

# CARE User Guide

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## TOOL DEVELOPERS

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## TOOL COMPONENTS

CARE User guide (Word doc)  
Example CARE Analysis (Excel)  
CARE Model Template (Excel)

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Battista, W. and Karr, K., (2017). Comprehensive Assessment of Risk to Ecosystems (CARE). Environmental Defense Fund.

## BACKGROUND

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The Comprehensive Assessment of Risk to Ecosystems (CARE) model was developed in response to a growing demand for rapid yet comprehensive ecosystem risk assessment tools. The model is an Excel-based tool designed to systematically analyze the full suite of risks to selected “targets” (valued species and/ or ecosystems) within a spatially explicit site, from all of the potential “threats” that might impact that site. In 2020 the tool was updated to include an explicit climate vulnerability assessment component that allows users in data limited systems to systematically evaluate the expected impact of climate change on their system in a user-selected future time period, as well as their system's vulnerability to that impact. The scoring process was also updated to allow for generation of climate-impacted relative threat risk scores for all threats present in a site in the same future time period. This update made CARE the only tool currently available that facilitates the comprehensive, semi-quantitative evaluation of every threat facing any type of system or species, both now and in a climate-impacted future time period.

The CARE model can be used to evaluate risks facing a single site; to compare multiple sites for suitability/necessity of different management options; or evaluate the effects of a proposed management action aimed at reducing one or more risks. Results of the CARE model can be used to identify which threats are the most important in a given site, and for a given target, both now and in a climate-impacted future. This information can help inform where limited management resources should be directed. CARE can be applied to any spatially explicit system and can be adapted to better fit individual system characteristics.

This tool adds value to a variety of existing ecosystem risk assessment tools (e.g., Hobday et al., 2011; NOAA, 2011; Tallis, et al., 2011; Samhouri and Levin, 2012; Small et al., 2013; O et al., 2012) and climate vulnerability assessment tools (e.g., CEC, 2017; U.S. Federal Government, 2014) by:

- Allowing for semi-quantitative evaluation and comparison of climate change impacts along with all other system threats, including fishing and non-fishing anthropogenic threats as well as non-anthropogenic threats, both now and in a pre-selected future time period;
- Assessing the *interaction* (synergistic or antagonistic) of multiple threats with each other (other tools do not factor in synergistic effects);
- Allowing for evaluation of any ecosystem and/or species type with the same tool;
- Expanding the analysis of “ecosystem functioning” through a more comprehensive suite of attributes that quantify intrinsic system recovery potential (i.e. “regeneration time” and “connectivity”) and resistance to impact (i.e. “removability of system components” and “functional redundancy and diversity”);
- Facilitating participatory decision-making through interactive scoring, using scoring guidance designed to allow for accuracy without necessitating precision;
- And allowing for rapid risk analysis that can be completed in the field, in under two hours, using expert knowledge where data is lacking.

### Summary of Assessment Methodology and Outputs

Risk in the CARE model is estimated as the product of an Exposure score (the extent to which the target is exposed to threats, based on threat scale, frequency, and intensity) and a Response score (the likely response of the system or species to the threats, based on factors thought to contribute to system resistance to threats and to recovery time, such as species diversity and functional redundancy). The model also includes a way to score the effects of threats on each other, in order to estimate the degree of synergy between them and thus characterize the cumulative impact of threats more accurately. Climate Vulnerability is estimated as the product of this same Response score and a Climate Impact score, which is itself the product of Likelihood and Magnitude scores for a set of potential climate change drivers that might impact any given site. Finally, the model includes a way to calculate the impact of climate change on each of the existing threat's Exposure scores, as well as on the system's or species' ability to Respond to impact.

Thus, CARE generates: 1) a set of relative, semi-quantitative Individual and Cumulative Risk Scores for all "Threat Activities" present in a given site, both in the present moment and as impacted by climate change in a pre-selected future time period; 2) a set of semi-quantitative scores that characterize the magnitude of a given site's expected Climate Impact and resulting Climate Vulnerability; and 3) a subset of scores that characterize the risk that the local species community will experience range shifts and/or changes in overall productivity as a result of locally-expected climate change impacts.

Climate Impact and Vulnerability Scores can be used to help crystalize stakeholder understanding of the expected impacts of climate change in a given site over a user-selected time period. This information can inform goal setting and forward-looking management efforts. Climate-related scores are not intended to demonstrate a *quantitative* scale of impact or system change (e.g., a Climate Impact Score of 100 does not necessarily imply impacts will be twice as bad as those experienced in a system which receives a Climate Impact Score of 50), but should instead be taken as a qualitative assessment of climate impact and vulnerability, and of the risk posed by various existing threats in a climate changed future.

Individual Threat Risk Scores (present and climate changed-future) are ranked to identify the most important threats facing the site, in order to inform management and resource use decisions. For example, if a site is particularly at risk from fishing, but proves to be more resilient to the impacts of coastal development or nearby aquaculture, a Territorial Use Rights for Fishing (TURF)-reserve, which is a spatially explicit fishery management strategy, would be expected to result in significant improvements in fishery outcomes. Alternatively, if a site is at risk from a larger variety of nearby threats, such that reforming the fishing practices might not effectively prevent a decline in system health or promote recovery policies aimed at reducing the most important threats might be a more appropriate approach. Cumulative Risk Scores for multiple sites can be compared to inform management siting decisions.

In addition to the ecosystem analysis, users can choose to complete this assessment for multiple species within their site; however it is only necessary to complete a single CARE assessment worksheet—for the main, or the most vulnerable, ecosystem type found within the focal site.

Analysis of a single target (ecosystem or species) can be completed in as little as 2 hours. The greater the user's system familiarity/ expertise, the less time the analysis will take.

This document guides users through the steps involved in the application of the CARE model, providing additional information not included in the "Instructions" tab included in the Excel workbook. For more information on model design, and examples of its application, see Battista et al. (2016).

### **Intended Audience**

CARE was intended to be used collaboratively by fisheries managers, scientists, and local experts (e.g., fishermen). The application process can help to build consensus and increase buy-in, and the outcomes can guide site selection and management decisions.

### **When to Use This Tool**

CARE was designed to largely rely on local and expert knowledge, require minimal background research to complete, and can be implemented in the field in a matter of hours. These features make the CARE model singularly well-suited for use in Ecosystem Based Management in data-limited systems, for informing spatially explicit management decisions, and for prioritizing threats for efficient use of management resources.

The CARE model can be used to guide threat reduction strategies, including in data-limited systems, and/ or to assist the selection of sites for fishery reform interventions. This analysis can help users identify which threats are the most important in a given site, and for a given target, and therefore where limited management resources should be directed. It can also help to identify where different management approaches might be most appropriate. Climate Impact and Vulnerability scores, and future relative Threat Risk scores, allow users to understand how their management priorities might change as climate change progresses in their site. In this way communities can use the CARE model to make informed decisions about how best to manage their marine resources to achieve conservation and development goals. CARE can be applied to any spatially explicit system, and can be adapted to better fit individual system characteristics.

