



United States Environmental Protection Agency  
Office of Research and Development

# A Final Ecosystem Goods and Services Classification System (FEGS-CS)

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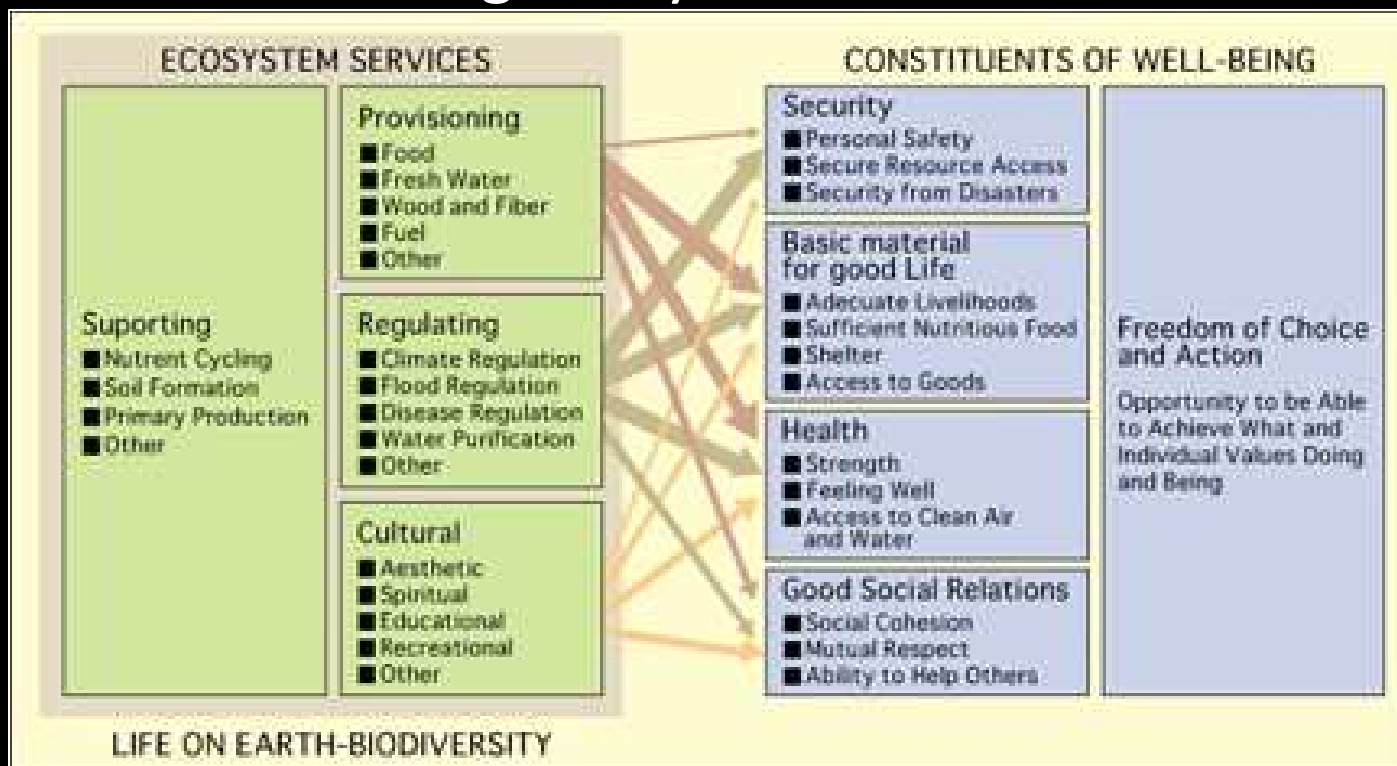
# Humans Define and Classify Items of Importance in Order to Communicate



