2011 Invasive Non-native Plant Inventory

Silvio O. Conte National Fish and Wildlife Refuge

US Fish and Wildlife Service

Final Report

June 2012

Prepared by

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Cover photo:

Japanese stiltgrass (*Microstegium vimineum*) found along Pine Brook in the Salmon River Division of Silvio O. Conte National Fish and Wildlife Refuge. Photo by Kimberly Edvarchuk, Utah State University.

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Inventory of Invasive Non-native Plants

Conducted in 2011 in portions of Silvio O. Conte National Fish and Wildlife Refuge

U.S. Fish and Wildlife Service

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Acronyms

DC	Detection Confidence
CCP	Comprehensive Conservation Plan
EDD	Effective detection distance
EDRR	Early detection rapid response
EDSW	Effective detection swath width
GIS	Geographic Information System
GPS	Global Positioning System
MDTS	Minimum detection target size
NAWMA	North America Weed Management Association
NFWR	National Fish and Wildlife Refuge
NWR	National Wildlife Refuge
NWRS	National Wildlife Refuge System
PSR	Patch separation resolution
RLGIS	Refuge Lands Geographic Information System
ST	Search target
USFWS	United States Fish and Wildlife Service
USU	Utah State University

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1 INTRODUCTION

Invasive species continue to be one of the largest threats to ecosystem health and function. Invasive plants have the ability to displace native vegetation, create monocultures, increase fire frequency, increase soil erosion, decrease the quality of habitat for wildlife, and lead to the extinction of native plants and animals. Based on interagency estimates, National Wildlife Refuge System (NWRS) lands have more than 2.5 million acres already infested with invasive species (USFWS 2011). Refuges spent $16.4 million in 2010 on invasive plant management (USFWS 2010) and invasive species are reported to be among the fastest growing areas of Refuge spending (USFWS 2011). Refuge biologists have also reported that invasive species problems ranked first for threatening the native wildlife habitats within the Refuge System (NWRS 2003).

Refuges are at a higher risk than many lands to the introduction and spread of invasive plants. Millions of people come from all over the world to recreate on the public lands and have the potential to bring new introductions of these problem plants on clothing, equipment, or vehicles. The management of invasive species can be overwhelming, especially when trying to manage numerous species spread across vast acreages on limited resources and staff. The purpose of the National Strategy for the Management of Invasive Species (NWRS 2003) was to provide guidance to staff and field offices in the management of these species on refuges around the country. The Strategy spells out the goals of reducing the impacts of invasive species on refuge habitats as well as using integrated approaches to finding and managing species once they are introduced.

Within the Strategy is the objectives to "increase and focus on invasive species research, surveys, mapping, and monitoring efforts" (NWRS 2003). Inventory and monitoring are important tools that allow land managers to find new species before they become large problems. A land manager cannot accurately or efficiently manage invasive plants without first knowing what species are present and to what extent they exist on the landscape. Inventories can provide these key pieces of information and allow land managers to allocate their resources and time in a much more cost-effective manner. An inventory can identify newly invading species, identify patterns on the landscape of the movement and spread a particular species, identify boundaries of more widespread species, and identify lands currently clean of invasive plants. Deciding which species and which methods to use for inventory and monitoring can be challenging when dealing with multiple species, several unique environments, or large landscapes.

With the National Strategy in mind, Silvio O. Conte National Fish and Wildlife Refuge (NFWR) was one of four refuges selected to participate in a pilot project to evaluate the similarities and differences in invasive plant inventory objectives and methods among a variety of refuge environments (e.g., types and diversity of ecosystems/vegetation communities, staffing and expertise, partner engagement, spatial scale, presence of sensitive species, other stressors). This information will inform the degree to which the U.S. Fish and Wildlife Service (USFWS) NWRS Inventory and Monitoring Initiative can

develop a standardized guide or protocol for conducting invasive plant inventories on refuge lands.

Established in 1997, Silvio O. Conte NFWR was set aside to conserve, protect, and enhance the abundance and diversity of fish and wildlife species and their ecosystems within the greater Connecticut River watershed (USFWS SOC 2011). This watershed provides valuable nesting habitat for migrant birds in its forests as well as rivers and streams that are used by migratory fish species. It is also contains uniquely tidal fresh, brackish, and salt marshes. The 7.2 million acre Connecticut watershed is spread across Connecticut, Massachusetts, New Hampshire, and Vermont. At the time of the inventory, the refuge owns numerous parcels and 32,862 acres across these four states and this inventory included the Salmon River Division in Connecticut, the Mohawk River Division in New Hampshire, and the Fort River Division in Massachusetts. The three divisions were recently acquired by the refuge and the full scope of the invasive species issue remained relatively unknown prior to the inventory project (Figure 1). The main focus of the project was on the Salmon River Division, a flood plain forest that was set aside as resting sites for migratory birds and migratory fish habitat. The Salmon River and smaller Pine Brook are also important for cool water fish species as is the connection between the tributaries and the Salmon River for migrating fish species. This connection and the connection between the Salmon River and the forest are threatened by the introduction and spread of invasive species.

The Mohawk River Division and Fort River Division provide stark contrast to the Salmon River Division in habitat and size. The Mohawk River Division is comprised of old pastures, remnant hayfields, swamps, and dense coniferous forest. It was set aside to provide habitat for northern harrier nesting habitat as well as important habitat for native brook trout and juvenile Atlantic salmon. In contrast, the Fort River Division is a floodplain forest adjacent to the Fort River and was run as a horse farm until as late as 1995. The land is comprised of forested riparian habitat along the Fort River as well as hayfields, fallow cropland, and a horse track. The Division is set aside to support stopover sites for migrating songbirds and its habitat, increase populations of grassland birds such as bobolinks and vesper sparrows, and protect the nearby Fort River and its habitat for freshwater mussels.

The presence of invasive species at Silvio O. Conte NFWR threatens many of the resources and habitats that the refuge is tasked with protecting. Both the wetlands and forest habitat continue to be impacted by invasive plants. For example, invasive shrubs such as Oriental bittersweet (*Celastrus orbiculatus*), Japanese barberry (*Berberis thunbergii),* and multiflora rose (*Rosa multiflora*) already existed on the Fort River Division and on the surrounding private lands of the Salmon River Division. Efforts to stop the spread of Japanese stiltgrass *(Microstegium vimineum)* on the Salmon River Division and the invasive shrubs on the Fort River Division were already underway at the time of the inventory. An inventory of these and other invasive plants at Silvio O. Conte NFWR will improve strategic planning and increase the efficiency and effectiveness of invasive plant management operations already occurring on the refuge.

As part of the pilot project, Utah State University was asked to conduct an inventory for targeted invasive non-native plants within portions of these three new divisions of the

refuge. While the purpose of the larger project is to develop a guide for conducting inventories on refuges, this inventory also provided valuable information to meet the invasive species management goals established at Silvio O. Conte National Fish and Wildlife Refuge.

Objectives

1. Document areas free of targeted invasive non-native species that might be designated as weed – free prevention areas within the Salmon River Division, Mohawk River Division, and Fort River Division of the Silvio O. Conte National Fish and Wildlife Refuge.

2. Identify early detection species for eradication (EDRR). Detect and eradicate species that are currently rare but are known to cause significant harm to natural resources in ecosystems similar to the refuge.

3. Detect and document the overall abundance and locations of targeted invasive non-native plant species within the Salmon River Division, Mohawk River Division, and Fort River Division of Silvio O. Conte NFWR.

4. Strategic Management of Invasive Plants. Utilize inventory data to inform strategic planning and increase the efficiency and effectiveness of invasive plant management operations on the refuge, including appropriate measures for monitoring program effectiveness.

5. Detect and document the overall abundance and locations of targeted invasive non-native plant species on private lands surrounding the Salmon River Division for targeted invasive non-native species that pose an immediate threat to refuge lands. Utilize the data to develop partnerships with surrounding land owners dealing with similar invasive species issues and generate awareness and outreach to the general public.

2 MATERIALS AND METHODS

Utah State University supplied a four person crew in 2011 to inventory portions of Silvio O. Conte NFWR for invasive non-native plants as part of a larger national pilot study to provide guidance in conduction inventories on National Wildlife Refuges. The project was conducted at Silvio O. Conte NFWR between August 2 and 18, 2011. Utah State University and other members of the core team for the pilot project met with refuge staff in July to establish refuge inventory objectives and to select priority areas and the invasive non-native plant species to include in the inventory. Field methods were then determined with input from refuge staff to ensure that the data collected would meet the project objectives. Field methods were adapted from field protocols developed by Andersen and Dewey (2007) and modified to meet the needs of the individual objectives of the refuge.

