

United States Environmental Protection Agency
Office of Research and Development

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

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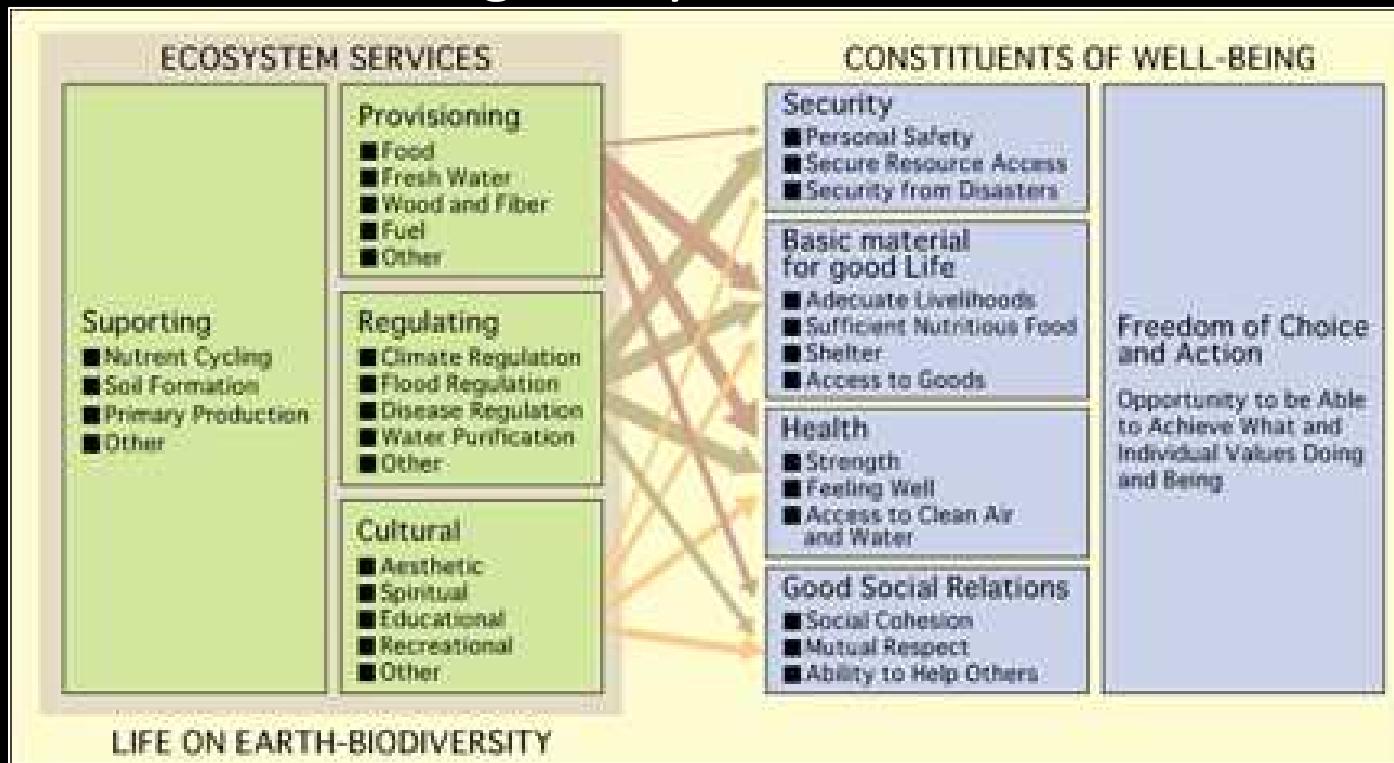
Humans Define and Classify Items of Importance in Order to Communicate



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.



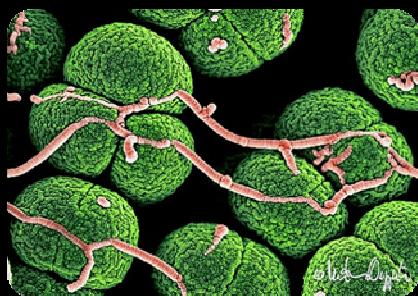
“Ecosystem services are the benefits people obtain from ecosystems.” (MEA 2005)

What is the problem?

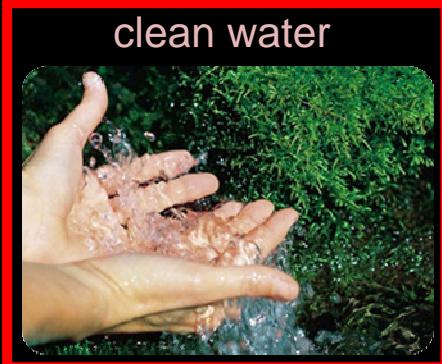
- Many definitions and disparate “lists,” “frameworks,” and “perceptions” of ecosystem services
- Miscommunication and discord among disciplines
- Disconnect between environment and human well-being
- Lack of consistency, rigor and a systematic approach; need typology and classification for “framework”

What do people care about?

