

JULY 2023



Practitioner Survey Report



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Key Findings

The North Central Regional Invasive Species and Climate Change (NC RISCC) network includes >100 members working at the nexus of climate change and invasive species. In late 2021, the NC RISCC leadership team surveyed regional practitioners working on issues related to invasive species management to understand their priorities and practices. Survey participants represented a variety of entities, with the most representation from: county government, academia/universities, federal government, non-governmental organizations (NGOs), and state government. They also represented all seven states in the NC region: CO, WY, MT, ND, SD, KS, and NE. Key findings include:

- Many practitioners in the NC RISCC network report having at least a moderate understanding of the interactions between climate change and invasive species and sometimes integrate climate change information into their invasive species management work. Major barriers to incorporation of climate change information into invasive species management include time, funding, and capacity.
- Practitioners spend most of their time on current invasive species (as opposed to future potential invasive species), which is reflected in the common species of interest.
- Practitioners rank native community resilience, environmental degradation, and range shifting species (researchers) or agricultural production (managers) as top priorities for invasive species management and research in a changing climate.
- Practitioners tend to use different scientific products depending on whether they are primarily a researcher or a manager, but both groups regularly use scientific literature.

Keywords

Invasive species; climate change; stakeholder engagement; resource management; native community resilience

Introduction

Natural resource practitioners consistently identify invasive species as one of the biggest challenges for ecological adaptation to climate change ([Buckley and Catford 2016](#), [Ernest Johnson 2020](#)). Yet managers report only sometimes considering climate change in their management activities ([Beaury et al. 2020](#)). Given the many ways that invasive species and climate change interact, such as facilitating more frequent fire and altering the distributions of high priority species ([Fusco et al. 2019](#); [Allen and Bradley 2016](#)), it is more critical than ever to integrate adaptation science and management for invasive species.

Previous surveys suggest that the coupling of climate adaptation and invasive species management remains limited by a lack of information, personnel, and funding ([Beaury et al. 2020](#), [NW RISCC 2021](#)). Those working on ecological adaptation to climate change have reported that information is not available or is not presented in a way that informs invasive species management ([Archie et al. 2012](#), [Archie et al. 2014](#), [Peters et al. 2018](#)).

In 2021, the North Central Regional Invasive Species and Climate Change (NC RISCC) Management Network was founded to bridge the gap between management and research communities to improve management of invasive species in a changing climate. The NC RISCC was formed based on the successful model of the [Northeast \(NE\) RISCC](#) (founded in 2016). In recent years a number of regional RISCCs have been formed (Table 1) and aim to address these same challenges, while focusing on key regional priorities (e.g., cheatgrass invasion and the prevalence of the grass-fire cycle in the North Central region).

Table 1: List of regional RISCC networks including hosting organizations and links to regional RISCC websites.

Region	Hosting Organizations
NC RISCC	NC Climate Adaptation Science Center, University of Colorado Boulder
NE RISCC	NE Climate Adaptation Science Center, University of Massachusetts Amherst, USGS, Cornell University, New York Invasive Species Research Institute
NW RISCC	NW Climate Adaptation Science Center, US Fish and Wildlife Service
SE RISCC	SE Climate Adaptation Science Center, Center for Invasive Species and Ecosystem Health
Pacific RISCC	PI Climate Adaptation Science Center, USGS

In late 2021, we surveyed regional practitioners working on issues related to invasive species management to understand their priorities and practices (i.e., what they are doing about invasive species and climate change from either the research or management side). Our survey expands upon results from the NE ([Beaury et al. 2020](#)), Northwest (NW), and Pacific Islands (PI) RISCC networks' surveys by assessing practitioner and organizational knowledge and action in the North Central region. Results from this survey will allow the NC RISCC to better tailor its activities to serve the community.

The main objective of this report is to summarize the key management challenges and research priorities regarding the interactions between invasive species and climate change in the North Central region. In order to assess research gaps and management needs in the North Central region, we sent this survey to regional practitioners to assess:

- The degree to which they are thinking about and working in the nexus of climate change and invasive species
- Emerging practices and policies that may address the dual goals of reducing climate-related vulnerabilities and invasive species management efforts
- Needs, opportunities, and limitations faced by practitioners in the region.

Methods

Survey Design

This survey was based on similar surveys developed by the NE and NW RISCCs ([Beaury et al. 2020](#), [NW RISCC 2021](#)) and adapted for the NC region. For instance, while the NW RISCC asked participants questions regarding marine issues, the NC survey adapted these to more regionally-appropriate topics like the interaction of fire, climate, and invasive species. To measure differences in priorities among research and management communities, we designed two different versions of the NC RISCC survey, one for each group (Appendices A and B). After a series of demographic questions, participants were asked to self-identify which version (management or research) they felt was most appropriate for them to answer. Participants then answered questions related to invasive species management, climate change, and knowledge, products and services. Based on their self-selected identity (i.e., researcher or manager), participants were asked slightly different questions, although the sections remained the same and the themes of the questions were similar. For instance, while managers were asked “What are your invasive species *management* priorities?”, researchers were asked “What are your invasive species *research* priorities?”.

Full versions of each survey as they were distributed are available in Appendix A and Appendix B. Survey responses in this report are organized into the following categories: 1) practitioner demographics; 2) invasive species management and research; 3) integrating invasive species with climate change management/research; 4) knowledge, products, and services; and 5) optional questions.

Survey Administration

This survey was approved by the Internal Review Board at The University of Colorado Boulder (Protocol 21-0460) on 10/07/21. The survey was hosted through Qualtrics. Survey distribution began on 11/2/21, following a review process by the NC RISCC’s external advisory board and partners, and ended on 1/3/22. The potential participant list was generated in advance, in which the team identified hundreds of stakeholders and researchers who work for a

variety of organization types from local weed managers to regional invasive species councils. Emails were sent to >200 individual addresses and 3 listservs (NC RISCC, NE RISCC, NC Climate Adaptation Science Center). Potential participants that were emailed individually were sent a series of three emails over ~6 weeks, including one introductory email and two reminder emails with deadlines. Up to two emails were sent to the listservs, depending on the comfort level of the administrators.

Quality Control / Data Processing

There were a total of 69 usable and appropriate surveys (44 manager responses and 25 researcher responses). Of these 69, 7 surveys were incomplete but still contained usable information and were included in the analysis. Participants who stated they worked or studied exclusively outside of the North Central region (e.g., the Northeast, Northwest, Southwest, Midwest, or at the national scale) were included in the analysis (11/69 responses). After collection, the survey results were de-identified and given a randomly generated, anonymous ID number. The original survey results with identifying information is password protected. All analyses were completed on de-identified and cleaned documents.

Data Analysis

All data analysis was done in R version 4.2.1 (R Core Team, 2023).

Results

We analyzed 69 usable survey responses (44 manager responses and 25 researcher responses) to a series of 19-20 questions. The sample size for each question varies because: 1) some survey responses were incomplete, 2) respondents were able to select multiple answers for some questions, and 3) for multi-part questions, respondents were not required to answer all parts of a question. Sample sizes for each question are presented in figures or their captions.

1) Practitioner Demographics

Location

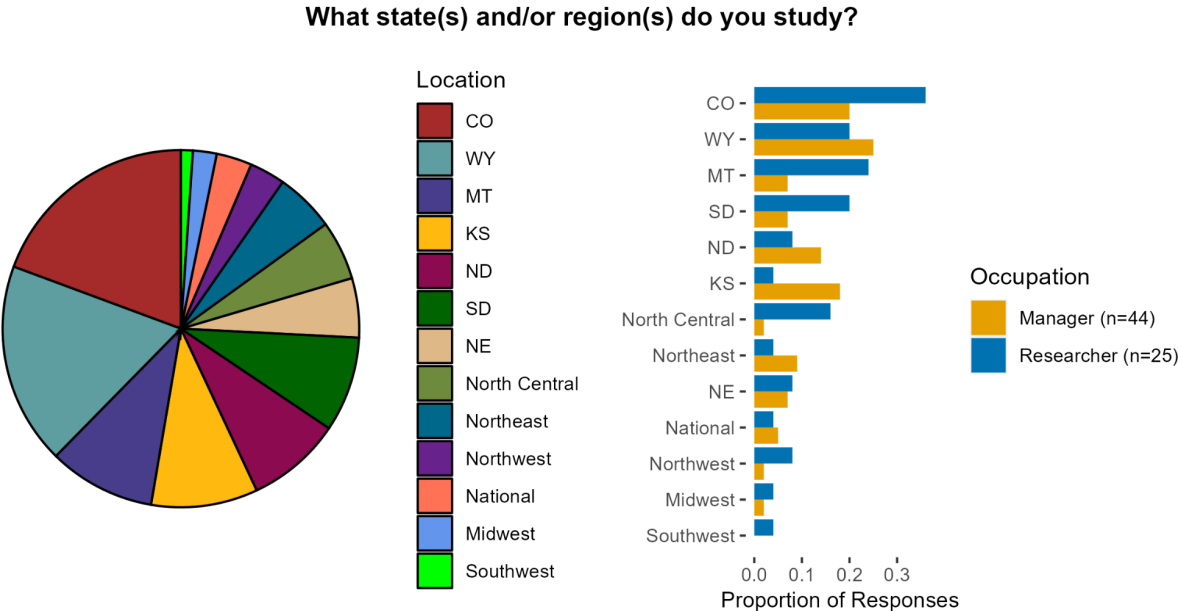


Figure 1: Location (region or state) that survey respondents (n = 69) work in. Participants were allowed to select multiple responses. “North Central” was a specific response that participants could select, and it is listed here as separate from individual North Central states.

