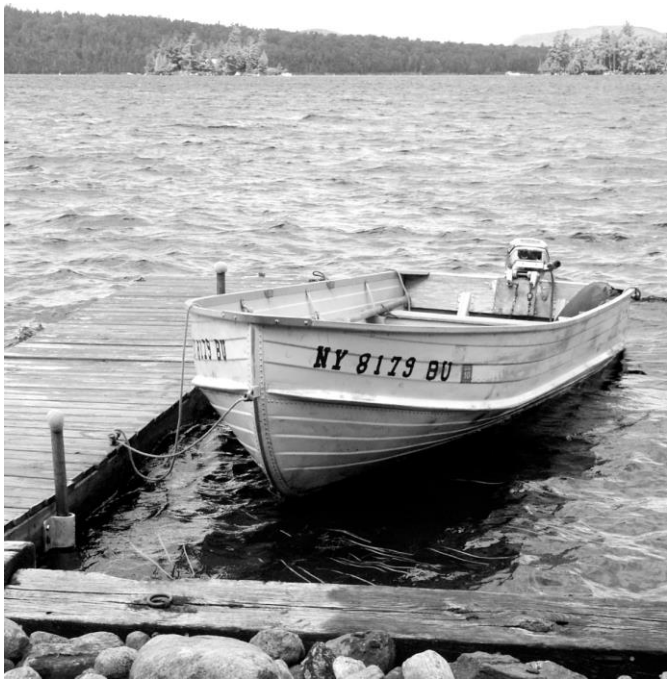
Boat Inspection and Decontamination for Aquatic Invasive Species Prevention

Recommendations for the Adirondack Region



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Prepared by

Meghan Johnstone and Hilary Smith, Adirondack Park Invasive Plant Program
Dr. Eric Holmlund, Paul Smith's College
Meg Modley, Lake Champlain Basin Program
Emily DeBolt and Kristen Rohne, Lake George Association

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Executive Summary

Aquatic invasive species (AIS) pose a significant threat to the Adirondack environment and economy. For more than a decade, organizations and communities in the Adirondack region have worked together to address invasive species through coordination, prevention, education, detection, and management initiatives. Shoreowners, municipalities, and state agencies spend millions of dollars managing infestations each year. Studies show that investments in prevention yield the greatest economic return. In recent years, greater attention has been given to the need for more effective AIS prevention programs.

As of 2013, nearly 90 waterways in the region had one or more AIS; however, more than two out of three waterways surveyed, at least 230, are still free of AIS, which presents an opportunity to limit their spread. While there are many AIS pathways, recreational boating remains one of the most significant in the Adirondack region. As a result, groups are promoting the expansion of the boat launch steward program, which conducts education and inspections at boat launches. Data from 25,000 boating parties surveyed in 2012 show that boaters are traveling from more than 600 destinations, and 35% are not taking any spread prevention measures. This signals the need for additional focus on the importance of cleaning recreational equipment.

Prevention efforts promoting clean boating practices are underway and include education, such as brochures, signage, presentations, news releases etc.; inspections, i.e. volunteer and paid boat launch stewards; local laws prohibiting the transport of aquatic species; and, boat washing, i.e. decontamination. An increasing emphasis on inspection and decontamination among lake communities highlights the need for determining its role in a regional AIS prevention program.

This report evaluates the concepts of inspection and decontamination and uses existing datasets to inform recommendations for the region. The process involved five steps: 1) reviewing peer-reviewed scientific literature on recreational watercraft as an AIS pathway and the effectiveness of inspections and decontamination in removing AIS, 2) compiling Adirondack AIS distribution and boat access data, 3) compiling Adirondack boat launch steward data, 4) analyzing information in aggregate to understand trends, and 5) developing recommendations appropriate to the region. The process began in January 2013, and several drafts of the report were shared with a team of reviewers and the Adirondack Aquatic Invasive Species Committee members for input.

Though the peer-reviewed literature on the effectiveness of inspection and decontamination is limited, the papers that are available are credible, informative, and provide important guidance on integrating inspection and decontamination in a regional prevention strategy. The reference material is further enhanced by white papers and state reports from across the country. In addition, the AIS distribution and steward data available for the Adirondack region are among the most complete in New York State and were instrumental for informing the specific recommendations presented here. Because it is difficult to forecast which AIS will arrive, survive, and reproduce in Adirondack waterways, it is necessary to take a multi-species, long-term approach to AIS prevention efforts in the region. Therefore, in order to address all possible threats and offer the highest possible protection to the region, the recommendations presented include methods shown to be *most* effective in removing, and in some cases, killing a wide range of AIS.

The following key concepts from the literature were instructive in formulating recommendations:

1) Early in an invasion, when the goal is to slow the spread of AIS through a collection of waterways, the best way to protect uninvaded areas is to allocate resources to containing invaded areas.

2) Boater use patterns among invaded and uninvaded waterways can help managers predict patterns of AIS spread and identify invasion spread hubs and important linkage waterways.

3) Site specific AIS distribution data and boater behavior and use patterns can help prioritize placement of prevention programs.

4) Inspection and high-pressure, hot water decontamination can help to limit the spread of AIS, particularly when practices target specific taxonomic groups such as aquatic invasive plants or small-bodied organisms.

5) Incorporating inspection and/or high-pressure, hot water decontamination at specific locations, ideally upon both entry and exit, can help to limit the landscape-level spread of aquatic invasive plants and small-bodied organisms.

Applying these key concepts in the Adirondack region, in combination with preliminary evaluation of regional datasets, including AIS distribution and boater use data, indicates that at least three overland transport sub-networks, three linkage waterways, and eight invasion spread hubs may exist in the Adirondack region. While this report's analyses of boater use patterns are preliminary, they suggest that there is an as-yet incompletely understood chain of connectivity and sequence between the region's waterways that could be exploited for maximum spread prevention on the landscape-level scale. This information and analyses informed the following recommendations:

1) Steward inspections *and* high-pressure, hot water decontamination stations at 13 specific waterways will help to limit the spread of aquatic invasive small-bodied organisms and also limit the spread of new AIS introductions to the region. Of those 13 waterways, four serve as invasion spread hubs, two serve as linkage waterways, and seven have aquatic invasive small-bodied organisms (Table 9).

2) Regional placement of high-pressure, hot water decontamination stations at overland transport sub-networks will help to limit the landscape-level spread of AIS (Appendix F).

3) Seventy-six of 88 waterways known to have aquatic invasive species contain only aquatic invasive plants (Appendix H). Steward inspections on those waterways with trailered boat access will help to limit the landscape-level spread of aquatic invasive plants.

4) Stewards deployed at priority uninvaded waterways will reduce the risk that those waters will become invaded.

Various levels of coverage also are presented for consideration based on risk reduction and resource availability. Importantly, initiatives are already underway that are implementing components of these recommendations that help to bolster prevention efforts. Furthermore, in absence of a comprehensive AIS prevention program, efforts underway by individual lakes to safeguard their waters are to be commended and supported.

This report presents recommendations for consideration based on the best available science and data to help inform decisions about prioritizing prevention efforts in the Adirondack region. The next step is to evaluate implementing the recommendations in the context of feasibility and funding. This will require working in collaboration with state agencies, elected officials, shoreowners, non-governmental groups, and additional stakeholders.

The following limitations on the data and analyses are to be noted: Since this report was prepared throughout 2013, it is based on AIS distribution data and steward data from 2012 and does not take into account new AIS detections or steward data collected in 2013, unless otherwise noted. Also, the data used in the analyses are based on best available information; therefore, the distribution data on the presence and absence of AIS reflect data on those waterways where surveys occurred. Similarly, boater behavior and use patterns reflect data where boat launch stewards are present. Thus, there is opportunity to apply the models and concepts discussed to other areas of the region.

Since the explicit goal of the report is to assess boat inspection and decontamination as it applies to the Adirondack region, the following issues are outside of the scope of the report: the role of *mandatory* inspection and decontamination programs; the role of inspection and decontamination across the state; the role of a

statewide transport law; and, the technical feasibility and resourcing required to implement this report's recommendations. The report does not cover other important AIS spread prevention measures, such as signage at boat launches, education, and regulation, among others. Other AIS pathways that are not addressed in this report include introduction or spread through canals, aquarium dumping, religious ceremonies, wildlife, illegal stocking, and water garden escapes, etc.

Since numerous Adirondack waterways are free of AIS, and, fewer numbers of AIS are in the region compared to neighboring regions, now is the time to take informed action to prevent landscape-level spread of AIS.

I. Introduction: The Need for Resource Protection

The Adirondack region[a] of upstate New York contains the six million acre Adirondack Park, the largest publicly protected area in the contiguous United States. With over 2,300 lakes and ponds, 1,500 miles of rivers, 30,000 miles of brooks and streams, the region's freshwater resources are extensive, diverse, and provide a range of services for both residents and visitors.[1] The region's 12 major watersheds drain to Lake Ontario, the St. Lawrence River, Lake Champlain, the Mohawk River, and the Lower Hudson River – significant freshwater systems in the state of New York and important for trade, tourism, and quality of life.

Water quantity and quality are of the utmost importance to communities in the Adirondack region. The recreational opportunities that lakes, ponds, rivers, and streams provide help to support the tourism-based economy. Clean and abundant water is a main ingredient of the tourism package that attracts visitors to the region, as over 85 percent of visitors desire waterside lodging and approximately 70 percent want to swim, fish, or boat while visiting the Adirondacks.[2] Visitors spend over $1.2 billion dollars annually and tourism provides employment for over 26,000 residents.[3] Water also affects the quality of life of Adirondack residents in several important ways, including drinking water quality, ecosystem health, and aesthetic and property values.


Photo by Meghan Johnstone, Adirondack Park Invasive Plant Program

The proliferation of aquatic invasive species (AIS) is a critical threat to water quality, ecosystem health, and the economy of the Adirondacks. An AIS is a non-indigenous species that harms the environment, economy, or human health. Several AIS such as Eurasian watermilfoil, water chestnut, and Asian clam are actively managed to limit their distribution and minimize their impacts. Management activities, however, can be complicated, are costly to implement, must be sustained, and, in most cases, will not result in complete elimination of the invasive species. Millions of dollars are spent each year managing AIS within the region. For example, in Lake George, Eurasian watermilfoil has been actively managed since its discovery in 1985 costing over $3M through 2012. More than $1.5M has been spent in Lake George managing Asian clam in 2011 and 2012 alone, and close to $1M has been spent on managing zebra mussels.[4] These management costs continue to rise each year.

Impacts of AIS in the Adirondack region will increase if current populations of AIS are left unchecked and new species enter the region. If action is taken in the near-term, it is possible to limit the spread of AIS and protect the ecologic and socioeconomic vitality of the Adirondacks. Managing AIS pathways[b] by implementing spread prevention measures is more cost-effective than managing the impacts once AIS are introduced (Appendix A).

Many waters remain free of AIS. An opportunity exists in the Adirondacks to prevent landscape-level spread of AIS through an integrated AIS prevention strategy to protect freshwater resources and local economies for future generations.

[a] The Adirondack region is defined by the boundaries of the Adirondack Partnership for Regional Invasive Species Management (PRISM), which includes the Adirondack Park and extends northward in Franklin and Clinton Counties to the Canadian border. The Adirondack PRISM border is shown in blue in Appendix B.

[b] Invasive species pathways are the means by which invasive species are moved from one location to another.

II. Aquatic Invasive Species Impacts and Pathways of Spread

The introduction and establishment of aquatic invasive plants, animals, and pathogens is ongoing and causes serious problems in New York and the Adirondack region. Aquatic invasive species threaten the diversity and abundance of native species and the ecological stability of waterways.[c] They may also threaten commercial, agricultural, aquacultural, and recreational activities dependent on those waterways. The impacts of invasive species are second only to habitat destruction as a cause of global biodiversity loss.[5] Examples of AIS impacts include:

Eurasian watermilfoil (*Myriophyllum spicatum*) can negatively affect recreation by interfering with boating and swimming and reducing the quality of sport fisheries.[6] Eurasian watermilfoil can also clog industrial and power generation water intakes, lower dissolved oxygen concentrations in infested waters, and even increase mosquito populations.[7]

Eurasian watermilfoil
Photo by Gordon Keyes

Spiny waterflea on fishing line
Photo by Emily DeBolt, Lake George Association

Predation by the invasive zooplankton, spiny waterflea (*Bythotrephes longimanus*), may result in reduced populations of preferred prey of native fish, resulting in negative consequences to native fish populations.[8]

In addition to the severe damage to the habitats they invade, AIS also negatively affect citizens and businesses by impeding economic development, preventing commercial and recreational activities, decreasing the aesthetic value of affected areas, and harming human health. For example, invasive mussels may increase human and wildlife exposure to organic pollutants such as polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs), as these toxins accumulate in wildlife's tissues when consumed and can be passed up the food chain.[9]

Zebra mussels on a native mussel
Photo by Randy Westbrooks
U.S. Geological Survey

There are numerous pathways for AIS introductions to New York, including ballast water in ships, the release of live bait, canals, and recreational boating, among others. In response, the New York State Department of Environmental Conservation (NYSDEC) is evaluating ship ballast water regulations, has developed baitfish regulations to address the live bait pathway, and is finalizing regulations to implement the Invasive Species Prevention Act of 2012, which addresses the commercial sale of invasive species through water gardens, aquaria, and live seafood. A US Army Corps of Engineers Champlain Canal Barrier Feasibility Study is underway to identify means of developing a hydrologic barrier in the canal system in order to prevent the spread of AIS.[10] More recently, state and local partners are increasingly working to address the AIS recreational boating pathway. A plan is required to help prioritize actions and resources.

The overland movement of small-craft recreational boats is a significant pathway of spread of AIS to inland waterways throughout North America.[11] [12] [13] Recreational boating, in particular, is implicated in the spread of aquatic invasive zooplankton, such as spiny waterflea (*Bythotrephes longimanus*),[14] [15] mollusks, such as zebra and quagga mussels (*Dreissena* spp.),[16] [17] [18] and aquatic vegetation, such as Eurasian watermilfoil

[c] Waterways include lakes and ponds.

(*Myriophyllum spicatum*).[19] Movement of non-native organisms by boaters can be intentional (e.g. as bait)[20] but is often times unintentional, with small-bodied organisms not visible to the naked eye (e.g. zebra mussel larvae or juvenile spiny waterflea) accidentally carried in bait buckets, live wells, and bilge water.[21] [22] Organisms can also be transported on the exteriors of boats, entangled on propellers and trailers, or even attached to other hitchhiking organisms.[23] Consequently, every time a recreational boat is transported overland after use in an AIS-invaded waterway, there is the opportunity that it will spread AIS to uninvaded waterways.[24]

Preventing AIS from entering the region's waterways by addressing pathways of spread, especially the recreational boating pathway, is necessary to manage this threat. Because it is difficult to forecast which AIS will arrive and have the ability to survive and reproduce in Adirondack waterways, the adoption of best management practices to preclude introductions of a broad range of taxa over the long-term is the most effective preventative action.

III. Aquatic Invasive Species Distribution in the Adirondack Region

Once an invasive species is established, knowing its distribution will inform an effective prevention program and prioritize limited resources. A variety of monitoring programs collect information directly or indirectly about the distribution of AIS in the Adirondack region including the NYSDEC, Darrin Fresh Water Institute, Adirondack Watershed Institute of Paul Smith's College, Lake Champlain Basin Program Long Term Biological Monitoring Program, and lake associations and lake managers, among others. In 2002, the Adirondack Park Invasive Plant Program (APIPP) compiled existing information about the distribution of aquatic invasive plants in the Adirondack region and instituted a regional long-term volunteer surveillance and monitoring program. APIPP trains volunteers in plant identification and reporting techniques to monitor Adirondack waterways for the presence of aquatic invasive plants.

Table 1. Aquatic non-native and invasive species in the Adirondack region, 2012.[d]

*Present in Lake Champlain only

**Alewife is present in Green Pond (Franklin County) and Lake Champlain; however, Green Pond is not included in analyses of invaded waterways because the presence of aquatic invasive animals was not yet fully accounted for in APIPP's GIS database at the time that analyses were performed.

Species Name	Number of Waterways
Alewife (*Alosa pseudoharengus*)**	2
Asian Clam (*Corbicula fluminea*)	1
Blueback Herring (*Alosa aestivalis*)*	1
Brittle Naiad (*Najas minor*)	3
Common Carp (*Cyprinus carpio*)*	1
Curly-leaf Pondweed (*Potamogeton crispus*)	14
Eurasian Watermilfoil (*Myriophyllum spicatum*)	57
European Frog-bit (*Hydrocharis morsus-ranae*)	5
European Rudd (*Scardinius erythrophthalmus*)*	1
Fanwort (*Cabomba caroliniana*)	4
Gizzard Shad (*Dorosoma cepedianum*)*	1
Spiny Waterflea (*Bythotrephes longimanus*)	5
Tench (*Tinca tinca*)*	1
Variable-leaf Watermilfoil (*Myriophyllum heterophyllum*)	30
Water Chestnut (*Trapa natans*)	2
White Perch (*Morone americana*)	2
Yellow Floating Heart (*Nymphoides peltata*)*	1
Zebra Mussel (*Dreissena polymorpha*)	2

Until recently, no systematic surveys were underway in the region for aquatic invasive animals. Data on non-native fish primarily are collected by the NYSDEC, but data on other aquatic invasive animals, such as zebra mussel and Asian clam, are largely limited to reports from individual lakes. In 2008, the NYSDEC contracted with APIPP to serve as the Adirondack Partnership for Regional Invasive Species Management (PRISM), and APIPP broadened its scope beyond plants to address all invasive species and now also serves as a repository for aquatic invasive animal distribution data. In 2012, APIPP initiated an annual training program for aquatic invasive animal identification and survey techniques and is expanding its volunteer surveillance and monitoring program to include aquatic invasive animals.

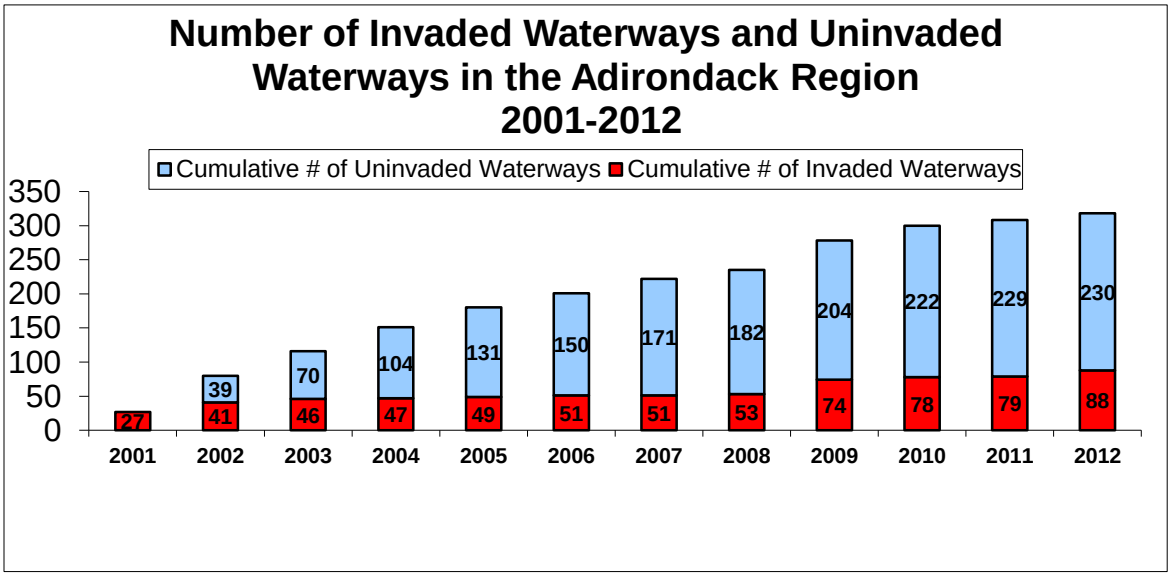
APIPP coordinates information exchange among monitoring programs operating in the region and maintains a database on the current distribution of AIS in the Adirondacks. As of 2012, 88 waterways in the Adirondack region (Appendix B), representing both public and private waterways, contained one or more aquatic non-native and invasive species (Table 1). Six have aquatic invasive small-bodied organisms: Lake Champlain, Lake George, Great Sacandaga Lake, Stewarts Bridge Reservoir, Sacandaga Lake, and Peck Lake; and, 85 have aquatic invasive plants. Two-hundred-thirty waterways surveyed by APIPP volunteers and partner staff have no invasive species observed. The number of "invasive-free" waterways is more than 2.5 times that of invaded waterways

[d] Some waterways contain more than one aquatic non-native and invasive species. Not all non-native species are invasive. Whether a fish is considered invasive or non-invasive depends on location and therefore is difficult to determine for an entire region. For example, fish that are considered native in Lake Champlain may be considered invasive in the interior Adirondacks. This table includes species invasive to Lake Champlain.