soil microbes



clean water



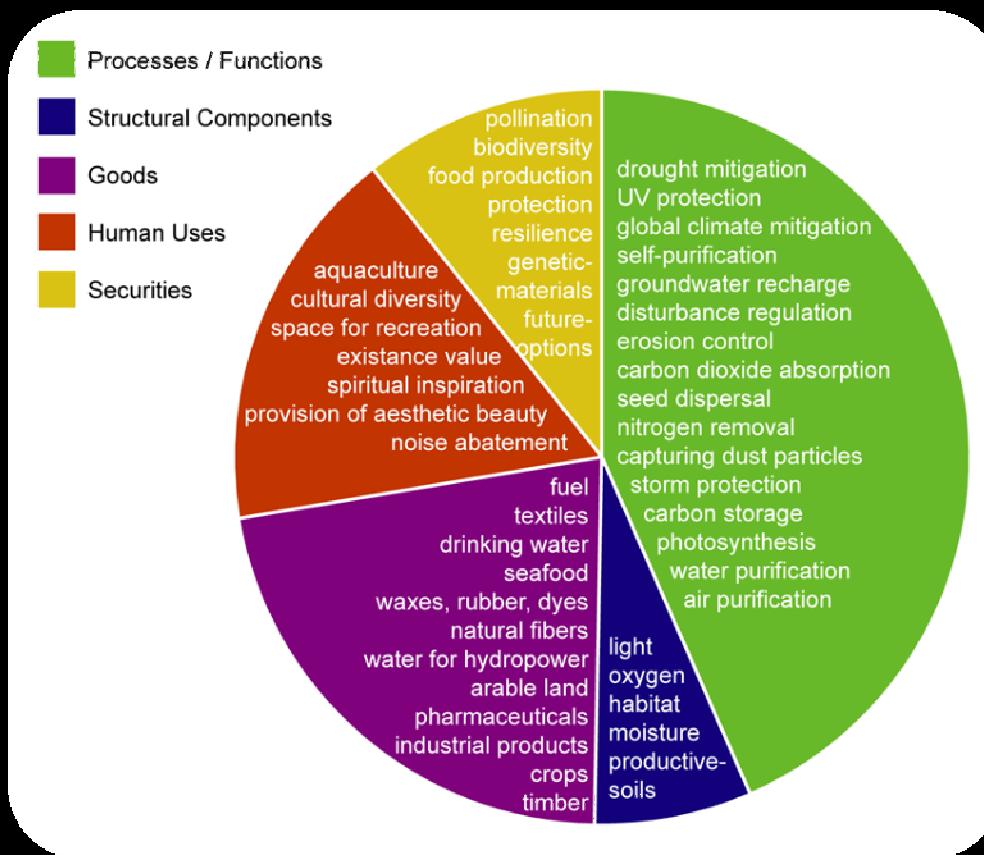
habitat



fauna

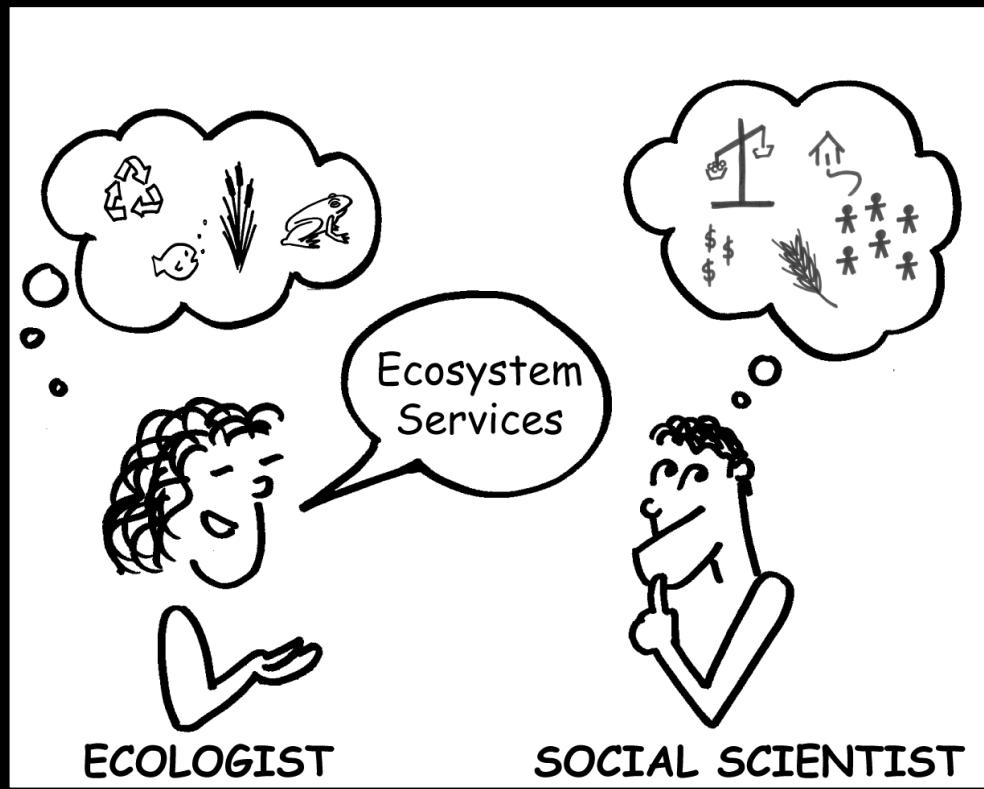


What ecosystem services do scientists measure from this seemingly endless list?



