United States Environmental Protection Agency
Office of Research and Development

A Classification System for Final Ecosystem Goods and Services

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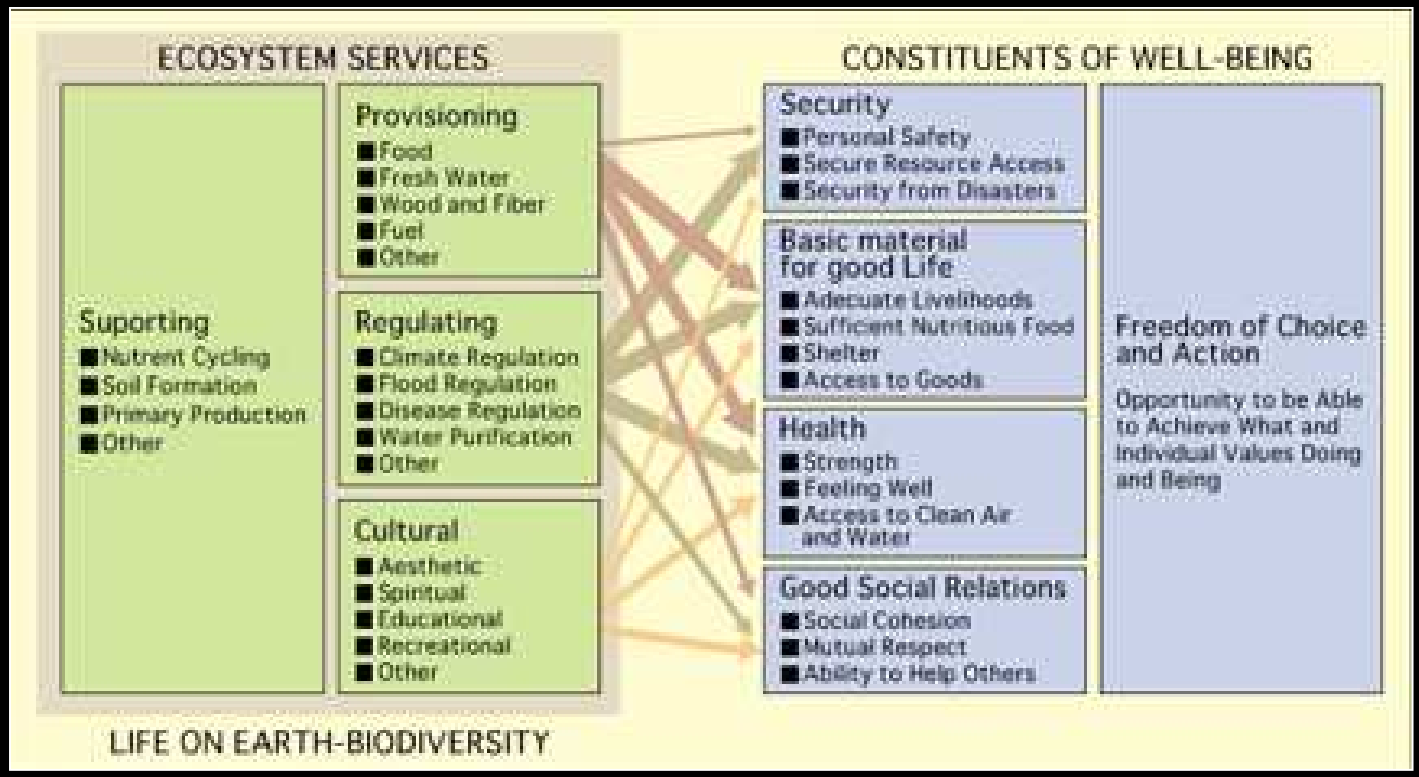
We started looking at ecosystems services using the MA approach, but we found the standard wanting, therefore we developed the Final Ecosystem Goods and Services Classification System, that seems to be an important improvement.

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

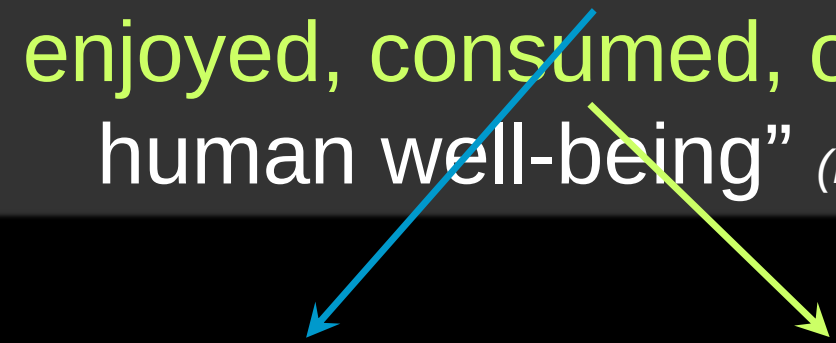
- Avoid Double Counting
- Comprehensive
- Links envieonmental production sectors directly to uses/users/Beneficiaries
- Facilitates identification of metrics and indicators

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

FEGS

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

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

Ecological Production Function

Economic Production Function

Environment

Processes/ Functions

FEGS

Input of Labor & Capital

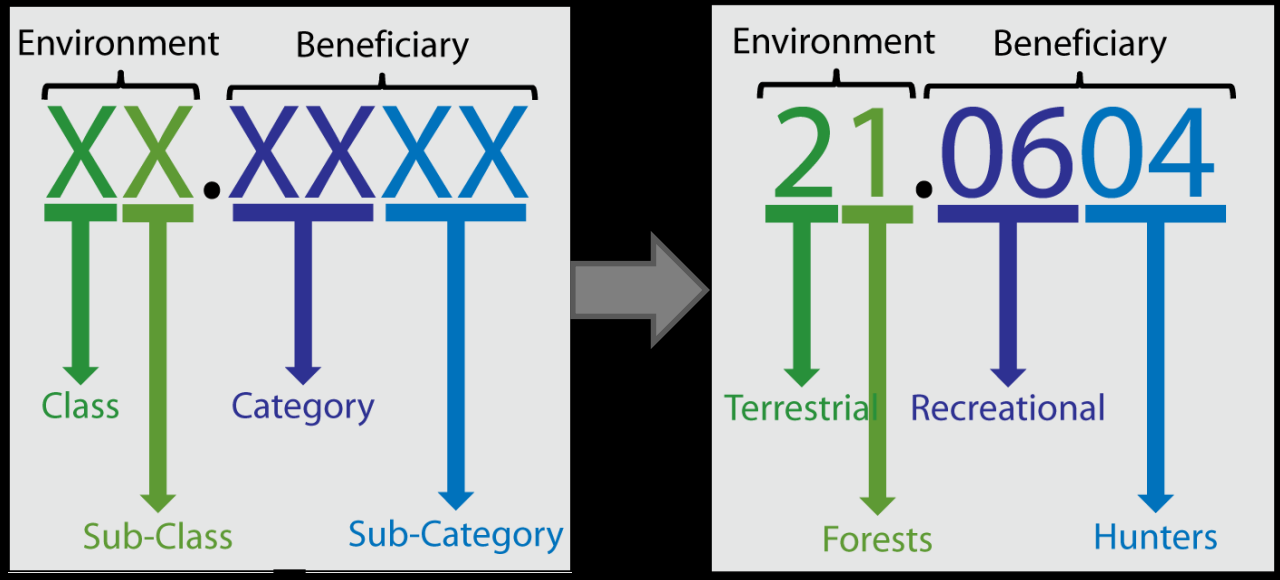
Total Economic Value

FEGS Beneficiary

Intermediate Goods and Services

Our Classification Scheme

FEGS Classification Structure	
X	Environmental Class
XX.	Environmental Sub-Class
XX.XX	Beneficiary Category
XX.XXXX	Beneficiary Sub-Category



