FEGS SCOPING TOOL USER MANUAL

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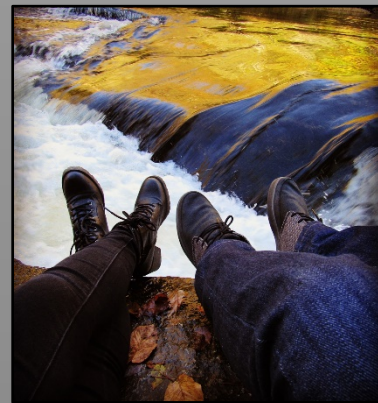
U.S. Environmental Protection Agency

Office of Research and Development

Center for Environmental Measurement and Modeling

Contents

Disclaimer:

Before You Get Started

This manual is meant to accompany the Final Ecosystem Goods and Services (FEGS) Scoping Tool, which is available as a separate downloadable file. Users may find it useful to follow along in the tool while reading the manual.

Those contemplating or analyzing a decision with environmental aspects under consideration may find this tool useful to identify the most critical aspects of the environment for that decision. For more information about the type of situations this decision support tool may be used for, the reader is directed to Sharpe et al. (2020).

This manual speaks about "users" and "decision makers." Tool users are those who will be using the FEGS Scoping Tool to examine a decision. Decision makers are those who are making the decision that is being examined. They may or may not be the same set of people.

The manual itself focuses on the instructions for using the tool. Appendix A covers the methodologies underlying tool function. Appendix B contains a narrative example of an application of the tool.

Purpose of the Tool

The FEGS Scoping Tool informs the early stage of decision-making, when decision makers are aware of a decision they need to make, but before any actions are taken. The tool helps users identify and prioritize stakeholders, beneficiaries, and environmental attributes (i.e., aspects of the environment) through a structured, transparent, and repeatable process. These relevant and meaningful environmental attributes can then be used to evaluate decision alternatives. The tool is transferrable across a wide range of decision contexts allowing it to be used in the scoping phase of any decision with an environmental context. The tool helps users identify meaningful environmental attributes for use in evaluating decision alternatives but does not provide additional guidance in selecting the preferred decision alternative.

All decision makers prioritize stakeholders, whether consciously or subconsciously. This tool formalizes and records the stakeholder prioritization process, making those priorities transparent. Decision makers can use prioritization process results to systematically identify environmental attributes most relevant to the prioritized stakeholders. A formal and transparent prioritization process also allows constituents to see what perspectives were most influential to the decision and why.

The FEGS Scoping Tool recognizes that community decisions are complex and environmental decision criteria are both relevant and hard to identify. The goal of the FEGS Scoping Tool is to provide a transparent, repeatable, defendable approach for selecting relevant environmental attributes as decision criteria.

The tool should be used by community-level decision makers involved in communicating objectives of choosing between decision options. Community-level decision makers should use the FEGS Scoping Tool in a participatory, iterative fashion with input from stakeholders. The specifics of tool application, however, will depend heavily on the decision-making processes already in use. No technical expertise is necessary to use the tool, only familiarity with the community and its stakeholder groups.

No software other than the tool is needed. The operating system and hardware requirements for tool installation are found in Table 1.

Table 1. Operating system and hardware requirements for tool installation.

	Operating System Requirements	Hardware Requirements
Windows	• Windows 7 or later	• SSE2 capable Intel Pentium 4 processor or later • 512 MB of RAM

Definitions

The following are key terms used in the tool and this manual.

FEGS – FEGS are Final Ecosystem Goods and Services. These are the aspects of the environment that are directly enjoyed, used, or consumed by humans. They are specified as *final* because of the *direct* benefit they provide to humans. For more discussion about FEGS, see Landers and Nahlik (2013) and DeWitt et al. (2020).

Stakeholder groups – Stakeholders are interested and affected parties. Their inclusion has become an important part of the environmental decision-making process and can lead to better informed and more accepted decisions. Stakeholder groups are groups based on the roles the parties within them play in the community. For example, a tourism industry group representing snorkeling and fishing tours could be considered a stakeholder group or the collection of those businesses could be considered a stakeholder group. Alternatively, if some of those businesses having differing interests or perspectives it might be more appropriate to treat them as separate stakeholder groups.

Stakeholder prioritization criteria – The stakeholder prioritization criteria were developed specifically for this tool and encompass all aspects of stakeholder groups that decision makers might consider when prioritizing one group over another. Inclusion of diverse stakeholder perspectives can lead to improved decision-making, but for many projects it is not feasible logistically or financially to include every possible stakeholder. These criteria offer a transparent, repeatable, and sharable approach to prioritize stakeholder perspectives. The stakeholder prioritization criteria were designed to cast as wide a net as possible to cover all potential criteria that decision makers currently consider when doing informal or subconscious stakeholder group prioritizations. It is not expected that all the criteria would be meaningful and relevant for all decision makers or decision contexts. Table 2 contains the full set of criteria used in the tool and their definitions. For more discussion on stakeholder prioritization, see Sharpe et al. (2021).

Beneficiary roles – Beneficiary roles are the ways an individual or group enjoys, uses, or consumes some aspect of the environment. Transitioning from stakeholder groups to beneficiary roles, helps decision makers better articulate the ways stakeholder groups are benefiting from the environment. Beneficiary roles are based on how individuals within them interact with the environment. For example, that snorkeling tour industry stakeholder group would be composed of several beneficiary roles covering the

different aspects of their interaction with the environment (i.e., boating, swimming, etc.). The FEGS Classification System (Landers and Nahlik 2013) defined a list of all potential beneficiary roles. The National Ecosystem Services Classification System Plus (Newcomer-Johnson et al. 2020) updated that list of beneficiary roles. This updated list, including definitions, is used in the Beneficiary step of the tool. The complete list of beneficiary categories and their definitions can also be found in Appendix C.

Environmental attributes – Environmental attributes are the specific aspects of the environment that are enjoyed, used, or consumed by beneficiaries. An initial list of these attributes was developed as part of the FEGS Classification System (Landers and Nahlik 2013). That list was refined and updated in the National Ecosystem Services Classification System Plus (Newcomer-Johnson et al. 2020) and the FEGS Metrics Report (USEPA 2020). The updated list, including definitions, is used in the Attribute step of the tool. The complete list of attributes and their definitions can also be found in Appendix D.

Table 2. Stakeholder prioritization criteria used in the tool and their definitions.

Criteria	Definitions
Magnitude/Probability of impact	The likelihood and degree of potential impact to the stakeholder group as a result of the decision
Level of influence	The level of influence that the stakeholder group has over the decision-making process
Level of interest	The level of interest that the stakeholder group has in the decision-making process or outcome
Urgency/Temporal immediacy	The degree to which the stakeholder group would like to see a decision made or action taken quickly
Proximity	How frequently the stakeholder group comes into contact with the area for which a decision is being made
Economic interest	Whether the stakeholder group has an economic interest in the outcome of the decision-making process (i.e., would their livelihoods or assets be impacted by the decision outcome)
Rights	Whether the stakeholder group has legal, property, consumer, or user rights associated with the decision-making process, the decision outcome, or the area the decision affects
Fairness	Whether the exclusion of the stakeholder group from the decision-making process would lead to the process being viewed as unfair by the community
Underrepresented/Underserved groups	Whether the stakeholder group represents any underrepresented or underserved populations

Tool Use

Overview

The FEGS Scoping Tool has three outputs: stakeholder prioritization, beneficiary profile development, and environmental attribute identification. Four steps, completed in sequential order and each building on the previous step, inform the three outputs:

1. Weights – In this step, users provide weights for each of the nine stakeholder prioritization criteria. Weights are purely subjective and should reflect the values that will be used when making the decision. There step has no output but informs the following step.
2. Stakeholders – In this step, users identify all stakeholder groups relevant to the decision context and score the stakeholder groups on all nine stakeholder prioritization criteria. The output of this step is a prioritized set of stakeholders.
3. Beneficiaries – In this step, users segment each stakeholder group into its component beneficiary groups. The output of this step is a prioritized set of beneficiaries.
4. Attributes – In this step, users identify the environmental attributes each beneficiary group cares about. The output of this step is a prioritized set of environmental attributes.

Tool Applications

The FEGS Scoping Tool can be applied in a variety of ways depending on what best fits the decision maker's needs and decision context (Sharpe et al. 2020). Options include:

- Using the tool as part of an interactive activity with a group of stakeholders;
- Using the tool with decision makers to help inform stakeholder engagement planning;
- Using the tool iteratively, with one group or individual working through the tool, sharing results with other groups or individuals, and then incorporating their feedback into the tool.

Getting Started

The FEGS Scoping Tool is run as an application on the user's computer. It is installed by downloading and opening the installer file (FEGS Scoping Tool 1.8.0.exe). The application opens as a single window (Figure 1) and can be opened via the application itself or by opening a saved project file with a .fegs extension. The left side of the window is a navigation panel that tracks project progress. Users can either scroll through the steps of the tool using a mouse or the scroll bars, or by clicking on the step name in the information bar to move from step to step. The navigation panel also includes a slider to allow users to zoom in or out and a check box to shift charts into alternative colors that may be easier for those with color blindness to read.

The center of the window shows the input areas for the first step (discussed further in the *Weights* section). The window name can be found in the top left of the window and will be "FEGS Scoping Tool" until the project file is saved. Once the file is saved (see instructions below), the window name will be the file name.

