

Science Priorities and Principles of Operation (2018-2023)¹

Southeast Climate Adaptation Science Center

The Southeast Climate Adaptation Science Center (SE CASC) was established in 2010 at North Carolina State University (NCSU) in Raleigh, North Carolina under a cooperative agreement with the U.S. Geological Survey (USGS). This plan presents science priorities and principles of operation for SE CASC that guides its activities. More details and background on science priorities, goals, and potential opportunities in Appendix A. Background and details on SE CASC principles of operation are provided in Appendix B. Appendix C provides background context on the challenges faced by resource management agencies in adapting to climate change.

SE CASC ***develops and delivers science-based information to support adaptation decisions by natural and cultural resource managers***. In the southeastern United States, the management partners consist primarily of US Fish and Wildlife Service, National Park Service, and state & tribal fish and wildlife agencies faced with the impacts of changing climate and land use in the region.

Consultation with these partners in 2018 identified three broad science priorities:

SE CASC Science Priority 1 - Exposure: Improve partner understanding of what climate and land use change processes and associated biophysical stressors will look like on the land and water they manage.

SE CASC Science Priority 2 - Impacts: Improve partner understanding of ecosystem, habitat, and species impacts of climate and land use change, as well as the understanding of how these changes affect resources of specific concern to resource managers.

SE CASC Science Priority 3 - Adaptation: Increase partner understanding of, and access to, practical guidance for framing and making smart climate and land use change adaptation decisions.

¹ September 2021 revision for formatting – no changes to priorities or content.

Strategic Science Priorities

For each of the three partner science priorities, a brief summary of DOI and other partner science interests, along with one or more potential science goals, follows. Appendix A of this memorandum presents additional background and science opportunities associated with these goals. These priorities, goals, and science opportunities will focus annual SE CASC funding opportunities.

Science Priority 1 - Exposure: Improve partner understanding of what climate and land use change processes and associated biophysical stressors will look like on the land and water they manage.

SE CASC Science Goals:

- **Advance partner understanding of regional climate-related stressors.** SE CASC will provide federal and state partners with guidance on the appropriate uses of the steady flow of new information about climate-related stressors such as sea level rise and wildfires.
- **Advance partner understanding of regional land use change-related stressors.** SE CASC will provide federal and state partners with up-to-date information about land use changes as well as science-based projections of change.

Science Priority 2 - Impacts: Improve partner understanding of ecosystem, habitat, and species impacts of climate and land use change, as well as the understanding of how these changes affect resources of specific concern to resource managers.

SE CASC Science Goals:

- **Improve partner understanding of how habitats and ecosystems will be affected by changing climate and land use.** SE CASC science will assist federal, state, and tribal resource management agencies understand the impacts of changing climate and land use in the Southeast on habitats and ecosystems that are important for meeting agency management goals.
- **Improve partner understanding of how species of conservation concern will be affected by changing climate and land use.** SE CASC will work as a science partner with federal and state conservation agencies and with other researchers to meet agencies at-risk and species of conservation concern science needs.

Science Priority 3 - Adaptation: Increase partner understanding of, and access to, practical guidance for framing and making smart adaptation decisions.

SE CASC Science Goals:

- **Improve partner understanding and characterization of why natural and cultural resources matter in the face of climate and land use change.** SE CASC science efforts should help those making management decisions understand how those decisions affect the resources that matter to them.
- **Improve partner understanding of the portfolio of potential adaptation actions available to managers in the Southeast.** SE CASC science efforts should support managers who are seeking the best possible portfolio of adaptation strategies for the resources they manage.

- **Improve partner understanding and use of tools for assessing competing adaptation options.** SE CASC will support the development and use of science knowledge needed by managers to make smart management decisions related to climate and land use change.
- **Work with partners to define an ongoing research and implementation strategy for the Southeast Conservation Adaptation Strategy.** SE CASC science will support efforts by federal and state natural resource management partners to coordinate adaptation efforts.
- **Prepare the next generation of scientists to better understand and address adaptation and resource management challenges.** SE CASC university and federal and state management partners will support efforts to train the next generation of natural resource managers and researchers so that they are well prepared to develop science that makes a difference for managers.
- **Build the capacity of professional natural resource managers to access and use climate and land use change science.** SE CASC staff and funded research will facilitate the understanding and wise use of climate and land use science products.
- **Improve understanding of communication needs for all stages of co-produced actionable science.** SE CASC will support researchers and managers to promote appropriate, effective communication throughout their project's life cycles.

SE CASC Operational Principles

Nine principles will guide SE CASC activities addressing these partner priorities. Together these principles suggest important expectations that SE CASC partners, including its Advisory Committee, should have regarding how SE CASC operates. Background and details of these principles is provided in Appendix B.

1. Resource management priorities drive SE CASC science activities.
2. Resources are biocultural, derived from interacting natural and human systems.
3. SE CASC science should be actionable, co-produced and useful.
4. SE CASC co-produced actionable science should acknowledge the “wicked” nature of most adaptation problems.
5. SE CASC co-produced, actionable science depends on collaboration among partners.
6. Successful SE CASC partnerships requires communication.
7. Successful SE CASC partnerships requires capacity building.
8. Successful SE CASC partnerships require coordination.
9. Success in addressing SE CASC partner priorities depends on collaborations between USGS and the NC State university consortium.

