A National Ecosystem Services Classification System (NESCS) Linking Final Ecosystem Services to Uses and Users

Forum of Experts in SEEA Experimental Ecosystem Accounting
UN Statistics Division

Session 3: Ecosystem Service Classification and
Links to Ecosystem Functions and Conditions

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Photo: James Balog, *Chasing Ice*

Recent Developments in Ecosystem Services Classification

What *type* of Ecosystem Services Classification System (**ES-CS**) is needed?

Who is asking?   What purpose must the ES-CS serve?

- Environmental "green" accounting   CICES

- Identify relevant environmental metrics   FEGS-CS

- **Scenario/Marginal Analysis (e.g., CBA)**   **NESCS**

Can a complex tool designed to fulfill one set of objectives be flexible enough to meet other useful objectives, while still remaining itself?

Does a "yes" mean we should consider integrating toward a single system?

Does a "no" mean we cannot integrate ES-CS?

ES-CS = ecosystem services classification system

Growing ES literature since Daily (1997), as ecologists, researchers, and policy makers try to apply *ES* concept:
De Groot et al (2002); ***MA (2005)****; Boyd and Banzhaf (2007); Wallace (2007); Fisher and Turner (2009); Staub et al (2011); Haines-Young and Potschin (2012); Landers and Nahlik (2013)*

Millennium Ecosystem Assessment (MA) *2005*:
Supporting Services: soil formation, nutrient cycling, primary production
Provisioning Services: fresh water, food, fiber, genetic resources
Regulating Services: water purification, climate and disease regulation
Cultural Services: spiritual, recreation & tourism, educational, heritage

Disagreement on where ecosystem services occur along continuum between ecosystems to human well-being. One problem with fuzziness:

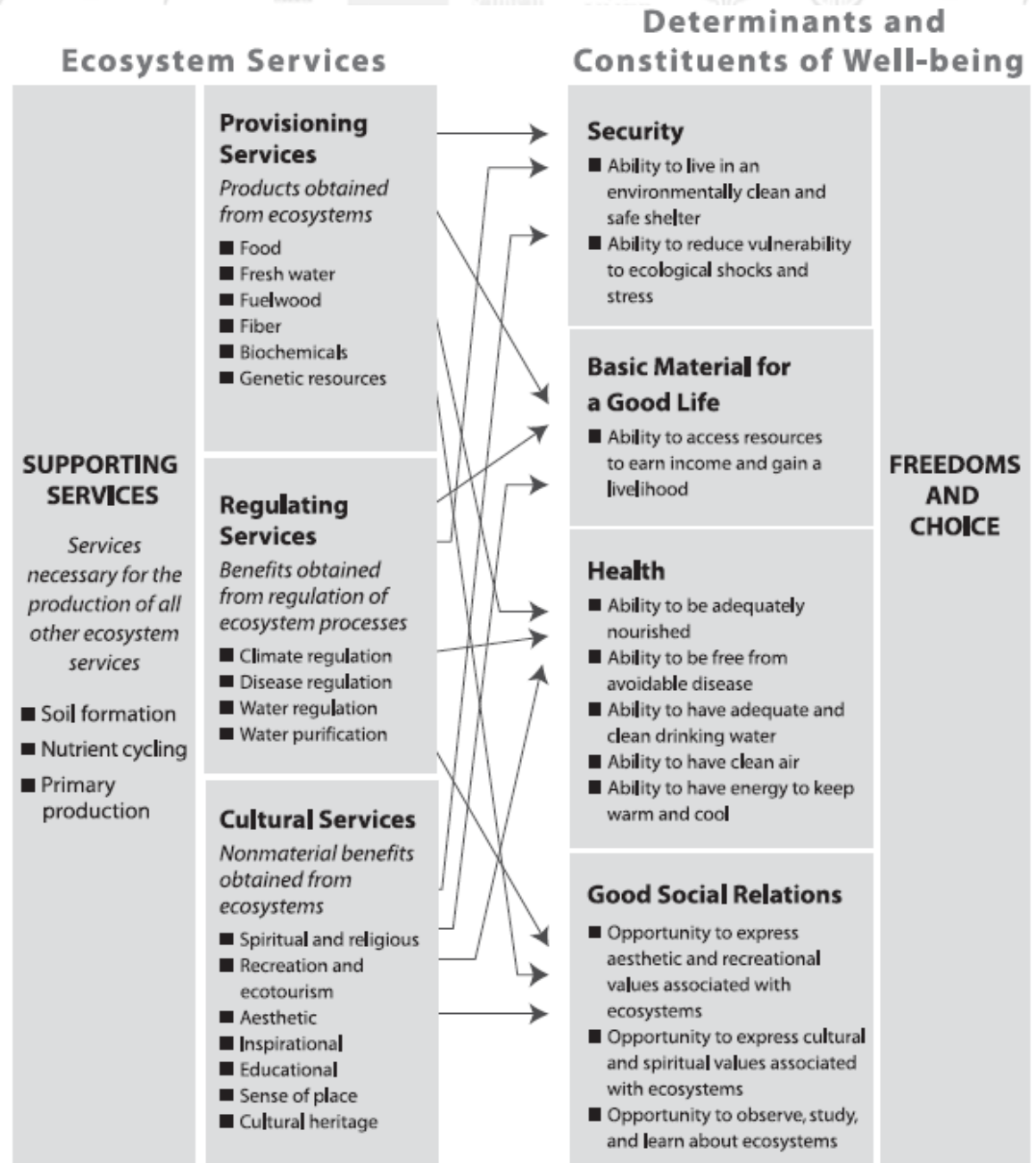**Double Counting – a "red flag" for accounting and for cost-benefit analysis**
- freshwater as provisioning and as water regulation and as purification?
- might most "regulating" services prove intermediate, as "supporting" are, but be counted again when "provisioning?"