Important note: All tool inputs result in "live time" updates of the outputs. At any point, changes to the data will be reflected in the outputs. Previous output is not saved unless they are saved as a separate FEGS file before changing inputs (see below).
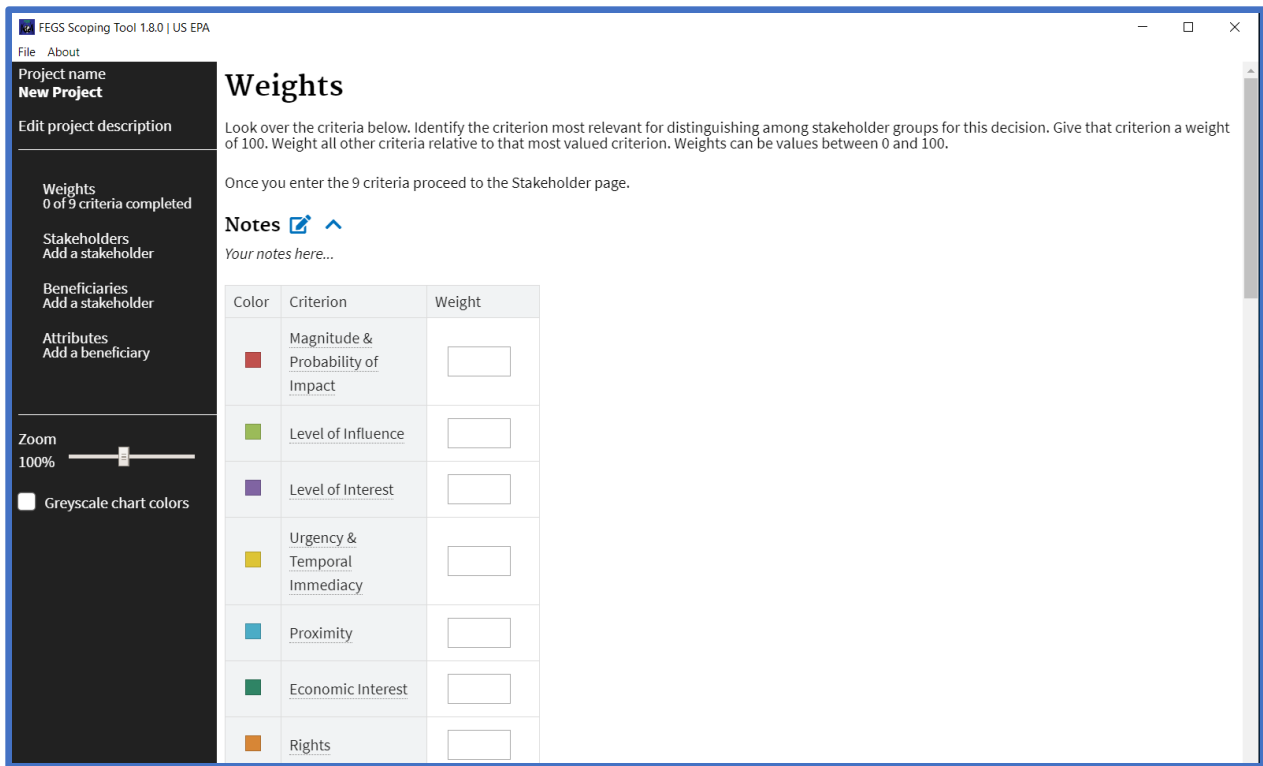
Figure 1. Tool window when initially opened.

Naming a Project

To give a new project a name, click on New Project in the navigation panel (Figure 2a). When the data entry field appears, replace "New Project" with the desired project name and click "Save Name" (Figure 2b). The new name will replace "New Project" under Project name (Figure 2c). Users follow the same steps to rename a project.
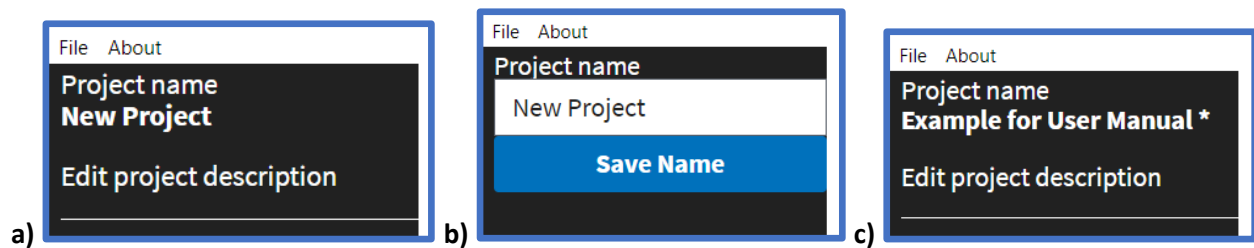

Figure 2. Naming a project.

Saving a Project

To save the project file use the "File" drop-down menu found in the top left of the window, under the window name. Click on "File" and then select the "Save" or "Save As" option. The project name is automatically suggested as a file name. All tool inputs result in "live-time" updates of the outputs. At

any point, changes to inputs will be reflected in the outputs. If users want to keep a set of outputs, they should save them as a separate FEGS file before changing inputs.

The project files are saved as separate documents with the file extension .fegs. Opening these files will automatically launch the application. The application must be installed on the computer for the file to open successfully. If the tool is closed without saving the project file, all progress will be lost. A project with unsaved information will have an asterisk by the name (Figure 3a), if there is no asterisk all entries have been saved (Figure 3b).
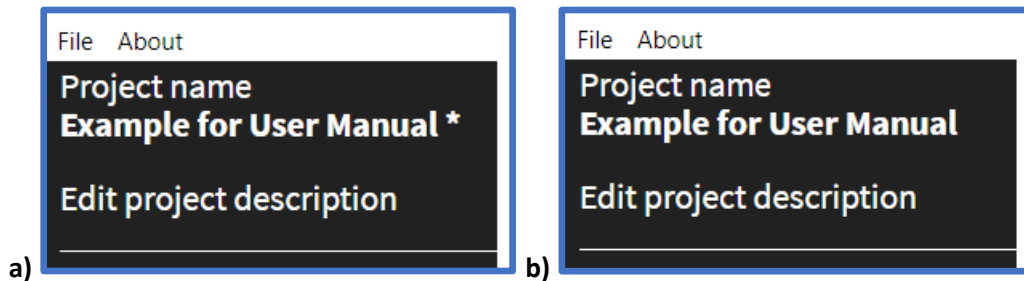

Figure 3. Determining whether tool inputs have been saved.

Including Additional Information

Users interested in adding information beyond the project name, can also add a project description. To do this, click on "Edit project description" in the navigation panel, add the desired description in the text box and click "Save Description" (Figure 4). The description is not always visible but can be seen by clicking "Edit project description".
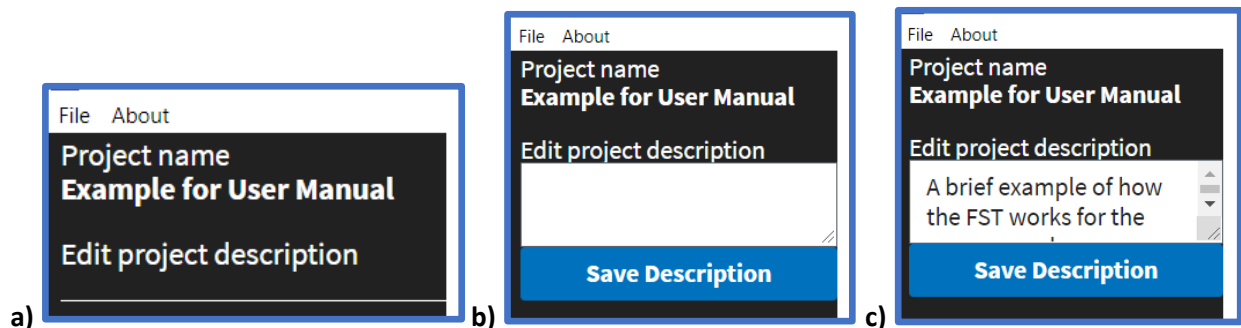

Figure 4. Adding a project description.

Beyond a project description, each of the four steps (Weights, Stakeholders, Beneficiaries, and Attributes) in the tool has an associated notes section. This provides a place for adding any information users think would be useful. This could include notes on discussions associated with that step or information used to support inputs. To enter information in any of these notes sections simply click on the pencil icon next to "Notes" at the top of each step. A text box will open, and users can enter any notes they have (Figure 5). Once complete, click the green checkmark to save the notes. Changes or additions can be made at any time by hitting the pencil icon again. To hide or view the notes, click the arrow next to pencil icon.

Weights

Look over the criteria below. Identify the criterion most relevant for distinguishing among stakeholder groups for this decision. Give that criterion a weight of 100. Weight all other criteria relative to that most valued criterion. Weights can be values between 0 and 100.

Once you enter the 9 criteria proceed to the Stakeholder page.

Notes

Your notes here...

a)

Weights

Look over the criteria below. Identify the criterion most relevant for distinguishing among stakeholder groups for this decision. Give that criterion a weight of 100. Weight all other criteria relative to that most valued criterion. Weights can be values between 0 and 100.

Once you enter the 9 criteria proceed to the Stakeholder page.

Notes ✔

b)

Weights

Look over the criteria below. Identify the criterion most relevant for distinguishing among stakeholder groups for this decision. Give that criterion a weight of 100. Weight all other criteria relative to that most valued criterion. Weights can be values between 0 and 100.

Once you enter the 9 criteria proceed to the Stakeholder page.

Notes

This decision could impact a neighborhood park, so we find the criterion of proximity to be most influential because we are interested in prioritizing those groups that come into frequent contact with the area.

c)

Weights

Look over the criteria below. Identify the criterion most relevant for distinguishing among stakeholder groups for this decision. Give that criterion a weight of 100. Weight all other criteria relative to that most valued criterion. Weights can be values between 0 and 100.

