NYISRI

New York Invasive Species Research Institute

Identifying Stakeholder Invasive Species Research Needs in NYS

Mapping stakeholder input on invasive species research priorities in New York State

2019-2020

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Executive Summary

In an ideal world, research and management activities would interact synergistically, such that both clearly communicate with, and inform the actions of the other. In reality, lack of communication, institutional barriers, and other obstacles frequently prevent researchers from understanding what questions need to be answered in order to benefit on-the-ground management and inform those making practical decisions in conservation. This is particularly true in the world of invasive species, where work in both management and research is frequently siloed.

A critical role of the New York Invasive Species Research Institute (NYISRI) is collecting research-related needs from stakeholders (researchers, policy makers, and managers) in New York State. These needs, and how they are prioritized, drive the actions that NYISRI takes toward fulfilling our mission. In this report, we detail the results from a novel application of a process, known as Group Concept Mapping (GCM), to collect research needs from our stakeholders. The GCM process allows us to integrate participant feedback from a diversity of locations, knowledge areas, and professions with equal weight and minimized bias.

We began this project in 2019, utilizing software from Concept Mapping, Inc. to collect and analyze stakeholder input on invasive species research needs across New York State (NYS). Stakeholders participated in three distinct phases, including: 1) brainstorming a comprehensive list of ideas that represent the spectrum of an issue to generate qualitative data, 2) rating ideas submitted in the brainstorming on a five-point scale to create quantitative data, and 3) sorting these ideas by category according to participants' perspectives. We then analyzed input from each phase and transformed into graphical representations of participant input.

We engaged roughly 2,000 individuals and professionals, including those who work with NYISRI and its partner organizations. We opened the brainstorming phase to anyone with knowledge of invasive species in NYS, generating 211 ideas that were then consolidated to around 100 unique ideas that could be evaluated by a smaller group of invited researchers and professionals. We then sent out a second call for participation in the sorting and rating phases, this time to a smaller group of more targeted participants representing the Partnerships for Regional Invasive Species Management (PRISM), PRISM Partner Organization Representatives, New York State Department of Environmental Conservation Invasive Species Coordination Unit, NYISRI Advisory Board, New York Natural Heritage Program / iMapInvasives, New York Invasive Species Advisory Committee, and New York Invasive Species Council.

Our results captured input from a wide range of relevant stakeholders based on demographic results from professional roles, regions, and habitats in New York State. The conceptual clusters produced in this report provide a lens through which we can understand the topics of invasive species research in New York State, including: 1) Institutional support and best management practices, 2) invasive species and climate change impacts on human health and the economy, 3) tools and strategies, such as DNA and other research, 4) control, and 5) impacts and related research.

The results from this project show a high level of agreement between stakeholders, with greatest importance placed on ideas in the generated category of “Institutional support and best management practices”. The most highly rated research statements for importance related to climate change, prevention, development of metrics for estimating impacts of and success in management, and building partnerships, which are well-aligned with past suggestions that have driven current NYISRI initiatives and projects. From our top 10 statements rated for feasibility, half of the statements related to control methods and best management practices mention specific species, including: Japanese knotweed, jumping worms, slender false brome, mugwort, and tree-of-heaven.

NYISRI’s role to communicate and coordinate invasive species science to prevent and manage invasive species and their impact in NYS is well-suited for addressing several of the top-rated priorities identified, such as “developing a newsletter that synthesizes recent invasive-related research and disseminates it to practitioners” and “strategies for working with transportation departments to help prevent spread." Many statements called for more or better control strategies for certain species, while some spoke generally about developing tools, metrics, and guides for management projects, which relate to an overarching challenge many managers face: measuring success of their efforts.

Through this exercise, we gained a vast amount of information on stakeholder research priorities and ideas for improvement moving forward. Our hope is to build upon this approach in future research priority solicitations from our stakeholders, as well as inform others about the most important and feasible research-related statements. More information on NYISRI stakeholders and research needs for accomplishing invasive species management goals can be found at: http://www.nyisri.org/research/ny-research-priorities/

Background & Introduction

As part of New York’s comprehensive invasive species network, the New York Invasive Species Research Institute serves to improve the scientific basis of invasive species management by connecting research and practice across the state.

Fulfilling this role requires an understanding of both 1) the current landscape of invasive species research, and 2) research needs that land managers, policy makers, and professionals in the State of New York would like addressed in order to better manage invasive species in NYS. In pursuit of the latter, NYISRI has solicited research-related needs and priorities annually from stakeholders since 2015.

NYISRI stakeholders are a diverse group of individuals working across New York State in aquatic, marine, and terrestrial ecosystems. They represent entities spanning the regional bodies that manage invasive species (PRISMs), state agencies, researchers, policy makers, and the private sector.

In previous years, NYISRI conducted and manually processed informal surveys to capture and synthesize research priority suggestions. These surveys required significant effort from internal staff and key stakeholders. Additionally, the methods did not provide the opportunity for all stakeholders to contribute ideas and see other suggested research needs. Informal methods also made it difficult to evaluate priorities on importance and feasibility in a methodical and unbiased way. After a review of past approaches and potential alternative options, we selected a group concept mapping process.

This report presents the results of the novel application of this Group Concept Mapping process to gather and analyze stakeholder input on invasive species research needs in New York State. We implemented this new approach to improve upon past years' efforts. Specifically, this project aimed to address the following limitations from previous surveys: 1) increase the number and diversity of stakeholder participants, 2) improve the transparency of the overall research priority collection process, and 3) utilize a standardized methodology that could be repeated to compare results across years.

Group concept mapping methodology

Group concept mapping (GCM) is a qualitative and quantitative method of gathering and processing stakeholder input. The process is structured and time bound. Stakeholders participate in three distinct phases, including brainstorming, rating, and sorting. Each phase is described below:

Brainstorming: Ideas are submitted by participants in response to a question or prompt. The goal is to develop a comprehensive list of ideas that represent the spectrum of an issue. These ideas comprise the qualitative data, and are used in the rating and sorting phases below.

Rating: The ideas submitted in the brainstorming phase are rated by participants on a scale of 1-5 for certain qualities, creating quantitative data. In our case, we asked participants to rate ideas on their importance and feasibility.

Sorting: The ideas submitted in the brainstorming phase are categorized by participants according to their perspective.

The input from each phase can then be analyzed and transformed into graphical representations of participant input. In our case, with such a broad stakeholder group, group concept mapping provided a practical way to integrate feedback from those representing a diversity of locations, knowledge areas, and professions. It allowed us to evoke broader and deeper participation, resulting in better representation of the community and their needs. It also integrated participant contribution with equal weight and minimized facilitator bias. Demographic questions answered by participants at the

beginning of the process allowed for interpreting and comparting results from different stakeholder groups.

The process produced a range of maps that represent participant input. The most basic is called a two-dimensional point map, which assigns a point with x and y values to each idea based on how often participants sorted it together with the other ideas. Clusters of points are then outlined and named.

The ideas with the highest importance and feasibility are represented in multiple ways. Each idea is placed on a four-quadrant graph, with its importance score on the Y-axis and its feasibility score on the X-axis. The quadrants are divided by the means of importance and feasibility. These ratings can also be represented in the cluster maps and pattern matches.

Concept mapping is effective at identifying priorities or fundamental ideas of a topic as well the relationships between them. The process not only defines consensus among stakeholders, but also helps foster a shared understanding about the group, their ideas, and how an individual's perspective relates to the group's collective perspective. In some cases, this may be the most important benefit.

Process Overview

We began in October 2019 with an evaluation of previous efforts to gather and process stakeholder input, while identifying necessary improvements and potential options moving forward. The project team included: Carrie Brown-Lima (NYISRI Director), Audrey Bowe and Sam Talbot (NYISRI staff), and Bryan Dailey (technical advisor). After selecting concept mapping, we purchased a software license from Concept Systems, Inc. The details of the project were then determined, including the participants, questions, invitations, instructions, and schedule. We utilized Concept Systems Global MAX platform as the interface since its features were a better fit for the project.

Participants

One of our main objectives was to include broad participation from stakeholders working with invasive species in New York. This project addressed professionals who work with NYISRI and its partner organizations. This included approximately 2,000 people from various institutions. The brainstorming phase was open to anyone with knowledge of invasive species in New York. During the sorting and rating phase, we sent invitations to a smaller group of more targeted participants representing invasive species expertise from the organizations below.

The list of participating organizations included:

- Partnerships for Regional Invasive Species Management (PRISM)
- PRISM Partner Organization Representatives
- New York State Department of Environmental Conservation Invasive Species Coordination Unit (NYSDEC)
- New York Invasive Species Research Institute (NYISRI) Advisory Board
- New York Natural Heritage Program / iMapInvasives (NYNHP)
- New York Invasive Species Advisory Committee (NY ISAC)
- New York Invasive Species Council (NY ISC)

Questions & Schedule

This process was exempt from Cornell's Institutional Review Board due to the following: 1) input from individual participants was confidential and aggregated with other participants, 2) the questions were not about participants themselves but rather about their professional opinion, and 3) this was a systematic investigation not designed to generate generalizable knowledge. Nevertheless, we asked participants to acknowledge an informed consent to confirm they understood that their participation was voluntary and that their input would be confidential and aggregated. To make the submission of ideas as easy as possible for participants, during the brainstorming phase we did not require registration and instead made participation anonymous.

The prompt we asked participants to respond to in the brainstorming phase was: ***"A specific invasive species research-related need in my region or NYS is …"***

In order to illustrate the broad types of responses one might submit to the prompt, and to integrate some continuity from past input, we prepopulated the prompt with some of the top ideas from the previous years. The full set of ideas suggested are included in Appendix I.

Once this initial brainstorming phase was complete, we consolidated the submitted ideas by the project staff around 100 statements that could be evaluated by participants. The evaluation included sorting ideas into similar groups and then rating the ideas according to importance and feasibility.

We sent out a second call for participation in the sorting and rating phases, this time of a smaller group of more targeted participants representing the PRISMs, NYSDEC, NYISRI advisory board, NYNHP, NY ISAC, and NY ISC. To avoid exceeding our limit of 100 participants, we directly invited individuals from these stakeholder and partner

organizations. For those who participated in the sorting and rating phases, we asked general demographic questions, but did not require answers to these questions.

The four demographic questions asked about professional role related to invasive species in New York State, PRISM involvement, and regional and habitat focus. We described the questions and instructions for rating and sorting generally in an email invitation and in more detail on the concept mapping platform.

For the sorting process, participants who preferred a demonstration could view a video on the more complicated process of sorting, which is available at: youtube.com/watch?v=XhzVi7n_lqM. Consistent with group concept mapping methodology, there were no pre-set categories for sorting statements, and participants were asked to create their own. For the rating process, we asked participants to rate each statement on importance and feasibility from their perspective. Each rating fell on scale of 1 to 5, with 5 being most important and feasible.

Our group concept mapping phases followed the schedule below:

Phase	Dates
Brainstorming	4 November 2019 – 12 November 2019
Sorting	20 November 2019 – 5 December 2019
Rating	10 December 2019 – 13 January 2020

Results & Analysis

Participation and representation

The first indication we have of participation is 242 total visits to the website where 211 ideas were submitted. Since the idea generation phase did not require registration, we do not know how many unique individuals participated in this phase, and it is possible that some participants visited multiple times. The subsequent rating and sorting phases did require registration and also benefited from solid participation, including 56 unique individuals. In total, 35 participants sorted ideas, 46 participants rated ideas on importance, and 32 participants rated ideas on feasibility.