Appendix A: Detailed SE CASC science priorities, goals, and potential opportunities

Science Priority 1 - Exposure: Improve partner understanding of what climate and land use change processes and associated biophysical stressors will look like on the land and water they manage.

Managers and agency scientists are interested in:

- *Increasing their knowledge and understanding of climate and land use change processes and biophysical stressors associated with these processes, such as:*
 - *temperature and precipitation (average and range across future scenarios);*
 - *change in water supply and quantity for humans;*
 - *eco-hydrology, including drought;*
 - *wildfire frequency and severity;*
 - *changing intensity, duration, and frequency of extreme events;*
 - *changes in sea level, coastal salinity, and the intensity, duration, and frequency of coastal inundation, including 'blue sky flooding';*
 - *land cover fragmentation*
- *Technical support from the SE CASC to explain the large amount of scientific information that is available about these processes and answer questions on an ongoing basis.*

Goal: Advance partner understanding of regional climate-related stressors.

SE CASC will provide federal, state, and tribal partners with guidance on the appropriate uses of the steady flow of new information about climate-related stressors such as sea level rise and wildfires.

Opportunity: Develop refined projections of climate variables and associated uncertainties that improve resource managers understanding at relevant spatial, temporal, and governance scales.

Opportunity: Develop estimates of rate of climate change at relevant spatial, temporal, and governance scaled that includes useful characterization of uncertainty.

Opportunity: Identify how climate change and land use change will affect key physical stressors, across resource-relevant temporal and spatial scales, such as:

- regional wildfire frequency and severity
- sea level rise
- extreme hydrologic flows
- intensity/duration/frequency of precipitation.

Opportunity: Identify how freshwater input, sea level rise, and storm surges may affect salinity of fresh, brackish, and estuarine waters under a changing climate.

Opportunity: Develop and deliver professional development programs on climate change science and data.

Opportunity: Establish a SE CASC supported climate and land use change oriented working group that can define specific climate and land use change understanding needs for state and federal partners who are facing adaptation decisions. Use the working group to define the objectives of a pilot SE CASC-supported project.

Goal: Advance partner understanding of regional land use change-related stressors.

Land use change, including urbanization, creates stresses for many important resources in the southeastern United States. SE CASC will provide federal and state partners with up-to-date information about land use changes as well as science-based projections of changes expected in the future, including changes in habitat fragmentation and wildlife corridors.

Opportunity: Develop refined projections of habitat fragmentation due to urbanization at relevant spatial, temporal, and governance scaled that includes useful characterization of uncertainty.

Opportunity: Develop improved methods for identifying habitat corridors and habitat connectivity necessary to support species of conservation concern for states and federal agencies.

Opportunity: For defined management problems, determine the scales for which the various inundation and sea-level rise models are most appropriately used.

Opportunity: Develop and deliver professional development programs on land use change science and data and the appropriate uses of these data.

Science Priority 2 - Impacts: Improve partner understanding of ecosystem, habitat, and species impacts of climate and land use change, as well as the understanding of how these changes affect resources of specific concern to resource managers.

Managers and agency scientists are interested in:

- *Increasing their general knowledge and understanding of the impacts of climate and land use change processes and associated stressors on valued biocultural resources (ecosystems, habitats, native species, invasive species, cultural resources) in order to better appreciate what the future holds for biocultural resources important for the quality of life in the Southeast. This includes understanding of both the current and future state of critical systems including grasslands, coastal marshes, open pine forests, bottomland hardwoods, and coastal and freshwater aquatic systems.*
- *When making a climate change adaptation decision, managers have a need to understand the impacts of potential adaptation actions in terms of clearly specified management objectives associated with the resources for which they are responsible.*

Goal: Improve partner understanding of how habitats and ecosystems will be affected by changing climate and land use.

Climate and land use change plays an increasingly important role in determining the condition of key resources, including species, habitats, and ecosystems. SE CASC science will assist Federal and State resource management agencies understand the impacts of changing climate and land use in the Southeast on habitats and ecosystems that are important for meeting agency management goals.

Opportunity: Understand how changing climate and land use will affect the location, structure, and viability of the following habitats of interest to SE CASC partners:

- Grasslands (including glades, barrens, prairies, savannas, balds, bogs, fens, marshes, meadows, and flood-scoured riparian herbaceous ecosystems)
- Isolated ecosystems (caves, outcrops)
- Coastal marsh and mangroves
- Coupled coastal urban and natural systems
- Open pinelands
- Coral reefs
- Freshwater aquatic systems
- Bottomland hardwoods.

Opportunity: Understand how projected climate and land use futures will affect habitats that serve as potential refugia for species of conservation concerns to SE CASC partners.

Opportunity: Understand climate and land use change-related thresholds or tipping points for key resources (species and habitats) identified in State Wildlife Action Plans, when resource conditions change enough that it is difficult to return to previous resource states and it may be difficult to meet existing agency objectives.

Opportunity: Define impact “signposts” or impact indicators, associated with decision maker and other stakeholder priorities, that can be measured and modeled to indicate when the impacts of climate and land use change might have reached a tipping points requiring adaptation actions (Tariq and others, 2017; Shriver and others, 2018).