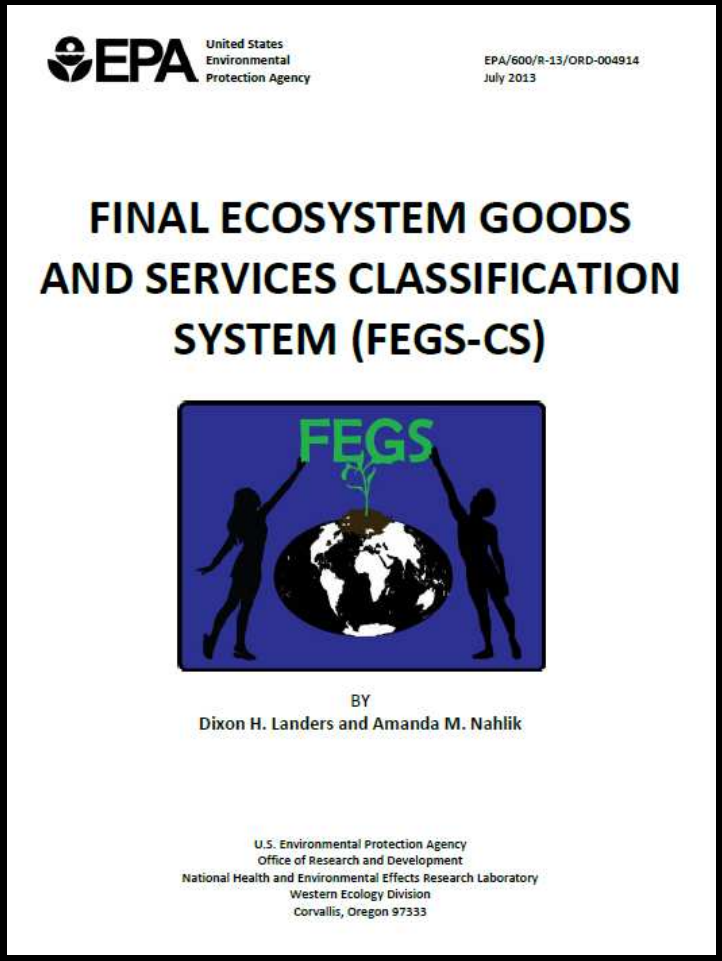
Identifying FEGS

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

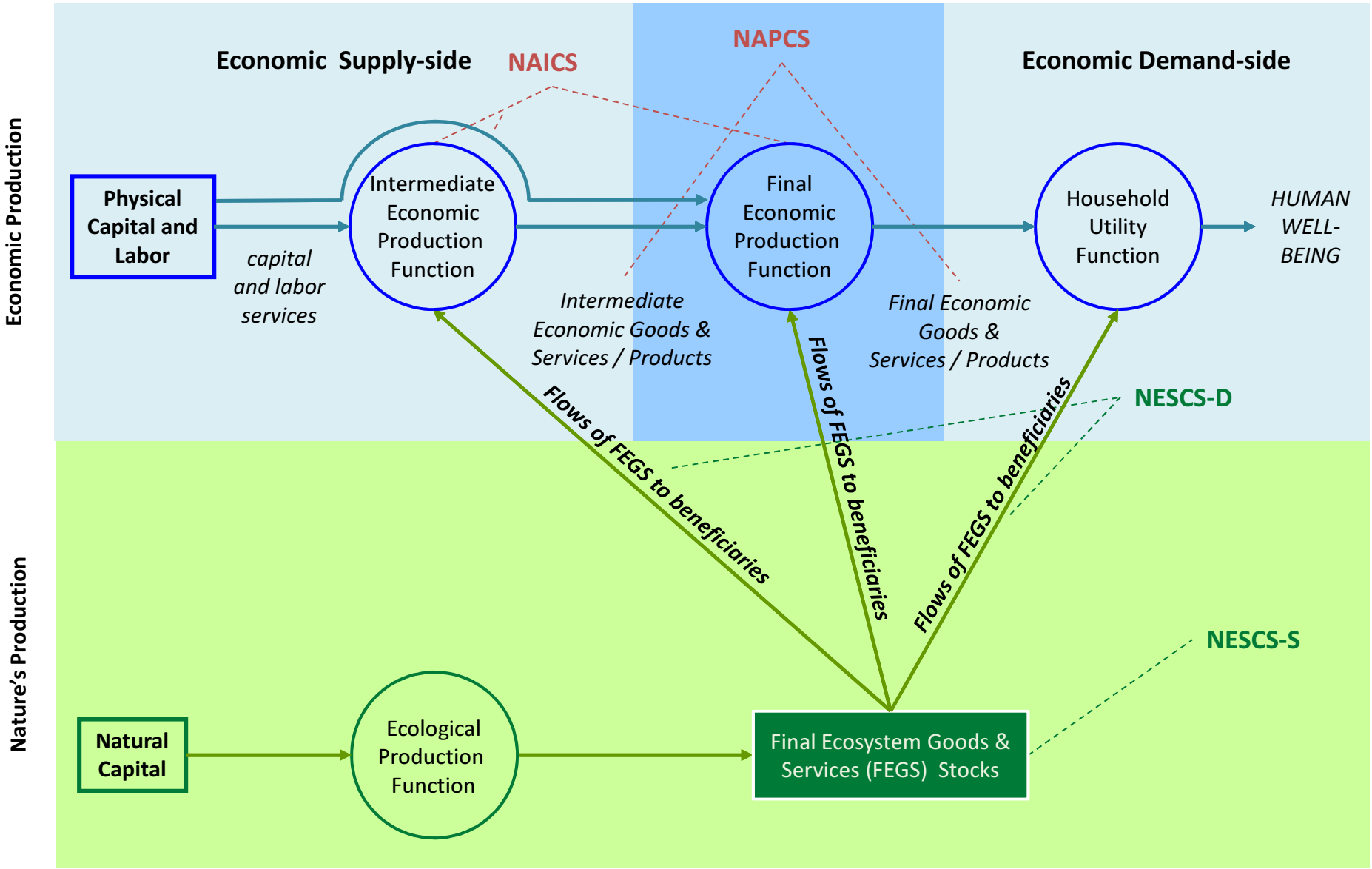
- FEGS-CS is an operational framework that standardizes identification of ecosystem services at multiple spatial scales