When using CARE as part of the Assessment and Engagement process, we suggest it be applied before Goal Setting so that short- and long-term management goals can be informed by its outputs. When using CARE in this manor, at a site where engagement is definitely proceeding, the tool can help you understand what non-fishing threats must be addressed to ensure fisheries reforms can achieve their desired outcomes.

If using CARE to inform Site Selection, CARE should be used at the point when a set of potential sites have been identified (i.e. through application of the Site Selection Matrix, or for political or other opportunistic reasons), but before final selections are made. Applying the CARE tool to all of the sites under consideration will help you understand the types and severity of all the threats facing each site, both now and in the future, so that you can determine if your planned fisheries reforms will be likely to result in the desired outcomes, or if they will be undermined by threats that are outside of the realm of your control.

## Limitations

There are a number of caveats that must be considered when applying the CARE tool. First, the validity and reliability of the CARE results depend on the quality and availability of expert knowledge and data used to populate the tool, as well as on the consistency of users in scoring attributes. For best results, we recommend filling the tool out collaboratively, with multiple local experts (e.g. local scientists, fishermen, managers) who have extensive knowledge of the system, and of any changes that may have come to pass. When using the model to compare different sites for selection of different management options, we recommend that at least one person participate in model scoring for all sites.

Second, as with all existing risk assessment tools, the CARE model results reveal only the *relative risk of harm* to ecosystem or species health from the set of threats facing a given system. These results do not inform what the actual impacts of these threats will be. Although it is possible, through examination of the scores for individual attributes, to identify specific system characteristics that are more likely to be damaged, or that are sources of weakness against a specific threat (including climate change), this should not be confused with a prediction of the real-world system changes.

Third, the inclusion of the Additional Threat and Climate Change Modification factors, while an important advance in the computation of system risk, also create additional and significant opportunities for user error which could skew the final risk scores. These scores should thus only be applied when users are relatively confident about the nature of the threat interaction in question.

Fourth, CARE is temporally static, and the results may therefore become outdated or irrelevant if the system undergoes a relevant change, such as a new management measure that changes the scale, frequency, or intensity of one or more system threats. We recommend that the CARE analysis be completed before and after such changes come into effect to help users get a sense of how the change in question will impact relative risk.

Finally, while our method of transforming threat characteristics into dimensionless index scores allows users to combine and compare threat impacts from different types of threats, it should be noted that the actual consequences of disparate threats that receive the same risk score will not necessarily be the same. For example, if the threat of fishing receives a threat score of 60 for a site, and mining also receives a threat score of 60 for that same site, it should not be assumed that the two threats will have the same practical outcomes (i.e., fish removed, effluent increased). Furthermore, although the cumulative risk score for this site (if it faced no other threats) as calculated with the simple additive model would be 120, this does not mean that the real-world consequence of both threats happening at once would be a simple doubling of the effects of one of the threats, for example, twice as many fish removed. This caveat is especially important with regard to the Climate Impact and Vulnerability scores, which should not be confused with a quantitative calculation of the scale of impact or system change (e.g., a Climate Impact Score of 100 does not necessarily imply impacts will be twice as bad as those experienced in a system which receives a Climate Impact Score of 50).

## INSTRUCTIONS

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### Getting Started

Select the appropriate CARE Excel Workbook for your goals – if you are evaluating threats to just one site, select the “Climate\_CARE\_Template,” **if you are seeking to compare sites to each other to inform site selection, open the “.**”

The tool begins with an Introduction tab and an Instructions tab, which provide simple guidance on how to use the tool. This User’s Guide is a more comprehensive version of these simplified instructions.

The next tab in **either version of** the workbook is a ClimateImpact assessment tab, where drivers of climate-change related impact are scored at the scale of the entire site, for a future time period that will be pre-selected by the user. Following this tab is the EcosystemRisk tab, its corresponding Results tabs (one tab for climate vulnerability results, and the subsequent tab presenting risk scores for all other threats), and then three SpeciesRisk tabs and their corresponding Results tabs. It is not necessary to fill out any or all Species assessments. All Results tabs are “output only,” meaning no user input is required on these tabs.

The Ecosystem tab contains sections (colored green and purple) where you will score the Recovery and Resistance attributes of the ecosystem. Below those Recovery and Resistance sections are Threat Assessment Fields (colored orange and yellow) where you will enter information on how the ecosystem interacts with the threats that you identify. Species tabs mirror the Ecosystem tab, with fields to fill out Recovery and Resistance scores for the species you are evaluating, followed by Threat Assessment Fields.

User input cells throughout the workbook are indicated with blue text or blue borders. User input cells also include drop-down menus that contain all possible values that may be entered in that cell. Users may select from drop-down menus or enter any of these values by hand. If values not included in these lists are entered in any of these cells a warning will pop up to alert the user to the error.

**The CARE Comparison workbook comes with four “Ecosystem” tabs and four “Species” tabs. Additional Ecosystem and/or Species tabs can be added by the user if needed, but comparative results will not be automatically generated for these added tabs (as modification of the Results tab is fairly complex), and so if users wish to evaluate more than four Ecosystems or Species, we recommend reaching out to the tool developers for assistance. When completing this comparison version of the CARE tool, simply repeat the below instructions for each addition Ecosystem and/or Species you wish to evaluate.**

*Note:* It is not necessary to complete both the Climate Vulnerability and the Relative Threat Risk assessments – they do not depend on each other (i.e., for a more rapid analysis, users can choose to fill in just the Climate Impact tab and receive just Climate Impact results, or just the Ecosystem or Species Risk tab, and receive just Threat Risk results).

## Step 1: Score Climate Impacts

### Scoring Drivers of Climate Change Impact

The first step in the Climate-updated CARE process is to quantify the likely impact of climate change on the entire site. To do so, users must first select a "future timescale" for which they wish to consider the potential impacts of climate change on their system. Suggestions are provided (Near term: 5-10 years in the future; Medium term: 30-50 years in the future; Long term: 100 years or more in the future); however, users should select any timescale for which the results of this analysis will be valuable, and for which they have at least some understanding of/information about the expected impacts of climate change in their system. Enter the future time scale selected into cell B11. Throughout the scoring process, users should keep in mind and be reminded of the time scale chosen for this evaluation to ensure consistency in climate-related scoring.

Next, for each possible Climate Impact Driver listed in column C, users should assign a score of Low, Moderate, or High (1, 2, or 3) for both the Likelihood of that driver impacting their site, and the expected Magnitude of that impact, should it come to pass. For example, storm severity may be expected to increase in a system with high likelihood (score of 3), but the magnitude of that change may be predicted to be relatively low (score of 1). Users should consider the climate time scale selected and use reports on anticipated climate impacts in the region or similar regions to inform the scoring. These scores are entered in the corresponding rows in columns J and K. If data is available to support the score assigned for a given driver, this information should be entered into the corresponding row in column H, with sources listed in column I.