From responses to the demographic questions, we can see that the ideas were evaluated by participants from each of the professional roles, PRISM involvement levels, geographic regions, and habitat types. The responses count each person who participated in any of the three phases. Each of the questions, possible responses, and actual response levels are shown below.

Response Distributions

Role: "What best describes your role(s) related to invasive species in NYS?" The results show good distribution across the roles, with almost a third of participants identifying as land managers. The "other" response was selected often, and the typical write-in response was related to program and project administration (Figure 1).

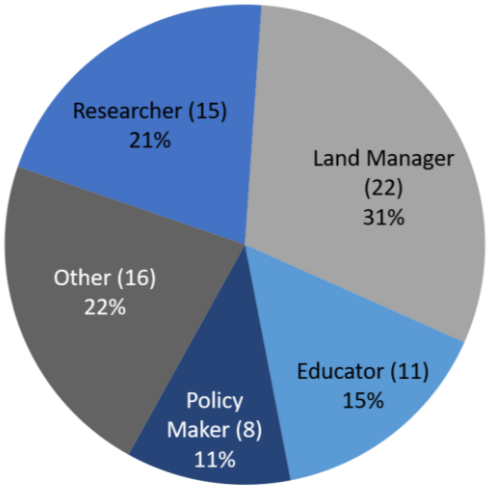

Figure 1. Role Response Distribution

PRISM Affiliation: "How involved are you with a Partnership for Regional Invasive Species Management?" The vast majority of respondents had a close relationship with their local PRISM either as a partner or a non-partner collaborator (Figure 2).

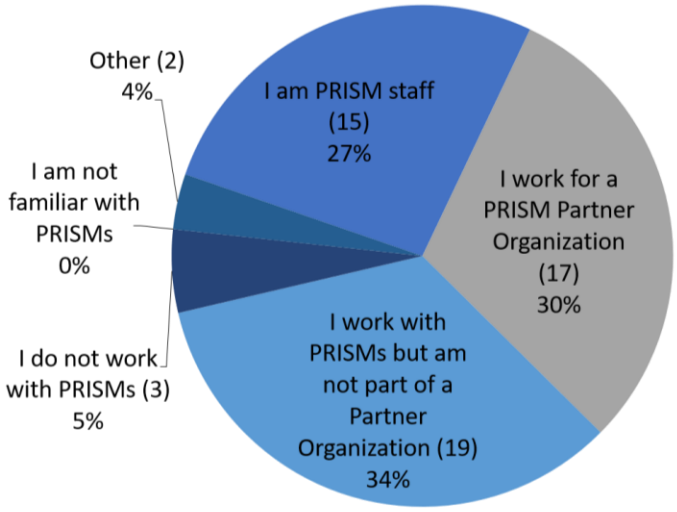

Figure 2. PRISM Response Distribution

PRISM Region: "In which NYS region(s) do you focus your work?" The possible answers were meant to reflect the PRISM geographies, but we worded the question to ensure that respondents unfamiliar with PRISMS would still be able to answer. Responses were distributed across the possible answers, with the highest number working statewide (Figure 3). For map of PRISM regions, refer to Appendix III.

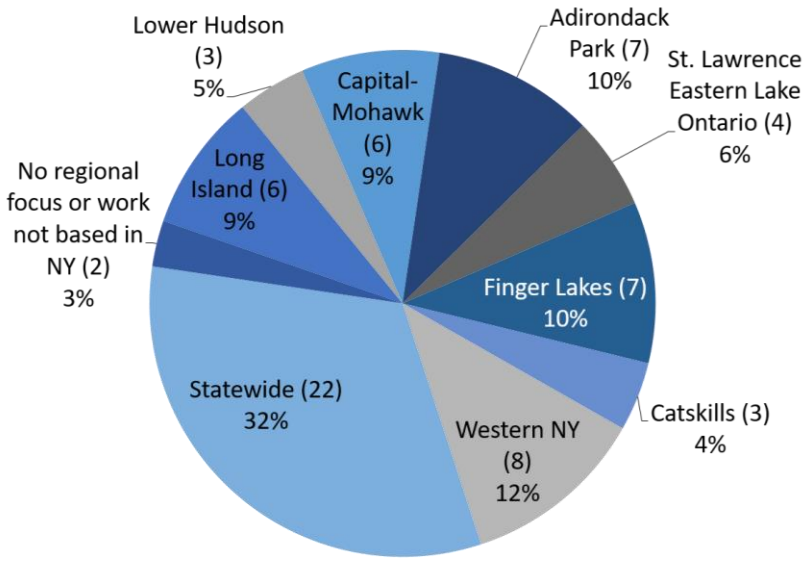

Figure 3. Region Response Distribution.

Combined Regions: As there are eight PRISM regions, however, the number of respondents in each region was relatively low and limits the potential for analysis at a regional level. We attempted merging the eight regions into four groups of adjacent regions to provide more meaningful responses, and possibly facilitate regional collaboration (Figure 4). For map of the combined PRISM regions, refer to Appendix IV.

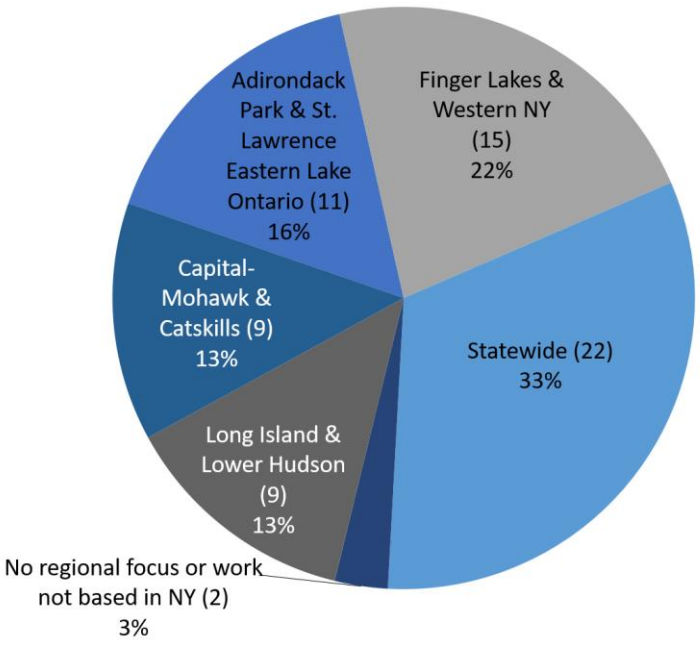

Figure 4. Combined Regions Response Distribution

Habitat focus: "In which type of habitat(s) do you focus your invasive species work? Once again, responses were distributed across each of the possible answers (Figure 5).

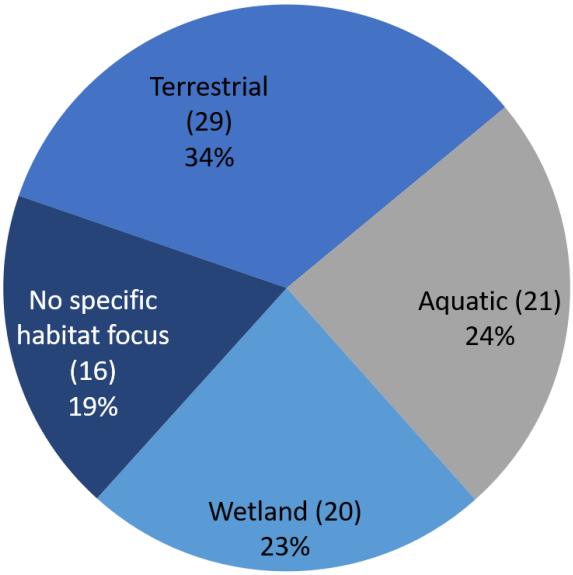

Figure 5. Habitat Response Distribution

The demographic segments indicate broad participation, but the number of participants in each segment limited the ability to make statistically significant analyses. Exceptions were between the answers to the PRISM affiliation and between those whose region was Statewide versus a single region. The response rates for the two rating phases are below in Table 1.

Table 1. Response rates for demographic and rating questions

	Statewide	Long Island	Lower Hudson	Catskills	Capital-Mohawk	Adirondack Park	St. Lawrence Eastern Lake	Finger Lakes	Western NY	Total
Importance	18	4	2	2	4	6	1	4	6	29
Feasibility	12	4	1	2	4	4	0	3	5	23

Brainstorming

In the brainstorming phase, a total of 211 ideas were submitted. We then took this list and consolidated it to 115 unique ideas by merging similar statements and excluding suggestions that were not research-related. The excluded ideas consisted of statements that were deemed unrelated to research or the role of NYISRI, and therefore were not appropriate for this exercise. Nonetheless, removed statements raised interesting themes around education and regulation.

Sorting

The data from the sorting phase is used to create the base, 2-dimensional concept maps. Points that appear closer together on the map represent ideas that participants sorted together more frequently (Figure 6). The clusters and the ideas that form them are discussed below.

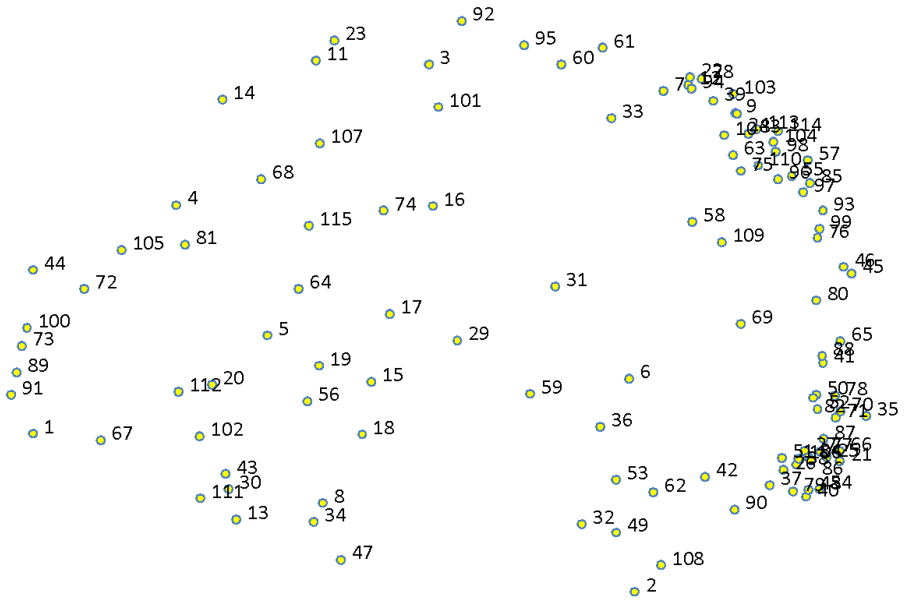

Figure 6. Point Map representing each idea as a single point and the distance between points represents the relative frequency at which participants groups the ideas together while sorting. Points that are closer together represent ideas that were frequently sorted together by participants. Those farthest away from each other were infrequently or never sorted together.

We used cluster analysis to identify groups of ideas within our brainstormed statements. Determining the number of clusters is a subjective decision, and more than one scenario may be valid. After review of possible scenarios, a map with five clusters seems to organize the ideas in the most logical way for our purposes (Figure 7). We interpreted each cluster generated by the software, and gave a title that best seemed to summarize the ideas contained, shown below (Figure 8). A final list of ideas organized by cluster is shown in Appendix II.