Opportunity: Improve SE CASC partner understanding of probabilistic climate and land use exposure and impact information and how this probabilistic information can be used when making decisions.

Goal: Improve partner understanding of how species of conservation concern will be affected by changing climate and land use.

Public resource agencies are charged with responsibilities to manage and sustain diverse assemblages of wildlife species. This is done for a variety of purposes associated with each agency’s authority, jurisdiction, and mission, such as sustaining hunting and fishing opportunities, maintaining persistent populations of rare and at-risk species, and maintaining ecosystem functions and services. Key management tools are state-specific State Wildlife Management Plans (SWAPS), and FWS-led Species Status Assessments (SSA). SE CASC will work as a science partner with federal and state conservation agencies and with other researchers to meet agencies at-risk and species of conservation concern science needs., with a specific focus on supporting the implementation of SWAPS in light of changing climate and land use, as well as providing support to FWS for meeting SSA obligations. Ideally, these efforts will support further development of the Southeast Conservation Adaptation Strategy (SECAS).

Opportunity: Understand how changing climate and land use will affect regionally important species of greatest conservation concern., and at-risk species Better understand how climate and land use change drive vulnerability of these biocultural resources. Develop models that improve understanding of how adaptive actions relate to outcomes for these species and associated habitats.

Opportunity: Assist states to develop multi-state analytical framework to assess species and habitat climate and land use change vulnerability when species and habitat ranges cross state boundaries under current or future climate and land use scenarios. Develop models to understand species and habitat vulnerability across current and future land use and climate scenarios.

Opportunity: Understand how changing climate and land use will affect important game species, such as bobwhite, turkey, migratory waterfowl, and ungulates.

Opportunity: Understand how non-native and invasive species are affected by changing climate and land use.

Science Priority 3 - Adaptation: Increase partner understanding of, and access to, practical guidance for framing and making smart adaptation decisions.

Any conservation planning effort, including efforts to adapt to climate and land use change, has at least three common elements: determining what matters (that is, planning objectives, which are always rooted in values); determining policy options for taking action on behalf of those objectives; and assessing how well those policy options do in achieving the original objectives. In taking on these three tasks, however, managers and agency scientists must deal with several challenging practical realities when developing and implementing climate adaptation strategies:

- Many potential partners have an interest in climate adaptation problems. These partners may have heterogeneous values and points of view, and none of these points of view are objectively wrong.
- Adaptation stakeholder objectives can be viewed at multiple spatial, temporal, and governance scales; again, no scale is “wrong.”
- Two factors—the natural human tendency to continue walking down existing management paths (which might be thought of a “sunk cost bias”) and institutional rigidity--may distort the assessment of whether further resistance to changing biophysical realities (such as investment of additional resources with the hope of accomplishing existing management objectives) makes less sense than changing the management objectives (that is, moving the goalpost, to reflect changing ecological realities). Natural and cultural resource managers in the Southeast will increasingly face the decision about when further resistance to global change processes is futile? In weighing this decision, they must confront the dilemma that acknowledging that resistance is futile may conflict with existing laws (e.g., ESA) and regulations.
- The available information needed to understand the potential impacts of climate and land use change on highly valued biocultural resources is complex, uncertain, and perhaps highly confusing or overwhelming.

- The outcomes of potential adaptation actions may be uncertain and it may be difficult to develop anything close to consensus among partners about what actions might narrow the gap between current conditions and desired future condition of a highly valued biocultural resource.

Goal: Improve partner understanding and characterization of why natural and cultural resources matter.

The diversity of conservation partners in the Southeast is reflected in the interests and values that they hold related to biocultural resources (e.g., species, habitat, ecosystem) that matter to them.

Understanding values-based objectives is a crucial foundation for sound adaptation planning and decision making. Defining what matters and which outcomes are most important is a challenging endeavor that requires deliberate, effortful thinking and communication, particularly since these objectives can exist at many scales (local, state, multi-state, regional). SE CASC will work with conservation partners, and those representing other interests, to examine tools and concepts (such as ecosystem services) that improve our ability to understand and measure the significance of resources for our partners.

Opportunity: Under the direction of Southeast Conservation Adaptation Strategy partners (SECAS; particularly FWS and state fish and game agencies), explore approaches to implement a multi-scale conservation adaptation planning process that addresses federal at-risk species and state SWAP planning and implementation, including SWAP plan coordination across state boundaries where that is advantageous to the states.

Opportunity Develop and employ measures of ecosystem services that translate management objectives into measurable endpoints and identify impacts of changing climate and land use to these measures.

Opportunity: Define the meaning of resource “significance” in a way that:

- is seen as legitimate and comprehensible to partners
- can be measured and managed, and
- can be used to explore impacts of changing climate and land use

Opportunity: Work with partners to develop a common understanding of terms such as resilience, risk, and vulnerability where all of these terms of understood with respect to the variety of partner management objectives and the services provided by attaining those objectives. Specifically consider the SE CASC advisory committee interest in coastal resilience activities that account for the interaction and interdependence of resilient natural and human communities. If appropriate make use of a SE CASC-supported working group to facilitate this conversation.

