Guidelines for Climate-Smart Invasive Species Management

Northeast Regional Invasive Species & Climate Change Management Network
Corresponding author: Eva M. Colberg (New York Invasive Species Research Institute, Department of Natural Resources & the Environment, Cornell University; emc343@cornell.edu)

Introduction:

Climate change and invasive species pose novel and combined challenges to ecosystem management and ecological restoration. Managers and decision-makers can address these challenges via climate-smart invasive species management, defined as any management strategy or action that considers and aims to reduce the interactive effects of climate change and invasions. To facilitate this approach in the Northeastern U.S. and Canada, members of the Northeast Regional Invasive Species & Climate Change Management Network (NE RISCC) have created a set of guidelines for how to consider and incorporate the interactive effects of climate change and invasions at multiple stages of management based on feedback from managers via surveys, formal research interviews, informal conversations, a workshop at the 2023 New York Invasive Species Expo, and an online workshop in April 2024. The focus of these guidelines is on the areas served by the NE RISCC, but can also serve as a starting point for climate-smart invasive species management efforts in other regions.

Our ultimate goal for these guidelines is to provide actionable options for climate-smart invasive species management from which practitioners can select and adapt ideas into their own planning and action. Some of these suggestions may already be standard practice in your own management, but by including them in this list, we explicitly call attention to them as part of ongoing efforts to make invasive species management more climate-smart (and as areas for continued funding and support). Given the wide variety of habitat types, focal species, and management priorities of different organizations and property owners in the Northeast, not all recommendations will be applicable in a given context. Furthermore, many options will require some investment of time, funding, or capacity, and further tailoring to fit your organization's values. We recognize that many barriers still limit the implementation of climate-smart strategies; to address these barriers, we also highlight areas where policy, funding, and research could further support and facilitate climate-smart invasive species management. Even when such barriers are addressed, considerable uncertainty may remain regarding the specific ways climate change and invasive species will interact in a given site and location. As such, climate-smart invasive species management will entail not only thinking about the future, but being flexible in the moment and learning by doing.

Suggested citation: E.M. Colberg, T.L. Morelli, & C.J. Brown-Lima. (10 May 2024). "Guidelines for Climate-Smart Invasive Species Management for the Northeast." NE RISCC Management Network.

Contents:

Our suggestions for climate-smart invasive species management are organized by stages of management. Managers and decision-makers may wish to focus on the stages most relevant to their own work, but still glance at other sections, as some suggestions may apply at multiple stages. Throughout this document, terms that may be confusing or require further explanation are defined in the glossary, and mentions of other sections or external sources link to those sections and resources.

Abbreviations used in this document:

CC = Climate change
EDRR = Early detection & rapid response
IS = Invasive species
NE CASC = Northeast Climate Adaptation Science Center
NYS = New York State
PRISM = Partnership for Regional Invasive Species Management
RISCC = Regional Invasive Species & Climate Change Management Network

Acknowledgments:

These guidelines would not exist without the contributions of the managers, practitioners, and decision-makers who participated in the various stages of data collection and feedback for this project, including members of the Northeast Regional Invasive Species and Climate Change Management Network. An extra thanks to the Northeast RISCC Leadership Team for their feedback, suggestions, and edits to this document's scope, content, and wording. Author E.M. Colberg's involvement was supported by the U.S. Geological Survey, Northeast Climate Adaptation Science Center (NE CASC) through Grant No. G21AC10648-02. Any use of trade, firm or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

1. Strategic planning

1.i. Strategic planning: Mission, values, & goals

Climate-smart invasive species management begins at the planning table, whether invasive species management is an organization's primary focus or just one of many tools used to meet broader management goals. By considering how climate change and invasive species can interact to impact management goals, managers can proactively plan for future conditions. Explicitly incorporating climate change (CC) and invasive species (IS) into organizational language can help ensure these interactions are routinely considered and acted upon. This consideration can be further bolstered by data on which IS and climate impacts are likely to occur in the area, whether in the form of regional climate-informed horizon scans and range-shifting species lists or more tailored vulnerability assessments done in partnership with researchers. Research and funding to facilitate assessment and streamline planning processes can help support these efforts, and can help ensure that planning supports rather than diverts time and resources from implementation.

