

# EcoValuator QGIS Plugin 2.0

User's Guide to Version 3.

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Maya Korb  
Anna J. Perry

**KEY-LOGECONOMICS**

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### NOTES

We are grateful to the National Fish and Wildlife Foundation, whose generous support of Key-Log Economics' research project "Ecosystem Services in the Roanoke River Basin" includes development of the EcoValuator.

We also thank Philip Ribbens, who did our coding and taught us all we know about creating and publishing QGIS plugins, and Erich Purpur who has enabled the plugin to make it so much easier to go from data to maps!

## ABOUT THE PLUG-IN

### Overview

The EcoValuator provides a simple means of estimating the dollar value of recreation, water supply, food, and other ecosystem services for a given study area. Once installed, the plugin combines satellite data on land cover with your own spatial data describing watersheds, conservation areas, townships, or other areas of interest. EcoValuator then estimates land area in each land cover type present in your region, and applies the Benefits Transfer Method (BTM) to generate a range of dollar-values for the ecosystem services supported by the land use/land cover present in your region<sup>1</sup>.

In the second step, EcoValuator generates a map of a chosen ecosystem service so that users can see what lands within their study region support that service. By repeating this step for other ecosystem services, the user can create a series of maps of different values that can be layered or stacked to show combined value for multiple services.

In the final step, EcoValuator allows the user to customize the print layout and export the file as a .pdf. This generates the final map of the chosen ecosystem service including a title, subtitle and source information.

We are in the process of updating the EcoValuator to use remotely sensed data from the North American Land Change Monitoring System (NALCMS), which will cover all of the U.S. as well as Mexico and Canada.

### What are ecosystem services?

Ecosystem services are the flow of benefits from ecosystems to people at a given extent of space and time.<sup>2</sup>

This definition emphasizes that ecosystem services are not just material things provided by nature, but also the benefits we receive from natural processes occurring in nature. It also emphasizes that it is not just *what* those effects are that matters: it is also *when* and *where* the effects occur. The “where” part, especially, is what drove us to create the EcoValuator as a tool for better understanding ecosystem service flows in one’s own region of interest.

### The Benefits Transfer Method

Benefit Transfer Method (BTM) provides an accessible way of estimating the value of ecosystem service flows in one setting (the policy area) based on the values estimated in another similar setting, called the

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<sup>1</sup> Not all combinations of land cover and ecosystem service are present in the literature, so EcoValuator will not provide estimates of the value of every service that could be flowing from every corner of your landscape. The absence of an estimate, therefore, should not be interpreted as an absence of value.

<sup>2</sup> Source: Johnson, G. (2010, March). AIRES (Artificial Intelligence for Ecosystem Services) Workshop. Burlington, VT, USA: Gund Institute.

“source” area. BTM is, in the words of the Organization for Economic Cooperation and Development, “the bedrock of practical policy analysis”.<sup>3</sup>

In the EcoValuator, we employ a version of “unit value transfer” and apply estimates from a source study (or studies) to the user-defined policy area based on matching land cover in both areas.

Ecovaluator uses values from source studies compiled by the “TEEB” effort (for “[The Economics of Ecosystems and Biodiversity](#)”) as well as those reviewed by Key-Log Economics in the course of our own ecosystem services assessments.

We began with an initial list of more than 1,200 specific estimates of the monetary value of specific ecosystem services arising from specific land cover types and then filtered out those for land covers not found in the conterminous United States, such as tropical rainforest, and polar and marine areas. We also excluded estimates from source areas where the nominal land cover might be similar, but where climate or other factors would make the estimates less applicable in the landscapes currently covered. Grasslands in Kenya, and wetlands in Vietnam are two examples. Finally, we excluded estimates from any source studies published before 1975.

We have classified each remaining source study estimate according to the ecosystem service (i.e., recreation, soil formation, water quality, etc.) and land cover type (open water, woody wetlands, etc.). We have also adjusted each value for inflation and for the relevant international currency exchange rates prevailing at the time of our latest update. That puts each value in units of 2,017 dollars per hectare per year (\$2017/ha/year).

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<sup>3</sup> Source: Organization for Economic Cooperation and Development. (2006). Benefits Transfer. In Cost-Benefit Analysis and the Environment (pp. 253–267). OECD Publishing. Retrieved [here](#).