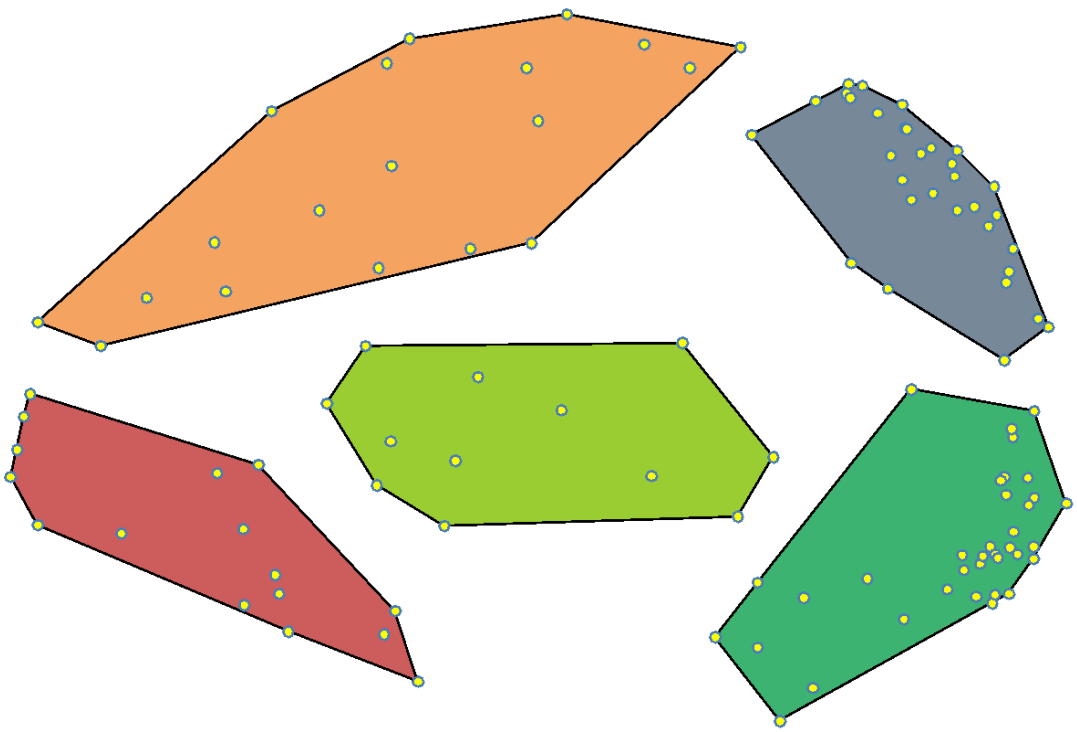

Figure 7. Five-Cluster Map, which organizes ideas by cluster and preserves location of ideas from their initial placement in the base point map.

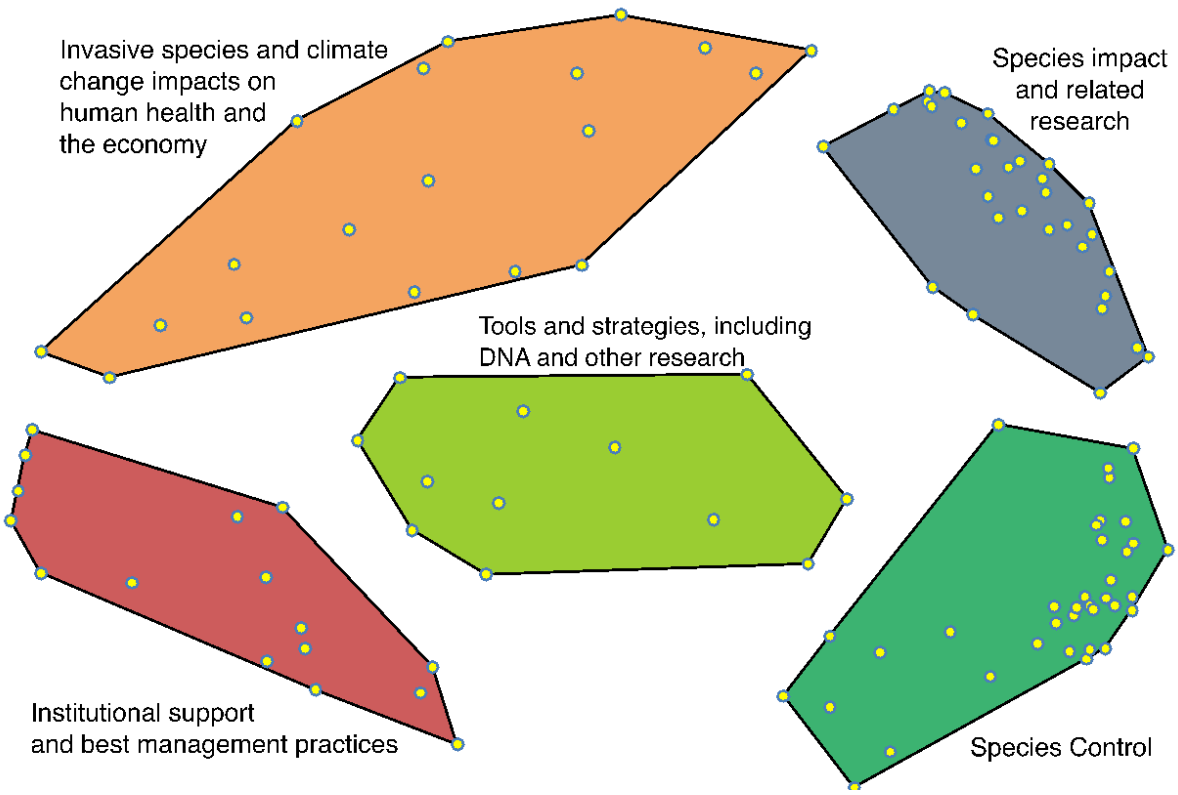

Figure 8. Five-Cluster Map with Names generated by interpreting each cluster to best summarize the ideas contained.

Rating

Based on the results of participant ratings of statements on a 1 - 5 scale, we were able to generate three ranked lists of statements:

- Importance: how important someone felt a statement would be to address
- Feasibility: how easy someone felt a statement would be to address
- Importance + Feasibility: the sum of importance and feasibility

The first two lists were based on average ratings of all participants for these categories, from highest to lowest. For the Importance + Feasibility list, we summed the average rating for importance and feasibility, giving each equal weight.

Top 10 for Ranked Lists

We generated top 10 lists of statements for each of the three ranked list categories. Overall themes we identified in the 10 statements rated most highly for importance included climate change, prevention or being proactive, developing metrics, and protocols & ways of assessing invasive species management efforts (Table 2).

Table 2. Top 10 statements rated for importance.

IMPORTANCE RANK	SUM RANK	STATEMENT
1	2	Designing and testing a protocol and developing metrics to assess the effectiveness of invasive species control measures.
2	4	Strategies for working with transportation departments to help prevent spread.
3	1	Continued identification of species (in horticulture & from the south) to screen for potential addition to Part 575 regulations.
4	10	Understanding the effect that a changing climate will have on the range and dynamics of existing invasive species.
5	5	Development of simple metrics for success of restoration efforts - for use in the monitoring phase after initial IS removal and to allow for quicker intervention. i.e., thresholds that are low enough to allow for (and recommend) intervention before issues become too costly to address.
6	14	Estimating efficacy of invasive species management in NYS to date. Have the benefits outweighed the costs?
7	6	Modeling what species we need to look out for due to climate change.
8	24	Understanding the long-term impact of invasive forest pests on forest ecosystem functions and services
9	7	Developing tools to connect New York managers to managers in the mid-Atlantic to put together proactive best management practices for invasive species likely to expand into New York with climate change.
10	12	Advancing swallow-wort biocontrol development and release.

For our top 10 list in feasibility, half of the statements mention specific species, including: jumping worms, Japanese knotweed, slender false brome, mugwort, tree-of-heaven. All of the statements mentioning specific species had to do with control methods and best management practices. Common themes included communicating research, and basic or biological research questions (Table 3).

Table 3. Top 10 statements rated for feasibility.

FEASIBILITY RANK	SUM RANK	STATEMENT
1	3	Developing a newsletter that synthesizes recent invasive-related research and disseminates it to practitioners.
2	1	Continued identification of species (in horticulture & from the south) to screen for potential addition to Part 575 regulations.
3	33	Establishing the temperature threshhold where composting kills jumping worm cocoons.
4	8	Establishing more best management practices for common invasives. These should utilize both organic and synthetic methods. And include comprehensive information about reproduction: seed dispersal, rhizome spread GGD time, longevity of seed viability.
5	27	Researching efficacy of Japanese knotweed (Reynoutria spp.) control options.
6	61	Researching the timing of flower and seed production in slender false brome. When does the species typically produce flowers, and how long after flowers appear is seed produced?
7	58	Researching efficacy of Mugwort (Artemisia vulgaris) control options.
8	66	Understanding seed viability of slender false brome. Research into conditions needed for germination of this species and seed viability after transportation in water.
9	41	Researching best management practices for how to control tree-of-heaven (Ailanthus altissima).
10	19	Communicating research-based recommendations for reducing the introduction of forest pests to policy makers.

In our sum Importance + Feasibility list, unsurprisingly, nine out of ten of the top ten statements also show up on either the top 10 Importance or top 10 Feasibility. The exception to this was the 9th statement: "Establishing regional cooperation with neighboring states where many invasive species are coming from. Let's stop them before they enter NYS." Overall themes for this list fell under climate change, prevention, developing metrics, and establishing new connections and engagement with partners (Table 4).

Table 4. Top 10 statements with summed Feasibility and Importance Rankings.

Sum Rank	Importance Rank	Feasibility Rank	Statement
1	3	2	Continued identification of species (in horticulture & from the south) to screen for potential addition to Part 575 regulations.
2	1	13	Designing and testing a protocol and developing metrics to assess the effectiveness of invasive species control measures
3	34	1	Developing a newsletter that synthesizes recent invasive-related research and disseminates it to practitioners.
4	2	14	Strategies for working with transportation departments to help prevent spread.
5	5	11	Development of simple metrics for success of restoration efforts - for use in the monitoring phase after initial IS removal and to allow for quicker intervention. I.E. thresholds that are low enough to allow for (and recommend) intervention before issues become too costly to address.
6	7	17	Modeling what species we need to look out for due to climate change.
7	9	16	Developing tools to connect New York managers to managers in the mid-Atlantic to put together proactive best management practices for invasive species likely to expand into New York with climate change.
8	28	4	Establishing more best management practices for common invasives. These should utilize both organic and synthetic methods. And include comprehensive information about reproduction: seed dispersal, rhizome spread GGD time, longevity of seed viability.
9	13	18	Establishing regional cooperation with neighboring states where many invasive species are coming from. Let's stop them before they enter NYS.
10	4	44	Understanding the effect that a changing climate will have on the range and dynamics of existing invasive species.

Integrating Rating & Sorting Results

Once we had ratings on importance and feasibility, we could then integrate the sorting clusters with this information. The clusters with most important and feasible statements are illustrated in the two cluster rating maps below (Figures 9 and 10). Clusters that appear with more layers scored higher for net importance and feasibility, respectively. In both cases, the most highly rated statements are in the clusters on the left. These clusters contain statements that are less likely to be specific to a species, region, or habitat. The two clusters on the right contain statements that are more specific, and perhaps individually relevant to a smaller group of participants.