Chauvet Cave in the valley of the Ardèche River in France, 30,000-32,000 BP

# 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)



# 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

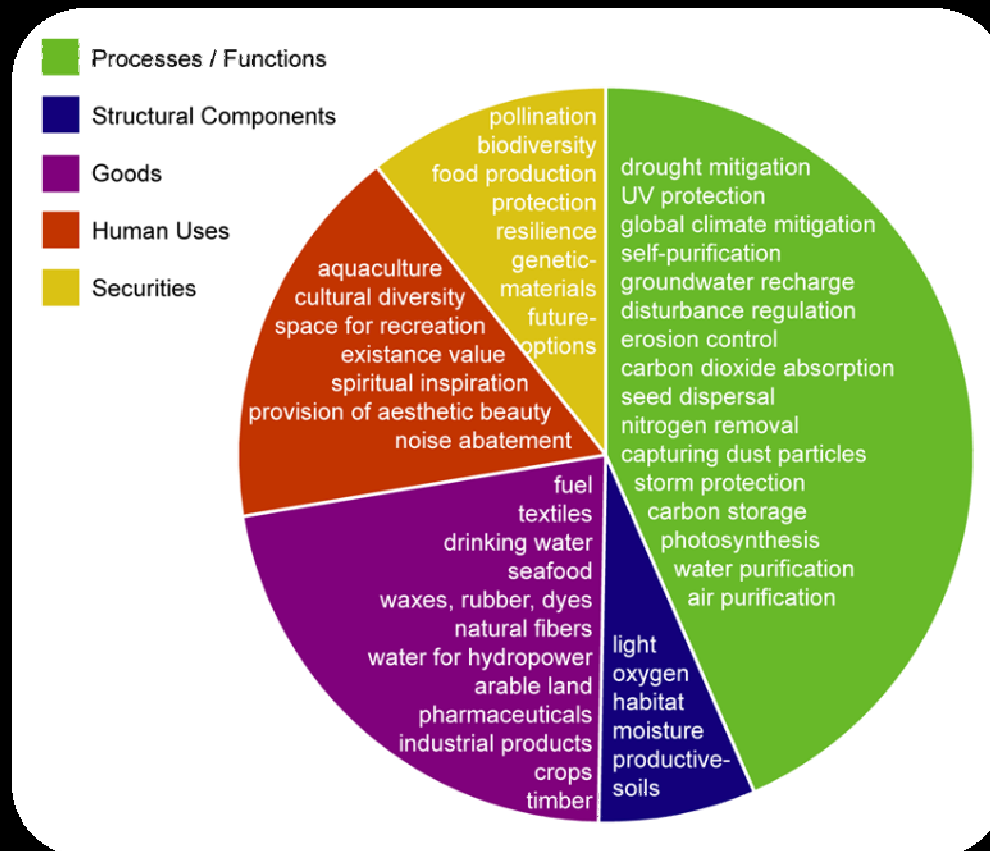


fauna



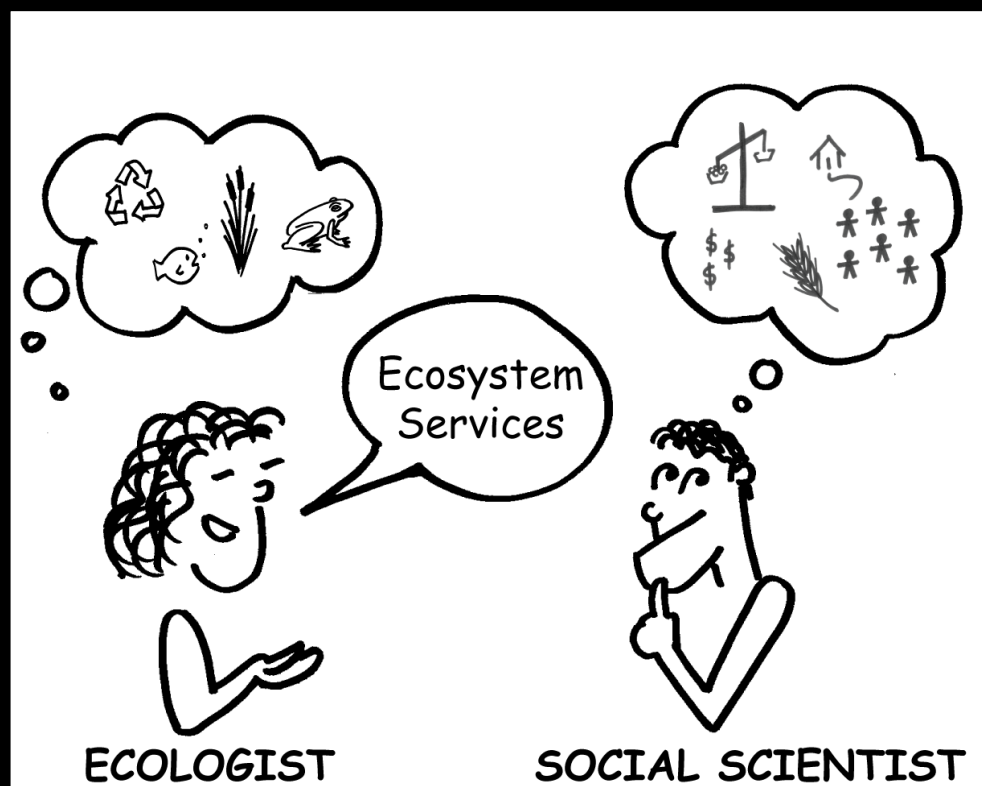


# What ecosystem services do scientists measure from this seemingly endless list?



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.