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

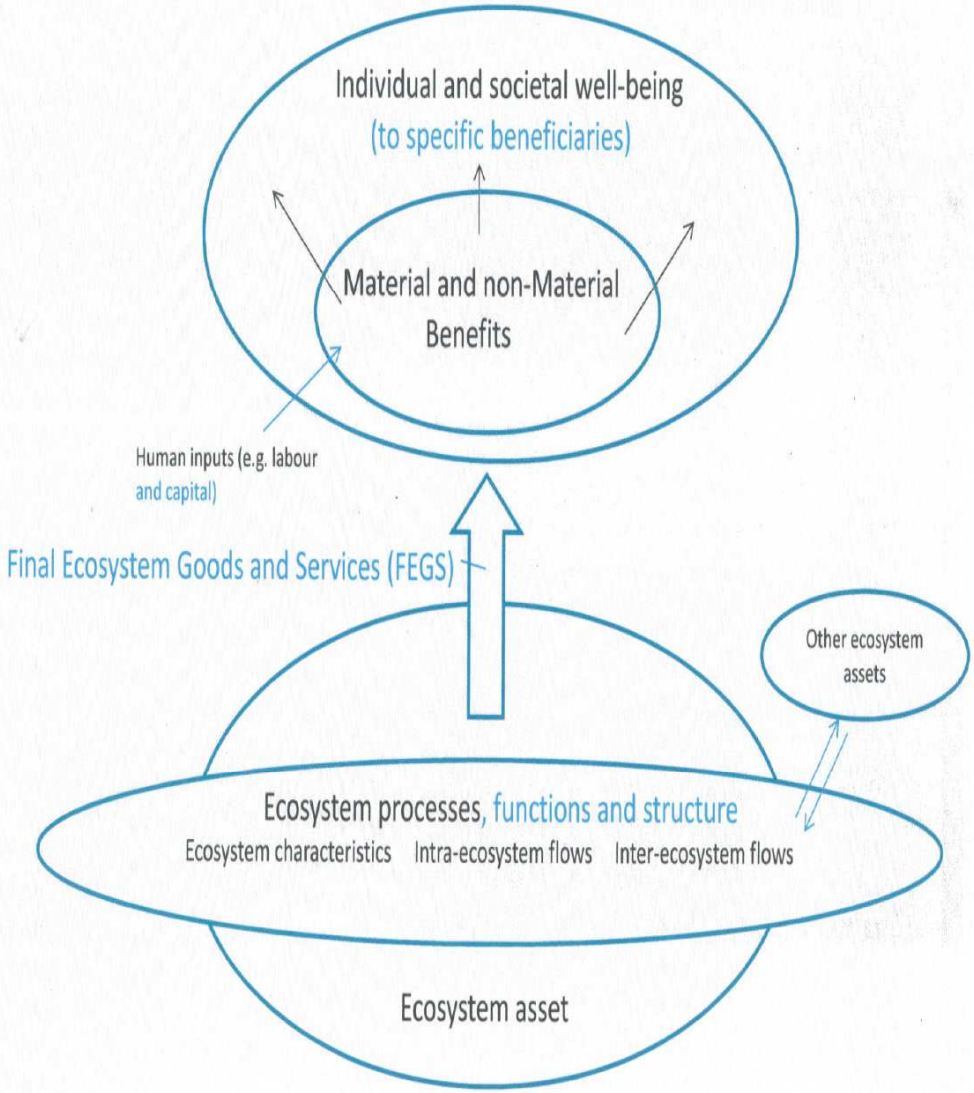
- Interactive FEGS-CS website (developing…)
  - *Create and download custom checklists of potential FEGS*
  - *Link with EnviroAtlas, mapping and models*
  - *Provide comments to the authors*
  - *Participate in forum discussions*
  - *WEB SITE OPERATIONAL*



NESCS (linking FEGS with Economic Benefit and Cost Analysis)