Areas selected for inventory included sites of management concern within the refuge. Those sites selected were recently acquired by the refuge and this inventory served to provide baseline data regarding the status of invasive species on refuge lands. The Salmon River Division (285 acres), Mohawk River Division (1,023 acres), and the Fort River Division (197 acres) were selected for inventory because they were recent acquisitions by the refuge and there was a lack of information regarding invasive species within these areas. The order in which areas within the Divisions were inventoried was determined by the USU crew leader in consultation with Cynthia Boettner, biologist for Silvio O. Conte NFWR. Daily planning by the crew leader took into consideration the invasive non-native species likely to be in the area as well as the accessibility of the terrain, native vegetative cover, and the visibility of the targeted species. All targeted invasive non-native species discovered were documented using global position system (GPS) units with 2-5 meter accuracy.

2.1 Selection of Refuge Objectives, Inventory Areas, and Target Species

A two-day workshop was held in Haddam Neck, Connecticut on July 27 and 28, 2011 with refuge staff and partners to determine inventory objectives for the Salmon River Division that would best address refuge priority management needs and to determine the priority areas and species to inventory. Participants in the workshop included refuge staff, NWR Regional Invasive Species Coordinator, Utah State University, The Nature Conservancy, Haddam Land Trust, and private citizens of Haddam Neck.

The first day of the workshop was spent allowing refuge staff to orient participants to the refuge and its history. Refuge staff presented information regarding the background of the refuge and its formation as well as its unique habitats and its land management goals. Refuge staff presented information regarding the refuge history, its unique features, and its land management goals. Challenges, issues, and impacts of invasive plant species on the refuge were also discussed. Information was also presented regarding the acquisition of the Salmon River Division and the potential invasive species in the surrounding area. Workshop participants were given a tour of the Salmon River Division inventory, thus

giving participants an opportunity to see the invasive species issues and the terrain and habitat on the refuge.

The second day of the workshop consisted of establishing inventory objectives that would best address refuge priority management needs. This process started with a review of the refuge's conservation goals and discussion of how the presence of invasive plants impacts those goals. The Nature Conservancy previously owned the Salmon River Division and presented information about invasive species impacts within the surrounding community and which species might be included in the inventory. Inventory objectives were based on how the refuge planned on utilizing the data once collected. The resulting objectives are listed in Section 1 of the report and led to a discussion of which areas and species to include in the inventory.

Prior to the start of the workshop a questionnaire was sent to the refuge that led to discussion amongst refuge staff and other workshop participants regarding the selection of areas and species to inventory and resulted in an initial working list of areas and species. The size of the refuge did not allow for a complete inventory of all areas and species by the field crew given the time frame (2 weeks) and size of the field crew (5-person). Criteria used by the refuge for prioritizing areas included habitat types, topography, recent management actions by The Nature Conservancy and refuge, species of concern for The Nature Conservancy in the local area, proximity of species to vector pathways, partner knowledge of invasive species present on neighboring lands, and partners interested in invasive species control and willing to coordinate with the refuge for their management. Refuge lands were inventoried first with the Salmon River Division receiving highest priority because of the presence of Japanese stiltgrass (a species targeted for eradication by the refuge). The Mohawk Division was inventoried second, followed by private lands of partners surrounding the Salmon River Division. Any time left at the end of the inventory of these areas was devoted to sections of the Fort River Division.

The target species list for the Salmon River District was a compilation of species that are relatively new to the area and highly invasive (candidates for early detection and rapid response including Japanese stiltgrass and garlic mustard), highly invasive species not known to exist in the area (pale swallowwort, black swallowwort), and more widespread species targeted for management (Japanese barberry, oriental bittersweet, purple loosestrife, multiflora rose, bush honeysuckle, and others). The species were broken into three priority lists (Table 1). Species found on the top of the top priority list were forbs that are known to be fast spreaders and thus important to detect and control promptly. Second priority species were vines and shrubs that impact the tree canopy and/or forest regeneration and riparian/wetland species. The third and lowest priority was shrub and tree species that were widespread in the surrounding area and likely to be widespread on the Salmon River site.

Species lists for the Mohawk Division (Table 2) and the Fort River Division (Table 3) were selected based on similar criteria as those used for the Salmon River Division although they lacked input from local land partners. Little was known of the Mohawk Division and so a representative list was put together based on species found on surrounding refuge divisions and species of overall concern for the refuge biologist.

Again the list was broken into three priority classes of: 1) early detection, 2) species likely established and targeted for management, and 3) invasive species that should be noted if seen. Any other non-native species crew members recognized as invasive in other areas of the United States were recorded when encountered during the project although they were not part of the original target list developed during the prioritization workshop. The refuge was desirous to add to their knowledge base regarding these divisions and to incorporate this information into their Comprehensive Conservation Plan (CCP) for the long-term management of these species.

2.2 Field Procedures

Many of the terms and field procedures used in this report were adapted from initial methodologies developed at Utah State University (Andersen and Dewey 2007) and modified to meet the objectives of the refuge.

2.2.1 Search Target (ST)

A list of targeted species was designated as priority species for each division in Silvio O. Conte NFWR. Fourteen species were designated for the Salmon River Division and targeted for inventory (Table 1). Four of those species were designated as early detection and relatively rare or unknown to exist on the Salmon River Division. The remaining ten species were designated as established and present in moderate to high abundance. Eleven species were designated for inventory on the Mohawk River Division (Table 2), of which six species were designated as early detection species and five were considered likely established. Sixteen species were identified for inventory for the Fort River Division (Table 3), of which four were designated as early detection species and twelve species were established. All species were at a reasonably recognizable growth stage during the time of the project although garlic mustard was often found in rosette form and could be difficult to detect at times in heavily forested areas.

2.2.2 *Minimum Detection Target Size (MDTS)*

It would be nearly impossible to find all single plants of the targeted species within all the targeted areas within the given time frame of the project. A minimum detection target size of 0.001 acre was designated. This is the smallest infestation of the least visible targeted invasive species that searchers were confident of detecting and identifying with 90 percent detection confidence based on the field conditions at the refuge. Realizing that some plants might be missed during the current inventory, the plants should be still at a small enough size to be discovered and still manageable when the next inventory is conducted.

2.2.3 Detection Confidence (DC)

The percentage of the total number of infestations that crew members estimated they were able to find in a management unit was set at 90 percent, based on the probability of seeing patches of 0.001 acre (MDTS) of the least visible target species at the refuge. Search patterns were adjusted as needed to maintain this percentage standard as field conditions changed.

2.2.4 Patch Separation Resolution (PSR)

The minimum distance between single plants or patches of the same species of plants considered to be separate infestations was set at 10 meters. Plants or patches of the same species of plants separated by more than 10 meters were mapped as separate infestations. Plants separated by less than 10 meters were generally mapped as a single infestation unless the surveyor felt it was beneficial to the refuge to provide more detailed information. Refuge staff determined a 10 meter PSR distance based on doubling the average accuracy of the GPS units used in the inventory. It was determined to be adequate for early detection species, although crew members were encouraged to provide more detailed information by using a smaller PSR distance if these species were encountered. The PSR distance was also deemed adequate for the established species because of their known abundance on the refuge.

2.2.5 Effective Detection Swath Width (EDSW)

The EDSW is the maximum width of a linear walking search pattern in which the surveyor was confident of visually detecting at least 90 percent of all the targeted species 0.001 acre in size or larger. This was set between 50 and 100 feet at the refuge, with an average use of 75 feet being used by crew members. If the EDSW was determined to be 50 feet, a surveyor used an effective detection distance (EDD) of 25 feet to search to the left and right of the search patch. The search pattern swath width distance was adjusted according to the visibility of the target species under varying field conditions in order to maintain at least 90 percent detection confidence by the individual crew member. For example, heavy forest canopy in the Mohawk River Division required a narrower swath width of approximately 50 feet because of limited visibility of the smaller targeted species. Visibility at the Salmon River Division was improved and enabled crew members to use an EDSW of 100 feet. The swath width was determined individually by each surveyor at the beginning of each day or at the start of each management unit based on each person's ability to see the targeted species. Any change in the ability of a crew member to see the targeted species due to field conditions reflected a change in the swath width.