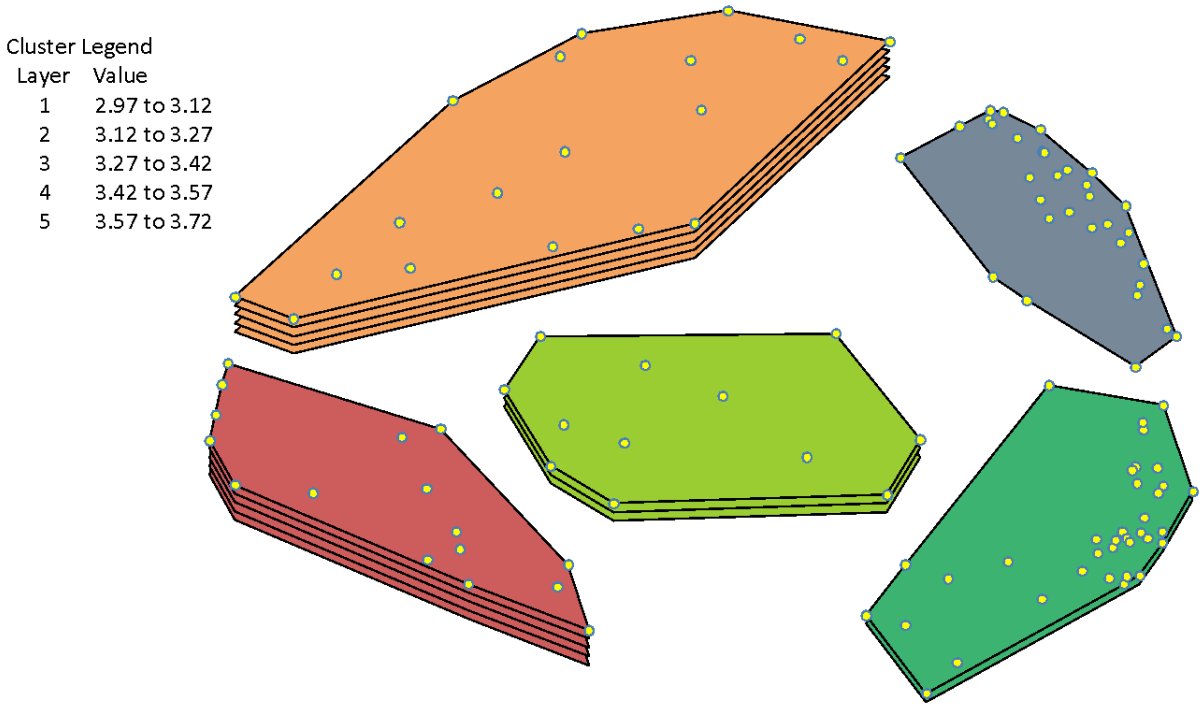

Figure 9. Cluster Rating Map for Importance. Clusters that appear with more layers scored higher for net importance.

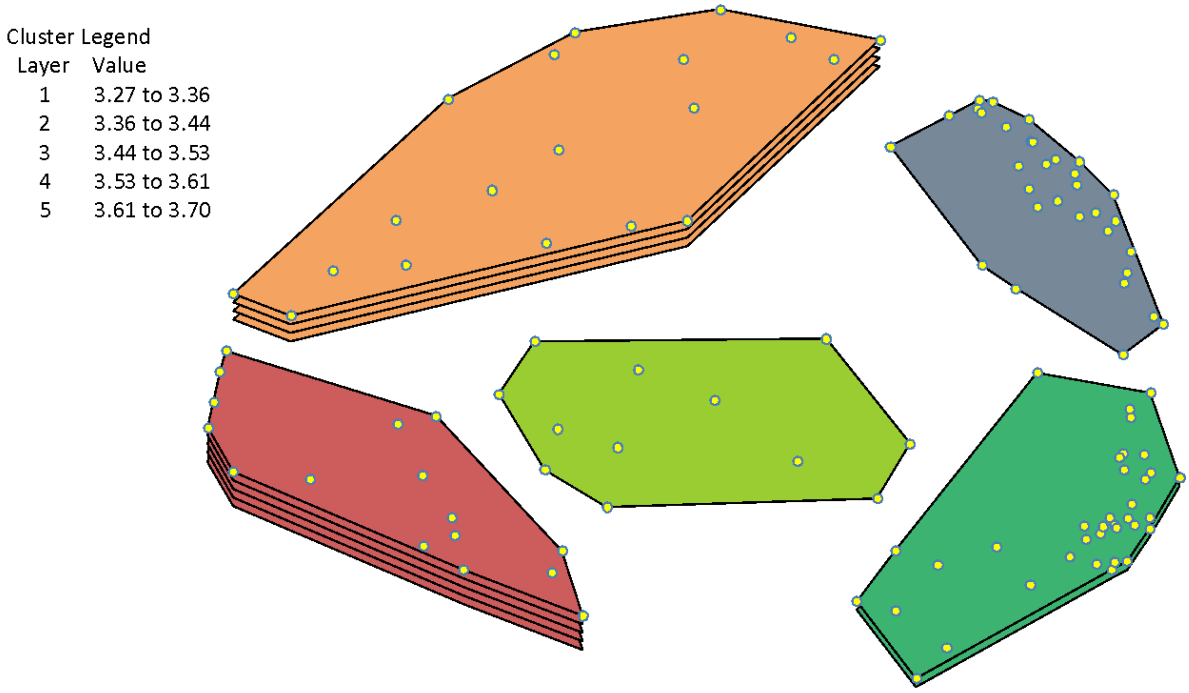

Figure 10. Cluster Rating Map for Feasibility. Clusters that appear with more layers scored higher for net feasibility.

Priority Matrix

The grid below illustrates the importance (Y-axis) and feasibility (X-axis) of the statements, with mean scores dividing statements into four quadrants (Figure 11). The lower left quadrant contains the statements that are low importance and feasibility, the top left quadrant is high importance and low feasibility, the bottom right quadrant is low importance and high feasibility, and the top right is high in both. Thirty-eight statements fall into the top right quadrant of high importance and high feasibility. The statements and their respective rating scores are listed in Appendix I.

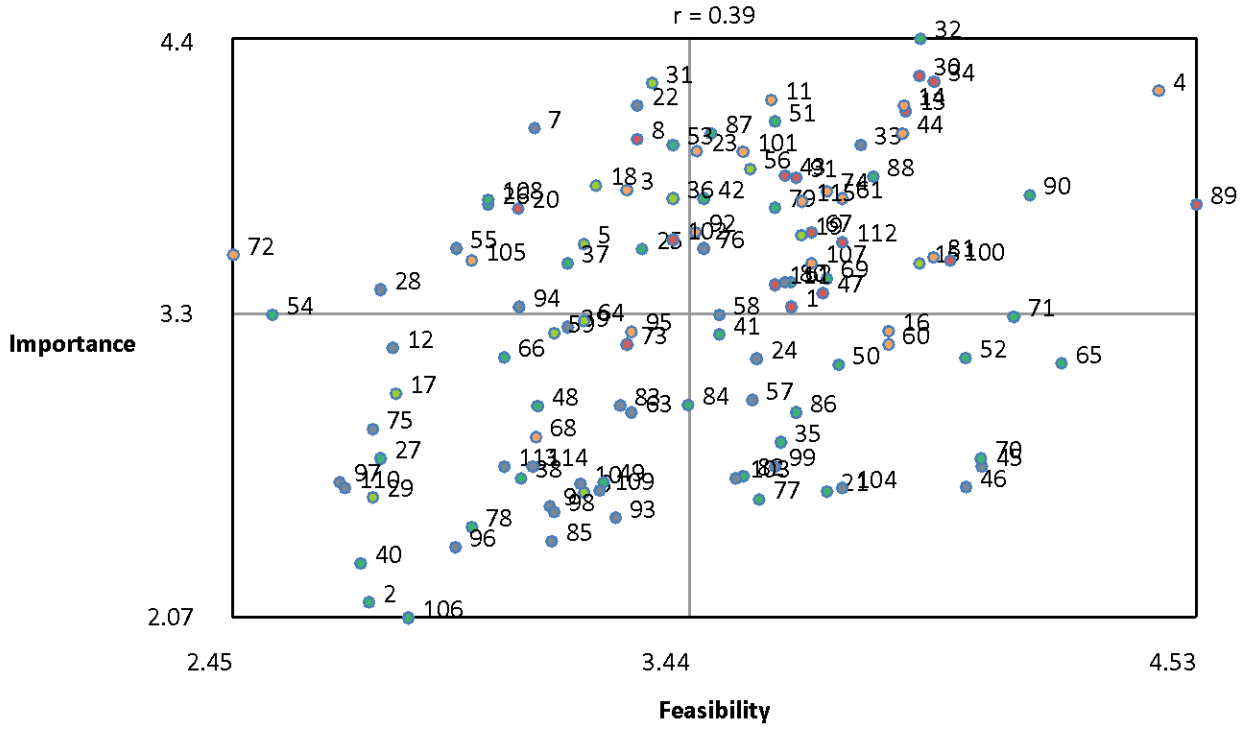

Figure 11. Distribution of statements according to Importance and Feasibility, each represented by a dot and its statement number. Lines diving quadrants are the mean score for each of the two ratings.

Rating Differences Between Stakeholders

Pattern Matches, also known as parallel coordinates, allow the comparison of ratings between participant groups. The groups are defined by participant responses to the demographic questions (i.e. PRISM region, role, etc.). There was broad agreement across groups about the relative importance of idea clusters. Participants did not rate the clusters themselves, but rather the individual ideas in the clusters. The average rating of the ideas within the clusters by different participant groups can then be more easily compared visually.

The relative importance of idea clusters was consistent across most participant groups, most commonly in the following order:

1. Institutional support and best management practices (red)
2. Invasive species and climate change impacts on human health and the economy (orange)
3. Tools and strategies, including DNA and other research (light green)
4. Invasive species control (dark green)
5. Invasive species impact and related research (grey)

This relative importance was consistent across those who worked in different habitats and across those in the roles of researcher and educator. The figure below illustrates the rating by researchers compared to non-researchers (Figure 12).

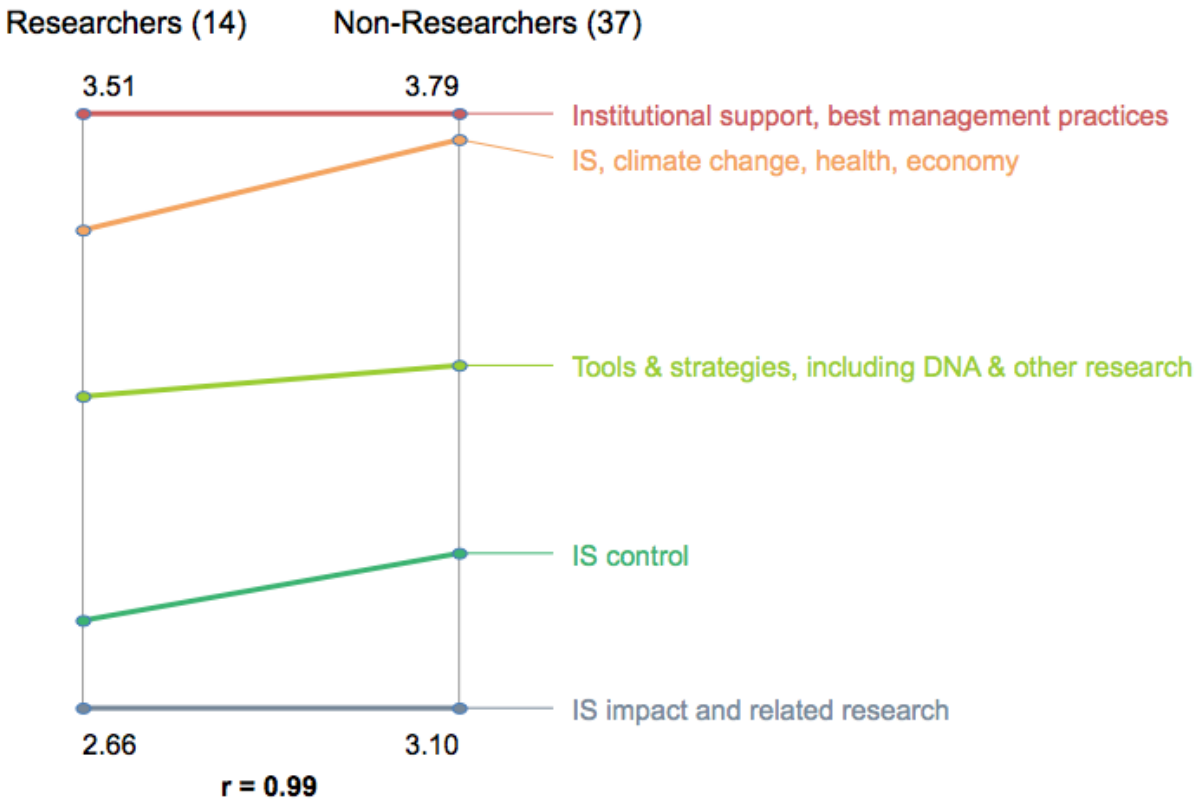

Figure 12. Importance Pattern Match between Researchers and Non-Researchers.

