



United States Environmental Protection Agency
Office of Research and Development

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)

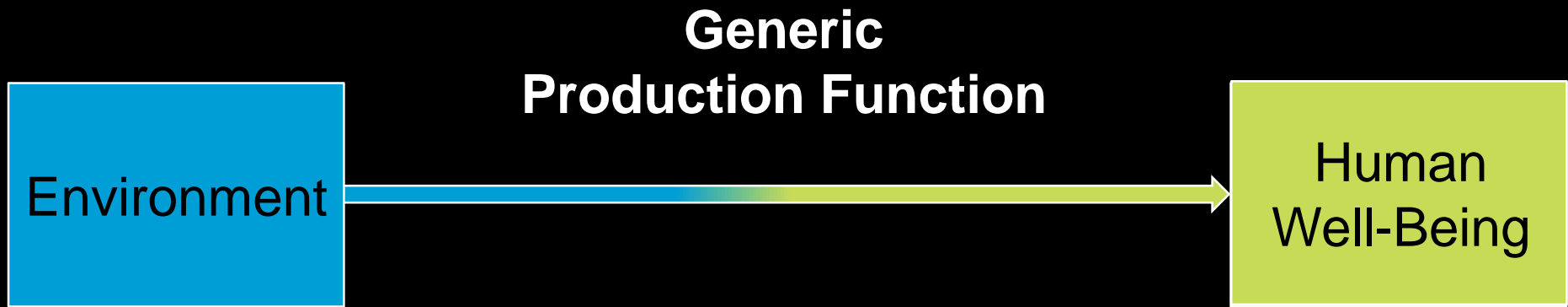


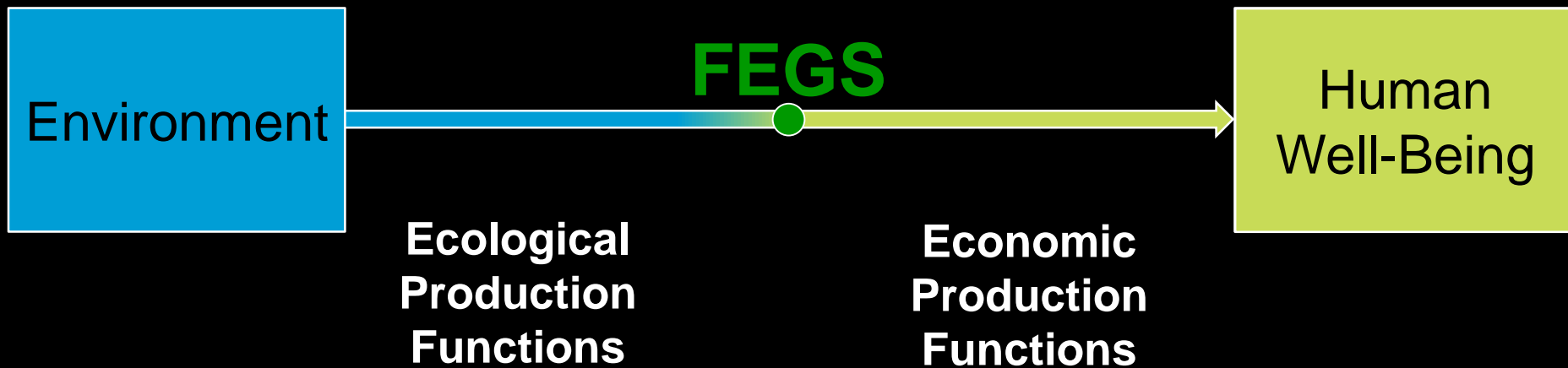
Environmental Class + Beneficiary → FEGS

Five Key Steps:

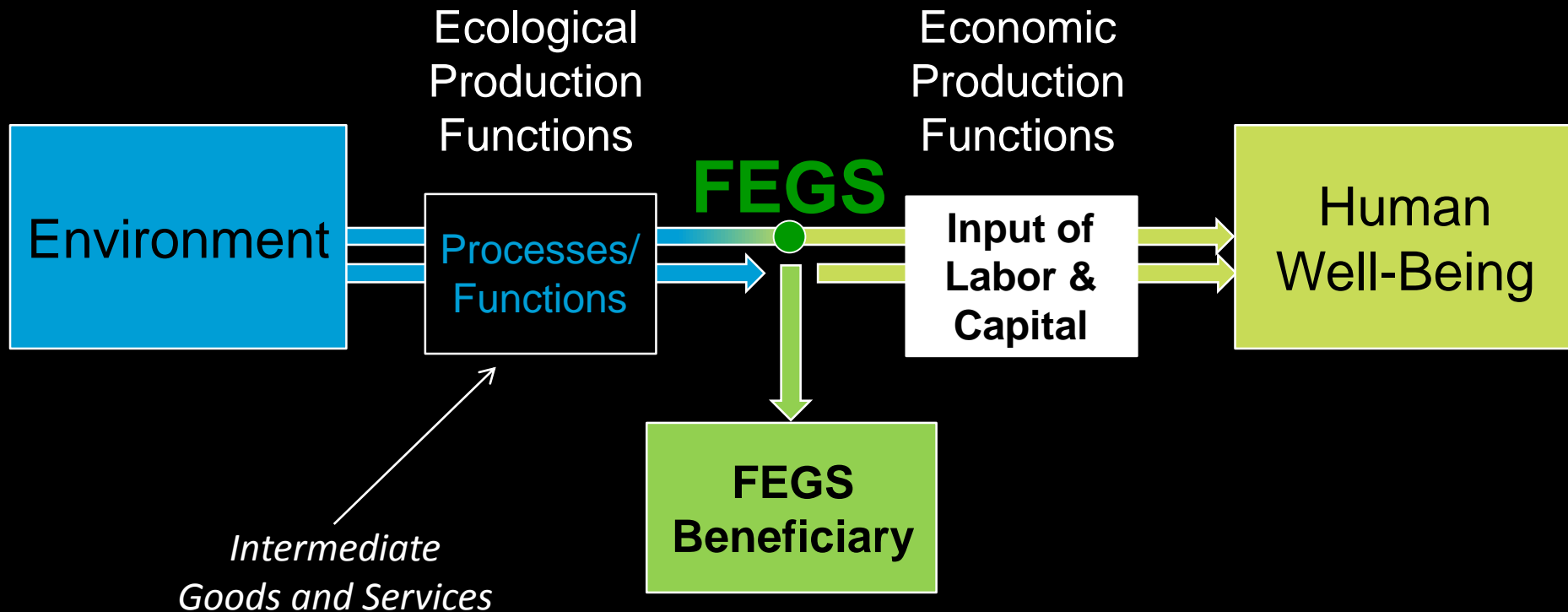
1. Clearly define the environmental boundaries
2. Identify categories of beneficiaries (users)
3. For any Beneficiary and Environmental Class, hypothesize **POTENTIAL FEGS**
4. Identify and avoid “intermediate services” (generally processes and functions)
5. Establish boundaries (EcolPF:EconPF, corn and carrots, lithosphere, hydrosphere)





