Exercise 1: Objectives, Scope, and Scale

A common question about vulnerability assessment and adaptation planning is what the best method for doing them is. The answer is "it depends." The goal of the exercises you will be completing during this training is to get you thinking about the various factors covered by this "it depends." Among the most important is the objective of your VA.

There are plenty of different reasons why you might do a vulnerability assessment. The goal might be to build general awareness of climate change among staff, to inform an educational campaign, or to inform culvert design for a restoration project. In the first case, maintaining involvement of a broad range of staff would be essential, whereas in the latter case hiring an external consultant would be completely acceptable. In the case of an educational campaign, qualitative information may be sufficient, whereas with culvert design you would need not just hard numbers for projected flow volumes, but information on uncertainty and the range of projected flow volumes. As you go through the suite of exercises during this training, consider how your goals and objective might influence how you answer the questions asked.

Your task for this exercise:
Your exercise packet has a set of background information on the NERR that will be your focus for a series of exercises during the training. For this exercise, focus on the Management Context section of your packet, particularly the Existing Missions and Goals section. With these in mind, do the following:

1. Write 3 different "problem statements" for why you might do a VA for this reserve (e.g. "We are undertaking a major revision of our management plan, and want to make sure we don't overlook anything important"). The goal of this question is to consider a wide range of reasons you might do a VA, so try to come up with three fairly different types of problems.

    a. Problem Statement 1:

    b. Problem Statement 2:

    c. Problem Statement 3:

2. For each problem statement, describe what the goals and objectives of a VA addressing that problem would be (e.g. informing agency investment priorities, selecting management measures, etc.). Again, the idea is to consider the range of possible goals and objectives for a VA, and how the goals of a VA relate to the problem that motivated the VA in the first place.

    a. G&O for Problem Statement 1:

    b. G&O for Problem Statement 2:

    c. G&O for Problem Statement 3:

3. Select one set of goals and objectives on which to focus for the purpose of this training. With these in mind, along with the overall mission and goals for your NERR, identify the audience, user requirements, and needed products for this particular VA.

    a. Who will use the results of your VA? Are there several distinct groups of users?

    b. How will they use the results—when, in what form, and how often?

    c. What decisions will the VA inform, and what decision-making processes will be used?

4. Given your goals, objectives, and audience, identify suitable VA targets—Ecosystem processes (e.g. nutrient or sediment flow; erosion and deposition; hydrology)? Management plans? Specific management measures? Species? Habitat diversity within your NERR? Explain why you selected the target(s) you did.

5. Given your goals, objectives, and audience, determine appropriate spatial and temporal scales for the assessment.

    a. On what scales do relevant population, community, and ecological processes operate?

    b. On what scale do relevant management, regulatory, and funding processes operate?

Exercise 2: Assessing sensitivity

We want you to gain experience identifying and articulating components of sensitivity for various possible targets. You may find yourself distracted by the question of whether a particular characteristic is a component of sensitivity, exposure, or adaptive capacity; in the end it doesn't matter which bin you put characteristics into. What matters is that you understand how particular characteristics contribute to vulnerability or lack thereof.

Steps:

I. Examine the sensitivity checklists (species, habitat, ecosystem process, and management action; species and habitat checklists based on Josh Lawler's Climate Sensitivity Database, http://climatechangesensitivity.org/).

II. Work through the sensitivity checklist most applicable to the VA target(s) you chose in Exercise 1. Information on habitats, species, and processes in your NERR has been provided in the packet to help you develop a rank for sensitivity.

III. Consider how you might present this information. As a single sensitivity score? As a detailed narrative? Graphically?

IV. How if at all might you modify the checklist we provided?

Reserve Habitat Climate Change Sensitivity Checklist

1. Sensitive habitats
Does the Reserve contain (or is it characterized by) many habitats that will be particularly sensitive to climate change (e.g., vernal pools, shallow wetlands, alpine areas, coastal marshes, coral reefs)?

Not many				Many
1	2	3	4	5

2. Habitat diversity
Is the administrative unit dominated by a single ecosystem/ habitat type, or does it encompass a range of climates and ecosystems?