2.3 Data Collection Methods

The search was conducted on foot by five crew members. Crew members walked multiple parallel passes through the Salmon River Division and the open fields and sections of forest in the Mohawk River Division. The EDSW varied between 50 and 100 feet depending upon the vegetation on site. The distance between passes was estimated by crew members in the field using either a laser rangerfinder, viewing the GPS tracklog function on the GPS screen, or by following UTMs coordinates to ensure that parallel passes were spaced accordingly and that no overlap occurred in the search pattern. Some sections of the Mohawk Division were not possible to thoroughly inventory due to heavy shrub and tree cover leading crew members to sample those areas by focusing on more accessible areas. Much of the dense forest did not appear to contain many invasive species so crew members concentrated their efforts on the wetland sites. The search of the Fort River Division was targeted to along the riparian sites and the racetrack since time did not allow for a complete inventory of the site. When targeted species were discovered, the locations were recorded using Juniper System Archer GPS units. Data was collected in ESRI's ArcPad software and entered into shapefiles extracted from the US Fish and Wildlife Service Refuge Lands Geographic Information System (RLGIS) Invasive Species Module.

Field searches were conducted on as fine a scale as required to ensure that 90 to 100 percent of all targeted invasive plant infestations 100 square feet or larger within each inventory area were detected within the EDSW for that particular site. Search swath widths were adjusted as needed based on variations of terrain, associated vegetation, and target species size but was generally maintained at 100 feet apart. Each crew member's daily search route was recorded automatically by the GPS. These tracklogs documented the daily inventory routes and demonstrate to some degree the level of intensity required for the search based on actual field conditions. The tracklog function recorded points at a set time interval determined by the surveyor and ranged from 15 to 30 seconds.

Surveyors used the RLGIS Invasive Plant Monitoring Point, Invasive Plant Monitoring Line, and Invasive Plant Monitoring Polygon features for this inventory. Surveyors utilized the RLGIS Invasive Plant Survey to document areas inventoried for this project. It was decided during the planning workshop to utilized point features rather than polygon features for infestations less than 0.25 acre in size for the majority of the inventory to increase the and maximize the number of acres that could be searched during the inventory. Recent research has demonstrated that there is no significant difference in accuracy of recording patch size and location between a buffered-point, screen-drawn polygon, and a perimeter-walked polygon, but a buffered-point allows a surveyor to cover ground more quickly and efficiently than either of the other two methods (Christensen et al. 2011). Surveyors utilized the RLGIS Invasive Plant Survey to document areas inventoried for this project.

2.3.1 Buffered Points

Invasive plant infestations less than 0.25 acre in size were recorded as buffered point features. A laser rangefinder was used to estimate patch size and determine whether infestations were sized appropriately for the use of point features (Andersen and Dewey 2007). Buffered points are point features with an associated patch size attached in the database table that allows points to be drawn to scale in ArcGIS. Buffered line features have an associated length and width recorded that allow lines to be drawn to scale. All of the data collected with each feature met the minimum data standards established by NAWMA (NAWMA 2003). With each recorded invasive plant occurrence, a surveyor would include: (1) surveyor name (origin), (2) observation date, (3) collection method, (4) common species name, (5) scientific species name, (6) percent cover (see below), (7) growth stage (see below), and (8) any additional comments. Surveyors also included an average patch radius (in feet) or an estimated length width (in feet) for each infestation and placed this information in the comments field. These distances were estimated visually by the surveyor or with the use of a laser rangefinder. The rangefinder was used to determine the length and width for more rectangular or square patches and an average radius for circular patches. Because the RLGIS database does not allow for length and width to be recorded, crew members recorded either an average patch radius or a length and width in the "Comments" field. This information was later used in the office to transform points into polygons and to calculate acres infested for each species. Multiple points rather than polygon features were used if the true size of the infestation was not discernable because of site conditions.

2.3.2 Polygons and Lines

Extensive infestations of a targeted species larger than 0.25 acres in size were mapped either as polygon features or as multiple point features. Line features were used for infestations that consistently followed an identifiable feature such as a road or a stream. If several species were present at a location, crew members had the option of using the same feature to record up to three species or to map them as three separate features in the GPS unit. Crew members often opted to record the species as separate point features for each species to ensure their visibility on a map.

2.3.3 Canopy Cover

Canopy cover of each infestation was estimated visually as the amount of ground covered by the invasive plant and placed into pre-determined categories taken from the RLGIS database:

1. <1% Scarce
2. 1-10% Poorly represented
3. 10-25% Well Represented
4. 25-60% Abundant
5. >60% Luxuriant

2.3.4 Phenology

Growth stage was also visually evaluated and placed in a corresponding. If multiple growth stages were encountered within the same infestation, then the growth stage of the majority of the plants was used. The categories available to surveyors from the RLGIS database include:

1. Senesced
2. Flowering
3. Basal rosette
4. Post-flowering
5. Pre-emergent
6. Pre-seed
7. Leaf off
8. Leaf on
9. Pre-flowering
10. Other

2.4 Field Data Processing

Daily inventory routes were recorded using the tracklog feature on the GPS unit. These routes as well as any data collected with the GPS units were downloaded onto a laptop computer each night. Each surveyor was expected to review the data collected each night. Edits (such as eliminating points or altering mis-entered information) were made to the data and any additional data (data not recorded with a GPS unit and hand mapped on field maps) were added at this time. Notes may have been expanded during the editing process to include more detailed information about the entry. Tracklogs were reviewed to ensure thorough coverage of each inventoried site. Data was then checked into the RLGIS geodatabase at the end of each week.

When data was downloaded each night, a folder was created on the computer to serve as a backup for data on the GPS units and to allow crew members to review their data on the laptop. Folders were named with a 6-digit date, followed by a 2-letter abbreviation of the first and last name of the surveyor. For example, the folder containing shapefiles collected by Parker Chapple on August 5, 2011 would be "08052011pc". Crew members also maintained a daily log of where they searched, which species they encountered, thoroughness of coverage achieved that day, their estimated detection confidence, and any additional information they felt might be important to the project.

2.5 Post-Season Processing

At the end of the field season, the project crew leader reviewed all data collected for quality assurance. Data files were compared to entries in the field log book and entries were evaluated for completeness. Tracklog features were used to help document areas

inventoried for the refuge and to create RLGIS Invasive Plant Survey Polygons. These polygons contain information describing the area searched, the originator of the search, the date, and size of the inventory area. The survey polygons shapefile document the areas that were searched during the inventory and help document not only the search effort but highlight areas where target species do not occur ('clean areas'). The surveyo polygons shapefile as well as the monitoring shapefiles of points, lines, and polygons were used in ArcGIS 10.0 for map-making and data analysis.

Buffered point features were modified in GIS to calculate the acreage values for each entry. Once back in the office, additional fields were created in the data table for length, width, and area. The new columns were populated with the measurements extracted from the "Comments" field and the square footage (area) was determined. The square footage was converted into acres and placed into a new column labeled "Acres". The acres reported reflect "infested acres" as defined by the NAWMA standards (NAWMA 2003). For the purpose of this report, an infested acre is defined as the actual perimeter of the infestation and the ground occupied by the plant species. Each infested area (acre) has an associated canopy cover representing the density of the plants contained within the infestation. Once the acreage was determined, points were drawn to scale with the ArcGIS Proximity Tool, using an average patch radius as the buffer distance.
The buffered line features contained a recorded length and average patch width. These two values were multiplied together to determine the area (square feet) and ultimately the acres infested, both of which were placed into new columns within the data table. The buffered line features were then buffered using the Proximity Tool in ArcGIS using the average patch width as the buffering distance. Maps were created displaying the locations of the infestations in ArcGIS and included as figures in this report. Because many of the infestations mapped were small and difficult to see (Figure 2), it was decided to display uniformly sized points and lines rather than buffered features for ease of viewing on the map and to ensure the refuge can find and locate each feature.

3 RESULTS

A total of 1,358 acres were inventoried by USU crew members in Silvio O. Conte National Fish and Wildlife Refuge during 2011, representing 4 percent of its managed lands. Each crew member averaged 31 acres per 8-hour day. The location and size of the areas inventoried within the Salmon River Division and surrounding private lands, Mohawk River Division, and Fort River Division are displayed in Figures 3, 6, and 9 respectively. The inventory included the complete inventory of the Salmon River Division as well as selected private lands, and the partial inventory of additional land in the Mohawk River and Fort River Divisions (Table 4).