Participants working in at least one North Central state made up 84.1% of respondents, while participants working exclusively in other regions (Midwest, Northwest, Southwest, Northeast, National) made up 15.9% of respondents (Figure 1). Two participants noted working in both the North Central and an adjacent region. The most common North Central states where respondents worked were Colorado (26.0%), Wyoming (24.6%), Montana (13.0%), and Kansas (13.0%). All North Central states were represented by at least 5 survey participants.

Employer Type

Please indicate the type of entity for which you work.

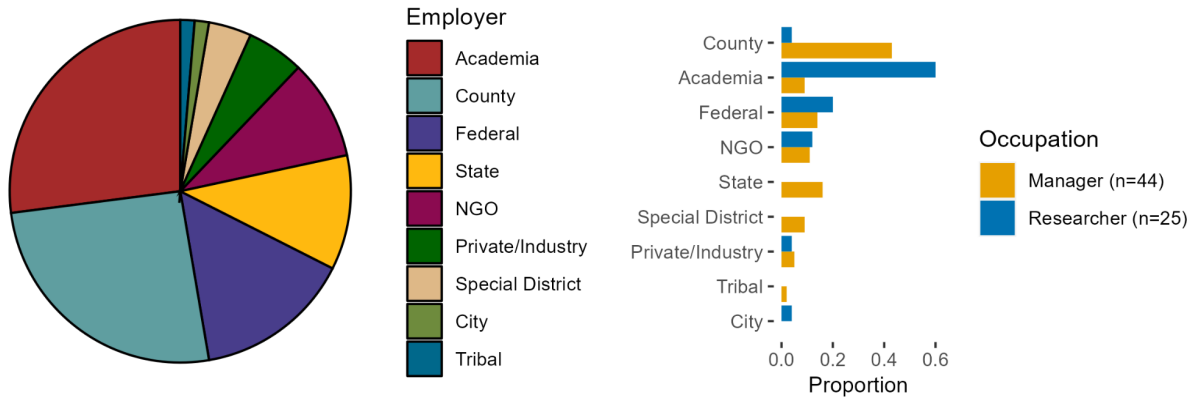


Figure 2: Employer categories of survey respondents (n = 69). Participants were allowed to select multiple responses.

County government (29.0%), academia/universities (27.5%), federal government (15.9%), non-governmental organizations (NGOs, 11.6%), and state government (10.1%) were the top five employers of participants (Figure 2). Our sample included many researchers from academic and federal agencies while managers primarily worked for county and state government. A few respondents selected “Other” and were employed by special districts, such as weed management districts or Partnerships for Regional Invasive Species Management (PRISMs).

Sector

Please indicate the primary sector in which you work.

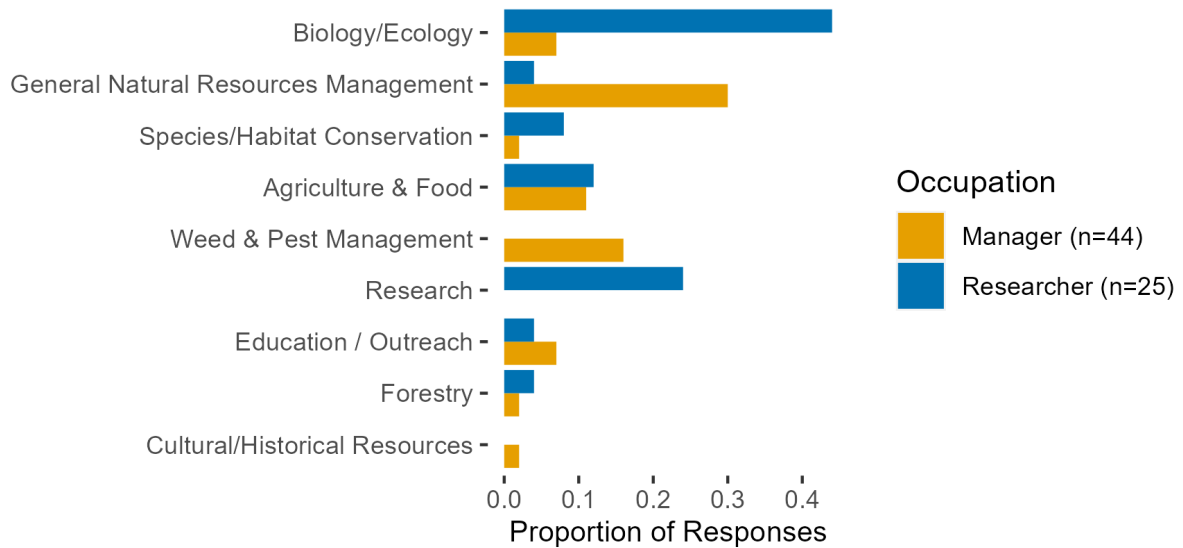


Figure 3: Primary sectors in which participants (n = 69) work. Participants were only allowed to select one response.

Biology/ecology (50.8%) and natural resources management (33.5%) were the most common sectors that participants worked in (Figure 3), with more researchers in biology/ecology and more managers in natural resources management. No respondents reported working in Commercial Fisheries/Aquaculture, Energy/Power Systems, General Environmental Quality Management, Public Health and Safety, Recreation/Tourism, Transportation, or Water Resources. All responses that were selected as “Other” were in the weed and/or pest management sector, and therefore Weed & Pest Management was created as a new category in Figure 3, though not included in the survey.

Role

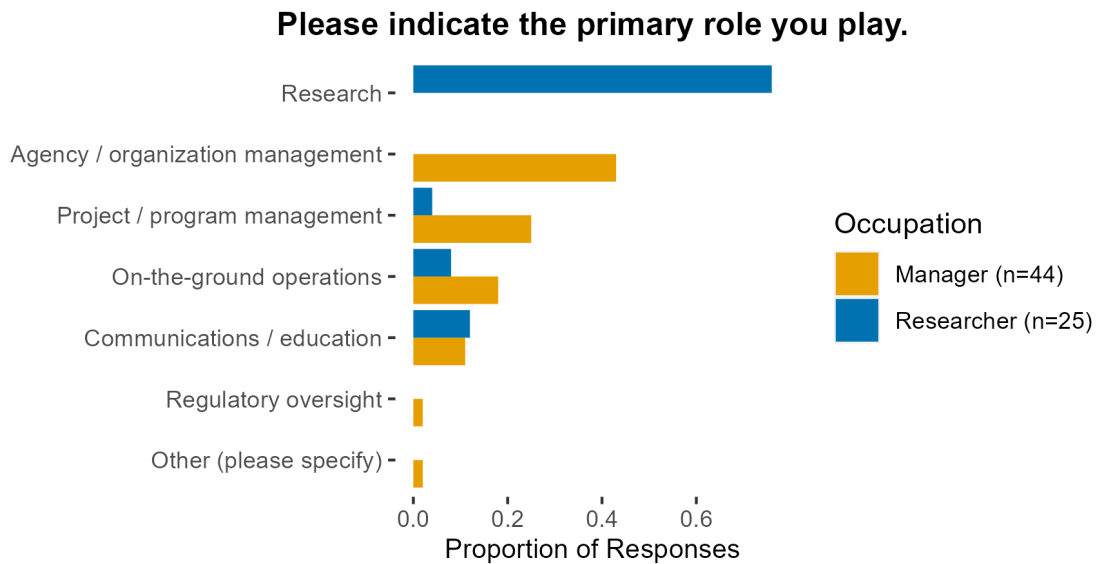


Figure 4: Primary role participants ($n = 69$) play in their organizations. Participants were only allowed to select one response.

43.2% of managers were involved in agency or organization management and 23.1% of managers were involved in project or program management (Figure 4). Unsurprisingly, the most common role for researcher respondents was research (76.0%), and other roles included communication/education, operations, and project/program management.

Experience

How many years have you worked in your current profession?

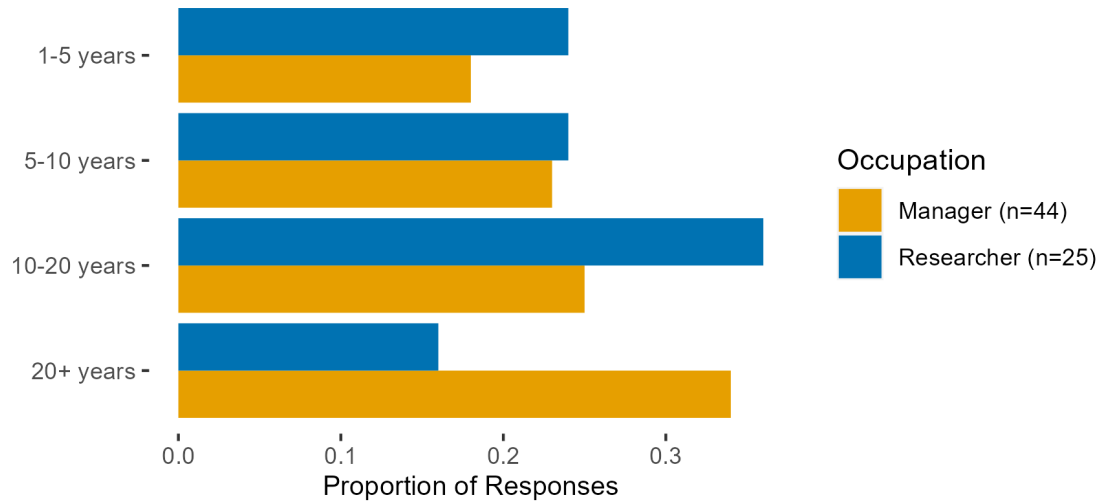


Figure 5: Number of years of experience of participants (n = 69) in their current profession. Participants were only allowed to select one response.