MA Categorization of Ecosystem Services and their Links to Human Well-Being

Source: Millennium Ecosystem Assessment. 2003. Ecosystems and human well-being: a framework for assessment, 266p.

The MA recognizes that these categories overlap, however, its developers argue that "*These categories overlap extensively, and the purpose is not to establish a taxonomy but rather to ensure that the analysis addresses the entire range of services*" **(p. 38).**
For example, erosion control can be categorized as both a supporting and a regulating service, "depending on the time scale and immediacy of their impact on people."
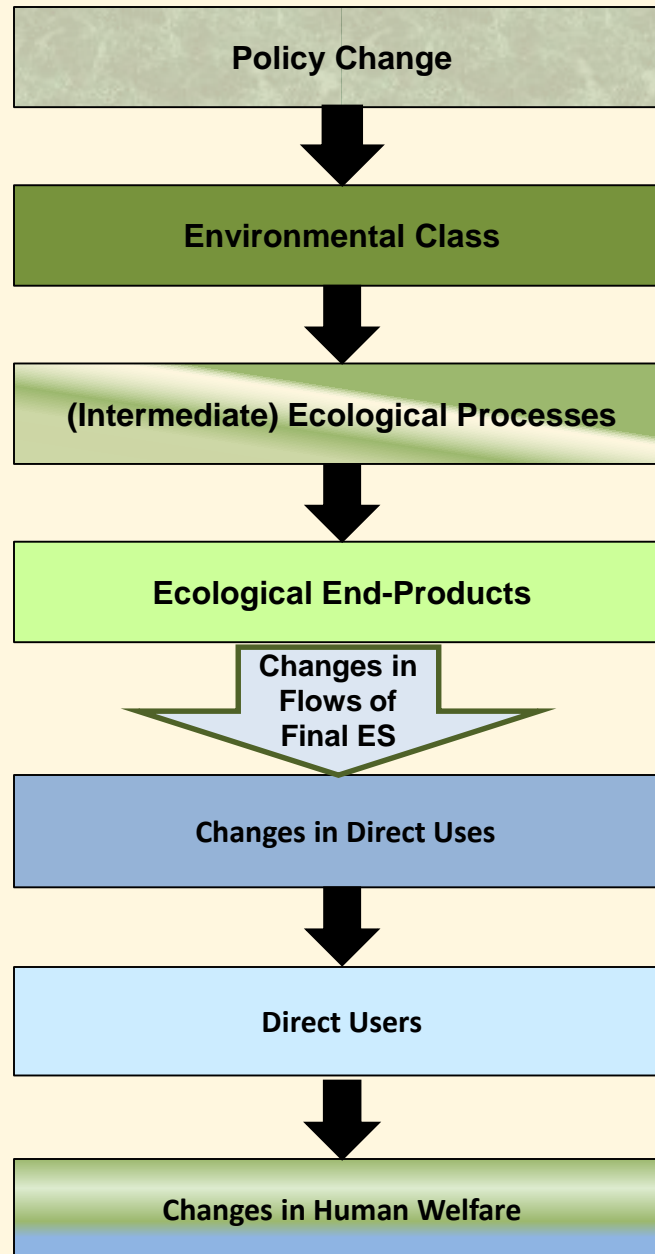
Ecosystem Services