3.1 Target invasive non-native plant list

A total of 1,355 individual infestations or patches were mapped of both targeted and non-targeted species totaling 27.7 acres, or approximately 2.04 percent of the total inventoried area. Of the nineteen targeted species for the overall refuge Utah State University crew members located thirteen targeted species within the selected Divisions (Table 5): garlic mustard (*Allaria petiolata*), Japanese barberry (*Berberis thunbergii*), Oriental bittersweet (*Celastrus orbiculatus*), pale swallowwort (*Cynanchum rossicum*), autumn olive (*Elaeagnus umbellata*), burning bush (*Euonymus alatus*), bush honeysuckle (*Lonicera sp*.), purple loosestrife (*Lythrum salicaria*), Japanese stiltgrass (*Microstegium vimineum*), reed canarygrass (*Phalaris arundinacea*), common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*Rhamnus frangula*), and multiflora rose (*Rosa multiflora*). The most abundant target species mapped on the refuge was Oriental bittersweet, infesting 7.07 acres or about 26 percent of the total infested acres of invasive species. The second most abundant species was Japanese barberry with 5.12 acres, or approximately 18 percent of the total target species acreage. The target species with the most infestations recorded was Japanese barberry at 424 infestations recorded, followed by Oriental bittersweet with 283 infestations (Table 5). What follows is a discussion of the targeted species found in each division.

3.2 Salmon River Division

The Salmon River Division in Haddam, Connecticut was the first Division inventoried. Crew inventoried a total of 645 acres, which included both refuge lands (303 acres) and surrounding partner lands (342 acres) (Figure 3). Crew found a total of 891 individual infestations totaling 17.79 acres across all lands inventoried in this area (refuge and non-refuge lands). The Salmon River Division was found to contain 214 individual infestations of invasive species for a total of 3.41 acres, representing 1.1 percent of the total refuge land (Table 6). Of the initial fourteen target species for the Salmon River Division, crew found the following seven: garlic mustard, Japanese barberry, Oriental bittersweet, burning bush, purple loosestrife, Japanese stiltgrass, and multiflora rose

(Figure 4). Crew did not find black swallowwort, pale swallowwort, bush honeysuckle, Japanese honeysuckle, phragmites, Japanese knotweed, or Norway maple. In addition to the targeted species, crew also noted the presence of two other nonnative species known to be invasive in other areas of the country. Those two non-target species were tree of heaven and yellow toadflax (Figure 5). Acreage of the two non-target species should not be considered complete inventories as not all crew members might have documented their presence.

Japanese stiltgrass was the most abundant target species with 1.11 acres recorded on Division lands, representing 33 percent of the species recorded on the refuge (Table 6). Oriental bittersweet was the second most abundant target species, representing 29 percent of the infestations found with approximately 1.0 acre documented. Although individual infestations or patches were small, Japanese barberry was the most commonly recorded species on the division with 110 infestations documented, representing 51 percent of the total infestations recorded. Table 7 documents the species and canopy cover classes found for each species found during the inventory of the Salmon River Division.

Japanese stiltgrass was found almost exclusively along Pine Brook, a small stream bisecting the refuge land. Japanese barberry was found intermittently along the numerous paths and trails that run across the Salmon River Division. It was also found scattered along the forest floor and was almost consistently found under any forest canopy openings as was multiflora rose. The remaining targeted species were often found at abandoned home sites on the refuge property as were the two non-target species.

It is noted that while crews did not document the presence of Norway maple on refuge or partner lands, it may have been present but crew members struggled to identify trees due to their size and numerous similar native species. Many of the trees were over 30 feet tall and in relatively closed canopy and the forest contained many species of native maple trees. Because of the difficulty in identification, crew members likely missed identifying infestations of Norway maple, even though this species was a low priority for the refuge. The infestations of pale swallowwort may also have been misidentified as the plants were vegetative and not at a fully recognizable stage of growth (found on neighboring private lands). Refuge biologists are encouraged to visit this site to verify the correct identification of this particular species.

The Salmon River Division was unique in the opportunity given to inventory neighboring private lands of land owners willing to partner with the refuge for invasive species management. The inventory found neighboring private lands to be heavily infested with many of the targeted species. Private lands contained ten of the fourteen species: garlic mustard, Japanese barberry, Oriental bittersweet, pale swallowwort, burning bush, bush honeysuckle, purple loosestrife, Japanese stiltgrass, multiflora rose, and phragmites. Partner lands did not contain any noted infestations of black swallowwort, Japanese honeysuckle, Japanese knotweed, or Norway maple. As with refuge land, the crew also noted the presence of several other non-native species in the area and documented those when encountered. These species included tree of heaven, burdock, bull thistle, autumn olive, kudzu, and wineberry.

The most widespread targeted species found on private neighboring lands was Japanese barberry, with 3.70 acres infested and 262 separate infestations recorded (Table 6), or approximately 26 percent of the total infested acres found on private lands. The second most commonly found target species was Japanese stiltgrass, found in 124 infestations on 3.77 acres of partner lands (26 percent of total infested acres). Japanese stiltgrass continued to follow Pine Brook on both refuge and private lands. Just as on refuge lands many of the shrub species and forb species were found in openings in the forest canopy. Numerous infestations of several species were found along the power line corridor running adjacent to the western boundary of the refuge. The report of kudzu was found on an abandoned site to the northeast of the refuge and was verified by the crew and refuge biologist after being reported by one of the partners involved in the project.

Visibility was generally very good throughout the Salmon River Division and partner lands and individual crew members felt confident in detecting at least 90 percent of all targeted species 0.001 acre or larger in size.

3.3 Mohawk River Division

The 1,023 acre size Mohawk River Division was inventoried from August 8 to 12, 2011. The native vegetation was dense and prevented a complete inventory of the entire division so the crew concentrated on inventorying the lands most accessible on foot, resulting in 625 acres searched for targeted invasive species, representing 61 percent of the refuge land in this division (Figure 6). The remaining 39 percent contained extremely dense forest and impenetrable wetland habitat and is unlikely to contain many of the targeted invasive species. Crew found a total of 195 individual infestations totaling 2.77 acres, representing both target and non-target species.

Of the lands searched, crew members found four of the eleven targeted species: autumn olive, purple loosestrife, reed canarygrass, and glossy buckthorn (Figure 7). The crew did not find garlic mustard, Japanese barberry, Oriental bittersweet, bush honeysuckle, multiflora rose, Japanese knotweed, or spotted knapweed. Crew members also noted the presence of nine other non-native and potentially invasive species: burdock, Canada thistle, bull thistle, field bindweed, orange hawkweed, oxeye daisy, yellow sweetclover, common reed, and sulfur cinquefoil (Figure 8). These non-target species were recorded because they have a known history of invasiveness in other areas of the country (particularly in the west) and crew members felt it important to document their locations here. Reed canarygrass was the most abundant target species with approximately 1.66 acres recorded as 41 separate infestations, representing 60 percent of the species recorded for this Division (Table 8). Autumn olive was the second most abundant target species, representing 0.1 percent of the infestations found with approximately 0.003 acres documented. This indicates that the remaining approximately 40 percent of species recorded in this inventory were non-target species. In fact, Canada thistle, while not a target species for this division, comprised 33 percent of the total species recorded at 0.91 acres infested. The most commonly recorded species on this division was oxeye daisy, with 89 separate infestations documented (0.11 acres), although individual infestations were typically not more than 5-10 plants in size. Table 9 documents the species and

canopy cover classes found for each species found during the inventory of the Mohawk River Division.

Most of the target and non-target species were found in the lower wetlands of the Division. Canada thistle, reed canarygrass, common reed, and purple loosestrife were all found along the smaller streams that run through the middle of the Division. Oxeye daisy, orange hawkweed, sulfur cinquefoil, burdock, glossy buckthorn, and bull thistle were found in the large abandoned agricultural field in the northeast corner of the refuge. Plants of all species were lightly scattered across these fields. None of the target or non-target species were located in the heavily forested sections of the division that were inventoried by the field crew, leading to the discussion that it is unlikely that the remaining unsearched but equally dense portions of the forest would contain these species. Visibility varied greatly from excellent in the open fields to very poor in some of the more dense portions of forest. Individual crew members varied in their detection confidence due to the changing site conditions and their ability to detect at least 90 percent of the targeted species 0.001 acre or larger in size. While search patterns were adjusted to account for the changes in detectability of the targeted species, 90 percent could not always be achieved. In those forested areas or riparian areas with dense vegetation, crew members sampled and accessed as much of the ground as was feasibly possible.