One significant ($p < 0.05$) difference in the relative importance ratings is illustrated below (Figure 13). Policy Makers rated the ideas in Tools and strategies, including DNA and other research (light green) as most important.

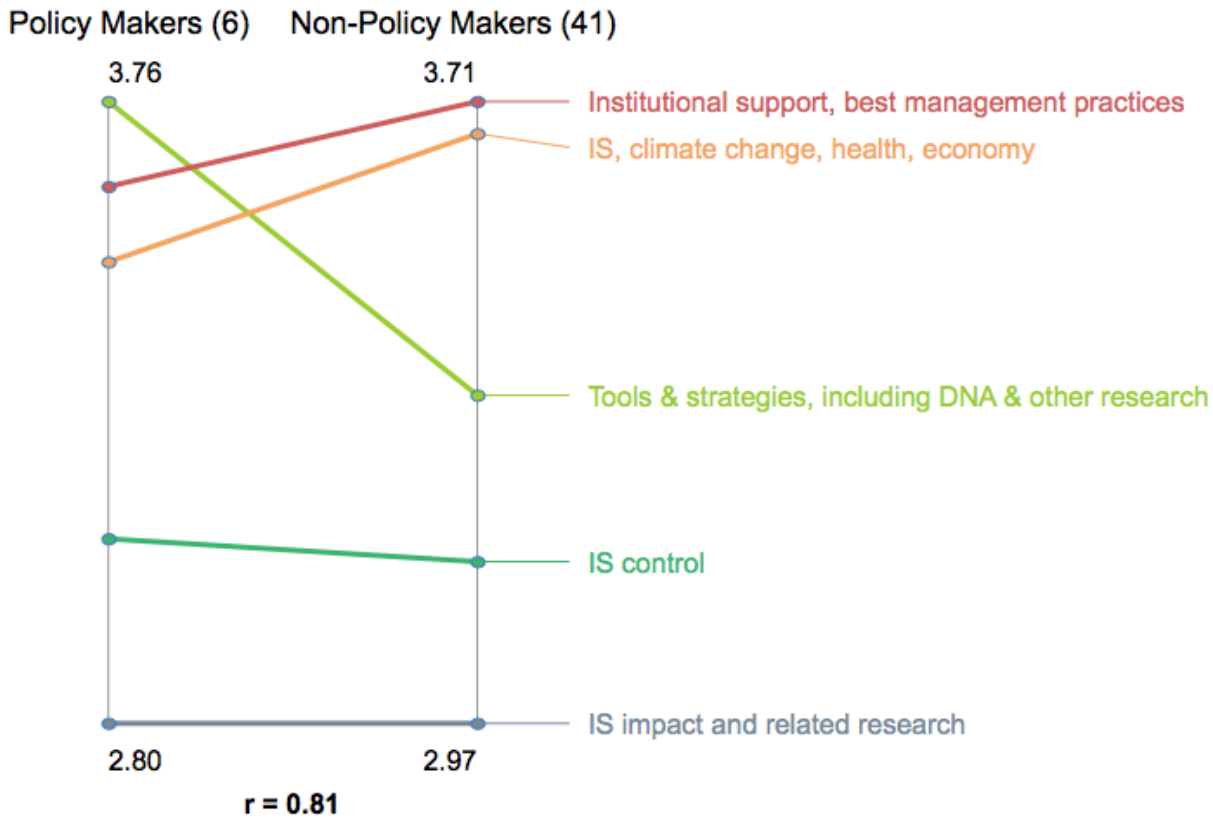

Figure 13. Importance Pattern Match between Policy Makers and Non-Policy Makers

Discussion

The main objective of this work was to identify New York State invasive species research needs using a reproducible process that would be more inclusive, capture comprehensive stakeholder input, and minimize manual staff effort.

The results from the demographic questions demonstrate that our study included participation across professional roles, regions, and habitats in New York State and therefore responses are representative of a wide array of relevant stakeholders.

Responses to the question on PRISM affiliation indicates that all participants were familiar with PRISMs and almost all had a working relationship with them. The high number of initial ideas contributed during the brainstorming phase and subsequent consolidation to 115 suggest that the final list of ideas which were rated was comprehensive. Our ability to consolidate the ideas indicates that idea submissions

began to overlap or duplicate, and that the ideas generated during brainstorming sufficiently represented the spectrum of existing ideas and thorough idea generation.

While some ideas were removed from the final list because they were not research-related, they nevertheless offered some interesting themes, which may warrant further exploration. A prominent example is addressing the supply chain of commercially available invasive species, including regulation and enforcement at ports of entry, coordination between bordering states, and education programs targeted to nursery owners and operators.

It is important to recognize that topics which may be rated very important or feasible by someone in a particular role or in a region or habitat may not appear prioritized when averaged across all participants. Ideas that are focused on species and specific ideas constituted the largest cluster. While the overall priorities may be most relevant for NYISRI and others with a statewide perspective, that should not diminish the importance or feasibility of the low rated ideas in a more focused context such as a specific region.

Sorting

The conceptual clusters that we arrived at through the sorting and rating process provide a lens through which we can understand the topics of invasive species research in New York State. The results from this project show a high level of alignment between stakeholders, with the ideas in Institutional support and best management practices being rated most important.

Reviewing the clusters and associated titles which emerged, we did not always feel they reflected cohesive or actionable groups of statements. For example, a few statements which included climate change were sorted into multiple groupings, making it hard to interpret overall importance of some topics that we identified.

While the five clusters that emerged were interesting, since we largely work on a project-scale, the specific statements and their individual rankings were the most valuable output from this process.

Top Research Needs

The most highly-rated research statements, included climate change, prevention, development of metrics for estimating impacts of and success in management, and building partnerships. These topics are largely well-aligned with past suggestions that have driven current NYISRI initiatives and projects. Several examples are listed below (Table 5).

Climate Change & Prevention

The Northeast Regional Invasive Species and Climate Change (RISCC) Management Network was established in response to our stakeholders' requests to understand how to manager for invasive species in light of climate change back in 2016. Over the past five years, the network has over 600 members now and is well positioned to address many of the climate-change related statements. More information on the research and resources offered by the Northeast RISCC Network can be found at: www.risccnetwork.org.

Table 5. Climate change-related statements.

Sum Rank	Importance Rank	Feasibility Rank	Statement
1	3	2	Continued identification of species (in horticulture & from the south) to screen for potential addition to Part 575 regulations.
6	7	17	Modeling what species we need to look out for due to climate change.
7	9	16	Developing tools to connect New York managers to managers in the mid-Atlantic to put together proactive best management practices for invasive species likely to expand into New York with climate change.
10	4	44	Understanding the effect that a changing climate will have on the range and dynamics of existing invasive species.

Communication

NYISRI's role, to communicate and coordinate invasive species science to prevent and manage invasive species and their impact in New York State is well-suited for addressing another top priority of "Developing a newsletter that synthesizes recent invasive-related research and disseminates it to practitioners." In the months after receiving this suggestion, NYISRI established and now maintains a monthly newsletter and blog featuring researchers and research.

One communications-related statement which was highly rated was "Strategies for working with transportation departments to help prevent spread." This came up as number 4 for Sum Importance & Feasibility and number two for Importance. NYISRI has identified this as an opportunity for future work.

Developing Tools & Metrics

Many statements called for more or better control strategies for certain species, while some spoke generally about developing tools, metrics, and guides for invasive species management projects. One of the challenges that invasive species managers face is knowing whether their management practices have successfully achieved the goals.

NYISRI, and the Blossey Lab at Cornell University have been facilitating discussions around the topic, are currently developing methodologies for evaluating ecological success of management activities and hosted a workshop to discuss the topic with stakeholders across NYS. The statements shared on this topic will require a more comprehensive approach to address these needs, and will be an active area of work in the future.

Recommendations

Group Concept Mapping Approach & Process

The group concept mapping approach worked well to meet our project objectives. The ranking exercise proved most useful for informing and aligning our actions, and the ability to understand and compare differences in stakeholder priorities proved valuable. We found the sorting aspect of the group concept approach to be less valuable, in part due to difficulties identifying practical differences between the clusters generated by sorting.

While we received a fair amount of participation, this is an area that could be improved moving forward. We suggest the following ideas for enhancing participation:

1. Future efforts could consider focusing different groups of participants on different phases of the project;
2. The majority of participants could fill out demographic questions and importance ratings, while the project team and selected participants could focus on the sorting and feasibility ratings;
3. Focusing on fewer activities could increase participation where it is most needed as well as shortening the time required for each phase.

Our schedule also overlapped with the busy holiday and end of year schedules, which certainly influenced participation. Starting earlier in the year could help avoid this in the future.

A bigger picture recommendation for future work would be to consider comparing the results of this project to smaller or larger scale regions. Doing so could help foster a greater understanding of invasive species priority needs at differing scales. For example, a multi-state or national process could offer valuable insights about potential

collaborations and synergies for addressing research needs at a larger scale. A process with sufficient participation would allow more detailed results for local geographies, as well as comparisons between them.

Research Priorities Moving Forward

This process provided us with a vast amount of information on stakeholder research priorities. Moving forward, the statements and rankings generated in this report will inform and balance the projects that NYISRI chooses to engage in, promote, or seek funding for as well as the kinds of information that we share via webinars, workshops and other communications avenues.

As a first step, we will engage in an internal review of all research priority statements to come out of this process, and identify venues and strategies for addressing top statements. We will promote these needs among researchers and facilitate their engagement on these issues.

In order to facilitate transparency and promote addressing research needs, we have also made the results from this and past processes publicly available on our website: http://www.nyisri.org/research/ny-research-priorities/. Our hope is that we can build upon this information in future solicitations of research priorities from our stakeholders, as well as inform researchers and other interested parties of the most important and feasible research-related statements to address.

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We appreciate the time and feedback from all of our stakeholders who were involved in this process. We count not do this work without the ongoing support and feedback from the eight PRISM leaders: Linda Rohleder, Andrea Locke, John Thompson, Kristopher Williams, Rob Williams, Tammara Van Ryn, Bill Jacobs, Hilary Mosher, and their teams. We also thank the New York iMapInvasives team, and the NYSDEC Invasive Species Coordination Unit.

