICIPAL, AND RESIDENTIAL
- 00.04. COMMERCIAL / MILITARY TRANSPORTATION
- 00.05. SUBSISTENCE
- 00.06. RECREATIONAL
- 00.07. INSPIRATIONAL
- 00.08. LEARNING
- 00.09. NON-USE
- 00.10. HUMANITY

...including,
- 00.0701 Spiritual and Ceremonial Participants
- 00.0702 Artists
- 00.0901 People Who Care (Existence)
- 00.0902 People Who Care (Option / Bequest)

Under the 10 Beneficiary Categories, there are a total of 37 Beneficiary Sub-Categories

- 00.0501 Water Subsisters
- 00.0503 Timber, Fiber, Fur / Hide Subsisters
- 00.0103 Livestock Grazers
- 00.0106 Farmers
**EnviroAtlas Approach**

Develop a web-based decision support tool giving users ability to view, analyze, and download information related to ecosystem services (nature’s benefits) for the US

Include:

- Geospatial indicators and indices of the supply, demand, and benefits of ecosystem services
- Indicators of drivers of change
- Reference data (e.g., boundaries, land cover, soils, hydrography, impaired water bodies, wetlands, demographics)
- Analytic and interpretive tools
EnviroAtlas Strategic Direction (1)

- Update EnviroAtlas based on NLCD 2011
- Incorporate future land use, climate, & ES scenarios
- Develop “what if” tools
- Build out communities to reach 50 by 2017
- Update Eco-health Relationship Browser with 2013 literature
- Conduct stakeholder outreach (e.g., PO’s, Regions, NEEF, ICMA, APA, ACES, State DENRs, regional partnerships, communities)
- Develop / integrate additional mapping and analysis tools
- Crosswalk with FEGS & other ES classification systems
- Develop “use cases”
Next Steps

Field test the FEGS-CS by applying and testing it as the ecological currency in specific and diverse places.

Begin populating the FEGS-CS with PROVISIONAL metrics and indicators

Update the web site as need and based on user feedback (new or additional FEGS; beneficiaries, environmental sub-classes...
### Beneficiary Categories

<table>
<thead>
<tr>
<th>00.01 Agricultural</th>
<th>00.02 Commercial / Industrial</th>
<th>00.03 Government, Municipal, and Residential</th>
<th>00.04 Commercial / Military Transportation</th>
<th>00.05 Subsistence</th>
</tr>
</thead>
<tbody>
<tr>
<td>00.0101 Irrigators</td>
<td>00.0201 Food Extractors</td>
<td>00.0301 Drinking Water Consumers</td>
<td>00.0401 Transporters of Goods</td>
<td>00.0501 Water Subsistents</td>
</tr>
<tr>
<td>00.0102 CAFO Operators</td>
<td>00.0202 Mineral Extractors</td>
<td>00.0302 Waste Water Treatment Plant Operators</td>
<td>00.0402 Transporters of People</td>
<td>00.0502 Food Subsistents</td>
</tr>
<tr>
<td>00.0103 Livestock Grazers</td>
<td>00.0203 Timber, Fiber, and Ornamental Extractors</td>
<td>00.0303 Residential Property Owners</td>
<td>00.0503 Fiber and Fur Subsistents</td>
<td>00.0504 Building Material Subsistents</td>
</tr>
<tr>
<td>00.0104 Agricultural Processors</td>
<td>00.0204 Industrial Processors</td>
<td>00.0304 Military / Coast Guard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00.0105 Aquaculturists</td>
<td>00.0205 Industrial Dischargers</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>00.0106 Farmers</td>
<td>00.0206 Electric and other Energy Generators</td>
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<tr>
<td>00.0107 Foresters</td>
<td>00.0207 Business Property Owners</td>
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<td></td>
<td>00.0208 Pharmaceutical and Food Supplement Suppliers</td>
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<td></td>
<td>00.0209 Fur and Hide Trappers/Hunters</td>
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</tr>
</tbody>
</table>

### Beneficiary Categories

<table>
<thead>
<tr>
<th>00.06 Recreational</th>
<th>00.07 Inspirational</th>
<th>00.08 Learning</th>
<th>00.09 Non-Use</th>
<th>00.10 Humanity</th>
</tr>
</thead>
<tbody>
<tr>
<td>00.0601 Experiencers and Viewers</td>
<td>00.0701 Spiritual and Ceremonial Participants</td>
<td>00.0801 Educators and Students</td>
<td>00.0901 People Who Care (Existence)</td>
<td>00.1001 All Humans</td>
</tr>
<tr>
<td>00.0602 Food Pickers and Gatherers</td>
<td>00.0702 Artists</td>
<td>00.0802 Researchers</td>
<td>00.0902 People Who Care (Option / Bequest)</td>
<td></td>
</tr>
</tbody>
</table>
Distinguishing FEGS from Non-FEGS