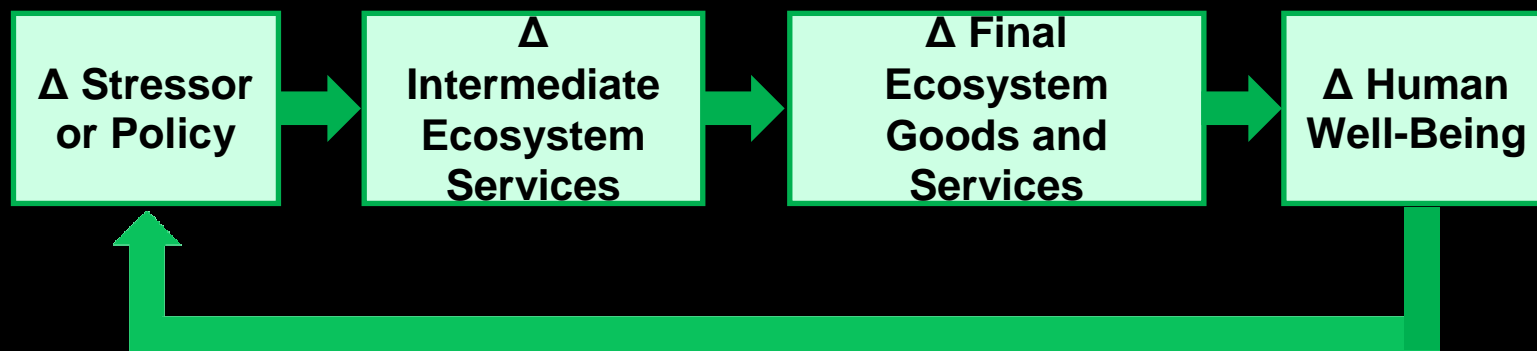
How do we connect  
ecosystem services to human  
well-being?