Most survey respondents were in mid-career stages, with 23.2% having 5-10 years of experience and 29.0% having 10–20 years of experience (Figure 5). Experience levels were relatively similar across managers and researchers.

2) Invasive Species Management and Research

Management and Research Priorities

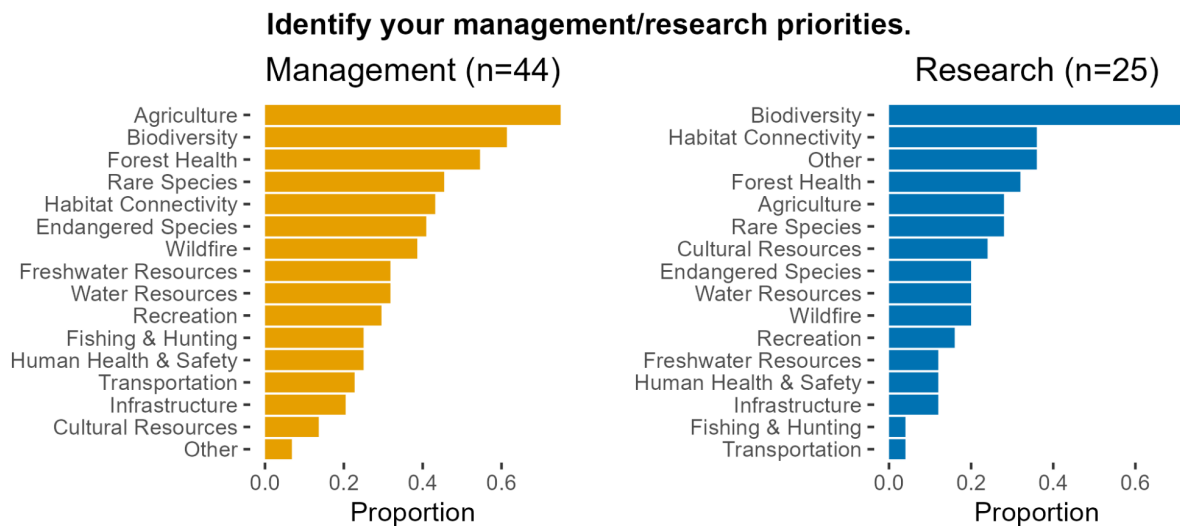


Figure 6: Research and management priorities of participants (n = 69). Participants were allowed to select multiple responses.

Among managers, agriculture was the highest-ranking management priority (75.0%), followed by biodiversity (61.36%), forest health (54.54%), rare species (45.45%), habitat connectivity (43.18%), endangered species (40.91%), and wildfire (38.63%) (Figure 6). With the exception of agriculture, management priorities focusing on humans (e.g. cultural resources, infrastructure) ranked lower than those focused on ecological factors (e.g. habitat connectivity, rare or endangered species).

For researchers, biodiversity was ranked the highest research priority (72.0% of respondents), followed by habitat connectivity (36.0%), “other” (36.0%), forest health (32.0%), agriculture (28.0%), and rare species (28.0%) (Figure 6). Some of the responses in the “other” category included: human dimensions of socio-environmental systems, actionable science, grassland and rangeland science, remote sensing, and mechanisms of invasion, or taxa of invasive species. Human-focused priorities similarly ranked lower for researchers than ecological objectives.

Existing vs. Future Invasives

Practitioners reported spending the majority of their time managing current invasives compared to planning for new invasives (80% vs 20% of their time, respectively). Importantly, participants could have interpreted the current vs. future invasives phrasing in a variety of ways, including: currently listed vs. non-listed species, currently prominent invasive populations vs. imminent invasive populations of species, or stable invasive populations vs. rapidly growing invasive populations.

Personal and Organizational Success in Managing Invasive Species

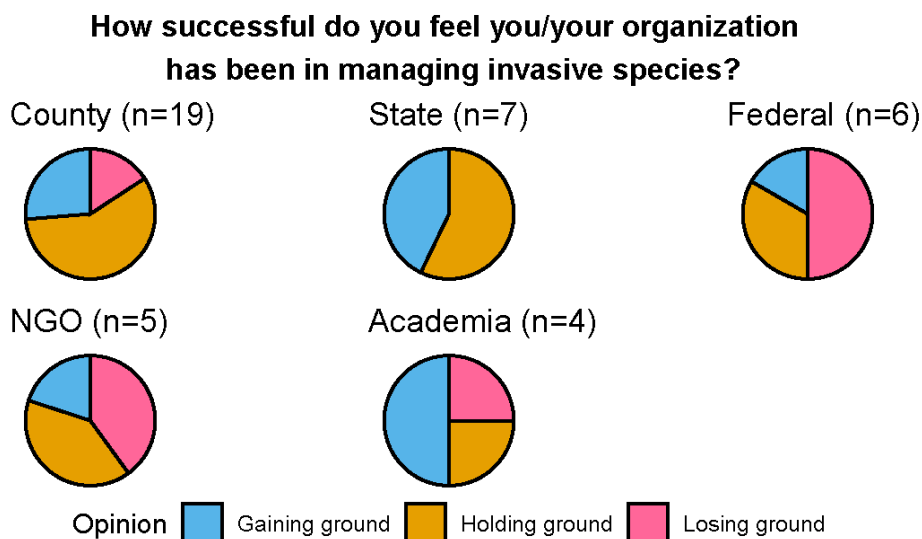


Figure 7: The success of individuals and their employers in managing invasive species, as perceived by management respondents (n = 44). Participants assessed their organization as either gaining ground, holding ground, or losing ground against invasive species. Responses for the top five categories of employers are shown.

Management participants perceived different levels of success in invasive species management, depending upon their employer and the spatial scale at which they worked (Figure 7). State employees reported their organizations only gaining and holding ground, while county employees reported mostly holding ground with some gains and losses. Academia and federal agencies reported the greatest success in gaining ground. NGOs reported mixed results with high losses and holding ground, but less success gaining ground. These analyses do not account for participants who reported working for multiple organizations but answered this question only for one (i.e., their primary employer).

Challenges to Invasive Species Management

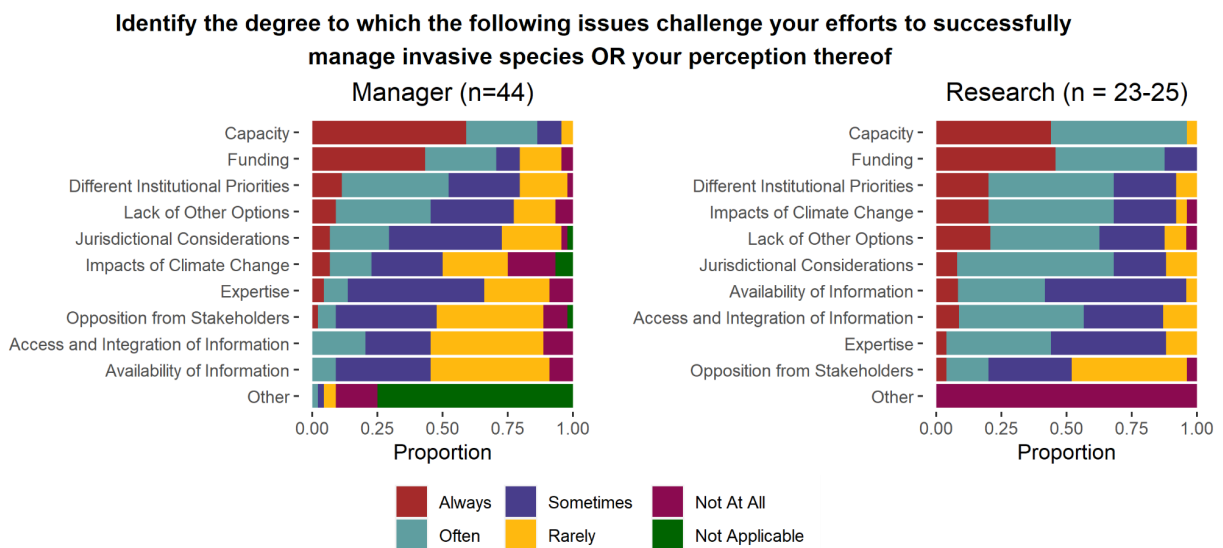


Figure 8: Participants’ challenges in managing invasive species (managers) or their perception of those challenges (researchers)

Managers consistently listed capacity and funding as two major challenges to managing invasive species (Figure 8). 59.1% of managers reported that capacity was always a challenge, and 43.2% reported that funding was always a challenge. Availability of information was less of a limitation for most managers, as the majority (81.8%) reported only rarely or sometimes being limited by this. Additional challenges that managers reported in the Other category included: “Access to Private Lands - Often” and “Collaboration with partner agencies/organizations - Sometimes”.

These questions were intended to ascertain not only what challenges managers face in managing invasive species, but also how researchers perceive the challenges of invasive species managers. As researchers listed capacity, funding, and different institutional priorities as their perceived top challenges (Figure 8), it appears as though there is alignment between their perceptions and what managers report. However, researchers may overestimate the challenges managers face, as they consistently rate challenges as being “Often” present more than managers do.