Likelihood and Magnitude of Change scores are averaged for all Drivers (d) in the site, and then the Anticipated Climate Impact (I) for the site is calculated as the product of these scores.

$$1. \text{ Anticipated Climate Impact}_i = \text{Avg}(\text{Likelihood}_d) \times \text{Avg}(\text{Magnitude of Change}_d)$$

To allow for comparison with the Target Response and Threat Exposure scores (described below), this Anticipated Climate Impact score is normalized through scaling down (divided by the maximum possible value (9), and then multiplied by 10 to allow for a wider range of possible scores).

A qualitative interpretation of this score (based on the range of possible scores) will be generated in cell N25. These values will also appear on each of the ClimVulnResults Tabs.

Data and information necessary to complete the Climate Impact assessment module may be available at one of the following sources (depending on the site and scale of analysis):

- IPCC Regional Climate Impacts report: <https://www.ipcc.ch/report/ar5/wg2/>
- FAO report on Impacts of climate change on fisheries and aquaculture: <http://www.fao.org/documents/card/en/c/I9705EN>
- "FishCast" – Shiny App for predicting climate impacts on specific species: <https://emlab-ucsb.shinyapps.io/fishcast2/>
  - Also the underlying database, "AquaMaps": <https://www.aquamaps.org/search.php>



- “OceanAdapt” – Shiny App for exploring changes already detected in species ranges and depths in North America: <https://oceanadapt.rutgers.edu/>

### **Climate Impact Uncertainty Scoring**

Users should indicate their level of Uncertainty around the scores for each Climate Impact Driver in the corresponding row in column O. The level of uncertainty should be based on the Uncertainty Scoring Metric provided in column N.

Numerical quantifications of the different levels of uncertainty will generate a total Response Uncertainty score. This value will appear in cell O25, with a qualitative interpretation of this score (based on the range of possible scores) generated in cell P25. These values will also appear on each of the ClimVulnResults Tabs.

### **Step 2: Identify Targets**

The next step in the CARE model is to identify a target or targets for analysis. Targets in the CARE model are separated into the “**ecosystem**” and individual “**species**.” It is only necessary to complete the analysis for the ecosystem as a whole, but if you wish, you may also evaluate individual Species targets.

In order to minimize CARE model application time requirements, you should attempt to select the smallest number of targets that can be considered representative of the system under analysis. A CARE “Risk” worksheet must be completed for each target identified.

#### **Ecosystem Target Analysis**

- a. You should identify the main (most predominant), or most vulnerable, “ecosystem” present in the site, as characterized by the dominant habitat type (e.g. coral reef, seagrasses, mangroves, muddy bottom) and community structure. Navigate to the “EcosystemRisk” tab and fill in a name for this ecosystem (e.g. "Fringing Coral Reef") in cell B2 (labeled "Fill in Ecosystem Type" in blue text).

#### **Species**

- b. Now that you have specified the Ecosystem Target, you may identify any species of interest that you wish to include in the CARE analysis. Note that it is not necessary to evaluate any species (or to utilize all Species tabs) to complete the CARE analysis. Species Targets may fall into one or more of the following categories:

- keystone species (species with a specialized role in a food web or guild such that impact would cause trophic cascades or other drastic changes, or species that transfer energy or nutrients that would otherwise be a limiting factor to system productivity);
- engineer species (species that create habitat for other species)
- depleted, threatened or endangered species;
- rare/ endemic species;
- charismatic species valued by site users, local communities, or other target audiences of the assessment; and

- economically valuable species that could be targeted by fisheries should fishing be deemed appropriate at the site.
- c. If you have identified a species you'd like to evaluate, navigate to the "Species1Risk" tab and fill in the species name in cell B2 (labeled "Fill in Species Name" in blue text).
- d. Each Species Target identified will be scored on a separate Species tab. For any additional species that you would like evaluate, fill in the corresponding Species Name field on additional sheets provided ("Species2Risk" and "Species3Risk"). To evaluate additional Species Targets beyond the three tabs provided, you can copy-paste additional Species tabs to the end of the workbook.

You have now finished identifying the Targets that will be analyzed with CARE. The next step will be to identify the Threats affecting that Ecosystem and/or those Species.

### Step 3: Identify Threat Activities and Associated Stressors

Next users should identify all (non-climate change driven) activities in and around the site that might be posing a potential threat to the Target(s) under analysis. Each of these threat activities will be assessed against the Target or Targets. They will also be examined for potential synergistic or antagonistic interactions with each other. The more threats that are included, the longer the CARE analysis will take to complete.

To inform this process, we provide the following semi-comprehensive list of potential threat activities (aside from climate change), along with their associated stressors. This list was developed with reference to the ERAEF, as well as the UN Atlas of the Oceans list of Ocean Uses, and other sources from an extensive literature review, but users should not feel limited to the items on this list if the stressors impacting their sites are not represented here.

#### List of Potential Threat Activities and related Stressors that may impact a site:

- **Fishing**
  - Capture/ removal
  - Gear-specific impacts
  - Bait collection
  - Gear loss/ ghost fishing
  - Incidental behavior change
  - Anchoring/ mooring
  - Navigation/steaming
  - Boat launching
  - Re-ballasting
  - On-board processing
  - Discarding
  - Stock enhancement
  - Provisioning
  - Organic waste disposal
  - Debris
- Chemical pollution
- Exhaust
- **Coastal development**
  - Reclamation
  - Exploitation
  - Pollution/ waste disposal
  - Habitat damage
  - Habitat elimination
  - Underwater infrastructure
- **Shipping/ Transportation**
  - Air and water pollution
  - Transport of invasive species
  - Environmental and human risks associated with fires, groundings and sinkings
  - Wildlife strikes

- **Aquaculture/ Mariculture**
  - Chemical and effluent pollution
  - Invasive species
  - Habitat alteration or destruction
  - Removal of wild postlarvae or juveniles
  - Removal of forage fish biomass for fishmeal
- **Oil, gas and mineral mining**
  - Seismic exploration impacts
  - Drilling muds
  - Chronic leaks
  - Large spills
  - Construction impacts
  - Decommissioning impacts
- **Tourism**
  - Direct impacts on habitat (boat strikes, fin clips, removals. Etc.)
  - Habitat destruction or modification for infrastructure
  - Increased local demand for seafood
- Pollution
- Life cycle disruptions (e.g., lights and sea turtles)
- **Land-based impacts (waste treatment, runoff, etc.)**
  - Changes in sediment transport and loads
  - Changes in hydrology
  - Chemical pollution
  - Sewage/ nutrient/ pathogen inputs
- **Deforestation**
  - Sedimentation
  - Nutrient inputs
  - Alteration of hydrological cycle
- **Storms**
  - Damage from wind, waves, currents
  - Precipitation (too much, too little)
  - Pressure changes

Identify the main threat activities facing the site. Consult the list above to drive discussions with local experts and system stakeholders aimed at collecting a list of activities that may be impacting the site.