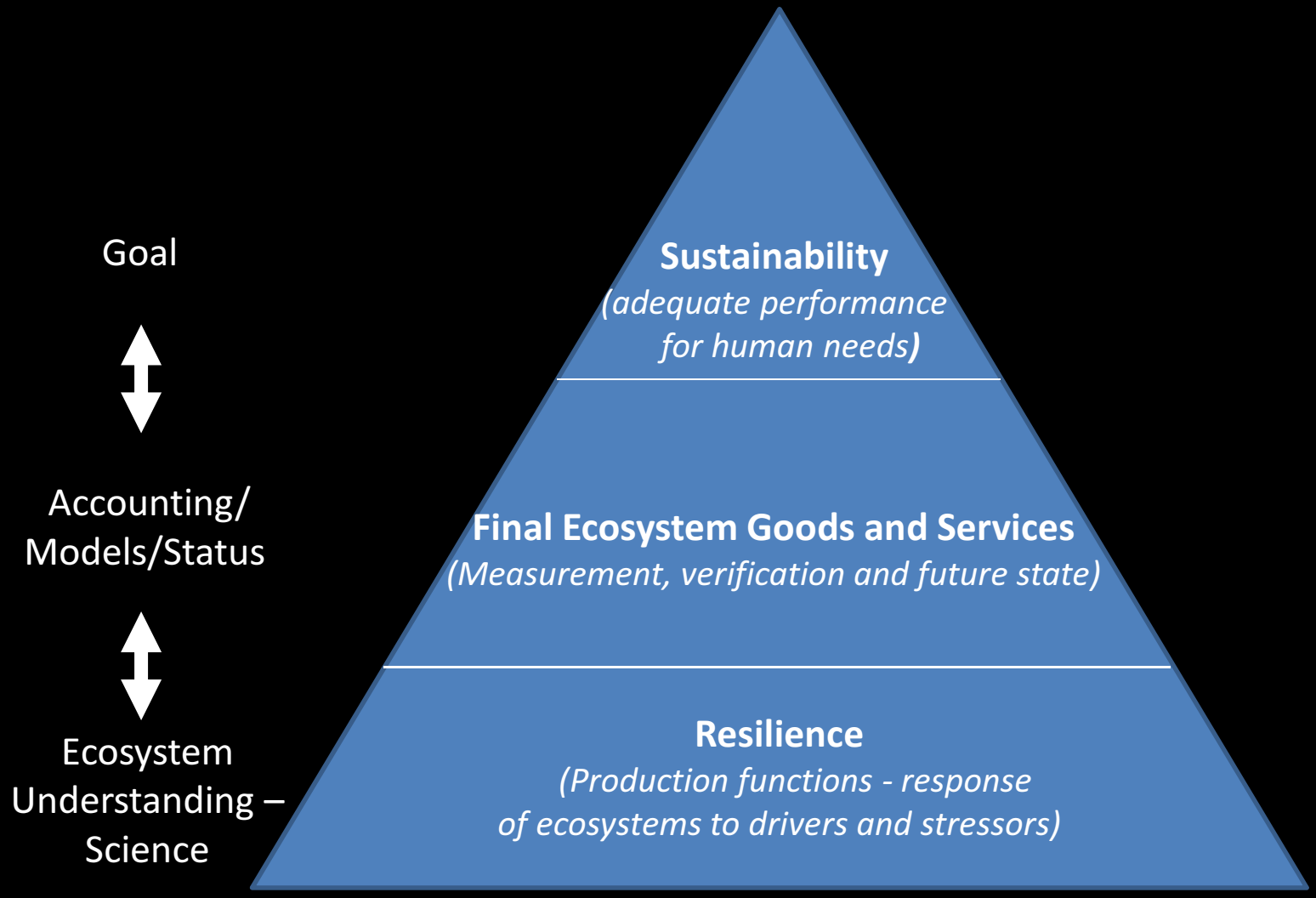


REVISED *Figure 1: General model of flows related to ecosystem services*

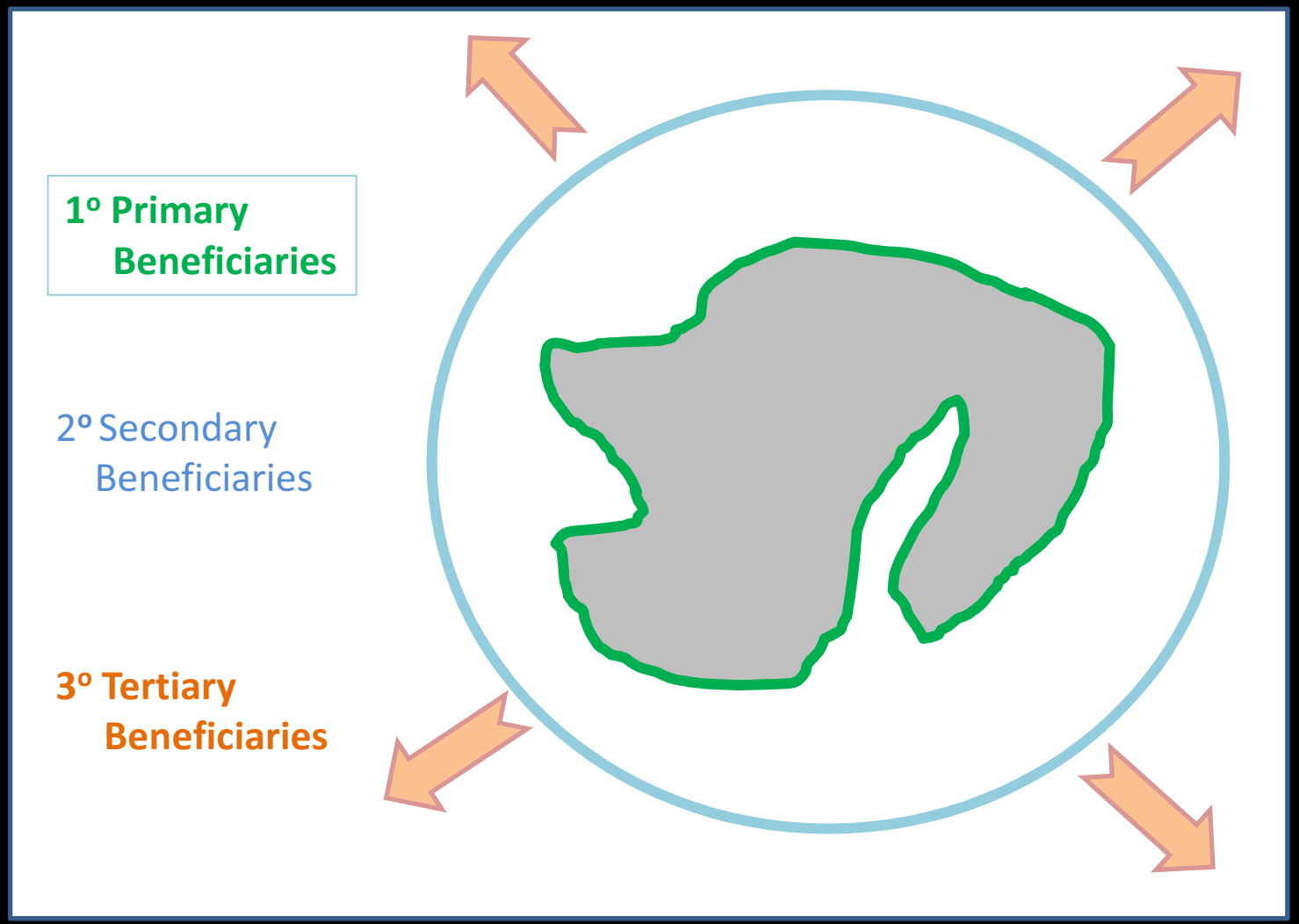


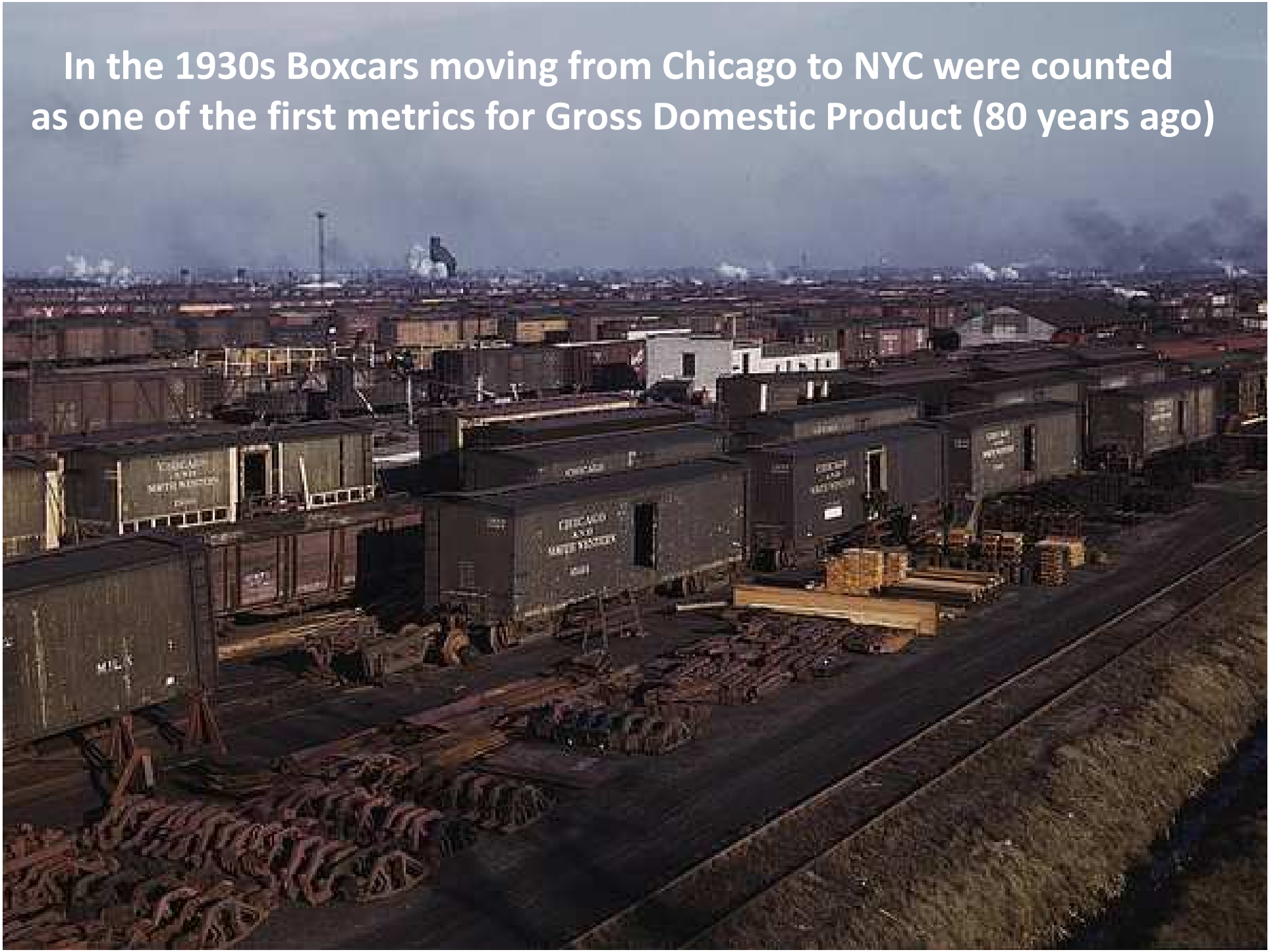
Modified from: ***System of Environmental –Economic Accounting 2012 Experimental Ecosystem Accounting***

FEGS could well function as the currency of the Ecosystem component of sustainability.