Broad range				Single ecosystem
1	2	3	4	5

3. Disturbance regimes
How sensitive are habitats in the Reserve to a change in a disturbance regime (e.g., fire, flooding)?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

4. Individual species sensitivities
How sensitive are key species in the Reserve to climate change (e.g., flagship species, ecosystem engineers, keystone species)

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

5. Physiological sensitivity
How sensitive is the physiology of the dominant vegetation type to changes in moisture, temperature, CO_2 concentrations, pH?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

6. Non-climatic stressors
To what degree are the habitats in the Reserve affected or threatened by non-climatic stressors that might influence sensitivity to climate change (e.g. groundwater withdrawal, pollution, etc.)?

Slightly affected				Severely affected
1	2	3	4	5

Management Action Climate Change Sensitivity Checklist

1. Species composition
How sensitive is the management action to changes in species composition or interactions?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

2. Disturbance regimes
How sensitive is the management action to a change in a disturbance regime (e.g., fire, flooding)?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

3. Soil and water chemistry
How sensitive is the management action to changes in soil or water chemistry (e.g. salinity, pH)?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

4. Hydrological changes
How sensitive is the management action to changes in hydrological regime (changes in timing of peakflow, average or max/min flow, etc)?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

5. Sea level rise
How sensitive is the management action to sea level rise

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

6. Human behavior
How sensitive is the management action to human response to climate change (e.g. increased hard armoring of shorelines; reduced permitting of prescribed burns; etc.)

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

Ecosystem Process Climate Change Sensitivity Checklist

1. Temperature sensitivity
How sensitive is the process to changes in temperature (max, min, average, etc.)?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

2. Hydrological sensitivity
How sensitive is the process to changes in hydrological regime (changes in timing of peakflow, average or max/min flow, etc)?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

3. Other climatic sensitivity
How sensitive is the process to other physical or chemical changes (e.g. CO2 concentrations, pH)?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

4. Disturbance regimes
How sensitive is the process to changes in a disturbance regime (e.g., fire, flooding)?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

5. Species composition
How sensitive is the process to changes in species composition or interactions?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

6. Human behavior
How sensitive is the management action to human response to climate change (e.g. increased hard armoring of shorelines; reduced permitting of prescribed burns; etc.)

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

7. Non-climatic stressors
To what degree are the processes affected or threatened by non-climatic stressors that might influence sensitivity (e.g., invasive species, overharvest, habitat loss)?

Slightly affected				Severely affected
1	2	3	4	5

Species Climate Change Sensitivity Checklist

1. Physiological sensitivity
How sensitive is the physiology of the species to changes in moisture, temperature, CO_2 concentrations, pH?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

2. Generalist or specialist
Is the species more of a generalist or a specialist?

Generalist				Specialist
1	2	3	4	5

3. Disturbance regimes
How sensitive is the species likely to be to a change in a disturbance regime (e.g., fire, flooding)?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

4. Interspecific interactions
How sensitive are key interspecific interactions to climate change (e.g., competitive relationships, predator prey relationships, diseases, parasites)

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

5. Sensitive habitats
Does the species rely on habitats that will be particularly sensitive to climate change (e.g., vernal pools, shallow wetlands, alpine areas, coastal marshes, coral reefs)?

Not dependent				Highly dependent
1	2	3	4	5

6. Non-climatic stressors
To what degree is the species negatively impacted by other, non-climatic stressors (e.g., invasive species, overharvest, habitat loss)?

Slightly impacted				Severely impacted
1	2	3	4	5

Exercise 3: Assessing Exposure

The goal of the questions below is to get you thinking about what elements of exposure are most important for assessing the vulnerability of the particular species, habitats, or places with which you are concerned. The metrics of change most commonly presented in the media—e.g. changes in average global or regional temperature and changes in average global or regional rainfall—aren't always the most appropriate metrics for a particular VA.

Resources:

I. Maps or graphs of projected changes in various climate variables for the relevant area
II. Information in the "climate change context" section of your packet

Questions to consider:

1. What elements of exposure are likely to be most relevant or important for your VA target? (NOTE: there may be elements that are in the "most relevant" category that have not been provided to you in the packet. List any layers missing that you think would help you better evaluate exposure).

2. Given your goals and objectives, what level of precision would be ideal for measuring exposure?

3. What factors might influence exposure? That is, what factors influence the actual amount of climatic change experienced by your VA target? For example, some types of air pollution reflect heat and thereby slow warming; type and density of plant cover can influence heating, cooling, moisture, and fire regime.

4. For ecosystem processes: Think about all the various components of this process. Is exposure to change different for each of them?