Options for climate-smart invasive species management:
Mission, values, & goals

a. Explicitly address the impacts of IS and CC, as well as climate adaptation and mitigation, in organizational mission, goals, and strategic plans.
    i. Consider including ecosystem services that contribute to climate adaptation and mitigation in management goals.
    ii. Consider setting CC resilience as a management goal.
b. Consider potential impacts of CC and IS on reference ecosystems, target native species, and management goals.
    i. Assess the vulnerability of target species and ecosystems to CC and IS.
    ii. Understand and act to reduce co-occurring stressors (Section 3a) that may interact with and compound the effects of CC and IS.
c. Incorporate predicted CC impacts on IS range shifts when selecting watchlist species for early detection and rapid response (EDRR).
d. Conduct regular inventory of which species (native and non-native) are present, and where, to facilitate planning.
    i. Knowing the location and population size of current species on your organization's property can facilitate climate-smart planning and preventative action.
e. Prioritize and incentivize adaptive management and monitoring.
f. Simplify processes to focus on implementation (to avoid over-planning).

1.ii. Strategic planning: Budgets & hiring

Unforeseen or unaccounted-for impacts of CC and IS may create new or unexpected strains on management budgets. These can include extreme climate events diverting resources, changes in IS phenology requiring extending seasonal staff contracts or relying upon additional contractors, and climate-driven changes in treatment efficacy and feasibility requiring additional inputs or rounds of treatment to achieve management goals. As treatment efficacy and feasibility shift with CC, an experimental approach where multiple strategies are implemented and evaluated can inform best practices. Partnerships with researchers and boundary-spanning organizations can assist agencies and organizations that lack capacity for experimental and adaptive approaches. When thinking about staff positions and hiring, CC-driven shifts in phenology and seasonal events may conflict with current timelines (also see Section 1.iii). Proactive hiring and even creating new positions dedicated to aspects of climate-smart invasive species management can allow managers to better adapt timelines. Although CC and IS may interact to complicate management, these interactions may also open new avenues of funding for IS management through climate adaptation funds.

Options for climate-smart invasive species management: Budgets & hiring

a. Rethink budgets to account for known and potential IS and CC impacts.
    i. Dedicate more time/resources to monitoring and adaptive management, with the understanding that the season for monitoring will likely expand.
    ii. Ensure budgets and timelines include time to evaluate success and adapt plans.
    iii. Budget for more frequent and/or alternative treatments and approaches.
    iv. Bet-hedging: consider implementing multiple strategies at once to evaluate effectiveness and inform the best way forward. Many strategies will fail.
    v. Budget for increased early detection and rapid response (EDRR).
        - Create dedicated EDRR positions (also see Section 2).
    vi. Allow for flexibility in budgets such as dedicated climate adaptation "slush funds" across fiscal years to address changing timelines and variable treatment schedules.
b. Rethink and adjust hiring timelines to maximize windows of opportunity.
    i. Shift seasonal and contract-hire timelines to account for extended growing seasons.
    ii. Prepare for seasonal staff shortages.
        - Leverage volunteers, school groups, or contractors when possible.
        - Consider investing in trainings and insurance plans that allow skilled volunteers to conduct more specialized tasks.
c. Apply for climate adaptation funding sources to support climate-smart IS management.

1.iii. Strategic planning: Schedules & timelines

Climate change can impact invasive species management by disrupting and shifting management timelines, requiring quick decisions and often reprioritization of management activities. Changes in phenology and weather may require shifting schedules, which may not always be compatible with funding timelines or personnel availability. Climate-smart invasive species management will be flexible and proactive in adapting to these changes, but flexibility is often limited by external barriers such as funding timelines, seasonal staff availability, and bureaucratic hurdles. Policy and funding to increase flexibility, as well as more real-time data on species phenology and research on treatment efficacy under novel climate conditions, could all increase managers' ability to adapt to the shifting timelines of invasive species management in a changing climate.