## PRELIMINARY SETUP

### How to download QGIS

1. In a web browser, open the [QGIS installation download](https://qgis.org/en/site/forusers/download.html) site (<https://qgis.org/en/site/forusers/download.html>). The recommended version of QGIS for this plugin is version 3.4 (Madeira).
2. Select the appropriate download for the computer type.
3. Follow the prompts until QGIS is installed as an application.

### How to download the plugin

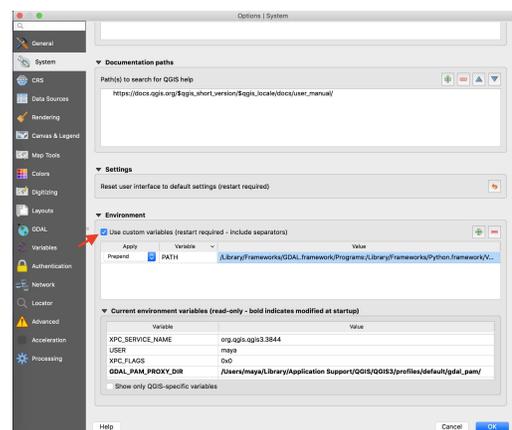
1. In a web browser, open the [QGIS python plugins repository](https://plugins.qgis.org/plugins/ecovaluator/) (<https://plugins.qgis.org/plugins/ecovaluator/>). Click on “download latest button” which will download the EcoValuator 3.0.

### How to install the plugin in QGIS

1. Open QGIS.
2. Go to “plugins” at the top of the screen and select “manage and install plugins.” Under the “All” tab, search for EcoValuator. Then choose “Install Plugin”. Once installed look in the “Installed” tab and check the box next to EcoValuator.
3. The plugin is found in the processing toolbox, located on the right side of the screen. If not already visible, find “processing” at the top of the screen and select “toolbox”. You can access it by clicking the left arrow.

### If working with QGIS 3.0.0+ set up the GDAL tool path

1. The tool path for QGIS 3 on has not been set up. To allow QGIS to look for the GDAL tool that will allow raster tools to be used go to QGIS 3 > Preferences > System.
2. Scroll down to “environment”, select “use custom variables” and click .
3. Add a path as follows:  
Select prepend, type in “PATH” and including the text  
“/Library/Frameworks/GDAL.framework/Programs:/Library/Frameworks/Python.framework/Versions/3.6/bin:” for each of the columns. Then click “ok”.
4. QGIS will restart.



## STEP 1: ESTIMATE ECOSYSTEM SERVICE VALUES FOR STUDY REGION

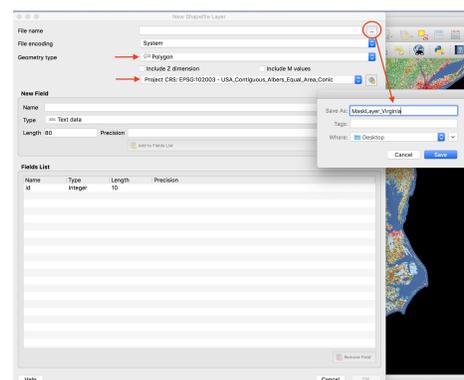
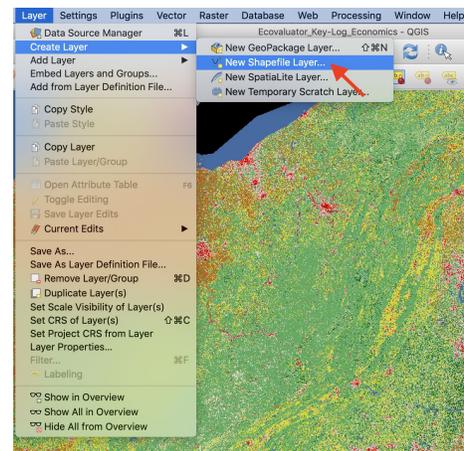
In the first step, the user-defined area of study will be clipped to the input National Land Cover data. Within this area, the plugin calculates how much area each type of land cover accounts for in the region, and multiplies those areas by each of the associated per-hectare ecosystem service values from ESV research data. The output includes a clipped raster and a table of aggregate ecosystem values for each land cover type.