- a. Navigate to the EcosystemRisk tab. In cell B45 where the blue text indicates “Fill in Threat 1”, indicate the name the Threat you have identified.
- b. While still on the EcosystemRisk tab, scroll down and continue to list *each* Threat you have identified by typing each additional Threat in the appropriate cells (labeled "Fill in Threat x" in blue text) in column B at the top of each Threat Evaluation Field. For example, Threat 2 can be typed into cell B58, and Threat 3 in cell B71. Continue until you have listed all of the Threats.
- c. Threat names in columns G through K at the top of each Threat evaluation field will auto-populate once users input Threat names in column B.

Note: While the tool contains fields to enter 6 Threats on each Target worksheet, it is not necessary to fill in all the provided Threat fields if there are fewer than 6 Threats you'd like to evaluate in a given site. Alternatively, if you wish to evaluate *more than* 6 Threats in one site, please contact the tool developers and they will help you adjust the spreadsheet to allow this.

- d. Now that you have finished entering all of the Threats in the EcosystemRisk tab, repeat this process for *each* of the Species Targets you identified in Step 1.

For consistency, Threats should be listed in the same order for all Targets under evaluation. For example if Fishing is identified as Threat 3 in the EcosystemRisk tab, it should also be listed as Threat 3 in all SpeciesRisk tabs.

#### Step 4: Fill in Response Scores and Uncertainty Scores

In the CARE model, risk to each target (c) from each present system threat (t) is calculated as the product of the intrinsic target “Response” score and an “Exposure” score specific to each threat as it relates to that target (see Equation 1). Response scores are calculated from a set of attributes thought to contribute to the productivity and vulnerability of the target, while Exposure scores are calculated from a set of attributes that control the potential for the given threat to impact that target. In Step 4 you will calculate the Response score and in Step 5 you will calculate the Exposure score.

$$2. \text{ Base Risk}_{ct} = \text{ Base Response}_c \times \text{ Base Exposure}_t$$

Step 4 requires you to quantify Recovery and Resistance attributes, the product of which creates a Response Score. This calculation is done one time for each target being assessed. Your Response Score will be multiplied by the Exposure Score you calculate later on in Step 5 to calculate a Risk Score (see Equation 2 below):

$$3. \text{ Base Response}_c = \left( \frac{\text{AvgRecovery}_c \times \text{AvgResistance}_c}{9} \right) \times 10$$

In this Step, the specific characteristics of the target (ecosystem or species) that govern its intrinsic ability to recover from a negative impact are averaged to generate a Recovery score, and the characteristics that govern its intrinsic sensitivity or vulnerability to negative impact are averaged to generate the Resistance score (see Appendix for attributes with example scoring). These two values are then multiplied to create the target Response score. To make this value comparable with the Exposure score (described below), it is then normalized through scaling down (the product of the scores is divided by the maximum possible value (9), and then multiplied by 10 to allow for a wider range of possible Risk scores).

Note that the scores generated are Risk scores, so higher numbers = higher risk. In the Response section, this means that systems with higher Recovery potential will receive LOWER scores.

**For an example of how Recovery and Resistance attributes are scored, creating a Response Score, see Appendix: Example CARE Analysis.**

#### Recovery Scores

Recovery scores quantify the Target's ***intrinsic productivity/ ability to recover from any impact***. For example, a given Coral Reef ecosystem that experiences frequent (i.e. daily)

natural disturbance, is close to many other similar habitat patches of high quality (High Connectivity); has high Species Richness and high Productivity (based on nutrients and light availability, etc.), may have high intrinsic Recovery potential, which would result in a Low score for the Recovery section.

When determining Recovery Score, you will score a set of attributes thought to control each of these qualities on a 1-3, low to high scale. The structure and process of the assessment is exactly the same for Species as for the Ecosystem, but the Recovery attributes are different. When scoring, you should consider the intrinsic qualities of the Target (qualities inherent to the Ecosystem or Species, irrespective of any present Threats), and its Scores should be based on the scoring criteria provided in columns C, D, and E, and can be determined through relevant literature and/ or expert knowledge.

If the information necessary to score a given attribute will be unknown for all Targets in the site, users may instead enter "NA" (not applicable) in place of a score for that attribute. To enter a score, click on appropriate cell and a drop down will appear with the choices. For an example of a completed Recovery attribute scoring section, see Appendix.

- a. Navigate to the top of the EcosystemRisk tab. In cell B4 you can read the first Recovery Attribute and its description.
- b. After reading the attribute, read the scoring criteria in columns C, D, and E, and use this information to enter a score of 1, 2, or 3 (low, moderate, or high) in the Attribute Score cell (column H).
- c. When scoring, if you use any data to support your scoring decision, you may enter it in the "Data Value" column (F), and record the source in the "Data Source" column (G).
- d. In column J, you should indicate your level of Uncertainty around the score for each attribute. You can enter a value of: 5 (Very Low), 4 (Low), 3 (Moderate), 2 (High), 1 (Very High), or NA. The level of uncertainty should be based on the Uncertainty Scoring Metric provided in column I. A total Recovery Uncertainty score will appear in cell J16.
- e. Now continue to score the remaining Recovery Attributes and Uncertainty score (from row 5 through row 14) in the EcosystemRisk tab. These scores will be automatically combined to generate a total Recovery Score for the Ecosystem.

### **Resistance Scores**

Resistance scores quantify the Target's *intrinsic resilience/ vulnerability to any impact*. For example, a given Coral Reef composed of mostly small, smooth, robust types of coral, with high Functional Diversity, Redundancy, and Complementarity, and with a long, complex foodweb, may have low intrinsic Resistance, which would result in a Low score for the

Resistance section. The structure and process of the assessment is exactly the same for Species as for the Ecosystem, but the Resistance attributes are different.

Note that a small subset of the Resistance attributes are differentiated from the rest with a slightly different cell color (a rose-pink). Scores on these four attributes are pulled into the calculation for the Fishery-Specific Climate Scores (found at the bottom of the worksheet, and also on the ClimVulnResults tab(s)). The scoring process is the same for these four attributes as for the rest of the Response attributes.