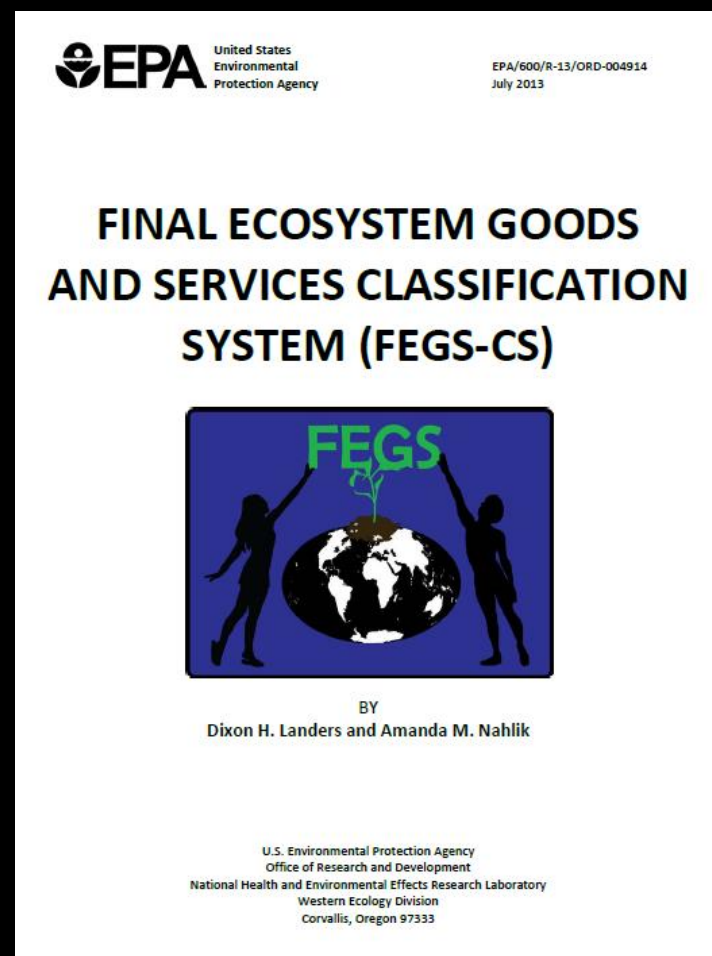


Example : Agroecosystems



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>
 - 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

Beneficiary Categories and Sub-Categories	Potentially Relevant NAICS Code(s)	General Beneficiary Description	FEGS	Examples of FEGS	Importance of FEGS to the Beneficiary	Potential Metric(s) and/or Indicator(s)
22.01 Agricultural						
22.0103 Livestock Grazers	112	<i>This beneficiary uses the environment to graze livestock. Cultivated vegetation is NOT considered a FEGS. For agroecosystems, "planted" pastures only provide space and opportunity to grow feed (not the vegetation itself).</i>	<ul style="list-style-type: none"> • soil • open space 		<ul style="list-style-type: none"> • 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 	
22.0106 Farmers	111, 113	<i>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.</i>	<ul style="list-style-type: none"> • soil • open space • pollinators • depredators and (pest) predators 		<ul style="list-style-type: none"> • 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 depredators and (pest) predators that provide opportunity to grow annual or perennial crops 	
22.02 Commercial / Industrial						
22.0202 Timber, Fiber, and Ornamental Extractors	113, 339, 424, 453, 454	<i>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, gems, etc.) are considered FEGS.</i>	<ul style="list-style-type: none"> • natural materials 		<ul style="list-style-type: none"> • non-cultivated ornamental products or by-products (from cultivation) used ornamentally for commercial use or sale 	
22.0205 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"> • presence of the environment 		<ul style="list-style-type: none"> • opportunity to install power generation structures 	
22.0206 Resource-Dependent Businesses	487, 712, 713, 721, 722	<i>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.</i>	<ul style="list-style-type: none"> • presence of the environment 		<ul style="list-style-type: none"> • opportunity for placement of infrastructure and reduced/increased risk of erosion, fire, and pest infestation on the property 	
22.03 Government, Municipal, and Residential						
22.0303 Residential Property Owners	531, 532, 814	<i>While changes in property value are not a FEGS, residential property owners are affected by the environment in which their property resides.</i>	<ul style="list-style-type: none"> • presence of the environment 		<ul style="list-style-type: none"> • opportunity for placement of infrastructure and reduced/increased risk of erosion, fire, and pest infestation on the property 	
22.06 Recreational						