# 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**

# 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.



# 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

**Generic  
Production Function**

Environment

Human  
Well-Being



Environment

**FEGS**

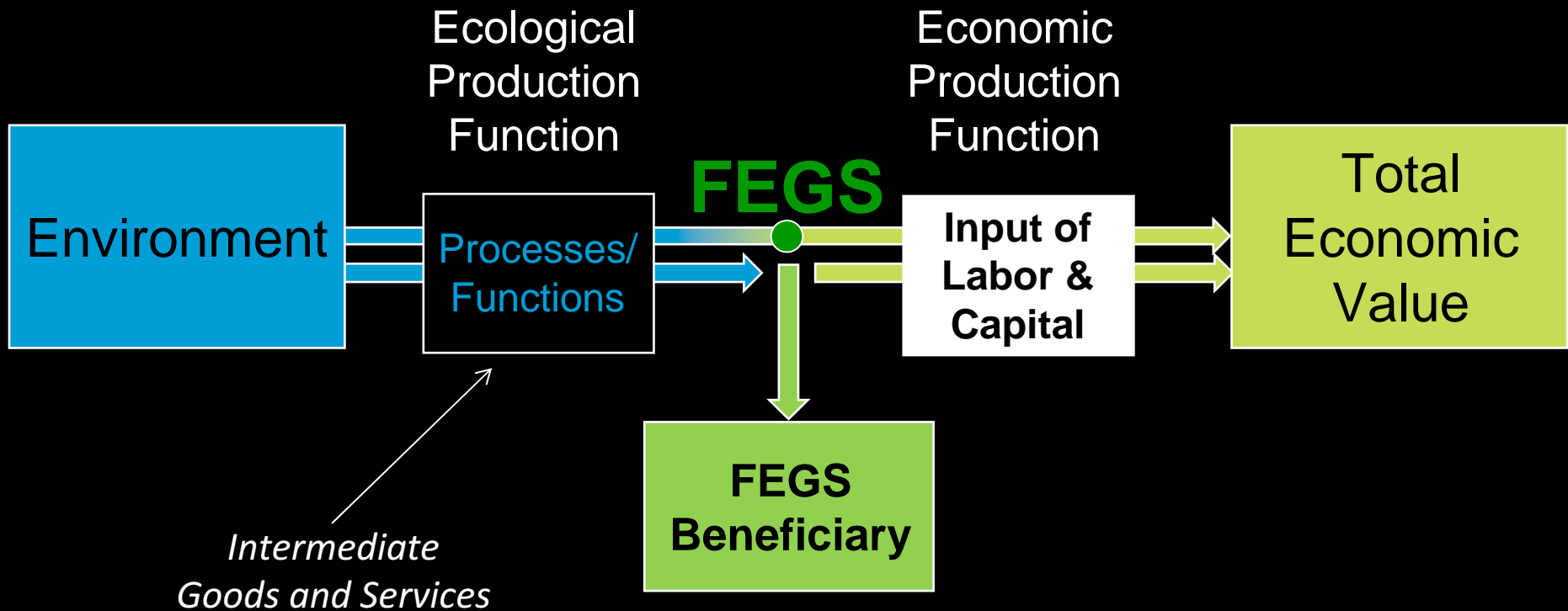
Human Well-Being

**Ecological  
Production  
Function**

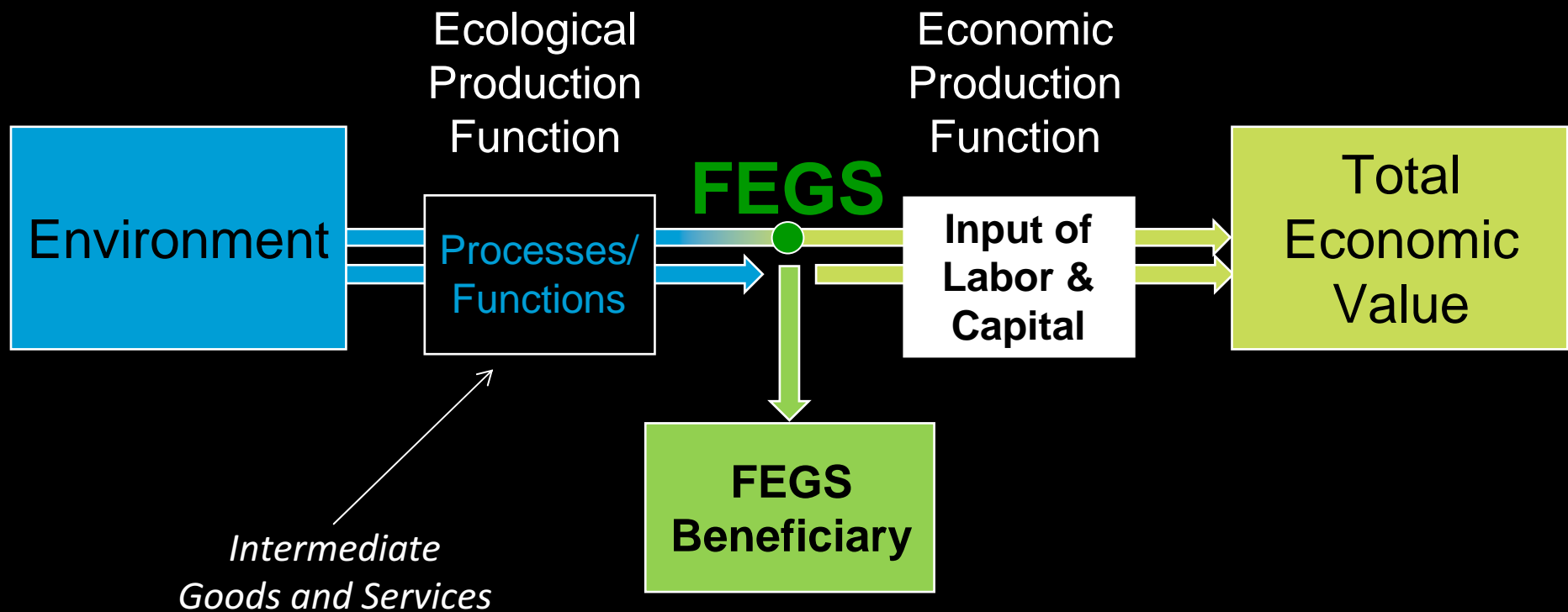
**Economic  
Production  
Function**



# Example 1: Recreational Fishing

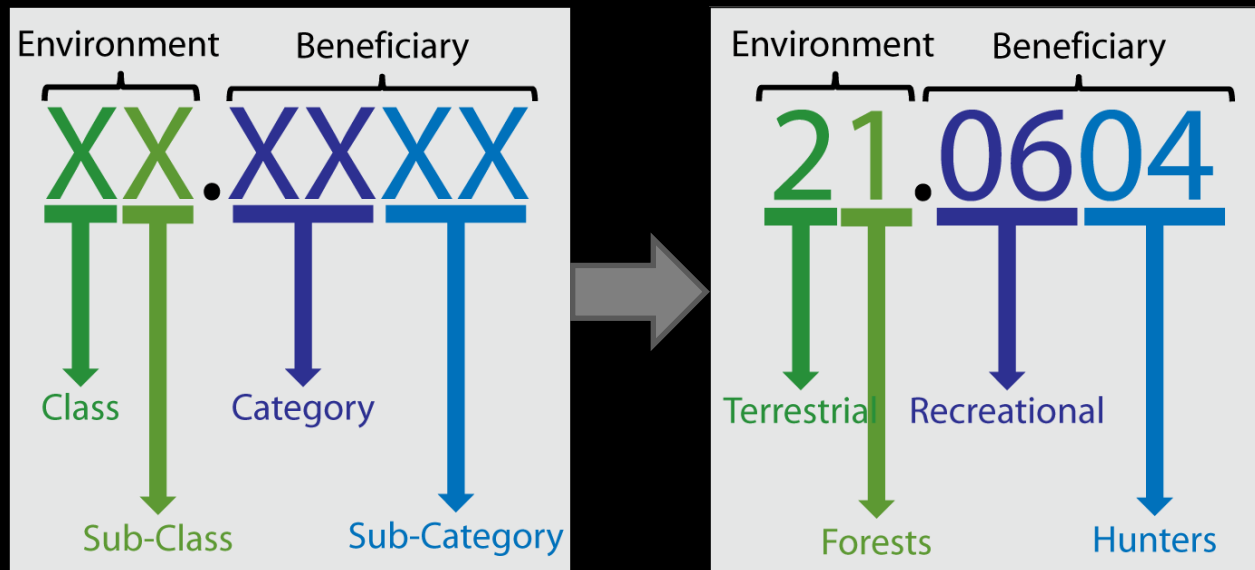


# Example 2: Carrot Farming



# Our Classification Scheme

X	Environmental Class
XX.	Environmental Sub-Class
XX.XX	Beneficiary Category
XX.XXXX	Beneficiary Sub-Category