Appendices

Appendix I. All Statements, Sorted by Sum of Importance and Feasibility Ratings

Sum	Imp.	Feas.	#	Statement
8.68	4.23	4.45	4	Continued identification of species (in horticulture & from the south) to screen for potential addition to Part 575 regulations.
8.28	4.34	3.94	32	Designing and testing a protocol and developing metrics to assess the effectiveness of invasive species control measures.
8.21	3.67	4.53	89	Developing a newsletter that synthesizes recent invasive-related research and disseminates it to practitioners.
8.18	4.24	3.93	30	Strategies for working with transportation departments to help prevent spread.
8.12	4.16	3.97	34	Development of simple metrics for success of restoration efforts - for use in the monitoring phase after initial IS removal and to allow for quicker intervention. For example, thresholds that are low enough to allow for (and recommend) intervention before issues become too costly to address.
8.01	4.11	3.90	14	Modeling what species we need to look out for due to climate change.
7.95	4.04	3.90	13	Developing tools to connect New York managers to managers in the mid-Atlantic to put together proactive best management practices for invasive species likely to expand into New York with climate change.
7.88	3.71	4.17	90	Establishing more best management practices for common invasives. These should utilize both organic and synthetic methods. And include comprehensive information about reproduction: seed dispersal, rhizome spread GGD time, longevity of seed viability.
7.87	3.98	3.90	44	Establishing regional cooperation with neighboring states where many invasive species are coming from. Let's stop them before they enter NYS.
7.79	4.17	3.61	11	Understanding the effect that a changing climate will have on the range and dynamics of existing invasive species.
7.71	3.91	3.81	33	Developing tools for assessing the impact of invasive species.
7.67	4.04	3.62	51	Advancing swallow-wort biocontrol development and release.
7.64	3.81	3.83	88	Completing research and submitting petition for the water chestnut biological control project.

7.51	4.16	3.35	31	Estimating efficacy of invasive species management in NYS to date. Have the benefits outweighed the costs?
7.48	3.75	3.73	74	Assessing drivers of aquatic invasive species spread: Do lakes that have New York State installed public boat launches have a greater percentage of invasive species than lakes without? Do fishing boats carry more invasive species than pleasure boats and do they travel to more lakes in a season, thus potentially spread more invasive species?
7.48	3.51	3.97	81	Developing recommendations of native plants for restoration that are 'climate smart' - i.e. not necessarily native to New York, but adapted to climate warming and unlikely to become invasive.
7.46	3.70	3.77	61	Estimating the impact of forest pests on the NY economy.
7.46	3.98	3.48	87	Evaluating potential for select biological control agents for control of Japanese knotweed (*Reynoutria spp*).
7.45	3.45	4.00	100	Communicating research-based recommendations for reducing the introduction of forest pests to policy makers.
7.44	3.78	3.67	91	Identifying effective methods of outreach to and coordination with commercial suppliers of products which can be widely distributed (compost and mulch facilities, plant nurseries, agriculture suppliers) regarding invasive species detection and control.
7.43	3.88	3.55	101	Providing impact studies of invasive species and forecasting distribution models, to help prevent the spread before species become widespread throughout NYS. In many cases, NYC and the southern tier is a gateway with many widespread species. Studies that focus on impact there could help prevent throughout the rest of the state.
7.43	3.79	3.64	43	Tools and frameworks to help prioritize limited resources in order to minimize impacts and reach management goals.
7.41	3.84	3.57	56	Using eDNA to target multiple species/taxa in both the aquatic and terrestrial environments for early detection/rapid response.
7.39	4.07	3.32	22	Understanding the long-term impact of invasive forest pests on forest ecosystem functions and services.
7.39	3.89	3.50	23	Understanding interactions of climate change and exotic forest pests, including expansion of pest ranges and vulnerability of trees.
7.38	3.44	3.93	15	Testing whether detection dogs are more effective at detecting Tier 1 species than traditional search methods

7.37	3.23	4.14	71	Researching efficacy of Japanese knotweed (*Reynoutria spp.*) control options.
7.33	3.93	3.40	53	Developing strategies and infrastructure to screen for and treat invasive seed banks in topsoil and gravel pits.
7.31	3.61	3.70	67	Identifying best strategies for directing volunteers to search for new infestations (early detection).
7.31	3.59	3.72	19	Developing eDNA tests for aquatic invasive plants.
7.30	3.68	3.62	79	Developing IPM tools to manage spotted lanternfly in grapes, forests, and landscapes.
7.29	3.52	3.77	112	Structured prioritization of early detection surveys across species and locales.
7.29	3.05	4.24	65	Establishing the temperature threshold where composting kills jumping worm cocoons.
7.26	3.93	3.32	8	Testing which strategies (user fees, boat launch lockdowns, mandatory inspection) are most effective at reducing the spread of aquatic invasive species.
7.24	3.54	3.70	107	Modeling habitat suitability for the high priority aquatic invasive plants.
7.18	3.68	3.50	115	Conducting a horizon scan of introduction pathways to New York (including from domestic and international sources) to enable better targeting of prevention and early detection interventions.
7.16	3.70	3.47	42	Comparing the environmental impacts of herbicide usage versus other methods of invasive control.
7.12	4.02	3.10	7	Understanding how invasive species have impacted biodiversity in NYS over time, and how this can help pinpoint biodiversity areas at highest risk.
7.12	3.72	3.40	36	Understanding which planting strategies would maximize the survival, growth, and recruitment of native plants in natural areas, in nurseries, and in afforestation sites? Would a combination of annuals, early flowering perennials, or fall flowering perennials that leaf out early prevent invasive species from dominating?
7.11	3.38	3.73	69	As volunteers participate in invasive removals, test the following: 1) what grows back at the site on its own, 2) what grows back at the site if it is deer-fenced; 3) what native plants can be quickly seeded or planted to serve as a filler and compete with returning invasives until a restoration project has been implemented.
7.10	3.07	4.03	52	Researching best management practices for how to control tree-of-heaven (*Ailanthus altissima*).
7.09	3.22	3.87	16	Modeling which areas within New York the Spotted Lanternfly will establish.
7.08	3.78	3.30	3	Assessing and addressing the potential of public health pests making their way into NYS and the disease vectors like invasive ticks, which have already arrived.

7.07	3.35	3.72	47	Establishing the most effective education and outreach strategies for spotted lanternfly.
7.07	3.41	3.66	62	Establishing the most cost-effective methods to monitor hemlock health, Hemlock Woolly Adelgid, and Elongate Hemlock Scale over a large landscape.
7.05	3.76	3.29	18	Developing eDNA for forest pests and their biocontrols.
7.01	3.56	3.45	92	Improving information on the connection between invasive species and human health and economics/cost of living.
7.01	3.37	3.64	80	Determining the epidemiology of beech leaf disease and potential mitigation measures or prevention of spread.
6.99	3.12	3.87	60	Identifying invasive species that have a negative economic impact on agriculture including the horticulture industry.
6.98	3.58	3.40	102	Using artificial intelligence/computer learning to analyze photos submitted by citizen scientists for accuracy.
6.98	3.36	3.62	111	Structured prioritization of state resource allocation for managing established Invaders, accounting for federal resource investments.
6.97	3.50	3.47	76	Understanding the impact of various invasive management strategies on soil health.
6.94	3.36	3.58	1	Comparing strategies (gamification, location-based alerts, etc.) for retaining citizen scientists and volunteers for invasive species initiatives.
6.83	3.50	3.33	25	Assessing the efficacy and developing new control strategies for hemlock woolly adelgid (*Adelges tsugae*).
6.82	3.61	3.21	5	Developing artificial intelligence/computer learning tools to analyze large-scale spatial digital imagery databases.
6.80	3.05	3.76	50	Researching best management practices for how to eradicate, contain, and suppress Japanese stilt-grass (*Microstegium vimineum*).
6.79	3.72	3.06	108	Developing and sustaining large-scale biological control rearing facilities.
6.74	2.67	4.07	70	Researching efficacy of Mugwort (*Artemisia vulgaris*) control options.
6.74	3.24	3.50	58	Establishing the current distribution of jumping worms (*Amythas spp.*). Are they spreading in commercial plant stock? Compost? Soil?
6.72	3.66	3.06	20	On a regional or statewide basis, institute/test an early-warning/early detection system survey of lakes (and possibly river systems) using environmental DNA. Spatial priorities for such a system could be set in consultation with DEC, PRISMS and other stakeholder groups based on where the biggest bang for the buck would be if a harmful species was detected.

6.71	2.64	4.07	45	Researching the timing of flower and seed production in slender false brome. When does the species typically produce flowers, and how long after flowers appear is seed produced?
6.70	3.70	3.00	26	Developing better management tools for hydrilla (*Hydrilla verticillata*).
6.69	3.11	3.58	24	Determining the impact that quagga/zebra mussels have on nutrient levels and harmful algal blooms in lakes.
6.66	3.16	3.50	41	Understanding the environmental impacts of low-dose pesticide application techniques (i.e. cut stump application of triclopyr) over short and long term (impacts of breakdown products and movement through the environment from application site).
6.61	3.44	3.17	37	Researching and making available non-herbicidal treatments.
6.60	2.56	4.03	46	Understanding seed viability of slender false brome. Research into conditions needed for germination of this species and seed viability after transportation in water.
6.58	3.21	3.37	95	Developing a carbon loss model which estimates the amount of carbon released into the atmosphere as the result of deforestation by invasive forest pests and pathogens. This can be used to determine the potential impacts on climate change as a result of deforestation.
6.52	2.85	3.67	86	Developing methods for controlling and removing Japanese angelica tree (*Aralia elata*).
6.52	3.22	3.30	73	Establishing a public / private partnership involving local businesses, local government, NFP's and individuals who work together with IS groups and scientists to fight IS. The government cannot do it alone.
6.47	2.90	3.57	57	Understanding Japanese stiltgrass (*Microstegium vimineum*) and its interaction with native flora, and Jumping worm (*Amythas spp*) species.
6.47	3.26	3.21	64	Identifying factors that influence invasives reporting bias in the statewide database.
6.44	3.21	3.23	39	Better understanding of the impact that aquatic invasive plants have on internal nutrient loading of lakes and embayment's and the potential of aquatic invasive plants to facilitate harmful algae blooms.
6.43	3.50	2.93	55	Understanding the extent and rate of invasion, impacts, and long-term threat of the multiple Asian Worm/Jumping Worm species on forest ecosystems and critical watersheds? Our processes seem best tuned to respond to invasive plants, insects, and pathogens, not worms. But if these prolific leaf-litter-

				strippers become broadly established, their full-stack ecosystem impact could be severe and permanent.
6.42	3.45	2.96	105	Addressing the political/legislative/economic issues behind invasive species in New York State in addition to the biological.
6.38	2.93	3.45	84	Developing a control for wild parsnip (*Pastinaca sativa*) as it seems to be flourishing everywhere, especially along travel corridors.
6.37	2.74	3.63	35	Understanding the relative effectiveness and merits of different methods for controlling Eurasian water milfoil by hand-harvesting, including hand-pulling by SCUBA divers, diver-assisted suction harvesting (DASH), and initial treatment with herbicides followed by harvesting.
6.34	3.27	3.07	94	Understanding the actual impacts of some of the aquatic species. If there is no to minimal impact then maybe resources are better spent elsewhere but without knowing the actual impacts of a species this decision can't be made.
6.32	2.56	3.77	104	Assessing the impact of barberry (*Berberis spp.*).
6.31	3.17	3.14	59	Evaluating the role of biotechnology in addressing various invasive species threats (social acceptance and/or scientific feasibility for different applications).
6.28	2.55	3.73	21	Assessing efficacy of flowering rush (*Butomus umbellatus*) control strategies.
6.26	2.64	3.62	99	Researching the genetics of *Myriophyllum heterophyllum* and *Cabomba caroliniana* to determine nativity.
6.17	2.88	3.29	83	HWA has not caused erosion in Massachusetts and Connecticut, but the Catskills have different geography/geology and flashier stream systems. It would helpful to verify that erosion has not been an issue in areas where mortality has already occurred there.
6.16	2.85	3.31	63	Assessing the impact of the carnivorous invasive aquatic plant waterwheel (*Aldrovanda vesiculosa*) on aquatic ecosystems in NY State and what is the risk of spread to other water bodies in the state?
6.16	2.60	3.55	82	Researching controls for wild chervil (*Anthriscus sylvestris*) this invasive is spreading rapidly in NYS and is very difficult to control.
6.13	2.60	3.54	103	Assessing the impact of Southern Pine Beetle. The Southern Pine Beetle issue is also related to climate change and potential impacts.
6.11	3.34	2.77	28	Novel ecosystems arising from non-native plant introductions: Impact on biodiversity, ecosystem function, natural succession, other species groups, etc.

