EPA’s EcoService Models Library (ESML): A New Tool for Quantifying and Valuing Ecosystem Services

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What is ESML? [https://ESML.epa.gov/](https://ESML.epa.gov/)

A searchable database of ecological models for estimating the production of ecosystem goods and services.
What does ESML help you to do?

**Objective:** ESML provides informative model descriptions that help users find, examine, and compare models.
Why did we build ESML?

• EPA Office of Water Economists
• Help planners, analysts, and scientists to understand and select useful ecological models
• Help researchers interested in improving ecological modeling methods
Some things ESML is **not**: 

- not a modeling system 
- not an ecological valuation database 
- not a decision support system 
- not a compendium of model software 
- not a substitute for original documentation 
- not an endorsement
What’s in ESML? https://ESML.epa.gov/

- Detailed descriptions of **>150 ecological models** (>50 informative model descriptors – covering purpose, approach, and environmental use)
- Detailed descriptions of **ecological model variables** (40 additional descriptors)
- **Variable Relationship Diagrams**, conceptual diagrams for each model
Learn more about descriptors with the ESML Data Map
Example Source Documents


Search Ecological Models

Ecosystem Service

Ecosystem Services are defined as outputs of ecological functions or processes that directly or indirectly contribute to social welfare, or have the potential to do so in the future. Filter on one or both of two ecosystem service classification systems (CICES or NESCS) to limit the EMs displayed; multiple selections are allowed.
Common International Classification of Ecosystem Services (CICES)

- Developed by European Environment Agency with international participation
- Based on Millennium Ecosystem Assessment
- Intuitive groupings of services
- Mix of intermediate and final ecosystem services
- Classification is independent of environment or human beneficiary
- For further information: cices.eu
National Ecosystem Service Classification System (NESCS)

- Based on EPA’s Final Ecosystem Goods and Services Classification System (https://gispub4.epa.gov/FEGS/)
- Includes only final ecosystem services (avoids double-counting)
- Classification recognizes environment and human beneficiary
- For further information: https://www.epa.gov/eco-research/national-ecosystem-services-classification-system-framework-design-and-policy
Partial breakdown of service classes, with number of models in ESML: CICES

- **Provisioning**
  - Nutrition: 21
  - Materials: 21
  - Bio-based Energy: 0
  - Total: 37

- **Regulation & Maintenance**
  - Mediation of wastes, toxics: 18
  - Mediation of flows: 26
  - Maintenance of conditions: 62
  - Total: 94

- **Cultural**
  - Physical, intellectual: 18
  - Spiritual, symbolic: 1
  - Total: 19
### Detail of CICES category, “Maintenance of physical, chemical, biological conditions”

<table>
<thead>
<tr>
<th>Category</th>
<th>Action</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifecycle maintenance, habitat and gene pool protection</td>
<td>Pollination and seed dispersal</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Maintaining nursery populations and habitats</td>
<td>23</td>
</tr>
<tr>
<td>Pest and disease control</td>
<td>Pest control</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Disease control</td>
<td>0</td>
</tr>
<tr>
<td>Soil formation and composition</td>
<td>Weathering processes</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Decomposition and fixing processes</td>
<td>8</td>
</tr>
<tr>
<td>Water conditions</td>
<td>Chemical condition of freshwaters</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Chemical condition of salt waters</td>
<td>2</td>
</tr>
<tr>
<td>Atmospheric composition and climate regulation</td>
<td>Global climate regulation by reduction of greenhouse gas concentrations</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Micro and regional climate regulation</td>
<td>6</td>
</tr>
</tbody>
</table>
Partial breakdown of service classes, with number of models in ESML: **NESCS**

Note 1: NESCS identifies these 7 End-product categories for each of 14 different environments. The environments are combined for this presentation.

Note 2: Because intermediate services are excluded, fewer models align with the final services included in NESCS.
Partial breakdown of service classes, with number of models in ESML: **NESCS**

- **Presence of environmental class**: 16
- **Regulation of extremes**: 14
- **Scapes: sensory**: 3
- **Seashells**: 1
- **Air**: 4
- **Specific types of soil**: 5

**Composite End Products**
- **Water**: 18
- **Flora, Fungi**: 6
- **Fauna**: 22
- **Soil**: 5
- **Atmospheric Components**: 4
- **Other Biotic, Other Abiotic**: 1

**Liquid water**: 18

**Other categories**
- **Fodder**: 2
- **Green biomass**: 2
- **Seaweed**: 2
- **Trees**: 3
- **Birds**: 2
- **Crabs**: 1
- **Fish**: 14
- **Pest predators**: 1
- **Etc. (many)**: ......
Compare Selected EMs

Which comparison is best for me?

EM Variables by Variable Role

One quick way to compare ecological models (EMs) is by comparing their variables. Predictor variables show what kinds of influences a model is able to account for, and what kinds of data it requires. Response variables show what information a model is capable of estimating.

This first comparison shows the names (and units) of each EM’s variables, side-by-side, sorted by variable role. Variable roles in ESML are as follows:

- Predictor Variables
- Time- or Space-Varying Variables
Variable units, if available, are given in brackets following variable name. Arrows denote that one variable (or variables, if gathered within a box) is required for computation of the other. 

Double dagger denotes a variable whose value is constant with respect to a driving class variable (such as when derived from a lookup table).
What are the benefits of ESML?

• Detailed descriptions of:
  1. Source documents
  2. Ecological models (>50 individual descriptors)
  3. Ecological model variables (40 additional descriptors)

• Variable Relationship Diagrams

• Ability to find, compare, and save descriptions of models for estimating the production of ecosystem goods and services
Please nominate new models!

CROWD SOURCING
Fill out the EMSubmissionTemplate.xlsx:

1. Describe the source document
2. Describe the variables
3. Sketch a Variable Relationship Diagram

Email to ESML@epa.gov
InVEST (Integrated Valuation of Environmental Services and Tradeoffs) Water Yield

1. Land Use Land Cover
2. Latitude
3. Elevation
4. Slope aspect
5. Solar declination
6. Sunset hour angle
7. Inverse distance Earth-Sun
8. Solar constant
9. Mean max daily temp
10. Mean min daily temp
11. Mean annual precip
12. Soil depth
13. Plant available water content
14. Zhang constant
15. Max root depth
16. Plant evap coefficient
17. Sub-watershed ID
18. Extraterrestrial Radiation
19. Potential ET
20. Pixel water yield
21. Watershed H2O yield
22. Sub-watershed H2O yield
Wave Height and Attenuation

1. $H_2O$ depth over reef flat (m)
2. Meteorological surge (m)
3. Significant wave height (m)
4. Wave height offshore (m)
5. Slope angle (reef face)
6. Wave period (s)
7. Gravitational accel (m/s²)
8. Friction over reef top

Predictor Variables

9. Wave set up on reef (m)
10. Wave height attenuation (%)

Response Variable
Hope you enjoyed our ESML tour!

Next steps:

• Develop use case demonstrations
• Add more models
• Linking to EnviroAtlas data layers
• Outreach: model authors and others...
Thanks for the opportunity to share!

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