MEMORANDUM

DATE	August 12, 2020
TO	Kristy Williams, MLTPA, Project Management Specialist John Wentworth, MLTPA, Board President
FROM	Tammy L. Seale, PlaceWorks, Climate Action & Resilience Associate Principal Eli Krispi, PlaceWorks, Climate Action & Resilience Senior Associate Jacqueline Protsman, PlaceWorks, Project Planner
SUBJECT	Eastern Sierra Sustainable Recreation and Tourism Initiative Vulnerability Assessment Method Recommendation

Introduction to Vulnerability Assessment Approach

The climate change vulnerability assessment process typically includes an analysis of exposure, sensitivity, and adaptive capacity of populations and assets to climate change hazards.[1] For the Eastern Sierra Sustainable Recreation and Tourism Initiative Climate Adaptation and Natural Capital Assessment, the goals of the vulnerability assessment are to prioritize the most vulnerable recreation and tourism assets and inform the Natural Capital Assessment that will be conducted by ICF. The project team is committed to following state guidance and best practices for preparation of vulnerability assessment; however, there are different methods to addressing exposure, sensitivity, and adaptive capacity to evaluate vulnerability. This memo summarizes the three methods have been used in the Eastern Sierra region by the U.S. Forest Service, EcoAdapt, and the Town of Mammoth Lakes, and provides our recommended method for a vulnerability assessment that best meets the needs of this project.

Recommendation

After reviewing these three methods, we recommend using the U.S. Forest Service reports as a basis for the infrastructure and recreation assets chosen for this assessment based on our specific findings and conclusions as detailed in the next section. We also recommend using a combination of hazard and climate data available from both the U.S. Forest Service project ArcGIS tool and the Town of Mammoth Lakes Vulnerability Assessment, which can be used at the regional scale of this project. We propose combining these data with a method that will provide scoring or ranking of each population or asset to each climate hazard, as these scores will be used in the Natural Capital Assessment. The matrix scoring method used in the Town of Mammoth Lakes Vulnerability Assessment, which is also the method described in the California Adaptation Planning Guide, can be easily replicable in other regions, used at various scales, and can consider benefits, unique opportunities, impact, and adaptive capacity, and therefore, we recommend this method for ranking or prioritizing vulnerabilities. We do, however, understand that the vulnerability assessment method should factor in the location and management of specific assets, as this additional

detail will affect the impacts (or sensitivity) and adaptive capacity, so we also recommend using the descriptions of benefits, impacts, adaptive capacity, and niche opportunities of both infrastructure and recreation assets from both the U.S. Forest Service Reports and EcoAdapt Assessment. Overall, this recommended method would combine the data, results, and methods of the three assessments described above, to effectively assess the vulnerabilities of populations, infrastructure, and recreation assets in the Eastern Sierra region.

Vulnerability Assessment Methods

U.S. FOREST SERVICE

The U.S. Forest Service's *Climate Change Vulnerability and Adaptation for Infrastructure and Recreation in the Sierra Nevada* report uses the Adaptation Partners approach to assess the vulnerability of water resources, infrastructure, and outdoor recreation in the region. A similar report, *Climate Change Vulnerability and Adaptation in the Intermountain Region,* which includes the northernmost part of the Eastern Sierra region, used the Adaptation Partners approach to develop a state-of-science climate change vulnerability assessment and adaptation options for federal lands.[2] This approach summarizes the "state of the science" on the impacts of climate change for resources, in addition to modeling the climate change hazards and synthesizing peer-reviewed literature with the goal of creating a list of prioritized adaptation strategies for resources.[3] The U.S. Forest Service adaptation guidance suggests the use of an average of multiple climate models for modeling climate change hazards.[4] In the context of the U.S. Forest Service assessment guidance exposure is the degree or extent of deviation in climate to which a system is exposed; sensitivity is the degree to which a system is affected, either positively or negatively by climate related stimuli; and adaptive capacity is the ability of a system to adjust to climate change, to moderate potential damage, to take advantage of opportunities, or to cope with the consequences.[5] The vulnerability assessment team held a preliminary workshop with scientists and resource specialists, followed by a process to refine key questions that the assessment needed to address, select values to assess, and determine which climate change effects models best informed the assessment.[6] The assessment for infrastructure and recreation activities included the following steps, in addition to various questions for determining the condition of assets and vulnerability:[7,8]

1. Create an asset inventory.
2. Form an interdisciplinary team.
3. Define assets at risk.
4. Examine site data and history.
5. Review relevant climate projections and climate-related stressors.
6. Summarize relevant hydrology projections.
7. Conduct risk analysis.
8. Rank asset vulnerability.
9. Prioritize needed work or adaptation measures.