• We used rigid boundaries for FEGS, and made our boundary decisions explicit in FEGS-CS
Identifying FEGS

• While using guiding questions to identify FEGS, we also followed a distinct set of principles and rules

1. Intermediate goods and services, often structural components, functions, and processes, are not FEGS
2. FEGS are components of the natural, not the built environment
3. Policy endpoints do not create FEGS
4. Human-made infrastructure, buildings, or goods and services with a large input of labor and/or capital are not FEGS
5. Incidental non-marketed by-products of intensively produced goods and services may be considered FEGS
6. Increased value or sense of happiness are not FEGS
7. The environment itself can be a FEGS
What are ecosystem services?
The Future of FEGS-CS – CONTINUED…

• Field (Real World) Place-based Testing
• Defining and weighting the Beneficiary-scape

• FEGS are the intersect between the environment and people, and as such, they could be used as:
  – a common linkage AND language among EPA Programs and their larger SUSTAINABILITY mission
  – the environmental currency for policy analysis and future sustainability projections
Guiding Questions to Determine FEGS

• For a specific Environmental Sub-Class, which Beneficiary Sub-Categories are present?
  – **Q:** Do Recreational Food Pickers and Gatherers utilize Estuaries and Near Shore Marine environments? **A:** Yes.

• For a specific Beneficiary Sub-Category interested in a specific Environmental Sub-Class, what are the FEGS? Or, what does the beneficiary utilize or care about that is directly provided by the environment?
  – **Q:** What do Recreational Food Pickers and Gatherers utilize from Estuaries that result in a benefit? **A:** Flora and fauna, such as seaweed, kelp, mussels, crabs, etc.

• What is the importance of this FEGS to the beneficiary?
  – **Q:** Why do Recreational Food Pickers and Gatherers in Estuaries care about flora and fauna? **A:** These are edible organisms that can be collected for personal use.
Categories of FEGS Identified in FEGS-CS

• We identified 21 Categories of FEGS

  01  water
  02  flora
  03  presence of the environment
  04  fauna
  05  fiber
  06  natural materials
  07  open space
  08  viewscapes
  09  sounds and scents
  10  fish
  11  soil
  12  pollinators
  13  depredators and (pest) predators
  14  timber
  15  fungi
  16  substrate
  17  land
  18  air
  19  weather
  20  wind
  21  atmospheric phenomena

• Note that these FEGS are categorical, not actual FEGS, because they are not connected to an environment or beneficiary
Classifying FEGS

• Identified 338 sets of FEGS
  – Each associated with a Beneficiary Sub-Category and Environmental Sub-Class
  – Potential for more, as FEGS-CS is a “living-document”

• Each set of FEGS can be identified by a unique, binominal, identification number

11. RIVERS AND STREAMS

<table>
<thead>
<tr>
<th>Beneficiary Categories and Sub-Categories</th>
<th>Potentially Relevant NAICS Code(s)</th>
<th>General Beneficiary Description</th>
<th>FEGS</th>
<th>Examples of FEGS</th>
<th>Importance of FEGS to the Beneficiary</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.02 Commercial / Industrial</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Electric and other Energy Generators</td>
<td>221</td>
<td>This beneficiary relies on the environment for energy or placement of power generation structures, including dams, wind, water, or wave turbines, solar panels, geothermal systems, etc.</td>
<td>• presence of the environment</td>
<td>• opportunity to install power generation structures, such as dams and water turbines</td>
<td>• flowing water that can be used for energy generation</td>
</tr>
</tbody>
</table>
ORIGINAL ES CLASSIFICATION GOAL

Identify, measure, and quantify ecosystem services in a scientific, rigorous, and systematic way that can be aggregated to regional and national scales.
The Future of FEGS-CS

• Widespread-release of the FEGS-CS report has generated interest
  – Safe and Healthy Communities Research Program (SHCRP)
  – Office of Water & Office of Air and Radiation
  – Other government agencies (e.g., USGS)
  – Private Firms (e.g., Earth Economics)

• Continued development of FEGS measures and indicators
  – Collaborating with NARS groups and other government agencies (NOAA...)
  – Common list of metrics and indicators will facilitate on-the-ground collaborative research and site-to-program comparisons
Contact Information

• Use the EPA.gov search engine to search for:
  – FEGS-CS
  – Publication Number EPA/600/R-13/ORD-004914

• Email:
  – FEGS.CS@epa.gov
  – landers.dixon@epa.gov
  – nahlik.amanda@epa.gov