Beneficiaries (utility functions) lead to Valuation



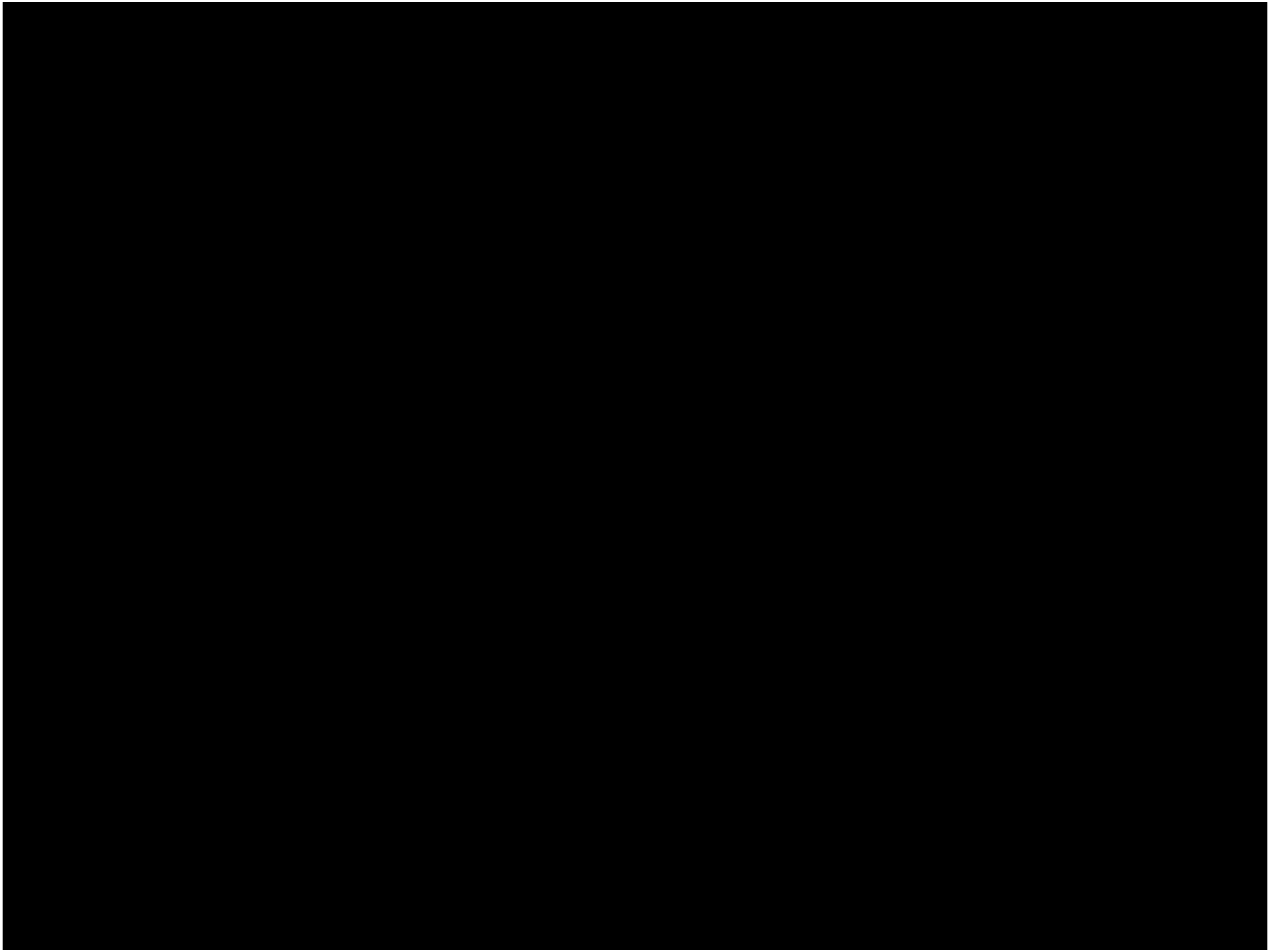

In the 1930s Boxcars moving from Chicago to NYC were counted
as one of the first metrics for Gross Domestic Product (80 years ago)

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?