Once you enter the 9 criteria proceed to the Stakeholder page.

Notes

Notes hidden...

d)

Figure 5. Adding notes.

Exporting Results

The Scoping Tool provides graphical outputs from the Stakeholders, Beneficiaries, and Attributes steps in bar charts and pie charts. To export any of these results, click the arrow icon next to the chart title (circled in red in Figure 6). A new window will open with a prompt to name and save the chart. Users can choose to save the charts in one of three different file formats – PNG, JPEG, and SVG. PNG is the default and generally the best choice. JPEG is best for generating a smaller file size. SVG is best when users want to make the chart very large without pixilation.
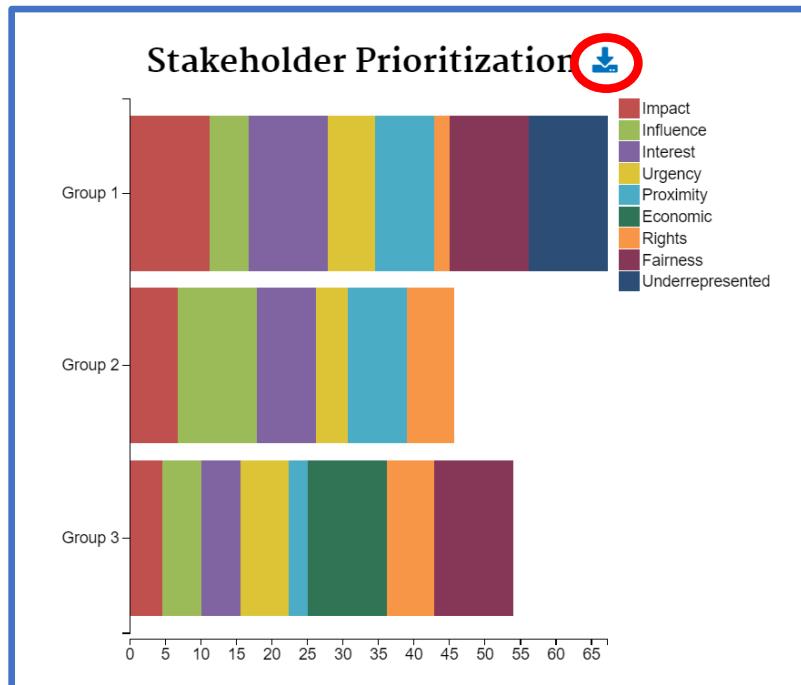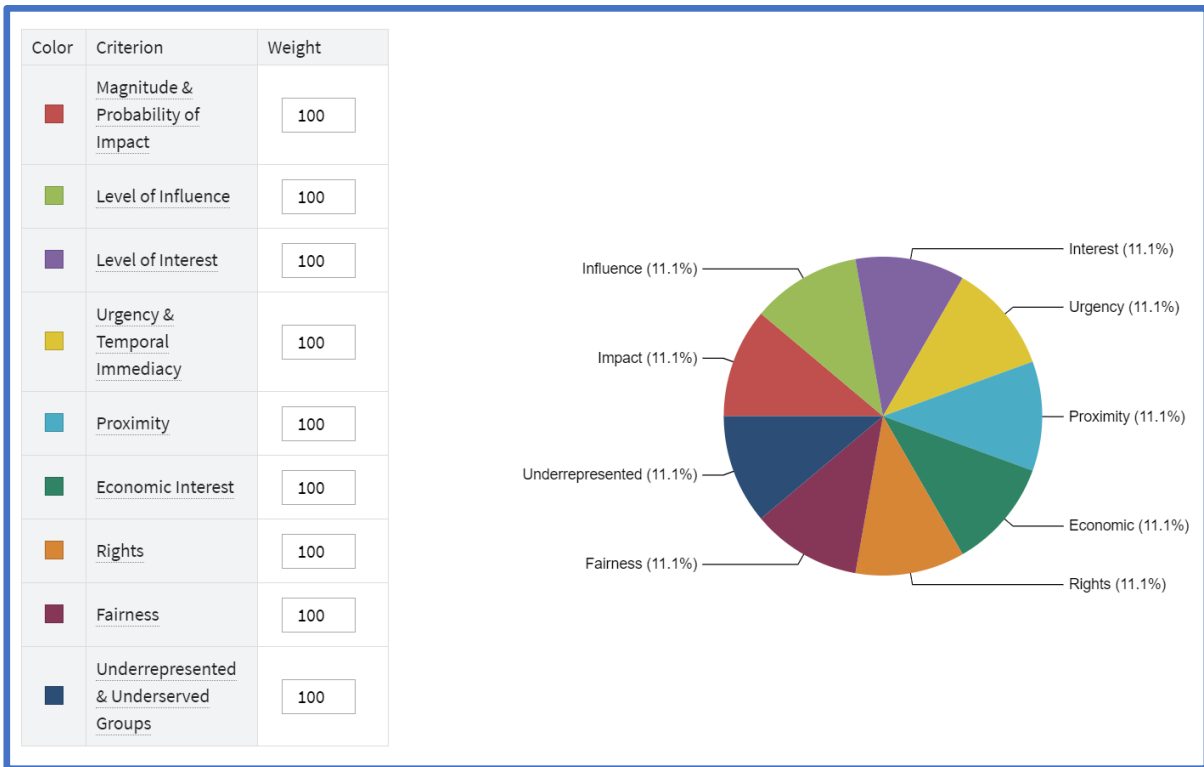

Figure 6. Exporting results.

Step 1: Weights

In this step users provide weights for the stakeholder prioritization criteria. Users identify the criterion they value the most and give that criterion a weight of 100. Users should ask themselves, "*When prioritizing stakeholder groups, which of these criteria is most meaningful to me for this decision context?*". Users should consider what criteria are meaningful for distinguishing among the stakeholder groups for their specific decision context. The relative influence of each criterion, and whether each is considered at all, will likely shift from decision to decision. For example, when making a decision about a neighborhood park, decision makers may give more weight to proximity because they want to prioritize groups that frequently interact with the park. However, if decision makers are considering impacts to a port that is associated with many jobs in the area, they may give more weight to economic impact because they want to prioritize groups that may be financially impacted by their decisions.
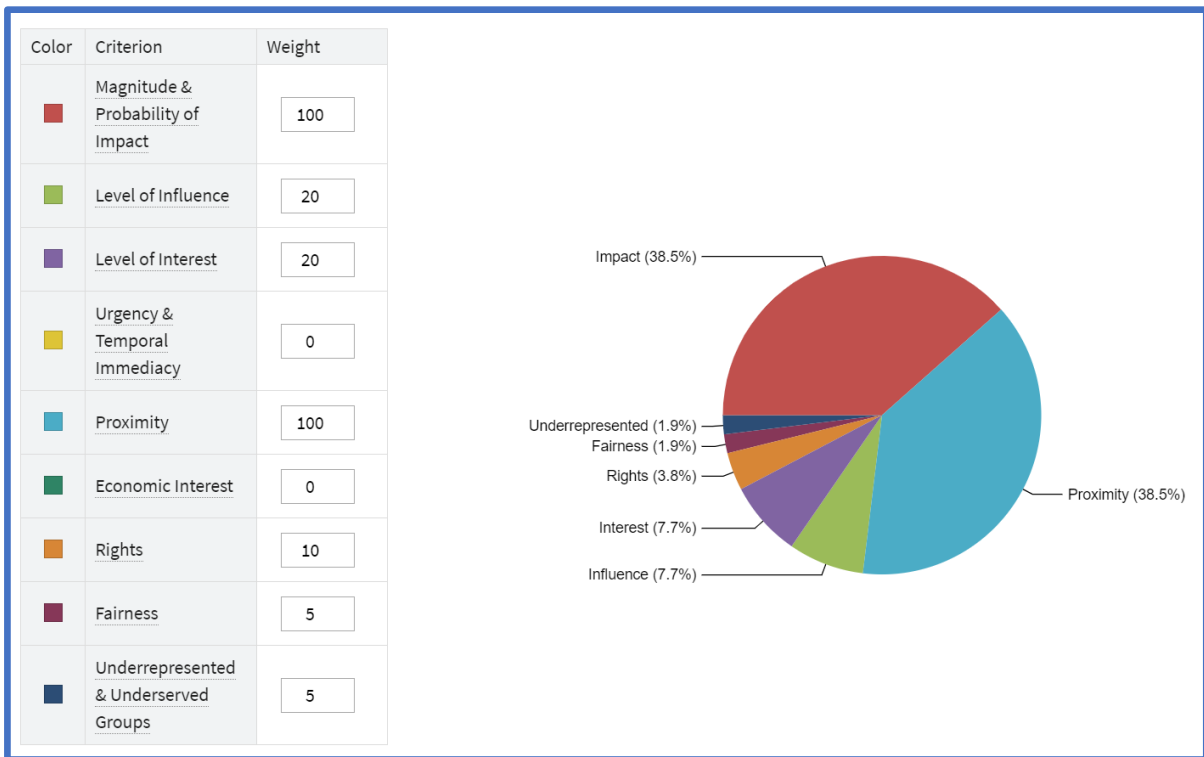
Once the most influential/valued criterion is given a weight of 100, all other criteria should then be weighted relative to that most valued criterion (from 0-100, with 0 being totally unvalued and 100 being

valued as much as the initial, most valued criterion). As weights are entered, a pie chart is displayed to help users visualize the relative influence their input weights will have on the prioritization. Until the first weight is assigned, the area will be blank and look like Figure 1.