				Understanding to what extent (and when, where) should we accept these novel ecosystems, or try to manage species composition and function?
6.11	3.07	3.03	66	Identifying safe and effective treatments to reduce jumping worms for homeowners.
6.10	2.51	3.59	77	Assessing control options for Goutweed (*Aegopodium podagraria*). This invasive species is spreading extremely rapidly in our region.
5.99	2.88	3.11	48	Establishing management strategies for invasive snails (Chinese/Banded Mystery Snails and others). These species are becoming a big issue for some lake associations on small lakes in New York, but there is very little documentation on control mechanisms.
5.96	3.51	2.45	72	Stopping the influx of invasive species that arrive at our international ports. There are not enough inspectors to adequately inspect incoming goods.
5.90	3.11	2.79	12	Understanding the impacts of marine invasive species in New York.
5.86	2.76	3.10	68	Surveying marine invasive species (fauna and flora) in NYS waters. Survey could consist of events such as "BioBlitz" held throughout the marine district or concerted scientific study.
5.83	2.58	3.25	49	Establishing effective education and management strategies for Southern Pine Beetle, perhaps putting together a team to visit parks and combat the issue.
5.79	2.55	3.24	109	Assessing potential spread of European frog-bit (*Hydrocharis morsus-ranae*) by waterfowl.
5.78	2.58	3.20	10	Understanding populations dynamics, feeding preferences and impacts of grass carp on aquatic invasive plants in New York waterbodies.
5.78	2.98	2.80	17	Whole-genome sequencing and genomic analysis of invasive species.
5.77	3.24	2.53	54	Developing strategies for management and control of invasive Asian jumping worms (*Amythas spp.*). These are prevalent in parts of Westchester and Putnam County but have not appeared in other parts of New York so they haven't gotten the attention they require.
5.75	2.54	3.21	6	Exploring alternative uses for invasive plants (fiber, biodigester, biofuel applications).
5.74	2.64	3.10	114	Understanding the impact of feral/free roaming cats on native ecosystems.
5.71	2.44	3.28	93	Understanding the relationship between porcelain berry (*Ampelopsis brevipedunculata*) and soil contaminants along roadsides and highways? Is porcelain berry a nitrogen-fixing vine? If so, is the presence of nitrous oxides from car exhaust related to its promotion?

5.68	2.64	3.03	113	Understanding the impact of Chinese and banded mystery snails, and other invasive snails.
5.67	2.60	3.07	38	Developing non-chemical controls for lesser celandine (*Ficaria verna*).
5.62	2.49	3.13	9	Researching and quantifying impacts of invasive common carp on water quality and aquatic plant assemblages.
5.61	2.46	3.14	98	Studying impact of Chinese bush clover (*Lespedeza cuneata*) and other invasives on structure and species composition of grasslands, including insects and soil microorganisms.
5.54	2.79	2.75	75	Understanding the effect on nesting birds / migrating birds / mating birds when a porcelainberry vine patch is replaced with native tree saplings and shrubs during the first growing season after planting? After 5 years? 10 years?
5.49	2.35	3.14	85	Understanding Callery/Bradford pear crosses and cultivars and their invasive potential.
5.44	2.67	2.77	27	Determining ways to control and eliminate Spotted Knapweed and other invasive knapweeds (black, brown, diffuse), including biocontrol.
5.37	2.40	2.96	78	European Cherry Fruit Fly (*Rhagoletis cerasi*) control or eradication. This could also include research into treating native hosts such as honeysuckle for either the pest or to eliminate the honeysuckle in areas of concern.
5.31	2.56	2.75	29	Information relating to strategies for living alongside of invasive plants rather than engaging in practices with non-target impacts.
5.26	2.58	2.68	97	Studying all of the exotic Carex in New York and compare their population sizes, natural history plant geography, biology, and ecology so land managers would be aware of which ones to be concerned about. Most people (and botanists) don't know about our 14 exotic *Carex* species. *Carex kobomugi*, *Carex flacca*, and *Carex expansa* seem to be the worst.
5.25	2.33	2.93	96	Establishing the extent and impact of European alder (*Alnus glutinosa*) hybridization with native alders.
5.25	2.56	2.69	110	Understanding impacts of freshwater jellyfish.
4.99	2.26	2.72	40	Developing non-chemical or low toxicity methods to manage spotted wing drosophila (*Drosophila suzukii*)
4.88	2.05	2.83	106	Establishing a better non-biological control method for purple loosestrife (*Lythrum salicaria*).
4.85	2.11	2.74	2	Managing exotic lawn grasses (i.e. *Elymus repens, Dactylis glomerata, Poa pratensis*) to convert lawns to native meadows in WNY.

Appendix II. All statements sorted by cluster

Cluster	#	Statement
1. Institutional support and best management practices		
	1	Comparing strategies (gamification, location-based alerts, etc-) for retaining citizen scientists and volunteers for invasive species initiatives
	8	Testing which strategies (user fees, boat launch lockdowns, mandatory inspection) are most effective at reducing the spread of AIS
	13	Developing tools to connect New York managers to managers in the mid-Atlantic to put together proactive best management practices for invasive species likely to expand into New York with climate change.
	20	On a regional or statewide basis, institute/test an early-warning/early detection system survey of lakes (and possibly river systems) using environmental DNA. Spatial priorities for such a system could be set in consultation with DEC, PRISMS and other stakeholder groups based on where the biggest bang for the buck would be if a harmful species was detected.
	30	Strategies for working with transportation departments to help prevent spread.
	34	Development of simple metrics for success of restoration efforts - for use in the monitoring phase after initial IS removal and to allow for quicker intervention. I.E. thresholds that are low enough to allow for (and recommend) intervention before issues become too costly to address.
	43	Tools and frameworks to help prioritize limited resources in order to minimize impacts and reach management goals
	47	Establishing the most effective education and outreach strategies for spotted lanternfly
	67	Identifying best strategies for directing volunteers to search for new infestations (early detection).
	73	Establishing a public/private partnership involving local businesses, local government, NFP's and individuals who work together with IS groups and scientists to fight IS. The government cannot do it alone.
	89	Developing a newsletter that synthesizes recent invasive-related research and disseminates it to practitioners.
	91	Identifying effective methods of outreach to and coordination with commercial suppliers of products which can be widely distributed (compost and mulch facilities, plant nurseries, agriculture suppliers) regarding invasive species detection and control.

	100	Communicating research-based recommendations for reducing the introduction of forest pests to policy makers
	102	Using artificial intelligence/computer learning to analyze photos submitted by citizen scientists for accuracy.
	111	Structured prioritization of state resource allocation for managing established Invaders, accounting for federal resource investments.
	112	Structured prioritization of early detection surveys across species and locales.
2. Tools and strategies, including DNA and other research		
	5	Developing artificial intelligence/computer learning tools to analyze large-scale spatial digital imagery databases.
	6	Exploring alternative uses for invasive plants (fiber, biodigester, biofuel applications).
	15	Testing whether detection dogs are more effective at detecting Tier 1 species than traditional search methods
	17	Whole-genome sequencing and genomic analysis of invasive species.
	18	Developing eDNA for forest pests and their biocontrols.
	19	Developing eDNA tests for aquatic invasive plants.
	29	Information relating to strategies for living alongside of invasive plants rather than engaging in practices with non-target impacts.
	31	Estimating efficacy of invasive species management in NYS to date. Have the benefits outweighed the costs?
	36	Understanding which planting strategies would maximize the survival, growth, and recruitment of native plants in natural areas, in nurseries, and in afforestation sites? Would a combination of annuals, early flowering perennials, or fall flowering perennials that leaf out early prevent invasive species from dominating?
	56	Using eDNA to target multiple species/taxa in both the aquatic and terrestrial environments for early detection/rapid response.
	59	Evaluating the role of biotechnology in addressing various invasive species threats (social acceptance and/or scientific feasibility for different applications).
	64	Identifying factors that influence invasives reporting bias in the statewide database.
3. Invasive species and climate change impacts on human health and the economy		
	3	Assessing and addressing the potential of public health pests making their way into NYS and the disease vectors like invasive ticks, which have already arrived
	4	Continued identification of species (in horticulture & from the south) to screen for potential addition to Part 575 regulations.

11	Understanding the effect that a changing climate will have on the range and dynamics of existing invasive species.
14	Modeling what species we need to look out for due to climate change.
16	Modeling which areas within New York the Spotted Lanternfly will establish.
23	Understanding interactions of climate change and exotic forest pests, including expansion of pest ranges and vulnerability of trees.
44	Establishing regional cooperation with neighboring states where many invasive species are coming from. Let's stop them before they enter NYS.
60	Identifying invasive species that have a negative economic impact on agriculture including the horticulture industry.
61	Estimating the impact of forest pests on the NY economy
68	Surveying marine invasive species (fauna and flora) in NYS waters. Survey could consist of events such as "bioblitzes" held throughout the marine district or concerted scientific study.
72	Stopping the influx of invasive species that arrive at our international ports. There are not enough inspectors to adequately inspect incoming goods.
74	Assessing drivers of aquatic invasive species spread: Do lakes that have New York State installed public boat launches have a greater percentage of invasive species than lakes without? Do fishing boats carry more invasive species than pleasure boats and do they travel to more lakes in a season, thus potentially spread more invasive species?
81	Developing recommendations of native plants for restoration that are 'climate smart' - i.e. not necessarily native to New York, but adapted to climate warming and unlikely to become invasive.
92	Improving information on the connection between invasive species and human health and economics/cost of living.
95	Developing a carbon loss model which estimates the amount of carbon released into the atmosphere as the result of deforestation by invasive forest pests and pathogens. This can be used to determine the potential impacts on climate change as a result of deforestation.
101	Providing impact studies of invasive species and forecasting distribution models, to help prevent the spread before species become wide spread throughout NYS. In many cases, NYC and the southern tier is a gateway with many widespread species. Studies that focus on impact there could help prevent throughout the rest of the state.