Downloading and opening the NLCD raster

1. In your web browser, go to the **Multi-Resolution Land Characteristics Consortium** and download the **2011 NLCD raster** (<https://www.mrlc.gov/data>). This is a copy of the National Land Cover Database depicting land cover in 16 types at the 30m resolution for the conterminous United States.
2. Expand this .zip file by double clicking on the folder
3. Open QGIS 3 and go to the file “browser” on the left side of the application, and open the NLCD layer by double clicking the NLCDrepro.tif file or by dragging it into the main window. Note that this layer is a large file and will take a moment to appear.

Adding/creating a mask layer

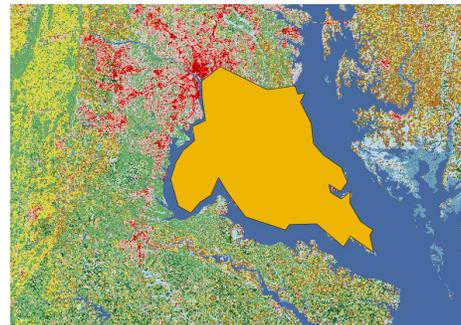
1. The EcoValuator is designed to accept user inputted mask layers which define the region of study within the NLCD. If you do not already have an existing mask layer (a vector layer) of your study area you should create a mask layer. To add a mask layer, drag the layer into the main window in a similar way.
2. To make a vector mask layer, begin by zooming to the appropriate scale using the  tool. You can adjust the field of view by using the  to drag the map to the appropriate region within the main window.
3. Once the region of study is in view, start creating a new layer by clicking **Layer > Create Layer > New Shapefile Layer...**
4. Save the new shapefile (.shp) by clicking the button to the left of the “File Name” box and save it in a preferred location using the selection tool . Click Save.
4. Ensure the mask layer is a polygon, and is in the appropriate projection that matches the national land



cover data (**EPSG:102003 - USA\_Continuous\_Albers\_Equal\_Area\_Conic**). Both NLCD and input mask layer must be in this projection in order to successfully execute the clip to the mask layer. Then, click ok.

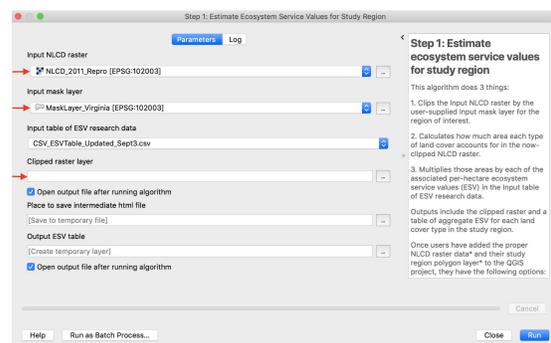
The new layer should appear above the NLCD layer.

- Right click on the mask layer on the bottom left corner of the window. **Select “toggle editing” and this  digitizing tool in the command bar. From here, begin outlining your region by clicking on points on the map.** For greater precision, you can use the coordinates listed at the bottom of the window. To close the polygon, right click. Input any whole number for the id (eg. 1) of the mask layer feature attributes window that pops up.
- Right click on the mask layer description on the bottom left corner of the window, and deselect “toggle editing”. When prompted, “save layer edits”.
- Confirm the mask is in the correct projection by right-clicking the layer, selecting Properties > Source and confirming the coordinate system used is “EPSG:102003 - USA\_Continuous\_Albers\_Equal\_Area\_Conic” in the “Geometry and Coordinate Reference System” section.



### Use Step 1 of the EcoValuator

- Access the plugin through the processing toolbox, which is located on the right side of the screen. Click the two drop down arrows for the plugin and open “Step 1: Estimate Ecosystem Service Values for Study Region” by double clicking the text.
- Input the NLCD layer as well as the created or imported mask layer into the first two fields of the dialogue box.**
- Optional: Save the “clipped raster” layer to the computer by clicking the box to the right of the text input box and save to a preferred location. This field can also be left empty. Then click “run”.
- Optional: Fill out the “place to save intermediate file” field to generate a html file with the number of pixels and total area (in m<sup>2</sup>) for each different pixel value in the input raster. Make sure to specify an .html file extension.
- Output ESV Table: **Leave this field blank!** We apologize as this is not intuitive.
- Once the dialogue box indicates the algorithm is finished, click close and return to the main window.