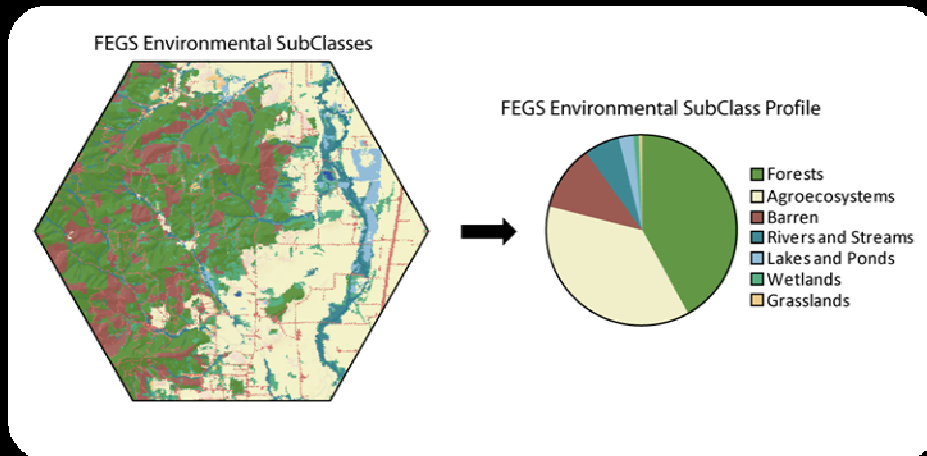




# Environmental Classes

“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)

14. Estuaries and Near Coastal and Marine

• saline lakes

15. Open Oceans and Seas

• reservoirs

16. Groundwater

→ ...include (but are not limited to)

• rechargeable aquifers

• geysers

• water in caves → ...include (but are not limited to)

• uncut and wilderness area forests

## 2. TERRESTRIAL

21. Forests

22. Agroecosystems

23. Created Greenspace

→ ...include (but are not limited to)

24. Grasslands

• parks, playgrounds, trees

25. Scrubland / Shrubland

• cemeteries and airfields

26. Barren / Rock and Sand

→ ...include (but are not limited to)

27. Tundra

• abandoned (dry) quarries

28. Ice and Snow

• dry desert

• beaches, unvegetated dunes

## 3. ATMOSPHERIC

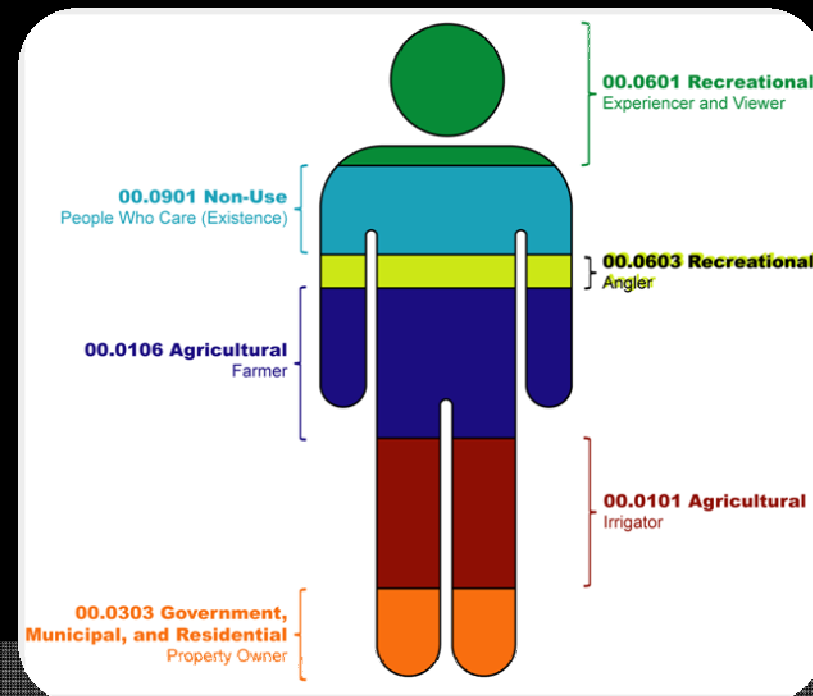
31. Atmosphere

# Beneficiary Categories

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

## Beneficiary

- 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, MUNICIPAL, 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,