The input area for weights is the weight column in Figure 7. In Figure 7a, all criteria have been weighted equally, indicating that no single criterion is more important than any other. In Figure 7b, two criteria have been weighted as substantially more important than the others and two criteria have been weighted as 0, meaning those criteria are not considered in the prioritization at all. The definitions for each criterion can be found in the Definitions section of this manual and by placing the cursor over the criterion name in the criterion column. When the cursor is placed on the name, the definition will appear.

a)

Color	Criterion	Weight
🟥	Magnitude & Probability of Impact	100
🟩	Level of Influence	20
🟪	Level of Interest	20
🟨	Urgency & Temporal Immediacy	0
🟦	Proximity	100
🟩	Economic Interest	0
🟧	Rights	10
🟥	Fairness	5
🟦	Underrepresented & Underserved Groups	5

b)

Figure 7. Weighting examples.

Step 2: Stakeholders

This step begins with users entering all relevant stakeholder groups. There is no mechanism in the FEGS Scoping Tool to ensure that all stakeholder groups are considered and represented. However, by using a transparent and documented process, decision makers using this tool will be explicit about which stakeholder groups they are considering and why (Sharpe et al. 2020). This transparency allows others to see what groups were considered and provide feedback about any left out of the process. Taking an iterative approach at this step allows for additional stakeholders to be identified and incorporated into the tool.

Stakeholder groups are those groups that would be interested in or affected by the decision under consideration. Another way to think about it would be to consider what groups should be "at the table" when making the decision. The tool itself does not suggest a preset list of stakeholder groups because the groups will vary widely from one decision and location to another. In a decision about a neighborhood park, stakeholder groups may include neighborhood residents, local sports leagues, and neighboring property owners. In a decision about a port, stakeholder groups may include boating and fishing clubs, cargo shipping organizations, and marinas.

Users enter stakeholder groups by name in the stakeholder entry area (Figure 8a). After typing in the name, users click "Add Stakeholder Group" or hit enter to enter the group into the tool. Entered groups are listed below the stakeholder entry area. Users can enter as many or as few stakeholder groups as desired (Figure 8b). A stakeholder group is removed by clicking the red box next to the stakeholder group name.
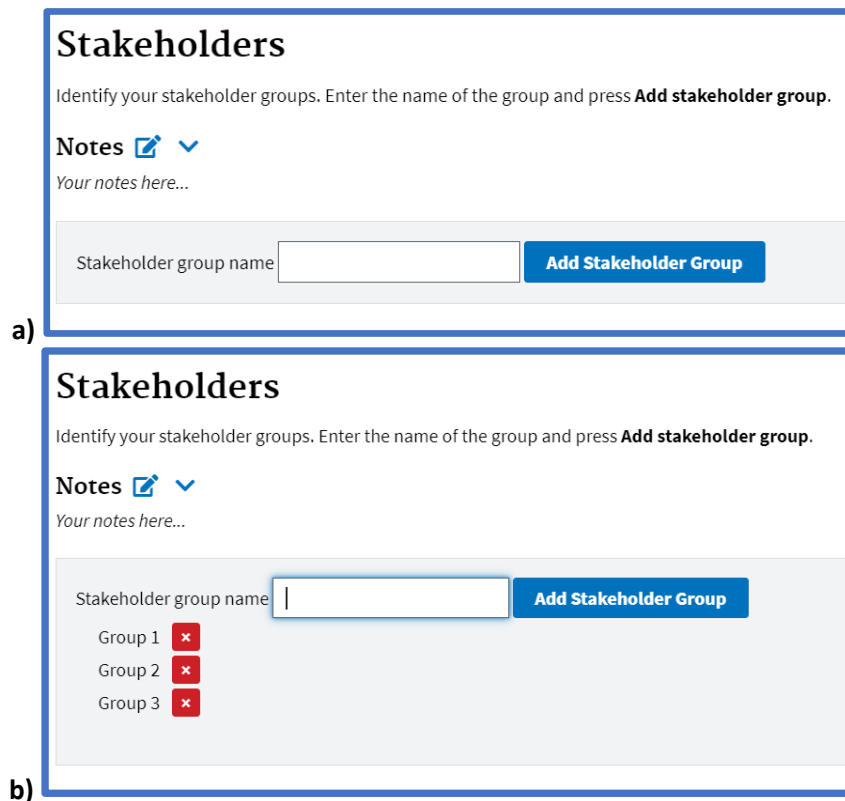
Figure 8. Stakeholder group entry area.

Once stakeholder groups are entered, a new area will appear below the stakeholder entry area. This area has a box for each of the nine stakeholder prioritization criteria. These boxes contain scoring instructions for each criterion as well as input boxes for each stakeholder group (Figure 9). Each criterion input box contains the question users should ask themselves when scoring the stakeholder groups for that criterion. The box also contains guidance for turning their answer to that question into a numerical score. The guidance is a suggestion and final scoring is left to the discretion of the user. The scoring step was designed to be quickly performed by those with knowledge of the community and its stakeholder groups and does not require specific data collection activities.

Figure 9. Stakeholder criterion score input box.

The navigation panel shows progress as users score each stakeholder group and criterion. Under the "Stakeholders" heading, the tool shows the number of criteria scored for each stakeholder group (Figure 10a). When all stakeholder groups have been scored across all criteria, click the "Add stakeholder scores" button beneath the final criteria input box (Figure 11). The navigation panel will then show all stakeholder scores as added (Figure 10b).

Important note: Do not leave this section without hitting "Add stakeholder scores" or the scores will not be saved. You can save this information even if data entry is not complete. You can return to complete this list or add to it at any time.
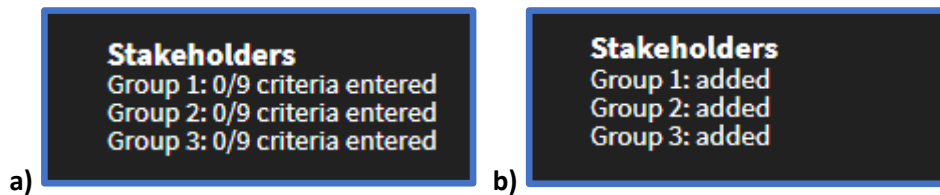

Figure 10. Navigation panel for the Stakeholders step.

Figure 11. Final stakeholder criterion score input box with "Add Stakeholder Scores" button.

Pressing the "Add stakeholder scores" button converts the scores in each box into an editable table (Figure 12). A bar chart displaying the stakeholder prioritization output for this step will appear beneath that table (Figure 13). To edit a stakeholder group name or criteria score click the pencil icon in that stakeholder group's row of the table (located on the far left of a row as shown in Figure 12).

The bar chart output (Figure 13) shows the relative priority of each stakeholder group, broken down by criteria and as a numerical result. This result helps show relative differences in priority and is not meaningful outside of this specific project and set of stakeholders. Beneath the output, the pie chart from the Weights step is also displayed. This allows users to see the weights influencing the result without scrolling back up to the previous step.

Important note: To export the output of this step, or any other, click the arrow icon next to the graph title. A new window will open with a prompt to name and save the chart as a .PNG file.

	Stakeholder Group	Magnitude & Probability of Impact	Level of influence	Level of interest	Urgency & Temporal immediacy	Proximity	Economic interest	Rights	Fairness	Underrepresented & Underserved Groups
✏️ 🗑️	Group 1	100	50	100	60	75	0	20	100	100
✏️ 🗑️	Group 2	60	100	75	40	75	0	60	0	0
✏️ 🗑️	Group 3	40	50	50	60	25	100	60	100	0

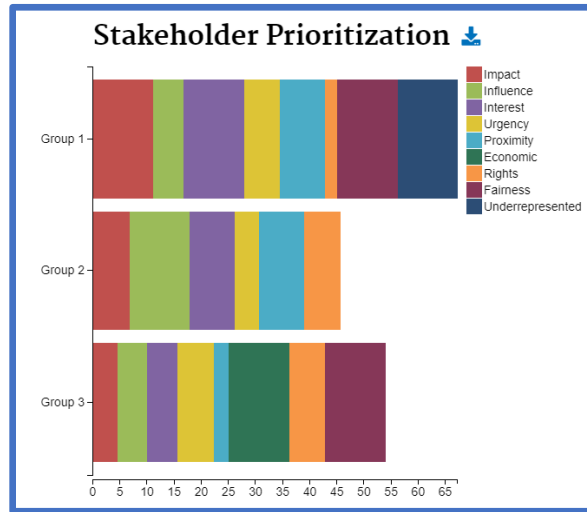**Figure 12. Stakeholder score table.**

Figure 13. Stakeholder step output – a prioritization of stakeholder groups.

Step 3: Beneficiaries

In this step, users segment each stakeholder group into its component beneficiary groups, by percentage, for a total of 100%.

The step has a drop-down menu, a series of buttons for beneficiary categories, and a check box option (Figure 14).

Figure 14. Beneficiary step.

Users begin by selecting a stakeholder group from the drop-down menu (boxed in red in Figure 14). They then click the buttons of the beneficiary categories relevant for the selected stakeholder group. If no beneficiary groups are relevant (i.e., the stakeholder group is important to consider for the decision, but do not directly benefit from environment in any way) users should check the box indicating that fact (circled in yellow in Figure 14).

As beneficiary categories are selected, a table will appear below the beneficiary buttons (Figure 15). This table consists of four columns: 1) the beneficiary categories; 2) the specific beneficiary types within each of those categories; 3) definitions for each beneficiary type; and 4) a data entry column. Definitions can be hidden by clicking the "Hide Definitions" button above the second column ("Subcategory"). The top of the data entry column shows the stakeholder group's prioritization results from the previous step.