7. **Right-click the output\_ESV\_table at the bottom left corner of the window, and select “open attributes table”.** This output from the first step of the EcoValuator plugin is a table of aggregate ecosystem service values for each land cover type in the study region. The data from this table offers a per-hectare-per-year minimum, average and maximum dollar value estimate for all ecosystem service within each land cover type<sup>4</sup>.

Note that many NULL values will appear in the table due to a lack of existing research on certain ecosystem services in each land cover type, and NULL does not correspond to a dollar value of 0. It simply indicates a current lack of primary studies determine the dollar amount.

Also note that the nature of the BTM and land cover classifications require some discretion by the user, as overgeneralizations may occur when classifying and assigning value to land. For example, beaches and gravel pits are both classified as “barren land” in the NLCD. Considering that beaches and rocky mountaintops tend to have high recreation and aesthetic value (while gravel pits do not), there are obvious limitations to this design. User knowledge about the area of study will help to determine whether minimum, mean and maximum values would be appropriate.

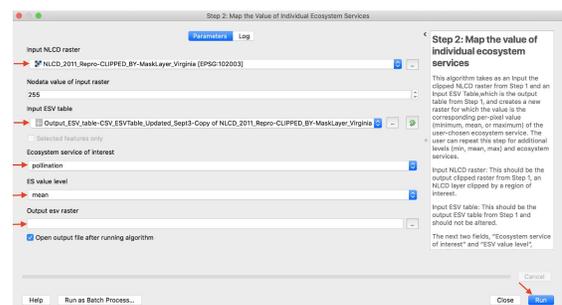
8. The first step also generates clipped raster layer, found under the “layer” box on the bottom left corner of the window. This will be used in the second step, so the contents of the table should not be altered.

## STEP 2: MAP THE INDIVIDUAL ECOSYSTEM SERVICE

This algorithm takes as an input the clipped NLCD raster from Step 1 and an input ESV table, which is the output table from Step 1, and creates a new raster for which the value is the corresponding per-pixel value (minimum, mean, or maximum) of the user-chosen ecosystem service. The user can repeat this step for additional levels (min, mean, max) and ecosystem services. The raster output is shaded depending on the ecosystem service chosen and its values are broken into 5 even quintiles.

Use Step 2 of the EcoValuator

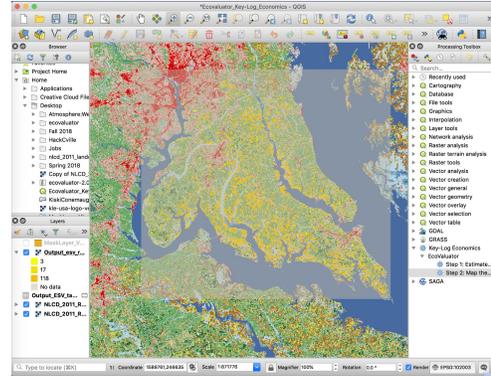
1. Open “Step 2: Map the Individual Ecosystem Service” by double clicking the section’s text, located in the processing toolbox.
2. **Input the new, clipped raster (NLCD clipped to the mask layer) generated in Step 1 into the first field of the dialogue box.** The name of the layer should be formatted similar to this: “[NLCDLayerName]-CLIPPED



<sup>4</sup> These figures are also adjusted for the exchange rate and inflation. These figures are derived from an extensive [database](#) (see Benefit Transfer Methods section).

\_BY-[MaskLayerName]”. These files can be renamed later on.

3. Select the output ESV table layer generated in step 1 for the “Input ESV table” in the dialogue box.
4. In the “Ecosystem service of interest” and “Ecosystem Service Value Level”, select the user-preferred ecosystem service to be mapped and which values (minimum, average or maximum) should be taken from the ESV table.
5. Specify an output location for the “output ESV raster”, this should be a .tif. Then click “run”. Once the dialogue box indicates the algorithm is finished, click close and return to the main window.
6. The output layer for the user-defined ecosystem service and value will appear in the layer panel in the bottom left of the main window. To see the output layer, deselect the layers above it.
7. The output will be a modified version of your “input NLCD raster”. The output will be shaded, according to the ecosystem service chosen, and its values are divided into even quintiles. Lastly, the output will have a descriptive name (ex: [ecosystem service] - [Ecosystem Service Value level]).
8. Keep in mind, you can always modify the output to look differently if you want, after the output raster has been generated.