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.



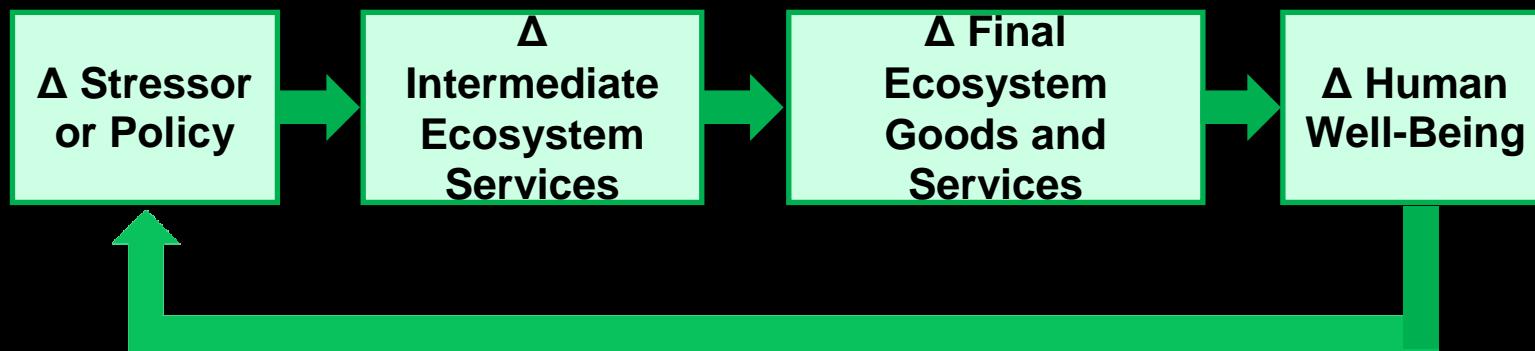
Connecting ecosystem services to benefits requires interdisciplinary approaches.

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.”



water quality?



water quantity?