Figure 15. Beneficiary input table

For each stakeholder group, users should first select the relevant beneficiary categories by clicking on the respective beneficiary category buttons at the top of the window. Then, by entering numbers as a percentage (do not include the "%" symbol), users should identify the types of beneficiaries making up each stakeholder group. As percentages are entered, the column will remain red unless the percentages sum to 100%. Figure 16 shows the table with definitions hidden, with inputs both not summing to 100% (a), and correctly summing to 100% (b).

Figure 16. Beneficiary input table examples.

When completing this step, users should ask themselves how each stakeholder group benefits from, uses, or values the ecosystem under consideration. For example, a stakeholder group consisting of businesses that take tourists out for snorkeling tours could benefit from the ecosystem through a waterbody that can be navigated by their tour boats (the "Boaters" beneficiary), water that can be snorkeled in (the "Waders/Swimmers/Divers" beneficiary), and a pleasing view when traveling to and from the snorkeling site (the "Experiencers/Viewers" beneficiary).

The navigation panel shows the number of completed stakeholder groups as users progress through this step. As stakeholder groups are segmented into constituent beneficiaries, the output appears below the table (Figure 17). This output shows the relative priority of each beneficiary group. This relative priority is based on how much each beneficiary group is identified in each stakeholder group and the relative priority of those stakeholder groups found in the previous step. In this way, the prioritization criteria weights are integrated into this output as well. Once again, each beneficiary group is given a numeric result to demonstrate the relative priority of each beneficiary group. The output for this step is displayed as both a bar chart and a pie chart. The pie chart shows the relative influence of each beneficiary group (Figure 18). This output is referred to as the beneficiary profile. The beneficiary profile output allows users to take a more holistic view of stakeholder group interactions with the ecosystem under consideration. This helps identify common interests across stakeholder groups.
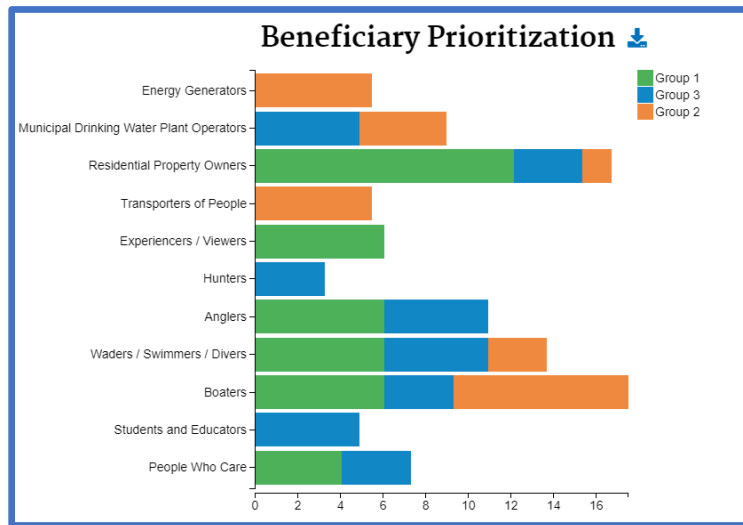
Figure 17. Beneficiary step output – a prioritization of beneficiary groups.
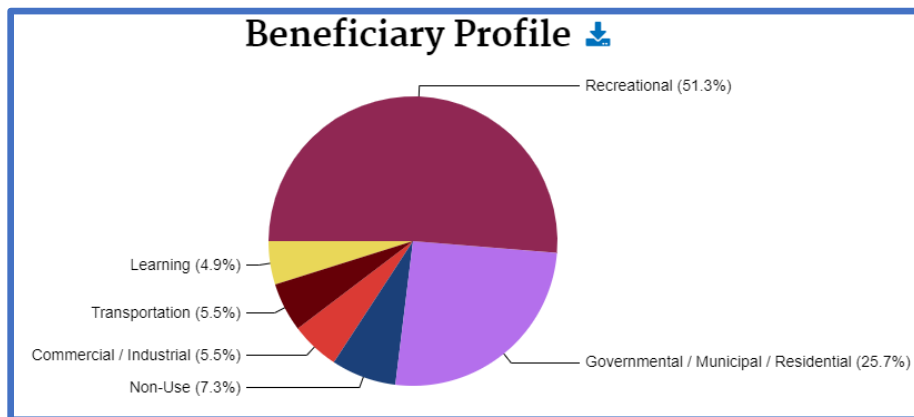
Figure 18. Beneficiary step output – the beneficiary profile.

Step 4: Attributes

In this step, users identify how much each beneficiary group cares about the listed environmental attributes, by percentage, adding up to a total of 100%. Users should consider which attributes each beneficiary group needs to realize their benefit. They should also focus on those attributes potentially affected by the decision.

Like the Beneficiary step, this step has a drop-down menu and a series of buttons for attribute categories (Figure 19).

Figure 19. Attribute step.

Users begin by selecting a beneficiary group from the drop-down menu (boxed in red in Figure 19). They then click the attribute category buttons relevant for the selected beneficiary group.

As attribute categories are selected, a table will appear below the attribute buttons (Figure 20). This table consists of multiple columns: 1) the attribute categories; 2) the specific attribute types within each of those categories; 3) definitions for each attribute; and 4) data entry columns for all of the specific beneficiary types within the beneficiary category selected from the drop down menu. The attribute definitions in column 2 can be hidden by clicking the "Hide Definitions" button. This button is found above the second column ("Attribute Tier 2"). The top of each data entry column shows the beneficiary result for each beneficiary type from the previous step. The beneficiary result is shown above each beneficiary column to remind users of the relative weight given to each beneficiary type within the group. These beneficiary results are only intended to indicate the relative priority of each beneficiary group and do not connect to any other measurements.

Figure 20. Attribute input table.

As percentages are entered in the input column (do not include the "%" symbol), the column will remain outlined in red unless the percentages sum to 100%. Figure 21 shows the attribute table with the input for the first beneficiary ("Anglers") outlined in red, warning the user that the inputs are not summing to 100%, and the second beneficiary ("Boaters") correctly summing to 100%.

Attribute Tier 1	Attribute Tier 2 **Show Definitions**	Recreational	
		Anglers	Boaters
Beneficiary Result		18.15	16.13
Atmosphere	Air Quality		
	Wind Strength / Speed		10
	Precipitation		
	Sunlight		
	Temperature		
Water	Water Quality	30	30
	Water Quantity		45
	Water Movement		15

Figure 21. Attribute input table examples.

When completing this step, users should ask themselves which environmental attributes are necessary for the beneficiary groups to succeed in using and benefiting from the ecosystem under consideration. Continuing the earlier example, the "Boaters" beneficiary type may care most about "Water quantity" (i.e., deep enough water for their boats), followed by "Water quality" (i.e., water that is safe to boat in). To a lesser extent they may also care about "Water movement" and "Wind strength/speed" (i.e., wind and wave intensities that allow for safe boating).

As relevant environmental attributes are completed for each beneficiary group, the output appears below the table. This output displays the relative priority of each environmental attribute, based on the environmental attributes of concern for each beneficiary group and the relative priority of those beneficiary groups found in the previous step (Figure 22). Each environmental attribute is given a relative numeric result. The output for this step is also displayed as a pie chart, showing the total relative priority of each attribute category (Figure 23).

Outputs from this step allow users to see what environmental attributes are relevant for evaluation of decision alternatives, provide a clear explanation of why those attributes are relevant, and indicate the relevant biological and environmental features to focus on for model development.
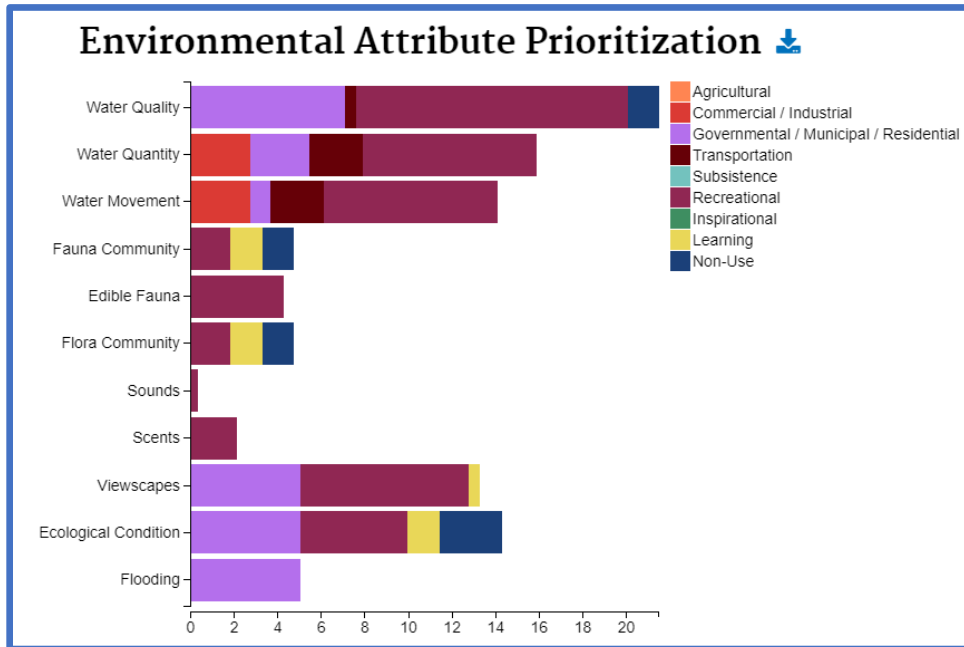
Figure 22. Attribute step output – a prioritization of environmental attributes.
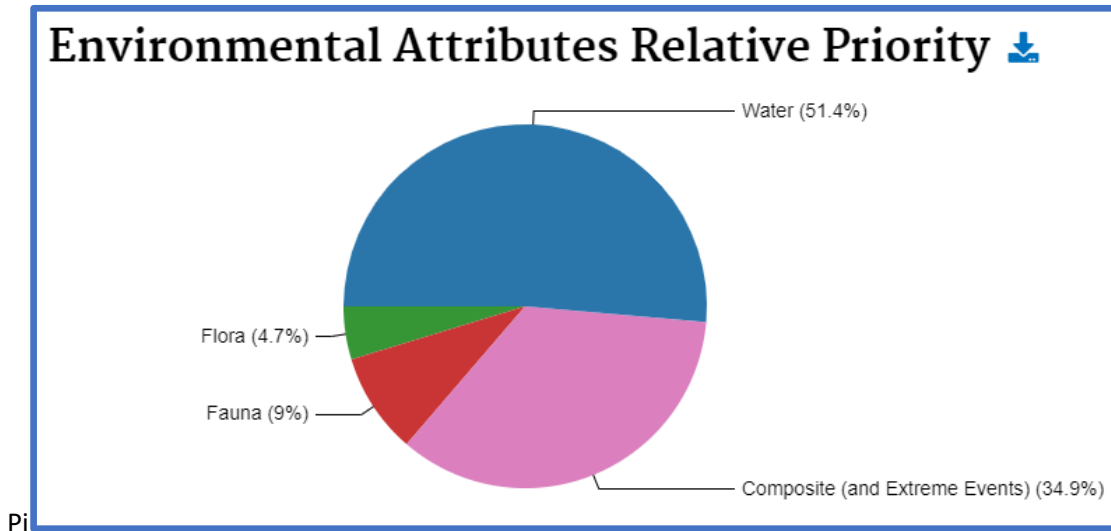
Figure 23. Attribute step output – key attribute profile.