3) Integrating Climate Change with Invasive Species Management/Research

Level of Concern Regarding Climate Change

Indicate your level of concern about the effect of climate change on invasive species management.

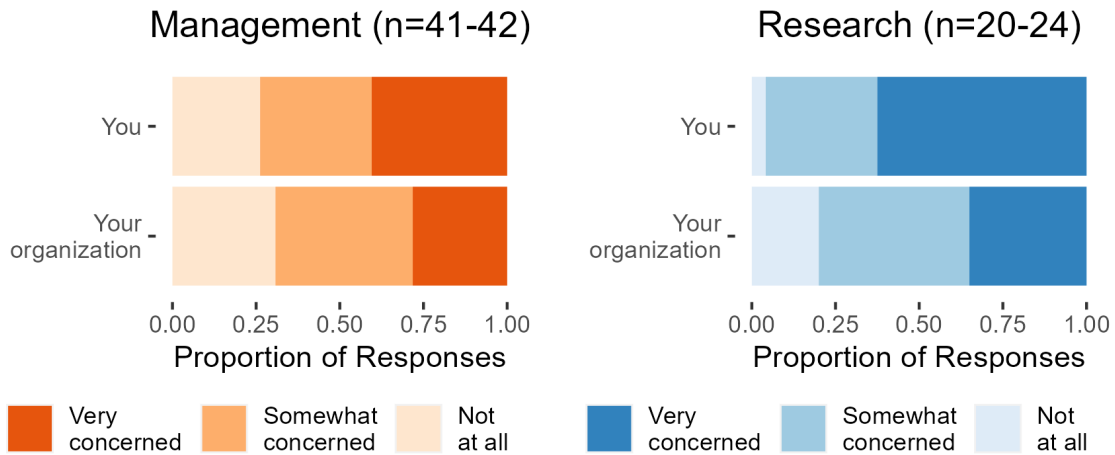


Figure 9: Manager and researcher responses to personal and organizational concern over the effect of climate change on invasive species management.

Both managers and researchers report slightly less organizational concern than personal concern regarding the effect of climate change on invasive species management (Figure 9). More managers report being “not at all concerned” with the effect of climate change on invasive species management (25.0%), while only a few researchers were “not at all concerned” (4.0%).

Indicate your level of concern about the effect of climate change on invasive species management.

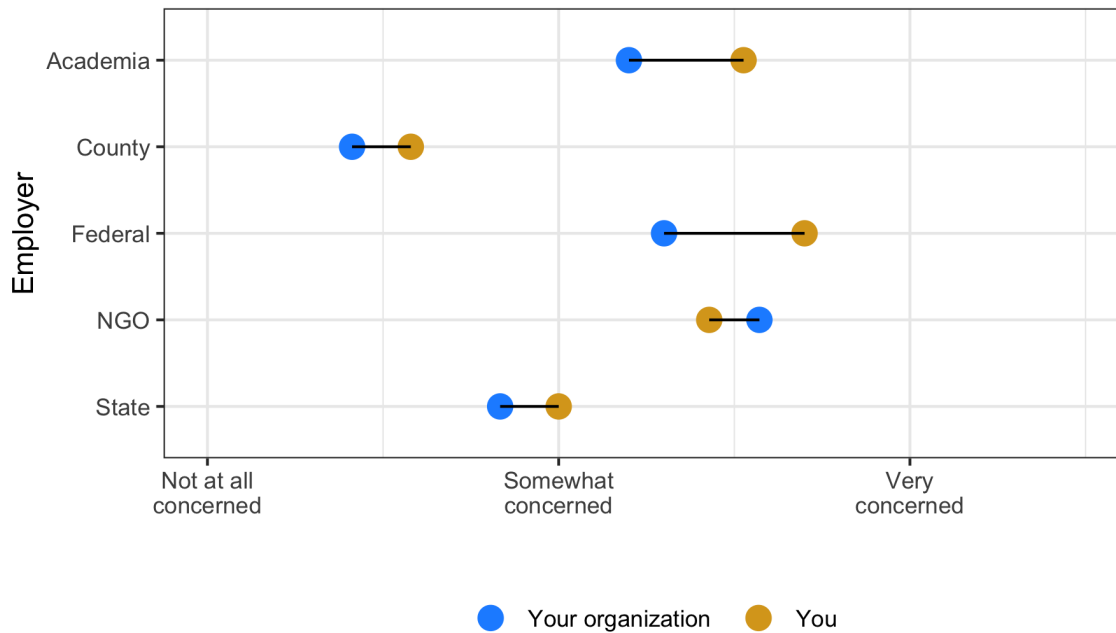


Figure 10: Comparison of personal (yellow) and organizational (blue) concern about climate change and invasive species, broken down by type of employer type (academia n = 19, county n = 19, federal n = 10, NGO n = 7, state n = 7). The figure combines manager, researcher, personal, and organization responses.

Academia, NGO, and federal groups appear the most concerned with the impacts of climate change on invasive species management (Figure 10). Within government groups, as the spatial scale of the management unit increases, the level of concern with climate change also increases (county concern < state concern < federal concern). NGO was the only group (employer type) in which the organizational concern was higher than of the respondents.

Self-Assessment of Existing Knowledge

How would you rate your existing knowledge about the intersection of invasive species management and climate change?

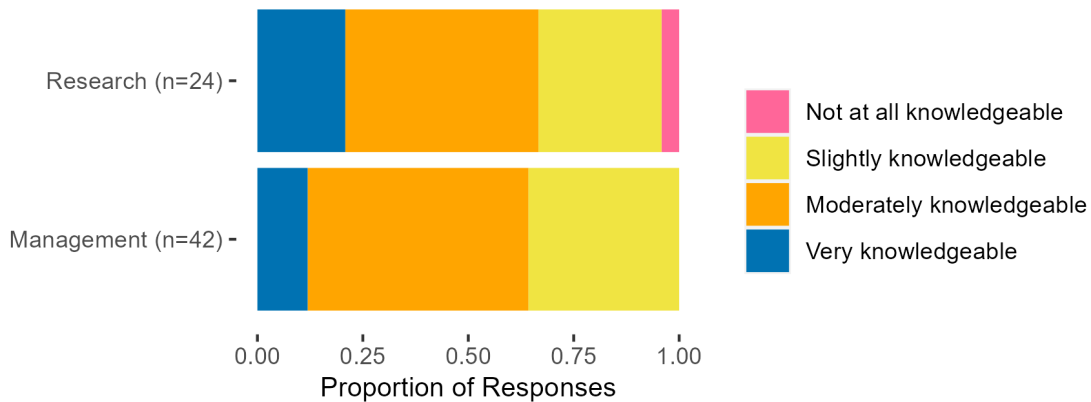


Figure 11: Manager and researcher evaluations of their existing knowledge about the nexus of climate change and invasive species management.

Most participants rated themselves as either “moderately” or “slightly” knowledgeable about the intersection of climate change and invasive species management, with only one participant responding that they didn’t know much at all (Figure 11). Managers rate themselves as similarly knowledgeable as researchers - 61.3% of managers rate themselves as “moderately” or “very” knowledgeable, compared to 64.0% of researchers.

Current Climate Change Incorporation

Identify the extent to which you currently incorporate climate change into invasive species management decisions.

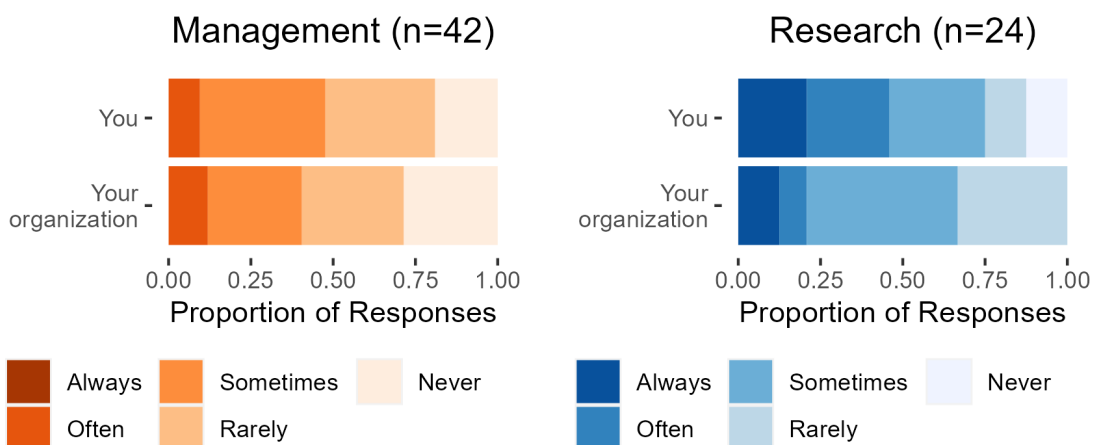


Figure 12: Comparison of manager and researcher responses to how often they integrate climate change into their work with invasive species. The darkest red “Always” category is not present on the manager figure, because no participants responded with this answer.

Incorporating climate into work with invasive species remains largely occasional for both managers and researchers (Figure 12). While 43.2% of managers rate that they “sometimes” or “often” incorporate climate change in their personal practice, no managers report that either they or their organization “always” incorporate climate change into invasive species management decisions. However, while some researchers never incorporate climate change into their invasive species work, a large proportion (72.0% for personal, 64.0% for organizations) report “always”, “often”, or “sometimes” incorporating climate change.