Options for climate-smart invasive species management:
Schedules & timelines

a. Prepare for changing timing of phenological and seasonal events.
    i. Schedule staff and volunteer trainings earlier in the season to account for shifting seasons.
    ii. When possible, include contingency dates in permit applications to enable flexibility.
    iii. Plan for more frequent treatments in priority areas.
b. Include IS management in extreme event response plans.
    i. Involve local partners and stakeholders.
    ii. Include and fund post-event EDRR & restoration, particularly for riparian areas.
    iii. Identify suppliers for post-event proactive plantings.

2. Preventative action

Although proactive and preventative management of potential future invasions is a smart invasive management strategy regardless of climate change, the majority of invasive species management remains reactive (Beaury et al., 2020, *Biological Invasions*). When considering the potential for climate-driven range-shifting invasive species, however, the need for preventative action becomes even more imperative. As such, we include several general strategies to prevent the spread of invasive species as part of our climate-smart preventive actions, which may be the easiest to implement. Preventative action can also be important for preparing the ways in which extreme climate events may facilitate IS spread and establishment. However, some suggestions will require further research support and more specific guidelines for implementation at local scales. In particular, the appropriateness and feasibility of actions such as planting for resilience and function may vary widely with habitat and context, but can nonetheless be effective measures in the appropriate context.

Options for climate-smart invasive species management:
Preventative action

a. Prevent unnecessary disturbance.
    i. Confine and consolidate new construction to existing disturbed sites to prevent creating conditions ideal for invasive establishment.
b. Require staff and contractors to clean equipment before leaving a site.
c. Engage in early detection and rapid response (EDRR), especially of species predicted to benefit and spread with climate change.
    i. Consult climate projections to inform species watchlists for EDRR monitoring and action.
    ii. Monitor & target potential sleeper species populations, especially in sensitive areas.
    iii. Stay abreast of U.S. national EDRR framework developments.
d. Plan for potential interactions of extreme climate events and IS.
    i. Incorporate invasive management into extreme event preparedness plans.
    ii. Preemptively plant native species in vulnerable areas to control erosion.
    iii. Identify and build relationships with sources for native and cover crop seed/plant stock for post-disturbance plantings.

3. Treatment & control

For invasive species already present in an area, climate change may affect the efficacy and feasibility of treatment and control options through impacts on chemical uptake, plant response, phenological timing, biocontrol life cycles, and more. In many cases, the ability to account for and accommodate these changes will depend upon decisions during the strategic planning stage of management, thus many of the recommendations here will resemble those in Section 1. Adaptive management techniques, including adjusting methods based on prior years' outcomes and experimenting with multiple approaches, can help in some cases, but in other cases, new techniques may take priority. Employing multiple management options alongside ongoing monitoring and regular adaptation can help address uncertainty in how new conditions may interact with current and alternative treatment approaches.

Options for climate-smart invasive species management:
Treatment & control

a. Beware of potential shifts in treatment efficacy and feasibility.
    i. Evaluate success and practice adaptive management.
    ii. Consider increasing treatment frequency, or trying alternative treatments and approaches.
    iii. Learn by doing, but do so intentionally: Consider implementing multiple strategies at once to evaluate effectiveness and inform the best way forward.
b. Monitor for changes in treatment efficacy and practice adaptive management.
    i. Document phenology and compare to previous years.
    ii. Record weather conditions during treatment.
    iii. Monitor for target outcomes and non-target outcomes.
    iv. Consider combining and adjusting treatments.
c. Consider follow-up with planting after invasive removal.
    i. Practice climate-smart native planting (Section 4.c.).
    ii. Consider cover crops to prevent invasion and erosion in vulnerable sites.
        - Use short-lived annual seed mixes mixed with perennial ground covers (but avoid mixes containing known or potential invasive species).
d. Budget for increased early detection and rapid response (EDRR).
    i. Create dedicated EDRR positions (also see Section 2.c.).
e. Minimize soil disturbance.
    i. Minimize off-trail access and trampling.
    ii. Limit heavy equipment.
    iii. Leave dead wood (rather than moving or removing it).