- a. After finishing the scoring for all Recovery Attributes, proceed to Resistance Attributes (beginning in cell B17).
- b. You should score each Resistance attribute on the EcosystemRisk tab through the same process as for the Recovery attributes, using relevant literature and/ or expert knowledge. These scores are entered in the purple highlighted cells with blue borders in column H just below the Recovery scores. For the first Recovery Attribute, enter the score in cell H17.
- c. Again, if users have any data to support the score selected they may enter it in the "Data Value" column (F), and record the source in the "Data Source" column (G).
- d. Resistance attribute scores will be automatically combined to generate a total Resistance Score for the Target in question.
- e. In column J, you should indicate your level of Uncertainty around the score for each attribute. The level of uncertainty should be based on the Uncertainty Scoring Metric provided in columns I. A total Resistance Uncertainty score will appear in cell J40.

### **Total Response Scores and Response Uncertainty Score**

Assessing only intrinsic qualities allows the CARE model to use a single Response score for each target to calculate the risk from each system threat, thereby significantly reducing the time and computation requirements as compared with more traditional, hierarchical risk assessment methods, while sacrificing minimal validity.

A total Response Score will be automatically calculated from the Recovery and Resistance scores by the provided worksheets in cell H40 for the Ecosystem and cell H28 for Species. This value will also appear in the scoring section at the bottom of each Target tab, and on the ThreatResults tabs.

Numerical quantifications of the different levels of uncertainty will auto-populate in column J to generate a total Response Uncertainty score. This value will appear in cell J40 for the Ecosystem and cell J28 for Species.

*\*NOTE that at this stage users have already generated Climate Impact and Vulnerability scores, which can be viewed on the ClimVulnResults Tab(s) - see Step 8 for interpretation guidance.\**

## Step 5: Fill in Climate Modification Factors for Target Response Scores

The next step in the Climate-updated CARE assessment is to score the impact of climate change on the Target's (Ecosystem or Species) ability to respond to impact. Users should indicate how climate will modify the score of each attribute in the Response section (Recovery and Resistance attributes) by considering the future time scale chosen on the Climate Impact assessment Tab. Modification scores for each attribute range from -1 to 1 by increments of 0.25. Remember, because these are *risk* scores, meaning higher values are always worse, assigning a negative Climate Modification value would indicate that climate change is expected to *improve* the Target's Response ability on the given attribute.

For an example of how Climate Modification Factors are scored see *Appendix: Example CARE Analysis*.

- a. Navigate back to the top of the EcosystemRisk worksheet, and scroll horizontally to the left to find the Climate Modification section beginning in column L.
- b. Considering the Climate Modification metric/ guidance provided in column L, assign a score for each Response attribute in the corresponding cell (in the same row as the score in question) in column M (indicated with blue borders). A space is provided to input your data (if available) and/or reasoning for the Climate Modification (in the same row as the score in question) in column O.
- c. Numerical adjustment of the attribute score will auto-populate in column N to generate a total Climate Modified Response score. This value will appear in cell N39 for Ecosystems and cell N28 for Species.

### Climate Modification Uncertainty Scoring

- a. Indicate your level of Uncertainty around the Climate Modification score for each Response attribute in the corresponding cell (in the same row as the score in question) in column Q (indicated with blue borders). The level of uncertainty should be based on the Uncertainty Scoring Metric provided in column P.
- b. Numerical quantifications of the different levels of uncertainty will auto-populate in column R to generate a total Climate Modification Uncertainty score. This value will appear in cell Q42 for Ecosystems and cell Q30 for Species.

## Step 6: Fill in Exposure Scores and Additional Threat Modifications

You will now complete scoring a Threat Evaluation Field for every Threat you identified in Step 2. You will begin by compiling Base Exposure and Base Threat Risk scores. The Base Exposure scores will be combined to create an Exposure Score for the Threat. The Base Threat Risk scores will adjusted automatically based on Additional Threat Modifications.

### Base Exposure Scores

The first step is to determine a Base Exposure Score for each Threat as it relates to the Target under evaluation. ***The Base Exposure Score measures the extent to which the target***

**is exposed to threats, based on threat scale, frequency, and intensity.** Each base exposure score is given a value between 0-4 using a set of scoring criteria.

To be precautionary in the face of uncertainty, users should assign these scores based on the plausible worst-case scenario (i.e. greatest plausible spatial scale, frequency, and intensity) impacting the most vulnerable aspect of each target (e.g. population size; habitat extent; nutrient cycling; trophic size).

These three values are then multiplied together and, as with the Response scores, normalized through scaling down (the product is divided by the maximum possible score (64) and then multiplied by 10 to allow for a wider range of possible Risk scores).

$$4. \text{ Base Exposure } e_t = \left( \frac{\text{Scale}_t \times \text{Frequency}_t \times \text{Intensity}_t}{64} \right) \times 10$$

**Table 1 | CARE model Exposure scoring guide.**

| Scoring          | 0                              | 1  | 2   | 3   | 4  |
|------------------|--------------------------------|--|---|---|--|
| <b>Scale</b>     | no threat                      | single restricted location in site   | few restricted locations in site  | affecting large percent of site, but not whole site                           | widespread, throughout site  |
| <b>Frequency</b> | never occurs                   | rare   | occasional, reasonably often  | Frequent, regular   | persistent, continual  |
| <b>Intensity</b> | no impact OR beneficial effect | affects one or more species only (no cascading effects); low intensity/ severity | affects multiple species within one trophic level; moderate intensity/ severity | affects multiple species in multiple trophic levels; high intensity/ severity | affects entire community, cascading effects; very high intensity/ severity |

- a. To score Base Exposure Score, navigate to cell B45 of the EcosystemRisk tab, where you will find the name of the first Threat that you will assess. Directly below the Threat name in column B are the different exposures (Scale, Frequency, and Intensity).
- b. Read the scoring criteria for each Threat’s Exposure in column C and enter the scores for Scale, Frequency, and Intensity for the Threat in column D. Remember that you are evaluating this Threat in relation to the Target under evaluation (Ecosystem or Species). These scores can be determined through relevant literature and/ or expert knowledge. If you have any data or information to support their score decision, they may enter it in the corresponding cells in column E.

*Example Base Exposure Score (See Appendix):* A given Legal Fishery may impact a large percent of the given site, but not the whole site (Scale score of 3); and it may happen frequently, but not persistently (Frequency score of 3). If multiple species within a single trophic level are targeted, and there are no cascading effects, this fishery would receive a score of 2 for Intensity



in an Ecosystem assessment. Species assessment Intensity scores are based on the impact on the species under analysis (low, moderate, or high).

### Base Threat Risk Score

- c. As a result of completing the previous step, your user-generated Scale, Frequency and Intensity scores will be automatically combined to generate an Exposure Score for the Threat in question as it relates to the Target under evaluation. For the first Threat, this can be found in cell D50. This value will be combined with the Target's Response Score (which you completed in Step 4) to result in a Base Threat Risk Score, which will appear in column D of each Threat Evaluation Field (for the first Threat, this can be found in cell D56). This score can also be found at the bottom of each Target tab, and in the ThreatResults tab(s).