Challenges in Integrating Climate Change

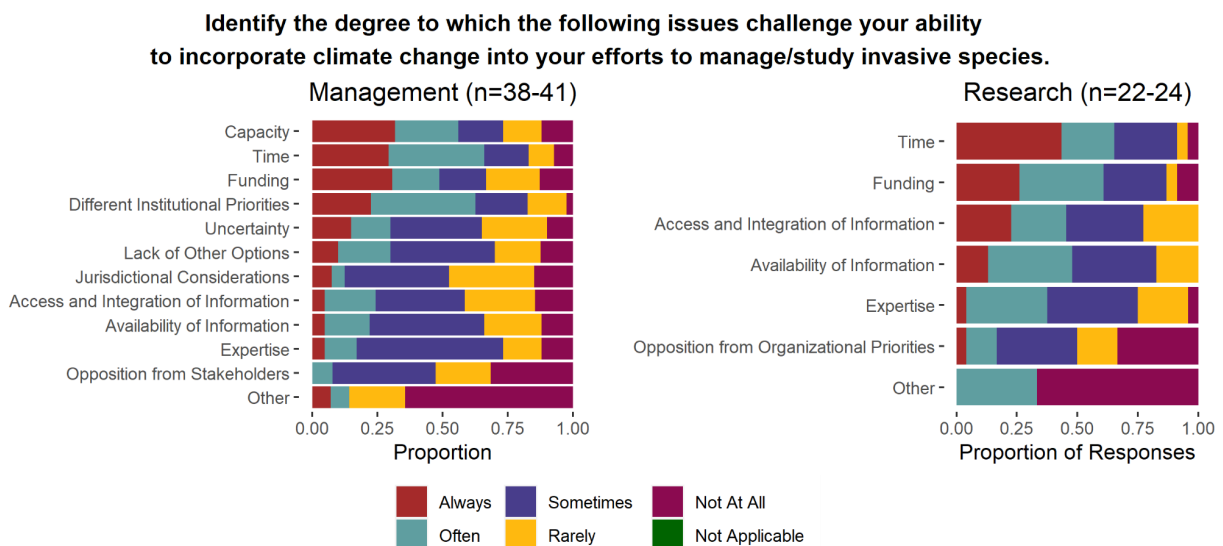


Figure 13: Manager and researcher responses regarding their challenges in integrating climate change with invasive species management/research.

Capacity, time, and funding are some of the most important challenges to incorporating climate change into invasive species management ranked by managers (Figure 13). Managers report that they always or often experience the challenges of capacity (56.1%) and time (65.8%) when integrating invasive species and climate change. Like managers, researchers are similarly limited by time and funding in terms of incorporating climate change information with the study of invasive species. Opposition from organizational priorities and stakeholder groups is noted as the least prevalent concern for both managers and researchers (“not at all” a challenge for 31.6% and 33.3%, respectively). For each challenge listed, at least some managers report that it is “not at all” a problem for them, which suggests that challenges faced by managers in incorporating climate change into invasive species management are employer- or location-specific. Similarly, researchers consistently face a variety of the listed challenges related to project or individual contexts.

Management and Research Priorities

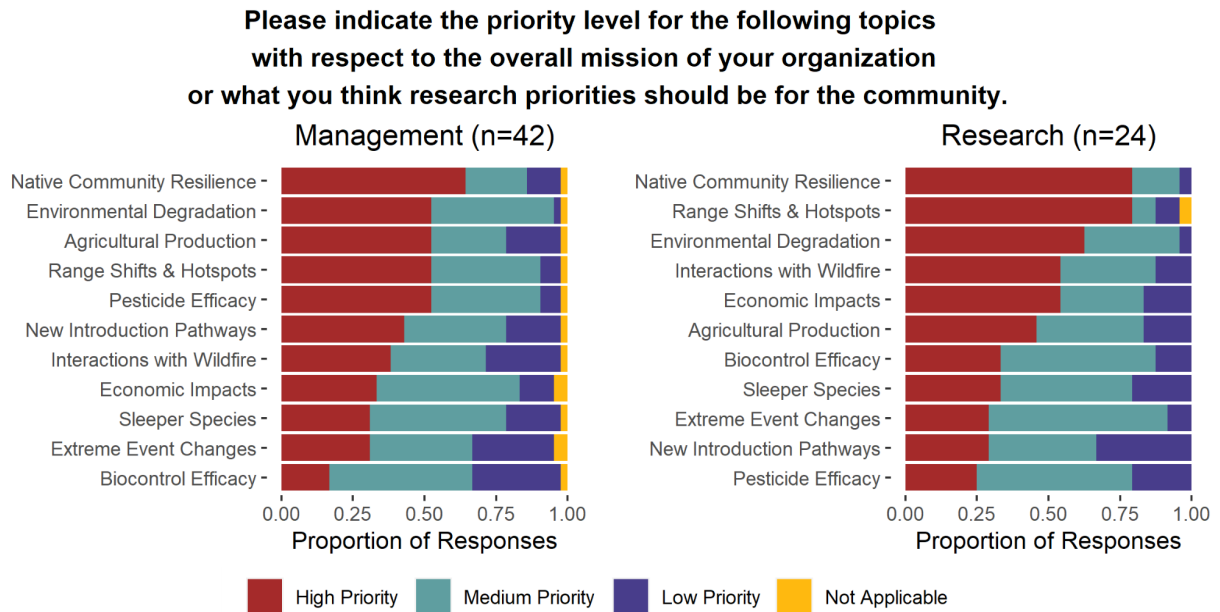


Figure 14: Manager and researcher responses regarding topical priorities related to invasive species management/research in a changing climate.

Both managers and researchers rank native community resilience as a high priority topic (64.2% and 79.1%, respectively) (Figure 14). Environmental degradation was also very important for both groups. Range shifts and hotspots are important for researchers. Agricultural production is important for managers, but less so for researchers. Pesticide efficacy was a high priority topic for 52.4% of managers, but was only considered a high priority topic for 25.0% of researchers. Similarly, biocontrol efficacy was a high priority for 33.3% of researchers, but only 16.7% of managers.

4) Knowledge, Products, and Services

Scales of Knowledge

At what temporal and spatial scales do you need climate projections to best manage/understand invasive species?

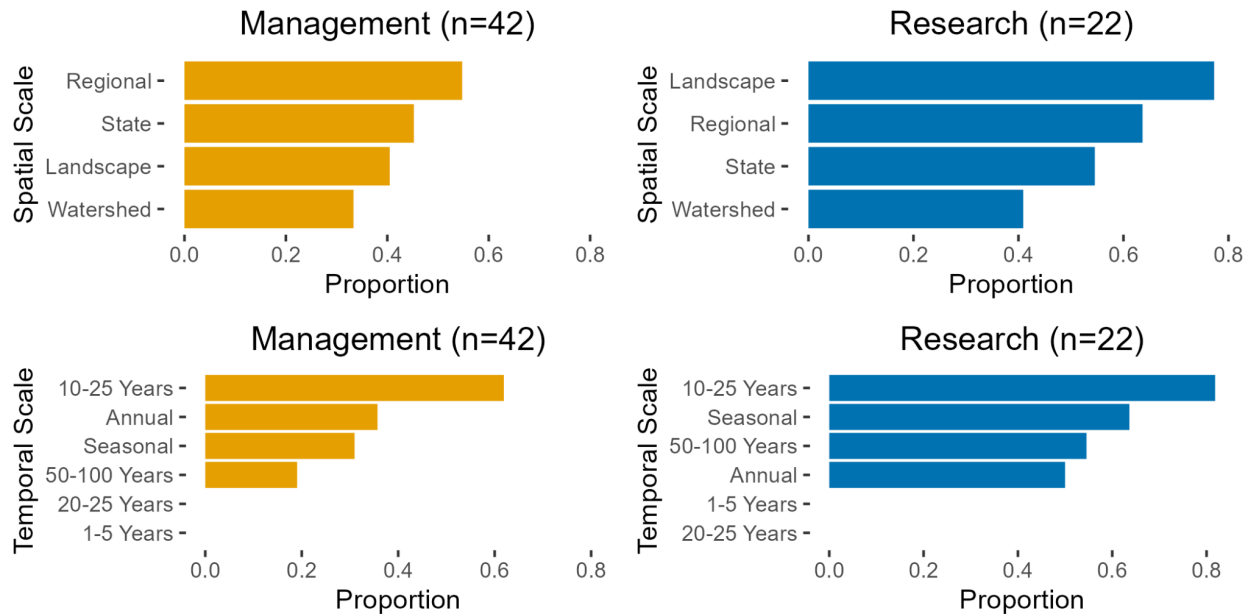


Figure 15: Spatial and temporal scales at which managers and researchers need climate information to better understand or manage invasive species.

Managers prioritized climate projections over the next 10–25 years, along with annual and seasonal projections for managing invasive species (Figure 15). A smaller proportion found longer timescales (i.e., 50-100 years) to be a priority. Managers ranked climate information at the regional scale as most important, followed by the state, landscape, and watershed scales.

Researchers similarly list the 10–25 year timescale as the most important scale for integrating information on climate change into invasive species management (Figure 15). This was followed by projections on seasonal, much longer timescales (i.e., 50–100 years), and annual timescales. Researchers ranked climate information at the landscape, regional, and state spatial scales higher than the watershed scale.