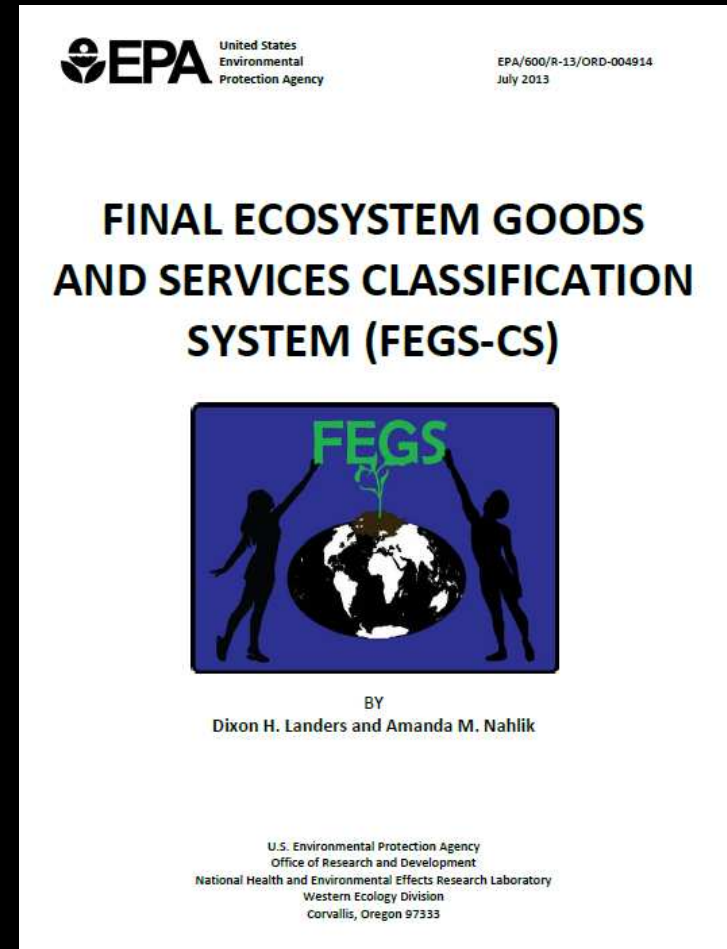
- 00.0901 People Who Care (Existence)
- 00.0902 People Who Care (Option / Bequest)

## 00.10. HUMANITY

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

# 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/](http://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 Atlas, mapping and models
  - Provide comments to the authors
  - Participate in forum discussions
  - Web development currently in progress