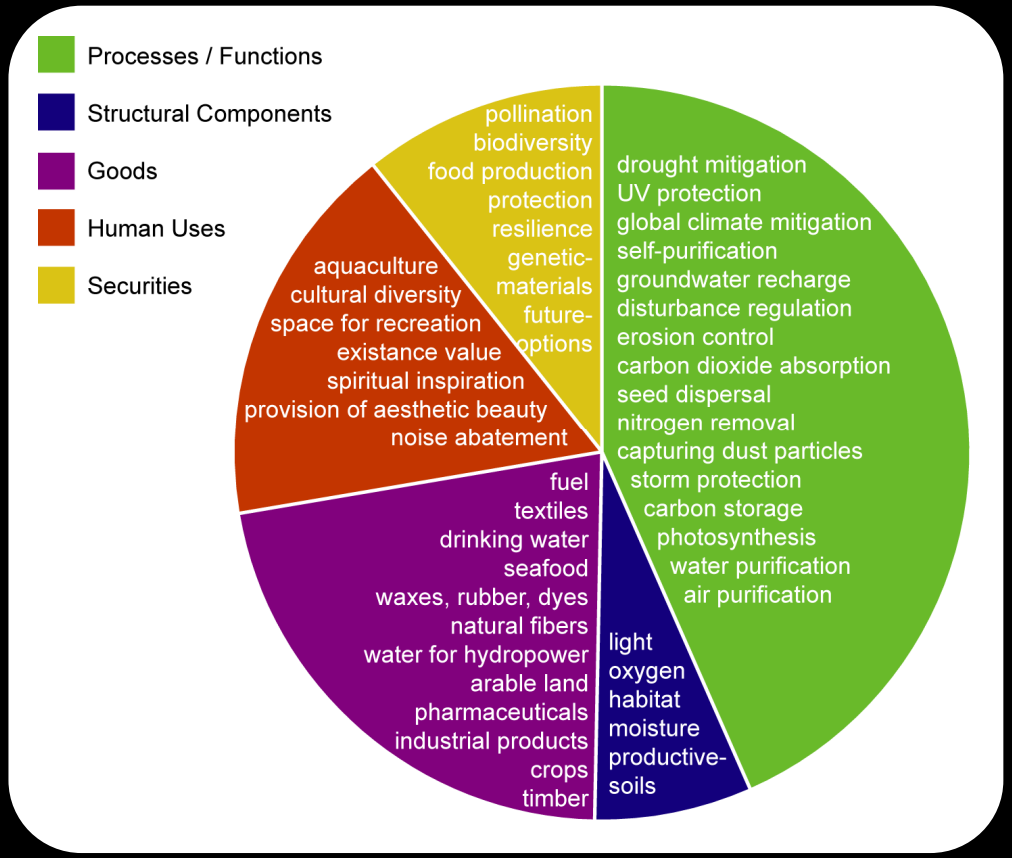
soil microbes

clean water

habitat

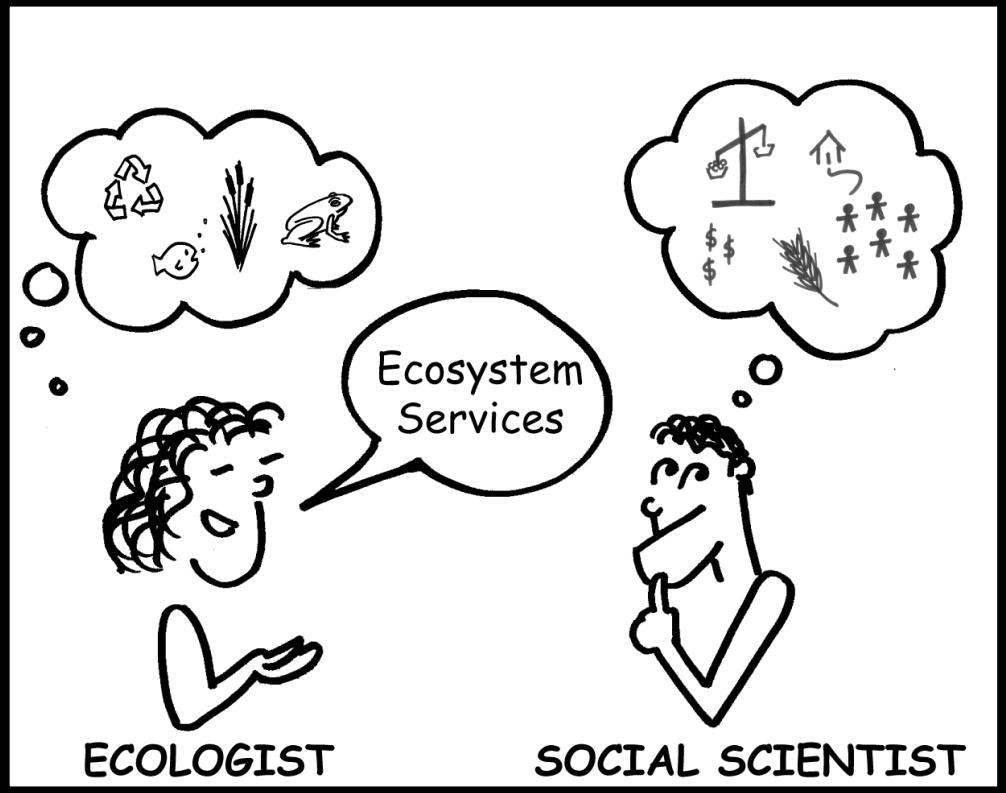
fauna

What ecosystem services do scientists measure from this seemingly endless list?



Nahlik AM, Kentula ME, Fennessy MS, Landers DH. *2012. Where is the consensus? A proposed foundation for moving ecosystem service concepts into practice. Ecological Economics 77: 27-35.*

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



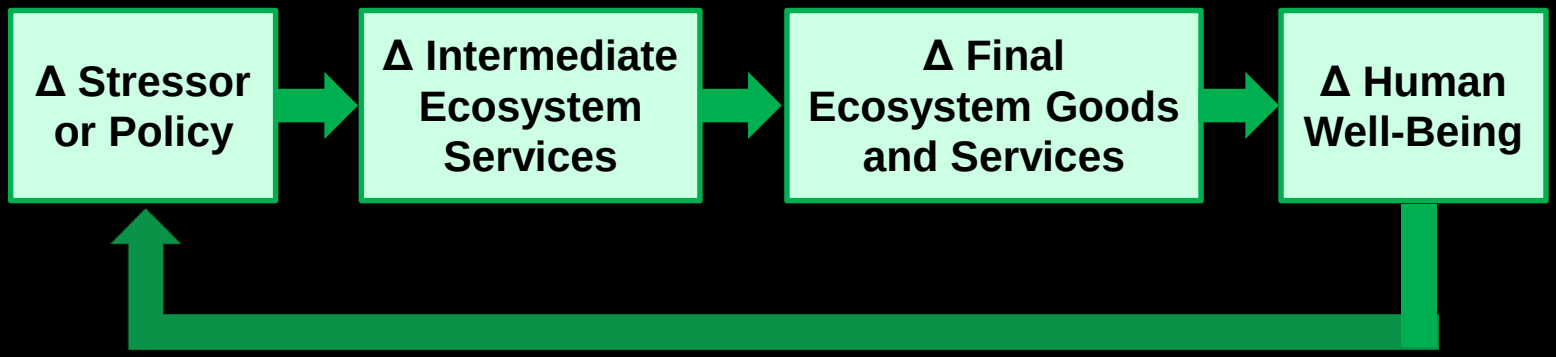
Connecting ecosystem services to benefits requires interdisciplinary approaches.

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.

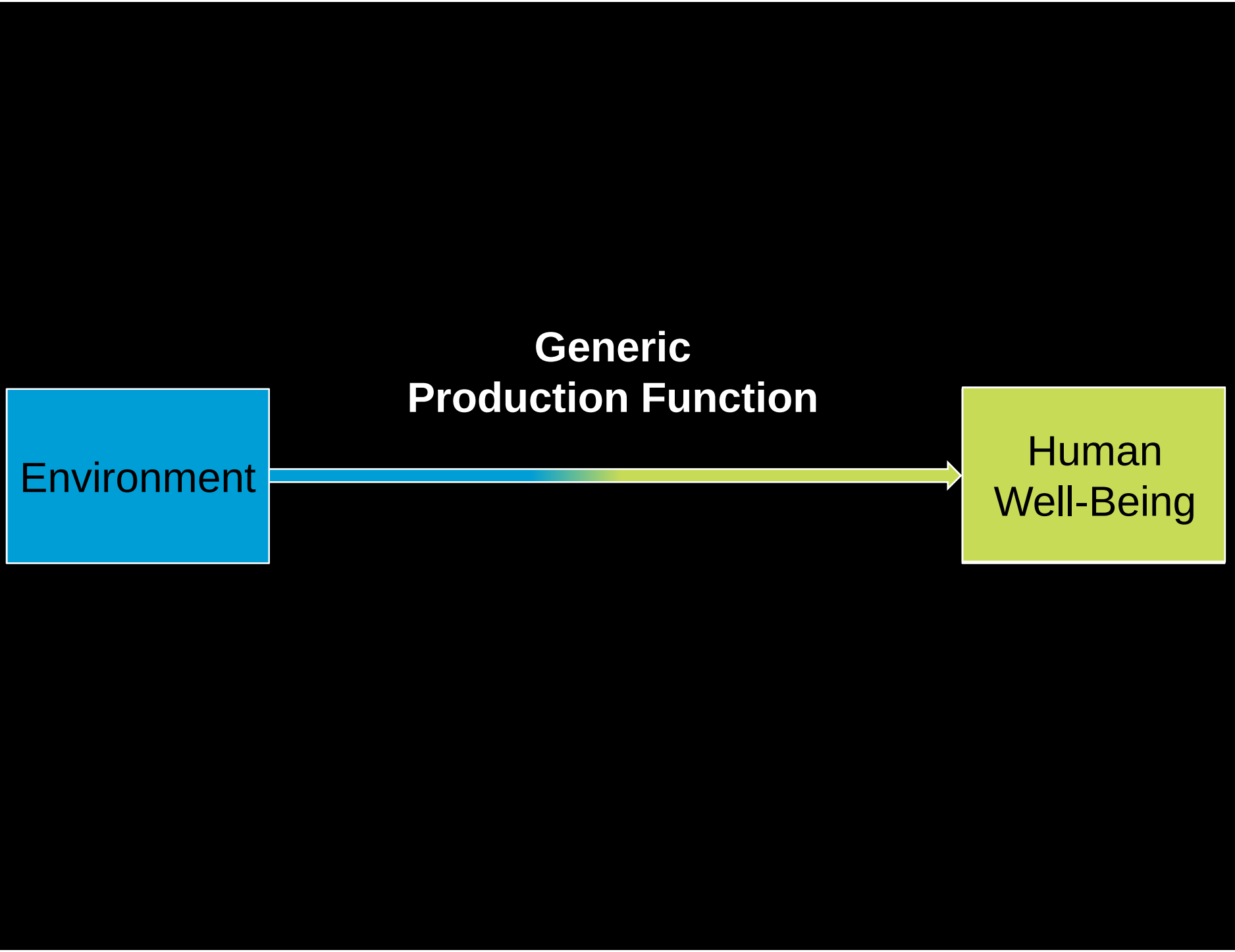
What to measure depends on the beneficiary and what they directly utilize, consume, or enjoy from the environment.