3.4 Fort River Division

The field crew inventoried 88 acres of the Fort River Division on August 18, 2011, representing 45 percent of the Division (Figure 9). Time did not permit the full inventory of this Division and efforts focused on the roads and sections of stream corridor at the direction of the refuge biologist. Of the initial 16 species targeted for this Division, the field crew found nine (Figure 10): garlic mustard, Japanese barberry, Oriental bittersweet, autumn olive, burning bush, bush honeysuckle, common buckthorn, glossy buckthorn, and multiflora rose. The crew did not find black swallowwort, pale swallowwort, Japanese stiltgrass, Japanese honeysuckle, purple loosestrife, Japanese knotweed, or Norway maple in the inventoried portions of this Division. Crew members also recorded the locations of four other non-target species present on the Fort River Division: tree of heaven, catalpa, bull thistle, and black locust (Figure 11).

Of the nine targeted species located, Oriental bittersweet was the most common. Oriental bittersweet was found infesting 65 percent of the lands inventoried, or 4.60 acres (Table 10). It was also the most frequently recorded species with 118 separate infestations documented. Glossy buckthorn was the second most common species, with 0.73 acres infested (10 percent) and 42 separate infestations recorded. Table 11 documents the species and canopy cover classes found for each species found during the inventory of the Mohawk River Division.

While this was not a full inventory, the entire Fort River Division has received heavy disturbance as a result of its recent history as a horse farm. The racetrack and several outbuildings are still present on the property and many of the fields contain numerous

invasive species. It is also known that the riparian habitat, although not fully documented, is heavily infested with multiflora rose. The targeted and non-targeted species were scattered throughout the fields and roadsides throughout the property and could be difficult to see at times due to their small size in some of the fields.

4 DISCUSSION and RECOMMENDATIONS

The distribution and relative abundance of the targeted plant species collected in the 2011 inventory of Silvio O. Conte National Fish and Wildlife Refuge are to support the objectives laid out by the refuge staff to: 1) document areas free of targeted invasive non-native species that might be designated as weed – free prevention areas within the three Divisions, 2) identify early detection species newly invading the refuge (EDRR), 3) detect and document the overall abundance and locations of targeted invasive non-native plant species across the three Divisions, 4) utilize the data to inform strategic planning and increase the efficiency and effectiveness of invasive plant management operations on the refuge, including appropriate measures for monitoring program effectiveness, and 5) document the overall abundance and locations of targeted invasive non-native plant species on private lands surrounding the Salmon River Division for targeted invasive non-native species that pose an immediate threat to refuge lands to be used to develop partnerships with surrounding land owners dealing with similar invasive species issues and generate awareness and outreach to the general public.

The data collected during the 2011 inventory not only indicates the location and abundance of the targeted invasive species but will provide valuable information when developing an integrated pest management plan for the refuge. The data provides a more thorough understanding of each species' distribution across the three Divisions inventoried as well as to some extent the overall health of the lands. For example, Japanese stiltgrass was usually concentrated along riparian corridors on the Salmon River Division and purple loosestrife and reed canarygrass were found along stream channels in the Mohawk River Division. All other species were found in either open meadows or in openings of the forest canopy. Few species were found under a closed forest canopy. Knowing the relative abundance and distribution of these species will allow Silvio O. Conte NFWR to prioritize how best to allocate management resources in a given year (e.g. eradication, containment, control).

To truly understand the full impact of invasive species are having on the refuge's natural resources, patterns of spread, and environmental correlations, the dataset should be examined relative to other environmental data such as vegetation or land cover maps, pathways of spread (roads, trails, waterways), or sensitive species maps. Integrating inventory data with other natural resource data will provide a more complete picture of the species distribution and potential impacts and will allow refuge staff to more accurately identify leading edges and patterns on the landscape for more widespread species such as Oriental bittersweet, Japanese barberry, multiflora rose, and Japanese stiltgrass. Integration of inventory data with other refuge environmental data will also

inform how best to prioritize allocation of refuge resources to manage invasive populations.

Silvio O. Conte NFWR is commended for its continuing efforts to treat and manage many of the invasive species present. Volunteers were seen out pulling Japanese stiltgrass on the Salmon River Division and it was known that ongoing efforts were continuing on the Fort River Division to control the numerous invasive species through hand pulling and herbicides. The refuge is encouraged to use the inventory data to write an invasive species management plan and the information is intended to help refuge staff improve upon strategies already being utilized. As the refuge is in the process of writing its Comprehensive Conservation Plan (CCP), this data is also being incorporated with their long-term management goals.

The first step in developing a strategic management plan will be to evaluate the individual species. Budgets never allow for all invasive species problems to be addressed equally. The inventory identified two early detection species at the Salmon River District (with three early detection species on private lands), one early detection species at the Mohawk River Division, and one early detection species at the Fort River District. Aside from Japanese stiltgrass at the Salmon River site, all other early detection species were found in very small numbers and in all cases but one less than 0.10 acre in size for each occurrence. While Japanese stiltgrass on the Salmon River Division appears to be more common than originally thought, it is an example of a species relatively new to the area, with the potential to impact a large area of relatively uninfested land and thus still qualifies for status as an early detection species. Purple loosestrife and glossy buckthorn in the Mohawk River Division are other examples of early detection species in small isolated patches, although both were considered priority 2 species. In these cases, the two species are fairly common in the New England area, but only two plants were located of each species in the Division. In the case of purple loosestrife, the plants were pulled when discovered, but the seed bank is still present and will require follow up. Reed camarygrass may also fit these criteria as it was found in isolated patches across the Mohawk River Division. Autumn olive, another common species in the New England area was also found an isolated area within the Mohawk Division and could be targeted for removal. These early detection species should be given the highest priority for assessment and treatment with the ultimate objective of eradication.

The inventory also found orange hawkweed, sulfur cinquefoil, burdock, Canada thistle, bull thistle, and phragmites at the Mohawk River Division. These species were not targeted during the inventory but are known to be invasive in other areas of the country and are listed on numerous state noxious weed lists (USDA 2012). Their presence and known invasiveness should alert refuge staff to their being targeted for candidates for eradication from this division.

The more widespread species found during the inventory would not necessarily fit into the category of eradication at this time but could be targeted for containment within individual Divisions with the ultimate goal of a reduction in the acres infested over time. The control of outlier populations of Oriental bittersweet in the Salmon River Division

dispersed outside of Pine Brook and Autumn olive at the Fort River Division might fit this category. When containment is no longer feasible, the goal becomes reducing overall impact. Many of the targeted species found in this inventory are widespread across not only refuge lands but across neighboring lands as well. The goal is to reduce the impact of these species on the resources the refuge is tasked with protecting.

Management should not be focused solely on the treatment of invasive species but recognizing that treatment is ultimately to protect the resources and ecosystem they invade. The refuge provides resting sites for migratory birds and migratory fish habitat in the Salmon River Division, habitat for northern harrier nesting habitat and habitat for native brook trout and juvenile Atlantic salmon in the Mohawk River Division, and support stopover sites for migrating songbirds and its habitat, increase populations of grassland birds such as bobolinks and vesper sparrows, and protect the nearby Fort River and its habitat for freshwater mussels at the Fort River Division. The value of the inventory data can be seen when overlaid on these species' habitat and the relative proximity of the invasive species to these species. The presence of invasive species in this or other sensitive habitat necessitates the treatment of those plants as high priority.

As with prioritizing species, the refuge will need to determine the proper approach for prioritizing management actions. Focus should first be place on keeping uninfested areas clean from future introductions, especially in areas containing or adjacent to sensitive refuge resources. Prevention should play a large role in the management strategies for invasive species. Prevention is the most cost effective tool available in invasive species management as it is much cheaper to keep a new species from establishing when compared to the costs associated with the multiple years and resources expended to treat a species that becomes widely distributed over time. Prevention strategies include minimizing the potential movement of invasive species around the refuge and mitigating any other management activities that might contribute to their spread. The refuge does an excellent job of cleaning boots with hand brushes when moving in and out of infested invasive species areas and this was evident particularly by refuge biologists when working around Japanese stiltgrass in the Salmon River Division.