Table 2 shows a hypothetical example with scores for the impacts of a theoretical fishery (the threat) on the theoretical coral reef ecosystem (the target), taken from *Appendix: Example CARE Analysis*. In this example, the fishery impacts the entire site being evaluated (Scale = 4), fishing happens only occasionally (Frequency = 2), and it impacts multiple species in multiple trophic levels (Intensity =3) (See Table 1). The resulting Exposure score of 3.75 is calculated as the product of these three scores (24) divided by the maximum possible value (64) and then multiplied by 10. Multiplying this Exposure score by the Response score of 5.40 (already generated for this hypothetical coral reef, see *Appendix*) results in a Base Risk Score of 20.25 for this ecosystem.

**Table 2 |** Example calculation of Base Threat Risk Score for a focal threat (fishery) on a target (coral reef ecosystem), with example values

|                                     |                                    |
|-------------------------------------|------------------------------------|
| <b>Response:</b>                    | <b>Target Response Scores:</b>     |
| Recovery Score (see Table 4)        | 2.182                              |
| Resistance Score (see Table 4)      | 2.227                              |
| <b>Response Score:</b>              | <b>5.40</b>                        |
| <b>Exposure:</b>                    | <b>Base Threat Exposure Scores</b> |
| Scale                               | 4                                  |
| Frequency                           | 2                                  |
| Intensity                           | 3                                  |
| <b>Exposure Score:</b>              | <b>3.75</b>                        |
| <b>Total Base Threat Risk Score</b> |                                    |
| <b>20.25</b>                        |                                    |

### Additional Threat Modifications

Additional Threat Modification factors allow users to quantify *the effect of each additional system threat on the Focal Threat* (the threat for which a Base Risk Score has just been calculated) and on the Target's Response to the Focal Threat. These values are numerical representations of the interaction effects of all threats in the system. These values, which can range between -1 and 1 by increments of 0.25, are entered in the blue-bordered cells that

correspond to each Exposure and Response attribute (row) as it's affected by each Additional Threat (column).

- d. In column G you will see the first additional system threat. Each Additional Threat will be indicated by the auto-filled column headers at the top of each Threat Evaluation Field. You should assign a “Additional Threat Modification” score based on the criteria provided in column F for each of the three Threat Exposure attributes (Scale, Frequency, and Intensity), as well as for the Target Response attributes, Recovery and Resistance, which are automatically populated in the Threat Evaluation Fields from their respective calculations above. For example, for the first Threat on the EcosystemRisk tab, you would fill in G47:G53).
- e. After completing the First Additional Threat Modification, fill out Threat Modifications for addition threats using columns H-K.
- f. If users have any data or information to support their Additional Threat Modification score decisions, they may enter it in the corresponding cells in column L.

*Example Additional Threat Modification (See Appendix):* Illegal Fishing may moderately increase (scores of 0.5) the Frequency and Intensity of Legal Fishing because the additional fishing pressure may cause the legal fishers to have to fish more frequently and catch smaller individual fish in order to make the same living. Alternatively, aquaculture may slightly decrease (score of -0.25) the Scale of Legal Fishing by reducing nearshore area available to fishers, but it might moderately decrease (score of -0.5) the Resistance of the ecosystem to the threat of Illegal Fishing by removing more small forage fish that help keep the system regulated. Pollution may result in a large (score of 0.75) decrease in both the Resistance and the Recovery potential of a Target Ecosystem to fishing by lowering the inherent health of the system.

### **Adjusted Threat Risk Score**

Adjusted Threat Exposure and Adjusted Target Response scores will be automatically calculated through combination of the adjusted Scale, Frequency, and Intensity scores for each Threat (as modified by all other threats in the system), and of the adjusted Recovery and Resistance scores for the Target, respectively. These two scores will then automatically combine to result in a Total Adjusted Threat Risk Score. This value will appear in column M in the bottom row of each Threat Evaluation Field, as well as in the scoring area at the bottom of each Target's tab, and on the ThreatResults tab(s).

- g. This process should be repeated with each Threat in the system treated as the Focal Threat, and Additional Modification Factors calculated for all other system threats, using the corresponding Threat Evaluation Fields as they were labeled in Step 2.

### **Exposure Uncertainty**

Just as you scored your Uncertainty about Recovery and Resistance Attributes, you will also score your Uncertainty about Base Exposure Scores and Additional Threat Modification Scores.

- a. You should indicate your level of Uncertainty around each of the Base Exposure attribute scores (Scale, Frequency, and Intensity) in column P of the same row as the attributed score in question. The level of Uncertainty should be based on the Uncertainty Scoring

Metric provided in column N of each Threat Evaluation Field.

- b. You should also indicate your level of Uncertainty around *all* the Additional Threat Modifications scores assigned to a given attribute in column R, using guidance from column M. You will also your Uncertainty around the Additional Threat Modifications assigned to the Response attributes in the corresponding cells in column R. These scores should also be based on the Metric in column M.
- c. Numerical quantifications of the different levels of uncertainty will auto-populate in columns P and R. These values will be combined with the Response Uncertainty scores (Step 3a) to generate a Total Uncertainty score. Corresponding qualitative interpretations of these scores will appear in columns Q and S at the end of each Threat Evaluation Field, as well as at the bottom of the TargetRisk Tab(s) and on the ThreatResults tab(s).

Now that you have completed Base Exposure, Base Threat Risk, Additional Threat Modifications, and Uncertainty scoring for the first Threat to the Ecosystem, you will continue down the CARE worksheet to fill out these scores for each additional Threat being analyzed.

### **Step 7: Fill in Climate Modification to Threat Exposure Scores**

The next step is to capture your understanding of how climate will modify the Base Exposure attribute scores (Scale, Frequency, and Intensity), in the chosen future time period (from ClimateImpact Tab).

- a. Using the Climate Modification metric provided in column T, score Climate Modification factors in the blue-bordered cells that correspond to each Exposure attribute (row), for every Threat you've assessed in the present time period. Climate Modification factors can range between -1 and 1 by increments of 0.25, similar to the Additional Threat Modification factors. A space is provided for users to input their reasoning for the Climate Modification (in the same row as the score in question) in column W.
- b. Numerical adjustment of the Adjusted attribute scores will auto-populate in column V to generate a total Climate Modified Exposure score. These values will be combined with the Response scores (from Step 4) to generate a Climate Modified Threat Risk score, which will appear in column V at the end of each Threat Evaluation Field, as well as at the bottom of each Target tab, and on the ThreatResults tab(s).

*Example Climate Modification of Exposure Scores (see Appendix):* The expected impacts of climate change over the pre-selected time scale may result in a large increase (score of 0.75) the Scale of legal fishing activities if the fishers will have to go further out or to new areas to catch fish that have moved to track preferred water temperatures; if legal fishers shift their efforts to target a different species on a different trophic level after their historic target species leaves, this may result in an extreme increase (score of 1) of the Intensity of the legal fishery.