Opportunity: Explore approaches to assist managers to define the limits of resource “resilience” and limits on the ability to conserve. Develop a pilot framework to help managers answer questions such as: When, if ever, is resistance to changes induced by climate and land use change futile? Is that even possible given existing laws and regulations? What realistic management options are there (e.g., different management objectives; novel management practices) when managers are faced with situations of substantial ecosystem transition and transformation?

Opportunity: Explore ways to incorporate traditional knowledge concepts to assign meanings and values to resources. Explore ways to incorporate these values and understandings into adaptation decisions.

Opportunity: Develop methods to assess and measure the social acceptability of novel ecosystem, habitat, and species outcomes.

Opportunity: Develop methods for defining climate adaptation objectives that account for the practical challenges described above.

Goal: Improve partner understanding of the portfolio of potential adaptation actions available to managers in the Southeast.

Identifying potential adaptation actions is a key step in making adaptation decisions. At minimum, there should be enough adaptation actions under consideration to potentially achieve all the desired management objectives. SE CASC will work closely with partners and researchers active in the decision sciences to identify and utilize the most appropriate tools and methods to assist those making adaptation decisions understand and define potential adaptation actions.

Opportunity: Develop “state of the science” summaries of potential adaptation actions associated with managing resources important to SE CASC partners.

Opportunity: Improve practical capacity of SE CASC partners to define and assess resource management-oriented adaptation actions in one or more pilot Landscape Conservation Design projects, specifically in the context of the Southeast Conservation Adaptation Strategy.

Goal: Improve partner understanding and use of tools for assessing competing adaptation options.

Scientists and managers at partner agencies in the Southeast have expressed interest in developing a better understanding of approaches for assessing the impacts of potential adaptation actions on accomplishing agency management objectives. SE CASC will work closely with partners and researchers active in the decision sciences to identify and utilize the most appropriate tools and methods to assist those making adaptation decisions understand the impact of potential adaptation actions on desired objectives and outcomes, and approaches to select one or more actions from a larger suite of adaptation options.

Opportunity: Convene working group to identify Robust Decision Making tools when there are multiple decision makers with different values, decision time horizons, and risk perceptions, especially in situations with limited and highly uncertain information and dynamic objectives. Discuss where the greatest return is for SE CASC involvement, including what the appropriate niche for SE CASC involvement with decision making under uncertainty.

Opportunity: Pilot a project in consultation with the FWS and state fish and wildlife the assessment of the impacts of a suite of different adaptation actions associated with a specific adaptation decision problem in one or more Landscape Conservation Design projects, specifically in the context of the Southeast Conservation Adaptation Strategy (see below).

Opportunity: SE CASC support for a 2-3 year PhD level position as climate and land use change adaptation decision extension specialist, to assist specific SE CASC partners frame and make progress on specific adaptation problems.

Goal: Work with partners to define an ongoing research and implementation strategy for the Southeast Conservation Adaptation Strategy.

Dramatic changes sweeping the Southeastern United States — urbanization, competition for water resources, extreme weather events, sea-level rise, and climate change — pose unprecedented challenges for sustaining the natural and cultural resources that are the heritage and future of the people of the Southeast. However, these changes also present a clear opportunity to unite the conservation community around a shared, long-term vision for the future. The Southeast Conservation Adaptation Strategy (SECAS) provides a process leading to this conservation vision (<http://secassoutheast.org/>). Together, public and private organizations are coordinating their conservation actions and investments to focus on identifying common goals and a way forward to accomplish these goals. SE CASC will continue to work with SECAS partners, helping to convene conversations and define and undertake investigations that contribute to accomplishing the SECAS vision.

Opportunity: Work with SECAS partners to elaborate the values-based objectives and measurable endpoints that will help frame SECAS activities.

Opportunity: Consider developing an intermediate scale SECAS-like Conservation Blueprint associated with a habitat of interest to adjoining states, seeking to protect a common set of SGCN. The Blueprint would indicate current high priority conservation lands necessary for supporting this habitat and would also indicate, at several points in the future, how/whether the location of high priority conservation lands would change as potential climate and land use change occur.

Opportunity: Develop a coordinated land use and climate change adaptation research agenda for one or more of the change-related stressors (such as hydrology, wildfire, salt water intrusion) and key resources (such as coastal marshes, grasslands, threatened and endangered species) in the Southeast that have been prioritized as part of SECAS.

Opportunity: Engage SE CASC partners to increase awareness about each other's existence, management values and challenges, and information needs, particularly as those needs concern resources that function and must be managed across jurisdictional boundaries and avoid duplication of efforts.

Opportunity: Identify and implement one or more projects that link local climate adaptation projects, Landscape Conservation Design, and the Southeast Conservation Adaptation Strategy, with a particular focus on developing comparable measures of outcome at each management to assess how local-scale conservation activities “add up” to create regional conservation benefits.

Goal: Prepare the next generation of scientists to better understand and address adaptation and resource management challenges.

Training for students and early career professionals is of core importance to the SE CASC mission. The next generation of natural and cultural resource scientists and managers need multi-disciplinary training to understand and address immediate and longer-term adaptation challenges. SE CASC will work with partners to develop and deliver educational programs in climate and land use change science, decision analysis, and science communication to students and professionals interested in adaptation.

Opportunity: Provide education, mentoring, professional development, and training for students and early career researchers.

