Are Carrots, Corn and Cattle Really Provided by Nature? If Not, How Can We Appropriately Identify the Goods and Services Derived from Agroecosystems?

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What is the Problem?

We need to develop a science based environmental currency that can be consistently used for multiple purposes such as:

- Quantification of Ecosystem Services
- Mapping of Ecosystem Services
- Modeling of Alternative Futures (Restoration, Climate Change, Land-use changes, etc.)
- Policy Decisions (what if? Trade-off analyses)
- National Ecosystem Services Accounts
- Support Valuation (monetary and/or non-monetary)

...and Agroecosystems (i.e. cultivated lands) are important sources of ecosystem services
Final Ecosystem Services

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

Advantages of a Final Ecosystem Services Approach:

- Comprehensive
- Minimally duplicative (unlike the MA)
- Identifies potential beneficiaries (users)
- Facilitates metric selection
- Works at multiple spatial scales (with some minor adjustments)
- Broadly applicable
Final Ecosystem Services Approach

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

Environmental Class + Beneficiary → FEGS

Five Key Steps:

1. Clearly define the environmental boundaries
2. Identify categories of beneficiaries (users)
3. For any Beneficiary and Environmental Class, hypothesize POTENTIAL FEGS
4. Identify and avoid “intermediate services” (generally processes and functions)
5. Establish boundaries (EcoPF:EconPF, corn and carrots, lithosphere, hydrosphere)
Environment \rightarrow \text{Generic Production Function} \rightarrow \text{Human Well-Being}
Example: Agroecosystems

Environment → Ecological Production Functions → Processes/Functions → FEGS → Human Well-Being

Input of Labor & Capital

Intermediate Goods and Services

Economic Production Functions
Identifying FEGS

• By using the FEGS approach, an infinite list of ecosystem services was pared down to ~500 FEGS

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

• Published EPA Report
  – Available at [https://gispub.epa.gov/FEGS](https://gispub.epa.gov/FEGS)
  – EPA/600/R-13/ORD-004914

• Interactive FEGS-CS website (developing...)
  – Create and download custom checklists of potential FEGS
  – Link with Atlas, mapping and models
  – Provide comments to the authors
  – Participate in forum discussions
  – Web development currently in progress
## 22. AGROECOSYSTEMS

<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>
<th>Potential Metric(s) and/or Indicator(s)</th>
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<tbody>
<tr>
<td><strong>22.01 Agricultural</strong></td>
<td></td>
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<tr>
<td>22.0103 Livestock Grazers</td>
<td>112</td>
<td>This beneficiary uses the environment to graze livestock. Cultivated vegetation is NOT considered a FEGS. For agroecosystems, &quot;planted&quot; pastures only provide space and opportunity to grow feed (not the vegetation itself).</td>
<td>* soil</td>
<td>* open space</td>
<td>* suitable soil in which fields of feed (i.e., on which livestock will directly graze) can be grown (NOT feed itself) * suitable conditions (i.e., land) to graze livestock</td>
<td></td>
</tr>
<tr>
<td>22.0106 Farmers</td>
<td>111, 113</td>
<td>Farmers may plant annual crops (e.g., corn, soybeans, rice) or introduce cultivars that produce perennial, long-term crops (e.g., hay, grapes, cranberries, watercress, Christmas trees). Note that Farmers and irrigators are different beneficiaries.</td>
<td>* soil</td>
<td>* open space * pollinators * predators and (pest) predators</td>
<td>* suitable soil in which annual or perennial crops (NOT crops themselves) can be grown * suitable conditions (i.e., land) in which to grow annual or perennial crops (NOT crops themselves) * wild pollinators that provide opportunity to grow annual or perennial crops * wild predators and (pest) predators that provide opportunity to grow annual or perennial crops</td>
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<tr>
<td><strong>22.02 Commercial / Industrial</strong></td>
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<td></td>
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<tr>
<td>22.0202 Timber, Fiber, and Ornamental Extractors</td>
<td>113, 339, 424, 453, 454</td>
<td>Timber, fiber, and ornamental extractors rely on the environment for products used or sold commercially. Only non-cultivated, renewable material (i.e., NOT oil, ore, gums, etc.) are considered FEGS.</td>
<td>* natural materials</td>
<td></td>
<td>* non-cultivated ornamental products or by-products (from cultivation) used ornamentally for commercial use or sale</td>
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<tr>
<td>22.0205 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></td>
<td>* opportunity to install power generation structures</td>
<td></td>
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<tr>
<td>22.0208 Resource-Dependent Businesses</td>
<td>487, 712, 713, 721, 722</td>
<td>Without the environment, this beneficiary would not have the opportunity for businesses, including marinas, stables, and ecotourism (e.g., rafting companies, hot air balloon companies, beach resorts, hot springs, ice hotels) - but not farm or forest land.</td>
<td>* presence of the environment</td>
<td></td>
<td>* opportunity for placement of infrastructure and reduced/increased risk of erosion, fire, and pest infestation on the property</td>
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<tr>
<td><strong>22.03 Government, Municipal, and Residential</strong></td>
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<tr>
<td>22.0303 Residential Property Owners</td>
<td>531, 532, 814</td>
<td>While changes in property value are not a FEGS, residential property owners are affected by the environment in which their property resides.</td>
<td>* presence of the environment</td>
<td></td>
<td>* opportunity for placement of infrastructure and reduced/increased risk of erosion, fire, and pest infestation on the property</td>
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<tr>
<td><strong>22.06 Recreational</strong></td>
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| 22.0001 Experiencers and Viewers        | None                              | This beneficiary views and experiences the environment via an activity, such as scenery gazing, hiking, bird watching, botanizing, ice skating, rock climbing, flying kites, etc. This beneficiary does not have physical contact with water. | - presence of the environment  
- viewscapes  
- flora  
- fauna  
- fungi  
- sounds and scents | - opportunity to view the environment and organisms within it  
- landscape that provides a sensory experience  
- organisms (i.e., flowers, plants, etc.) that can be viewed  
- organisms (i.e., birds, mammals, reptiles, etc.) that can be viewed  
- organisms (i.e., mushrooms, shelf fungus, puffballs, etc.) that can be viewed  
- sounds and scents that provide a sensory experience | |
| 22.0603 Hunters                         | None                              | This beneficiary is primarily interested in hunting mammals and fowl (not flora or fungi) recreationally (i.e., not for survival). In aquatic environments, this beneficiary has potential contact with water. | - fauna  
- pheasant, deer, elk, rabbit | - organisms (i.e., birds, mammals, reptiles, etc.) that can be hunted | |