Resources Used

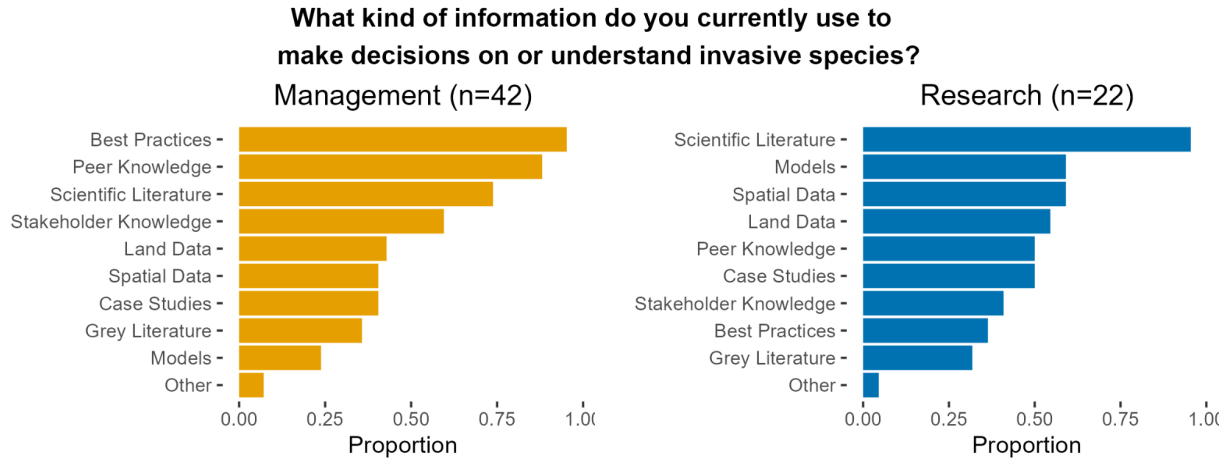


Figure 16: Sources of information used by researchers and managers to help manage or understand invasive species.

In order to understand and make decisions about invasive species, managers prioritize best practices (95.2%), peer-to-peer knowledge exchange (88.1%), scientific literature (73.8%), and stakeholder knowledge exchange (59.5%) (Figure 16). Modeled data appears to be less of a priority for managers than other sources of information (23.8%). In contrast, researchers rely heavily on scientific literature (95.4%), models (59.1%), spatial data (59.1%), and land use/cover data (54.5%) (Figure 16). Additional resources in the ‘Other’ category included personal experience (including having boots on the ground) and consultation with experts (e.g., researchers, pesticide manufacturers). Several participants (n=6) responded that they currently do not use any resources in their integration of climate change and invasive species, because 1) their institution’s priorities are elsewhere, 2) they lack the capacity to plan for future invasives, or 3) they don’t know where to begin looking.

Table 2: Specific resources listed by participants about what tools and resources they currently use to make decisions about invasive species, climate change, and/or their interaction.

Resource Name	Link to Resource
USGS NAS	https://nas.er.usgs.gov/
ANSTF Documents	https://www.fws.gov/program/aquatic-nuisance-species-task-force
Kansas ANS Management Plan	https://ksoutdoors.com/Fishing/Aquatic-Nuisance-Species/Learn-More-About-Aquatic-Nuisance-Species/Kansas-Aquatic-Nuisance-Species-Management-Plan
Fire Effects Information System	https://www.feis-crs.org/feis/
RISCC repository + models	https://www.risccnetwork.org/
Kansas State University Extension	https://www.ksre.k-state.edu/
Herbicide labels / Manufacturing Information	https://www.cropscience.bayer.us/products/herbicides/roundup-powdermax/label-msds
NYS Prioritization Models	https://www.capitalregionprism.org/ny-invasive-species-prioritization

	n-map.html
New York Protected Areas Database (NYPAD)	https://www.nypad.org/
Environmental Resource Mapper	https://www.dec.ny.gov/animals/38801.html
EDDMaps	https://www.eddmaps.org/
Agriculture Weather Network	https://ndawn.ndsu.nodak.edu/ ; http://coagmet.colostate.edu/
NIACS	https://www.nrs.fs.fed.us/niacs/
Wyoming Weed & Pest Council	https://wyoweed.org/
MA Climate Action Tool	https://climateactiontool.org/
Suasco CISMA Partnership	https://cisma-suasco.org/about/
University of Wyoming	http://www.uwyo.edu/uwe/ ; https://www.uwyo.edu/
North Dakota Weed Control Guide	https://www.ndsu.edu/agriculture/ag-hub/publications/north-dakota-weed-control-guide
Techline Invasive Plant news	https://www.techlinenews.com/
Snotel data	https://www.nrcs.usda.gov/wps/portal/nrcs/detail/co/snow/products/?cid=nrcs144p2_063323
PRISMs	https://www.nps.gov/articles/000/ncr-prism.htm
gridMET	https://www.climatologylab.org/gridmet.html
Landsat	https://landsat.gsfc.nasa.gov/
WebSoil Survey	https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
SWAPs for NC States	https://www.fishwildlife.org/afwa-informs/state-wildlife-action-plans
Professional Societies (NAISMA, SAF, ANREP)	https://naisma.org/ ; https://www.eforester.org/ ; https://www.anrep.org/
CMIP-5 climate projections	https://toolkit.climate.gov/tool/maca-cmip5-statistically-downscaled-climate-projections
Rangelands Analysis Platform	https://rangelands.app/
Climate Smart Restoration Tool	https://climaterestorationtool.org/csrt/
National Weather Service Climate Prediction Center	https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml
GOES X Ray Flux	https://www.swpc.noaa.gov/products/goes-x-ray-flux-dynamic-plot
Midwest Invasive Plant Network	https://www.mipn.org/
Minnesota Department of Natural Resources	https://www.dnr.state.mn.us/invasives/index.html

Interest in NC RISCC Products and Activities

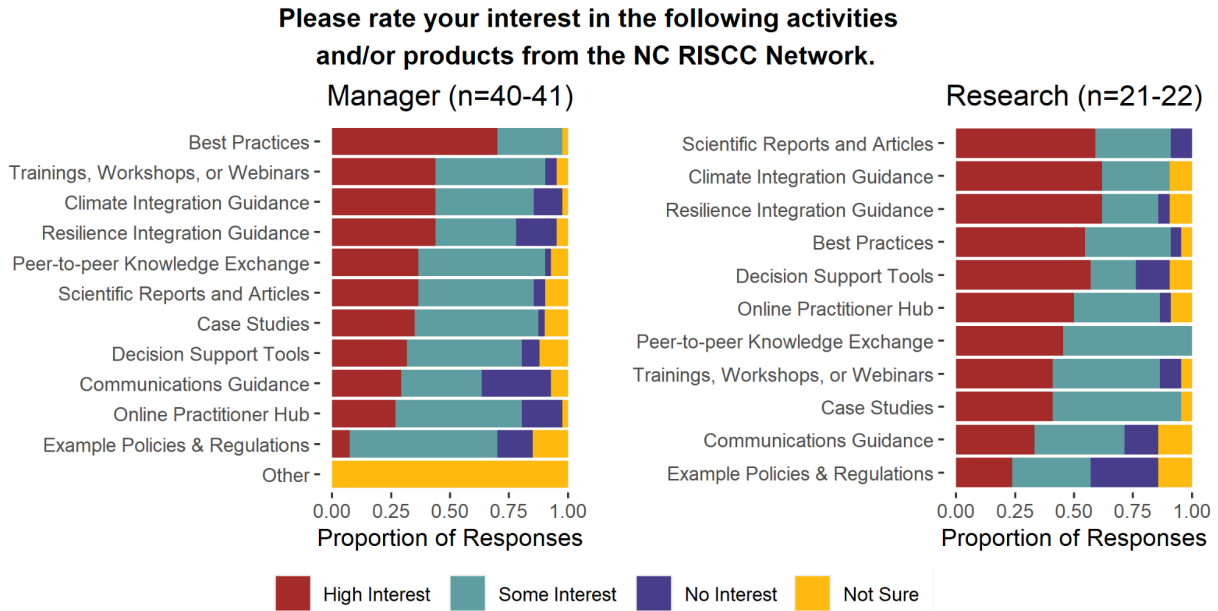


Figure 17: Manager and researcher interest in products and activities from the NC RISCC network.

The rankings for desired products and activities (Figure 17) closely reflected the sources of information used by managers and researchers (Figures 16). Managers place high priority on best practices (70%) and want to see this type of information produced by the NC RISCC, while researchers place a high priority on scientific reports and journal articles (59.1%; Figure 17). However, both groups are interested in additional climate and resilience integration guidance (43.9% of managers and 61.9% of researchers ranked each climate integration guidance and resilience integration guidance as high interest). Example policies or regulations and communications guidance are of less interest to either group, although some participants from both researchers and managers report that they have high interest - again reflecting differences in individual roles and responsibilities as well as impact of policy/communications on their work. Thus, the NC RISCC may best serve the community by providing a range of different products and activities for different audiences.

5) Optional Questions

Other Research Projects or Management Efforts

Of the 44 manager responses, 8 (18.2%) completed an optional question about other research projects or management efforts combining invasive species and climate change. Of the 25 researcher responses, 5 completed this optional question (25.0%). Of the 13 total respondents (including researchers and managers), 7 (53.8%) indicated that they did not know of any programs or that these programs were not applicable to their organization or background. A few of the specific programs listed by the remaining 6 participants include:

- WI Initiative on Climate Change Impacts: <https://wicci.wisc.edu/plants-and-natural-communities-working-group/>
- NC CASC Grasslands Synthesis Project: <https://doi.org/10.3133/ofr20231036>
- USDA ARS National Programs

These findings suggest that current programs or projects that are working on this effort are: 1) either too widespread/general to report on, or are 2) rare and/or not easy to find. Either way, respondents do not seem to be in-tune with specific programs enough to quickly reference them. However, participants did report common tools and products that they regularly use (Table 2), which indicates that while some models and tools are available, there are fewer groups bringing them together in the intersection of climate change and invasive species.