The *Climate Change Vulnerability and Adaptation for Infrastructure and Recreation in the Sierra Nevada* and *Climate Change Vulnerability and Adaptation in the Intermountain Region* reports describe how the team identifies at risk infrastructure, which is based on scientific literature and expert knowledge, quantifying the level of risk relative to value, age, condition, and climate exposure/sensitivity, and

summarizing the potential adaptation measures needed to minimize risk. The assessment built on previous studies completed in the region of both the watershed and forest level to ensure that it captures what is already being done, and what the projected future may hold. The infrastructure assessments used both GIS and literature to create a final product that summarizes vulnerability (instead of ranking vulnerability) and prioritizes where funds may best be invested for adaptation. Based on conversations with the U.S. Forest Service on July 21, 2020, the assessment in the Sierra Nevada region for recreation assets used the synthesis of infrastructure assets and the broader benefits, risks, adaptive capacity, and niche opportunities to evaluate the vulnerability, without ranking the assets. The U.S. Forest Service team explained that both infrastructure and recreation asset assessments did not use a prioritization method and the *Climate Change Vulnerability and Adaptation for Infrastructure and Recreation in the Sierra Nevada* report is intended to be used as a resource of synthesized information for additional adaptation efforts in the region.

ECOADAPT

The ecosystems in the Eastern Sierra region have been assessed through EcoAdapt's Southern California Climate Adaptation Project.[9] In the context of this assessment exposure is a measure of how much of a change in climate or climate-driven factors a resource is likely to experience; sensitivity is a measure of whether and how a resource is likely to be affected by a give change in climate or factors driven by climate; and adaptive capacity is the ability of a resource to accommodate or cope with climate change impacts with minimal disruptions.[10] This vulnerability assessment evaluated 12 focal habitats through a series of questions for sensitivity, adaptive capacity, and exposure. Each of the three components of vulnerability were assigned one of five rankings (High, Moderate-High, Moderate, Low-Moderate, or Low)[11], which were converted into scores (High-5, Moderate-High-4, Moderate-3, Low-Moderate-2, or Low-1)[12]. The following equation was used to generate a vulnerability score, with the exposure ranking weighted less due to greater uncertainty[13]:

$$Vulnerability \; = \; [(Climate\; Exposure \; \times 0.5) \times Sensitivity] - Adaptive\; Capacity$$

Each score was also given a confidence ranking to account for uncertainty. This process used ecosystem specialists, scientific literature, and a peer-review process to ensure accuracy of the scores.

TOWN OF MAMMOTH LAKES VULNERABILITY ASSESSMENT[14]

The vulnerability assessment for the Town of Mammoth Lakes used the method provided in the California Adaptation Planning Guide (APG), which is based on evaluating populations and assets for sensitivity, exposure, and adaptive capacity. In the context of the California Adaptation Planning Guide sensitivity is the level to which an asset would be affected by changing climate conditions; exposure is the presence of populations or assets in areas that are subject to harm from hazards; and adaptive capacity is the ability of a population or asset to prepare for and take actions to reduce adverse impacts to climate change effects. This assessment used scholarly research, local data, state and federal data, and input from the Town's Climate Change Adaptation Team (CCAT) and community workshops to validate the scoring. The CCAT included representatives from Mono County, the Town of Mammoth Lakes (Public Works, Engineering Services, and Planning departments), the Mammoth Lakes Fire Protection District, Mammoth Lakes Tourism, Valentine Reserve, the Sierra Club, Mammoth Mountain Ski Area, Mammoth Lakes Chamber of Commerce, Town of Mammoth Lakes Planning and Economic Development Commission, Town of Mammoth Lakes Town Council, Caltrans, Mammoth Community Water District, MLTPA, and the U.S. Forest Service.

Climate models from CalAdapt and other sources for climate change hazards were averaged to account for uncertainty in the data. This vulnerability process included the identification of 10 distinct climate change hazards and specific community assets that were grouped into the following categories: populations, buildings and infrastructure, important economic assets, ecosystems and natural resources, and key community services. The process then looked at which hazards would be likely to effect which populations and assets. Each of these hazard/community asset pairings were assessed for impact and adaptive capacity. The vulnerability assessment ranked each sensitivity on a five-point scale (0 to 4) for each relevant exposure based on a series of five questions. IM0 is the lowest score (lowest impact), and IM4 is the highest score (highest impact). The vulnerability assessment ranked each sensitivity on a five-point scale (0 to 4) ranging from AC0 (the lowest adaptive capacity) to AC4 (the highest adaptive capacity), based on a series of three questions. These scores were then combined in a vulnerability scoring matrix with scores ranging from V1 – Minimal Vulnerability to V5 – Severe Vulnerability. These scores were then prioritized based on severity of vulnerability.

Since preparation of this Vulnerability Assessment, the state has updated the APG to include four primary phases, instead of the previous 9-step process. Phase 1 was added as a pre-assessment step to scope the adaptation planning process. Phase 2 of the APG combines Step 1 through Step 5, which focus on identifying hazards, populations, and assets; evaluating sensitivity, impact, and adaptive capacity; and integrating risk and onset into assessing vulnerability. Phase 3 merges Step 6 and Step 7, which includes the prioritization of vulnerabilities and adaptive needs, as well as the identification of an adaptation framework and strategies. Step 8 and Step 9 of the previous APG have been combined into Phase 4, which is to implement, monitor, evaluate, and adjust adaptation strategies as needed. The approach for the Town of Mammoth Lakes vulnerability assessment followed these phases, and therefore remains consistent with the APG. The APG remains the state's primary guidance for local adaptation planning in California at the community and regional levels.