Determinants and Constituents of Well-being

SUPPORTING SERVICES

Services necessary for the production of all other ecosystem services

- Soil formation
- Nutrient cycling
- Primary production

Provisioning Services

Products obtained from ecosystems

- Food
- Fresh water
- Fuelwood
- Fiber
- Biochemicals
- Genetic resources

Regulating Services

Benefits obtained from regulation of ecosystem processes

- Climate regulation
- Disease regulation
- Water regulation
- Water purification

Cultural Services

Nonmaterial benefits obtained from ecosystems

- Spiritual and religious
- Recreation and ecotourism
- Aesthetic
- Inspirational
- Educational
- Sense of place
- Cultural heritage

Security

- Ability to live in an environmentally clean and safe shelter
- Ability to reduce vulnerability to ecological shocks and stress

Basic Material for a Good Life

- Ability to access resources to earn income and gain a livelihood

Health

- Ability to be adequately nourished
- Ability to be free from avoidable disease
- Ability to have adequate and clean drinking water
- Ability to have clean air
- Ability to have energy to keep warm and cool

Good Social Relations

- Opportunity to express aesthetic and recreational values associated with ecosystems
- Opportunity to express cultural and spiritual values associated with ecosystems
- Opportunity to observe, study, and learn about ecosystems

FREEDOMS AND CHOICE

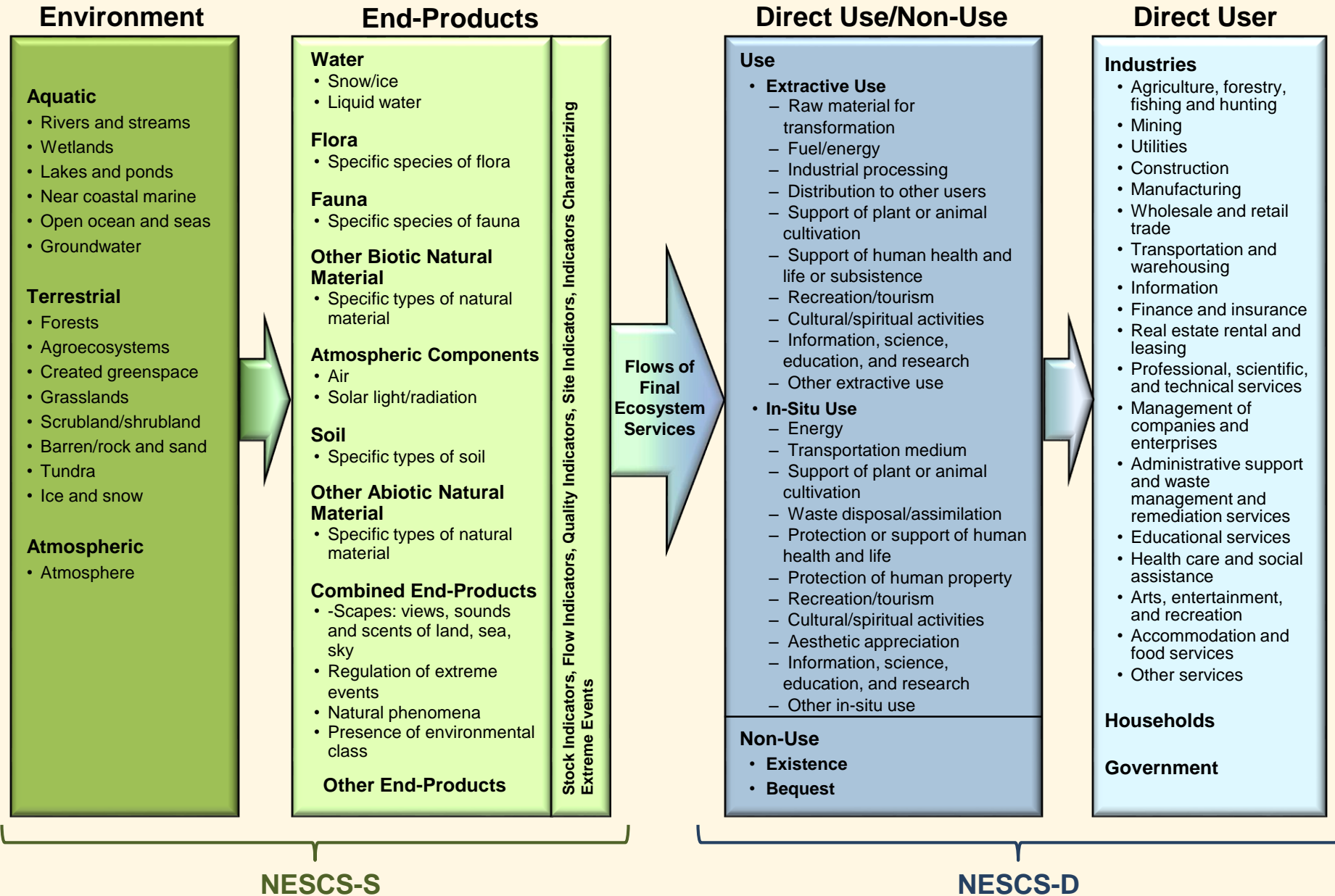Questions when attempting to quantify or assess value for ES from within the MA classification:

1) "value" is a function of ecosystem condition, but also a function of human context – the same use is valued differently by different users; MA seems to have ES uses, and not ES users?

2) MA classification mixes "processes (means) for achieving services and the services themselves (ends) within the same classification strategy" *Boyd and Banzhaf (2007)*

3) how can a set of *clear, unique, unduplicated* measures for ES that matter to people arise if these are constraints?

Boyd and Banzhaf (2007) indicate a potential way forward: **count only those ES that directly enter the human economy, at the point they do –** *Final Ecosystem Services*

Pathway Linking Policy Changes to Human Well-Being

Policy Change

↓

Environmental Class

↓

(Intermediate) Ecological Processes

↓

Ecological End-Products

Changes in Flows of Final ES

Changes in Direct Uses

↓

Direct Users

↓

Changes in Human Welfare

National Ecosystem Services Classification System, Four-Group Structure

Environment

Aquatic
- Rivers and streams
- Wetlands
- Lakes and ponds
- Near coastal marine
- Open ocean and seas
- Groundwater

Terrestrial
- Forests
- Agroecosystems
- Created greenspace
- Grasslands
- Scrubland/shrubland
- Barren/rock and sand
- Tundra
- Ice and snow

Atmospheric
- Atmosphere

End-Products

Water
- Snow/ice
- Liquid water

Flora
- Specific species of flora

Fauna
- Specific species of fauna

Other Biotic Natural Material
- Specific types of natural material

Atmospheric Components
- Air
- Solar light/radiation

Soil
- Specific types of soil

Other Abiotic Natural Material
- Specific types of natural material

Combined End-Products
- -Scapes: views, sounds and scents of land, sea, sky
- Regulation of extreme events
- Natural phenomena
- Presence of environmental class

Other End-Products

Stock Indicators, Flow Indicators, Quality Indicators, Site Indicators, Indicators Characterizing Extreme Events

Flows of Final Ecosystem Services

Direct Use/Non-Use

Use
- **Extractive Use**
  – Raw material for transformation
  – Fuel/energy
  – Industrial processing
  – Distribution to other users
  – Support of plant or animal cultivation
  – Support of human health and life or subsistence
  – Recreation/tourism
  – Cultural/spiritual activities
  – Information, science, education, and research
  – Other extractive use
- **In-Situ Use**
  – Energy
  – Transportation medium
  – Support of plant or animal cultivation
  – Waste disposal/assimilation
  – Protection or support of human health and life
  – Protection of human property
  – Recreation/tourism
  – Cultural/spiritual activities
  – Aesthetic appreciation
  – Information, science, education, and research
  – Other in-situ use