Opportunity: Through the University host agreement and through involvement in SE CASC-funded research projects, provide financial support for graduate students who have research interests connected to SE CASC mission.

Opportunity: Improve graduate student and agency professionals understanding of climate and land use change processes through formal and informal training.

Opportunity: Improve graduate student and agency professionals understanding of resource management and adaptation methods through formal and informal training in decision science and decision analytics.

Opportunity: Improve graduate student understanding of resource management challenges by connecting students to partnering scientists and managers for internships and joint projects.

Goal: Build the capacity of professional natural resource managers to access and use climate and land use change science.

Natural resource professionals may find the volume of information available about environmental change and associated stressors overwhelming and difficult to assimilate into the day-to-day business of their organizations. SE CASC will work with partners to identify the value of extension programs, communities of practice, and continuing education in increasing partner's ability to make use of science information and also to implement activities in these areas.

Opportunity: Identify regional networks to build and support "communities of practice" around climate adaptation for fish, wildlife, and conservation managers and researchers.

Opportunity: Provide and promote CASC staff and partner experts to support ad hoc and project-level technical support.

Opportunity: Train partners to use decision sciences-based tools to identify the specific forms of information that will best support their adaptation decision making.

Opportunity: Connect fish, wildlife, and habitat managers with training and education opportunities that address their priorities.

Opportunity: Collaborate with tribal nations and indigenous communities to identify their challenges for adaptation and connect them with appropriate training and expertise.

Opportunity: Identify and realize opportunities for University consortium student internships to support student learning and support agency adaptation capacity needs. Because many partners, including management agencies and tribal nations, need staff capacity to work on projects, it should be possible to identify practical learning opportunities for students that will make a substantive contribution to conservation management agencies.

Goal: Improve understanding of communication needs for all stages of co-produced actionable science.

SE CASC intends to understand and respond to information needs at all stages of the co-production process with usable, useful products and tools. We work with our partners to ensure that our communication products, including publications, syntheses, tools, and trainings, meet the needs of resource managers. We provide access to information, such as comprehensive websites, newsletters, and social media and support training and other opportunities to increase knowledge and use of communications best practices. SE CASC will support researchers and managers to promote appropriate, effective communication throughout their project's life cycles.

Opportunity: Require all projects funded by SE CASC to include engagement plans. These will define a clear plan of activities for communication, engagement, and collaboration between research and management teams at all stages of a research project.

Opportunity: Support the implementation of engagement plans through training or assistance in communication activities, such as fostering broad participation of potential stakeholders in determining project objectives and developing communications approaches and products appropriate at each of the co-production stages.

Opportunity: Support information exchange and foster professional networks of scientists and managers. Knowledge sharing between scientists and managers is essential to successful adaptation.

Opportunity: Provide decision support and technical assistance to advance the integration of new information in resource management.

Opportunity: Conduct activities that package information in usable forms (such as synthesis of data, state of the science reports, and tool development) that enable partners to utilize information about exposure to change processes, associated stressors, and impacts on resources.

Opportunity: Contribute to annual regional mission-focused symposia to help connect adaptation researchers and resource management community.

Appendix B: Detailed SE CASC Operational Principles

Nine principles will guide SE CASC activities addressing these partner priorities. Together these principles suggest important expectations that SE CASC partners, including the Advisory Committee, should have regarding how the SE CASC operates.

1. Resource management priorities drive SE CASC science activities.

The most efficient way to ensure that SE CASC-sponsored science is relevant to natural and cultural resource management priorities is to solicit those priorities from our partners. Through deliberate processes (conversations between SE CASC partners, NCSU and USGS scientists, polls of SE CASC resource management partners, and listening sessions), SE CASC has identified three partner priorities for 2018-2023, identified strategic goals for addressing each priority, and identified key science opportunities for accomplishing each goal.

2. Resources are biocultural, derived from interacting natural and human systems.

Biocultural resources —diverse populations of plants, animal, fish, and wildlife, thriving agriculture and economic opportunities, human settlements, and diverse recreational opportunities— are place-based resources that help define and support the identity of the land and peoples of the Southeast. They have made the Southeast a special place to live for thousands of years. These resources will be affected directly and indirectly by climate and land use change processes, both natural (e.g. drought) and human (e.g., globalization, carbon dioxide emissions, migration).

3. SE CASC science should be actionable, co-produced and useful.

At heart, the SE CASC mission is science-focused and this science should be actionable, co-produced, and useful. Co-produced, actionable science embodies intentional processes in which scientists, stakeholders and decision makers work collaboratively to develop research via joint consideration of the social, ecological, and political contexts of a climate adaptation problem that ideally results in improved adaptation decisions (Enquist and others, 2017). SE CASC partners should expect that SE CASC supported science is:

- actionable, intended to ultimately support adaptation actions, either directly or to assist managers and partners to better understand the field of potential adaptation actions;
- co-produced at all stages of the scientific endeavor, with partners who use science to make and implement policy and resource management decisions (Meadow and others, 2015); and,
- useful, in several senses (Forester, 1989; Cash and others, 2006b; Enquist and others, 2017; Wall and others, 2017). SE CASC science should be seen as comprehensible at all stages of the co-production process (framed in terms that all parties understand to do the work they need to do at that stage), trustworthy or credible (derived from trusted and authoritative sources), legitimate (information is perceived to be free from systematic misrepresentation, political manipulation, and hidden bias), and salient (relevant to a particular decision making context, including being produced in a timely manner at an appropriate scale (Lemos and Morehouse, 2005)). It is important to note that the absence of one of these characteristics cannot be offset by an overabundance of one of the others; all must be present in a balance that may be unique to any individual problem (Wall and others, 2017).