Conclusion

Each of the three vulnerability assessment methods described above use exposure, sensitivity, and adaptive capacity to essentially rank or score the vulnerability of each asset to each hazard. The definitions of these three components were generally consistent among the three vulnerability assessments, with the resulting vulnerability considering the projected exposures or hazards, the sensitivity or impacts of these hazards on specific assets or ecosystems, and the ability of the assets or ecosystems to adapt to these future conditions.

The three vulnerability assessments differ on how these components were analyzed and assessed. The EcoAdapt assessment used a more quantitative, numerical approach, with a specific equation that accounts for the uncertainty. This evaluation resulted in a combined vulnerability of the ecosystems to all applicable climate change related hazards. The method used in the Town of Mammoth Lakes vulnerability assessment follows guidance provided by the APG, which is the typical method used by PlaceWorks and is the one recommended by the Governor's Office of Emergency Services and Office of Planning Research for use at the community and regional level. This method involves scoring impact and adaptive capacity and putting those scores into a matrix to identify the severity of vulnerability of each population or asset to each climate change related hazard. The U.S Forest Service used both a qualitative and quantitative process to assess vulnerability and adaptation methods. Based on the vulnerability assessment in the Intermountain region, the draft vulnerability assessment in the Sierra Nevada region, and conversations with the U.S. Forest Service, these reports evaluate vulnerability of specific assets to a combination of applicable climate change

related hazards through scientific literature, expert knowledge, and GIS. The goal of these assessments are to provide a synthesis of information to use in other or more localized adaptation efforts in the region.

Endnotes

[1] Thomas J. Timberlake and Courtney A. Shultz. November 2019. *Climate Change Vulnerability Assessment for Forest Management: The Case of the U.S. Forest Service*. Department of Forest and Rangeland Stewardship, Colorado State University, Fort Collins, Colorado.

[2] Halofsky, Jessica E.; Peterson, David L.; Ho, Joanne J.; Little, Natalie, J.; Joyce, Linda A., eds. 2018. Climate change vulnerability and adaptation in the Intermountain Region. Gen. Tech. Rep. RMRS-GTR-375. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Part 1. pp. 1–197.

[3] Thomas J. Timberlake and Courtney A. Shultz. November 2019. *Climate Change Vulnerability Assessment for Forest Management: The Case of the U.S. Forest Service*. Department of Forest and Rangeland Stewardship, Colorado State University, Fort Collins, Colorado.

[4] U.S. Forest Service. November 2011. *Responding to Climate Change in National Forests: A Guidebook for Developing Adaptation Options*. General Technical Report PNW-GTR0855.

[5] Solomon, S.; Quin, D.; Manning, M. [et al.], eds. 2007. Climate change 2007: the physical science basis. Contribution of working group I to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom: Cambridge University Press. 996 p.

[6] U.S. Forest Service. 2020. *Climate Change Vulnerability and Adaptation for Infrastructure and Recreation in the Sierra Nevada.*

[7] U.S. Forest Service. 2020. *Climate Change Vulnerability and Adaptation for Infrastructure and Recreation in the Sierra Nevada.* Box 4.2.

[8] Halofsky, Jessica E.; Peterson, David L.; Ho, Joanne J.; Little, Natalie, J.; Joyce, Linda A., eds. 2018. Climate change vulnerability and adaptation in the Intermountain Region. Gen. Tech. Rep. RMRS-GTR-375. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Part 1. pp. 1–197.

[9] Thomas J. Timberlake and Courtney A. Shultz. November 2019. *Climate Change Vulnerability Assessment for Forest Management: The Case of the U.S. Forest Service*. Department of Forest and Rangeland Stewardship, Colorado State University, Fort Collins, Colorado.

[10] Glick, P., Stein, B., & Edelson, N. (2011). Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment. Washington, D.C.: National Wildlife Federation.

[11] EcoAdapt. 2017. *Climate change vulnerability assessment for the Southern California Climate Adaptation Project: Vulnerability Assessment Model and Methods*.

[12] EcoAdapt. 2017. *Climate change vulnerability assessment for the Southern California Climate Adaptation Project: Vulnerability Assessment Model and Methods*.

[13] EcoAdapt. 2017. *Climate change vulnerability assessment for the Southern California Climate Adaptation Project: Vulnerability Assessment Model and Methods*.

[14] PlaceWorks. August 2019. *Resilient Mammoth Lakes Vulnerability Assessment*.
https://www.townofmammothlakes.ca.gov/DocumentCenter/View/10140/Mammoth-Lakes-VA_Final?bidId=.