### **Climate Modification to Threat Exposure Uncertainty Scoring**

- a. Indicate your level of Uncertainty around the Climate Modification score for each Base Exposure attribute score in the corresponding cell (in the same row as the score in question) in column Z (indicated with blue borders). The level of uncertainty should be based on the Uncertainty Scoring Metric provided in column X.
- b. Numerical adjustment of the attribute scores will auto-populate in column V at the end of each Threat Evaluation Field. These values will be combined with the Response Uncertainty scores (Step 4a) to generate a Climate Modification Uncertainty score, which will appear in column Z at the end of each Threat Evaluation Field, as well as at the bottom of each Target tab, and on the ThreatResults tab(s).

*\*You have now completed application of the Climate-Updated CARE tool to your site's predominant or most vulnerable ecosystem community. The remaining three steps will walk you through interpretation of your results, but no further scoring/ data entry is necessary for this Target. To see examples of the scores discussed below, open the Appendix: Example CARE Analysis.\**

### Interpretation of Climate Impact and Vulnerability Scores

Anticipated system-wide and fishing community-specific Climate Impact and Vulnerability scores and ranked climate drivers are generated through the CARE analysis in order to help users conduct more informed short- and long-term goal setting, management planning and decision-making. To view these scores for your Target(s), navigate to the corresponding “ClimVulnResults” Tab<sup>1</sup> (i.e., the “EcosystClimVulnResults” tab for the Ecosystem, or the “SX<sub>ClimVulnResults</sub>” tabs for the *X* Species assessed).

**Critical caveat: Throughout the process of CARE results interpretation, but especially with relation to the Climate Change-related scores, numerical values should be considered far less important than the qualitative interpretations of these scores, and their relationships to each other. The CARE tool does not collect enough quantitative data, nor do its equations sufficiently capture the complex interactions of all relevant ecosystem dynamics, to generate meaningfully quantitative climate change impact or vulnerability information. Climate-related scores are significantly less precise and more uncertain than the Risk Scores generated for the current system Threats and are intended to provide general guidelines for expectations rather than explicit predictions.** In other words, a Climate Impact score of “10” does not mean the system is going to be “10 times worse off” in a climate changed future, nor does a Climate Vulnerability score of 75 mean the site in question is “75% vulnerable” to climate change.

#### System-Wide Climate Scores:

- a. A score quantifying the total Anticipated Climate Impact for the site as a whole, as generated in step 1, will be displayed in cell B5 on the ClimVulnResults Tab(s) corresponding to the Target(s) assessed. These scores range from 0-10. The qualitative

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<sup>1</sup> All results can also be viewed at the bottom of each TargetRisk assessment tab.

interpretation of this score will be displayed adjacent to this value, in cell C5. Anticipated Climate Impact scores are a representation of the severity of impacts in the site from all climate change drivers that are expected to manifest in this part of the world relative to the range of possibility for climate impact severity (i.e., ranging from a baseline of “no impact” all the way to a theoretical “complete impact”). In other words, an Anticipated Climate Impact Score of “Major” suggests that climate change will have a relatively significant impact in this site, relative to *other parts of the world* that are expected to be impacted by fewer climate drivers, and/ or impacted to a lesser degree.

- b. Average user uncertainty around these scores is also captured and qualitatively displayed in cell D5. This information should inform interpretation of the Climate Impact Scores, and drive future collection of data and analyses.
- c. The Anticipated Climate Vulnerability Score, which ranges from 0-100, will be generated in cell E5 on the ClimVulnResults Tab(s), and the qualitative interpretation of this score will be displayed in cell F5. These values capture the Anticipated Climate Impact Score for the entire Site multiplied by the Target's intrinsic ability to respond to any negative impact (in the present, without modification by climate change).

**IMPORTANT NOTE: The Climate Vulnerability Score can be thought of as *analogous* to the individual Threat Risk scores (on the next tab), in that it is a quantification of the amount of damage the threat is expected to cause (in this case “Impact,” in the case of the individual threats, “Exposure”) multiplied by the ability of the system to withstand and bounce back from damage (the target Response scores). However, as the Climate Impact score is calculated through a different method than the Individual Threat Exposure scores are, the Climate Vulnerability Score is *not comparable* with the Threat Risk Scores (either now or in the future time period selected).** In other words, if a system receives a Climate Impact score of 60 and also receives a Threat Risk score of 60 for the legal fishing operation, this does not mean that the threat of climate change is equivalent for these two system stressors. Please use caution when interpreting and discussing these different outcome values. We recommend keeping the discussion of Anticipated Climate Impacts separate from that of the relative Risk posed by different threats currently impacting the system (now and in a climate impacted future). For this reason, these scores are presented on separate tabs in the CARE workbook.

#### **Top Climate Drivers:**

- a. The most significant drivers of climate change in the assessed site are listed in descending order (i.e., more significant to less significant) in column H of the ClimVulnResults Tab. Color coding indicates whether a given driver received high scores for *both* the likelihood and magnitude of change (red); a high score for one of these two metrics, with a moderate score for the other (dark orange); moderate scores for both metrics (light orange); or a low likelihood score, but a high magnitude of change. **Drivers that users indicate to be high likelihood, but low magnitude of change are not included in this list,** nor are drivers that receive lower scores on

both metrics. Note that it is possible that not all colors will be displayed in a given set of results.

### **Fishery-Specific Climate Scores:**

- a. Qualitative evaluations of the expected increase in average sea surface temperature (SST) and decrease in average pH (i.e., increased acidification) in the site are displayed in cells J5 and K5, respectively, on the ClimVulnResults Tab(s). These scores are directly user-generated on the ClimateImpact tab (likelihood x magnitude of change). They are extracted from the averaged Climate Impact score (above) because of their special significance to fishery management – as they are the two top drivers of climate-driven species range shifts and changes to stock productivity.
- b. In cell L5 a qualitative score is generated for the sensitivity of the community as a whole<sup>2</sup> to these two types of climate-driven changes. This score is calculated as an average of scores from a relevant subset of user-scored Response attributes from the TargetRisk tab (i.e., the Resistance attributes colored rose-pink).
- c. Cells JK8 and L8 of the ClimVulnResults Tab(s) display qualitative, *general predictions for the overall impact of climate change on the species community*<sup>2</sup> in a site, in terms of likely species range shifts and changes to productivity, respectively. Outputs in these cells are based on user-generated scores for the expected changes to average sea surface temperature and pH in the site, combined with user-generated scores for the proportion of the species community<sup>2</sup> that is sensitive to these changes, as well as the proportion that is habitat dependent and/ or constrained by their prey (i.e., prey selective).
- d. These scores can be viewed in relation to each other to give the user a general sense of how significantly the species community<sup>2</sup> in the site will be impacted by climate change.