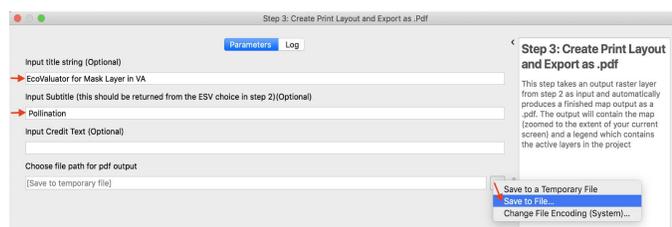
### STEP 3: CREATE PRINT LAYOUT AND EXPORT AS .PDF

This step allows users to easily and automatically produce a finished map, saved as a .pdf file. The output will contain the map, legend, title, subtitle, and credit text.

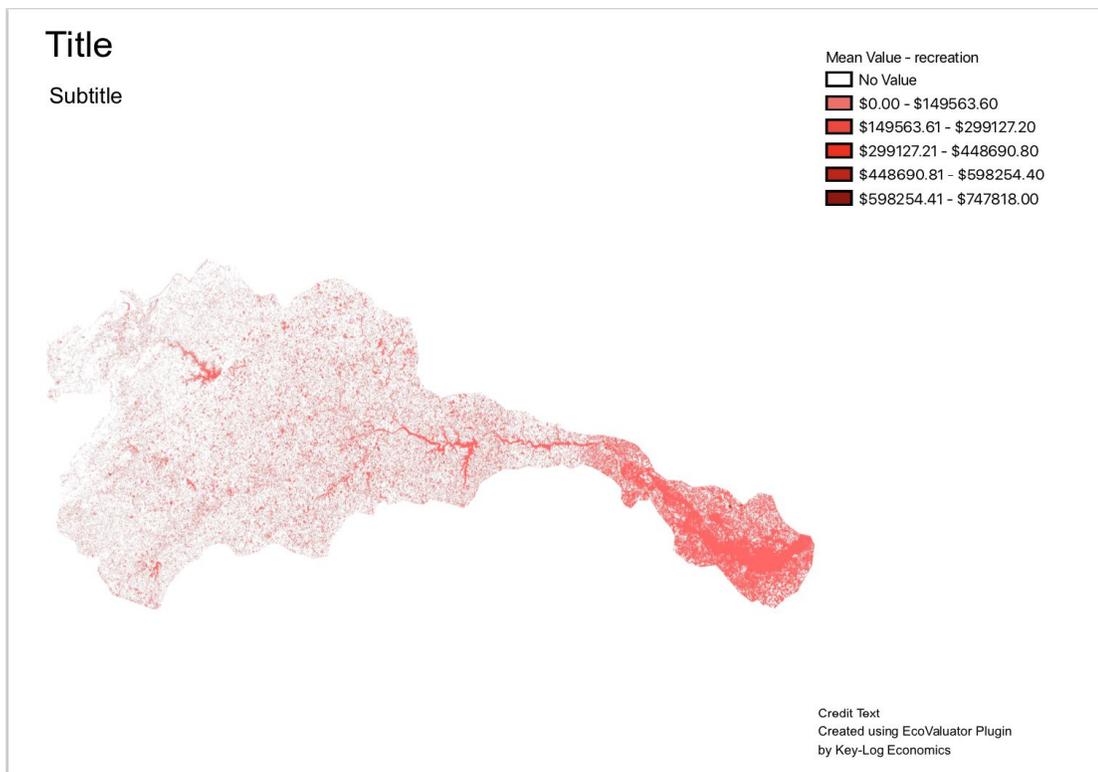
Using Step 3 of the EcoValuator

1. First, the map in the final output will reflect what is visible in your QGIS project. **To adjust this (either a widen or narrow the extent) for the product generated, simply zoom in or out on the map in QGIS to the desired level of detail.** If you are zoomed out, your map in the output will be small. If you zoomed in, your map might be bigger than the box in the final layout. You might need to experiment with this for best results.
2. The final product will produce a map legend containing all the active (selected) layers. If you do not wish to include a layer in the legend, you must deselect it. This includes tables (such as the output ESV table from step 1). You must also remove tables from the layers panel if you do not wish them to be included in the legend.
3. Open “Step 3: Create Print Layout and Export as .pdf” by double clicking the section’s text, located in the processing toolbox.