5. For habitats and species: What factors are most important in determining where this species or habitat occurs? Think not just about climate variables, but about other factors as well (e.g. presence of particular plants, absence of particular competitors, soil type, etc.). How might this influence the variables on which you chose to focus?

6. How would you express exposure for your VA target—maps of each variable separately? Of only the most important variables? A combined map showing average change in all variables? A single ranking or score for exposure across the entire range/unit? Exposure maps or scores for a few key species or habitat types within the administrative unit? Think about various ways you might want to use the VA results and how different ways of expressing exposure (and ultimately overall vulnerability) might be better or worse for each type of use.

Exercise 4: Adaptive Capacity and Assessing Vulnerability

In this exercise, we're asking you to think about the ability of your VA target to respond to climate change or be adjusted in ways that minimize the negative effects. Remember, don't get too caught up in whether you'd categorize a particular characteristic as adaptive capacity vs. exposure or sensitivity; the key is to think about vulnerability from a number of angles.

Output:

1. A measure of adaptive capacity for your VA target
2. An overall vulnerability score/ranking/description for your VA target. Do this by pooling the results of your sensitivity, exposure, and adaptive capacity analyses in a way that makes sense to you. This could be qualitative or quantitative, spatial or numeric, it's up to you. Just be ready to defend your choices!

Resources:

I. Pollution sources map (Air Releases, Superfund National Priorities List Sites, Toxics Release Inventory, Water Discharge Permits; (created using the National Atlas; can go to nationalatlas.gov and look at the "environment" layer if you want to zoom in)
II. Google map showing nearby protected areas
III. Forest fragmentation map (from National Atlas)

Questions to consider:

Habitat:

- What are the defining characteristics of the habitat/community, and how likely are they to change as a result of climate change? E.g. the presence of particular minerals in the soil may not be affected by climate change, whereas presence of vernal pools may be heavily affected.
- Is the geography, land use, etc. such that it would be possible for the community/habitat to shift location over time?
- Are there microclimates within the area that could support refugial communities?
- What is the nature of people's relationship to this habitat/community? Does it occur in areas where there is strong development pressure? Do people value this habitat because of services it provides (e.g. clean water, hunting or fishing opportunities, etc.)?

Management actions:

- How rigid and specific are the rules governing management of the unit (e.g. for National Parks, what is in the enabling legislation)? How much do they constrain possible goals and management options? How easily could they be changed if needed?
- How rigid and specific are the existing goals and mission? How much do they constrain possible management options? How easily could they be changed if needed?
- Are the assumptions underlying the use of this management measure (i.e. the "theory of change" that informs its design and application) clearly articulated? This could facilitate an adaptive hypothesis-testing approach to management.
- Are there groups of constituents who might be strong opponents or supports of changing management plans or actions?

Ecosystem processes:

- Can your target ecosystem processes be engineered, supplemented, or maintained by human intervention?
- Do the processes rely on unique species or pathways (e.g. a single source of water), or are there multiple pathways (e.g. sediment is delivered via longshore flow, bluff erosion, and riverine sources)?
- Is there a diversity of species in each functional group within the community/habitat?
- Do processes depend on species or pathways that are threatened or hard to protect, e.g. anadromous or catadromous fishes or migratory birds?
- Are there existing or likely invasions by non-native species that are hard to control and could transform ecosystem processes? E.g. The cordgrass *Spartina alterniflora* on the Pacific coast is transforming sediment retention in many estuaries.
- Are the processes affected by human activities that are unlikely to change or be significantly controlled, e.g. major water withdrawals for desert cities?

Species:

- Is its evolutionary rate fast? Slow? Somewhere in between?
- Roughly speaking, is there sufficient genetic diversity or availability of favorable alleles within the species to support evolutionary adaptation?
- Are individuals in this species capable of phenotypic adjustment in response to changes in their environment?
- Is there evidence that this species is already adjusting/adapting to change (e.g. shifting behavior, range, host plants, etc.)?
- Is the geography, land use, etc. such that it would be possible for individuals to seek out refugia during times of particular climate stress (e.g. prolonged heat wave)?
- Is the geography, land use, etc. such that it would be possible for species range shift to occur? Remember that species' range shifts typically happen by differential survival and reproduction, not by the purposeful movement of individuals to new locations.
- Are there multiple populations with enough connectivity among them to allow for rescue effects and gene flow?