4. SE CASC co-produced actionable science should acknowledge the “wicked” nature of most adaptation problems.

Adaptation decisions arise from a combination of: identifying values-based decision objectives and potential adaptation actions or strategies for accomplishing these objectives; assessing how well potential actions can accomplish the objectives and implementing one or more of these actions. While sounding straightforward, accomplishing these tasks is complicated by what might be thought of as “wicked problems” (Rittel and Webber, 1973; see Appendix C for additional guidance on SE CASC approaches to dealing with these challenges). Scientists and managers who construe adaptation problems as tame and overlook or ignore the complexities of the adaptation problem may do so at the peril of the eventual success of their adaptation efforts. SE CASC partners should expect that SE CASC supported projects will acknowledge and shed light on how to address these challenges for co-producing useful, actionable science:

- Many potential partners have an interest in climate adaptation problems. These partners may have heterogeneous values and points of view, and none of these points of view are objectively wrong.
- Adaptation stakeholder objectives can be viewed at multiple spatial, temporal, and governance scales; again, no scale is “wrong.”
- Two factors—the natural human tendency to continue walking down existing management paths (which might be thought of as a “sunk cost bias”) and institutional rigidity—may distort the assessment of whether further resistance to changing biophysical realities (such as investment of additional resources with the hope of accomplishing existing management objectives) makes less sense than changing the management objectives (that is, moving the goalpost, to reflect changing ecological realities). Natural and cultural resource managers in the Southeast will increasingly face the decision about when further resistance to global change processes is futile? In weighing this decision, they must confront the dilemma that acknowledging that resistance is futile may conflict with existing laws (e.g., ESA) and regulations.
- The available information needed to understand the potential impacts of climate and land use change on highly valued biocultural resources is complex, uncertain, and perhaps highly confusing or overwhelming.
- The outcomes of potential adaptation actions may be uncertain, and it may be difficult to develop anything close to consensus among partners about what actions might narrow the gap between current conditions and desired future condition of a highly valued biocultural resource.

5. SE CASC co-produced, actionable science depends on collaboration among partners.

SE CASC partnership activities are aimed at understanding and responding to high priority natural and cultural resource management challenges and fostering substantive, sustained engagement between partners, particularly natural and cultural resource managers and scientists whose work provides information needed by managers to address their adaptation responsibilities. Key SE CASC management partners include managers working for DOI bureaus such as the Fish and Wildlife Service and the National Park Service, managers that work for state agencies (such as wildlife agencies and state historic preservation agencies), and managers that work for tribal governments (such as environmental-natural resources and cultural-historic preservation departments). Researchers at the six member institutions comprising the SE CASC university consortium (NC State, University of Tennessee, Auburn University, University of Florida, University of South Carolina, and Duke), along with USGS researchers, are the primary science partners of SE CASC.

6. Successful SE CASC partnerships requires communication.

Communication is critical to the kind of collaboration on which co-produced actionable science is based (Enquist, 2017). Communication needs to be more than successful “messaging” at the back end of SE CASC science investigations. Co-production success depends on communication characterized by respect for different points of view and the use of communication strategies that elicit diverse perspectives in a manner that leads to mutual learning and growing trust (van Kerkhoff and Lebel, 2006; Enquist and others, 2017). SE CASC communication activities will focus on meeting partner communication needs at all stages of co-produced actionable science, including:

- effective communication among partners when resource management objectives are defined,
- development of effective, science-based communication products that address land use and climate change processes and their impacts, and
- effectiveness of potential adaptation decisions to protect resources and the services they provide.

7. Successful SE CASC partnerships requires capacity building.

The SE CASC will work to build the science capabilities of a community of researchers and managers, with a particular focus on making climate and land use-smart adaptation decisions. This includes training for both current professionals and graduate students who will become future natural resource professionals.

8. Successful SE CASC partnerships require coordination.

The Southeast Conservation Adaptation Strategy (SECAS) provides an important opportunity for many partners—state, federal, and tribal—to identify and act on behalf of shared or complementary management objectives, including Species Status Assessments (SSA), and State Wildlife Action Plans (SWAPS) for biocultural resources (e.g., species and habitats) whose ranges cross state lines, either under current climate and land use conditions or for plausible future land use and climate scenarios. The SE CASC will assist SECAS partners to identify and pursue opportunities to improve coordinated science activities, especially those associated with improved understanding of climate and land use change exposure and impacts, and approaches for adapting to these changes.

9. Success in addressing SE CASC partner priorities depends on collaborations between USGS and the NC State University consortium.

The NC State University consortium (which includes University of Tennessee, University of South Carolina, Auburn University, and University of Florida) provides ready access to scientific resources valuable for addressing DOI Secretarial priorities, including a readily available pool of talented graduate students and faculty; high performance computing; advanced media technology, and excellent library resources that allow us to co-produce trans-disciplinary science. The cooperative agreement between USGS and the consortium led by NCSU fosters the flexibility to explore novel and cutting-edge research and thought processes that respond to Secretarial priorities. NC State University is also able to connect partners with diverse and underrepresented populations. The university’s reputation as a trusted source of information allows SE CASC to engage with communities and partners that might be less accessible to government agencies working outside the university setting.