Final Comments

The outputs from the FEGS Scoping Tool are subjective, specific to decision maker priorities, and reflect the knowledge of those involved in the process. As the process becomes more iterative and participatory in nature, the results will become more valid and meaningful.

Important note: It is important to note that the outputs are only relevant to the decision context for the specific project the tool was used to assess. Results and outputs should not be generalized beyond their specific project.

Contact/Support

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Appendix A: Tool Methods

The FEGS Scoping Tool is a multi-criteria decision analysis tool that uses the method of ranking the alternatives on the sum of weighted criteria.

Multi-criteria decision analysis (MCDA) is a formal approach to problem solving that attempts to represent the decision goals in terms of explicitly evaluated criteria (Stewart 1992). The MCDA approach is a transparent method of informing decision making; it formalizes key criteria, explicitly states priorities, and permits easy replication and justification of results. Multi-criteria decision analysis leaves a 'paper trail' of the criteria & relative weights used when evaluating alternatives.

The MCDA approach allows users to prioritize investments of limited resources and evaluate their choices relative to strategic plans or other higher-level priorities. It allows for a formal exploration of trade-offs (e.g., using different sets of weights to compare the priorities of different groups, manipulating the weights to explore the sensitivity of the tool output, etc.).

Finally, MCDA tools can be used in an iterative and participatory fashion, involving representatives and feedback from various stakeholder groups, providing a clear pathway for stakeholder engagement in the process.

There are seven steps in a generic MCDA process. Different methods will approach these steps in a variety of ways, but the essentials will remain the same. This tool addressed these steps in the following manner:

1. *Identify decision objectives* - The overall objective of the tool is to prioritize the relevant stakeholder groups for a decision with an environmental context and, building on that initial prioritization, also prioritize the beneficiary groups and key environmental attributes for that decision context.
2. *Identify decision criteria* - Decision criteria are the factors that should be considered when evaluating alternatives to ensure project objectives are met. These are the stakeholder prioritization criteria laid out in the tool.
3. *Identify metrics and value functions for the criteria* - Metrics are measurable properties that are used to quantify and compare the performance of the alternatives for each criterion. These criteria should be as objective as possible. Value functions then relate performance scores on each metric to value on the criteria by converting the alternative's scores on each metric into a numerical value that captures the relative performance on a fixed scale. These are contained in the Stakeholder scoring step of the tool.
4. *Develop a range of alternatives* - These are the alternatives that will be scored by the metrics for each criterion and ultimately prioritized by the tool. In this case, the alternatives are the stakeholder groups that are identified and input into the tool by the users.
5. *Weight the relative importance of the criteria* - Weights capture the preference for, or importance of, each decision criterion relative to the others. This step is entirely subjective and aimed at clearly expressing the decision maker's priorities. User input is the sole source of weights in this tool.
6. *Evaluate the performance of each alternative with respect to each of the metrics and assign value scores* - In this step, the decision maker simply uses the metrics identified in Step 3 and the value functions developed in Step 4, to assign scores to all criteria for each of the alternatives identified in Step 5. This is what the user is doing in the Stakeholder step of the tool.

7. *Calculate the MCDA value* - In this step, the weights and the value scores are used to calculate the overall MCDA value of each alternative. The tool performs these calculations displaying the MCDA value as the bar chart output of the Stakeholder step.

The FEGS Scoping Tool, however, does not merely prioritize the stakeholder groups. It uses that initial prioritization to subsequently also prioritize beneficiary groups, and then environmental attributes. It does this by taking an approach we are calling a tiered MCDA. This approach uses the output from the stakeholder prioritization MCDA as input in a beneficiary prioritization MCDA, and then the output from the beneficiary prioritization as input in an environmental attribute prioritization. This is described in Table A-1.

Table A-1. The MCDA steps in each of the three tiers of the FEGS Scoping Tool. The colored boxes indicate how the output of one tier is used as an input in the next. The output from Tier 1 (red box) is used as an input in Tier 2 (red box). The output from Tier 2 (orange box) is used as an input in Tier 3 (orange box).

MCDA Steps	Tier 1: Stakeholders	Tier 2: Beneficiaries	Tier 3: Attributes
1. **Objective**	Prioritize stakeholders	Prioritize beneficiaries	Prioritize environmental attributes
2. **Decision criteria**	Used when prioritizing stakeholder groups – supplied by the tool	Used when prioritizing beneficiaries – the stakeholder groups themselves are used as these criteria (i.e., which beneficiary groups are relevant to stakeholders)	Used when prioritizing attributes – the beneficiary groups are used as these criteria (i.e., which attributes are relevant to beneficiaries)
3. **Metrics & Value functions**	Used to score each stakeholder group for each criterion – supplied by the tool	Used to score each beneficiary group for each stakeholder group – this is done in the Beneficiary step of the tool when users are asked to identify those beneficiary categories found within each stakeholder group	Used to score each attribute for each beneficiary group – this is done in the Attribute step of the tool when users are asked to identify attributes of concern for each beneficiary group
4. **Alternatives**	Stakeholders identified by tool users	Beneficiary list from the FEGS Classification System	Attribute list from the FEGS Classification System
5. **Weighting**	Done by users in the first step of the tool	Stakeholder MCDA values from the output of Tier 1 are used as weights in this step	Beneficiary MCDA values from the output of Tier 2 are used as weights in this step
6. **Score alternatives**	User input at the Stakeholder step	User input at the Beneficiary step	User input at the Attribute step
7. **Calculate value**	Output at Stakeholder step	Output at Beneficiary step	Output at Attribute step

The FEGS Scoping Tool calculates a value for each alternative (e.g., a specific stakeholder, beneficiary, or attribute) by summing the weighted scores for each alternative. The value, $y(i)$, of an alternative, i, is calculated as:

$$y(i) = \sum_{m=1}^{M} w_m z_i$$

where M is the number of possible metrics for which i can be scored, w_m is the weight given to each criterion, and z_i is the score of alternative i on metric m. The value, $y(i)$, is then normalized, $n(i)$, to a $0 - 100$ scale by dividing $y(i)$ by the sum of all weights:

$$n(i) = \frac{y(i)}{\sum_{m=1}^{M} w_m}$$

The same calculations are used for each tier of the FEGS Scoping Tool. The output values, $n(i)$, from Tier 1 are then used as the weights, w_m, for Tier 2. Subsequently, the output values, $n(i)$, from Tier 2 are used as the weights, w_m, for Tier 3.

Appendix B: Example Application

In the example below we lay out a hypothetical example in which a community is contemplating developing a lake management plan for a small freshwater lake near a town. We are at the stage when there is a desire to develop a management plan and some key concerns about managing the lake is driving this desire, but plan development had not yet begun. This is the appropriate stage of decision making at which to use the tool: 1) a decision is being contemplated, but 2) no specific decision alternatives (i.e., plan management goals or strategies) have been selected. Using the FEGS Scoping Tool (FST) in this application will help the decision makers identify the environmental metrics that should be used to evaluate the decision alternatives later in the lake management plan development process. These environmental metrics can then be used alongside other decision criteria relevant to the decision makers (i.e., cost) when selecting the preferred option.

For tool users, the user experience begins by clearly defining the decision context for which the FST is being used. In this case:

> Decision Context: A lake management plan is being developed for Lake X, the FST is being used to identify the environmental services metrics that should be used for setting management goals. One of the key concerns driving the lake management plan development process is concerns related to encroachment of invasive plant species in the lake.