(Figure 1), reinforcing the opportunity to prevent the spread of AIS among inland waterways in the Adirondack region.[e]

Preventing the spread of aquatic invasive small-bodied organisms that are already in the Adirondack region, such as zebra mussel and Asian clam juveniles and spiny waterflea, is of special concern. Asian clam and spiny waterflea have demonstrated their ability to survive and reproduce in Adirondack waterways. Due to their limited calcium and pH tolerance ranges, zebra mussels are not predicted to survive and reproduce in most Adirondack waterways; however, waterways can receive excessive inputs of calcium from human activities creating situations where populations can persist. For example, calcium chloride is often used for roadway deicing in the winter. When calcium chloride is applied for these purposes in close proximity to waterways, or streams that drain into them, the compound can be transported into the waterway during periods of high runoff (e.g. spring snowmelt) or through the soil. This results in localized areas of lake shoreline with high calcium concentration, which can increase the potential for zebra mussels to colonize, as shown in Lake George by the NYSDEC.[25] Furthermore, the possibility exists for zebra mussel populations to evolve genetic adaptations to local ecological conditions.[26] Thus, zebra mussels do pose a risk to waterways within the Adirondack region and actions should be taken to limit their spread.

Figure 1. Cumulative number of invaded waterways and waterways monitored by APIPP volunteers where no invasive species were detected. The increase between 2001 and 2002 is accounted for by the inception of a standardized regional volunteer monitoring program (2001 was pre-volunteer surveys and 2002 was the first year of systematic volunteer surveys). The increase between 2008 and 2009 is accounted for by the inclusion of variable-leaf watermilfoil as an invasive species, rather than as a watched species. The increase between 2011 and 2012 is accounted for by the inclusion of thorough, systematic surveys on numerous waterways performed by the Aquatic Rapid Response Team. APIPP began including invasive animal data in 2009.



[e] AIS and survey data are summarized in the Adirondack Park Invasive Plant Program 2012 Annual Report.

III. Aquatic Invasive Species Distribution in the Adirondack Region

Many other AIS are established in NY waterways surrounding the Adirondack region (Table 2). With fewer than 20 AIS, the Adirondack region is relatively free of AIS; however, the Great Lakes have 184 aquatic non-native and invasive species, the St. Lawrence River has 87, Lake Champlain has 49, and the Hudson River has 122 (Figure 2), reinforcing the importance of instituting programs to prevent the spread of new AIS into the Adirondack region. For example, hydrilla (*Hydrilla verticillata*) is listed as one of the world's worst aquatic invasive plants and new infestations continue to be discovered in New York. Two different biotypes of hydrilla are found in the United States, dioecious and monoecious. Less is known about the monoecious biotype, which is the biotype found in New York; however, the monoecious biotype has grown prolifically in certain areas. In New York, hydrilla infestations exist in Cayuga Lake in the Finger Lakes, Erie Canal in Tonawanda, several small ponds in Broome County, Creamery Pond in Orange County, and nine lakes and ponds on Long Island. Hydrilla displaces native plants and forms dense mats that obstruct boating, swimming, and fishing. Dense infestations could reduce the value of shorefront property.[27] Since hydrilla's discovery in 2011 until September 2013, management costs have exceeded $985,000 for Cayuga Inlet alone. If left to spread, hydrilla has the potential to pose significant threats to waterways and communities in the Adirondack region.

Table 2. Examples of priority AIS in the New York region outside of the Adirondacks.
Bloody Red Shrimp (*Hemimysis anomala*)
Brazilian Elodea (*Egeria densa*)
Hydrilla (*Hydrilla verticillata*)
Parrotfeather (*Myriophyllum aquaticum*)
Quagga Mussel (*Dreissena rostriformis bugensis*)
Starry Stonewort (*Nitellopsis obtusa*)

Figure 2. Total number of known aquatic non-native and invasive species in the regions hydrologically connected to the Lake Champlain Basin as of 2011.[28]

DATA SOURCE: UVM, Lake Champlain Sea Grant, Great Lakes Environmental Research Laboratory, Lafontaine and Costan 2002, and Strayer 2012.

III. Aquatic Invasive Species Distribution in the Adirondack Region

AIS Distribution at State-operated Boat Access Points

The presence of AIS is largely associated with waterways with public boat access. As of 2013, the University of Wisconsin-Madison was two years into a five-year study monitoring inland waterways to evaluate the rate and mechanisms of spread of AIS. The preliminary results from this study show that inland waterways with public boat access are more likely to become infested than those lakes with no public boat access.[29] Similarly, a preliminary analysis of waterways surveyed for AIS in the Adirondacks shows that 82 percent of the waterways with boat launches are invaded, while only 12 percent of the waterways without boat launches are invaded.[f] In several cases, however, the invaded waterways without boat launches are hydrologically connected to invaded waterways that do have boat launches. These findings suggest that it is critical to focus spread prevention efforts on waterways with public boat access in order to limit the spread of AIS.

It is critical to work with the public and the authorities overseeing public boat access points to prevent the introduction and spread of AIS. In the Adirondack region, the NYSDEC, and to a lesser degree the Office of Parks, Recreation and Historic Preservation (OPRHP), manage public state-operated boat access points to waterways via boat or river launches or state campgrounds. Eighty-three waterways in the Adirondack PRISM have state-operated public boat access points,[g] including hard surface ramps and beach and hand launches. Thirty-seven (approx. 45 percent) have AIS, 42 have no AIS observed (approx. 51 percent), and four have not been surveyed (approx. 4 percent) (Appendix C). Some of these public boat access points are associated with state-operated campgrounds. Thirty-seven campgrounds in the Adirondack PRISM offer public boat access to a waterway. Nineteen (approx. 51 percent) provide access to invaded waters. State campgrounds typically receive high amounts of visitor traffic throughout the summer months and may be particularly vulnerable to AIS transport via boats entering and exiting the campground.

Numerous municipally operated and privately operated access sites also exist throughout the region, though the total number is not known; thus, the total number of waterways with public boat access points and AIS is even higher. Also, the use of unofficial access points poses risks for AIS introductions.

[f] Differences are statistically significant based on a preliminary Chi-Square analysis performed by Paul Smith's College incorporating data provided by the Adirondack Park Invasive Plant Program.

[g] Some waterways have more than one public boat access point. There are 109 public state-operated boat access points (hard surface ramps and beach and hand launches) in the Adirondack PRISM. Data provided by the NYSDEC.

IV. Inspection and Decontamination Efforts in the Adirondack Region

Current AIS Spread Prevention Efforts

Preventing the spread of AIS requires an integrated approach using a variety of strategies. Numerous efforts are underway in the Adirondack region, such as shoreowner, boater, angler, and public education; signage and AIS disposal stations at boat launches; both professional and volunteer AIS surveys of waterways; and, local transport laws. As of 2013, seven Towns, one Village, and three Counties in the Adirondack Park passed aquatic transport laws. Visual boat inspections and decontamination are increasingly being used and/or considered to complement these efforts, which primarily aim to address the recreational boating pathway.

Status of Inspections

One way to limit the spread of AIS via recreational boating is through boat launch steward programs. Boat launch steward programs are growing in number in the region and are recognized as an effective method to prevent the overland transport, introduction, and spread of AIS that can hitchhike from one waterway to another on boats, trailers, and other recreational equipment.

Boat launch steward programs employ trained staff to greet users to a waterway, conduct a courtesy visual inspection of boats, trailers, and equipment before they enter a waterway and after they are retrieved to remove any visible aquatic plant or animal life, share information about spread prevention measures, and inform users about AIS impacts. This interaction provides an opportunity to gather information about the user, the last body of water the vessel was in, the state of vessel registration, and whether or not the operator of the vessel has taken any AIS spread prevention measures. The Paul Smith's College Watershed Stewardship Program, the Lake George Lake Steward Program, and the Lake Champlain Boat Launch Steward Program are the most established boat launch steward programs in the Adirondack region and have been in operation for many years.


Photo by Erica Miller

The region's first and largest boat launch steward program, the Paul Smith's College Watershed Stewardship Program (WSP), started in 2000. The WSP has grown in coverage from one waterway, Upper St. Regis Lake, in 2000 to 24 waterways staffed by 26 boat launch stewards across the Adirondack region in 2012 (Table 3). Coverage varies from weekends to all-week and runs from Memorial Day to Labor Day. Boat launch stewards generally cover boat launches for 8-hour work days. In 2012, the WSP inspected nearly 25,000 watercraft, removed 732 AIS samples, and educated approximately 50,000 visitors. Since 2000, the program inspected more than 87,000 watercraft and interacted with 187,000 visitors (some of which were repeat visitors).

Table 3. Paul Smith's College Watershed Stewardship Program boat launch steward locations, 2012.

Duty post	Coverage, days per week
Chateaugay Lake	2
Cranberry Lake	5
Eighth Lake Campground	1
Forked Lake Campground	1
Fourth Lake	4
Hoel Pond, St. Regis Canoe Area	1
Lake Flower	5
Lake Placid	7
Lake Placid Village	2
Little Clear Pond, St. Regis Canoe Area	3
Limekiln Lake Campground	1
Long Lake	7
Meacham Lake	2
Osgood Pond	2
Rainbow Lake	5
Raquette Lake, Village Boat Launch	7
Raquette Lake, Burke's Marina	2
Saratoga Lake	7
Second Pond	5
Seventh Lake	5
Stillwater Reservoir	4
Tupper Lake	5
Upper St. Regis Lake	7
White Lake	2

The Lake George Lake Steward Program began as a two year pilot program in 2006 through the Lake George Watershed Coalition's Invasive Species Task Force. In 2008, the Lake George Association (LGA) assumed

management of the program. From 2008-2012, the LGA's boat launch stewards inspected nearly 25,000 boats at high traffic launches around the lake, removed more than 400 AIS samples from boats, and educated approximately 60,000 boaters about invasive species spread prevention.

The Lake Champlain Basin Program's Lake Champlain Boat Launch Steward Program began as a pilot program in 2007 with four boat launch stewards stationed at the highest use NYSDEC and Vermont Fish and Wildlife Department launches on Lake Champlain. The program grew to ten boat launch stewards in 2013. In 2011, the program developed an Environmental Protection Agency and New England Interstate Water Pollution Control Commission approved Quality Assurance Protection Plan to document survey data collection methods, data quality checks, and storage to ensure data collection is consistent. Boat launch stewards inspect between 5,000 and 15,000 boats a year depending on available resources.

Boat launch stewards in the Adirondack region have intercepted various AIS hitchhiking on boats and gear, including quagga mussels, zebra mussels attached to strands of Eurasian watermilfoil, spiny waterflea on fishing line, and water chestnut nutlets. Had these boat launch stewards not been inspecting boats entering and leaving the waterways in question, new introductions and subsequent invasions may have occurred.

In addition to the larger boat launch steward programs mentioned previously, numerous lake or municipally run boat launch steward programs are in place across the region (Table 4).

Annual training hosted by Paul Smith's College Watershed Stewardship Program for stewards participating in boat launch steward programs around the region, including Paul Smith's College Watershed Stewardship Program, Lake Champlain Basin Program, Lake George Association, and East Shore Schroon Lake Association. Photo courtesy of LGA

Table 4. Boat launch steward programs in the Adirondack region. This table is not exhaustive. It provides a representation of the types of boat launch steward programs in existence in the Adirondack region and how they operate. Widespread interest exists to implement steward programs, but inconsistent funding leads to inconsistent implementation from year to year.
*Denotes a program known to be active in 2013.

Waterway name	Organization	# of launches with a steward	Years of steward coverage to-date	General coverage
Ausable River	AuSable River Association		3	5 days a week May-October
Brant Lake*	Brant Lake Association and Town of Horicon	1 (with three stewards)	3	3 days a week May-September
Blue Mountain Lake*				Steward interacts with the public at boat launches and monitors for invasives
Canada Lake*	Canada Lake Protective Association	1 (West Lake Boat Launch on Saw Dust Creek)	5	2-7 days a week Memorial Day-Labor Day
Lake Champlain*	Lake Champlain Basin Program	5 in NY (5 in VT)	7	3-4 days a week Memorial Day-Labor Day
Lake George*	Lake George Association	5-6	7	5-7 days a week Memorial Day-Labor Day
Loon Lake*	Town of Chester and Loon Lake Park District Association	1 (Loon Lake Park District Boat Launch)		3 days a week Memorial Day-Labor Day
Paradox Lake*	Paradox Lake Association	1 (NYS boat launch)	3	4 days a week Memorial Day-September
Peck Lake*	Peck's Lake Protective Association (PLPA)	1 (Peck's Lake Marina)	4	7 days a week Memorial Day-Labor Day
Sacandaga Lake*	Lake Pleasant Sacandaga Association (LPSA)	1 (Moffitt's Beach state campsite)	10	7 days a week late June-September
Schroon Lake*	Town of Horicon and East Shore Schroon Lake Association	1 (Horicon Boat Launch)	3	3 days a week May-September
Various*	Paul Smith's College Watershed Stewardship Program	24 in 2012	14	Weekends to all-week Memorial Day-Labor Day

IV. Inspection and Decontamination Efforts in the Adirondack Region

Alternatives to Inspections

A common concern among lake communities is that AIS can be spread when stewards are not on duty. One tool that is available during those times is the Internet Landing Installed Device Sensor (I-LIDS). A private company in the mid-west developed I-LIDS, which is a motion-activated camera installed at a boat launch. When a boater enters or exits the launch, the camera is triggered, playing an audio message reminding boaters to inspect and clean their gear and taking images and videos of the boat. This technology was in its third year of use on Raquette Lake in 2013, which is complementary to the steward program. Boat launch stewards review the videos to check for signs of AIS on boats and trailers to record frequency of usage and number of instances where plant material is visible.


Photo by Meghan Johnstone, APIPP

Status of Washing and Decontamination

Boat launch stewards generally focus on inspecting boats, removing or draining any water, and hand-removing any aquatic plants and debris, but often they do not have the time or the equipment to wash or decontaminate boats entering and exiting launches. Boat washing involves rinsing and flushing boat compartments and recreational equipment, which removes AIS, whereas boat decontamination involves high-pressure, hot water spraying, which removes and often kills AIS.

While some boaters may be able to wash their watercraft and gear at their homes, this may not always be the case. Boaters may visit various waterways in a short period of time while recreating or vacationing. In the last decade, shoreowners and municipalities have expressed increasing interest in offering public boat wash and decontamination stations. Currently, there are several active public boat wash and decontamination stations in the Adirondack region.

Upper St. Regis Lake

Upper St. Regis Landing in the Town of Harrietstown has a high-pressure, cold water boat wash with a catchment vault and screen-protected overflow pipe to Upper St. Regis Lake. The Upper St. Regis Foundation sponsors 7-day per week steward coverage at this moderate-to-lightly-used boat launch. When speaking with boaters, the boat launch steward recommends that they use the wash station upon entering and exiting the launch.

Buck Pond

Buck Pond State Campground has a low-pressure, cold water hose at the R.V. dump station adjacent to the boat launch into the Kushaqua Narrows. The boat launch steward recommends that boaters use the hose upon entering and exiting the launch.

Paradox Lake

Paradox Lake State Campground has a frequently used low-pressure, cold water boat wash station.

Lake George

In 2006 and 2007, as part of the pilot Lake Steward Program on Lake George, the Lake George Watershed Coalition purchased two portable boat wash units for use at launch locations. The units consisted of pressure washers powered by portable gas-powered generators. Boat launch stewards washed boats on a large mat

and a bilge pump collected the water from the mat. When the LGA began coordinating the Lake Steward Program in 2008, they discontinued the use of the units for numerous reasons, including logistical issues associated with set-up and break-down of the equipment, staffing of the units, as well as lack of available data supporting the effectiveness of the units. The LGA preferred to staff launch locations with boat launch stewards who provided boater education and visual inspection.


Portable decontamination unit in use around Lake George
Photo by LGA

The LGA continued visual inspection by boat launch stewards from 2008-2011. Due to the awareness raised by the Lake Steward Program about the threat of AIS, the Lake George community was ready to try washing boats again, this time with a more rigorous, better-funded program. In 2012, Warren County Soil and Water Conservation District purchased a high-pressure, hot water portable decontamination unit designed to kill and remove AIS. The Lake George Park Commission (LGPC) staffed the unit to decontaminate boats on a voluntary basis. In 2013, the LGPC purchased two additional units. Decontamination units were located at three locations around Lake George for voluntary decontamination. In April 2013, the LGPC released a *Draft AIS Prevention Plan* proposing a mandatory inspection and decontamination program. A public comment period for the plan was open from August 21-October 18, 2013. In November 2013, the LGPC Board of Commissioners unanimously voted to approve the *Final Generic Environmental Impact Statement (GEIS)/Lake George AIS Prevention Plan*. The Aquatic Invasive Species Regulation for Lake George was then approved and adopted in January 2014. Beginning May 15, 2014, all trailered boats entering Lake George will be inspected, prior to launch, for any plant or animal material. Any that do not pass inspection will be required to be decontaminated at a nearby boat decontamination station.

Loon Lake

In June 2013, the Town of Chester purchased a high-pressure, hot water boat decontamination station designed to kill and remove AIS. Operation of the station began in July 2013 at the Town-owned Loon Lake boat launch. Boat launch stewards inspect watercraft, and, if they are not found to be clean, drained, and dry, then they are decontaminated using the station. The Loon Lake boat launch gate is locked when unattended. The decontamination station is also available to boaters planning to launch watercraft in other lakes. All use is free of charge.

Other

Other efforts are underway in the region that utilize existing washing infrastructure to slow the spread of AIS. In 2012, the Lake Champlain Basin Program and its partners organized the Lake Champlain Cooperative Boat Wash Program. The program provides a map to boaters to locate car wash stations that are suitable for pressure washing boats, trailers, and other equipment. The map identifies suitable car wash stations in the Champlain Basin in Vermont and New York.[30] To expand this effort, the Adirondack Park Invasive Plant Program is creating a similar map for the Adirondack region.

IV. Inspection and Decontamination Efforts in the Adirondack Region

Boater Trends

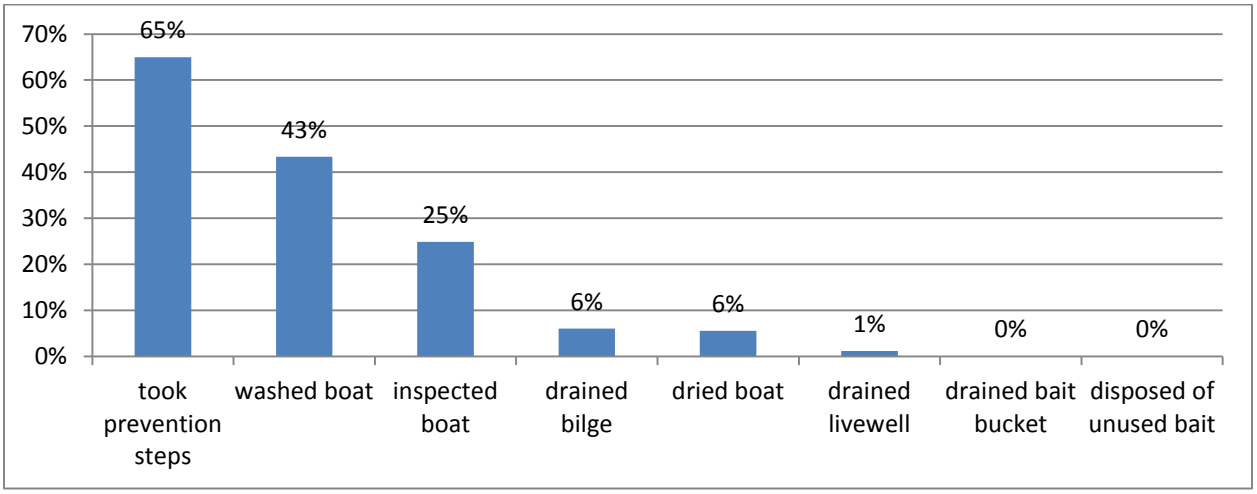
Waterways in the Adirondacks have been attracting visitors for recreation and sport for hundreds of years and continue to draw visitors from both within and outside the region year-round. Understanding recreational boater trends can help to inform AIS spread prevention strategies. Boat launch stewards generally cover boat launches for 8-hour work days, though most boat launches are available for public use around the clock. Additionally, boat launches are used for the entire ice-free season, and many, if not a majority, of publically accessible boat ramps in the Adirondack region have no boat launch steward presence. Despite these limitations, data that boat launch stewards collect can be used to derive an informative picture of the character of use at dozens of boat launches across the Adirondacks.