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



subsister



irrigator

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

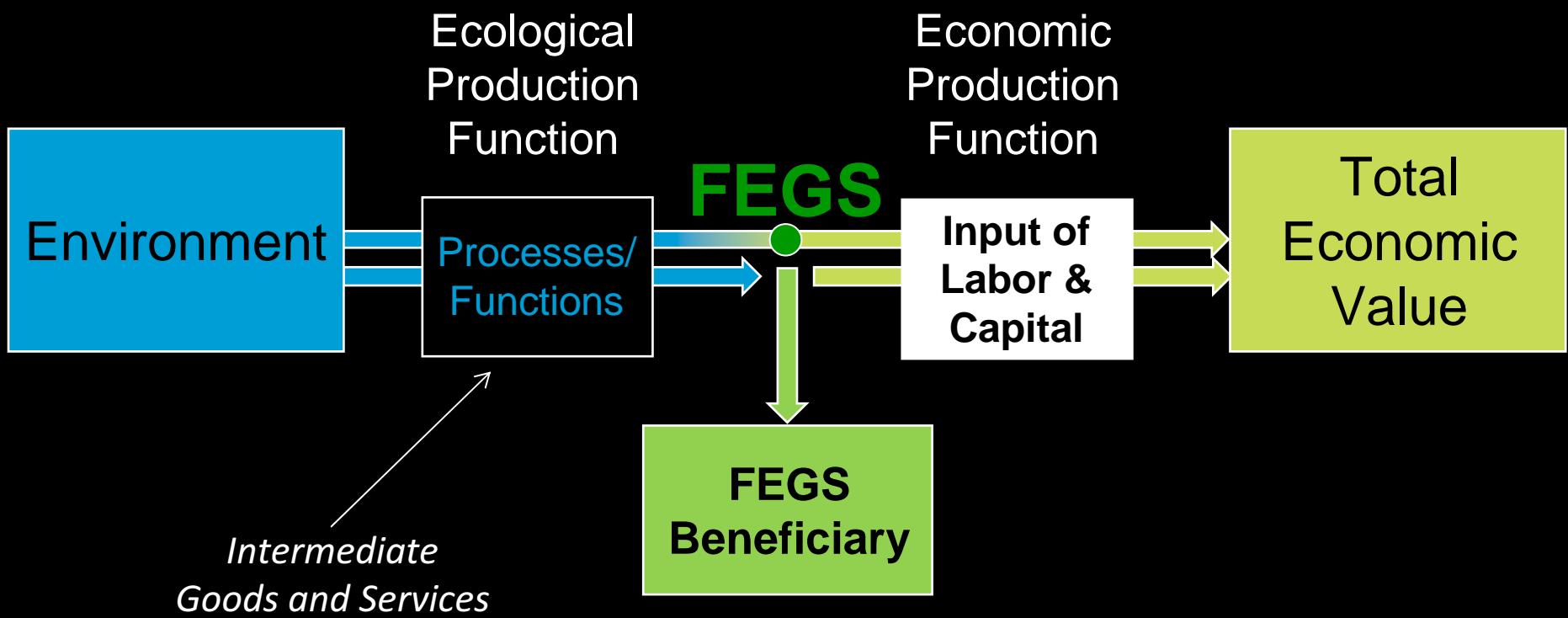




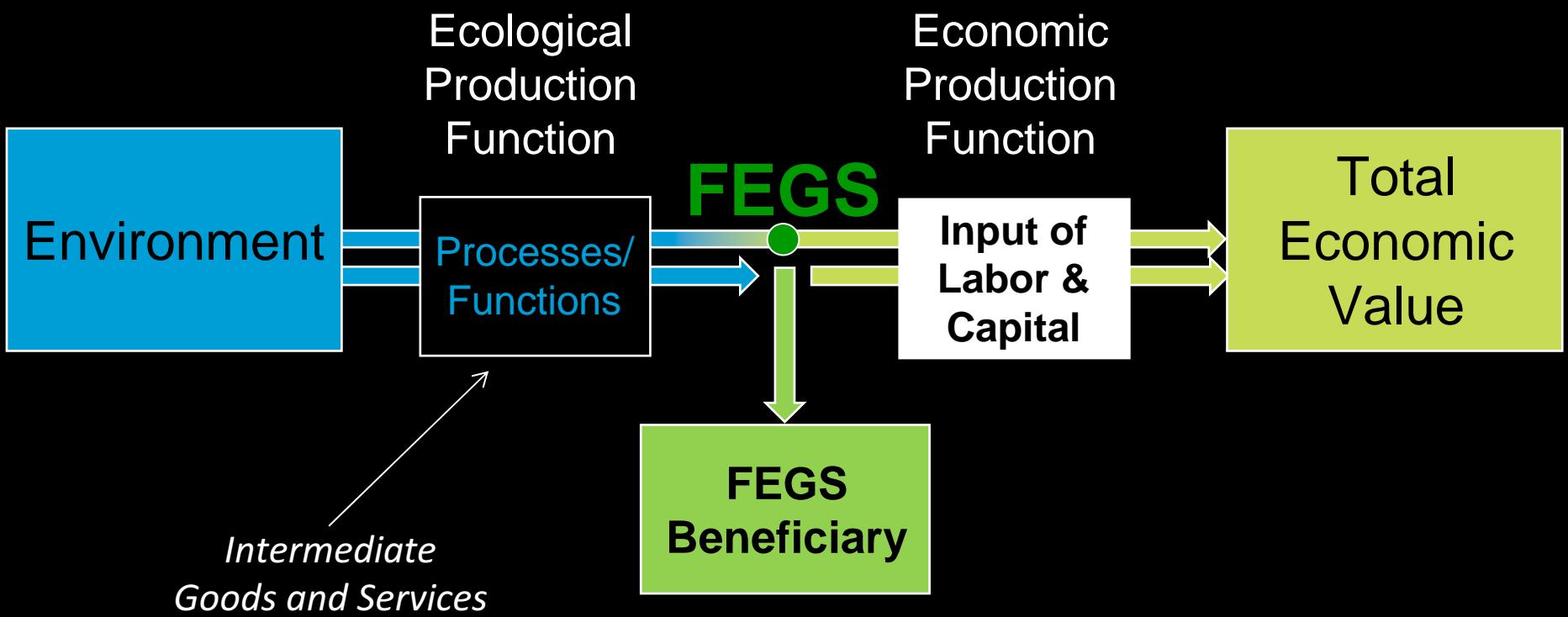
Ecological
Production
Function

Economic
Production
Function

Example 1: Recreational Fishing



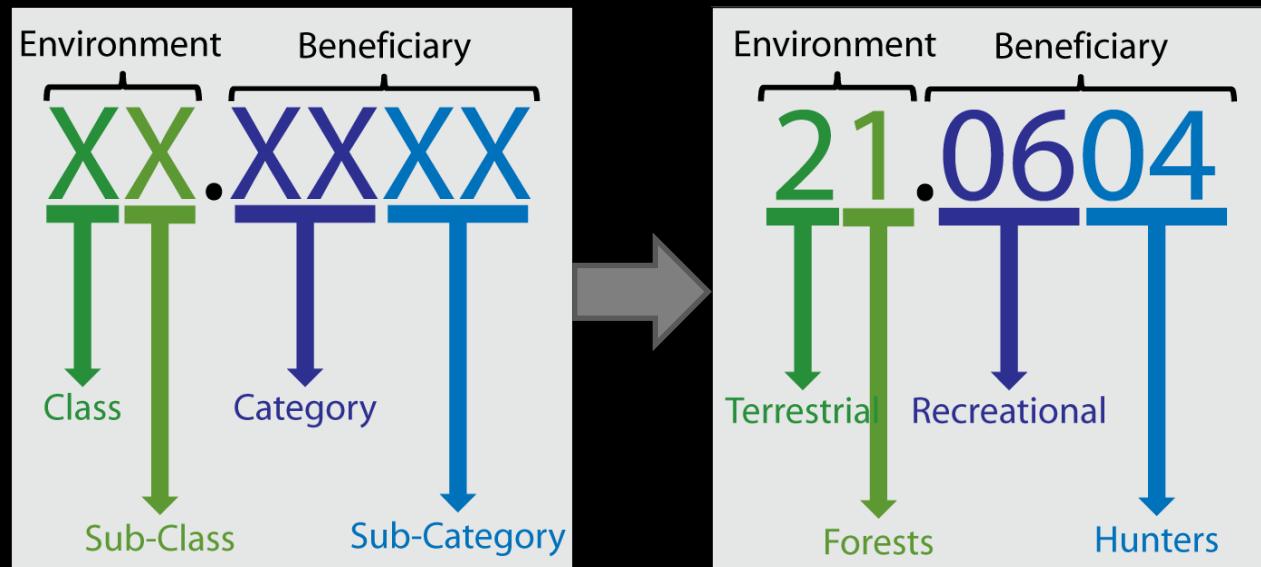
Example 2: Carrot Farming



Our Classification Scheme

FEGS Classification Structure

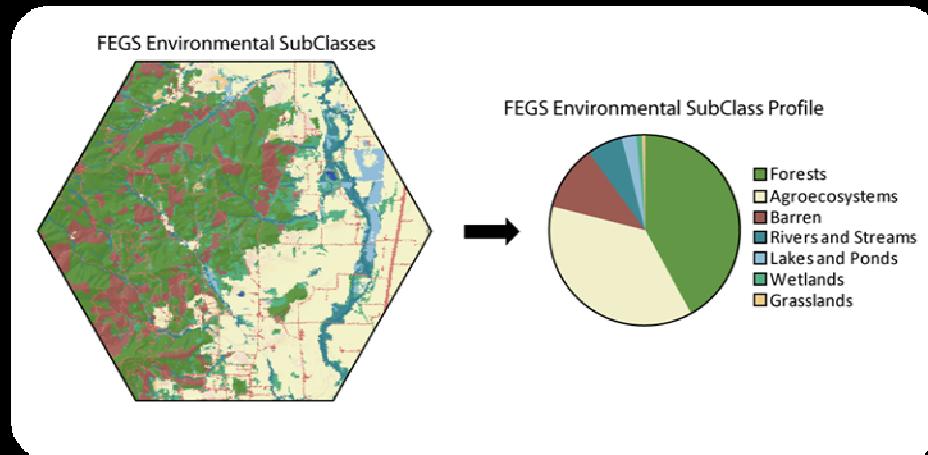
X	Environmental Class
XX.	Environmental Sub-Class
XX.XX	Beneficiary Category