Non-Use
- **Existence**
- **Bequest**

Direct User

Industries
- Agriculture, forestry, fishing and hunting
- Mining
- Utilities
- Construction
- Manufacturing
- Wholesale and retail trade
- Transportation and warehousing
- Information
- Finance and insurance
- Real estate rental and leasing
- Professional, scientific, and technical services
- Management of companies and enterprises
- Administrative support and waste management and remediation services
- Educational services
- Health care and social assistance
- Arts, entertainment, and recreation
- Accommodation and food services
- Other services

Households

Government

NESCS-S

NESCS-D

Proposed 4-Group NESCS Structure – "Wiring Diagram" with Proposed Metrics By Group
Example: (a) lake, river, or stream water for drinking – m³ fresh water (m3frshw)
(b) same water in composite viewing environment – degree natural/unbuilt

Environment

Aquatic
- Rivers and streams (11.)
- Wetlands
- Lakes and ponds (13.)
- Near coastal marine
- Open ocean and seas
- Groundwater

Terrestrial
- Forests
- Agroecosystems
- Created greenspace
- Grasslands
- Scrubland/ shrubland
- Barren/rock and sand
- Tundra
- Ice and snow

Atmospheric
- Atmosphere

End-Products

Water
- Snow/ice
- Liquid water
  - fresh water (13.12.) (11.12.)
  - metric: m3frshw

Flora
- Specific classes/species of flora

Fauna
- Specific classes/species of fauna

Other Biotic Components
- Specific types of natural material

Atmospheric Components
- Air
- Solar light/radiation

Soil
- Specific types of soil

Other Abiotic Components
- Specific types of natural material

Composite End-Products
- -Scapes: views, sounds, scents of land, sea, sky
- beach envrnmt (13.81.)
  - metric: degree natural/unbuilt

- Regulation of extreme events
- Presence of environmental class

Other End-Products

Stock indicators, Flow Indicators, Quality Indicators, Site Indicators, Indicators Characterizing Extreme Events

Flows of Final Ecosystem Services

Direct Use/Non-Use

Use
- **Extractive Use**
  - Raw material for transformation
  - Fuel/energy
  - Industrial processing
  - Distribution to other users
  - Support of plant or animal cultivation
  - Support of human health and life or subsistence
- freshwater (13.12.1106.) (11.12.1106.)
  - metric: m3frshw
  - Recreation/tourism
  - Cultural/spiritual activities
  - Information, science, education, and research
  - Other extractive use

- **In-Situ Use**
  - Energy
  - Transportation medium
  - Support of plant or animal cultivation
  - Waste disposal/assimilation
  - Protection or support of human health and life
  - Protection of human property
  - Recreation/tourism
  - Cultural/spiritual activities
  - Aesthetic appreciation beach environment (13.81.1209.)
    - metric: degree natural/unbuilt
  - Information, science, education, and research
  - Other in-situ use

Non-Use
- **Existence**
- **Bequest**
- **Other non-use**

Direct User

Industries
- Agriculture, Forestry, Fishing and Hunting
- Mining
- Utilities
- Construction
- Manufacturing
- Wholesale Trade
- Retail Trade
- Transportation and Warehousing
- Information
- Finance and Insurance
- Real Estate Rental and Leasing
- Professional, Scientific, and Technical Services
- Management of Companies and Enterprises
- Administrative Support and Waste Management and Remediation Services
- Educational Services
- Health Care and Social Assistance
- Arts, Entertainment, & Recreation
- Accommodation & Food Services
- Other Services

Households
- freshwater (13.12.1106.201) (11.12.1106.201)
  - metric: m3frshw / effort
  → satisfaction / $-equiv. source at intake
    freshwater (13.81.1209.201)
  - metric: degree natural/unbuilt/access
  → satisfaction / $-equiv. source at intake

Government

(a)

(b)