Prevention strategies include identifying any areas free of invasive species (designated as Weed Prevention Areas) and concentrating efforts to maintain those clean areas as such. The data collected found much of the Mohawk River Division and several areas within the Salmon River Division to be relatively free of the targeted invasive species and entirely free of several species of many of the species on the target list.

Prevention strategies might mean minimizing disturbance in the Divisions and cleaning equipment before moving between areas. Minimizing traffic through heavily infested areas could be applied across the refuge as well as washing equipment before moving from heavily infested to minimally infested sites. Prevention also includes minimizing disturbance through routine maintenance activities since disturbance appears to contribute to the establishment and introduction of new species. Other activities include using clean mulch and gravel in construction projects, and educating hunters, recreationists, and the general public about the general risks they pose of accidentally

introducing new species through their use of the refuge. New introductions into these currently uninfested sites would be part of an early detection and rapid response strategy and part of routine monitoring of these clean areas. In 2011, the California Invasive Plant Council produced a report summarizing best management practices land managers can use to prevent the spread of invasive plants (http://www.cal-ipc.org/ip/prevention /landmanagers.php). The report, titled "Preventing the Spread of Invasive Plants: Best Management Practices for Land Managers" was developed in partnership with several land management agencies including the National Park Service, the U.S. Forest Service, and the USFWS. Several of the strategies included in the report could be incorporated into a future invasive plant management strategy for Silvio O. Conte NFWR.

As part of the management prioritization, the data should be overlaid on other spatial data such as roads, trails, vegetation classes, and topography. Other refuge activities or habitats may be linked with the spread of a particular species. Patterns emerge when the two resources are looked at simultaneously that are not as readily apparent when studies individually. Japanese stiltgrass infestations strongly followed Pine Brook in the Salmon River Division while many of the invasive shrub species followed along the powerline on the neighboring private lands. Reed canarygrass was found in the Mohawk River Division along the open water channels while the non-target species of orange hawkweed and oxeye daisy were heavily tied to the open fields. The dataset should also be utilized for any future refuge management actions. The location of large infestations will factor into the development of new roads and trails or necessitate the control of these infestations before construction.

The results of the inventory should also be shared with other groups' existing invasive species data in the surrounding community. This dataset is intended to encourage partnerships with neighboring land owners and The Nature Conservancy as invasive species readily cross boundaries. This is especially important in the case of the Salmon River Division, where multiple land owners are adjacent to the refuge boundary. Numerous entities expressed an interest in preserving the land surrounding the Salmon River Division during the two day prioritization workshop help in July. Two days of the project were dedicated to searching private lands adjacent to the refuge. The 2011 inventory results demonstrate the vital importance that partnerships can have in effectively managing invasive species. Of the approximate 18 acres of invasive species documented during the Salmon River inventory, 14.39 acres, or 81 percent, were infestations found on private lands, with only 3.41 acres (or 19 percent) present on refuge lands. The populations of targeted invasive species found on private lands pose an immediate threat to the health and function of the refuge. Numerous land owners and land trusts expressed an interest in coordinating efforts to control many of the invasive species in the Salmon River Division. These partnerships are essential when managing invasive species, since these species readily move across boundaries and property lines. Sharing this information allows the refuge to coordinate management efforts with multiple land owners and work on similar problems.

In addition to prioritizing management actions, the refuge is encouraged to continue regularly scheduled inventories of the remaining 94 percent of the land not searched in the current project. The inventory of Silvio O. Conte National Fish and Wildlife Refuge

exhibits the challenge of inventorying and managing invasive species across a very large landscape with limited knowledge and resources. The distance between these divisions stretched across three states with at least 300 miles between the Salmon River Division and Mohawk Division. Habitats ranged from floodplain forest to coniferous forests to hayfields and cropland. Areas with the highest priority for inventory across this high landscape would be critical habitat for threatened and endangered species, followed by riparian habitat and areas receiving intense or routine disturbances. At a minimum, inspection of high visitation areas should be performed annually or every other year. Roads and developed sites often are the first place a new species is introduced so routine searches are crucial for early detection. Other management units containing species that the refuge has identified as early detection species and candidates for eradication should also be monitored on a regular schedule to locate new populations from any residual seed bank left after treating existing populations. The remaining management Divisions should be broken into groups that are searched on a rotating schedule so that the entire refuge is inventoried over a five to ten year period. It is encouraging that several targeted species were not discovered in the 2011 inventory. Continued monitoring and vigilance is required to ensure that they are detected in a timely manner if new introductions occur at a later time. The data collected in the 2011 inventory of Silvio O. Conte National Fish and Wildlife Refuge provides crucial baseline information that will help the refuge improve their strategic planning and increase the efficiency and effectiveness of invasive plant management operations on the refuge.

5 REFERENCES CITED

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Figure 1. Inventory sites included in the 2011 inventory of Silvio O. Conte National Fish and Wildlife Refuge included (clockwise from upper left) the Salmon River Division in Connecticut, the Fort River Division in Massachusetts, and the Mohawk River Division in New Hampshire.

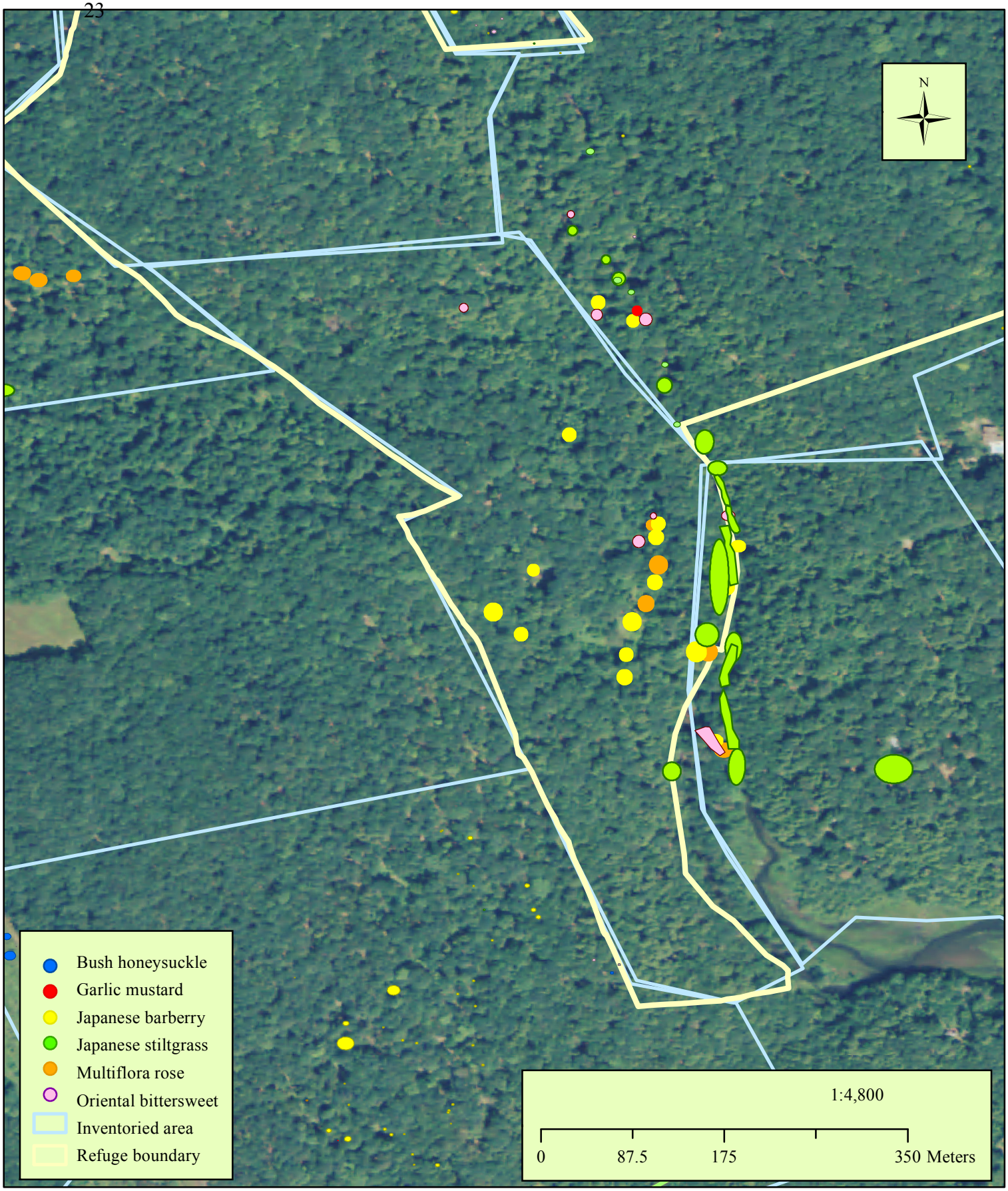

Figure 2. Targeted invasive non-native plants detected and buffered on the Salmon River Division of Silvio O. Conte National Fish and Wildlife Refuge and partner lands, August 2 - 18, 2011.