XX.XXXX	Beneficiary Sub-Category



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)
 - saline lakes
 - reservoirs
- 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
- 22. Agroecosystems
- 23. Created Greenspace → ...include (but are not limited to)
 - parks, parkways, trees
 - cemeteries and airfields
- 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

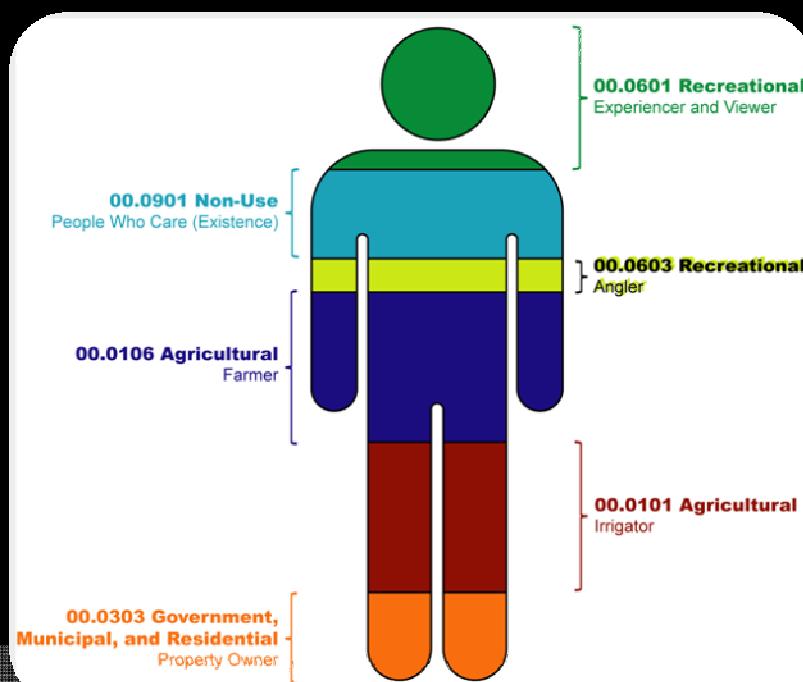
- 31. Atmosphere

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



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 Subsistors
- 00.0503 Timber, Fiber, Fur / Hide Subsistors