Visitors travel from all over the United States and Canada and use many forms of motorized and non-motorized watercraft, generally transported by standard cars, vans, and trucks. According to Paul Smith's College Watershed Stewardship Program (WSP) data, which is representative of other boat launch steward program data, motorized watercraft comprise approximately 66 percent of total boat traffic, followed by canoes and kayaks, both less than 20 percent, which rival each other depending on the yearly consumer trends. Sailboats, rowboats, and miscellaneous watercraft, such as stand-up paddleboards, are recorded only in the single percentages.[31]

Of 17,746 boating parties surveyed by Paul Smith's College boat launch stewards in 2012, 65 percent reported that they intentionally take at least one measure to prevent the spread of AIS on their watercraft (Figure 3). The most common method was washing one's boat (43 percent of groups). Many others inspected their boats without washing them, while very few reported draining their bilges, bait buckets, live wells, etc. (Figure 3). Thirty-five percent of boating parties did not take any measures to prevent the spread of AIS.

Boat launch steward programs also track the number of organisms detected on watercraft. Paul Smith's College boat launch stewards found organisms (AIS and indigenous) on 13 percent of watercraft in 2012. Organism transport rates were lower for Lake George and Lake Champlain.

Figure 3. Boater-reported AIS spread prevention measures (Paul Smith's College WSP, 2012). Some boaters take more than one spread prevention measure for their boat, which is why the spread prevention measures exceed 100 percent. Not all boats have bilges, carry bait buckets, or have live wells, and boat launch stewards did not record the presence or absence of live wells.



IV. Inspection and Decontamination Efforts in the Adirondack Region

Additional information collected by boat launch steward programs helps to inform the AIS spread risk for the region. The cooperating Adirondack regional steward programs (in this analysis, Paul Smith's College WSP, Lake George Lake Steward Program, Lake Champlain Boat Launch Steward Program, and East Shore Schroon Lake Association) also each ask visitors where they have used their boats last in the preceding two-week period. Out of 28,577 boating parties surveyed in 2012, the two most frequent answers were "nowhere" (38 percent of groups) and that the boat had previously been in the same lake (37 percent of groups). Since these two responses represent minimal risk of AIS transport (new to the waterway in question), then at least 75 percent of all boats launched in this analysis present minimal risk of spreading AIS.

These findings present resource managers with some interpretive challenges. Since 65 percent of the boating parties studied took some form of spread prevention measure, only 10 percent of inspected watercraft transported visible organisms, and, overall, 75 percent of boating parties present minimal risk of transporting AIS since they lack exposure to exogenous AIS, then the risk of spread of AIS between waterways at first appears small. Despite these otherwise positive indicators of voluntary prevention compliance and low-risk boat use, the fact remains that AIS detections continue to increase among Adirondack waterways. This suggests that either a comparatively small number of high-risk boats and equipment represent sufficient risk of effectively transporting AIS between waterways, and/or that seemingly small annual risks facilitate AIS transport when continued year after year. For example, a 2 percent confirmed AIS transport rate for one year might appear inconsequential; the same 2 percent AIS transport rate occurring annually for a decade represents a ten-fold increase in cumulative effective exposure compared with the one-year figure. Therefore, a comparatively small percentage of boat launch traffic presents AIS transport risk; however, AIS continue to be discovered in new waterways in the Adirondack region, corresponding to the presence of boat launches. Thus, prioritized inspection and decontamination needs to be paid to watercraft that present a high risk of spreading AIS.[32]

Additionally, there may be other ways by which lakes become invaded with AIS, e.g. bait bucket release or aquarium dumping. Furthermore, having boat launch stewards at a waterway will not prevent *all* AIS introductions, as they may not be covering the launch 100 percent of the time. This highlights the need to think critically about what types of coverage will offer the greatest amount of protection from AIS.

In addition to tracking prevention measures taken, data collected also describe the previous destination of the watercraft. Of the 25 percent of visitors to Adirondack boat launches that report a previously visited waterway *other* than the same lake, certain waterways see higher visitation rates (Appendix D). The Saranac Lake chain, Lake Champlain, Lake George, the Hudson River, Saratoga Lake, Lake Placid, and the St. Lawrence River are commonly mentioned. Another frequent response is that the previously visited waterway was unknown, which is often the response from boating parties using rental boats. Great Sacandaga Lake, which hosts spiny waterflea, a species of growing concern, is also a popular lake destination. Each of these commonly previously visited waterways hosts one or more AIS, further heightening the threat of AIS transport among Adirondack waterways.

After "none," the next most commonly named previous visit location represents only 1.4 percent of groups in 2011 and 2.6 percent in 2012, and percentages decline in value for each point of origin. Each named waterway in the top 50 represents a tiny fraction of previous visits; however, the vast *diversity* of previous visits is more important to consider. In 2012, visitors reported *590 different waterways* as origination points for previous visits. Thus, boats visiting Adirondack waterways pose some risk of transporting the organisms residing in nearly *600 origination waterways*, most with AIS, unless they are intercepted by boaters and/or boat launch stewards. Not all AIS may survive when introduced; however, it is a risk nonetheless.

V. Inspection and Decontamination: Efficacy and Considerations

In recent years, the scientific community has investigated the effectiveness of AIS spread prevention measures that are garnering attention in the Adirondack region: visual watercraft inspection by boat launch stewards and watercraft decontamination. These studies also offer insight into approaches that prevent landscape-level spread by reducing the risk of introducing AIS to new waterways through prioritizing where prevention measures are implemented. The following categories outline the main parameters to consider when integrating watercraft inspection and decontamination into an AIS spread prevention strategy.

Inspection and Hand-removal

Visual inspection is an important prevention step to take to minimize the risk of spreading AIS via recreational watercraft. A study by Rothlisberger et al. (2010) showed that visual inspection and hand-removal can reduce the amount of plants on a boat by 88 percent +/- 5 percent (mean +/- SE). While the transport of aquatic invasive plants can be prevented with a high probability through visual inspection and hand-removal, visual inspection often fails to detect seeds, small-bodied organisms, and resting egg stages of other species.[33] If the spread of aquatic invasive small-bodied organisms, such as spiny waterfleas and zebra mussel juveniles, or the deadly fish pathogen, Viral Hemorrhagic Septicemia Virus, VHSv, is of concern, visual inspection and hand-removal will not provide detection and removal with high probability.

Decontamination

Numerous methods are used to decontaminate boats, trailers, and recreational equipment which include washing, drying, chemicals and other liquids, and freezing. Some components of watercraft are more sensitive to disturbance than others and therefore should be decontaminated differently.

Washing

Low-pressure washing may not fully remove all AIS *and does not kill* the AIS that are retained on the boats. A study by Rothlisberger et al. (2010) showed low-pressure washing at 40 psi was less effective at removing plants off of a boat (62 percent +/- 3 percent removal rate) than high-pressure washing (83 percent +/- 4 percent removal rate). High-pressure washing at 1,800 psi was even more effective in removing small-bodied organisms off of a boat (91 percent +/- 2 percent), whereas low-pressure washing at 40 psi and hand removal were less effective (74 percent +/- 6 percent and 65 percent +/- 4 percent, respectively).[34]

Other studies evaluate effectiveness of hot water sprays for decontaminating recreational watercraft. For example, sprays at greater than or equal to 140 degrees Fahrenheit for five seconds were shown to be 100 percent lethal for quagga mussels.[35] For zebra mussels, sprays of greater than or equal to 140 degrees Fahrenheit for more than 10 seconds and sprays of greater than or equal to 176 degrees Fahrenheit for more than five seconds were both 100 percent lethal.[36]

The U.S. Federal Aquatic Nuisance Species Task Force (ANSTF) recommends spraying the boat hull and external surfaces with high-pressure (2,500 psi) hot water (140 degrees Fahrenheit) for 10 seconds and flushing motors and interior compartments with hot water (120 degrees Fahrenheit) for 2 minutes.[37] The Bureau of Reclamation[38] and Stop Aquatic Hitchhikers[39] guidelines include similar high-pressure, hot water recommendations.

Drying

Drying boats, trailers, and recreational equipment completely is an effective method to kill and prevent the spread of many AIS. Weather and humidity impact drying times. The 100th Meridian Initiative summarizes drying time parameters (http://www.100thmeridian.org).[h] Watercraft with ballast water and storage tanks that cannot be completely drained should be treated differently. A drying time of five days is recommended by a number of sources including the Stop Aquatic Hitchhikers (SAH) website (http://www.protectyourwaters.net/); however, this may not be sufficient to kill small-bodied organisms that can endure periods of desiccation. The 100th Meridian Initiative guidelines are more stringent and suggest seven additional days (for a total of 12 days) of drying time for temperatures ranging from 30-100 degrees Fahrenheit when relative humidity exceeds 50 percent.

Chemicals and Other Liquids

The ANSTF does not recommend the use of chemical prophylactics or disinfectants as a primary method for disinfection. Chemicals may damage equipment, pose risks to the environment, and have varying levels of effectiveness. The ANSTF therefore advises that chemical controls only be used if they are proven to be the most effective disinfection method for a particular species. The Bureau of Reclamation (BOR) 2010 *Inspection and Cleaning Manual for Equipment and Vehicles to Prevent the Spread of Invasive Species* makes a number of recommendations for chemical disinfection. Most of the recommendations provided are intended for the control of all stages of dreissenid mussel contamination. They include the following methods: salt - 1 percent salt solution for 24 hour soaking time (SAH same recommendation); vinegar - undiluted white vinegar contact for 20 minutes; and, bleach - diluted household bleach solution (>5 percent sodium hypochlorite) at a concentration of three ounces bleach to five gallons of water for one hour.

The BOR manual also recommends the use of potassium permanganate solutions and quaternary ammonium and poly quaternary ammonium compounds without application rate information. The Utah Division of Wildlife Resources recommends the use of potassium chloride (KCL) at 200 parts per million (ppm) and the use of quaternary ammonium in products such as Parvasol, Kennelsol, Formula 409, and Fantastik at full strength following label instructions for disinfection.[i] Using chemical or liquid decontamination methods must be in compliance with NYSDEC regulations.

Freezing

Freezing is another option for decontaminating watercraft and recreational equipment. The BOR manual recommends freezing gear at 14 degrees Fahrenheit for a period of at least four hours. Most household freezers maintain temperatures much colder than this, so they can be used to effectively decontaminate smaller pieces of equipment.

Decontamination of Specific Watercraft Components

Some components of watercraft are more sensitive to disturbance than others and therefore should be decontaminated differently. The National Oceanic and Atmospheric Administration (NOAA) Fisheries Service manual on *Preventing Invasive Species: Cleaning Watercraft and Equipment* provides guidance on how to clean, drain, and dry specific watercraft parts such as compartments, hull surfaces, anchors, trailers, and engines. The manual also provides guidance on how to clean gear via physical removal methods, such as brushing, vacuuming, and using adhesive rollers.[40]

[h] This information was developed in cooperation with Dr. McMahon from the University of Texas, Arlington.
[i] None of the chemicals mentioned are specifically labeled for AIS control and are therefore not legal to use for boat decontamination in New York.

V. Inspection and Decontamination: Efficacy and Considerations

Motorized and Non-motorized Watercraft

Both motorized and non-motorized vessels are able to transport AIS; however, motorized vessels, including personal watercraft, have more compartments and places in and on the motor where plants, animals, and water, which can contain small-bodied organisms not visible to the naked eye, can be transported. AIS may be transported via other locations in motorized vessels, including live wells, bilge water, on anchors and anchor lines, and on trailers. Non-motorized vessels such as kayaks and canoes have compartments, lines, and rudders where AIS can attach or hide. Stand-up paddleboards are growing in popularity, and mud and plant material can cling to those surfaces as well. Most of these non-motorized vessel components are more easily accessed and may be easier to drain or dry out. Few published papers exist that describe the risk of non-motorized vessels transporting AIS; however, Paul Smith's College Watershed Stewardship Program (WSP) data show while non-motorized vessels transport AIS, they pose less of a risk for transporting AIS than motorized vessels. According to 2013 WSP data, motorized vessels are 40 times more likely to transport AIS than are kayaks.[41] Despite this, inspecting, cleaning, draining, and drying non-motorized vessels is still important.

Invaded and Uninvaded Waterways and Inspection upon Exit and Entry

Determining where and when to implement prevention efforts when resources are limited can be a challenge and depends on the scale of the prevention program and its goals. Drury and Rothlisberger (2008) investigated the question of whether containing invasive species at invaded sources slows their spread more than preventing entry to uninvaded destinations. Results show that protecting only uninvaded, isolated waterways, rather than containing the invaded ones early on in the invasion process, allows AIS to spread from invaded sources at an unguarded rate to many other unprotected uninvaded locations. Recently invaded waterways can then become sources of AIS and contribute to the landscape-level spread. Therefore, early in an invasion, when the goal is to slow the spread of AIS through a collection of waterways, the best way to protect uninvaded areas is to allocate resources to containing invaded areas.[42] Because the number of "invasive-free" waterways in the Adirondack region is more than 2.5 times that of invaded waterways, it is beneficial to implement spread prevention measures at invaded areas. Visual inspection and hand-removal and/or decontamination of boats and equipment *after they exit* an invaded waterway are essential strategies to reduce the spread of AIS across the landscape.

Drury and Rothlisberger (2008) also discuss when it is appropriate to allocate resources to protect uninvaded waterways rather than contain invaded ones. Late in an invasion, protecting uninvaded waterways is the best strategy because "it yields lower per destination introduction rates at protected sites than containment at the same number of sites." Also, they advise that when the goal is to prevent AIS introductions into uninvaded waterways with high conservation value, for example, protecting that waterway is the best strategy.[43] Therefore, visual inspections and hand-removal and/or decontamination *upon entry* are appropriate and effective strategies to protect uninvaded waterways later in the invasion process *or* to prevent AIS introductions in priority waterways, which could be determined by conservation values, among other factors.

VI. Landscape-level Spread Prevention Concepts

Scale must be taken into consideration when evaluating the implementation of prevention programs. Is the prevention program targeting an individual lake, a grouping of lakes, a region, a state, or beyond? Important concepts emerged in the context of preventing the landscape-level spread of AIS and are presented here.

Landscape-level Analysis

Over the last several years, the most established boat launch steward programs in the Adirondack region— the Paul Smith's College Watershed Stewardship Program, the Lake George Lake Steward Program, and the Lake Champlain Boat Launch Steward Program—have worked together to collaborate on staff training, to develop and refine standard procedures, and to share findings. More recently, the collaborators have pooled and analyzed data from boat launch steward programs to arrive at a regional understanding of the spread of AIS through patterns of visitor use. For this paper, the boat launch steward programs combined all available data from 2011, 2012, and 2013 for an unprecedented, comprehensive analysis of 24 waterways represented by the three programs, also including the boat launch steward program run by the East Shore Schroon Lake Association. In order to begin assessing relative risk of AIS spread and implied allocation of boat inspection and decontamination, we asked a series of 13 questions about the 24 waterways and arranged the findings in a comprehensive risk assessment table (Appendix E). This process revealed that the lakes were different in many ways, implying nuanced and site-specific spread prevention responses. For example, a waterway might be heavily visited in terms of raw numbers, but the visitors might originate from a comparatively narrow array of previously visited waterways. Or, one lake might experience overwhelming use by motorboats and another by non-motorized watercraft. Or, as a final example, a lake on the Adirondack perimeter that appears to be a high-risk source of a particular AIS might in fact not originate very many outbound visits to pristine lakes deep within the Adirondacks. This comprehensive analysis allowed us to begin to understand the dynamics of interconnection within the 24-lake Adirondack Watershed Steward Network[j].

Invasion Spread Hubs

"Invasion spread hubs", a relatively new concept in the scientific literature, offers useful guidance on how to reduce the landscape-level spread of AIS in the Adirondack region. Invasion spread hubs are defined as AIS-invaded waterways with comparatively high outbound boat traffic traveling to uninvaded waterways. Efforts targeted to limit the development of invasion spread hubs may restrict the transport of AIS and reduce the predicted rate of new invasions.[44]

Since AIS invasion spread hubs are determined by whether and how frequently boats *departing* invaded waterways travel overland to waterways not currently invaded with the AIS in question, then the hubs are defined by species. That is, a lake might be an invasion spread hub for Asian clam (because it is relatively undispersed in the Adirondack region) and *not* serve as an invasion spread hub for Eurasian watermilfoil (because it already is present in the destination lakes connected to the lake in question). Knowing the most common destinations for overland boat travel within the Adirondack region will help to identify possible invasion spread hubs.

[j] The Adirondack Watershed Steward Network is defined as the lakes on which boat launch stewards are present and data is available. Boat launch stewards ask visitors only what lake they visited last rather than asking visitors to predict what lake they will visit next. To determine outbound visits, we analyzed previously-visited lake information, focusing on those lakes with boat launch stewards present. These visits represent confirmed trips from one lake within the Adirondack Watershed Steward Network to another. The two to five most commonly occurring destination lakes for each lake based on 2011-2013 data within the Adirondack Watershed Steward network can be found in the Adirondack Watershed Steward Network AIS Threat Analysis (Appendix E, column J) along with the percent of outbound visits to uninvaded lakes within the network; this threat analysis contributed to the designation of Adirondack invasion spread hubs.

VI. Landscape-level Spread Prevention Concepts

The data collected through the Adirondack Watershed Steward Network was used to map the interconnectivity among waterways in the network (Appendix F). Using the last-visited waterway responses supplied by visitors, a list of confirmed outbound overland boat transports between the 24 waterways in the Adirondack Watershed Steward Network was determined. This enabled the development of an overland transport model showing boater use patterns that has implications for AIS spread, based on the top most frequent outbound destinations for each lake in the network (Appendix E, Column J). For example, the top two most frequent Adirondack Watershed Steward Network destinations for boats leaving Chateaugay Lake were Second Pond, Lake Champlain, and Meacham Lake.

The network model identified three sub-networks of interconnected boater use: the Northway Network, High Peaks Network, and Fulton Chain Network. The network model allowed for the simulation of the predominant connections (AIS vectors) between waterways by following the connections between the 24 lakes in the Adirondack Watershed Steward Network from various starting points (Appendix F). It should be noted that other sub-networks may exist; however, due to funding gaps, boat launch steward data does not exist for all parts of the Adirondack region. For this reason, the function of other overland transport links and sub-networks is unclear at this time. The absence of boat launch use data in significant portions of the Adirondack region reinforces the need to expand boat launch steward programs in highly visited locations both in the region and outside of the region, such as the Hudson River Watershed, which is covered neither by the Great Lakes Restoration Initiative or the Lake Champlain Basin Program. Doing so would better protect the entire region from AIS and also allow for the full development of the Adirondack overland AIS transport model. Even so, the current network map is helpful in clarifying understanding of the most significant connections among regional waterways and in shaping informed responses to AIS transport threats.

Preliminary Adirondack Overland Transport Sub-networks: Northway, High Peaks, and Fulton Chain

Waterways in the Adirondack Watershed Steward Network are connected to each other in terms of potential AIS spread through overland transport of recreational watercraft; that is, most waterways in the region are connected by at least a few visits to most of the other regional waterways, along with hundreds of waterways from all over the eastern United States and Canada (Appendix D). However, the pattern of *highest-volume* outbound visits creates sub-networks of *strongly associated* waterways (Appendix F). The pattern suggests a functional separation of waterways in the Adirondack interior from those on the margins. One sub-network consists of Great Sacandaga Lake, Saratoga Lake, Schroon Lake, Lake Champlain, and Lake George. Each of these lakes has Eurasian watermilfoil, and all but Schroon Lake have one or more aquatic invasive small-bodied organisms (spiny waterflea, zebra mussels, or Asian clams). Collectively, this sub network, hereafter referred to as the Northway Network (for its proximity to I-87), contains the majority of aquatic invasive small-bodied organism occurrences in the Adirondack region.