Species of Concern

Survey respondents were asked to list the top invasive species (up to 10) they believe pose the greatest threat to their organization’s management goals / management in their region currently, as well as in the future (next 10–20 years). Of the 44 manager responses, 26 completed at least one of these optional questions (59.1%). Of the 25 researcher responses, 16 completed at least one of these optional questions (64.0%).

Table 3: List of top 20 most frequently mentioned species of concern among managers and researchers, with at least 4 respondents (5.8% of total responses, 9.5% of optional question responses) mentioning the species. If a species was listed at any jurisdiction in a state (e.g., state, county, or local) it was counted as being listed in that state. A full version of this table is available in Appendix C.

Scientific Name	Common Name	Current Concern	Future Concern	Habitat Type	Species Type	Times Mentioned (# of individuals)
<i>Bromus tectorum</i>	Cheatgrass	Yes	Yes	Terrestrial	Plant	15
<i>Euphorbia esula</i>	Leafy spurge	Yes	Yes	Terrestrial	Plant	12
<i>Taeniatherum caput-medusae</i>	Medusahead	Yes	Yes	Terrestrial	Plant	8
<i>Ventenata dubia</i>	Ventenata	Yes	Yes	Terrestrial	Plant	8
<i>Centaurea stoebe</i>	Spotted knapweed	Yes	Yes	Terrestrial	Plant	7
<i>Cirsium arvense</i>	Canada thistle	Yes	Yes	Terrestrial	Plant	7
<i>Bromus inermis</i>	Smooth brome	Yes	Yes	Terrestrial	Plant	6
<i>Lepidium draba</i>	Whitetop	Yes	Yes	Terrestrial	Plant	6
<i>Linaria vulgaris</i>	Yellow toadflax	Yes	Yes	Terrestrial	Plant	5
<i>Centaurea solstitialis</i>	Yellow starthistle	No	Yes	Terrestrial	Plant	5
<i>Kali tragus</i>	Russian thistle	Yes	Yes	Terrestrial	Plant	5

<i>Juniperus virginiana</i>	Eastern redcedar	Yes	Yes	Terrestrial	Plant	5
<i>Phragmites australis</i>	Common reed	Yes	Yes	Aquatic	Plant	5
<i>Dreissena rostriformis bugensis</i>	Quagga mussel	Yes	Yes	Aquatic	Invertebrate	4
<i>Elaeagnus angustifolia</i>	Russian olive	Yes	Yes	Terrestrial	Plant	4
<i>Cynoglossum officinale</i>	Houndstounge	Yes	Yes	Terrestrial	Plant	4
<i>Poa alpigena</i>	Kentucky bluegrass	Yes	Yes	Terrestrial	Plant	4
<i>Alliaria petiolata</i>	Garlic mustard	Yes	Yes	Terrestrial	Plant	4
<i>Rhamnus cathartica</i>	Common buckthorn	Yes	Yes	Terrestrial	Plant	4
<i>Lonicera spp.</i>	Honeysuckle	Yes	Yes	Terrestrial	Plant	4

The species that appear to be of most concern to researchers and managers alike are cheatgrass (*Bromus tectorum*) and leafy spurge (*Euphorbia esula*), with at ~22% of total survey participants mentioning them. Other common species of concern include other invasive grasses (Ventenata, medusahead, smooth brome, whitetop, Kentucky bluegrass), thistles, aquatic species, and invasive trees (Eastern redcedar, Russian olive).

Notably, while several participants mentioned both vertebrate and invertebrate species of concern, only one species (Quagga mussel) was mentioned by >4 respondents. Zebra mussels, emerald ash borers, and spotted lanternflies were mentioned by 3 respondents, and all others were only mentioned by one or two individuals.

We also compared the number of times a species was mentioned to the amount of states in the NC region that it was listed (see Appendix C). Generally, the species listed as most common concerns were officially listed as noxious weeds in several states in the North Central region, indicating that there is fairly good agreement (at least among plant-focused managers and researchers) about what species are problematic in the region as a whole. Annual fire-prone grasses such as Ventenata, medusahead, and smooth brome were mentioned more frequently by participants from Colorado, Wyoming, and Montana - the states in which they are listed. Cheatgrass was mentioned more than any other species and is listed in 6/7 North Central states. Russian thistle was mentioned by participants from Colorado, but is not officially listed in the region.

Current Climate Change Incorporation

The following are manager responses to the optional question, “Please explain how you/your organization incorporates climate change into invasive species management decisions” (Table 4). Only managers were asked this question. Of the 44 responses from managers, 14 completed this optional question (31.8%).

Table 4: Responses to optional manager question asking about the ways that managers or their organizations incorporate climate change information into invasive species management decisions.

Type of Incorporation	Quote(s)
No Current Incorporation	<p>“We currently do not.”</p> <p>“Not at this time.”</p>
Anticipation of Future Conditions	<p>“Invasive species in southern states may become problems in MN with warmer weather and especially winters. Both plant and insect overwintering and survival concerns.”</p> <p>“We also try to anticipate future conditions (drier, hotter, often a lower water table) when restoring areas such as riparian communities and plant more upland species the future we get from the main channel, even if existing conditions can support riparian species.”</p> <p>“We try to predict what species will be able to spread in WI in the new future and regulate, monitor for and manage them.”</p>
Scale Considerations (Spatial / Temporal)	<p>“Local level and consideration.”</p> <p>“We've been battling most of these species for over 40 years in the same areas. I think we deal more with land management practice than we do climate change.”</p>
Changes to on-the-ground practices	<p>“Our priority is actual weed management activities.”</p> <p>“We are extending our seasonal contract as needed.”</p> <p>“Reactive: flexibility in management timing and selection (the increasing frequency in outlier years with regard to moisture, temperature and even wind patterns make this a shifting target).”</p> <p>“The existing climate action plan includes improvement of degraded rangelands and other habitats, including control of invasive species.”</p>

	<p>“Altitude vigor in invasive plants can lead to far more aggressive management prescriptions (higher herbicide use rates) as seen in yellow toadflax.”</p>
Species Monitoring and Early Detection	<p>“Field observation and mapping of plant occurrence and density.”</p> <p>“Proactive: Higher elevation ecosystems that have been resistant to invasion are beginning to shrink necessitating more rigorous monitoring programs.”</p> <p>“We try to predict what species will be able to spread in WI in the new future and regulate, monitor for and manage them.”</p> <p>“Invasive species in southern states may become problems in MN with warmer weather and especially winters. Both plant and insect overwintering and survival concerns.”</p>
Value- or Priority-Based Changes	<p>“Knowledge of climate change patterns does not impact our invasive species management; it just makes it feel even more important at our higher priority sites.”</p> <p>“Into our state noxious weed list- prioritizing species based on a full review which includes climate adaptability, distribution, habitat resilience, suitability models, etc.”</p>

While some managers indicated that they or their organization are not integrating climate change into invasive species management decisions, many of the optional responses indicate that there are some planning and operations being modified in response to climate change. The most common trends include anticipation of future conditions, changing on-the-ground practices, and increased species monitoring and early detection/response initiatives.

Discussion

This study was intended to survey the priorities of practitioners to guide future directions and strategies for the NC RISCC. The delineation of manager versus researcher surveys will allow the RISCC to target outreach efforts to our two main audiences. The survey has revealed some important similarities and differences across manager and research communities in the North Central region. Future cross-RISCC network comparisons would be useful to analyze regional vs. national patterns, and are forthcoming.

Invasive Species Management and Research

Management and research priorities around invasive species differed slightly. Biodiversity and forest health are prioritized by both groups (Figure 6), but managers' top priority is agriculture, despite the low number of respondents from the agricultural sector. The prioritization of agriculture was the most notable difference between research and management priorities (75.0% versus 28.0%, respectively), suggesting opportunities to better align research with management priorities. Additionally, RISCC activities and research around biodiversity may be particularly useful for both communities of stakeholders. Managers also are more concerned with the protection of rare and endangered species than researchers, possibly due to the legal impact of the Endangered Species Act on their lands. Work on species that are invasive today occupies around 80% of participants' time, with only a small amount of time spent on (i.e., planning for) new invasive species. This finding may help explain some challenges with incorporating climate change into invasive species management. For example, if most of managers' time is spent on current invasives (reactive management), it may be hard to incorporate range shifting species in a changing climate (proactive management).

Participants reported mixed success in their management of invasive species depending on employer type and scale of their organization (e.g., local, state, federal; Figure 7), with larger agencies/organizations reporting more success than smaller agencies/organizations. Federal agencies may have more resources to address invasive species (e.g., coordination across the network) than local agencies. It's also possible that state-based regulations that govern or influence management decisions at smaller spatial scales add to the challenges of being proactive at the local level. Additionally, local and state agencies may work more closely with private landowners and thus have less control over management practices that are enacted across the landscapes they manage.