00.06. RECREATIONAL

00.07. INSPIRATIONAL

→ ...including,

- 00.0701 Spiritual and Ceremonial Participants
- 00.0702 Artists

00.08. LEARNING

00.09. NON-USE

→ ...including,

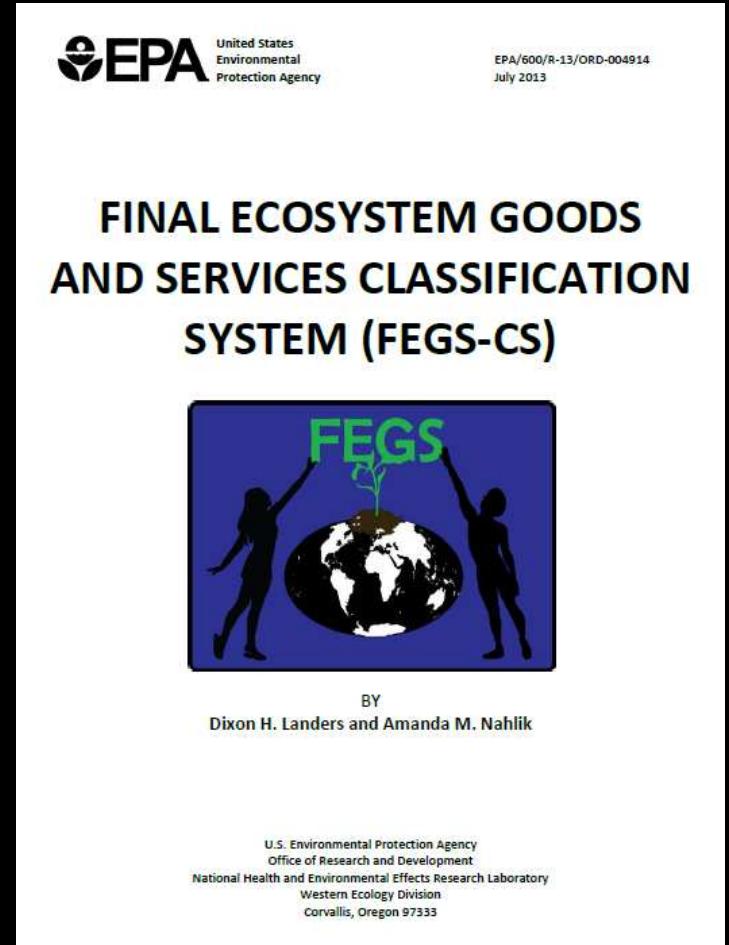
- 00.0901 People Who Care (Existence)
- 00.0902 People Who Care (Option / Bequest)

00.10. HUMANITY

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

Identifying FEGS

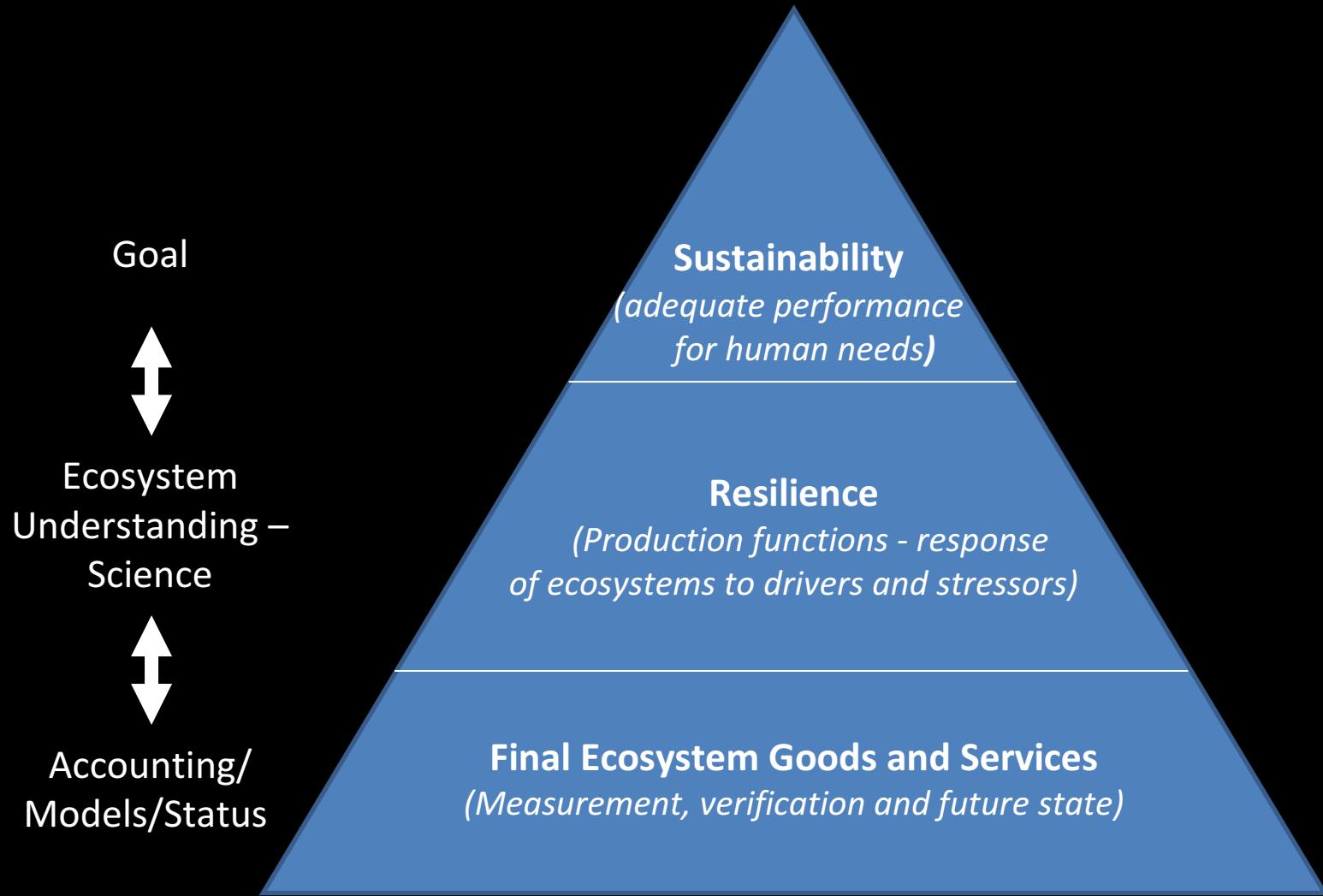
- By using the FEGS approach, an infinite list of ecosystem services was pared down to 338 FEGS
- FEGS-CS is an operational framework that standardizes identification of ecosystem services at multiple spatial scales
- Published EPA Report
 - Available at cfpub.epa.gov/si/
 - EPA/600/R-13/ORD-004914
- 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 FEGRS 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 FEGRS
- Collaboration on developing NESCS with Office of Water and Office of Air and Radiation to incorporate FEGRS 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