	105	Addressing the political/legislative/economic issues behind invasive species in New York State in addition to the biological
	107	Modeling habitat suitability for the high priority aquatic invasive plants.
	115	Conducting a horizon scan of introduction pathways to New York (including from domestic and international sources) to enable better targeting of prevention and early detection interventions.
4. Invasive species control		
	2	Managing exotic lawn grasses (e.g. Elymus repens, Dactylis glomerata, Poa pratensis) to convert lawns to native meadows in WNY
	21	Assessing efficacy of flowering rush (Butomus umbellatus) control strategies
	25	Assessing the efficacy and developing new control strategies for hemlock woolly adelgid (Adelges tsugae).
	26	Developing better management tools for hydrilla (Hydrilla verticillata)
	27	Determining ways to control and eliminate Spotted Knapweed and other invasive knapweeds (black, brown, diffuse), including biocontrol.
	32	Designing and testing a protocol and developing metrics to assess the effectiveness of invasive species control measures
	35	Understanding the relative effectiveness and merits of different methods for controlling Eurasian water milfoil by hand-harvesting, including hand-pulling by SCUBA divers, diver-assisted suction harvesting (DASH), and initial treatment with herbicides followed by harvesting.
	37	Researching and making available non-herbicidal treatments.
	38	Developing non-chemical controls for lesser celandine (Ficaria verna)
	40	Developing non-chemical or low toxicity methods to manage spotted wing drosophila (Drosophila suzukii)
	41	Understanding the environmental impacts of low-dose pesticide application techniques (i.e. cut stump application of triclopyr) over short and long term (impacts of breakdown products and movement through the environment from application site).
	42	Comparing the environmental impacts of herbicide usage versus other methods of invasive control.
	48	Establishing management strategies for invasive snails (Chinese/Banded Mystery Snails and others). These species are becoming a big issue for some lake associations on small

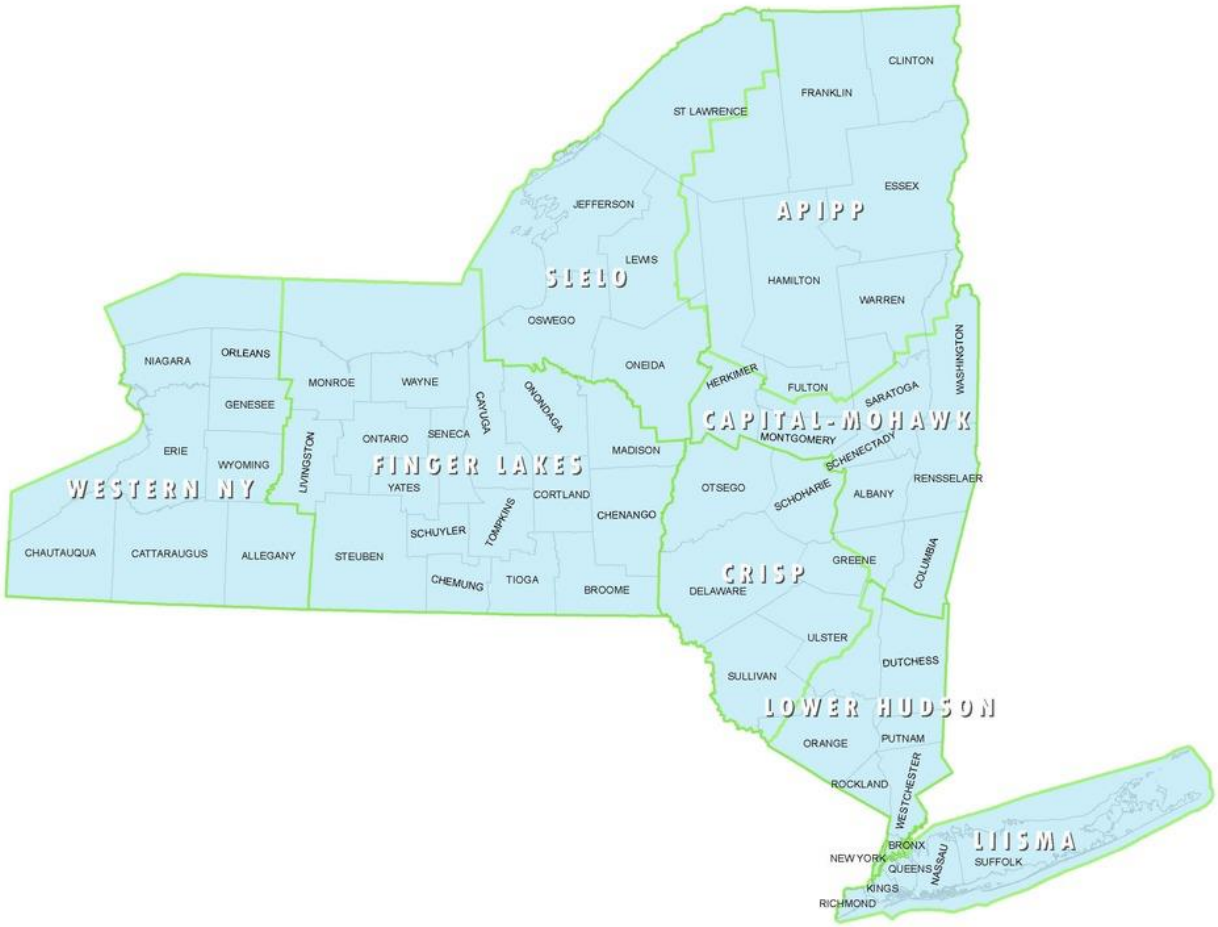
	lakes in New York, but there is very little documentation on control mechanisms.
49	Establishing effective education and management strategies for Southern Pine Beetle, perhaps putting together a team to visit parks and combat the issue.
50	Researching best management practices for how to eradicate, contain, and suppress Japanese stilt-grass (Microstegium vimineum)
51	Advancing swallow-wort biocontrol development and release
52	Researching best management practices for how to control tree-of-heaven (Ailanthus altissima)
53	Developing strategies and infrastructure to screen for and treat invasive seed banks in topsoil and gravel pits
54	Developing strategies for management and control of invasive Asian jumping worms (Amythas spp.). These are prevalent in parts of Westchester and Putnam County but have not appeared in other parts of New York so they haven't gotten the attention they require.
62	Establishing the most cost-effective methods to monitor hemlock health, Hemlock Woolly Adelgid, and Elongate Hemlock Scale over a large landscape.
65	Establishing the temperature threshold where composting kills jumping worm cocoons.
66	Identifying safe and effective treatments to reduce jumping worms for homeowners.
69	As volunteers participate in invasive removals, test the following: 1) what grows back at the site on its own, 2) what grows back at the site if it is deer-fenced; 3) what native plants can be quickly seeded or planted to serve as a filler and compete with returning invasives until a restoration project has been implemented.
70	Researching efficacy of Mugwort (Artemisia vulgaris) control options.
71	Researching efficacy of Japanese knotweed (Reynoutria spp.) control options.
77	Assessing control options for Goutweed (Aegopodium podagraria) -- this invasive species is spreading extremely rapidly in our region.
78	European Cherry Fruit Fly (Rhagoletis cerasi) control or eradication. This could also include research into treating native hosts such as honeysuckle for either the pest or to eliminate the honeysuckle in areas of concern.
79	Developing IPM tools to manage spotted lanternfly in grapes, forests, and landscapes

	82	Researching controls for wild chervil (Anthriscus sylvestris) this invasive is spreading rapidly in NYS and is very difficult to control.
	84	Developing a control for wild parsnip (Pastinaca sativa) as it seems to be flourishing everywhere, especially along travel corridors.
	86	Developing methods for controlling and removing Japanese angelica tree (Aralia elata)
	87	Evaluating potential for select biological control agents for control of Japanese knotweed (Reynoutria spp).
	88	Completing research and submitting petition for the water chestnut biological control project.
	90	Establishing more best management practices for common invasives. These should utilize both organic and synthetic methods. And include comprehensive information about reproduction: seed dispersal, rhizome spread GGD time, longevity of seed viability.
	106	Establishing a better non-biological control method for purple loosestrife (Lythrum salicaria)
	108	Developing and sustaining large-scale biological control rearing facilities
5. Invasive species impact and related research		
	7	Understanding how invasive species have impacted biodiversity in NYS over time, and how this can help pinpoint biodiversity areas at highest risk.
	9	Researching and quantifying impacts of invasive common carp on water quality and aquatic plant assemblages.
	10	Understanding populations dynamics, feeding preferences and impacts of grass carp on aquatic invasive plants in New York waterbodies.
	12	Understanding the impacts of marine invasive species in New York.
	22	Understanding the long-term impact of invasive forest pests on forest ecosystem functions and services
	24	Determining the impact that quagga/zebra mussels have on nutrient levels and harmful algal blooms in lakes.
	28	Novel ecosystems arising from non-native plant introductions: Impact on biodiversity, ecosystem function, natural succession, other species groups, etc. Understanding to what extent (and when, where) should we accept these novel ecosystems, or try to manage species composition and function?
	33	Developing tools for assessing the impact of invasive species
	39	Better understanding of the impact that aquatic invasive plants have on internal nutrient loading of lakes and

	embayment's and the potential of aquatic invasive plants to facilitate harmful algae blooms.
45	Researching the timing of flower and seed production in slender false brome. When does the species typically produce flowers, and how long after flowers appear is seed produced?
46	Understanding seed viability of slender false brome. Research into conditions needed for germination of this species and seed viability after transportation in water.
55	Understanding the extent and rate of invasion, impacts, and long-term threat of the multiple Asian Worm/Jumping Worm species on forest ecosystems and critical watersheds? Our processes seem best tuned to respond to invasive plants, insects, and pathogens, not worms. But if these prolific leaf-litter-strippers become broadly established, their full-stack ecosystem impact could be severe and permanent
57	Understanding Japanese stiltgrass (Microstegium vimineum) and its interaction with native flora, and Jumping worm (Amythas spp) species
58	Establishing the current distribution of jumping worms (Amythas spp.). Are they spreading in commercial plant stock? Compost? Soil?
63	Assessing the impact of the carnivorous invasive aquatic plant waterwheel (Aldrovanda vesiculosa) on aquatic ecosystems in NY State and what is the risk of spread to other water bodies in the state?
75	Understanding the effect on nesting birds / migrating birds / mating birds when a porcelainberry vine patch is replaced with native tree saplings and shrubs during the first growing season after planting? After 5 years? 10 years?
76	Understanding the impact of various invasive management strategies on soil health.
80	Determining the epidemiology of beech leaf disease and potential mitigation measures or prevention of spread.
83	HWA has not caused erosion in Massachusetts and Connecticut, but the Catskills have different geography/geology and flashier stream systems. It would helpful to verify that erosion has not been an issue in areas where mortality has already occurred there.
85	Understanding Callery/Bradford pear crosses and cultivars and their invasive potential
93	Understanding the relationship between porcelain berry (Ampelopsis brevipedunculata) and soil contaminants along roadsides and highways? Is porcelain berry a nitrogen-fixing vine? If so, is the presence of nitrous oxides from car exhaust related to its promotion?

	94	Understanding the actual impacts of some of the aquatic species. If there is no to minimal impact then maybe resources are better spent elsewhere but without knowing the actual impacts of a species this decision can't be made.
	96	Establishing the extent and impact of European alder (Alnus glutinosa) hybridization with native alders
	97	Studying all of the exotic Carex in New York and compare their population sizes, natural history plant geography, biology, and ecology so land managers would be aware of which ones to be concerned about. Most people (and botanists) don't know about our 14 exotic Carex species. Carex kobomugi and Carex flacca, and Carex expansa seem to be the worst.
	98	Studying impact of Chinese bush clover (Lespedeza cuneata) and other invasives on structure and species composition of grasslands, including insects and soil microorganisms.
	99	Researching the genetics of Myriophyllum heterophyllum and Cabomba caroliniana to determine nativity.
	103	Assessing the impact of Southern Pine Beetle. The Southern Pine Beetle issue is also related to climate change and potential impacts.
	104	Assessing the impact of barberry (Berberis spp.)
	109	Assessing potential spread of European frog-bit (Hydrocharis morsus-ranae) by waterfowl
	110	Understanding impacts of freshwater jellyfish.
	113	Understanding the impact of Chinese and banded mystery snails, and other invasive snails
	114	Understanding the impact of feral/free roaming cats on native ecosystems

Appendix III. Map of PRISM Regions, from dec.ny.gov/animals/107995.html



Appendix IV. PRISM Regions Combined