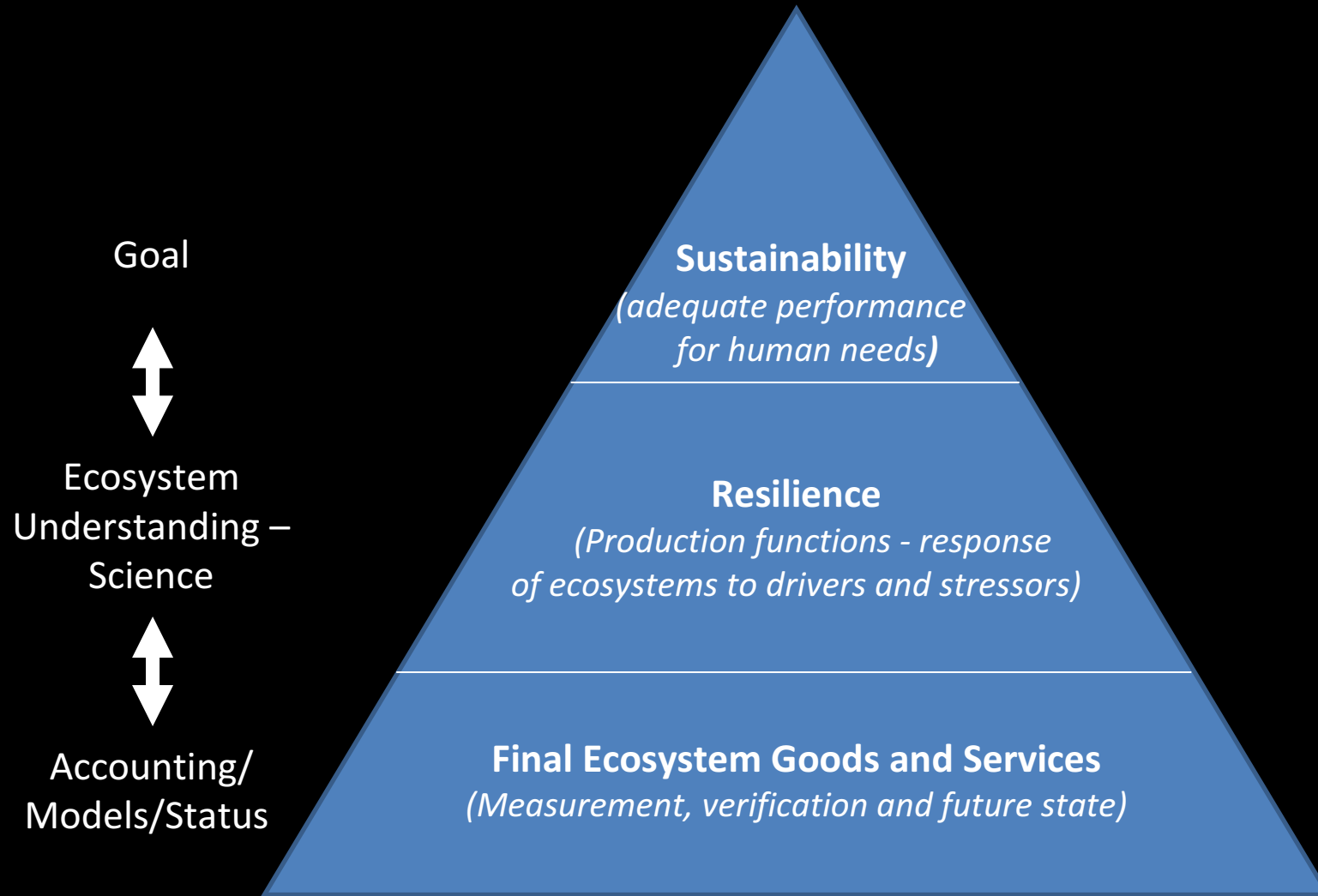




## Incorporation of FEGS to USEPA Decision Making

- 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

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



END

# 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.

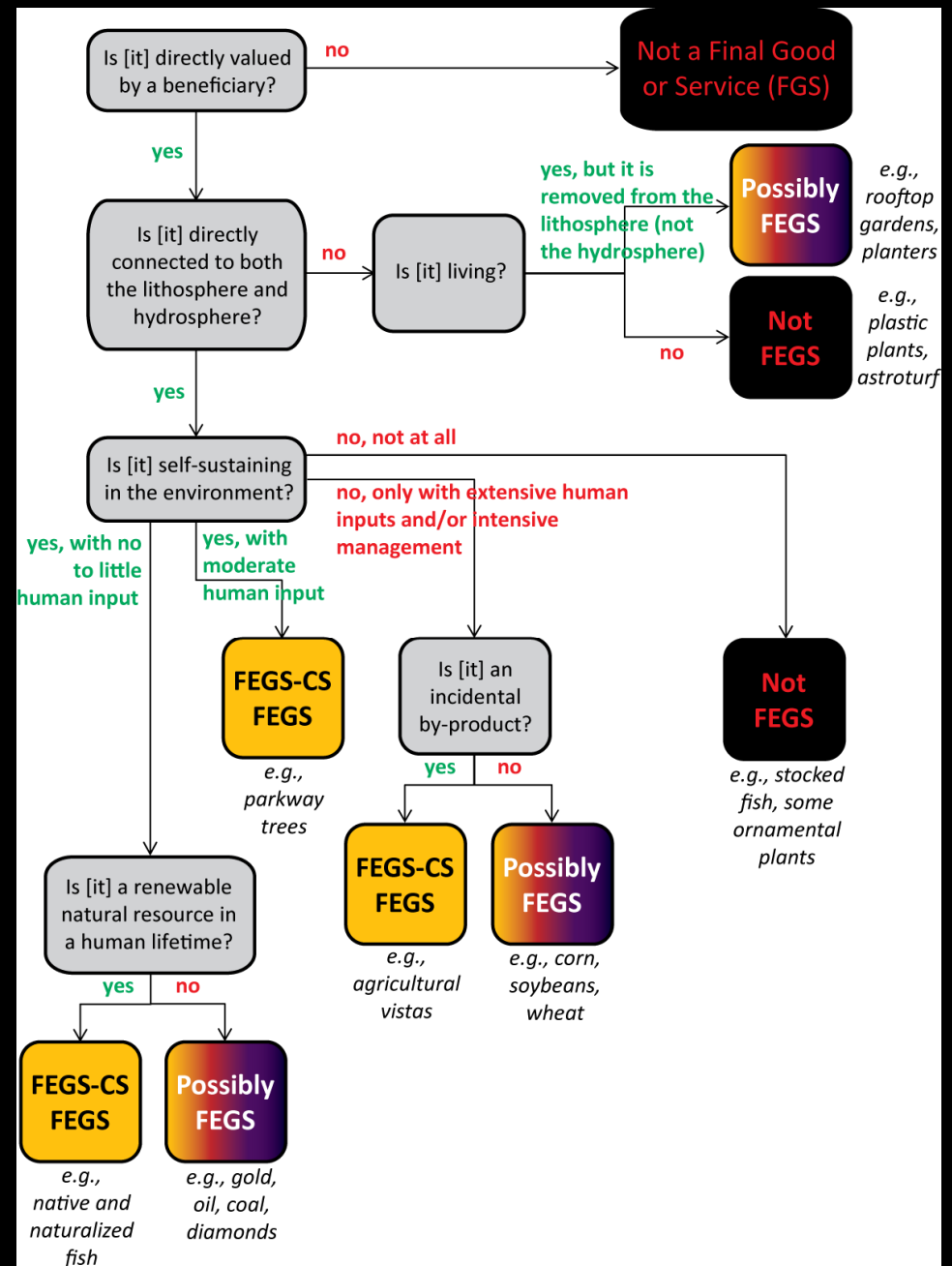
XX.XX Beneficiary Categories				
00.01 Agricultural	00.02 Commercial / Industrial	00.03 Government, Municipal, and Residential	00.04 Commercial / Military Transportation	00.05 Subsistence
XX.XXXX Beneficiary Sub-Categories				
00.0101 Irrigators	00.0201 Food Extractors	00.0301 Drinking Water Consumers	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 Residential 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*