4. Complementary management

Just as invasive species management is often part of a broader range of techniques used to reach a given management or restoration goal, multiple complementary techniques can contribute to reducing the interactive effects of climate change and invasive species. Although these methods may not directly target IS, they can still be considered part of climate-smart invasive species management by reducing co-occurring stressors, boosting native resilience, and reducing the invasibility of existing ecosystems.

Options for climate-smart invasive species management:
Complementary management

a. Understand and act to reduce co-occurring stressors, such as:
    i. Overabundant ungulates:
        - Control deer populations where possible.
        - Fence vulnerable sites.
    ii. Hydrology:
        - For sites where drainage is routinely an issue, expand culverts and fix drainage routes.
        - Plant functional native communities for wave absorption and erosion control.
    iii. Soil disturbance and compaction (See Section 3.e).
    iv. Extreme events (See Section 2.d).
    v. Human disturbance (including forestry, agriculture, and land use change):
        - Communicate with construction teams, development projects, and contractors to minimize soil disturbance and transport of invasive species on equipment.
b. Boost native resilience to climate stress and invasion (when applicable), such as via:
    i. Climate-smart forestry techniques.
    ii. Soil amendments and/or inocula.
    iii. Hydrology manipulation.
c. Practice climate-smart restoration as a way to reduce invasibility where appropriate.
    i. Reconsider restrictions on seed sourcing (local is not always better).
    ii. Include species predicted to perform well with climate change when planting.
    iii. Consider assisting migration of species or genotypes.

5. Education & outreach

Public opinion has the power to help or hinder many aspects of climate-smart invasive management. Volunteers and community scientists can help alleviate some of the funding and personnel limitations of on-the-ground management and data collection, and may gain a greater sense of connection and investment. Enthusiastic volunteers may also advocate for and support climate-smart invasive species management in their own communities and governments. Conversely, inaccurate public perceptions of many of the tools and aims of natural resource management can hinder effective management. For example, herbicide can be an important tool for climate-smart invasive species management in the hands of knowledgeable applicators, but public conflation of agricultural and horticultural chemical use with chemicals for invasive species management may lead to community-driven chemical bans that force managers to rely upon costlier and less effective non-chemical options.

Options for climate-smart invasive species management:
Education & outreach

a. Include CC in IS outreach and education efforts.
    i. *Example resources:*
        - RISCC resources
        - NE CASC outreach materials
        - NYS Climate Impacts Assessment
b. Incorporate information on co-occurring stressors (see Section 2) in outreach, particularly where public opinion might run counter to effective management.
c. Clearly communicate management goals in outreach, and reasoning behind the tools used to reach those goals (whether chemical or otherwise).
d. Provide native and climate-smart alternatives to common invasive species used in horticulture and ornamental trades.
e. Encourage and provide staff with opportunities to learn about the interactions of CC and IS.
f. Utilize community science to track invasive phenology and spread in a changing climate.
    i. *Example resources:*
        - National Phenology Network
        - iMapInvasives (currently available for AZ, ME, NY, OR, PA, SK, and Maritimes)
g. Communicate with managers in neighboring (especially southern) areas about the species they manage and monitor.

Options for climate-smart invasive species management:
Education & outreach

h. Participate in regional/sub-regional hubs for resource-sharing and targeted action, such as the NE RISCC and PRISMs.
i. Coordinate species watchlists and regulations across borders.
j. Collaborate with renewable energy projects and the horticulture industry to mediate novel introduction pathways (also see recommendations in Section 2).
k. Share your successes and failures in attempting climate-smart invasive species management to help colleagues and neighbors learn from your experiences.

6. Supporting policy, funding, and research

Many of the aforementioned climate-smart invasive species management options may be difficult if not impossible without accompanying changes in policy and funding. In some cases, these changes may need to address areas where restrictive or slow policy and a lack of funding hinder climate-smart invasive species management action, and in other cases, these changes may suggest areas where policy and more flexible funding timelines could better slow the spread of invasive species and reduce the impacts of climate change. Knowledge gaps may further prevent climate-smart invasive species management, but research and boundary-spanning can address these gaps by both creating new knowledge, facilitating access to existing knowledge, and ensuring that future research meets the needs of managers. To acknowledge these limitations, we suggest possibilities for how policy, funding, and research (including boundary-spanning) entities could support climate-smart invasive species management, although feasibility and priority will differ among states, agencies, and organizations.