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4. Optional: Input a user-defined title for the project in the first dialogue box. This will appear at the top left of the .pdf generated.
5. Optional: Input a user-defined subtitle, which might include a description of the ecosystem service that is observed, which per pixel value (mean, min, max) is used or additional notes about the project. This will appear below the title in the .pdf generated.
6. Optional: In the next dialogue box, credit text or source information can be included. This text will appear at the bottom right of the .pdf generated.
7. Select a location to save the .pdf by right clicking the  button and selecting "save to file." Name and selected a preferred location for the product (You may have to add ".pdf" to the end of your file name). Click "run". View the final product in the location specified.
8. Here is a generic example of what the output will look like. Note the location of the map elements including title, subtitle, credit text, legend, and map.



### Optional: Adjusting the Display

Keep in mind, you do not have to accept the default .pdf output from Step 3. You can always create your own print layout if you desire. After running Step 3, a Print Layout is automatically generated.

9. To find this print layout, look at the top of the screen under "Project" and "Layouts", you'll see "EcoValuator Layout", which you can modify. You can also create your own print layout from

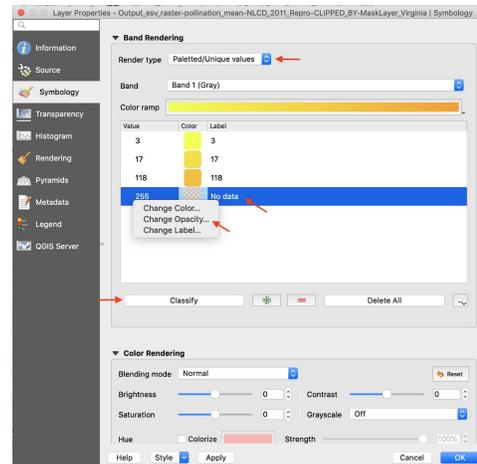
scratch and add map elements, titles, etc to it if you wish. You are not beholden to our Step 3 output.

Other ways to modify your final output:

10. Adjust the display of the map by right clicking the output ESV raster layer and selecting **properties > symbology** and choosing one of the “Render Type” options. We will give one example with “Paletted/Unique Values” for render type under the “Band Rendering” section.

11. Click the box next to the color ramp text and select a preferred color gradient. Then click “classify”.

12. Different values will appear value window, including a value of “0”. This value represents the regions where no data is available. To see the generated map in reference to a base map right-click the color that classifies the 0 value, and select “change opacity” and input “50” into the pop up window. Then change the color in the same way and select a white-grey shade.



13. The label for each of these values can also be changed to give a more informative legend manually in the layer box or by right-clicking the color that classifies each value and inputting the user-preferred name. Then click “ok” to save.

**APPENDIX 1: Ecosystem Services Covered in the EcoValuator**

<b>Ecosystem Service</b>	<b>Description</b>
Aesthetics	Formation of landscapes that are attractive to people
Air Quality	Removal of contaminants from the air flowing through an ecosystem, including through filtration or decomposition
Biodiversity	The process of increasing genetic diversity across and within species
Climate Regulation	Modulation of regional/local climate
Erosion Control	Control of the processes leading to erosion, for example, by controlling the effects of water flow, wind, or gravity
Food/Nutrition	Ecosystems provide the conditions for growing food. Food comes principally from managed agro-ecosystems but marine and freshwater systems or forests also provide food for human consumption.
Pollination	Contribution of insects, birds, bats, and other organisms to pollen transport resulting in the production of fruits and seeds. May also include seed and fruit dispersal
Protection from Extreme Events	Extreme weather events or natural hazards include floods, storms, tsunamis, avalanches, and landslides. Ecosystems and living organisms create buffers against natural disasters, thereby preventing possible damage
Raw Materials	Materials for construction and fuel including wood, biofuels, and plant oils that are directly derived from wild and cultivated plant species.
Recreation	Leisure and activity derived from ecosystems.
Soil Formation	Process by which soil is created, including changes in soil depth, structure, and fertility.
Waste Assimilation	Removal of contaminants from the soil in an ecosystem, including through biological processes such as decomposition
Water Supply	Filtering, retention, storage, and delivery of fresh water—both quality and quantity—for drinking, watering livestock, irrigation, industrial processes, hydroelectric generation, and other uses.