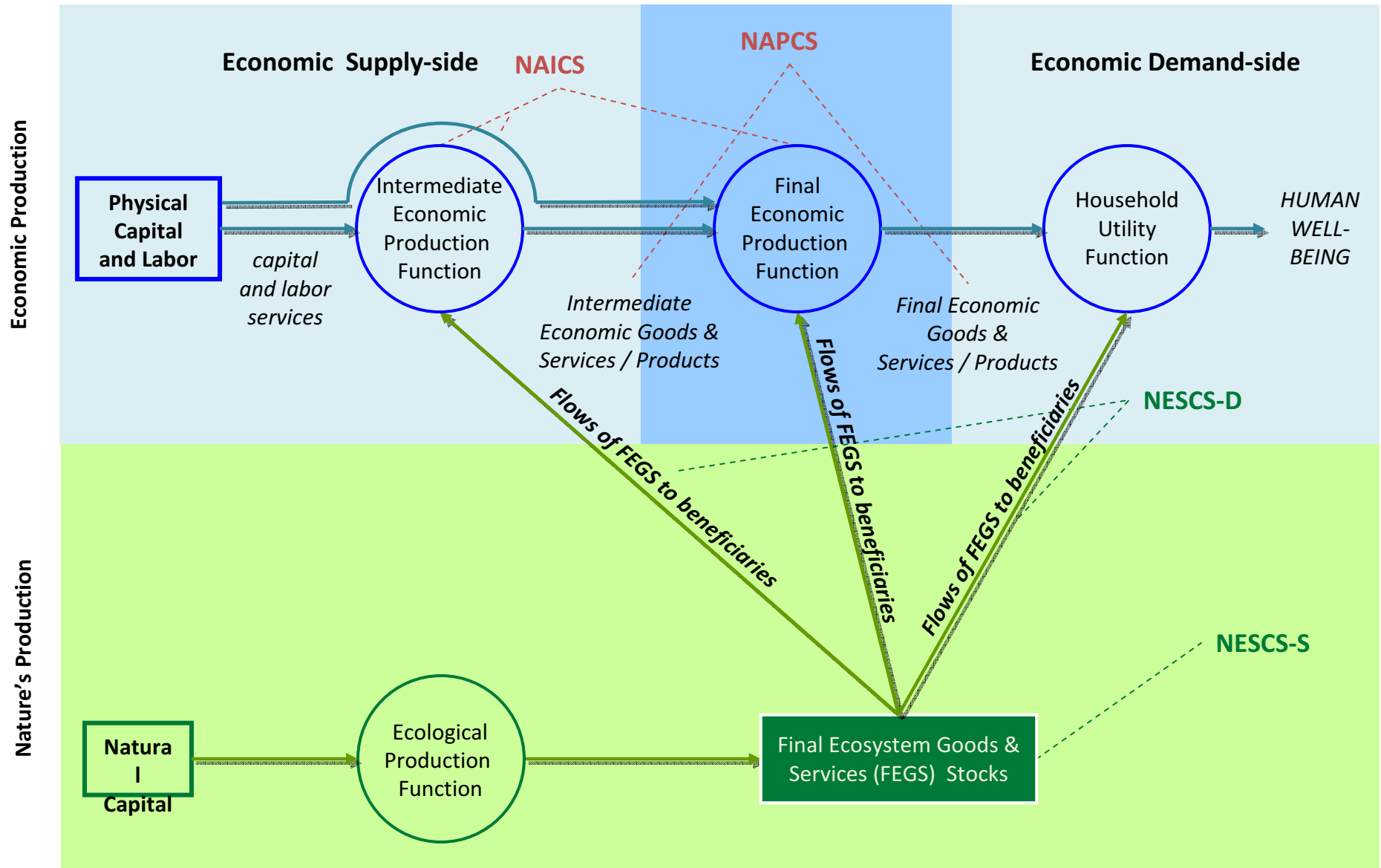
# What are ecosystem services?



# 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

# NESCS (linking FEGS with Economic Benefit and Cost Analysis)



# 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	<i>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.</i>	<ul style="list-style-type: none"> <li>• presence of the environment</li> <li>• water</li> </ul>		<ul style="list-style-type: none"> <li>• opportunity to install power generation structures, such as dams and water turbines</li> <li>• flowing water that can be used for energy generation</li> </ul>



# 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*