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22.0601 Experiencers and Viewers	None	<i>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.</i>	<ul style="list-style-type: none"> • presence of the environment • viewscapes • flora • fauna • fungi • sounds and scents 		<ul style="list-style-type: none"> • 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	<i>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.</i>	<ul style="list-style-type: none"> • fauna 	• pheasant, deer, elk, rabbit	<ul style="list-style-type: none"> • organisms (i.e., birds, mammals, reptiles, etc.) that can be hunted 	
22.07 Inspirational						
22.0701 Spiritual and Ceremonial Participants and Participants of Celebration	813	<i>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.</i>	<ul style="list-style-type: none"> • presence of the environment 		<ul style="list-style-type: none"> • opportunity and conditions for spiritual and ceremonial practices and celebrations 	
22.0702 Artists	339, 423, 424, 512, 711	<i>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.</i>	<ul style="list-style-type: none"> • presence of the environment • viewscapes • sounds and scents • natural materials 	• corn sheaths, dried flowers	<ul style="list-style-type: none"> • 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						
22.0801 Educators and Students	611	<i>This beneficiary includes both formal and self-taught educators and students. All parts of the environment are of interest.</i>	<ul style="list-style-type: none"> • presence of the environment 		<ul style="list-style-type: none"> • opportunities to understand, communicate, and educate 	

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22.0802 Researchers	541, 611	<i>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.</i>	• presence of the environment		• research opportunities	
22.09 Non-Use						
22.0901 People Who Care (Existence)	813, 924	<i>This non-use beneficiary believes it is important to preserve the environment because of a moral/ethical connection or for fear of unintended consequences.</i>	• presence of the environment		• knowing that the environment exists	
22.0902 People Who Care (Option / Bequest)	813, 924	<i>Option/Bequest 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.</i>	• presence of the environment		• knowing that the environment exists	

Why?



Cabbage is Not a FECS

- 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 FECS

- 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).