According to the overland transport model, the Northway Network is comparatively isolated from interior Adirondack waterways. However, the network model indicates a high-volume outbound travel connection from Lake Champlain to Chateaugay Lake, Lake Placid, and Second Pond, which serves as the bridge from the Northway Network to the High Peaks Network, which is comprised of Chateaugay Lake, Lake Flower, Lake Placid, the Saranac Lakes, and Tupper Lake. The High Peaks Network is similarly isolated, except for an inbound connection from Cranberry Lake and an outbound connection between Tupper Lake and Long Lake, which is strongly connected to the Fulton Chain Network, comprised of Long Lake, Raquette Lake, Fourth Lake, Seventh Lake, and Eighth Lake.

While these findings of boater use patterns are preliminary, they could have value in prioritizing AIS spread prevention resources across such an expansive landscape of high-value aquatic resources. Each waterway does not face the same kinds of threats, and each poses distinct levels of risk for the other waterways in the region. This analysis suggests that there is an as-yet incompletely understood chain of connectivity and

sequence between the waterways that could be exploited for maximum spread prevention management impact.

Linkage Waterways

The analysis of overland transport of recreational watercraft shows usage patterns among certain waterways that form networks, previously described as the Northway, High Peaks, and Fulton Chain sub-networks. The three apparent networks are connected by what we designated as “linkage waterways”, which may serve as strategic control points to interrupt the regional spread of various AIS. Linkage waterways serve as “bridges” that connect the Northway, High Peaks, and Fulton sub-networks, and therefore also should be prioritized for implementing spread prevention measures since they may allow the transport of AIS among these sub-networks.

Applying Scientific Principles to Prevent the Spread of AIS in the Adirondack Region

Preventing the landscape-level spread of boater dispersed AIS is a top priority in the Adirondack region. A review of the scientific literature indicates that steps can be taken to reduce the spread of aquatic invasive plants and small-bodied organisms. The literature supports the following guiding principles: 1) Inspecting recreational watercraft when *exiting* a waterway will limit the spread of aquatic plants. 2) Inspecting and decontaminating recreational watercraft with high-pressure, hot water upon *exiting* waterways with aquatic invasive small-bodied organisms will limit their spread. 3) Applying inspection and decontamination (high-pressure, hot water) interventions to recreational watercraft *entering and exiting* waterways that serve as invasion spread hubs will reduce the predicted rate of new invasions.

Risk assessment (RA) is another important component of an AIS prevention program. It promotes efficiencies by evaluating whether a boat is high or low risk for transporting AIS. The RA process involves asking the boater about previous waterways visited, where the boat is registered, and whether spread prevention measures were taken. The boat launch steward also notes whether the watercraft is motorized or non-motorized. This process determines if decontamination is necessary.

These principles, in combination with analyzing AIS distribution, boater travel patterns, and regional factors can inform a prevention approach in the Adirondacks. Both containing the spread of AIS from invaded waterways and protecting priority uninvaded waterways in the Adirondack region are important to consider, as the region is early in the invasion process and would benefit from extra protection. Because this paper's recommendations are aimed at preventing the *landscape-level spread of AIS*, and funding and resources are limited, spread prevention measures should be implemented at invaded and select priority uninvaded waterways. Spread prevention programs that are already underway for individual waterways in the Adirondack region should continue in order to safeguard those waters.

High-pressure, hot water has been selected as the preferred method to decontaminate recreational watercraft on a landscape-level scale because it effectively kills *and* removes small-bodied organisms and is widely recommended by various literature sources and national agencies such as the U.S. Federal Aquatic Nuisance Species Task Force, the Bureau of Reclamation, and Stop Aquatic Hitchhikers. The following recommendations incorporate risk assessment and regional criteria and are grouped by the primary considerations evaluated in the scientific literature (Table 5).

Table 5. Recommendations for preventing the landscape-level spread of AIS in the Adirondack region based on scientific literature reviewed and regional factors.
RA = Risk Assessment. Cells marked with an "X" indicate the priority action to be taken based on the literature. Cells marked with "RA" indicate additional actions to be taken on entry in order to prevent new AIS introductions. Blank cells indicate that no action should be taken.
*Inspection occurs with decontamination on exit because these processes are complementary; visual inspection can direct decontamination by identifying locations on recreational watercraft that are especially soiled or have AIS clinging to them, and plants can be removed by hand.

	Inspect Upon Entry	Decontamination Upon Entry	Inspect Upon Exit	Decontamination Upon Exit
Invasion spread hubs / linkage	X	X	X*	X
Invaded by small-bodied organisms	RA	RA	X*	X
Invaded by plants only	RA		X	
Priority uninvaded	X	RA		

Invasion Spread Hub Waterways

Certain waterways in the Adirondacks are popular recreational boating destinations for both residents and visitors. They may also serve as invasion spread hubs. These waterways 1) have high use, 2) are known to be invaded by species not widespread in the region 3) have boats that frequently depart these waterways and travel to uninvaded waterways, and 4) are likely to have new introductions occur. To prevent landscape-level spread from invasion spread hubs and to reduce introduction of new invasive species to the region, boat launch stewards and boat decontamination stations should be positioned at or near invasion spread hubs. For these waterways, inspection and decontamination should occur before recreational watercraft enter *and* after they exit a waterway. This will reduce the likelihood of new introductions and reduce the likelihood of spread from the invaded waterway to uninvaded waterways. An analysis of AIS distribution and boater use patterns in the Adirondacks informed the preliminary designation of invasion spread hubs (Table 6, Appendix G).

Table 6. Preliminary invasion spread hubs in the Adirondack region. *Denotes waterways with active boat launch steward programs in 2013. **Denotes waterways with active boat launch steward programs and boat decontamination units in 2013.
Chateaugay Lake (Clinton/Franklin)
Fourth Lake (Herkimer)
Great Sacandaga Lake (Fulton/Saratoga)
Lake Champlain (Clinton, Essex, Washington)*
Lake Flower (Franklin)
Lake George (Warren/Washington/Essex)**
Saratoga Lake (Saratoga)*
Second Pond (Franklin)

Boat launch stewards reported that some boaters were traveling from Sacandaga Lake to Long Lake, Schroon Lake, Lake George, and Saratoga Lake. Because Sacandaga Lake has spiny waterflea, but Long Lake, Schroon Lake, and Saratoga Lake do not, Sacandaga Lake has the potential to serve as an invasion spread hub for spiny waterflea. Because there is very limited boat launch steward data for Sacandaga Lake, it cannot be considered an invasion spread hub at this time. The placement of boat launch stewards at Sacandaga Lake would allow for more data collection on this specific waterway, which would in turn help to clarify the Adirondack overland transport model.

Linkage Waterways

Linkage waterways serve as "bridges" that connect the Northway, High Peaks, and Fulton sub-networks, and therefore also should be prioritized for implementing spread prevention measures since they may allow the transport of AIS among these sub-networks (Table 7, Appendix G). The three linkage waterways identified in preliminary analyses are Long Lake and Tupper Lake, which are both invaded with variable-leaf watermilfoil, and Lake Champlain, which is also an invasion spread hub and has a number of aquatic invasive plants and small-bodied organisms not yet widespread in the region. If these lakes did not connect the sub-networks, then the AIS within each of the sub-networks would be more likely to be contained only to those sub-networks and the landscape-level spread of AIS may be reduced.

Table 7. Preliminary linkage waterways in the Adirondack region. *Denotes waterways with active boat launch steward programs in 2013.
Long Lake (Hamilton)*
Tupper Lake (Franklin/St. Lawrence)*
Lake Champlain*

Overland Transport Sub-networks

According to the Adirondack overland transport model, patterns of highest-volume outbound boat visits creates sub-networks of strongly associated waterways. These sub-networks include the Northway, High Peaks, and Fulton Chain Networks. Regional placement of boat decontamination stations at the overland transport sub-networks can prevent the landscape-level spread of AIS (Appendix F).

Waterways Invaded by Small-bodied Organisms

At least six waterways in the Adirondack region have one or more aquatic invasive small-bodied organisms. This distribution is limited compared to the predominance of invasive species and invaded waters outside of the region. A critical opportunity exists to limit the spread of aquatic invasive small-bodied organisms in the region, particularly in light of lack of available controls for many species. To prevent landscape-level spread of aquatic invasive small-bodied organisms, boat launch stewards and boat decontamination stations should be positioned at or near waterways where aquatic invasive small-bodied organisms are present (Table 8). These waterways may also have aquatic invasive plants. Multiple stewards and stations may be necessary for large waterways. A risk assessment will determine if an inspection and decontamination upon entry are necessary. Decontamination upon exit should always occur since those waterways are known to harbor aquatic invasive small-bodied organisms.

Table 8. Waterways with aquatic invasive small-bodied organisms in the Adirondack region through 2012. *Denotes waterways with active boat launch steward programs in 2013. **Denotes waterways with active boat launch steward programs and boat decontamination units in 2013. Saratoga Lake is located outside of the Adirondack Park but is included in this table because it is included in the steward data network.
Great Sacandaga Lake (Fulton/Saratoga County)
Lake Champlain (Clinton/Essex/Washington)*
Lake George (Warren/Washington/Essex County)**
Peck Lake (Fulton County)*
Sacandaga Lake (Hamilton County)*
Stewarts Bridge Reservoir (Saratoga County)
Saratoga Lake (Saratoga County)*

Waterways Invaded by Plants Only

At least 85 waterways in the Adirondacks have aquatic invasive plants (Appendix H). Studies show that visual inspection of recreational watercraft is sufficient to limit their spread. To prevent landscape-level spread of aquatic invasive plants already in the region, boat launch stewards should be prioritized at trailered boat access points on waterways where aquatic invasive plants are present. A risk assessment will determine if an inspection upon entry is necessary. Inspections upon exit should always occur since those waterways are known to harbor invasive plants and removal of vegetation from recreational watercraft will prevent their spread to other waterways.

Priority Uninvaded Waterways

More than two out of three waterways surveyed in the Adirondacks are free of AIS, which presents an important opportunity to halt introductions and protect uninvaded waterways from invasion. Priority uninvaded waterways are not identified in this paper but could be determined by examining factors such as public access, motorized access, intensity of use, exposure to invaded lakes, hydrologic connectivity, and conservation values. When the appropriate time arises to select priority uninvaded waterways to implement spread prevention measures, various factors such as the ones previously mentioned can help in the determination of these waterways.

A list of waterways surveyed where no AIS have been observed is provided in Appendix I. Inspecting all watercraft entering priority uninvaded waterways with trailered boat access will limit aquatic invasive plant introductions. Since aquatic invasive small-bodied organisms are not visible to the naked eye, a risk assessment will determine whether the boat is high risk for their transport. If the risk assessment concludes that the boat is high-risk, then decontamination will reduce the likelihood of introducing aquatic invasive small-bodied organisms.

Summary of Recommended Waterways for Boat Decontamination Stations

Boat launch steward inspections *and* boat decontamination stations at 13 specific waterways will help to limit the spread of aquatic invasive small-bodied organisms and also limit the spread of new introductions to the region (Table 9). Of those 13 waterways, seven have aquatic invasive small-bodied organisms, four serve as invasion spread hubs, and two serve as linkage waterways. Note that some waterways are in more than one category. Also note that these are preliminary recommendations based on analyses of available data, and inspections and decontamination stations at additional waterways may be warranted.

Table 9. Summary of waterways recommended for boat launch steward inspections *and* boat decontamination stations.

● Waterways that serve as invasion spread hubs
♦ Waterways that serve as linkage waterways
■ Waterways with aquatic invasive small-bodied organisms

Lake Champlain ● ♦ ■
Great Sacandaga Lake ● ■
Lake George ● ■
Saratoga Lake ● ■
Chateaugay Lake ●
Fourth Lake ●
Lake Flower ●
Second Pond ●
Long Lake ♦
Tupper Lake ♦
Peck Lake ■
Sacandaga Lake ■
Stewarts Bridge Reservoir ■

Proposed Tiered Approach for Using Boat Inspection and Decontamination in an Integrated AIS Prevention Strategy

Agency, Executive, and Legislative guidance, resource availability, site requirements, and public opinion will determine an implementation plan for preventing the spread of AIS in the Adirondack region. The following approaches are categorized in terms of level of protection and risk management based on extent of coverage and various actions (Table 10). Note: Not all invaded waterways have trailered boat access (e.g. some invaded waterways lack trailered boat access but are hydrologically connected to invaded waterways that have trailered boat access). These different tiers apply to waterways named in Table 9 and subsets of waterways named in Appendices H and I.

Platinum

- Boat decontamination stations *at all* invasion spread hubs and linkage waterways. Inspection and decontamination on entry *and* exit.
- Regional placement of boat decontamination stations *at overland transport sub-networks.*
- Boat decontamination stations *at all* waterways with aquatic invasive small-bodied organisms. Inspection occurs on entry, decontamination occurs if necessary. Decontamination occurs on exit.
- Boat launch stewards at *all* waterways with aquatic invasive plants that have trailered boat access. Inspection occurs on entry *and* exit.
- Boat launch stewards at launches on *all* priority uninvaded waterways. Inspection occurs on entry.

Gold

- Boat decontamination stations *at all* invasion spread hubs and linkage waterways. Inspection occurs on entry *and* exit. Decontamination occurs if necessary.
- Boat decontamination stations *at all* waterways with aquatic invasive small-bodied organisms. Decontamination occurs on exit.
- Boat launch stewards at *all* waterways with aquatic invasive plants that have trailered boat access. Inspection occurs on entry *and* exit.
- Boat launch stewards at launches on *all* priority uninvaded waterways. Inspection occurs on entry.

Silver

- Strategic regional placement of boat decontamination stations *near* invasion spread hubs and linkage waterways. Inspection and decontamination occurs on entry.
- Strategic regional placement of boat decontamination stations *near all* waterways with aquatic invasive small-bodied organisms. Decontamination occurs on exit.
- Boat launch stewards at *all* waterways with aquatic invasive plants that have trailered boat access. Inspection occurs on exit.
- Boat launch stewards at launches on *all* priority uninvaded waterways. Inspection occurs on entry.

Bronze

- Strategic regional placement of boat decontamination stations *near high traffic* waterways with aquatic invasive small-bodied organisms. Decontamination occurs on exit.
- Boat launch stewards at *high traffic* waterways with aquatic invasive plants that have with trailered boat access. Inspection occurs on exit.

Table 10. Proposed tiered approach for using inspection and boat decontamination in an integrated AIS prevention program.
Visual inspection: Visual inspection and hand-removal = 88% +/- 5% effective at removing plants.
Decontamination: High-pressure (1,800 psi) sprays = 91% +/- 2% effective at removing small-bodied organisms; 140 degrees Fahrenheit sprays for five seconds 100% lethal for quagga mussels; 140 degrees Fahrenheit sprays for 10 seconds 100% lethal for zebra mussels.

	Invasion spread hubs / linkage	Overland transport sub-networks	Invaded by small-bodied organisms	Invaded by plants only	Priority uninvaded
Platinum	Boat decontamination stations *at all* waterways; inspection and decontamination on entry *and* exit	Regional placement of boat decontamination stations at sub-networks	Boat decontamination stations *at all* waterways; inspection on entry, decontamination if necessary; decontamination on exit	Boat launch stewards at *all* waterways that have trailered boat access; inspection on entry *and* exit	Boat launch stewards at launches on *all* waterways; inspection on entry
Gold	Boat decontamination stations *at all* waterways; inspection on entry *and* exit; decontamination occurs if necessary		Boat decontamination stations *at all* waterways; decontamination on exit	Boat launch stewards at *all* waterways that have trailered boat access; inspection on entry *and* exit	Boat launch stewards at launches on *all* waterways; inspection on entry
Silver	Strategic regional placement of boat decontamination stations *near* waterways; inspection and decontamination on entry		Strategic regional placement of boat decontamination stations *near all* waterways; decontamination on exit	Boat launch stewards *at all* waterways that have trailered boat access; inspection on exit	Boat launch stewards at launches on *all* waterways; inspection on entry
Bronze			Strategic regional placement of boat decontamination stations *near high-traffic* waterways; decontamination on exit	Boat launch stewards at *high-traffic* waterways that have trailered boat access; inspection on exit	

VIII. Next Steps

The recommendations presented are a first step at assimilating existing regional data, analyzing and describing trends, and offering guidance on a science-based approach to enhance a regional AIS prevention strategy. The goal is to inspire thoughtful discussion about, and implementation of, a regional AIS prevention program that incorporates boat inspection and decontamination to prevent landscape-level spread.

Applying the Recommendations

The report will be used in three initial ways: 1) The report will be distributed to stakeholders, including decision-makers, local governments, lake associations, and non-governmental groups, among others, to be considered when planning AIS programs. 2) The authors will take the recommendations into consideration as they plan for regional prevention programs, including placement of boat launch stewards and other interdiction strategies, such as signage, as well as for early detection monitoring priorities. 3) The overland transport model will be tested each year as new data becomes available to ensure the validity of the relationships identified in the preliminary analysis.

Discussions are underway at local, regional, and statewide scales about implementing boat inspection and decontamination programs at individual lakes, at networks of lakes, and/or park-wide. Lake groups, in particular, are important advocates for protection, and, in many cases are shouldering the costs of prevention and management along with municipalities. These efforts should be supported and continued. An important next step is to evaluate the feasibility of implementing the recommendations in the context of a regional strategy and preventing landscape-level spread. Feasibility depends on resource availability, agency and political support, the regulatory environment, and social acceptance. This will require working in collaboration with state agencies, elected officials, shoreowners, non-governmental groups, boaters, and additional stakeholders.

Using Existing Partnerships

Successfully integrating visual inspection and decontamination into an AIS spread prevention program in the Adirondack region requires using and strengthening existing partnerships, including the NYSDEC, the New York State Office of Parks, Recreation and Historic Preservation (OPRHP), local governments, lake associations, PRISM partners, legislative leaders, and boaters, among others. A number of efforts are underway by various agencies and organizations that can be enhanced to bolster a stronger prevention program. Continued attention to AIS, collaboration among various organizations, and expansion of AIS prevention programs are essential.

Efforts Underway by the New York State Department of Environmental Conservation

The NYSDEC plays a vital role in preventing the spread of boater-dispersed AIS, and efforts are underway both in the Adirondack region and at the statewide level. These efforts are necessary to supplement the use of inspection and decontamination programs. Some of the NYSDEC activities include incorporating AIS information on their website; posting AIS prevention signage at boat launches on both invaded and uninvaded waterways and posting invaded waterways with special signage; installing AIS disposal stations at launches; distributing an AIS informational tip-strip to licensed boaters, registered trailer owners, and licensed anglers; participating in species or lake-specific response planning; conducting surveillance, monitoring, and management site visits; coordinating the development of a statewide AIS Management Plan; and, evaluating regulatory improvements.

Opportunities also exist to increase prevention efforts based on the recommendations presented here. For instance, each of the eight designated invasion spread hub waterways has New York State-owned public access points. The NYSDEC has campgrounds at four of these waterways. Therefore, the NYSDEC can play a

role in implementing AIS spread prevention measures, especially at locations such as NYSDEC campgrounds (Appendix J, K), where staff interact with the public on a daily basis.

Engaging campground staff in efforts to prevent the spread of AIS utilizes existing staff to help promote prevention practices. The NYSDEC initiated this process in spring 2013 by inviting representatives from the Adirondack Park Invasive Plant Program, the Paul Smith's College Watershed Steward Program, and the Lake Champlain Basin Program to offer AIS training to the Campground Operations staff. The training sessions provided staff with AIS spread prevention rack cards that staff can hand out to guests, discussed AIS spread prevention messages that staff can share with guests, and demonstrated proper visual inspection techniques that could be performed by staff at the launches and/or campground entry and exit booths. Training is expected to take place again in 2014.

Additionally, because New York State lacks a state-wide aquatic species transport law, the NYSDEC is developing a regulation that will prohibit boats from entering or leaving a NYSDEC launch with visible plants or animals on the boat and also will prohibit leaving a launch without draining the boat. Education about and enforcement of the regulation, when in place, will help to limit the landscape-level spread of boater-dispersed AIS. This is of particular importance to those invasion spread hub waterways having New York State-owned public access points. Furthermore, the Invasive Species Prevention Act will stop the introduction of prohibited invasive species via commercial pathways, such as water gardens, aquaria, and live seafood.