After the decision context is clearly described, users next weight the stakeholder prioritization metrics. In this case, decision makers determine that the criteria of Magnitude and Probability of Impact and Proximity are the most influential in their decision making process because they are interested in prioritizing the voices of those groups that are potentially more impacted by the plan as well as those groups who spend the most time interacting with the lake. Decision makers want to give moderate weight to the criteria of Level of Influence and Rights because they are also interested in prioritizing the voices of those groups that are influential in other community planning activities (i.e., lake association members) and those that have property or user rights associated with the lake (i.e., lakeshore property owners). Finally, decision makers want to give some weight to the criteria of Level of Interest and Fairness because they want to make sure to give consideration to those groups that are interested in the project and to make sure that the plan development process is seen as fair. The relative impact of this weighting approach can be seen in Figure B-1.
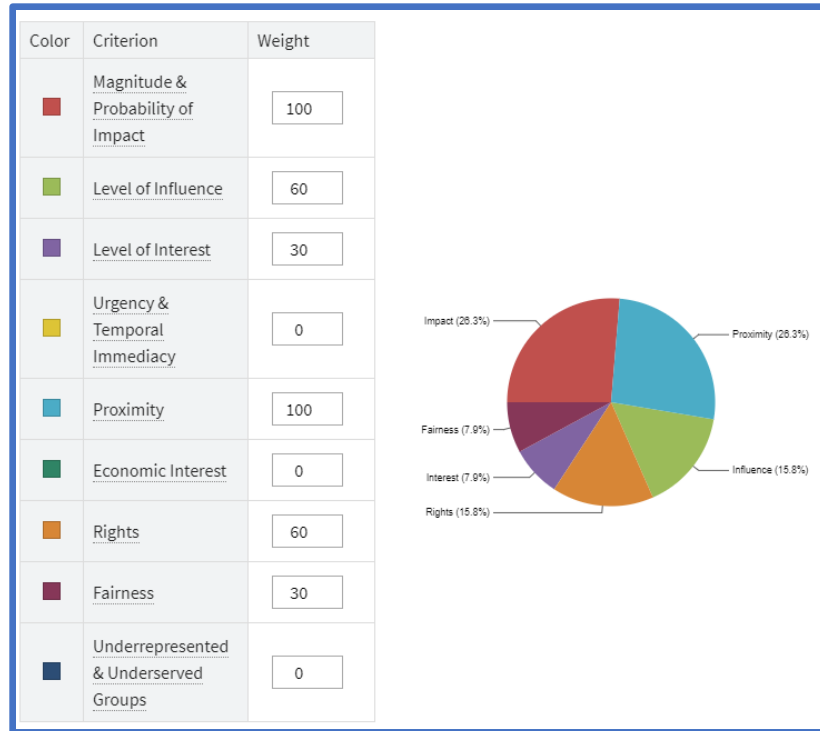
Figure B-1. The relative weights given to stakeholder prioritization criteria for the Lake X Management Plan project.

Decision makers now identify the full set of stakeholders that should be considered in the stakeholder group prioritization process (Figure B-2). For this lake management plan development process some stakeholder groups are straightforward. For example, the local town government and the local natural resource agencies need to be involved in the process. Other stakeholder groups can be more challenging to identify. For example, if the lake has both homeowners who live there full time and homeowners whose homes are only suitable for warmer weather, it may make sense to treat those two groups of homeowners as two separate stakeholder groups. Other stakeholder groups that may be worth considering are lake visitors and, once again, it may make sense to separate those visitors into those who boat on the lake and those who visit the beach. This cumulative list is shown in Figure B-2.

Figure B-2. The list of stakeholders being prioritized for the Lake X Management Plan project

The next step is to score the stakeholder on all the prioritization criteria. Ideally, users will score the groups on all the criteria, even those given a weight of zero. This is so they can easily experiment with giving weights to those criteria as part of scenario testing. The results of the prioritization are shown in Figure B-3. In this example, both types of lake homeowners are ranked as top priority stakeholder groups in large part due to the potential impact of changes to lake management on those groups and due to the proximity of those groups to the lake itself. This prioritization makes sense and is unsurprising given the weights given the criteria by the decision makers.
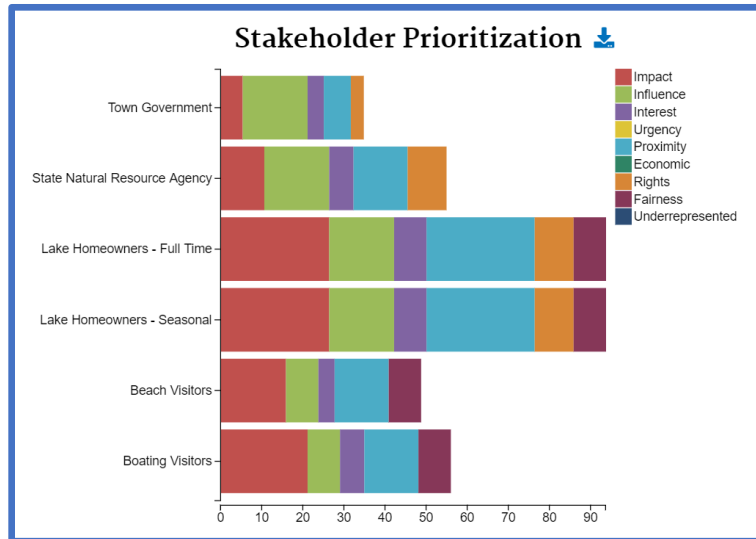
Figure B-3. Lake X Management Plan project stakeholder prioritization results

After the stakeholder prioritization is complete, decision makers now identify the ways in which each stakeholder group in benefiting from the lake. For example, full-time lake home owners benefit from the lake primarily through the role of "Residential Property Owners", but they also benefit from the range of recreational opportunities that they can take advantage of right outside their door. The seasonal homeowners benefit in those same ways, but since they also use the lake for running water in their homes, that benefit of water subsistence needs to be included for them as well. When looking at the full results of the beneficiary prioritization (Figure B-4), we can see that the top beneficiary for the lake is "Wader/Swimmer/Divers." This is makes sense given that every stakeholder group benefits in this way to some extent and it makes this beneficiary role is one of interest for finding common ground amongst the stakeholder groups when developing the lake management plan.
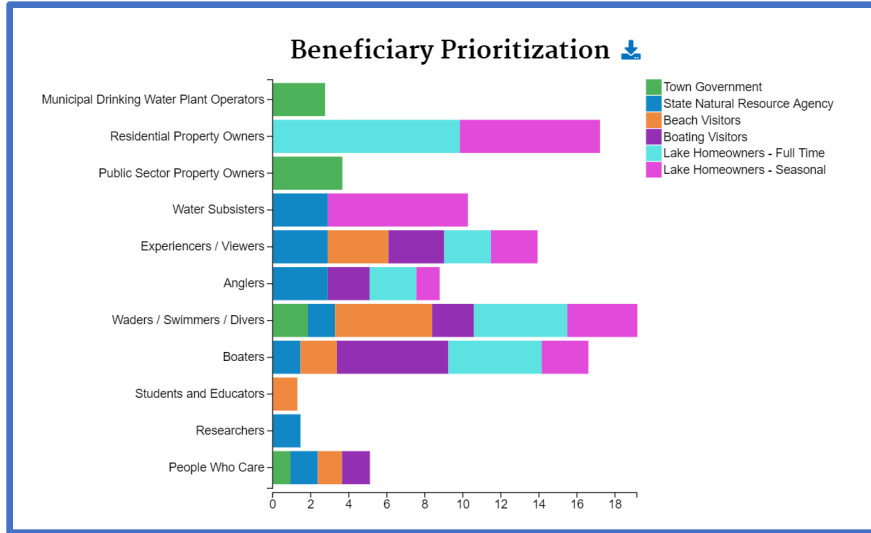
Figure B-4. Lake X Management Plan project beneficiary prioritization results

In the final step of the tool, decision makers identify the environmental attributes necessary to each beneficiary group to realize their benefits. In the results of this step (Figure B-5), we see that water quality is the top ranked environmental attribute because it is important to a wide range of beneficiaries for a variety of uses, ranging from being able to use the water for municipal needs to educational purposes to recreational activities. This suggests that the lake management plan should focus on protecting and improving the lake's water quality and that multiple measures of water quality will be needed to make sure that all the benefits are protected. For example, the water needs to of free of contaminants and pathogens that would make it unsuitable for swimming, residential, and municipal purposes, but measures like water clarity may matter more to boaters and other recreators.

Figure B-5. Lake X Management Plan project environmental attribute prioritization results

Appendix C: Beneficiary List

Table C-1: Beneficiary categories and their definitions[1]