### 22.07 Inspirational

| Spiritual and Ceremonial Participants and Participants of Celebration | 613 | This beneficiary uses the environment for spiritual, ceremonial, or celebratory purposes, such as harvest festivals, seafood festivals, Native American observances, religious rites (i.e., baptisms, weddings), personal growth, etc. | - presence of the environment  
- viewscapes  
- sounds and scents  
- natural materials | - opportunity and conditions for spiritual and ceremonial practices and celebrations | |

| 22.0702 Artists                        | 339, 423, 424, 512, 711 | Artists, amateur and professional, utilize the environment or their experience in the environment to produce art. This category may include writers, cinematographers, and recording artist among others. | - presence of the environment  
- viewscapes  
- sounds and scents  
- natural materials  
- corn sheaths, dried flowers | - opportunity for a sensory experience [which may lead to the benefit of inspiration for art]  
- landscape that provides a sensory experience [which may lead to the benefit of inspiration for art] or can be directly used in art (e.g., films, soundtracks, etc.)  
- sounds and scents that provide a sensory experience [which may lead to the benefit of inspiration for art] or can be directly used in art (e.g., films, soundtracks, etc.)  
- natural materials that provide a sensory experience [which may lead to the benefit of inspiration for art] or can be directly used in art (e.g., sculpture, mixed media paintings, etc.) | |

### 22.08 Learning

| Educators and Students                  | 611 | This beneficiary includes both formal and self-taught educators and students. All parts of the environment are of interest. | - presence of the environment | - opportunities to understand, communicate, and educate | |
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<td>22.0602 Researchers</td>
<td>541, 611</td>
<td>Researchers are interested in the environment for academic and applied purposes and as a group do not discriminate over which parts of the environment are of interest.</td>
<td>presence of the environment</td>
<td></td>
<td>research opportunities</td>
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<tr>
<td>22.09 Non-Use</td>
<td></td>
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<tr>
<td>22.0901 People Who Care (Existence)</td>
<td>813, 924</td>
<td>This non-use beneficiary believes it is important to preserve the environment because of a moral/ethical connection or for fear of unintended consequences.</td>
<td>presence of the environment</td>
<td></td>
<td>knowing that the environment exists</td>
<td></td>
</tr>
<tr>
<td>22.0902 People Who Care (Option / Request)</td>
<td>813, 924</td>
<td>Option/Request non-use beneficiaries consider that they or future generations may visit or rely on the environment. This includes beneficiaries that value the traditional aspects or features of an activity or FEGS.</td>
<td>presence of the environment</td>
<td></td>
<td>knowing that the environment exists</td>
<td></td>
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</table>
Why?

Cabbage is Not a FEGS

- Crops have a large and quantifiable input of human labor and capital.
- Crops are already accounted for in national industrial accounts.
- Crops are not naturally occurring in the environment – they are a product of compound production.

Soils are FEGS

- Beneficiaries (e.g., farmers) directly interact with soil.
- Soils are the ecological foundation for producing food and fiber.
- Soil “health” may be measured using several indicators (e.g., bulk density, reactive carbon, soil enzymes, earthworms, etc).
Environmental Classes

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

Environmental Class

- 15 Environmental Sub-Classes
- Facilitate classification of any area in the world
- Boundaries can be identified and mapped using satellite
FEGS could well function as the *Environmental Currency* of the ecosystem component of sustainability.
Relationships among Nature and Economic Systems

Physical Capital and Labour → Intermediate Economic Production Function → Final Economic Production Function → Household Utility Function → Human Well-Being

Economic Production

Natural Capital → Ecological Production Function → Final Ecosystem Goods and Services (FEGS) Stocks

Economic Supply-side

Economic Demand-side

flows of FEGS

NESC-S

NESC-D
Thank You
FEGS-CS Classification Scheme

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

Environment

XX

Class

21

Terrestrial

Environment

Beneficiary

XXX

Category

0604

Recreational

Sub-Class

Sub-Category

Forests

Hunters
Distinguishing FEGS from Non-FEGS

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