NESCS-S

NESCS-D

NESCS Classification Structure and Hierarchical Coding System

	NESCS–S		NESCS–D	
Group	**Environment**	**End-product**	**Direct Use/Non-use**	**Direct User**
Definition	Ecosystems where end-products spatially occur, or producers of "end-products"	Biophysical components of nature that are directly used or appreciated by humans	Different ways in which end-products are used or appreciated by humans	Sectors that directly use or appreciate the end-products
Hierarchy and Coding System NESCS Category Representation*: WW.XX.YYYY.ZZZZZZZ				
Class	W	WW.X	WW.XX.Y	WW.XX.YYYY.Z
Sub-Class	WW	WW.XX	WW.XX.YY	WW.XX.YYYY.ZZZ
Detail			WW.XX.YYYY	WW.XX.YYYY.ZZZZZZZ
Example 1 – ocean water used as a medium to haul freight NESCS Code = 15.12.1202.1483111				
Class	Aquatic: **1**	Water: 1	Direct Use: **1**	Industry: **1**
Sub-Class	Open Ocean and Seas: **15**	Liquid Water: **12**	In-Situ Use: **12**	Transportation and Warehousing: **148**
Detail			Transportation medium: **1202**	Deep Sea Freight Transportation: **1483111**
Example 2 – direct fresh water intake used for home gardening NESCS Code = 11.12.1105.201				
Class	Aquatic: **1**	Water: 1	Direct Use: **1**	Households: **2**
Sub-Class	Rivers and Streams: **11**	Liquid Water: **12**	Extractive Use: **11**	Households: **201**
Detail			Support of plant or animal cultivation: **1105**	

Note that this 15-digit code is the most disaggregated level of representation. Different levels of aggregation can be used depending on the context.

http://unstats.un.org/unsd/cr/registry/isic-4.asp has link: Correspondence tables between ISIC Rev.4 and NAICS-US 2012

FEGS-CS – NESCS Pass-Through Example:
7 times "wild mussels", 1 times "beach-scape" at the wild mussel site

FEGS-CS—FEGS-CS—FEGS-CS—FEGS-CS—FEGS-CS—FEGS-CS—FEGS-CS—FEGS-CS—FEGS-CS—FEGS-CS—FEGS-CS—FEGS-CS—FEGS-CS

Envrnm Class	Envrnm Sub-Class	Examples of FEGS	Beneficiary Category		Beneficiary Sub-Category		FEGS-CS 6-Digit Code
Aquatic	Near-Coastal Marine	*wild mussels*: "type 10" of 21 types of FEGS is "fish," but thousands of FEGS, so no #	Commercial/Industrial		Food Extractors	…if corp./food-processing, raw material for transformation →	XX.XXXX
(1)	14.		02		01		14.0201
			beneficiaries are a "use-user" combination ——————————————————→				b: FoodExtractors

NESCS—NESCS—NESCS—NESCS—NESCS—NESCS—NESCS—NESCS—NESCS—NESCS—NESCS—NESCS—NESCS—NESCS—NESCS

Envrnm Class	Envrnm Sub-Class	End-Product Class	End-Product Sub-Class	Use/Non-Use Class	Use/Non-Use Sub-Class	Use/Non-Use Detail (*Example*)	User Class	User Sub-Class / Detail	User Detail Example	NESCS 15-Digit Code WW.XX.YYY.ZZZZZZZ	FEGS-CS 6-Digit Code XX.XXXX
Aquatic	Near-Coastal Marine	fauna	*Ex.: wild mussels*	Use	extractn/ consump	raw material	Indus	Food Manuf	Seafood Prod. Prep & Packgg		
(1)	14.	(3)	3.	(1)	(11)	1101.	(1)	(311)	1311710	14.3.1101.1311710	14.0201
			(Thousands of species, so no #)	…if corp./food-processing, raw material for transformation				(UseClass+NAICS)			b: FoodExtractors
						distrib to others		Fishing Trapping	Shellfish fishing		
(1)	14.	(3)	3.	(1)	(11)	1104.	(1)	(114)	1114112	14.3.1104.1114112	14.0201
						OR …if self-employed harvester bags and sells wild mussels to passing cars					b: FoodExtractors
						info/educ/research		Educ Services			
(1)	14.	(3)	3.	(1)	(11)	1109.	(1)	(611)	1611310	14.3.1109.1611310	14.0801
						OR …if OSU class/research: where/how to harvest, with example harvest					b: Educs&Stdnts
					non-extractn/c..						
(1)	14.	(3)	3.	(1)	(12)	1209.	(1)	(611)	1611310	14.3.1209.1611310	14.0802
						OR …if OSU class/research: direct check species (mussel) condition without harvest					b: Researchers
				extractn/ consump	support human health subsistence			Households			
(1)	14.	(3)	3.	(1)	(11)	1106.	(2)	201	-	14.3.1106.201	14.0502
						OR …if mussels eaten by harvester					b: RecrPickGath
						cultural/spiritual activities					
(1)	14.	(3)	3.	(1)	(11)	1108.	(2)	201	-	14.3.1108.201	14.0701
						AND/OR also …if eating native seafood=spirit/culture (as PacNWTribal?)					b: SpiritCrmyPrtcp
						recreation/tourism					
(1)	14.	(3)	3.	(1)	(11)	1107.	(2)	201	-	14.3.1107.201	14.0602
						OR also …if tourist tries hand at mussel-ing					b: RecrPickGath
		combined end-products	-scapes, views, sounds, scents		non-extractn/c..	aesthetic appreciatn					
(1)	14.	(8)	81.	(1)	(12)	1209.	(2)	201	-	14.81.1209.201	14.0601
						AND …if "beach experience" is part of "ES" of mussel harvest, then a separate Non-Use ES "use" for any User, "combined end-product" here, not "fauna"					b: 06=non-extrct viewer
						…let's pick Household, not Industry for this example					