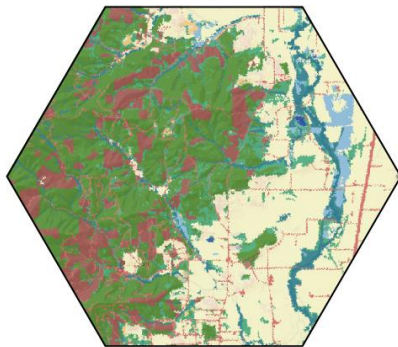
Environmental Classes

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

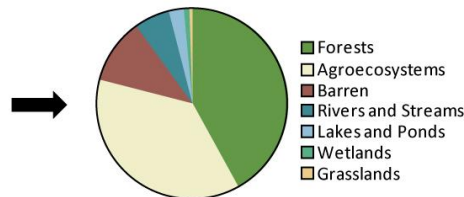
Environmental Class

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

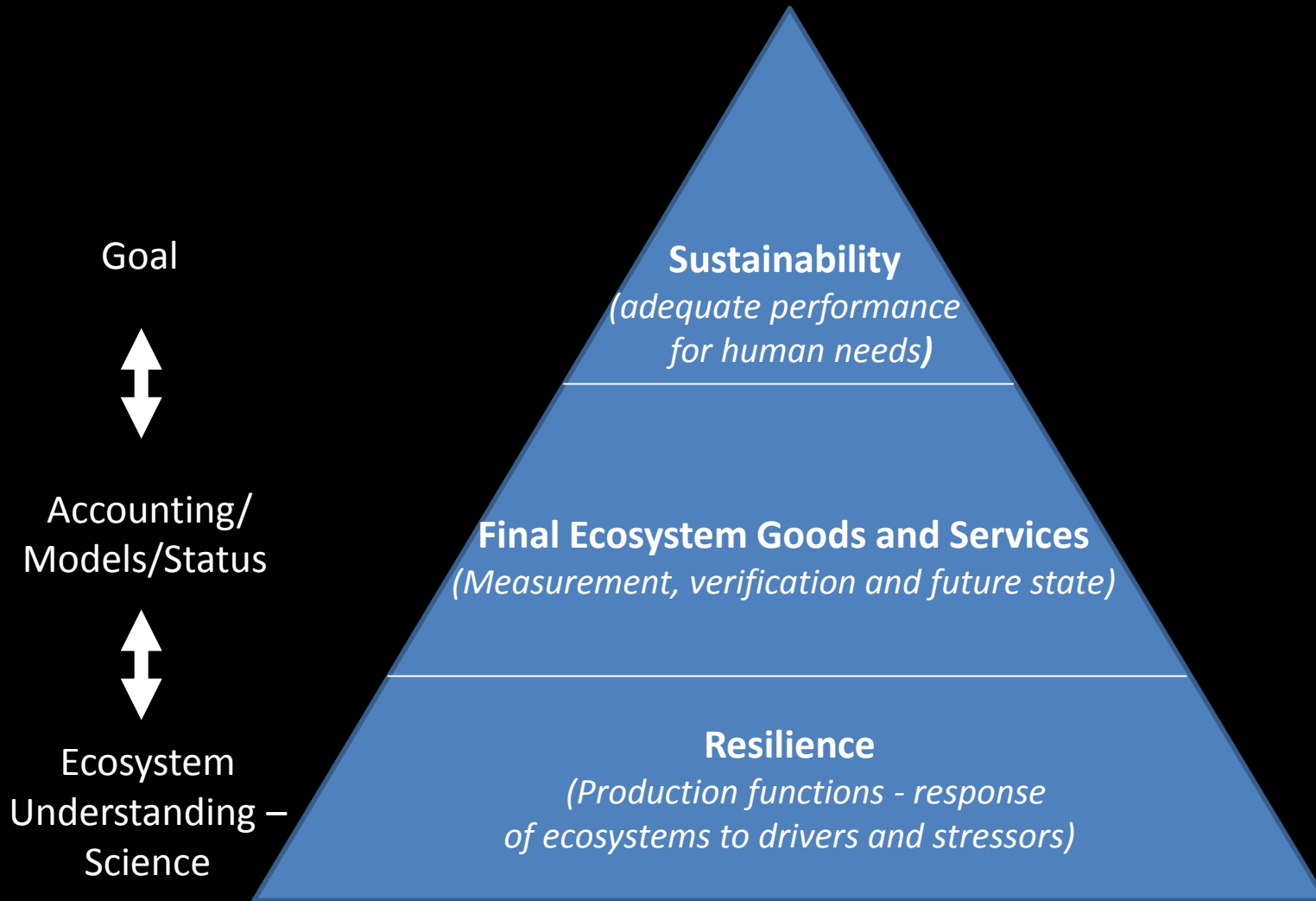
FEGS Environmental SubClasses



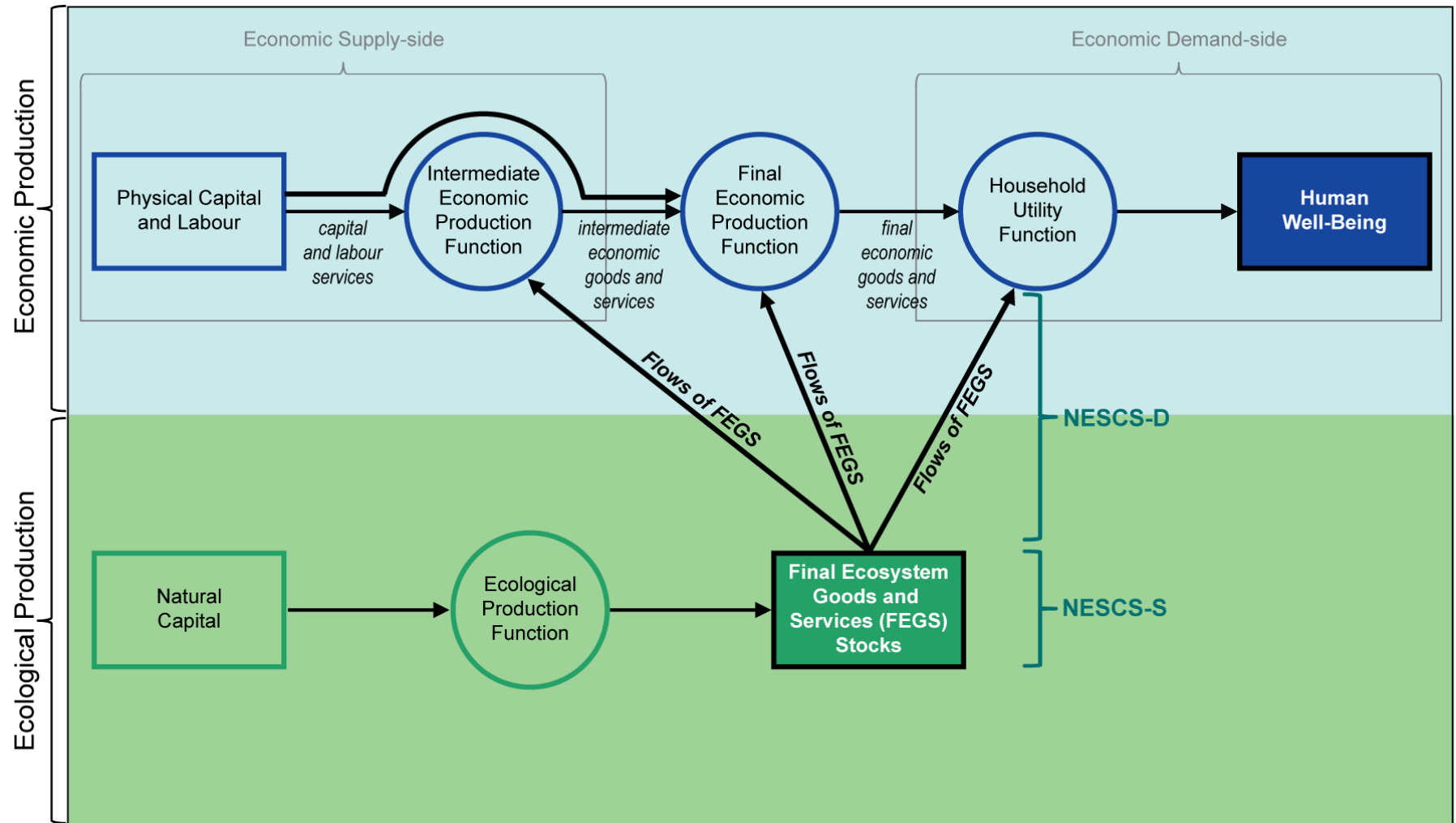
FEGS Environmental SubClass Profile



FEGS could well function as the **Environmental Currency** of the ecosystem component of sustainability.