Exercise 5: Information and Resources

1. **Information:** What information do you need to carry out a VA that will meet your goals and objectives? Below are some broad categories of information you might consider (although they may not all be relevant). Within each, think about specific information or areas of expertise you'd like covered, the relative importance of different types of information (e.g. desirable vs. essential), how you'd like gaps and uncertainties addressed and documented within your VA.

   For each type of information you list, be clear on its relevance to achieving your VA goals and objectives.

   For each type of information you list, consider what you would do if you were not able to get the desire information at the desired level of specificity or detail. What's your Plan B?

   a. ***Species, habitat, or ecosystem process*** information.

   Plan B?

   b. Historic, current, and future ***climatology***, focusing on ecologically relevant variables and suitable spatial and temporal scales

   Plan B?

c. Historic, current, and future ***responses*** of species, communities, or ecosystems to climatic change

Plan B?

d. ***Key threats*** to VA target beyond those linked to climatic change, and possible interactions between those threats and projected changes

Plan B?

e. ***Regulatory/management contex***t (mandates, laws, planning cycles, etc. that might influence both the VA process and the actual vulnerability of your assessment target)

Plan B?

2. Resources other than information. Think broadly: consider skills, funding, materials, infrastructure, permits, etc.

3. Partners. Who needs to be engaged in this effort, and at what stages and levels of engagement, for you to meet your goals and objectives? Whose support is essential for a VA that is both accurate and perceived as valid by users? If you don't know of the right partners off-hand, how might you go about identifying them? Consider:

a. Partners who have important resources (data, influence, funding, time, resource knowledge).

b. Partners important for making plans actually happen, providing credibility, etc.

Exercise 6 : Tools and approaches

As you hopefully know by now, there are a wide range of possible tools and approaches you can use for you VA. You don't have to use any formal tools if that doesn't make sense, and you aren't limited to using a single tool. You can create your own tools (models, check-lists, etc.), use existing tools, or some combination thereof. As you select or develop tools, consider the following categories of tool characteristics:

- Quantitative to qualitative
- Visual or not
- Complex models to transparent processes
- Descriptive to prescriptive
- Skills needed to use the tool, and time it takes to learn them

1. **Users and participants**. If there are distinct groups of VA participants/users with different needs and skills, answer for each separately (i.e. stratify your users/participants)

    a. Are there existing decision-making tools or processes within which the VA will or could take place? With which the VA users or participants are familiar?

    b. How do users/participants currently take in information? Are they comfortable with equations? Tables? Visualization?

    c. What's the level of scientific/technical comfort? If you need a transparent tool, how simple or detailed does it need to be to qualify as transparent for your users or participants?

    d. Where are they relative to climate change?

2. Resources
    a. Time. Do you need a tool or process that can be quickly learned by users/partners, or is there time for training or capacity-building? Is using tools that might require significant training, development, or time to run an option?

    b. Money. Could you hire someone to run a tool/process for you? Could you purchase additional hardware or software? Could you commission modeling or data collection?

    c. Technical capacity. What level of capacity do you currently have access to? What tools could you currently use in-house with no extra training or investment?

    d. Information. How much and what type of information do you have or could you get?

3. **Functionality and output.**
    a. Necessary spatial or temporal resolution?

    b. Necessary level of precision?

    c. Sectors/variables covered by the tool?

    d. Do you need a tool that could stand up in court?

Given your objectives, targets, users/partners, and available resources for this VA, what general approaches make sense? Are there tools that would facilitate your VA process?

Exercise 7: Synthesis, dissemination, measuring success

If you want your VA results to get seen and used, you need to think about what sorts of outputs you want before you get going. What *are* the best ways to get the results of your VA to be actually used rather than sitting on a shelf? Are there ways for you to shape your VA (e.g. target, partners, tools, approaches, etc.) that would increase the likelihood of your VA getting used?

a. Who will you want to inform about your VA results?

b. How might you best share VA results with them? Try visualizing the sort of graphs, charts, or other output you'd want to have at the end of the process.

1. Rough timeline: Given the steps you've outlined and the partners you've identified, what's a realistic timeline for making each step a reality? What steps can happen in parallel? Which steps are dependent on previous steps? Are there particular deadlines by which your intended users would need your VA results?

2. How will you **assess the success** of your plan?

a. Assessment points and metrics during implementation.

b. Assessment points and metrics following implementation.