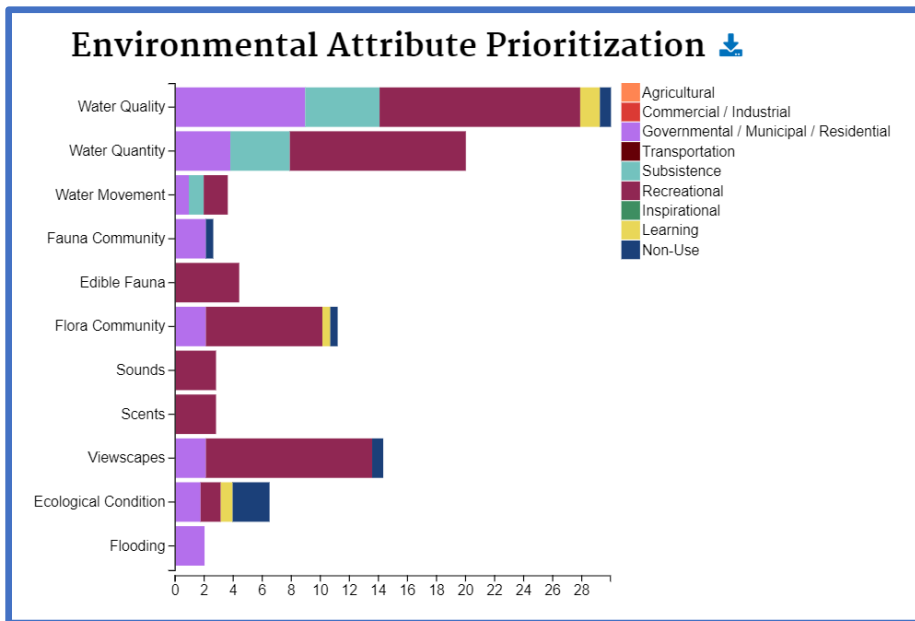| Beneficiary Categories and Definitions	
Agricultural _This class includes beneficiaries who use the environment for agricultural or forest production activities._	
Livestock Grazers	Uses the environment to graze livestock
Agricultural Processors	Cleans edible products
Aquaculturists	Farms aquatic fauna (e.g., fish, shrimp, oysters)
Farmers	Farms terrestrial or aquatic flora (e.g., crops, orchards)
Foresters	Plants and raises trees (i.e., silviculture)
Commercial/Industrial _This class includes beneficiaries who directly use the environment for industrial or commercial production activities not included in the other classes or subclasses._	
Food Extractors	Uses the natural abundance of edible organisms (e.g., hunting, trapping, or fishing for livelihood, job, commercial, or artisanal purposes)
Timber, Fiber, and Ornamental Extractors	Extracts or harvests timber, fiber, wood, or ornamental extraction or harvest for commercial or business purposes (e.g., logging, shell collection)
Industrial Processors	Uses natural resources in industrial processing such as manufacturing (e.g., textile or steel industries), mills, or oil and gas extraction and processing
Private Energy Generators	Uses the environment for energy production or placement of power generation structures includes power plants (electric and nuclear), dams, turbines (wind, water, or wave), solar
Pharmaceutical and Food Supplement Suppliers	Collects organisms from nature that are used for pharmaceuticals, medicines, food supplements, or vitamins for commercial sale
Fur / Hide Trappers and Hunters	Hunts or traps fauna for fur or hides for commercial sale
Private Drinking Water Plant Operators	Provides water for private purposes
Commercial/Industrial Property Owner	Owners of private land for commercial or industrial purposes
Government, Municipal, and Residential	

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[1] Newcomer-Johnson et al. 2020

This class includes governmental, military, and residential beneficiaries who make direct use of the environment in ways not included in the other classes or subclasses.	
Municipal Drinking Water Plant Operators	Provides water for a community
Residential Property Owners	Homeowners of private land
Military / Coast Guard	Uses the environment for placement of infrastructure or training activities
Public Energy Generators	Uses the environment for energy production or placement of power generation structures for the community, includes power plants (electric and nuclear), dams, turbines (wind, water, or wave), solar panels, and geothermal systems

Transportation This class includes military and commercial beneficiaries who use the environment as a media to transport goods or people.	
Transporters of Goods	Uses the environment to transport goods (e.g., shipping, cargo, commercial navigation, barges, freight, planes, trains)
Transporters of People	Uses the environment to transport people (e.g., cruises, ferries, airplanes, airports, trains, harbors)

Subsistence This class includes beneficiaries who use the environment to support subsistence activities.	
Water Subsisters	Relies on natural sources for water including drinking water and tribal or traditional uses (may use wells, cisterns, rain gardens, rain barrels, etc.)
Food and Medical Subsisters	Uses natural sources of edible flora, fauna, and fungi as a major source of food; includes hunting, fishing, and gathering, as well as other tribal or traditional uses
Timber, Fiber, and Fur / Hide Subsisters	Relies on timber, fiber, or fauna for survival (e.g., firewood), including tribal or cultural traditions
Building Material Subsisters	Relies on natural materials for infrastructure and housing

Recreational This class includes beneficiaries who use the environment to support recreational activities.	
Experiencers and Viewers	Views and experiences the environment as an activity (e.g., bird, wildlife or fauna watching, nature appreciation, hiking, biking, camping, climbing, outings, sunbathing, sightseeing, beach combing)
Food Pickers and Gatherers	Recreationally collects or gathers edible flora, fungi, or fauna (does not include hunting or

	trapping) (e.g., berry picking, mushroom gathering, clam digging)
Hunters	Hunts for recreation or sport
Anglers	Fishes for recreation or sport
Waders, Swimmers, and Divers	Recreates in or under the water (e.g., snorkeling, SCUBA, swimming, beachgoing, wading, diving, bathing)
Boaters	Recreates in motorized or unmotorized watercraft (e.g., sailboats, ski boats, jet skis, kayaks, surfboards)
Inspirational *This class includes beneficiaries who use or appreciate the environment as a source of inspiration.*	
Spiritual and Ceremonial Participants and Participants of Celebration	Uses the environment for spiritual, ceremonial, or celebratory purposes (e.g., harvest festivals, tribal observances, traditional ceremonies, religious rites)
Artists	Uses the environment to produce art, includes writers, painters, sculptors, cinematographers, and recording artists
Learning *This class includes beneficiaries who directly rely on the environment* *for educational or scientific research activities.*	
Students and Educators	Includes all educational uses, interests, or opportunities including field trips and outdoor laboratories
Researchers	Includes opportunities or interest for significant scientific research and improving scientific knowledge
Non-Use *This class includes individuals who benefit from the environment in ways that* *do not require or are not associated with direct use of or contract with FEGS.*	
People Who Care	Believes it is important to preserve the environment for moral or ethical reasons, for fear of its loss, or to allow their future selves or future generations to visit or rely upon it

Appendix D: Environmental Attributes List

Table D-1. The complete set of environmental attributes and their definitions.

Attribute Tier 1	Attribute Tier 2	Definition
Atmosphere	Air quality	The degree to which air is clean, clear, and pollution-free
	Wind strength/speed	The speed and force of the wind
	Precipitation	Weather in which something, including rain, snow, sleet, and/or hail, is falling from the sky
	Sunlight	Light from the sun
	Temperature	A measure of the warmth or coldness of the weather or climate
Soil	Soil quantity	The amount of soil present, could be measured in terms of volume, depth, and/or extent
	Soil quality	The suitability of soil for use based on physical, chemical, and/or biological characteristics
	Substrate quantity	The amount of substrate present, could be measured in terms of volume, depth, and/or extent
	Substrate quality	The suitability of substrate for use based on physical, chemical, and/or biological characteristics
Water	Water quality	The suitability of water for use based on physical, chemical, and/or biological characteristics
	Water quantity	The amount of water present, could be measured in terms of volume, depth, total yield, and/or peak flow
	Water movement	The amount of water flowing per unit of time, includes aspects such as surface water movement through watersheds, wave action, etc
Fauna	Fauna community	The interacting animal life present in the area
	Edible fauna	Fauna fit to be eaten by humans
	Medicinal fauna	Fauna that has healing properties as is or after processing
	Keystone fauna	Fauna on which other species depend, its absence would significantly alter the ecosystem
	Charismatic fauna	Fauna with symbolic value or widespread popular appeal
	Rare fauna	Fauna that are uncommon or infrequently encountered
	Pollinating fauna	Fauna that moves pollen from plant to plant
	Pest predator/depredator fauna	Fauna that prey upon pest species
	Commercially important fauna	Fauna that has importance for commerce

	Spiritually/culturally important fauna	Fauna that has importance for spiritual or cultural practices or beliefs
Flora	Flora community	The interacting plant life present in the area
	Edible flora	Flora fit to be eaten by humans
	Medicinal flora	Flora that has healing properties as is or after processing
	Keystone flora	Flora on which other species depend, its absence would significantly alter the ecosystem
	Charismatic flora	Flora with symbolic value or widespread popular appeal
	Rare flora	Flora that are uncommon or infrequently encountered
	Commercially important flora	Flora that has importance for commerce
	Spiritually/culturally important flora	Flora that has importance for spiritual or cultural practices or beliefs
Fungi	Fungal community	The interacting fungal life present in the area
	Edible fungi	Fungi fit to be eaten by humans
	Medicinal fungi	Fungi that has healing properties as is or after processing
	Rare fungi	Fungi that are uncommon or infrequently encountered
	Commercially important fungi	Fungi that has importance for commerce
	Spiritually/culturally important fungi	Fungi that has importance for spiritual or cultural practices or beliefs
Other Natural Components	Fuel quality	The suitability of material, based on physical, chemical, and/or biological characteristics, to produce heat or power through burning or other methods
	Fuel quantity	The amount of fuel present, could be measured in terms of volume, mass, and/or extent
	Fiber material quantity	The suitability of material, based on physical, chemical, and/or biological characteristics, to be used in production of textiles
	Fiber material quality	The amount of fiber material present, could be measured in terms of volume, mass, and/or extent
	Mineral/chemical quantity	The amount of material present, could be measured in terms of volume, mass, and/or extent
	Mineral/chemical quality	The suitability of material for use based on physical, chemical, and/or biological characteristics

	Presence of other natural materials for artistic use or consumption (e.g. shells, acorns, honey)		The presence and/or extent of materials suitable for artistic use or consumption
Composite (and Extreme Events)	Site Appeal	Sounds	The sounds or combination of sounds arising from the area
		Scents	The scents or combination of scents arising from the area
		Viewscapes	The views and vistas available in the area
		Phenomena (e.g. sunsets, northern lights, etc)	Natural phenomena arising from a combination of environmental attributes
	Ecological condition		The overall quality of the ecological system based on physical, chemical, and biological characteristics
	Open space		Land that is undeveloped, but may be landscaped or otherwise in use, and is available for use
	Extreme Events	Flooding	The likelihood the area will experience flooding and the likely severity of the flooding
		Wildfire	The likelihood the area will experience wildfire and the likely severity of the fire
		Extreme weather events	The likelihood the area will experience extreme weather events and the likely severity of the events
		Earthquakes	The likelihood the area will experience earthquakes and the likely severity of the earthquakes

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