Proposed 4-Group NESCS Structure – with FEGS-Metric Pass-Through
Example (a): mussels – m² mussels/km of beach (m2m/kmb)

The NESCS Conceptual Framework – Specialized to a Terrestrial Acidification Example
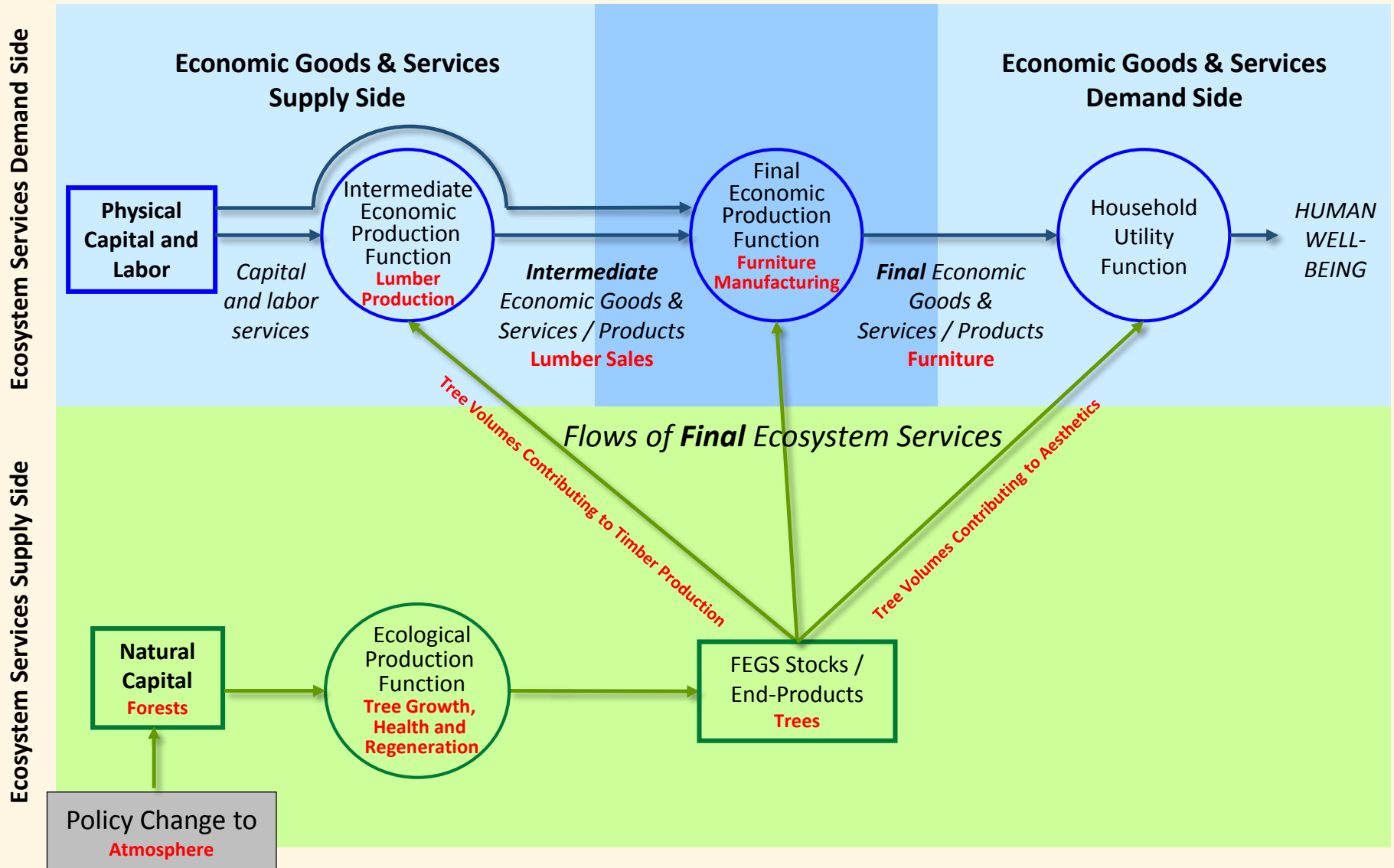
Applying NESCS: Policies Impacting Terrestrial Acidification – Two-species example table, with NESCS numeric coding pieces

