An operational structured decision making framework for assessing changes in final ecosystem goods and services with consequences to human well-being.

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The findings and conclusions in this presentation have not been formally disseminated by the EPA and should not be construed to represent any Agency determination or policy.
Per M-16-01, the “implementation guidance will outline the elements and approaches for integrating consideration of ecosystem services into existing agency decision processes such as:

1. Describing the Federal action

2. Identifying and selecting key ecosystem services

3. Quantifying changes in ecosystem services

4. Valuing the biophysical and socio-economic effects

5. Integrating those effects on ecosystem services into decisions
• Existing frameworks are conceptually sound but decision makers lack operational methods and tools

• Methods and tools are required before ecosystem services assessments can become standard practice

• Established approaches (NEPA) would benefit from the incorporation of ecosystem services change assessment with linkages to human well-being

• We propose an approach and tools for operationalizing this idea based on:
  • structured decision making (SDM; DASEES)
  • final ecosystem goods and services (FEGS-CS; NESCS; ESML)
  • human well-being index (HWBI)
  • scenario development (H2O; ENVISION)
Figure 1. The steps in a generic decision process (NRC 2011; Carriger and Benson 2012; Gregory et al. 2012).
Decision Analysis for a Sustainable Environment, Economy, and Society (DASEES)

Function and Philosophy:

- Web-based framework supporting stakeholder-driven group decision-making
- Organizes use of tools/data/information needed for decision
- Includes stakeholder perspectives and tools for analysis and evaluation

Problem Formulation → Alternative assessment → Selection → Implementation
1) Identify decision context and beneficiaries:
   • Structured decision making (SDM; DASEES)
   • Final ecosystem goods & services classification system (FEGS-CS or NESC)

Figure 2. Integrating FEGS approaches into a generic decision process.
“components of nature, directly enjoyed, consumed, or used to yield human well-being” (Boyd & Banzhaf 2007)

Environmental Class + Beneficiary → FEGS class

4-Group NESCS Structure – “Wiring Diagram” with Proposed Metrics By Group

Example: (a) lake, river, or stream water for drinking – m³ fresh water for Households (13.12.1106.201)
(b) same water in beach viewing environment – degree natural/unbuilt for Beach Goers (13.81.1209.201)

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.)
- 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 Environmt (13.81.)
  - Metric: degree natural/unbuilt
- Regulator of extreme events
- Presence of environmental class
- Other End-Products

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.)
  - 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 Use/Non-Use

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

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

- Government

- Households
  - Freshwater (13.12.1106.201)
  - Metric: m³frshw
  - Beach Environment (13.81.1209.201)
  - Metric: degree natural/unbuilt

- Other Services

- Other End-Products

- Stock Indicators, Flow Indicators, Quality Indicators, Indicators Characterizing Extreme Events
2) Weight objectives and identify metrics:
   • Determine stakeholder relative priorities for domains in the Human Well-Being Index (HWBI)
   • Identify beneficiary-relevant metrics for FEGS using either the National Ecosystem Services (NESCS) or Final Ecosystem Goods and Services Classification Systems (FEGS-CS)
Value-focused decision making places a much stronger emphasis on defining objectives before defining alternatives (Keeney 1992).

Decision participants can rank and assign weights for their objectives in DASEES.
The Human Well-Being Index (HWBI)

- Assess how ecosystem, economics, and social services influence eight well-being domains:
  1) social cohesion, 2) living standards, 3) education, 4) leisure time, 5) connection to nature, 6) safety and security, 7) health, and 8) cultural fulfillment (Smith et al. 2012)

- HWBI encourages stakeholders to characterize what fundamentally matters to them (Fulford et al. 2016)

- HWBI metrics useful as performance measures for comparing decision options

- Relative values of stakeholders can be applied to weight decision alternatives during tradeoff analysis
Figure 2. Integrating FEGS approaches into a generic decision process.

3) Develop alternative future scenarios

What intermediate ecosystem services might be means to achieving broader health, social or economic benefits?
Scenarios need to address and define the **inputs into ecological production functions**

Ways to generate alternative-future scenarios:

- story boarding
- conceptual modeling
- participatory development
- empirical and simulation modeling
Figure 2. Integrating FEGS approaches into a generic decision process.

4) Link decision alternatives to changes in FEGS
   • EPF’s in the EcoService Models Library (ESML)
Ecological production functions (EPFs):
“usable expressions (i.e., models) of the processes by which ecosystems produce ecosystem services, often including external influences on those processes” (Bruins et al. 2016).
5) Select preferred scenario through trade-off analysis:
   • How changes in FEGS affect well-being of beneficiaries and community for each scenario
     • DASEES
     • HWBI
A decision analysis approach requires exploring tradeoffs among the objectives (Keeney 1992).

Tradeoffs can be quantified, but their role should be to provide greater insight into the deliberation process, not prescribe an optimal solution or approach (Gregory et al. 2012).

The DASEES system can help decision makers to compare alternatives with a consequence table, and provides tools for assigning relative values to different stakeholder objectives.
Clear measures of human benefit that consider all important services to people from the ecosystem are a critical end point of best practices for FEGS-based decision making (Olander et al. 2015).

- The Human Well-Being Index (HWBI),
  - Defined in terms of how ecosystem, economics, and social services influence eight well-being domains
  - Encourages stakeholders to think beyond economic goals and to characterize what fundamentally matters to them (Fulford et al. 2016).
  - Metrics and indicators of the HWBI represent good examples of performance measures for comparing decision options.
  - Relative values of stakeholders for the domains of the HWBI can weight decision alternatives during tradeoff analysis.
6) Implement the selection and monitor changes in ecosystem status and human well-being:
   - FEGS metrics/indicators
   - HWBI
   - DASEES

What levels of ecosystem function are needed for meaningful change & measurable benefits?

Figure 2. Integrating FEGS approaches into a generic decision process.
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**DASEES**
http://beta.dasees.org

**ESML Beta sign up**
https://esml.epa.gov/epf_l/public/signup

**HWBI**
https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=318653

**FEGS-CS**  Published EPA Report: EPA/600/R-13/ORD-004914
Interactive FEGS-CS website at http://gispub4.epa.gov/FEGS

**NESCS**  Published EPA Report: EPA-800-R-15-002
http://www.epa.gov/eco-research/ecosystems-services

**EPA H2O** – Scenario Assessment Tool
https://www.epa.gov/water-research/ecosystem-services-scenario-assessment-using-epa-h2o