Relationships among Nature and Economic Systems



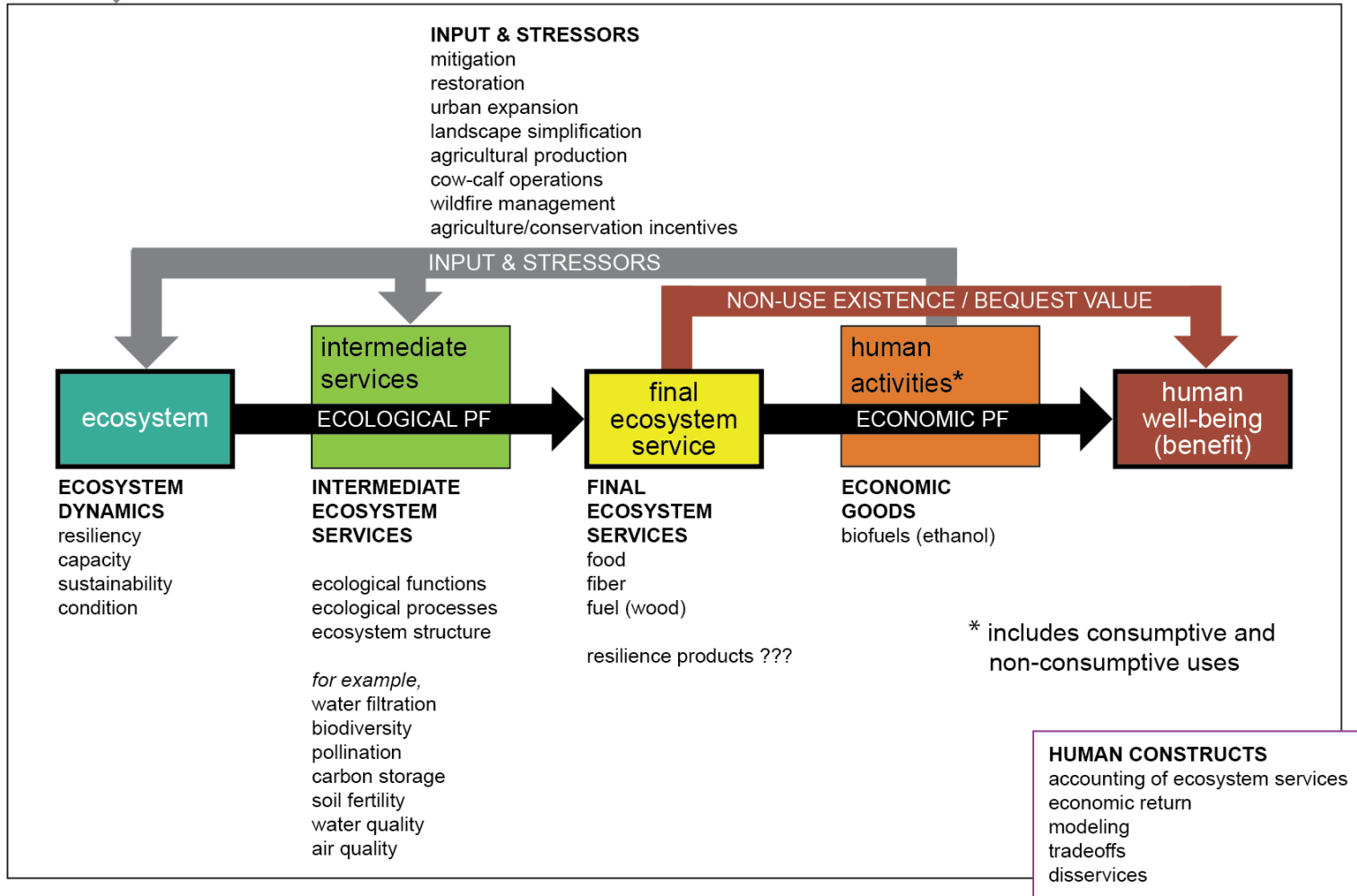
**NATURAL
EXTERNAL FORCING**
climate
extreme weather
volcanic eruptions



FINAL ECOSYSTEM SERVICE CONCEPTS

ENVIRONMENTAL CLASS
rangelands
watersheds
agricultural landscapes

Environmental Class

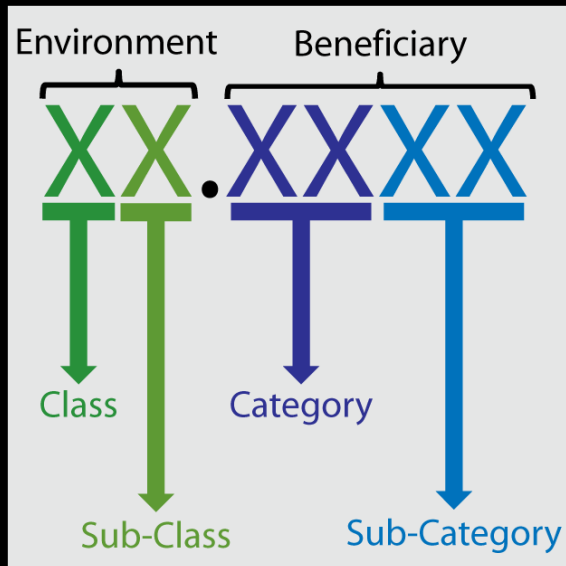


adapted from Bruins et al. 2016

Thank You

FEGS-CS Classification Scheme

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



Distinguishing FEGS from Non-FEGS



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