Efforts Underway by the New York State Office of Parks, Recreation and Historic Preservation

The New York State Office of Parks, Recreation, and Historic Preservation is working on increasing public knowledge and participation in slowing the spread of AIS. In 2013, OPRHP launched an education campaign at its 149 boat launch sites statewide urging boaters to help "Stop Aquatic Hitchhikers" by ridding their boats of potentially harmful AIS before and after each visit to State Park marinas and boat launches.

With Environmental Protection Fund support through New York's Department of State and the Department of Environmental Conservation Ocean and Great Lakes program, OPRHP developed and installed "Stop Aquatic Hitchhikers" signs in August 2013, informing visitors about what they can do to help prevent the spread of AIS. Each sign describes steps boaters should follow to clean, drain, and dry their boats. The "clean, drain, dry" message is being utilized by 29 other states and multiple federal organizations. OPRHP is interested in consistent messaging to generate greater public participation in the effort to reduce the movement of AIS. Installing AIS disposal stations adjacent to Parks boat launch sites is planned for 2014 with funding provided by NY Works. The number of disposal stations to be installed in 2014 has not yet been determined, but the goal is to have the disposal stations at as many boat launch sites as possible in parks statewide.

The NYS Parks Water Quality Unit conducts routine aquatic invasive plant surveys statewide at waterways of concern including waterways with known AIS, uninvaded waterways, and waterways with rare species. During these surveys, the Water Quality Unit monitors for the presence of invasive plants, makes management recommendations, and implements and assists with control measures. The NYSDEC assists Parks with the identification of aquatic invasive plants.

The Water Quality Unit has submitted a Great Lakes Restoration Initiative grant application in order to institute a boat launch steward program at the agency's Great Lakes boat launch sites and marinas. The "NYS Parks Boat Stewards - Great Lakes, Niagara and St. Lawrence Rivers" program will begin in 2014 and be active for 18 months, pending funding, with a focus on invasive species control. One full time coordinator, one seasonal lead steward, and 15 seasonal stewards will educate and provide hands-on instruction to park patrons who volunteer to participate in recreational watercraft and equipment decontamination and help prevent the spread of AIS.

OPRHP is also responsible for overseeing NYS Boater Safety Courses and is making efforts to enhance AIS information in training materials, through instructional videos, and on their website.

Efforts Underway by the Adirondack Partnership for Regional Invasive Species Management

The Adirondack Park Invasive Plant Program serves as the Adirondack Partnership for Regional Invasive Species Management and coordinates more than 30 organizations that work collaboratively on invasive species issues in the region. In summary, the partnership focuses on the following high priority strategies: coordinating stakeholders and collaborating on invasive species solutions; preventing new infestations by implementing innovative prevention programs and practices; enhancing a region-wide early detection network that utilizes professionals and volunteers to detect and report new infestations; formalizing Regional Response Teams, comprised of seasonal crews with the training and capacity to implement swift controls on new infestations; implementing strategic management on existing infestations to limit their spread; launching an invasive species education, marketing, and advertising campaign that raises awareness about how to stop the spread of invasive species; and, leveraging resources to the region to implement the full suite of actions required to stop the spread of invasive species.

Specific AIS actions that APIPP partners are working on include providing guidance to local governments on local transport laws; expanding the boat launch steward program; providing training to staff and volunteers on AIS identification, survey, and prevention techniques; coordinating volunteer monitoring for AIS; evaluating applications of new AIS surveillance methods; maintaining a database on the distribution of invaded and uninvaded waterways; managing AIS infestations; ensuring that aquatic invasive species prevention signage is posted at water access sites and that invaded waterways have special invasive species signage; designing and distributing AIS educational materials; offering educational presentations upon request; and, coordinating these and other priority actions as needed.

Numerous lake associations and municipalities in the Adirondack region are working on AIS prevention and management programs, many in partnerships with APIPP, the NYS Federation of Lakes Association, and the Adirondack Lakes Alliance, a network of lake groups throughout the Champlain Valley and beyond.

IX. Conclusion

The spread of aquatic invasive species (AIS) is an issue of national significance. The numbers of AIS are on the rise and moving at a faster rate due to global trade and transport. The subsequent ecological and economic impacts to industry, recreation, and the environment are costly and can be irreversible.

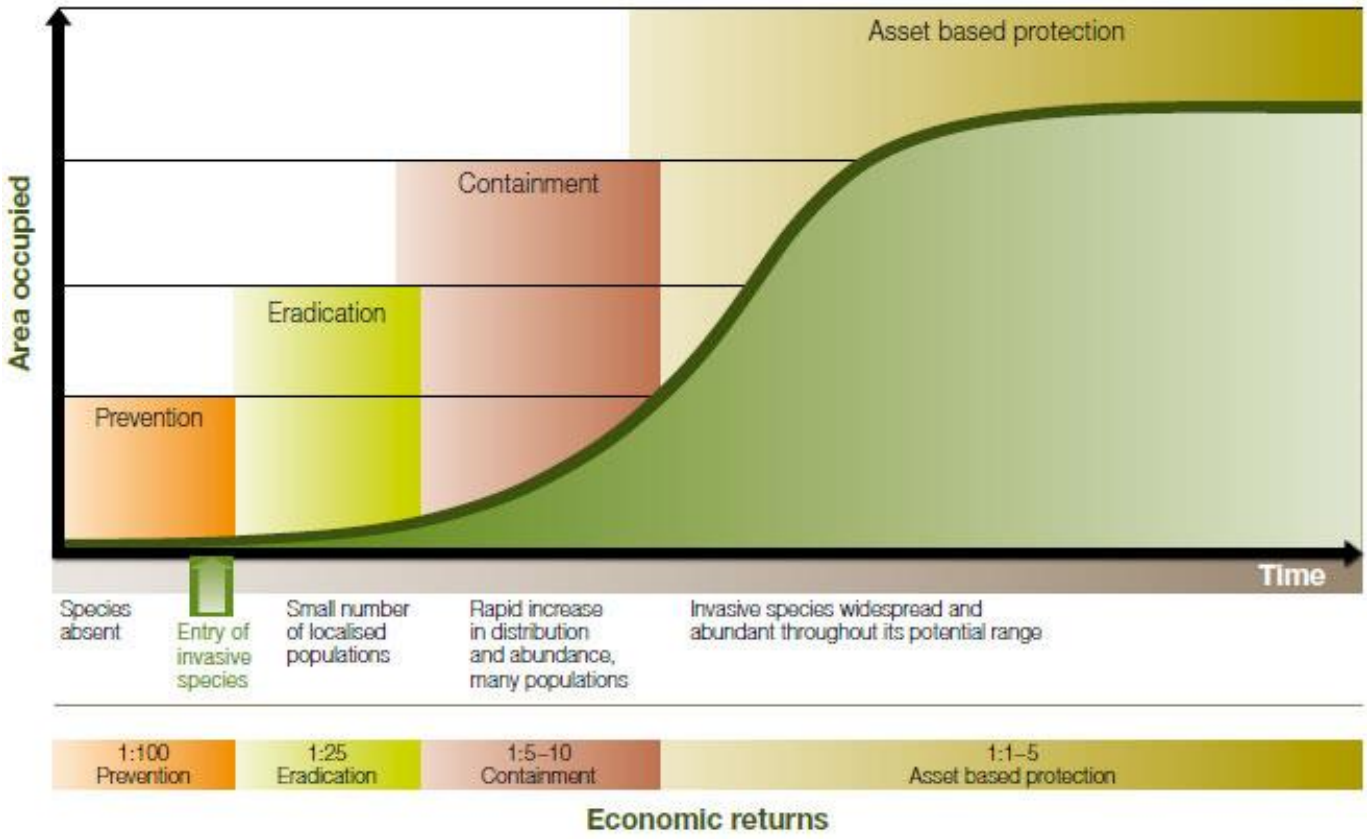
Management is expensive and complicated, and, for some species, no control measures exist. Prevention is the most cost-effective strategy. Comprehensive and integrated solutions, such as education, inspection, decontamination, surveillance, management, regulation, and enforcement, will be more effective in limiting the spread of AIS than pursuing any one strategy in isolation. An increasing emphasis on inspection and decontamination on Lake George and beyond led to the need for consideration of its relevance as a component of an integrated prevention strategy in the Adirondack region.

Substantial AIS information exists in the Adirondack region from existing surveillance, monitoring, and inspection programs that have been in place for more than a decade. The support of such programs reflects the great interest in aquatic resource protection among diverse stakeholders. Governmental and non-governmental groups alike are wrestling with the complex challenge of the prevention and management of AIS, i.e. how to implement the greatest level of protection given limited resources.

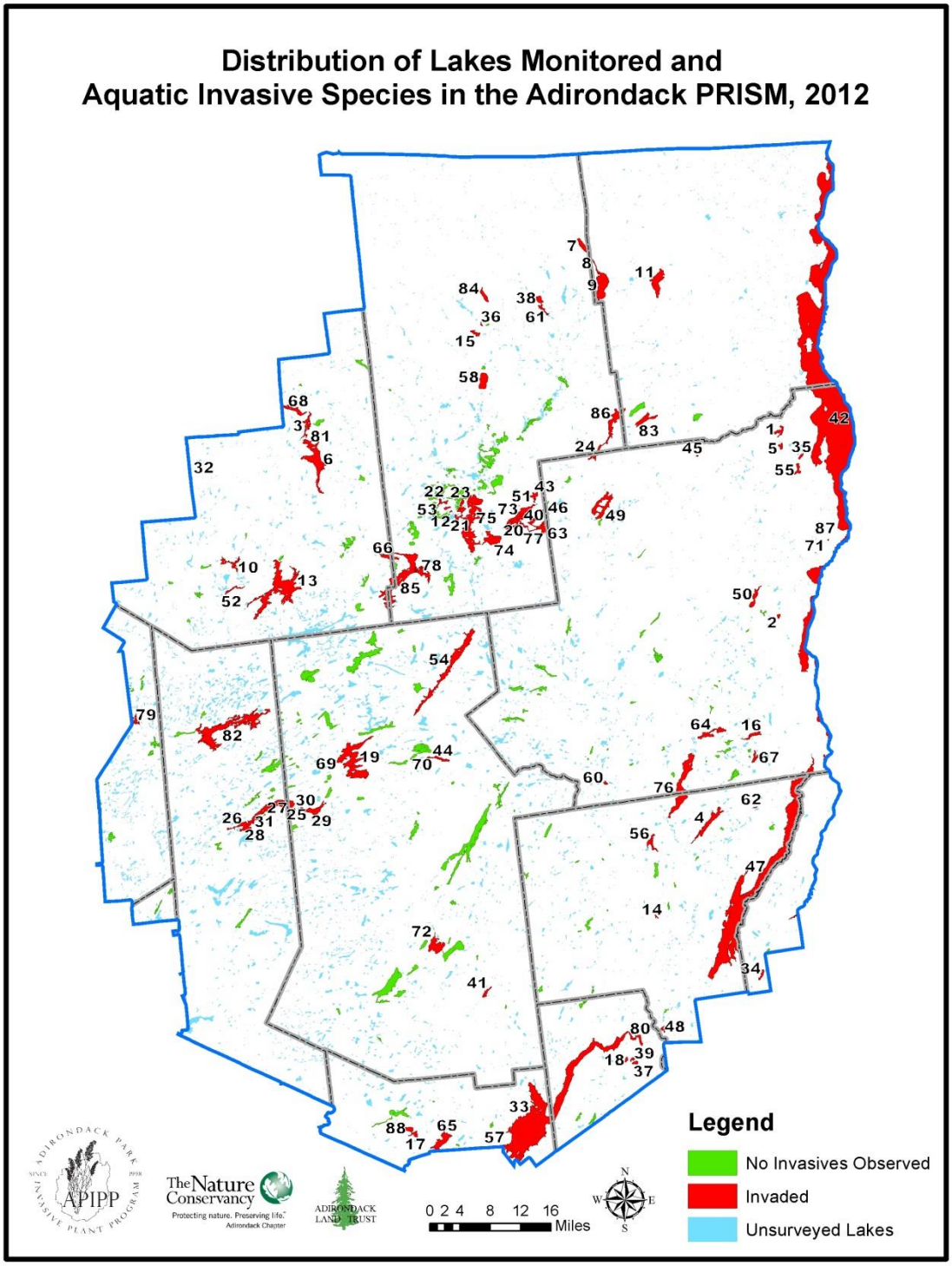
Many waterways in the Adirondack region remain free of invasive species, signaling the importance of acting now to prevent introductions. Every waterway is unique in terms of recreational use. Guiding principles from the literature can inform strategic, reasonable actions to reduce the risk of AIS spread given finite resources. A review of the literature indicates that inspection and decontamination can be effective in limiting the spread of aquatic invasive plants and small-bodied organisms. Appropriate locations to incorporate these actions can be determined by evaluating parameters such as whether or not a waterway is invaded, whether or not a waterway contains aquatic invasive plants or small-bodied organisms, whether inspections and/or decontamination occurs upon entry or exit of the waterway, and the travel patterns of boaters from invaded to uninvaded waterways.

Preliminary analyses of the guiding principles in combination with Adirondack AIS distribution data and boater use patterns enabled initial recommendations on where to deploy interventions to be the most effective in preventing landscape-level spread of AIS. This evaluation is a first step in planning for a more robust AIS prevention program in the Adirondack region. Various AIS programming is underway by agencies and stakeholders that can be leveraged for more comprehensive coverage. The next step will be for agencies, organizations, and communities to work together to determine the feasibility and resourcing required for implementation.

Appendix A. Invasion curve showing actions appropriate to each stage of invasion.[45]



Appendix B. Distribution of lakes within the Adirondack Partnership for Regional Invasive Species Management that contain aquatic invasive species. Please refer to the table on the next page to find lakes that correspond to numbers on the map.

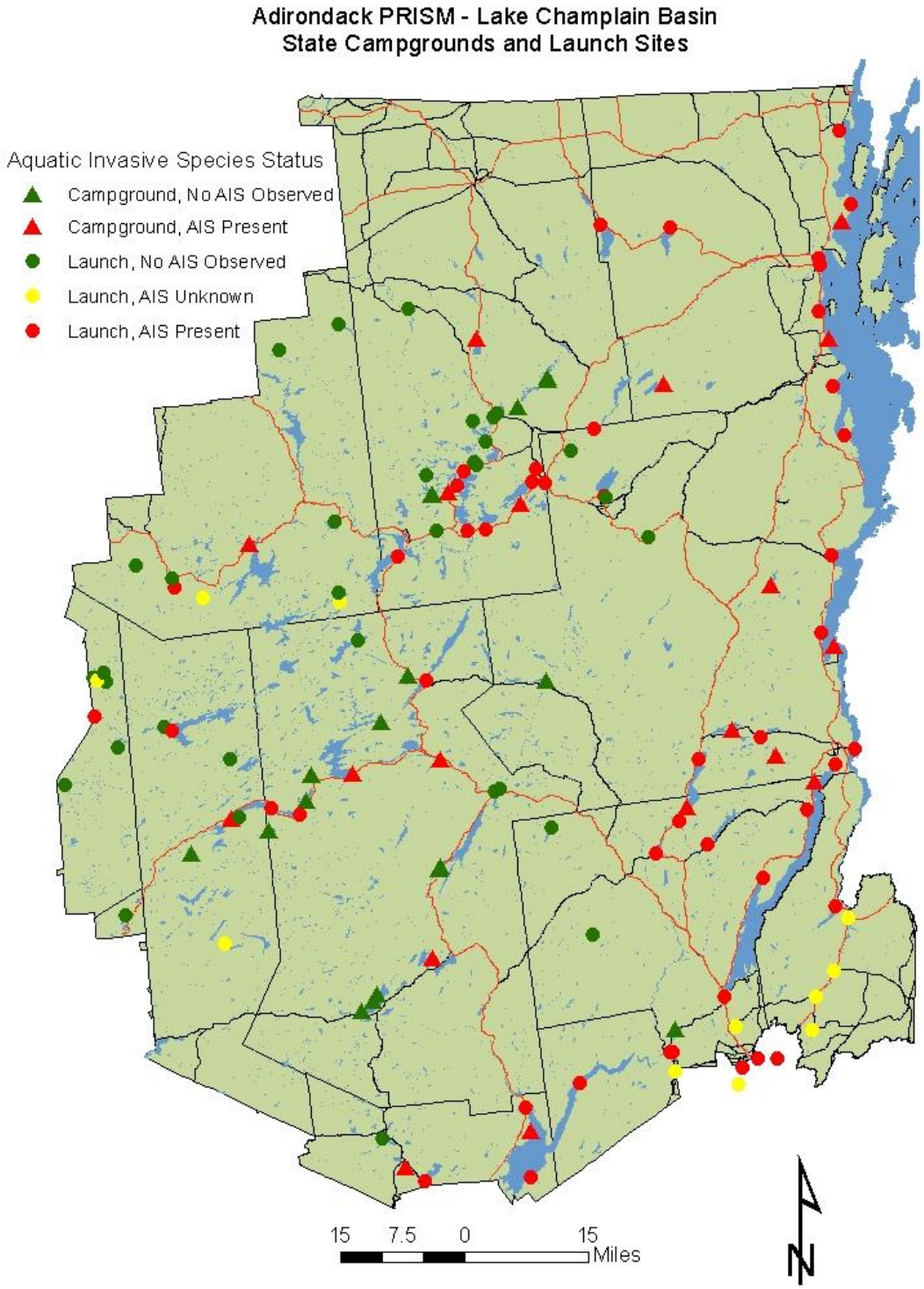


LIST OF ADIRONDACK WATERS WITH AQUATIC INVASIVE SPECIES		Key				EF - European Frog-bit						
		EWM - Eurasian Watermilfoil				Fan - Fanwort						
		VLM – Variable-leaf Milfoil				SWF - Spiny Waterflea						
		CLP – Curly-leaf Pondweed				BN - Brittle Naiad						
		WC - Water Chestnut				AC - Asian Clam						
		ZM - Zebra Mussel				YFH - Yellow Floating Heart						
Name (Alphabetized)	**#**	**EWM**	**VLM**	**CLP**	**WC**	**ZM**	**EF**	**Fan**	**SWF**	**BN**	**AC**	**YFH**
Augur Lake	**1**	X										
Bartlett Pond	**2**	X										
Blake Reservoir	**3**		X									
Brant Lake	**4**	X		X								
Butternut Pond	**5**	X										
Carry Falls Reservoir	**6**		X									
Chateaugay Lake (Lower)	**7**	X										
Chateaugay Lake (Narrows)	**8**	X										
Chateaugay Lake (Upper)	**9**	X										
Chaumont Pond	**10**		X									
Chazy Lake	**11**	X										
Copperas Pond	**12**	X										
Cranberry Lake	**13**		X									
Daggett Pond	**14**	X										
Deer River Flow	**15**	X										
Eagle Lake (Essex - Ticonderoga)	**16**	X										
East Caroga Lake	**17**	X										
Efner Lake	**18**							X				
Eldon Lake	**19**		X									
First Pond, Saranac Chain	**20**	X										
Fish Creek Ponds	**21**	X										
Floodwood Pond	**22**	X										
Follensby Clear Pond	**23**	X										
Franklin Falls Flow	**24**	X		X								
Fulton Chain, Fifth Lake	**25**	X	X									
Fulton Chain, First Lake	**26**		X									
Fulton Chain, Fourth Lake	**27**	X	X									
Fulton Chain, Second Lake	**28**	X	X									
Fulton Chain, Seventh Lake	**29**	X	X									
Fulton Chain, Sixth Lake	**30**	X	X									

Name (Alphabetized)	#	EWM	VLM	CLP	WC	ZM	EF	Fan	SWF	BN	AC	YFH
Fulton Chain, Third Lake	**31**		X									
Grasse River at Lampson Falls	**32**						X					
Great Sacandaga Lake	**33**	X							X	X		
Hadlock Pond	**34**	X		X	X					X		
Highlands Forge Lake	**35**	X										
Horseshoe Pond (Franklin - Duane)	**36**	X										
Hunt Lake	**37**							X				
Indian Lake (Franklin)	**38**	X										
Jenny Lake	**39**							X				
Kiwassa Lake	**40**	X										
Lake Algonquin	**41**	X										
Lake Champlain	**42**	X	X	X	X	X	X			X		X
Lake Colby	**43**	X										
Lake Durant	**44**		X									
Lake Eaton (Essex)	**45**						X					
Lake Flower	**46**	X	X	X								
Lake George	**47**	X		X		X			X		X	
Lake Luzerne	**48**	X		X								
Lake Placid	**49**		X									
Lincoln Pond	**50**	X										
Little Colby Pond	**51**	X										
Little River Flow	**52**		X									
Little Square Pond	**53**	X										
Long Lake (Hamilton)	**54**		X									
Long Pond (Echo Lake - Essex County)	**55**	X										
Loon Lake (Warren County)	**56**	X										
Mayfield Lake	**57**	X		X								
Meacham Lake	**58**	X										
Mill Pond (Saratoga County)	**59**							X				
Minerva Lake	**60**	X										
Mountain View Lake	**61**	X										
North Pond	**62**	X										
Oseetah Lake	**63**	X	X									
Paradox Lake	**64**	X		X								
Peck Lake	**65**								X			

Name (Alphabetized)	#	EWM	VLM	CLP	WC	ZM	EF	Fan	SWF	BN	AC	YFH
Piercefield Flow	**66**		X									
Putnam Pond	**67**	X										
Rainbow Falls Reservoir	**68**		X									
Raquette Lake	**69**		X									
Rock Pond (Hamilton)	**70**		X									
Rogers Pond	**71**						X					
Sacandaga Lake	**72**								X			
Saranac Lake, Lower	**73**	X		X								
Saranac Lake, Middle	**74**	X										
Saranac Lake, Upper	**75**	X										
Schroon Lake	**76**	X		X								
Second Pond, Saranac Chain	**77**	X	X									
Simon Pond	**78**		X									
Soft Maple Reservoir	**79**		X									
Stewarts Bridge Reservoir	**80**								X			
Stark Falls Reservoir	**81**		X									
Stillwater Reservoir	**82**		X									
Taylor Pond	**83**	X										
Titus Lake	**84**	X										
Tupper Lake	**85**		X									
Union Falls Flow	**86**	X	X									
Webb Royce Swamp	**87**						X					
West Caroga Lake	**88**	X										

Appendix C. New York State campgrounds and boat launch sites in the Adirondack Partnership for Regional Invasive Species Management (PRISM).