### **Interpretation of Present and Future Threat Risk Scores**

To understand how other (non-climate change) threats facing your site relate to each other, navigate to the ThreatResults tab<sup>3</sup> that corresponds to the Target you want to consider (Ecosystem or Species).

#### **Top 3 Threats:**

- a. At the top of this tab (rows 3-6) you will see two tables that display **the top three Threats facing this Target now (columns B-D) and in the climate-changed future period you selected (columns F-G)**. These threats are ranked by their Total Adjusted Threat Risk Scores (without and with Climate Change Modifications, respectively), which range from 0-100, and qualitative interpretations of these scores are provided. These relative threat rankings tell you which Threats are likely having the largest impact on the assessed Target in the present moment, and which threats are

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<sup>2</sup> For Species Targets (i.e., on the SXClmVulnResults Tabs), the information in cells L5, JK8, and L8 pertains to the *individual species* assessed on the relevant SpeciesRisk tab, not to the species community as a whole.

<sup>3</sup> All results can also be viewed at the bottom of each TargetRisk assessment tab.

likely to have the largest impact in a climate-changed future. This information can help inform allocation of limited management resources, as well as short- and long-term decision-making.

Scrolling down from these two tables reveals two larger tables that present an expanded version of the same information (i.e., a relative ranking of the Threats facing the given Target, both now and in a climate-changed future). These larger tables contain additional, but not different, information to the two tables at the top of the sheet about the suite of Threats facing this Target.

### **Base Threat Risk Scores:**

- a. For each Threat, the Base Risk Score generated in step 6 appears in column E of the table that begins on row 21. The Base Risk Score represents risk to the Target from the Threat based on the Target's intrinsic ability to Respond to negative impact (displayed in cell D22) multiplied by the Threat's intrinsic Exposure score (displayed in column D, in the row corresponding to each Threat). **The relative ranking of each Threat's Individual Base Risk Scores tells you which Threats are likely having the largest impact on your Target in the present moment, without considering threat interactions.**
- b. Qualitative representations of the total Uncertainty around scores contributing to the Individual Base Threat Risk Scores will be displayed in the corresponding cells in column E of this table. **This information should inform interpretation of the Threat Risk Scores, and drive future collection of data and analyses.**
- c. The Total Base Threat Risk Scores generated for each Threat in the system will be automatically combined (using the simple additive model) to generate a Cumulative Base Risk Score for each Target under evaluation. This value will appear in cell E33 of the results table. *Note that because of the calculation method used, it is possible for a system with many minor or moderate Threats to have a higher Cumulative Risk Score than a site with a smaller number of more serious Threats.*

### **Adjusted Threat Risk Scores:**

- a. For each Threat, the Total Adjusted Threat Risk Score generated in step 6 appears in column G, along with a qualitative interpretation of this score in column H, of the table that begins on row 21. This value represents risk to the Target from the Threat based on the Target's intrinsic ability to Respond to negative impact multiplied by the Threat's intrinsic Exposure score, as altered by interaction with the other Threats in the system. **The relative ranking of each Threat's Individual Adjusted Risk Scores tells you which Threats are likely having the largest impact on your Target in the present moment, given the interactions of Threats with each other.**
- b. Qualitative representations of the total Uncertainty around scores contributing to the Individual Adjusted Threat Risk Scores will be displayed in the corresponding cells in column I in the results table. **This information should inform interpretation of**

**the Threat Risk Scores, and drive future collection of data and analyses.**

- c. The Final Adjusted Threat Risk Scores generated for each Threat in the system will be automatically combined (using the simple additive model) to generate a Cumulative Adjusted Risk Score for each Target under evaluation. This value will appear in cell G33 of the results table, with a qualitative interpretation of this value in cell H33. **This score can help inform decisions about siting interventions in different sites.** *Note that because of the calculation method used, it is possible for a system with many minor or moderate Threats to have a higher Cumulative Risk Score than a site with a smaller number of more serious Threats.*

**Climate-Modified Threat Risk Scores:**

- a. For each Threat, the Climate-Modified Risk Score generated in steps 5 and 7 appears in column L, along with a qualitative interpretation of this score in column M, of the table that begins on row 21. The Climate-Modified Risk Score represents risk to the Target from the Threat based on the Target's intrinsic ability to Respond to negative impact as anticipated to be modified by climate change in the time period selected (displayed in cell K22), multiplied by the Threat's intrinsic Exposure score, as altered by interaction with the other Threats in the system, and as modified by climate change in the time period selected (displayed in column K, in the row corresponding to each Threat). **The relative ranking of each Threat's Individual Climate Modified Risk Scores tells you which Threats are likely to have the largest impact on your Target in the selected future period, given the impact of climate change.**
- b. Qualitative representations of the total Uncertainty around scores contributing to the Individual Climate Modified Threat Risk Scores will be displayed in the corresponding cells in column N in the results table. **This information should inform interpretation of the Threat Risk Scores, and drive future collection of data and analyses.**
- c. The Final Adjusted Threat Risk Scores for each Threat in the system will be automatically combined (using the simple additive model) to generate a Cumulative Climate Modified Risk Score for each Target under evaluation. This value will appear in cell L33, along with a qualitative interpretation of this score in cell M33. **This score can help inform decisions about siting interventions in different sites.** *Note that because of the calculation method used, it is possible for a system with many minor or moderate Threats to have a higher Cumulative Risk Score than a site with a smaller number of more serious Threats.*

**(Optional) Step: Conduct Species Analyses**

Once you have completed the CARE analysis for your site's predominant or most vulnerable ecosystem, you may also wish to conduct similar analyses for one or more species that are important in your site. To do so, repeat steps 4-9 using the SpeciesXRisk Tab(s) (where X is the number of species you wish to evaluate). Species results can help inform assessment and management prioritization, as well as short- and long-term goal setting.



## Results Comparisons Tabs

If multiple Targets have been assessed (i.e., one or more Species in addition to the Ecosystem Target), the last two tabs in the CARE workbook can help to more easily compare their scores.

The Threat Results Comparison tab organizes all assessed Targets by the Threats evaluated, so that you can more easily see how each individual Threat impacts the suite of Targets, both now and in the climate-changed future time period. Cumulative Threat Risk scores (present and future) are also provided for each Target so that you can get a quick glimpse of how the total levels of risk they each face compare.

The Climate Results Comparison tab presents the climate change-related scores for all assessed Targets. At the top of the tab you will see the scores that pertain to the entire site (including the ranking of climate drivers, which runs down the tab in the last column on the right), and then beneath these scores you will see the results that relate to each Target, in turn. Note that in the Ecosystem score field, the results about the likelihood of species range shifts and productivity changes refer to the *species community as a whole*, while these analogous scores in the Species results sections refer just to the individual species assessed.

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