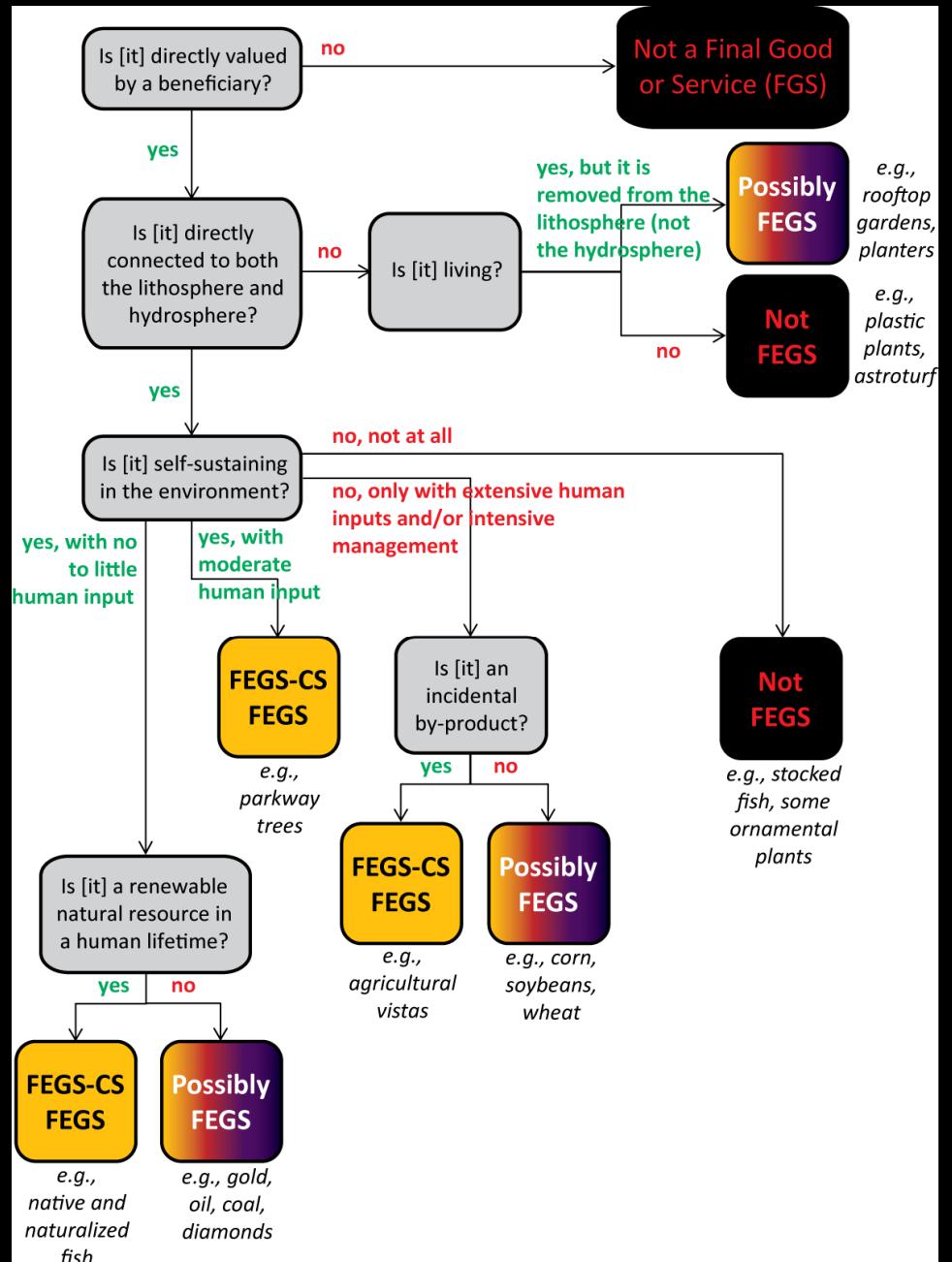
Flora and fauna, such as
mussels, seaweed, crabs, etc.