Appendix D. 2011 and 2012 top 50 previously visited waterways with combined data from the Lake Champlain Basin Program (LCBP), Lake George Association (LGA), Paul Smith's College (PSC), and East Shore Schroon Lake Association (ESSLA).

Same-lake visits have been removed (e.g. boat launch stewards at Lake George noted a very large number of responses of "Lake George" when they asked visitors where they had been in the previous two weeks. Such same-lake responses have been removed, because they do not represent an AIS transport risk factor).

Top 50 Previously Visited Waterways- Combined Data from LCBP, LGA, PSC, SLA						
Previously Visited Waterbody, 2011	Sum of # Visits	Percent of total visits		Previously Visited Waterbody, 2012	Sum of # Visits	Percent of total visits
None	8267	31.14%		None	10938	38.48%
Saranac Lake Chain	358	1.35%		Rental	733	2.58%
Rental	352	1.33%		Saranac Lake Chain	527	1.85%
Hudson River	293	1.10%		Lake Champlain	313	1.10%
Lake George	215	0.81%		Hudson River	264	0.93%
Lake Champlain	203	0.76%		Lake George	155	0.55%
Lake Placid	162	0.61%		Saratoga Lake	149	0.52%
Saratoga Lake	162	0.61%		Lake Placid	147	0.52%
Lake Flower	158	0.60%		Raquette Lake	123	0.43%
Upper Saranac Lake	129	0.49%		Mirror Lake	113	0.40%
Mohawk River	125	0.47%		St. Lawrence River	113	0.40%
St. Lawrence River	107	0.40%		Oneida Lake	110	0.39%
Lake Ontario	101	0.38%		Lake Ontario	106	0.37%
Schroon Lake	99	0.37%		Fourth Lake	103	0.36%
Tupper Lake	94	0.35%		Mohawk River	98	0.34%
Great Sacandaga Lake	86	0.32%		Atlantic Ocean	93	0.33%
Raquette Lake	85	0.32%		Tupper Lake	89	0.31%
Brant Lake	84	0.32%		Long Lake	82	0.29%
Fourth Lake	82	0.31%		Schroon Lake	82	0.29%
Oneida Lake	79	0.30%		Great Sacandaga Lake	77	0.27%
Atlantic Ocean	77	0.29%		Brant Lake, NY	74	0.26%
Buck Pond	76	0.29%		Lake Flower	72	0.25%
Candlewood Lake, CT	72	0.27%		Sacandaga Lake	70	0.25%
Mirror Lake	72	0.27%		Seventh Lake	67	0.24%
Long Island Sound	66	0.25%		Lake Hopatcong, NJ	62	0.22%
Connecticut River	64	0.24%		Indian Lake, NY	60	0.21%
Long Lake	64	0.24%		Upper St. Regis Lake	57	0.20%
Lake Hopatcong	59	0.22%		Lower Saranac Lake	52	0.18%
Sacandaga Lake	56	0.21%		Did not ask	51	0.18%
Fish Creek Ponds	50	0.19%		Long Island Sound	51	0.18%
Chateaugay Lake	49	0.18%		Unknown	51	0.18%
Lake Champlain	49	0.18%		Delta Lake	50	0.18%
Little Clear Pond	49	0.18%		Raquette River	48	0.17%
Upper St. Regis Lake	46	0.17%		Black River	43	0.15%
Raquette River	45	0.17%		Candlewood Lake, CT	42	0.15%
Lower Saranac Lake	40	0.15%		Follensby Clear Pond	42	0.15%
Seventh Lake	32	0.12%		Blue Mountain Lake	40	0.14%
Cossayuna Lake	31	0.12%		Lake Bonaparte	39	0.14%
Cranberry Lake	31	0.12%		Canandaigua Lake	38	0.13%
Lake Colby	31	0.12%		Chateaugay Lake	36	0.13%
Lake Bonaparte	30	0.11%		Connecticut River	36	0.13%
Canandaigua Lake	29	0.11%		Lake Colby	36	0.13%
Rainbow Lake	29	0.11%		No Data Collected	35	0.12%
Rollins Pond	29	0.11%		Black Lake	34	0.12%
Osgood Pond	28	0.11%		Fish Creek Ponds	34	0.12%
Rental	28	0.11%		Upper Saranac Lake	33	0.12%
Middle Saranac Lake	27	0.10%		Other (write in notes)	32	0.11%
Saranac River	27	0.10%		Saranac River	31	0.11%
Ballston Lake	26	0.10%		Skaneateles Lake	31	0.11%
Skaneateles Lake	26	0.10%		Kayuta Lake	30	0.11%

Appendix E. Adirondack Watershed Steward Network aquatic invasive species threat analysis.

Lake	A. # AIS present (plants)	B. # AIS present (animals)	C. Average # of boats inspected per day[2]	D. % of Incoming Boats At-Risk of AIS transport (boat operators report a visit to another waterbody within the previous two weeks)	E. % of all boats encountered transporting any organism (launching plus retrieving)[3]	F. % of all boats encountered transporting AIS (launching plus retrieving)	G. Number of *different* previously-visited waterbodies reported by all boat operators over the summer. (higher values = greater degree of potential connectivity)	H. % of confirmed outbound visits to *lakes with no AIS* in ADK steward network[4]	I. % of confirmed outbound visits to lakes with *no invasive animals* present in ADK steward network	J. Top 3 previously visited water bodies	K. Most frequently occuring outbound connections within ADK steward network[5] (lakes that are next in the AIS spread vector chain. 2011-2013 data.)	L. Inbound AIS vulnerability[6] (Columns D + E + G)	M. Risk of lakes functioning as invasion spread hubs[7] (Columns A + B + C+ F + H + I)
Chateaugay Lake	1	0	35	16%	14%	7.1%	54	14%	81%	Champlain, St. Lawrence, Chazy	Lake Champlain, Second Pond, Meacham Lake	low	high
Cranberry Lake	1	0	25	22%	11%	2.2%	77	6%	94%	St. Lawrence, Bonaparte, Black	Tupper Lake	medium	low
Eighth Lake	0	0	6	36%	1%	0.0%	15	10%	100%	Seventh, Fulton Chain, Raquette	Fourth Lake, Seventh Lake, Raquette Lake	low	low
Forked Lake	0	0	18	59%	34%	0.0%	24	3%	100%	Rental, Raquette, West	Long Lake	high	low
Fourth Lake	2	0	31	28%	9%	1.2%	76	7%	100%	Raquette, Oneida, Seventh	Raquette Lake, Seventh Lake	medium	medium
Great Sacandaga Lake	2	1	19	19%	0.3%	0.0%	42	2%	20%	Saratoga, Lake George, Hudson River	Saratoga Lake, Lake George	low	medium
Hoel and Little Clear Pond	0	0	9	53%	4%	0.0%	59	44%	100%	Rental, St. Regis, Saranacs	not enough data	medium	low
Lake Champlain	7	1	24	10%	13%	8.0%	92	4%	55%	Hudson, Candlewood, Lake George	Lake George, Saratoga Lake, Chateaugay Lake, Lake Placid,	medium	high
Lake Flower	3	0	21	37%	18%	4.2%	80	23%	99%	Saranacs, Placid, Rental	Lake Placid, Second Pond, Upper St. Regis	high	high
Lake George	3	3	84	13%	2.7%	2.0%	156	2%	48%	Champlain, Hudson Riv, Saratoga	Saratoga Lake, Schroon Lake, Lake Champlain	high	medium
Lake Placid	1	0	21	25%	2%	0.0%	128	15%	93%	Mirror, Rental, Lake Flower	Lake Flower, Second Pond	high	low
Long Lake	1	0	24	20%	14%	0.2%	102	9%	92%	Rental, Raquette, Tupper	Tupper Lake, Raquette Lake	high	low
Meacham Lake	1	0	9	44%	5%	0.4%	26	17%	92%	Chateaugay, St. Lawrence, Upper St. Regis	not enough data	low	low
Osgood Pond	0	0	7	81%	5%	0.0%	31	70%	100%	St. Regis River, Champlain, Jones Pond	Upper St. Regis Lake	low	low
Rainbow Lake	0	0	10	43%	13%	0.1%	52	31%	93%	Champlain, Saranacs, Kushaqua	Upper St. Regis Lake	medium	low
Raquette Lake	1	0	18	58%	17%	2.7%	92	5%	97%	Fourth, Blue Mountain, Seventh	Long Lake, Fourth Lake, Seventh Lake	high	low
Saratoga Lake	3	1	37	12%	25%	10.2%	81	0%	37%	Hudson R., Lake George, Champlain	Lake George, Lake Champlain, Schroon Lake, Great Sacandaga	medium	high
Schroon Lake	2	0	29	16%	0%	0.0%	45	3%	31%	Lake George, Hudson R., Brant Lake	Lake George, Saratoga Lake	low	low
Second Pond	3	0	43	54%	7%	2.2%	162	20%	94%	Rental, Saranacs, L. Placid	Lake Placid, Upper St. Regis Lake	high	medium
Seventh Lake	2	0	8	49%	4%	1.0%	59	9%	100%	Fourth, Raquette, Eighth	Fourth Lake, Raquette Lake	low	low
Stillwater Reservoir	1	0	18	26%	10%	2.3%	47	7%	100%	Black, Ontario, Fourth	not enough data	low	low
Tupper Lake	1	0	16	19%	12%	0.2%	62	6%	97%	Long L., Saranacs, Rental	Long Lake, Second Pond, Lake Flower, Cranberry Lake	low	low
Upper St. Regis Lake	0	0	10	48%	3%	0.2%	88	22%	96%	Rental, Lower Saranac, L. Placid	Second Pond, Lake Placid, Lake Flower, Chateaugay Lake	low	low
White Lake	0	0	10	17%	6%	0.01%	27	0%	57%	Oneida, Kayuta, First Lake	Fourth Lake	low	low

Notes:

Explanation of the assignation of risk colors: The team assigned the three AIS spread risk colors (green = lowest risk; yellow = medium risk; red = high risk) according to defensible breaks in the data and collective judgment. A summary of the categorization rules follows. Column A: low = 0 AIS plants; medium = 2; high >2. Column B: low = 0 AIS animals; no medium-risk category; high > 0. Column C: low = 0-10 boats per day; medium = 11-30; high >30. Column D: low = 0-19% of boats at risk of AIS transport; medium = 20-49%; high >50%. Column E: low = 0-5% organism transport rate; medium = 6-14%; high >14%. Column F: low = 0-2% AIS transport rate; medium = >2 – 4%; high > 4%. Column G: low = 0-50 previous waterbodies; medium = 51- 100; high >100. Column H: low = 0-9% of outbound visits; medium = 10 – 25%; high >25%. Column I: low = 0 – 40% of outbound visits; medium = 41- 59%; high > 59%.

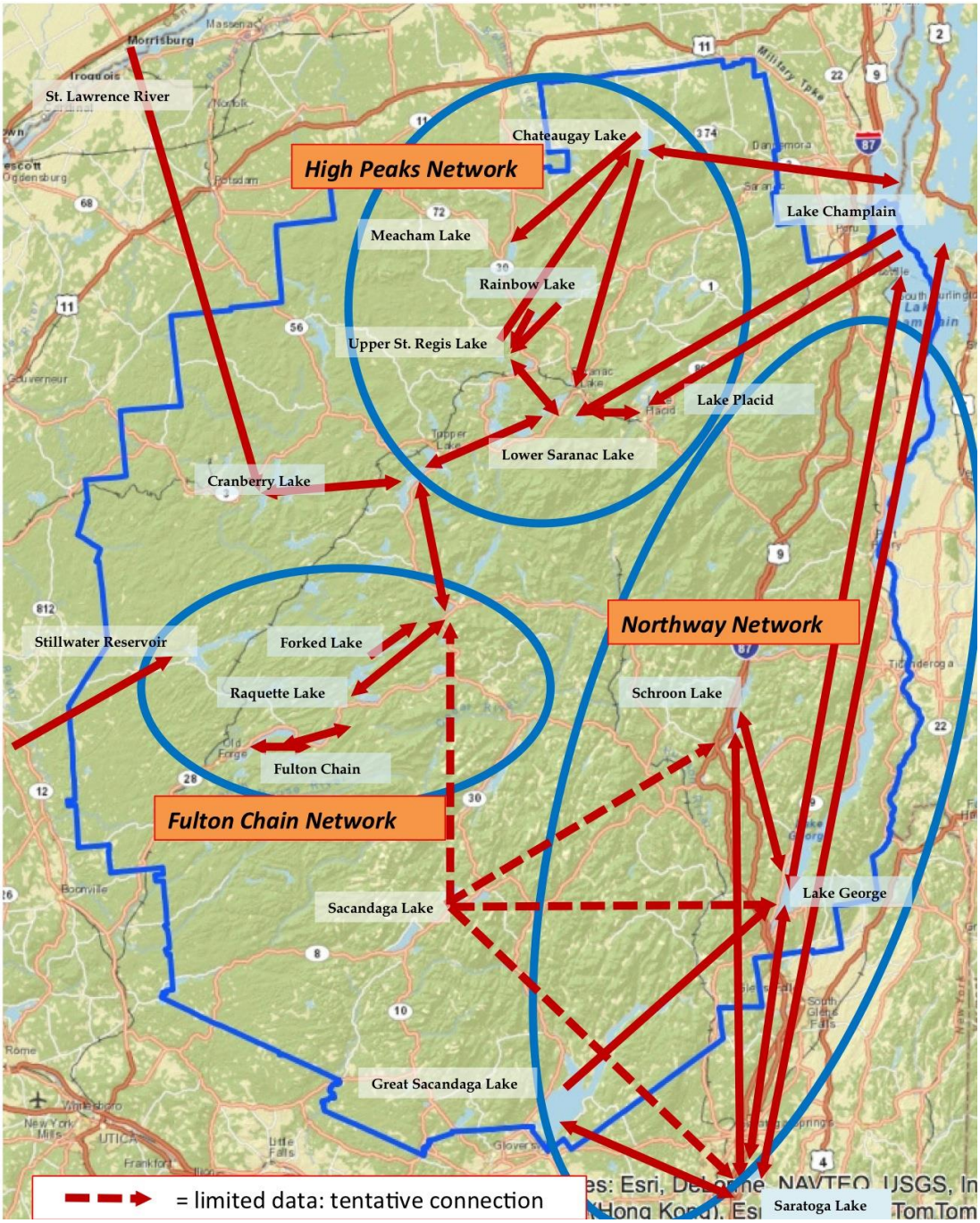
1. The Adirondack Watershed Steward network consists presently of active boat launch steward programs managed by the Lake Champlain Basin Program, the Lake George Association, Paul Smith's College, and the East Shore Schroon Lake Association.

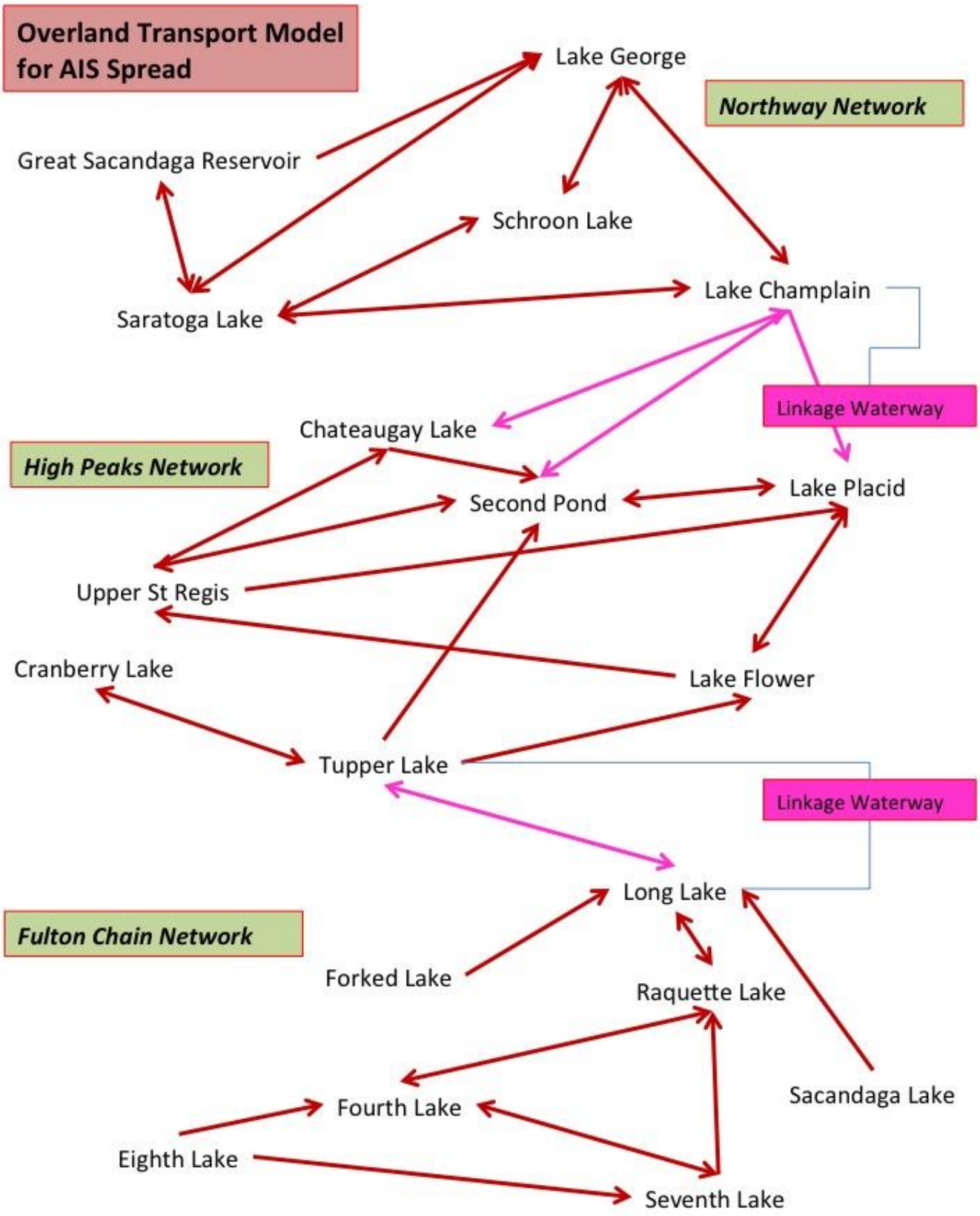
2. Unequal boat launch coverage was accounted for by dividing the total number of boats inspected by total days of service over the field season. Figures for lakes with multiple launches were combined and averaged using available data. These figures are based on 2012 steward coverage from Memorial Day to Labor Day. Not all sites had seven day per week steward coverage. Boat launch steward coverage is limited to working hours (typically eight hours per day), less breaks. Actual traffic is undoubtedly higher at each location for a 24 hour period.
3. The AIS transport rate is influenced by the combination of human factors (boat launch steward effort, ability, work pattern) and environmental factors (variation in annual density of vegetation growth, prevailing wind, water temperature, etc.).
4. "Outbound visits" take place when a boat is retrieved from one lake and launched in another, within a two-week period. "Confirmed" indicates that these visits are *actual* visits based on voluntary visitor statements about the last waterway they had visited prior to boat launch steward contact. E.g., if a visitor to Lake Placid states that they had visited Lake George last, this counts as a confirmed *outbound* visit from Lake George to Lake Placid.
5. This column indicates the lakes most likely to serve as destinations for boats leaving the lake in question. N.B., outbound visits can only be determined for the 24 lakes within the Adirondack Watershed Steward Network. The list includes the top two to five outbound destinations, in descending order. It is possible that other destinations not within the network are more common, but this information is not available. By analyzing these most frequently occurring outbound destination connections, managers can infer typical pathways for the spread of invasive species new to the region, and institute appropriate spread prevention interventions and/or facilities.
6. Inbound vulnerability to AIS infestation is an important defensive consideration. Managers must prioritize certain high value or high risk lakes for protection from outside invasion by considering placing boat launch stewards and/or boat washes at these locations.
7. In order to determine outbound invasion spread hub status, we looked for patterns of low, medium, and high comparative risk in terms of combinations of the following criteria: # AIS present (plants), # AIS present (animals), volume of boater traffic, how "dirty" boats are at particular locations, and the likelihood of boats departing the waterway to visit uninvaded (by plants and/or animals) waterways. Outbound AIS spread hubs are important to consider for effective and well-resourced intervention. Boat launch stewards and the accessibility of effective boat wash facilities provide boaters departing infested waterways with usable and timely ways to disinfect watercraft, thus providing residual protection to the entire Adirondack network.