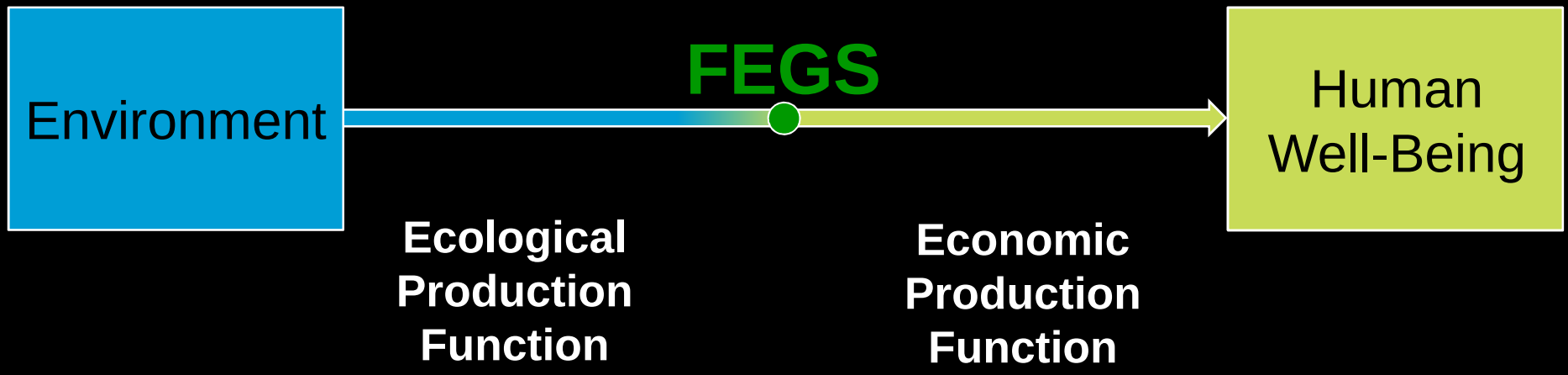
FEGS

EPA

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.


Generic
Production Function
Environment
Human
Well-Being


Environment
FEGS
Human
Well-Being
Ecological
Production
Function
Economic
Production
Function

Example 2: Carrot Farming

Ecological Production Function

Economic Production Function

Environment

Processes/ Functions

FEGS

Input of Labor & Capital

Total Economic Value

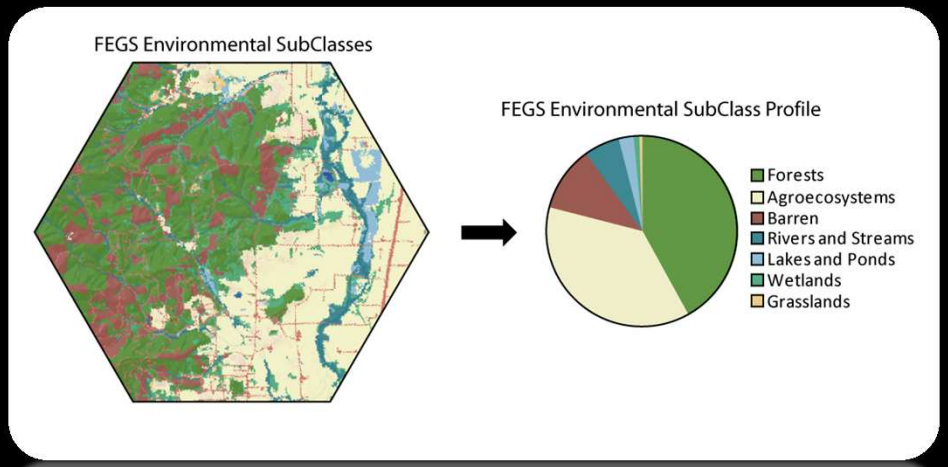
FEGS Beneficiary

Intermediate Goods and Services

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

Environmental Classes

1. AQUATIC

11. Rivers and Streams
12. Wetlands
13. Lakes and Ponds → …include (but are not limited to)
    - saline lakes
    - reservoirs
    - quarries
14. Estuaries and Near Coastal and Marine
15. Open Oceans and Seas
16. Groundwater → …include (but are not limited to)
    - rechargeable aquifers
    - geysers
    - water in caves

2. TERRESTRIAL

21. Forests → …include (but are not limited to)
    - uncut and wilderness area forests
    - rainforests
22. Agroecosystems
23. Created Greenspace → …include (but are not limited to)
    - parks, parkways, trees
    - cemeteries and airfields
    - lawns and golf courses
24. Grasslands
25. Scrubland / Shrubland
26. Barren / Rock and Sand → …include (but are not limited to)
    - abandoned (dry) quarries
    - dry desert
    - beaches, unvegetated dunes
27. Tundra
28. Ice and Snow