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 Subsistors
00.0102 CAFO Operators	00.0202 Mineral Extractors	00.0302 Waste Water Treatment Plant Operators	00.0402 Transporters of People	00.0502 Food Subsistors
00.0103 Livestock Grazers	00.0203 Timber, Fiber, and Ornamental Extractors	00.0303 Residential Property Owners		00.0503 Fiber and Fur Subsistors
00.0104 Agricultural Processors	00.0204 Industrial Processors	00.0304 Military / Coast Guard		00.0504 Building Material Subsistors
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*

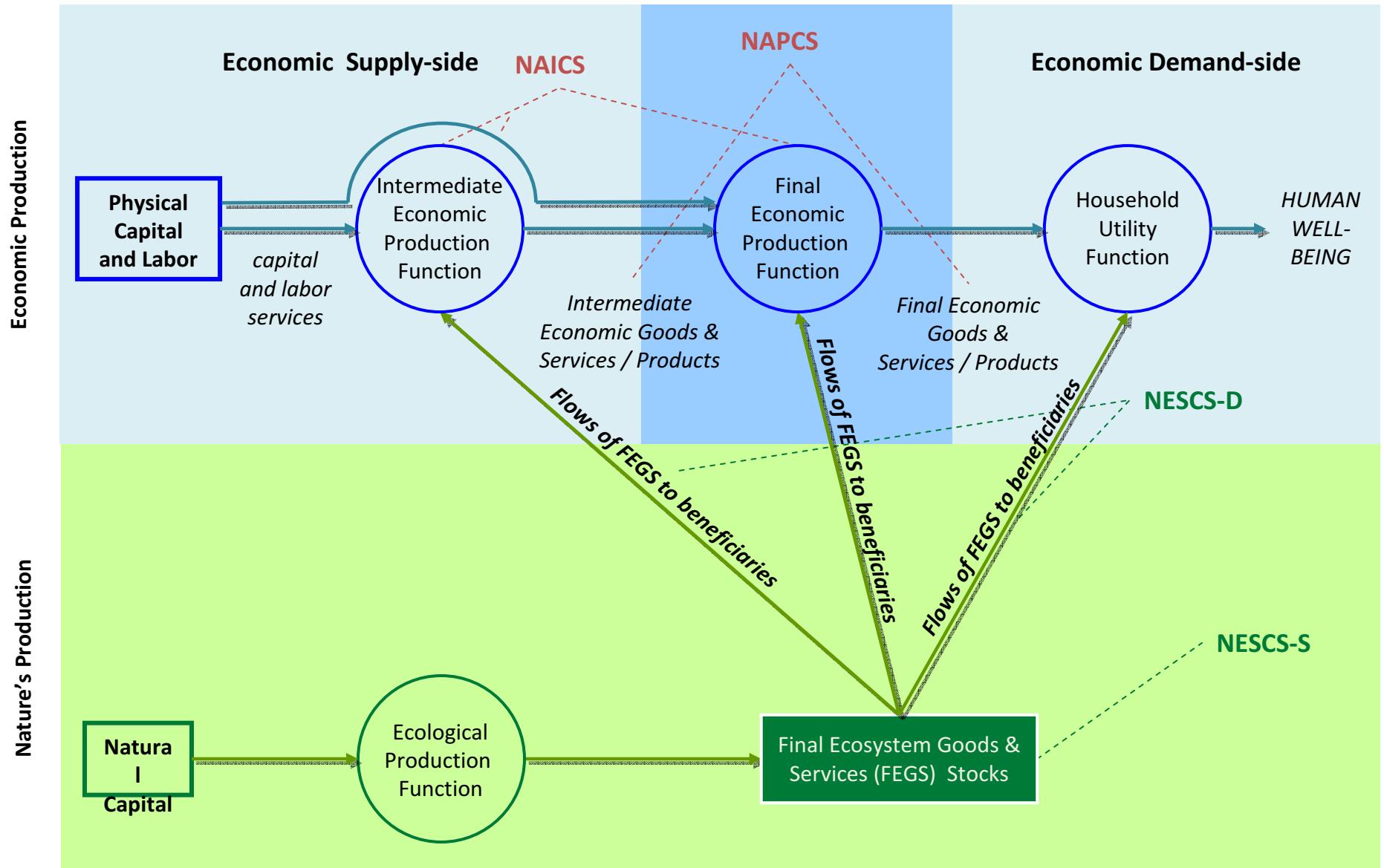
What are ecosystem services?



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	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*