Appendix C: Challenges of “wicked” adaptation problems

Adaptation decisions arise from a combination of values-based decision objectives, potential adaptation actions or strategies for accomplishing these objectives, an assessment of how well potential actions can accomplish the objectives, and the choice and implementation of one or more of these actions. While sounding straightforward, accomplishing these tasks is complicated by real world challenges (Fig C1).

These challenges can be approached by decision-makers and scientists as either tame or wicked problems. In general, a tame definition of an adaptation decision problem will tend to simplify some of the characteristics of the problem, making the problem more tractable. On the other hand, recognizing some of the wicked dimensions of an adaptation problem, such as many stakeholders, with varying values, points of view, and power (or responsibility) to influence a decision, may “keep things real”, but probably at the cost of making an expeditious decision. Scientists and managers who construe adaptation problems as tame must balance the peril inherent in overlooking or ignoring the complexities of the adaptation problem, with the need to reach and implement adaptation decisions.

Several typical challenges associated with adaptation decisions are described below, along with ways that the problems might be understood and addressed as either tame or wicked problems. The intention is not to indicate that one approach or the other is preferable. Rather, it is to indicate that participants in a co-produced actionable science effort aimed at making an adaptation decision should be aware that there will be consequences for construing a problem as tame, wicked, or somewhere in between.



Figure C1. The values attached to biocultural resources resources in Puerto Rico may be defined from a variety of valid points of view; this heterogeneity is suggestive of some of the potential challenges of developing a climate and land use change adaptation strategy.

Challenge: Many stakeholders exist for most climate adaptation problems and they often have heterogeneous values and points of view and none of these are objectively wrong.

A decision-maker who construes this challenge as a tame problem might focus on a single important stakeholder, and frame an adaptation problem in terms of values, objectives, adaptation strategies, and outcomes that make sense to that single decision-maker. A more realistic assessment of the problem acknowledges that while there may, in fact, be a single decision maker, implementing a decision may be complicated by the reality that many people may have an interest in the decision, their values may diverge from those of the single decision-maker, and, from an objective standpoint, it is impossible to say that anyone's point of view is objectively wrong. And these diverse stakeholders may be motivated to obstruct the implementation of the single decision maker's decision.

Challenge: Some of these potential partners may feel that their opportunities to participate at any stage of the conservation planning process are limited: not having a place at the planning table in the first place; not feeling like they know enough to participate if they did have a place at the table.

In its simplest form, as with the case above, this challenge can be masked as a tame problem when the adaptation decision is viewed as solely the decision maker's responsibility. A somewhat more realistic assessment of the challenge is to open the decision-making process to public participation and input, which allows those that are willing and able to weigh in on the decision. But a public participation process may not solve the challenges faced (even partially created by) some potential partners, who for reasons ranging from limited time and expertise, to concluding from past experiences that they don't belong at the table in the first place, effectively remove themselves from sitting at the table. The wicked nature of climate adaptation problems may be enhanced by power differences among those with an interest in the decision.

Challenge: Objectives can be viewed at multiple spatial, temporal, and governance scales; again, no scale is "wrong."

One way to construe a complex, multi-scale climate and land use change management challenge as a tame problem is to define the problem from the spatial, temporal, and governance perspective of a single decision maker, such as an individual refuge or park manager (Fig C2). Such determinations may lead to an inappropriate choice of scale to frame the adaptation problem, such as defining the problem based on a scale relevant to the decision maker's objectives or sphere of influence, when these scales are not determinative of the population viability of a species. Effective problem framing, with careful consideration of the match between adaptation objectives and strategy alternatives, can help identify an effective decision scale at which to operate. For example, a management problem that is focused on population persistence of a migratory species should recognize that critical habitat conditions, including food and habitat availability at various life stages of an animal, can be targeted at many spatial, temporal, and governance scales. Conditions experienced by a population of animals during other phases of their life cycle (i.e., when they are residing or migrating at a location removed from the geography of any management unit) may negate even the best efforts of a manager at an individual management unit. In fact, a complex set of objectives associated many people and governments, mostly uncoordinated, along with biological and physical processes not under the immediate control of any manager, shape the realities faced by a migratory bird species during its life cycle. Therefore, achieving population-level objectives requires developing management actions at a scale much larger than available to a local land manager.