Appendix F. Preliminary Adirondack Overland Transport Sub-networks maps.

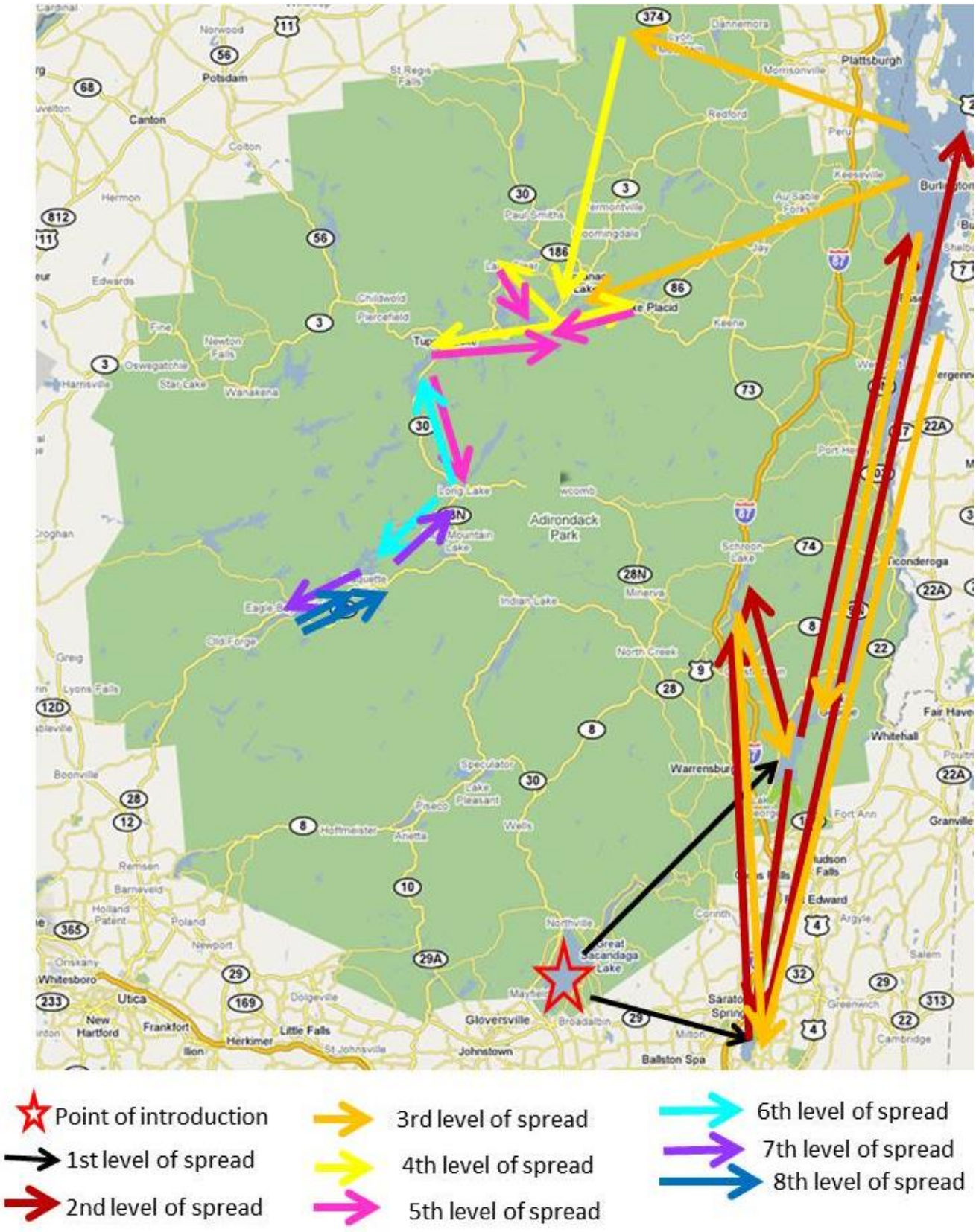
Other sub-networks may exist; however, because boat launch steward data does not exist for all parts of the Adirondack region, the presence of other sub-networks is unknown at this time. Note: Boat launch stewards reported that some boaters were traveling from Sacandaga Lake to Long Lake, Schroon Lake, Lake George, and Saratoga Lake. Because Sacandaga Lake has spiny waterflea, but Long Lake, Schroon Lake, and Saratoga Lake do not, Sacandaga Lake has the potential to serve as an invasion spread hub for spiny waterflea. Because there is very limited boat launch steward data for Sacandaga Lake, it cannot be considered an invasion spread hub at this time. The placement of boat launch stewards at Sacandaga Lake would allow for more data collection on this specific waterway, which would in turn help to clarify the Adirondack overland transport model.

Boat Launch Use Network Data, 2011-2013:
Primary Outbound Destinations from Boat Launches in the Adirondack Region

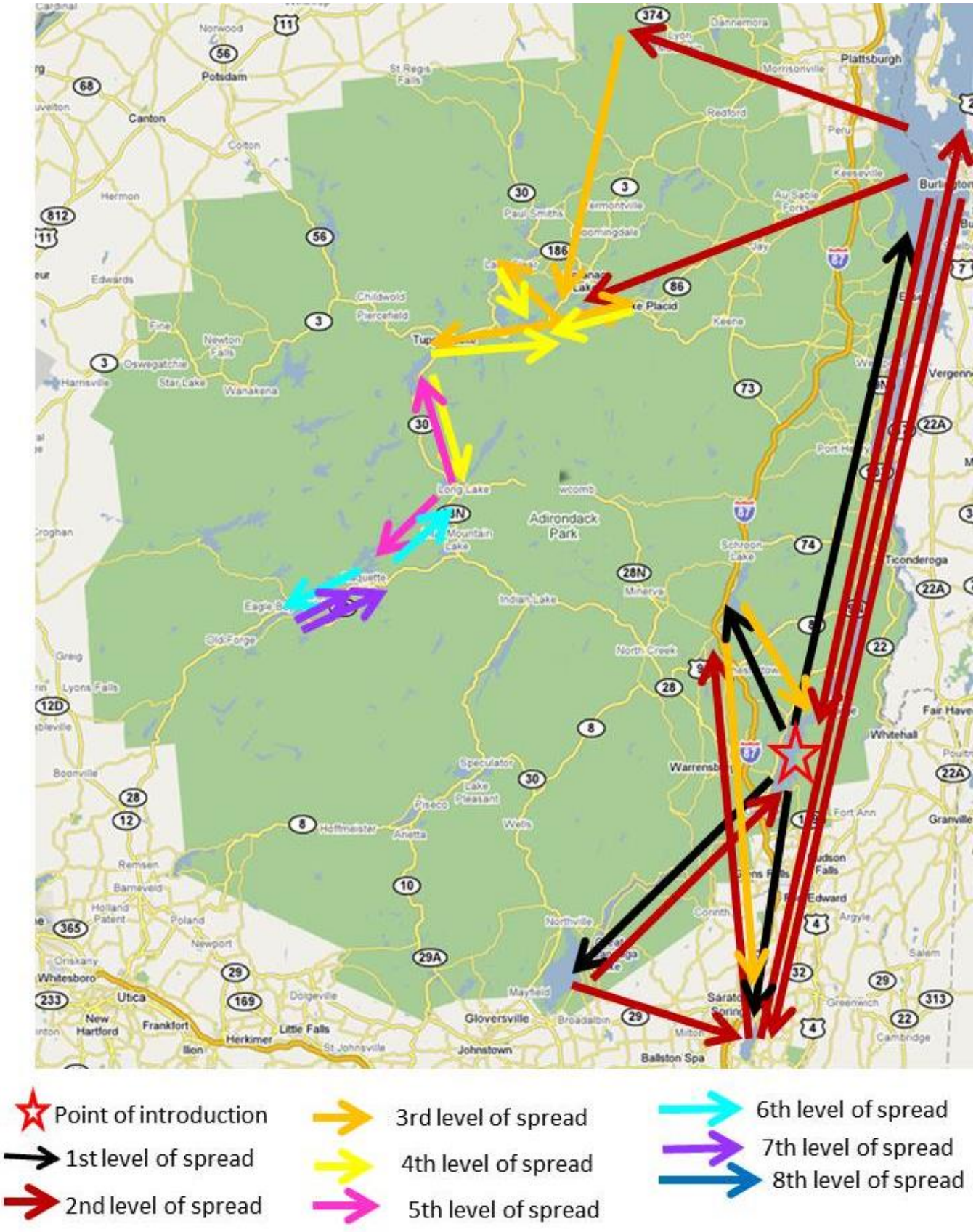



Overland Transport Model for AIS Spread
Lake George
Northway Network
Great Sacandaga Reservoir
Schroon Lake
Lake Champlain
Saratoga Lake
Linkage Waterway
Chateaugay Lake
High Peaks Network
Second Pond
Lake Placid
Upper St Regis
Cranberry Lake
Lake Flower
Tupper Lake
Linkage Waterway
Long Lake
Fulton Chain Network
Forked Lake
Raquette Lake
Sacandaga Lake
Fourth Lake
Eighth Lake
Seventh Lake

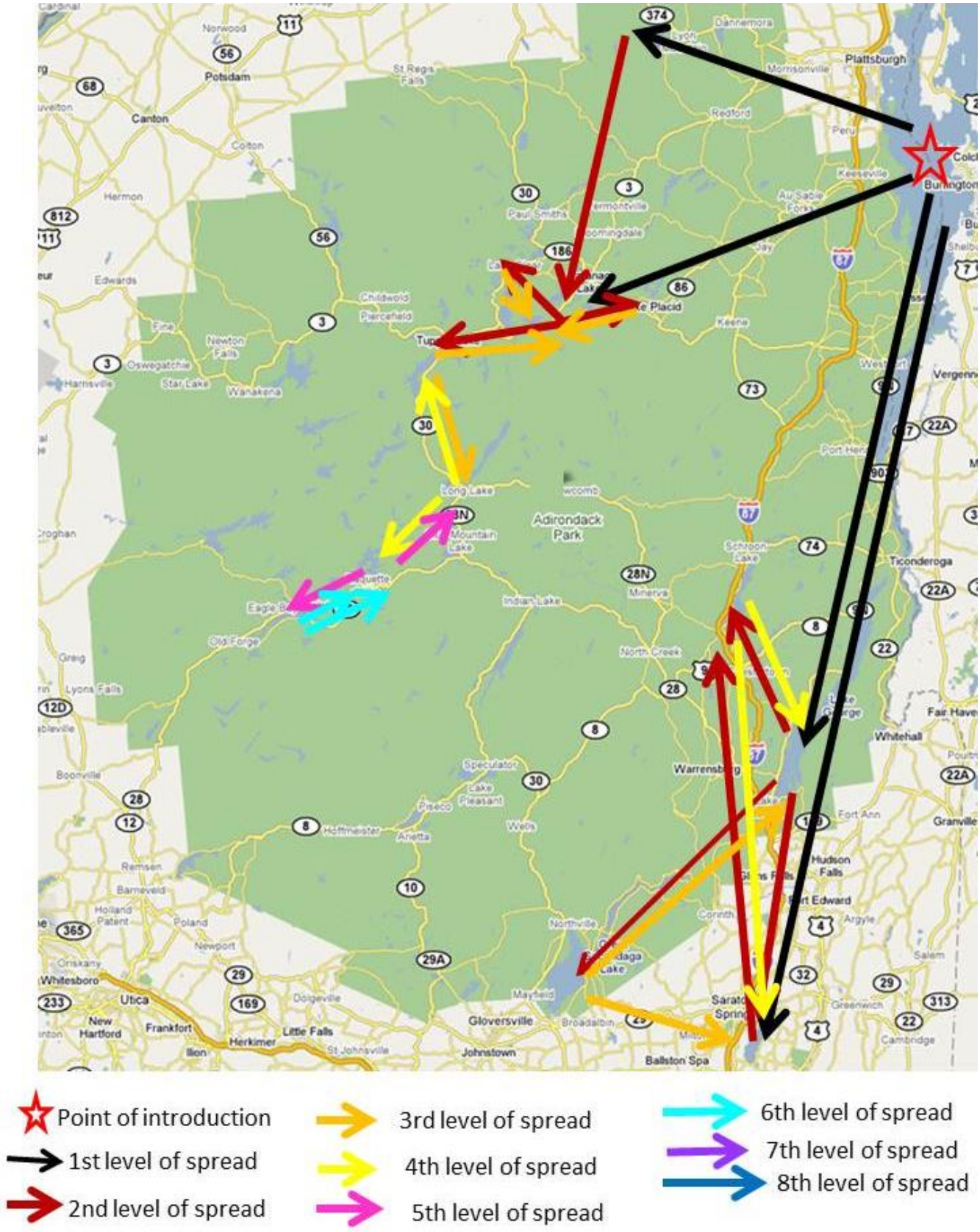
AIS Spread Potential from Great Sacandaga Lake



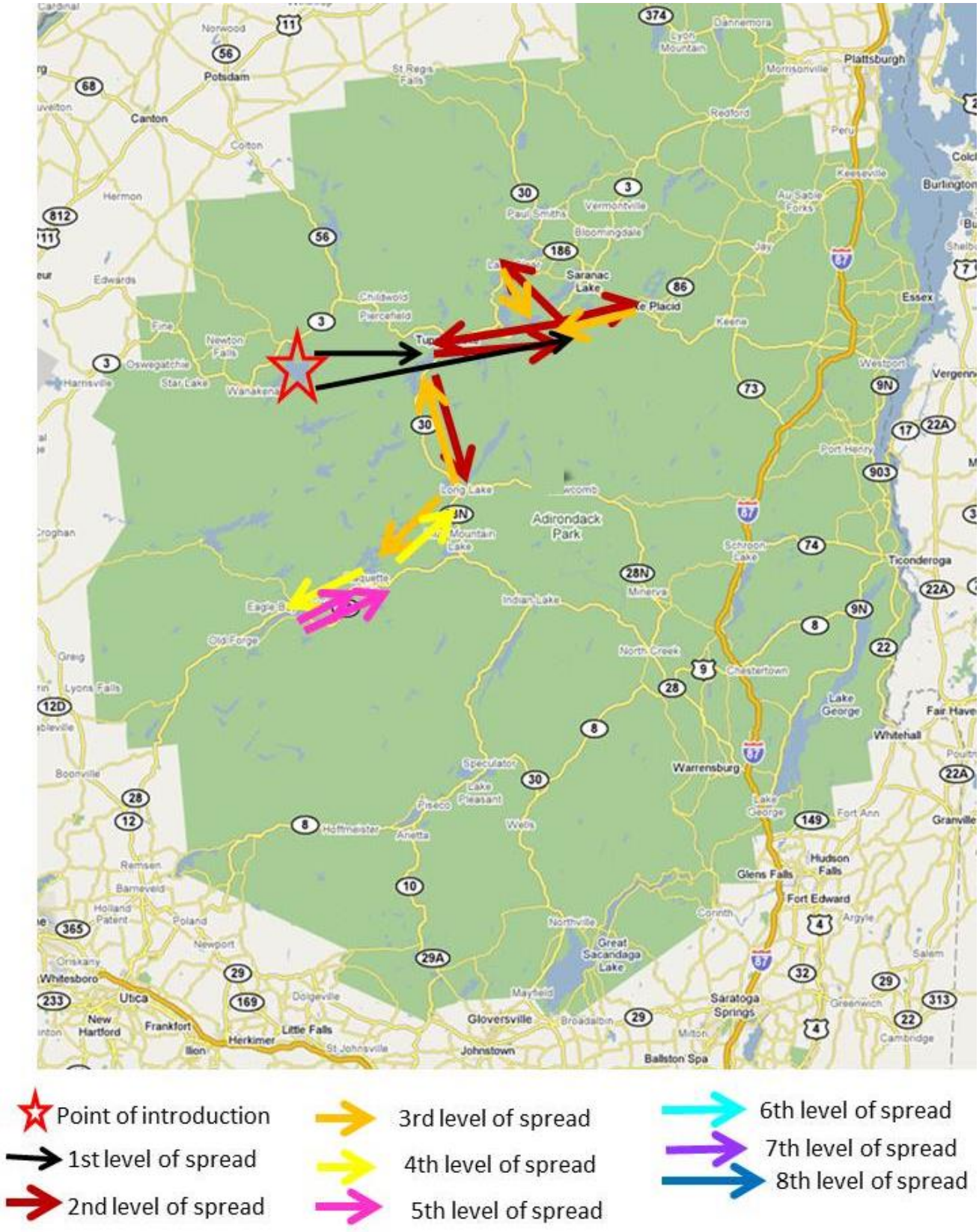
AIS Spread Potential from Lake George



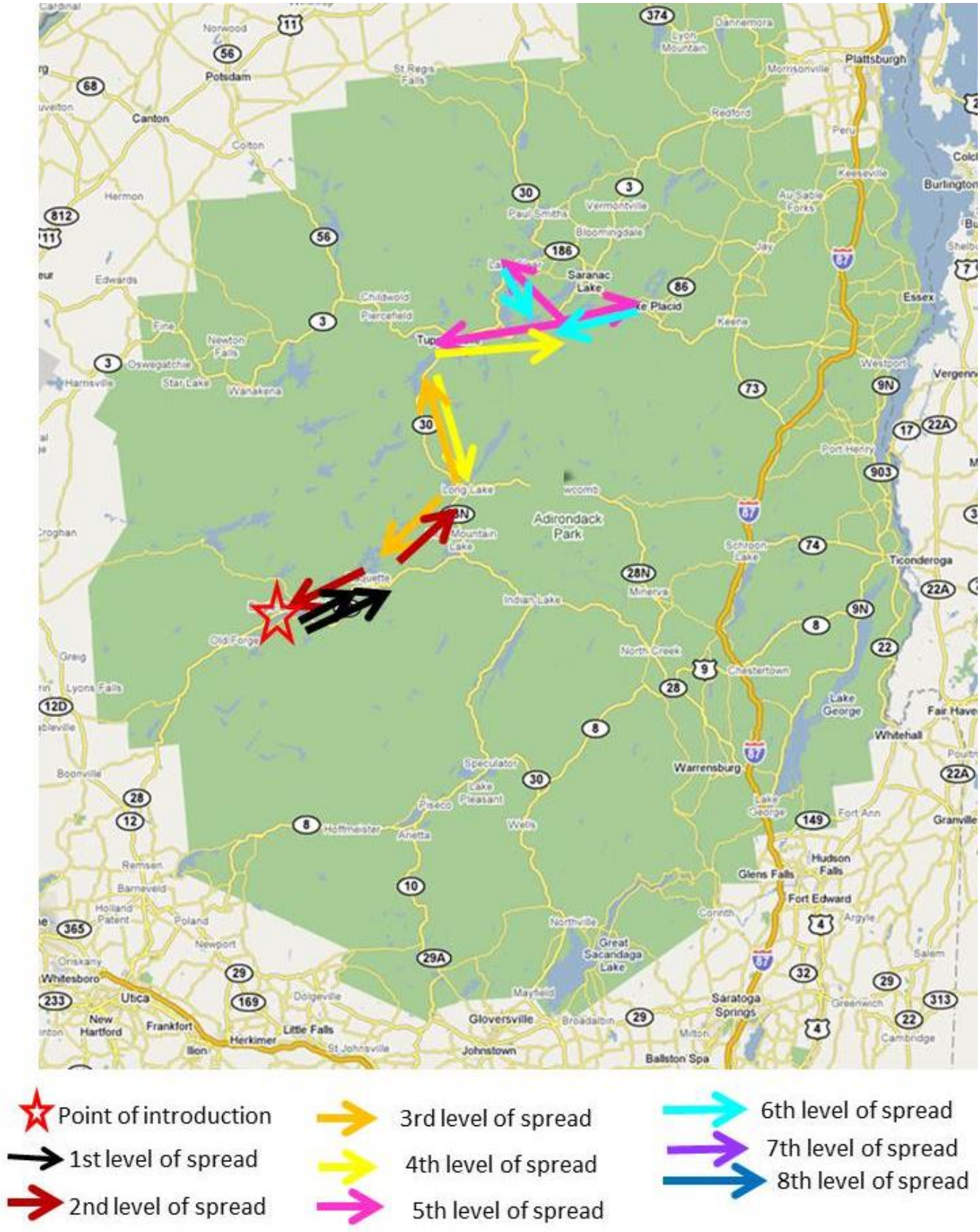
AIS Spread Potential from Lake Champlain