Policy options to support climate-smart invasive species management

a. Include IS management in climate adaptation policy and planning.
b. Ensure permits facilitate and support flexible and adaptive management.
    - Incorporate backup dates or swift turnaround of chemical and prescribed burn permits to allow flexibility in the case of unsuitable conditions.
    - Provide expedited permit approval options for IS management and prevention after extreme climate events.
    - Ground chemical regulations and restrictions in scientific evidence.
c. Incorporate CC and IS into trade and development regulations.
    - Proactively regulate the sale of predicted range-shifting IS, potential sleeper species, and nuisance neonatives.
    - Coordinate trade regulations across borders, particularly to prevent the spread of climate-facilitated novel invaders and novel range-matching species.
    - Coordinate with neighboring states/countries to share resources and information for risk assessment and regulation.
    - Regulate and monitor pathways of IS spread (e.g., cargo ships, trains, trucking routes), especially between climate-matched or future climate-matched areas.
    - Require consideration of the joint effects of CC and IS in development projects, including potential spread and facilitation of invasions.
    - Require contractors to clean equipment, monitor and treat invasions after infrastructure projects.
d. Facilitate complementary management actions, including control of ungulate herbivores.

Funding options to support climate-smart invasive species management

a. Adjust and allow more flexibility in funding timelines and applications.
    - Understand that unpredictable events and variable phenologies may lead to between-year differences in budgets.
    - Provide expedited funding options for IS management and prevention after extreme events.
    - Adjust timelines of funding applications and availability to allow earlier start and later end dates for seasonal staff.
    - Facilitate the use of contractors during seasonal staff shortages.
        - Allow use of funds for contract hires.
        - Create guidelines for contractor hiring.
        - Adjust current and write future MOUs and policy to allow contractors to bridge seasonal staff shortages.
    - Facilitate use of emergency response funds for IS management.
b. Fund climate-smart invasive species management and supporting actions, including:
    - Invasive species management and monitoring.
    - Regional and local IS horizon scans and climate vulnerability assessments.
    - Early detection and rapid response (EDRR) efforts, including but not limited to dedicated EDRR staff and teams, horizon-scanning research, and tools to facilitate EDRR.
    - Novel treatment methods and adaptive management.
    - Climate-smart restoration efforts.
    - Community science platforms that can facilitate better tracking of shifting phenology and ranges.
    - Efforts to bolster and connect native plant suppliers with invasive species managers.
c. Fund knowledge-sharing about CC and IS.
    - Provide funding for IS managers to attend workshops and conferences about CC.
    - Provide IS managers access to CC journals and publications.

Research & boundary-spanning options to support climate-smart invasive species management

a. Fill knowledge gaps around the interactive effects of CC and IS.
    - Include CC impacts in IS horizon scans and risk assessments and provide results at local scales.
    - Include IS impacts in climate vulnerability assessments.
    - Investigate climate-smart restoration methods and impacts on IS.
    - Facilitate use of community science platforms for better tracking of shifting phenology and ranges.
    - Consider future climate conditions and during IS treatment trials (whether chemical, biocontrol or mechanical).
    - Recommend metrics and methods to assess and evaluate IS treatment efficacy in a changing climate.
b. Facilitate communication to support climate-smart invasive species management across jurisdictional borders.
    - Facilitate meetings between managers in different jurisdictions to discuss range-shifting IS of concern.
    - Facilitate communication about chemical permitting requirements across state borders.
    - Create (where nonexistent) or join (where already established) regional/sub-regional hubs for resource-sharing and targeted action, such as the NE RISCC and PRISMs.
c. Connect potential collaborators and facilitate connections that support climate-smart invasive species management.
    - Connect management organizations to potential contractors.
    - Connect native plant suppliers with invasive species managers.
    - Facilitate data-sharing between organizations.
d. Provide IS managers access to CC journals and publications.