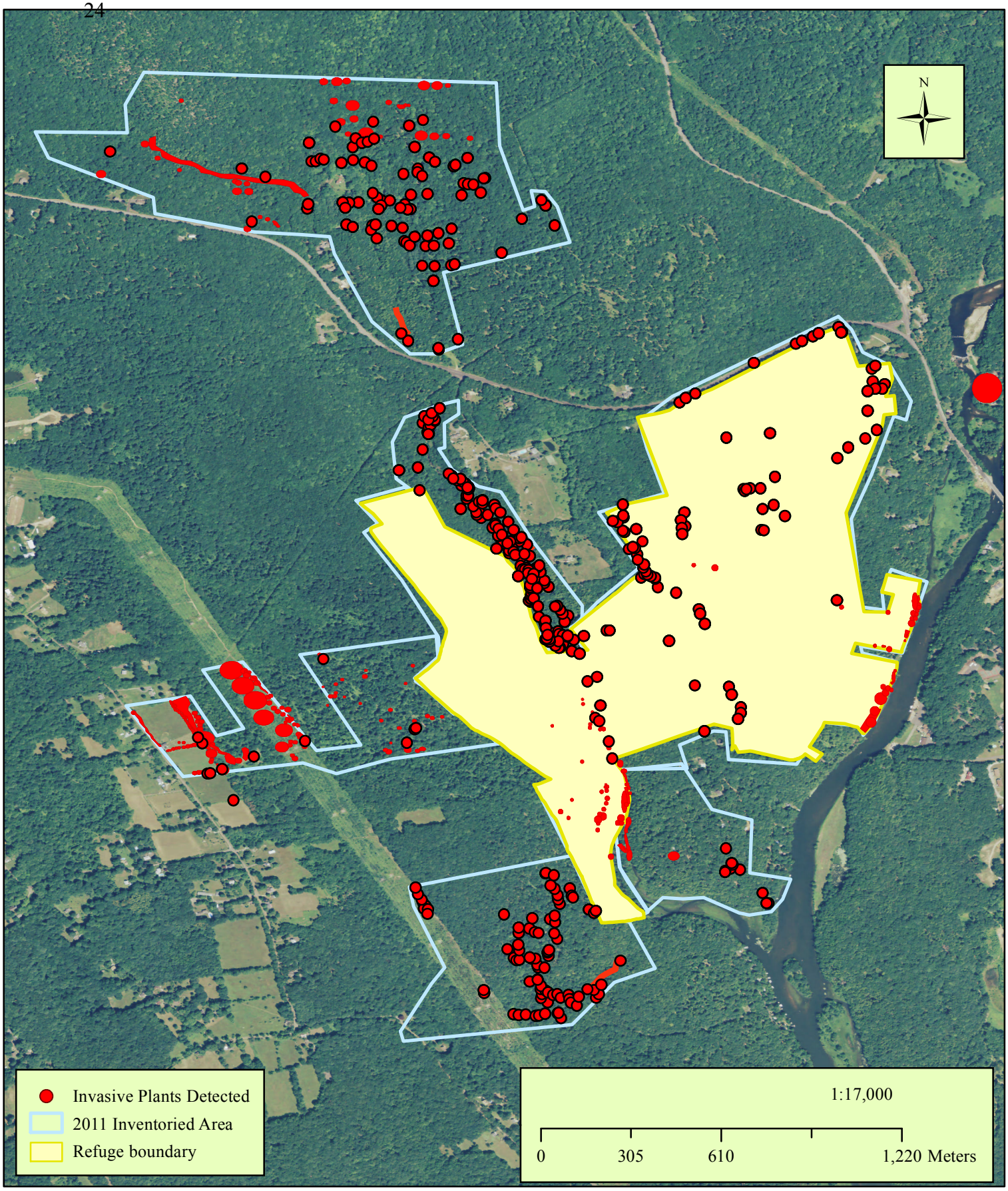

Figure 3. Lands inventoried for invasive non-native plants on the Salmon River Division of Silvio O. Conte National Fish and Wildlife Refuge and partner lands, August 2 - 18, 2011.

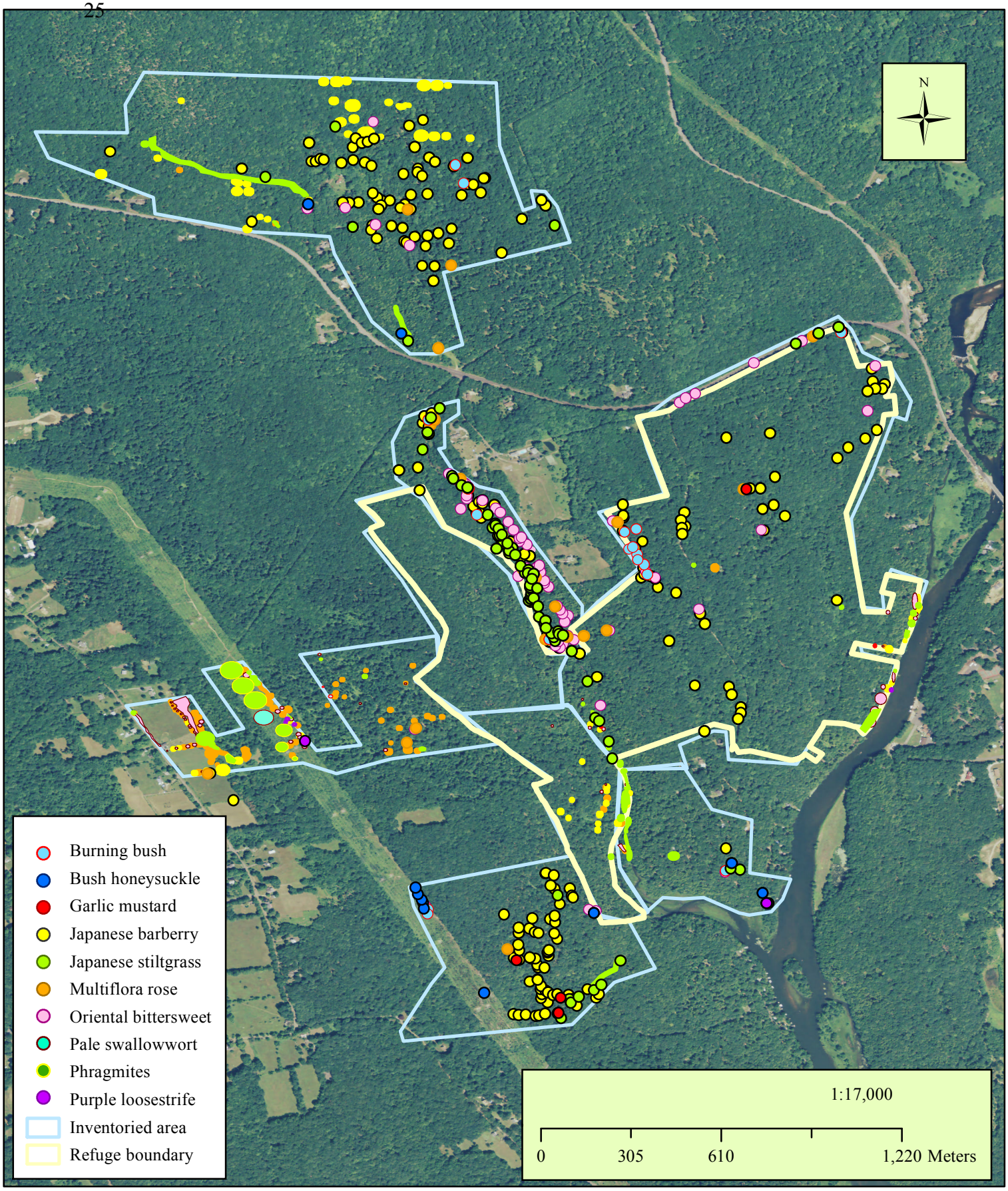

Figure 4. Targeted invasive non-native species detected on the Salmon River Division of Silvio O. Conte National Fish and Wildlife Refuge and partner lands, August 2 - 18, 2011.