Managers report that capacity and funding are their top challenges for managing invasive species (Figure 8). This finding has been observed in other regions in the U.S. ([Beaury et al. 2020](#)). When researchers were asked what their perceptions were of the challenges to implementation, they also ranked these three challenges towards the top - indicating a fairly good understanding of the challenges facing managers. Staying ahead of invasive species management will require work to overcome these institutional barriers and the NC RISCC may be able to make new connections and partnerships to this end. The NC RISCC also reduces the barrier to entry for using data, tools, and information which may be helpful for managers, but this is less often a limitation than capacity or funding.

One manager commented:

"I think most land managers know we have an issue...a big issue. Yet we don't put the funds towards trying to solve this issue. Leaving the little funds we have to try and keep us afloat. I sadly have sat in on many calls where we all agree that one of the top threats to our ecosystem is invasive species...then nothing is done. No extra funding. No extra staffing, etc. You all have heard this same spiel before, 'but I can't do this.'"

This quote is reflective of several patterns seen in the analysis. First, 80% of managers' time is spent managing current invasive species instead of preparing for future ones. Lack of funding and capacity are consistently among the highest ranked challenges for managers (Figures 8, 13) in this area. Finally, most managers are at least moderately concerned with the impact of invasive species and climate change on their ecosystems (Figures 9, 10), but these challenges may prevent them from acting on this concern. In many ways, this quote can serve as a summary of the barriers to tackling the combined issues of invasive species and climate change. It may also be reflective of a pessimistic attitude felt by practitioners in this area. This phenomenon is noted elsewhere as climate, ecological, or environmental grief ([Cunsolo & Ellis 2018](#)), and has also been mentioned in response to other RISCC materials ([NC RISCC 2022](#)). This may be a future avenue for investigation by the NC RISCC or the broader cross-RISCC network - maintaining optimism while also a sense of agency in face of significant environmental challenges.

Integrating Climate Change

Level of concern about the impacts of climate change on invasive species varies by organization and generally increases with spatial scale (i.e., more concern at the federal level than at the local level) (Figures 9, 10). Employees from universities, NGOs, and federal agencies appear more concerned with how climate change will affect invasive species than county or state employees. This may be due to increased attention to climate change at the federal level ([Gore 2022](#)), continuing politics surrounding climate change ([Kennedy et al. 2022](#)), differences in management timeframes and scales, or simply a difference in personal or organizational duties regarding jurisdiction and issues of global environmental change.

Interestingly, managers tend to rate themselves as similarly knowledgeable to researchers about the intersection of climate change and invasive species (Figure 11), but less concerned about climate change's effects than the research community (Figure 9). Instead, managers seem to be more focused on native community resilience, regulating agricultural practices, and managing for biodiversity and rare species (Figures 6, 14), which may align more closely with agency/organizational priorities and directives.

Practitioners in the North Central region are generally aware that climate change might interact with invasive species management (Figure 11), but face significant challenges in incorporation of climate change into their plans (Figure 13). Together these challenges – such as capacity, funding, lack of time, different priorities, and informational barriers – lead to only moderate levels of climate incorporation (Figure 12). The RISCC's role in helping to understand and overcome these challenges becomes more salient regarding the incorporation of climate change into invasive species planning as there are fewer organizations operating in this area (see Other Research Projects or Management Efforts above). However, to make meaningful progress towards the time, capacity, and funding needed to incorporate climate change in invasive species work will require alignment with agency/organizational priorities and partnership opportunities.

While most proposed topics appeared to be of interest to some participants (Figure 14), native community resilience and environmental degradation were of highest interest across both managers and researchers. These topic areas will be prioritized in future NC RISCC activities

(e.g., webinars) and products (e.g., Management Challenges). Managers reported agriculture as a higher priority topic than researchers (Figures 6, 14) - indicating that the NC RISCC could work more closely with extension agencies and other agricultural organizations to bridge the practitioner-researcher divide in this area.

Knowledge, Products, and Services

Both managers and researchers indicated that climate projections for 10–25 years into the future and at regional scales are of high value (Figure 15). However, managers also value climate projections on shorter timeframes (e.g., annual and seasonal), which may be a reflection of their budget and staffing considerations that change at these finer temporal scales. Additionally, managers also value climate projections at the state level, which may reflect the differences in policy among neighboring states and the impact of this policy on management decisions, while researchers reported that landscape scale projections would be most useful for their work. Thus, while information access and availability were not ranked as the most limiting factors for invasive species management (Figure 6), providing information at multiple spatial and temporal scales may be important to bridge across research and management groups. The RISCC can fill a key niche by highlighting existing products (i.e., datasets, research summaries, synthesis products) or creating novel products at these scales.

Respondents use a variety of tools and datasets to assist their decision-making related to climate change and invasive species. The most common tools and data sources mentioned by respondents (Table 2) included climate models/downscaled climate data, mapping or spatial tools, and professional networks for expert opinion. RISCC webinars in the spring of 2023 addressed a community priority on decision support systems (data from Science Integration Workshop in 2022) and future webinars could highlight some of these other types of tools and datasets.

Managers and researchers differed in the sources of information that they used to make decisions or understand invasive species (Figure 16). Managers tended to use more qualitative measures, such as best practices, peer consultation, and stakeholder/community knowledge, while researchers relied on quantitative sources, such as models and a variety of spatial data. Scientific literature appears to be highly referenced by both groups, indicating that connecting both managers and researchers with new literature in a digestible way may be a solid strategy (e.g., Research Summaries written by the NE RISCC team). Future work by the NC RISCC could also focus on bridging the qualitative/quantitative or the manager/researcher gap. This could be done via workshops that include many different perspectives, and forms of information and synthesis products that actively seek out multiple sources of information. Not only does the NC RISCC offer different avenues for providing information but also opportunities for managers to network with researchers as well as other managers.

Interest in different RISCC products (Figure 17) appeared to reflect what sources of information respondents currently use to make decisions, with a request for extra guidance about integrating climate and resilience into their work. Ultimately however, it appears as though most products would be of interest to some RISCC stakeholders, even if the products aren't currently used by their organization or network.

Optional Questions

The optional questions were intended to glean additional information from participants regarding species of concern and specific resources/adaptation strategies. Terrestrial plants (specifically annual invasive grasses) were the most common species of concern listed (Table 3, Appendix C), possibly in part due to high representation in survey participants who are plant-focused managers and researchers. However, other species groups of note included aquatic vertebrates and invertebrates (e.g., mussels, carp) and woody plants (e.g., Eastern redcedar, Russian olive). Future work in this area should integrate more aquatic, invertebrate, vertebrate, and/or pathogen specialists to give a more comprehensive view of these species' role in the North Central region. Most of the common species listed as current management priorities/issues were noted as potential future concerns as well.

When asked to provide examples of other organizations or projects working at the intersection of invasive species and climate change, not many participants provided specific examples. However, several managers had ideas or examples of how to incorporate climate change into invasive species management (Table 4). The general categories of responses include: anticipating future conditions, accounting for spatial scale, changing on-the-ground practices, and species monitoring/early response. This indicates that managers are thinking of specific, concrete actions to integrate climate change into their invasive species planning, although the lack of voluntary responses suggests that they are not very common. To address this gap, the NC RISCC hosted a series of webinars in the Spring/Summer of 2023 to highlight decision support tools and systems that incorporate climate change information with invasive species management.

Climate Skepticism

Three survey respondents that work in the North Central region expressed explicitly or implicitly that they do not believe in anthropogenic climate change. We included their responses in our analyses to reflect the reality of the population of managers and researchers in the region. All three reported that their organizations were either “not at all concerned” or “somewhat concerned” with climate change while they reported that they as individuals were “not at all concerned”. All listed themselves as “moderately knowledgeable” or “very knowledgeable” about climate change, and that they (and their organizations) almost never incorporate climate change into their invasive species management. The community priorities and knowledge/products/scales of two of these three respondents were similar to the broader community of survey respondents (e.g., topical focus on native community resilience, use of best practices as a product of interest). The third reported that no listed topical priorities were relevant and did not respond to the question about RISCC products of interest.

Limitations

One limitation of this survey is the small sample sizes within certain subgroups (e.g., managers working for local entities). Our network of engaged stakeholders was small at the time of conducting the survey. It is also possible that managers and researchers in our geographic

area were not incentivized to share their expertise via surveys before having engaged with the NC RISCC in a meaningful way (i.e., before our first Science Integration Workshop or 2023 Spring Webinar Series). The low participation may also reflect a larger problem within the social sciences of survey fatigue ([Porter et al. 2004](#)) and/or a general sense of being overwhelmed due to normal work constraints and the pandemic.

Conclusions

This survey, distributed in Fall 2021, clarifies the priorities, challenges, and opportunities of the practitioner community in the North Central region regarding the intersection of invasive species and climate change. Although sample sizes were small, participants represented a variety of organizations, states, and employer types in the region. This survey revealed that practitioners: 1) understand some of the effects of climate change on invasive species management and moderately integrate climate change information into their work; 2) desire different products and resources (with some overlap) depending on whether they are a researcher or a manager; 3) spend most of their time on current invasives (as opposed to future potential invasives), which is reflected in the common species of interest; and 4) rank native community resilience, environmental degradation, and range shifting species (researchers) or agricultural production (managers) as top priorities. The NC RISCC will use this information to tailor future products and outreach efforts to meet community needs. The NC RISCC plays an important role in bridging the gap and helping to build partnerships between researchers and managers working on invasive species in a changing climate.

Acknowledgements

This work was supported by The Department of the Interior North Central Climate Adaptation Science Center (NC CASC) via Award #G21AC10278 to Principal Investigator R. C. Nagy.

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Appendices

[Appendix A](#)

[Appendix B](#)

[Appendix C](#)