	NESCS-S				NESCS-D					
Env. Class	Env. Sub-Class	End-product Class	End-product Sub-Class or Example	Direct Use/ Non-Use Class	Direct Use/ Non-Use Sub-Class	Direct Use/ Non-Use Detail	Examples of Direct Uses/ Non-Use	Direct User Class	Direct User Sub-Class	User Detail
2. Terrestrial	21. Forests	2. Flora	Sugar maple trees	1. Direct Use	11. Extractive Use	1101. Raw material for transformation	Input for maple syrup, furniture, construction	1. Industry	111. Agriculture, Forestry, Fishing and Hunting	1113. Forestry and Logging (e.g., **21.2.1101.1113**)
									123. Construction	123. Construction
									131–33. Manufacturing (Manufg.)	1311. Food Manufg. 1321. Wood Product Manufg. 1337. Furniture and Related Product Manufg.
					12. In-situ Use	1207. Recreation/tourism	Fall color viewing	1. Industry	148–49. Transportation and Warehousing	1487. Scenic and Sightseeing Transportation
									172. Accommodation and Food Services	1721. Accommodation 1722. Food Services and Drinking Places
								2. Households	201. Households	
						1209. Aesthetic appreciation	Scenic views for commuters	2. Households	201. Households	(e.g., **21.2.1209.201**)
				2. Non-Use	21. Existence	2101. Existence	Existence use	2. Households	201. Households	
					22. Bequest	2201. Bequest	Bequest use	2. Households	201. Households	
			Red spruce trees	1. Direct Use	11. Extractive Use	1101. Raw material for transformation	Input for musical instruments, furniture, construction	1. Industry	111. Agriculture, Forestry, Fishing and Hunting	1113. Forestry and Logging
									131–33. Manufacturing (Manufg.)	1321. Wood Product Manufg. 1337. Furniture and Related Product Manufg. 1339992. Musical Instrument Manufg.
				2. Non-Use	21. Existence	2101. Existence	Existence use	2. Households	201. Households	
					22. Bequest	2201. Bequest	Bequest use	2. Households	201. Households	(e.g., **21.2.2201.201**)

Core Features for a Desirable Ecosystem Services Classification System (ES-CS)

Exhaustive and Mutually Exclusive
uniquely identifies all structures, processes, functions, and products of natural systems (separate from human-driven systems) that humans use or appreciate

Non-Duplicative
focuses attention and measurement on those ecosystem services that humans use or appreciate directly (*final* versus intermediate *ecosystem services*), *to avoid double-counting*

Practical for Users
groups or separates candidate elements in a way easy to conceive and use, with clear definitions, and rules for classifying that appeal across disciplines and users – *avoiding overwhelming complexity, confusion, fuzzy classification boundaries, and thus avoiding divergent choices for similar cases by similar users*

Helpful for Selecting Appropriate Metrics
uniquely identifying the environment, the precise flows of ecosystem services, the users, and how they use the ES, all *help to determine what ecologists and economists should measure*

Wish List:

Modular
a "bonus" for practical use, if an ES-CS interfaces with other standard classification systems or ecosystem service tools without extensive exceptions and patching

Appropriate to be a Standard
a "bonus" for practical use, if an ES-CS is stable, its rules for use are well-explained, and it is practical enough to serve as the standard for many types of users