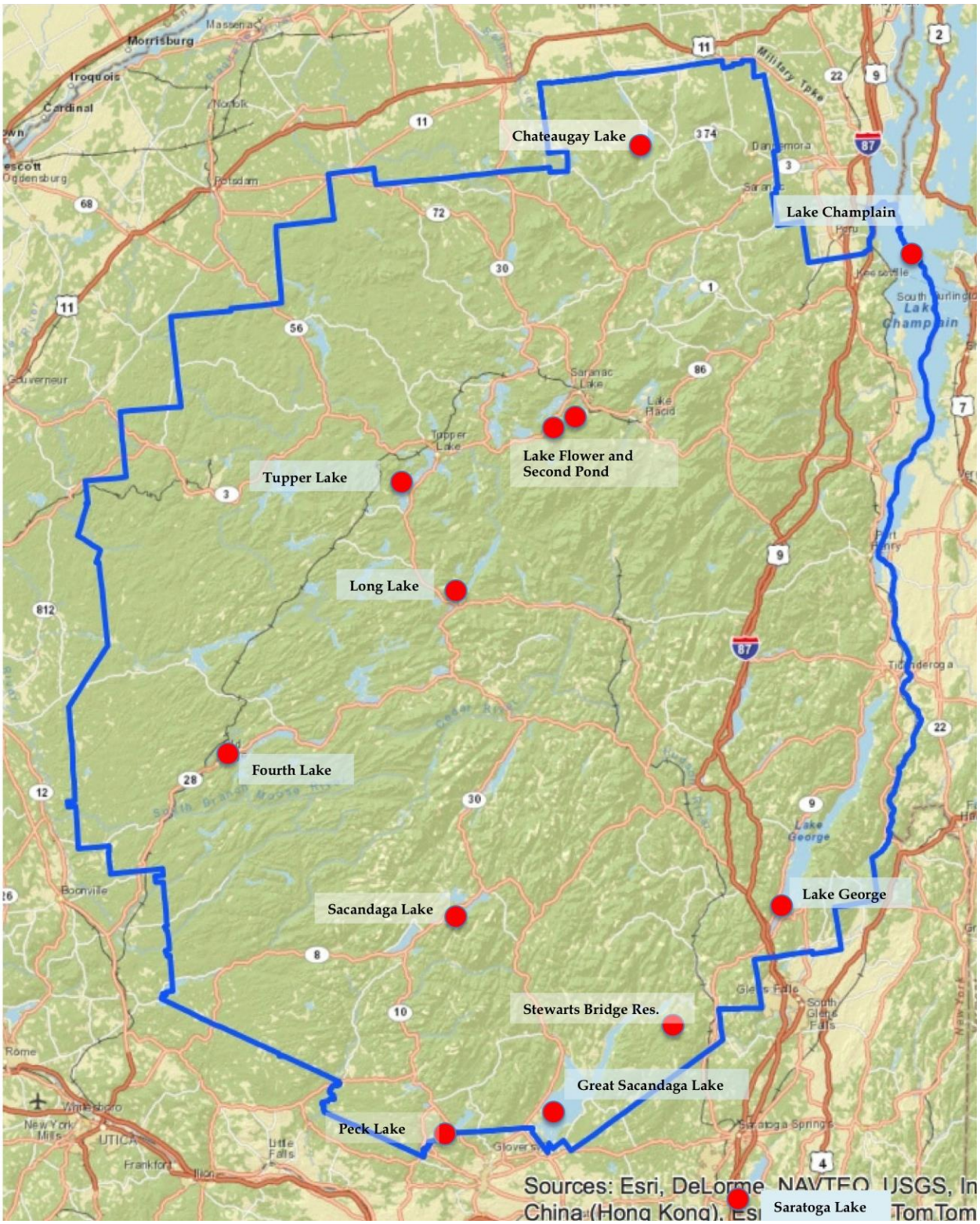
AIS Spread Potential from Cranberry Lake



AIS Spread Potential from Fourth Lake



Appendix G. Adirondack Watershed Steward Network: Invasion Spread Hub Waterways and Linkage Waterways



Appendix H. Waterways with aquatic invasive plants in the Adirondack region through 2012.

*Denotes waterways with active boat launch steward programs in 2013.

Augur Lake (Essex)	Fulton Chain, Sixth Lake (Hamilton)	Mill Pond (Saratoga)
Bartlett Pond (Essex)	Fulton Chain, Third Lake (Herkimer)	Minerva Lake (Essex)
Blake Reservoir (St. Lawrence)	Grasse River at Lampson Falls (St. Lawrence)	Mountain View Lake (Franklin)
Brant Lake (Warren)*	Great Sacandaga Lake (Fulton/Saratoga)	North Pond (Warren)
Butternut Pond (Essex)	Hadlock Pond (Washington)	Oseetah Lake (Franklin)
Carry Falls Reservoir (St. Lawrence)	Highlands Forge Lake (Essex)	Paradox Lake (Essex)*
Chateaugay Lake (Lower) (Franklin)	Horseshoe Pond (Franklin – Duane)	Piercefield Flow (St. Lawrence)
Chateaugay Lake (Narrows) (Franklin)	Hunt Lake (Saratoga)	Putnam Pond (Essex)
Chateaugay Lake (Upper) (Clinton)	Indian Lake (Franklin)	Rainbow Falls Reservoir (St. Lawrence)
Chaumont Pond (St. Lawrence)	Jenny Lake (Saratoga)	Raquette Lake (Hamilton)
Chazy Lake (Clinton)	Kiwassa Lake (Franklin)	Rock Pond (Hamilton)
Copperas Pond (Franklin)	Lake Algonquin (Hamilton)	Rogers Pond (Essex)
Cranberry Lake (St. Lawrence)	Lake Champlain*	Saranac Lake, Lower (Franklin)
Daggett Pond (Warren)	Lake Colby (Franklin)	Saranac Lake, Middle (Franklin)
Deer River Flow (Franklin)	Lake Durant (Hamilton)	Saranac Lake, Upper (Franklin)
Eagle Lake (Essex – Ticonderoga)	Lake Eaton (Essex)	Schroon Lake (Essex/Warren)*
East Caroga Lake (Fulton)	Lake Flower (Franklin)	Second Pond, Saranac Chain (Franklin)
Efner Lake (Saratoga)	Lake George (Warren/Washington/Essex)*	Simon Pond (Franklin)
Eldon Lake (Hamilton)	Lake Luzerne (Warren)	Soft Maple Reservoir (Lewis)
First Pond, Saranac Chain (Franklin)	Lake Placid (Essex)	Stark Falls Reservoir (St. Lawrence)
Fish Creek Ponds (Franklin)	Lincoln Pond (Essex)	Stillwater Reservoir (Herkimer)
Floodwood Pond (Franklin)	Little Colby Pond (Franklin)	Taylor Pond (Clinton)
Follensby Clear Pond (Franklin)	Little River Flow (St. Lawrence)	Titus Lake (Franklin)
Franklin Falls Flow (Franklin)	Little Square Pond (Franklin)	Tupper Lake (Franklin/St. Lawrence)*
Fulton Chain, Fifth Lake (Hamilton)	Long Lake (Hamilton)*	Union Falls Flow (Clinton)
Fulton Chain, First Lake (Herkimer)	Long Pond (Echo Lake) (Essex)	Webb Royce Swamp (Essex)
Fulton Chain, Fourth Lake (Herkimer)	Loon Lake (Warren)*	West Caroga Lake (Fulton)
Fulton Chain, Second Lake (Herkimer)	Mayfield Lake (Fulton)	
Fulton Chain, Seventh Lake (Hamilton)	Meacham Lake (Franklin)	

Appendix I. Waterways surveyed where no aquatic invasive species have been observed in the Adirondack region through 2012.

Alder Pond (Essex)	Eighth Lake (Hamilton)	Little Lilly Pad Pond (Hamilton)	Rock Pond (Essex)
Ausable Lake (Lower) (Essex)	Elk Lake (Essex)	Little Long Pond (near Bear Pond) (Franklin)	Rock Pond (Franklin)
Ausable Lake (Upper) (Essex)	Fawn Lake (Hamilton)	Little Long Pond (near Fish Pond) (Franklin)	Rock Pond (Lewis)
Austin Pond (Warren)	Fern Lake (Clinton)	Little Rankin Pond (Essex)	Rollins Pond (Franklin)
Balfour Lake (Essex)	Fish Pond (Franklin)	Little Tupper Lake (Hamilton)	Rose Pond (Herkimer)
Barnes Pond (Essex)	Follensby Pond (Franklin)	Little Wolf Lake (Franklin)	Round Lake (Hamilton)
Barnum Pond (Franklin)	Forked Lake (Hamilton)	Livingston Lake (Warren)	Round Pond (St. Lawrence)
Bass Lake (Essex)	Fourth Lake (Warren)	Lizard Pond (Warren)	Russett Pond (Essex)
Bear Pond (Franklin)	Francis Lake (Lewis)	Long Lake (Oneida)	Russian Lake (Hamilton)
Beaver Lake (Lewis)	French Pond (Lewis)	Long Pond (Franklin)	Sagamore Lake (Hamilton)
Big Moose Lake (Herkimer)	Friends Lake (Warren)	Long Pond (Lewis)	Saint Regis Lake (Lower) (Franklin)
Big Pond (Essex)	Garnet Lake (Warren)	Long Pond (St. Lawrence)	Saint Regis Lake (Upper) (Franklin)
Big Wolf Lake (Franklin)	Gilman Lake (Hamilton)	Loon Lake (Franklin)	Sand Pond (Essex)
Black Pond (near Lower St. Regis Lake) (Franklin)	Glenn Pond (Franklin)	Lost Pond (Franklin)	Shallow Pond (Herkimer)
Black Pond (near Whey Pond) (Franklin)	Goodnow Flow (Essex)	Marvin Pond (Franklin)	Shingle Shanty Pond (Hamilton)
Blue Mountain Lake (Hamilton)	Goose Pond (Essex)	Mason Lake (Hamilton)	Siamese Pond (Lower) (Warren)
Blynkin Pond (Spectacle Pond) (Franklin)	Green Lake (Fulton)	Massawepie Lake (St. Lawrence)	Siamese Pond (Upper) (Warren)
Bog Pond (Franklin)	Green Pond (Franklin)	McCavanaugh Pond (Franklin)	Silver Lake (Clinton)
Boottree Pond (St. Lawrence)	Gull Pond (Essex)	Middle Pond (Franklin)	Silver Lake (St. Lawrence)
Brandreth Lake (Hamilton)	Gull Pond (St. Lawrence & Franklin)	Mill Pond (Essex)	Sis Lake (Herkimer)
Brantingham Lake (Lewis)	Harris Lake (Essex)	Mirror Lake (Essex)	Slang Pond (Franklin)
Brown Tract Pond (Lower) (Hamilton)	Heavens Pond (Franklin)	Mohegan Lake (Hamilton)	South Pond (Hamilton)
Brown Tract Pond (Upper) (Hamilton)	Henderson Lake (Essex)	Moody Pond (Essex)	South Pond Outlet (Hamilton)
Brown's Falls Reservoir (St. Lawrence)	Hoel Pond (Franklin)	Moose Pond (Essex)	Sperry Pond (Hamilton)
Bubb Lake(Herkimer)	Holmes Lake (Fulton)	Morehouse Lake (Hamilton)	Spitfire Lake (Franklin)
Buck Pond (Franklin)	Horseshoe Lake (St. Lawrence)	Moshier Reservoir (Herkimer)	Sprague Pond (Hamilton)
Burnt Pond (Warren)	Horseshoe Pond (St. Lawrence)	Moss Lake (Herkimer)	Spy Lake (Hamilton)
Canada Lake (Fulton)	Horseshoe Pond (Franklin)	Mount Arab Lake (St. Lawrence)	Star Lake (St. Lawrence)
Cascade Lake (Hamilton)	Indian Lake (Hamilton)	Mountain Lake (Fulton)	Steele Reservoir (Saratoga)
Cascade Lake (Lower) (Essex)	Ireland Vly (Saratoga)	Mountain Pond (near Barnum Pond) (Franklin)	Stoner Lake (East) (Hamilton)
Cascade Lake (Upper) (Essex)	Jabe Pond (Warren)	Mountain Pond (near Ledge Pond) (Franklin)	Stony Creek Ponds (Franklin)
Catamount Pond (St. Lawrence)	Jackson Summit Reservoir (Fulton)	Mud Pond (Lewis)	Streeter Lake (St. Lawrence)
Cedar River Flow (Hamilton)	Joe Indian Pond (St. Lawrence)	Murrey (Smokey) Pond (Essex)	Sucker Lake (St. Lawrence)
Center Pond (Hamilton)	Johnson Pond (Essex)	Nellie Pond (Franklin)	Tanaher Pond (Essex)
Challis Pond (Essex)	Jones Pond (Franklin)	Newcomb Lake (Essex)	Thayer Lake (Hamilton)
Chase Lake (Lewis)	Jordan Lake (St. Lawrence)	Newport Pond (Essex)	Thirteenth Lake (Warren)
Chatiemac Lake (Warren)	Kennels Pond (Hamilton)	Nicks Lake (Herkimer)	Thurman Pond (Essex)
Chub Lake (Hamilton)	Lake Abanakee (Hamilton)	North Lake (Herkimer)	Tooley Pond (St. Lawrence)
Church Pond (Franklin)	Lake Adirondack (Hamilton)	Oliver Pond (Essex)	Town Line Pond (St. Lawrence)
Clamshell Pond (Franklin)	Lake Clear (Franklin)	Osgood Pond (Franklin)	Tripp Pond (Warren)
Clear Pond (near Rainbow Lake) (Franklin)	Lake Clear Outlet (Franklin)	Otter Lake (Oneida)	Trout Lake (Lewis)
Clear Pond (Essex)	Lake Eaton (Hamilton)	Oven Mountain Pond (Warren)	Turtle Pond (Franklin)
Clear Pond (near Meacham Lake) (Franklin)	Lake Kushaqua (Franklin)	Oxbow Lake (Hamilton)	Twitchell Lake (Herkimer)
Clear Pond (Lewis)	Lake Lila (Hamilton)	Pack Forest Lake (Warren)	Unknown (near Fish Pond) (Franklin)
Clear Pond (St. Lawrence)	Lake Nebo (Washington)	Palmer Pond (Warren)	Unknown (near Fish Pond) (Franklin)
Cleveland Lake (Lewis)	Lake Ozonia (St. Lawrence)	Payne Lake (Lewis)	Utowana Lake (Hamilton)
Constable Pond (Hamilton)	Lake Pleasant (Hamilton)	Pharaoh Lake (Essex)	Wakely Pond (Hamilton)
Crane Mountain Pond (Warren)	Lake Rondaxe (Herkimer)	Piseco Lake (Hamilton)	West Lake (Herkimer)
Crane Pond (Essex)	Ledge Pond (Franklin)	Polliwog Pond (Franklin)	West Pine Pond (Franklin)
Deer Pond (Hamilton)	Lens Lake (Warren)	Proctor Pond (Essex)	Whey Pond (Franklin)
Deer Pond (St. Lawrence)	Lewey Lake (Hamilton)	Pyramid Lake (Essex)	Whitaker Lake (Hamilton)
Eagle Crag Lake (St. Lawrence)	Lily Pond (Warren)	Quiver Pond (Herkimer)	Wilcox Lake (Warren)
Eagle Lake (Hamilton)	Limekiln Lake (Herkimer)	Rainbow Lake (Franklin)	Willis Lake (Hamilton)
Eagle Pond (Franklin)	Little Clear Pond (Franklin)	Rankin Pond (Essex)	Woodruff Pond (Essex)
East Pine Pond (Franklin)	Little Fish Pond (Franklin)	Rat Pond (Franklin)	Wynkin Pond (Spectacle Pond) (Franklin)
Echo Lake (Hamilton)	Little Green Pond (Franklin)	Rich Lake (Essex)	Zack Pond (Essex)

Appendix J. NYSDEC campgrounds with aquatic invasive species present and boat launches in the Adirondack region. Recommended action based on aquatic invasive species distribution data, boat launch steward data, and scientific literature.

Campground Name	Waterway Name	Aquatic Invasive Plants	Aquatic Invasive Small-bodied Organisms	Action
Alger Island	Fourth Lake	X		Inspection/hand-removal
Ausable Point	Lake Champlain	X	X	Inspection/hand-removal and decontamination
Caroga Lake	East Caroga Lake	X		Inspection/hand-removal
Cranberry Lake	Cranberry Lake	X		Inspection/hand-removal
Crown Point	Lake Champlain	X	X	Inspection/hand-removal and decontamination
Eagle Point	Schroon Lake	X		Inspection/hand-removal
Fish Creek Pond	Square Pond, Fish Creek Pond	X		Inspection/hand-removal
Golden Beach	Raquette Lake	X		Inspection/hand-removal
Lake Durant	Lake Durant	X		Inspection/hand-removal
Lincoln Pond	Lincoln Pond	X		Inspection/hand-removal
Meacham Lake	Meacham Lake	X		Inspection/hand-removal
Moffitt Beach	Sacandaga Lake		X	Decontamination
Northampton Beach	Great Sacandaga Lake	X	X	Inspection/hand-removal and decontamination
Paradox Lake	Paradox Lake	X		Inspection/hand-removal
Putnam Pond	Putnam Pond	X		Inspection/hand-removal
Rogers Rock	Lake George	X	X	Inspection/hand-removal and decontamination
Saranac Lake Islands	Lower/Middle Saranac Lake	X		Inspection/hand-removal
Scaroon Manor	Schroon Lake	X		Inspection/hand-removal
Taylor Pond	Taylor Pond	X		Inspection/hand-removal

Appendix K. NYSDEC campgrounds without aquatic invasive species in the Adirondack region. Note: One campground, Meadowbrook, does not have water access. Three campgrounds – Sacandaga (Sacandaga River), Sharp Bridge (Schroon River), and Wilmington Notch (West Branch Ausable River) – have not been surveyed.

Campground Name	Waterway Name
Brown Tract Pond	Lower Brown Tract Pond
Buck Pond	Buck Pond, Lake Kushaqua
Eighth Lake	Eighth Lake
Forked Lake	Forked Lake
Indian Lake Islands	Indian Lake
Lake Eaton	Lake Eaton
Lake Harris	Lake Harris
Lewey Lake	Lewey Lake, Indian Lake
Limekiln Lake	Limekiln Lake
Little Sand Point	Piseco Lake
Luzerne	Fourth Lake
Nicks Lake	Nicks Lake
Point Comfort	Piseco Lake
Poplar Point	Piseco Lake
Rollins Pond	Rollins Pond

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