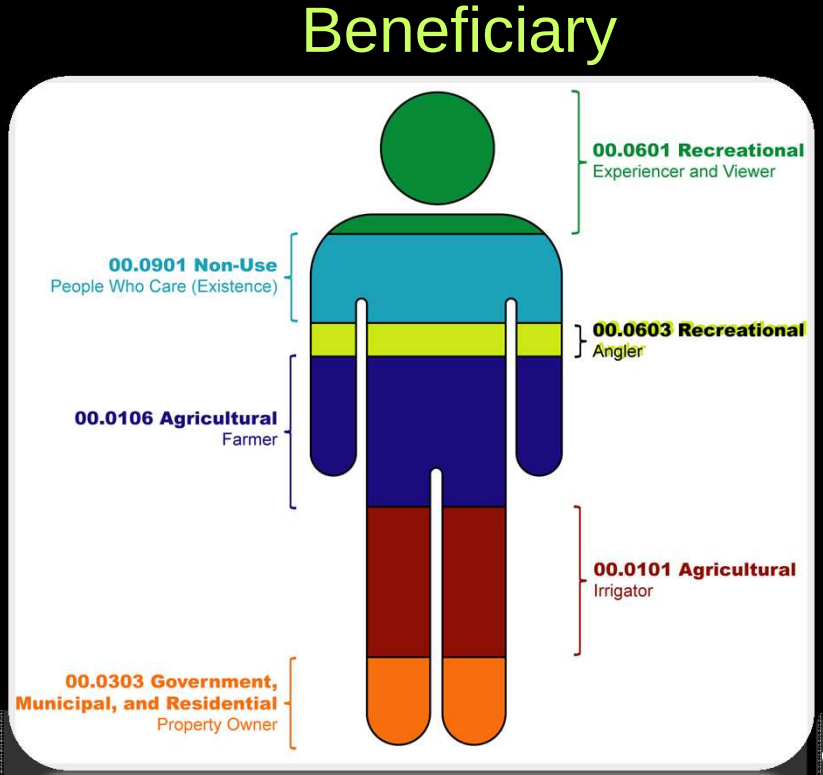
3. ATMOSPHERIC

31. Atmosphere

Beneficiary Categories

"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 → …including,
- 00.0103 Livestock Grazers
- 00.0106 Farmers

00.02. COMMERCIAL / INDUSTRIAL

00.03. GOVERNMENT, MUNICIPLE, AND RESIDENTIAL

00.04. COMMERCIAL / MILITARY TRANSPORTATION

00.05. SUBSISTENCE → …including,
- 00.0501 Water Subsisters
- 00.0503 Timber, Fiber, Fur / Hide Subsisters

00.06. RECREATIONAL

00.07. INSPIRATIONAL → …including,
- 00.0701 Spiritual and Ceremonial Participants
- 00.0702 Artists

00.08. LEARNING

00.09. NON-USE → …including,
- 00.0901 People Who Care (Existence)
- 00.0902 People Who Care (Option / Bequest)

00.10. HUMANITY

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

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

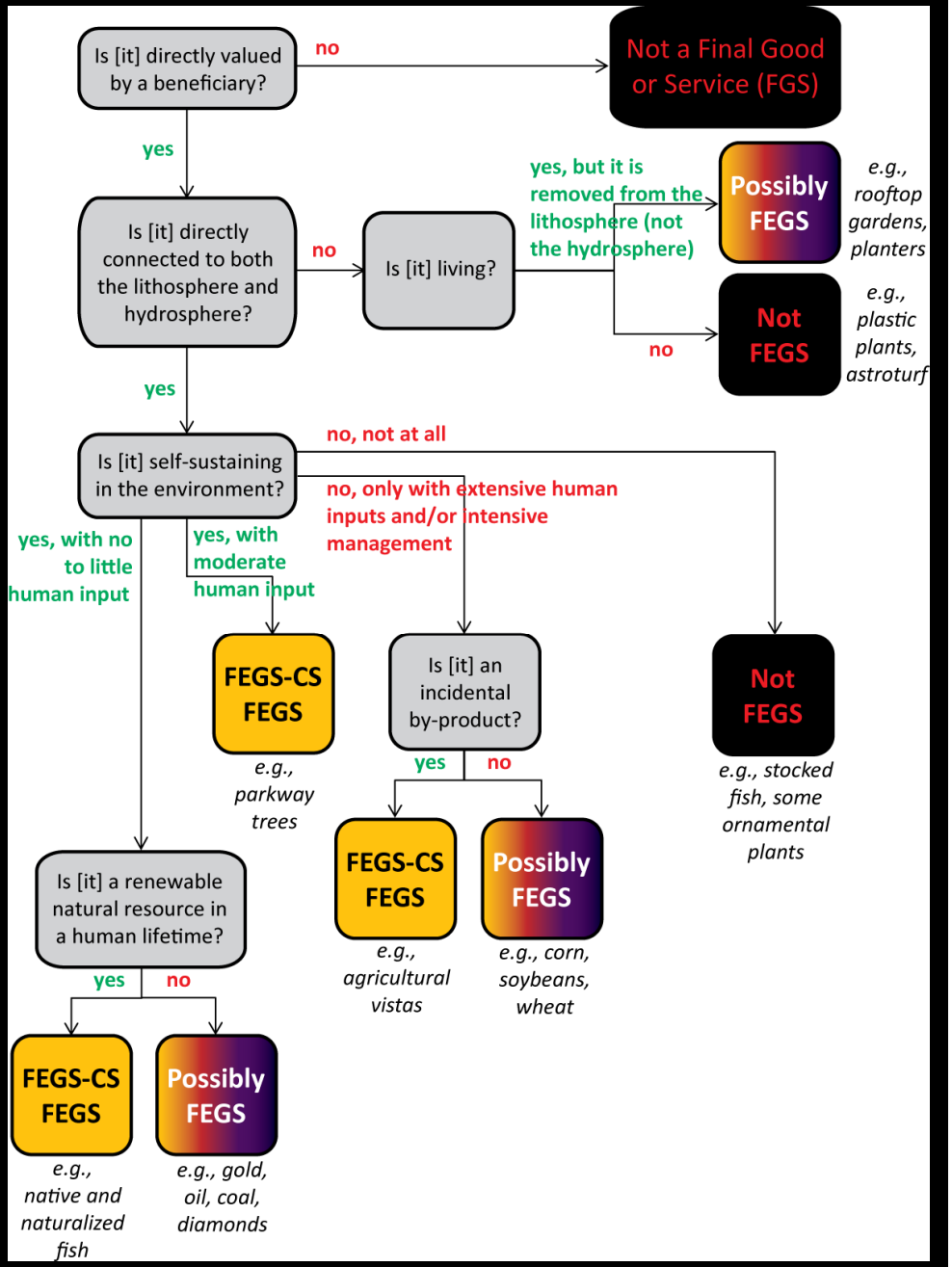
Update the web site as need and based on user feedback (new or additional FEGS; beneficiaries, environmental sub-classes…

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

XX.XX Beneficiary Categories				
00.06 Recreational	**00.07 Inspirational**	**00.08 Learning**	**00.09 Non-Use**	**00.10 Humanity**
XX.XXXX Beneficiary Sub-Categories				
00.0601 Experiencers and Viewers	00.0701 Spiritual and Ceremonial Participants	00.0801 Educators and Students	00.0901 People Who Care (Existence)	00.1001 All Humans
00.0602 Food Pickers and Gatherers	00.0702 Artists	00.0802 Researchers	00.0902 People Who Care (Option / Bequest)	
00.0603 Hunters				
00.0604 Anglers				
00.0605 Swimmers, Waders, and Divers				
00.0606 Boaters				

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, binomial, identification number

11. RIVERS AND STREAMS

Beneficiary Categories and Sub-Categories	Potentially Relevant NAICS Code(s)	General Beneficiary Description	FEGS	Examples of FEGS	Importance of FEGS to the Beneficiary
11.02 Commercial / Industrial					
11.0205 Electric and other Energy Generators	221	*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.*	• presence of the environment • water		• opportunity to install power generation structures, such as dams and water turbines • flowing water that can be used for energy generation

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*