7. Glossary of terms

We define potentially confusing or ambiguous terms used in this document to aid its use and provide links to resources for further learning where appropriate.

Term	Definition
Adaptation, climate adaptation	The process of changing to better address the impacts of climate change. **Learn more:** Northeast Climate Adaptation Science Center.
Adaptive management	A process of learning by (and from) doing by integrating assessment into the management process.
Assisted migration	Facilitating the spread or movement of a species or genetic material into new areas of future climate suitability by planting or translocating outside its native range. Related terms include managed relocation. **Learn more:** NE RISCC Research Summaries on Climate-smart restoration and assisted migration.
Biocontrol	Also known as biocontrol; the use of one species (such as a predator, parasitoid, or pathogen) to limit the population or impact of another (usually invasive) species. **Learn more:** "Out of control?" NE RISCC Management Challenge.
Climate-smart invasive species management	Any management goal-setting, planning, or implementation that considers and aims to reduce the interactive effects of climate change and invasions.
Climate-smart restoration	Assisting and facilitating ecosystem recovery and resilience in present and future conditions. **Learn more:** NE RISCC Research Summaries on Climate-smart restoration and assisted migration.
Co-occurring stressors	The presence of more than one type of disturbance or other factor that impacts native fitness. Co-occurring stressors beyond CC and IS can include overabundant ungulates and human-derived disturbances.
Early detection & rapid response (EDRR)	A framework to minimize invasive species impacts through observing, documenting, and identifying an invasive species early in its invasion, and then swiftly taking action. **Learn more:** Reaser et al., 2020, *Biological Invasions*.

Term	Definition
Extreme climate events	Extreme weather and climate events influenced by climate change, including heavy precipitation and flooding, drought, and temperature extremes. **Learn more:** IPCC Sixth Assessment Report Chapter 11: Weather and Climate Extreme Events in a Changing Climate.
Horizon scan	The process of considering possible future risks; in relation to IS, horizon scans aim to identify species with high likelihood of establishment and impact in a given area.
Invasibility	The extent to which an ecosystem can be invaded by invasive species due to favorable conditions.
Invasive species	Established, non-native species with negative ecological consequences. **Learn more:** IPBES Invasive Alien Species Assessment Summary for Policymakers.
Mitigation, climate mitigation	Reducing the amount of greenhouse gasses in the atmosphere by reducing emissions or increasing carbon capture and storage.
Nuisance neonatives	Species whose ranges are shifting with CC and that pose negative impacts in their novel ranges. **Learn more:** "Nuisance neonatives" NE RISCC Management Challenge.
Phenology	The study of the timing of biological life cycles. Can also refer to the timing of biological events, especially in relation to other biological or seasonal events. **Learn more:** National Phenology Network.
Range-shifting invasive species	Species for which climate change is impacting the extent and spread of their invasive ranges. **Learn more:** "Prioritizing range-shifting invasive plants" NE RISCC Management Challenge.
Resilience	The "ability [of an ecosystem] to experience disturbances or environmental change without changing to a fundamentally different state" [Holling, 1973]. **Learn more:** "Embracing the Future" NE RISCC Management Challenge.

Term	Definition
Risk assessment	In relation to IS, the process of evaluating species for likelihood of being invasive and potential impacts.
Sleeper species	Naturalized but not yet invasive species whose impacts are currently limited by biotic or abiotic conditions, but for which may become newly invasive as CC increases population growth and impacts. **Learn more:** "Are you sleeping? Are you sleeping?" NE RISCC Management Challenge & "Preparing for sleeper species" NE RISCC Management Challenge.
Vulnerability assessment	Climate change vulnerability assessments use climate projections to predict which habitats and species will be most susceptible to the impacts of CC in a given area.
Watchlist	A list of invasive species to monitor and prepare for due to potential to spread into and establish in an area. Species on a watchlist may be further ranked by impact and feasibility of control.