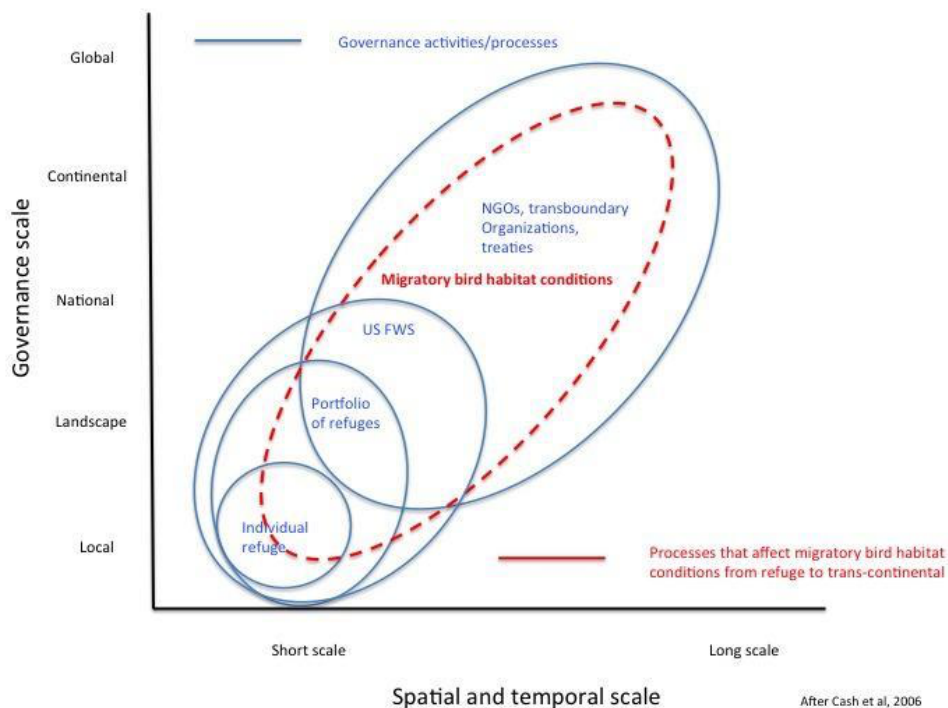


Figure C2. The condition of a migratory bird population is likely to be influenced by natural and socioeconomic processes that operate at many scales, most of which are outside the influence of managers of any individual management units, such as an individual refuge. (after Cash et al, 2006a)

Challenge: Two factors—the natural human tendency to continue walking down existing management paths (which might be thought of as a “sunk cost bias”) and institutional rigidity—may distort the assessment of existing management strategies in the face of changing biophysical realities. For example, continuing investment of additional resources with the hope of accomplishing existing management objectives may make less sense than refining the management objectives to reflect changing ecological realities.

Human nature and institutional inertia each contribute to a tendency to construe climate and land use change driven management problems as tame. Essentially, adaptation problem framing becomes constrained by a desire to continue to view and treat the management challenges as if these challenges were not evolving in a dynamic manner. A more realistic view on these challenges might be framed by beginning conversations focused by questions such as: when do we decide that further resistance to these changes is futile? When should we decide that it no longer makes sense to devote limited resources toward management objectives that may not be achievable under current or future conditions? Do federal and state laws and regulations even allow revising conservation objectives in the face of changing ecological realities; if so, who has the authority to modify an agency's mission or objectives? As with other wicked problems, there are no absolutely right or wrong answers to these questions, but the SE CASC is committed to fostering these conversations among our partners.

Challenge: The available information needed to understand the potential impacts of climate and land use change on highly valued biocultural resources may be complex, voluminous, and/or uncertain; for these reasons, the information may seem confusing or overwhelming.

This challenge can be masked as a tame problem when managers assume that current or future conditions can be perfectly understood; that is, when it is assumed that uncertainty in describing these conditions doesn't exist or is small enough to be assumed away. A more realistic perspective acknowledges that managers are confronted with a huge volume of science-based information about global change processes and impacts; this information is challenging to understand and assimilate, in part, because these characterizations and predictions have inherent uncertainty. Managers need assistance to understand, assimilate, and make use of available scientific information that could help them manage biocultural resources in the face of global change processes.

Challenge: An integrated portfolio of adaptation strategies may be needed in order to accomplish a set of partner objectives that truly reflect the complexity of the adaptation problem and multiplicity of interests and scales that can be in play. This is likely to complicate the identification and selection of a 'best way forward'.

This challenge can be masked as a tame problem when the adaptation decision focuses on a limited set of adaptation alternatives needed to accomplish a static, narrowly defined management objective, despite the reality that those interested in the outcome of the adaptation decision have many other objectives and may object to an adaptation decision that ignores what matters to them. A more realistic approach to identifying potential adaptation actions acknowledges existence of multiple objectives and considers a range of management options that at least theoretically could accomplish all the objectives. The practicality of actually implementing all these potential actions is less important at this stage than determining, in a transparent manner, what actions might be necessary to accomplish these objectives.

Challenge: Because the outcomes of potential adaptation actions are uncertain, it is difficult to develop anything close to consensus among partners about what actions might narrow the gap between what is and what ought to be in terms of the desired condition of a highly valued biocultural resource.

This challenge can be masked as a tame problem when the adaptation decision is framed as the responsibility of a single decision maker, and when the adaptation decision objectives, potential actions, and potential outcomes are framed in a way that simplifies reality, where future change conditions and their impacts can be known with relative certainty, as can the impacts of any management actions. A more realistic perspective acknowledges that uncertainty exists in characterizing the outcomes of global change processes, as well as in characterizing the impacts of these processes on biocultural resources of interest to managers. The adaptation reality is that managers must make adaptation decisions, and allocate resources, without complete or perfect information about the impacts of global change processes on the future state or condition of valued biocultural resources. SE CASC is committed to working with managers within the context of these adaptation realities.

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