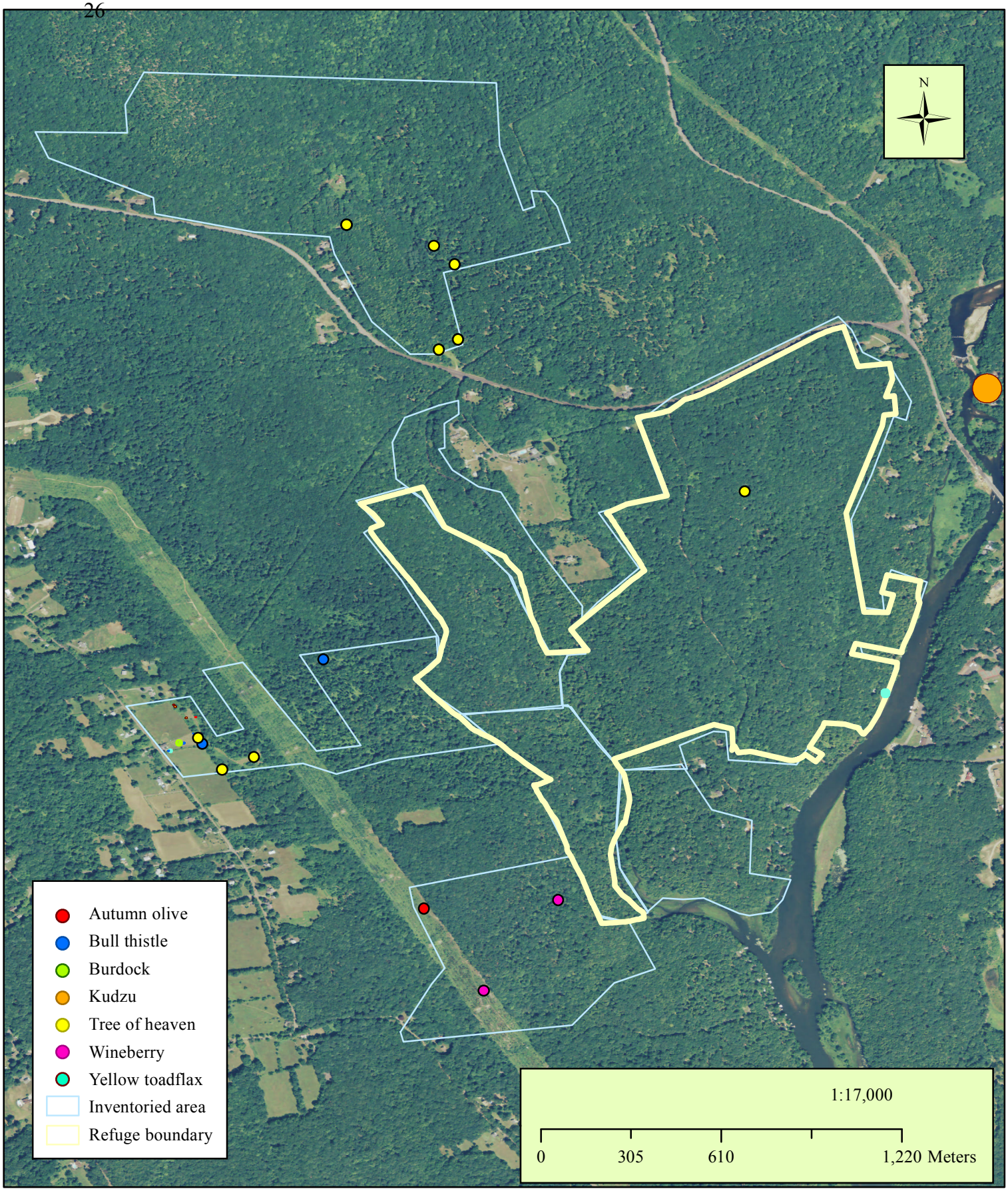

Figure 5. Non-target invasive non-native species detected on the Salmon River Division of Silvio O. Conte National Fish and Wildlife Refuge and partner lands, August 2 - 18, 2011.

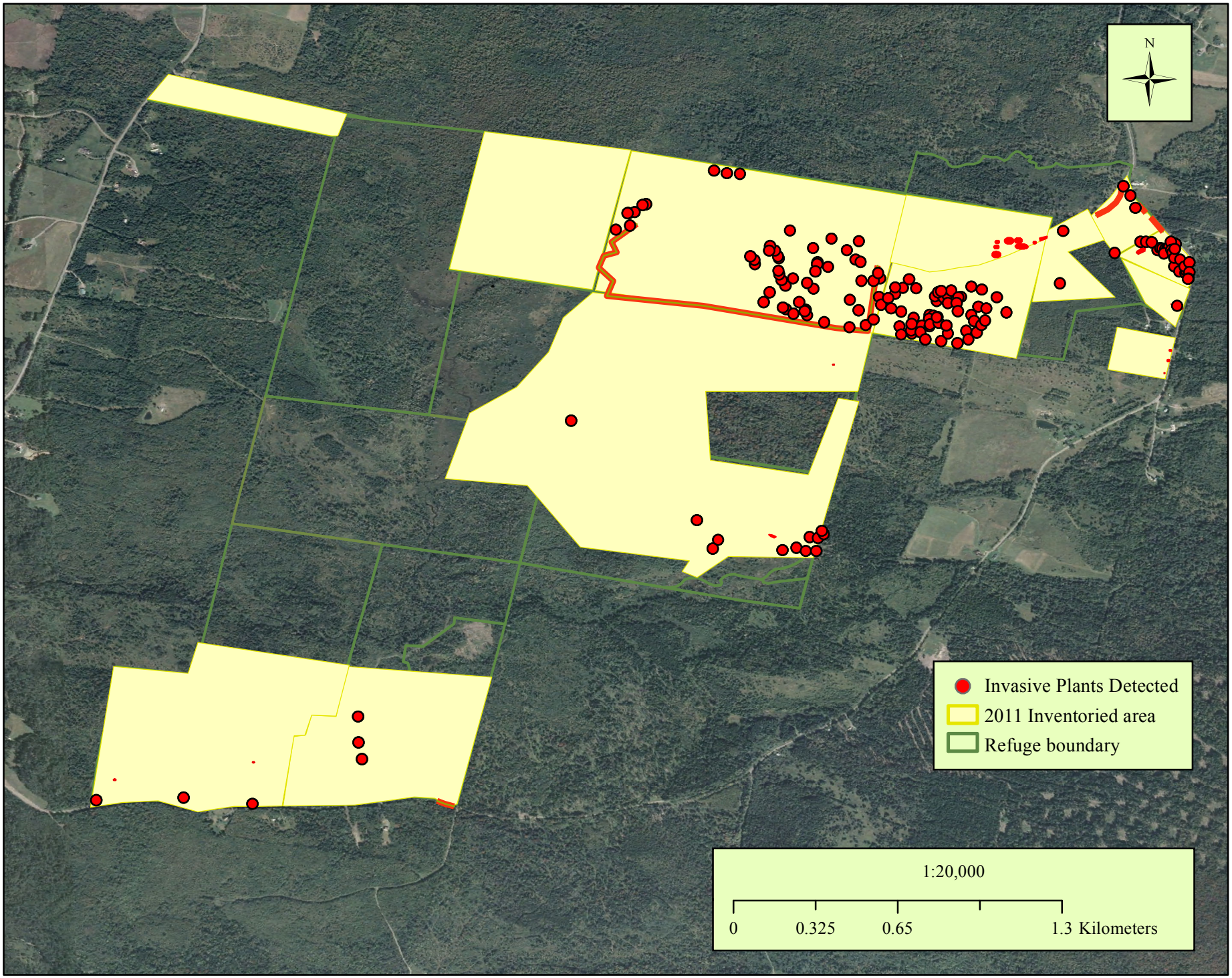

Figure 6. Lands inventoried for invasive non-native plants on the Mohawk River Division of the Silvio O. Conte National Fish and Wildlife Refuge, August 2 - 18, 2011.

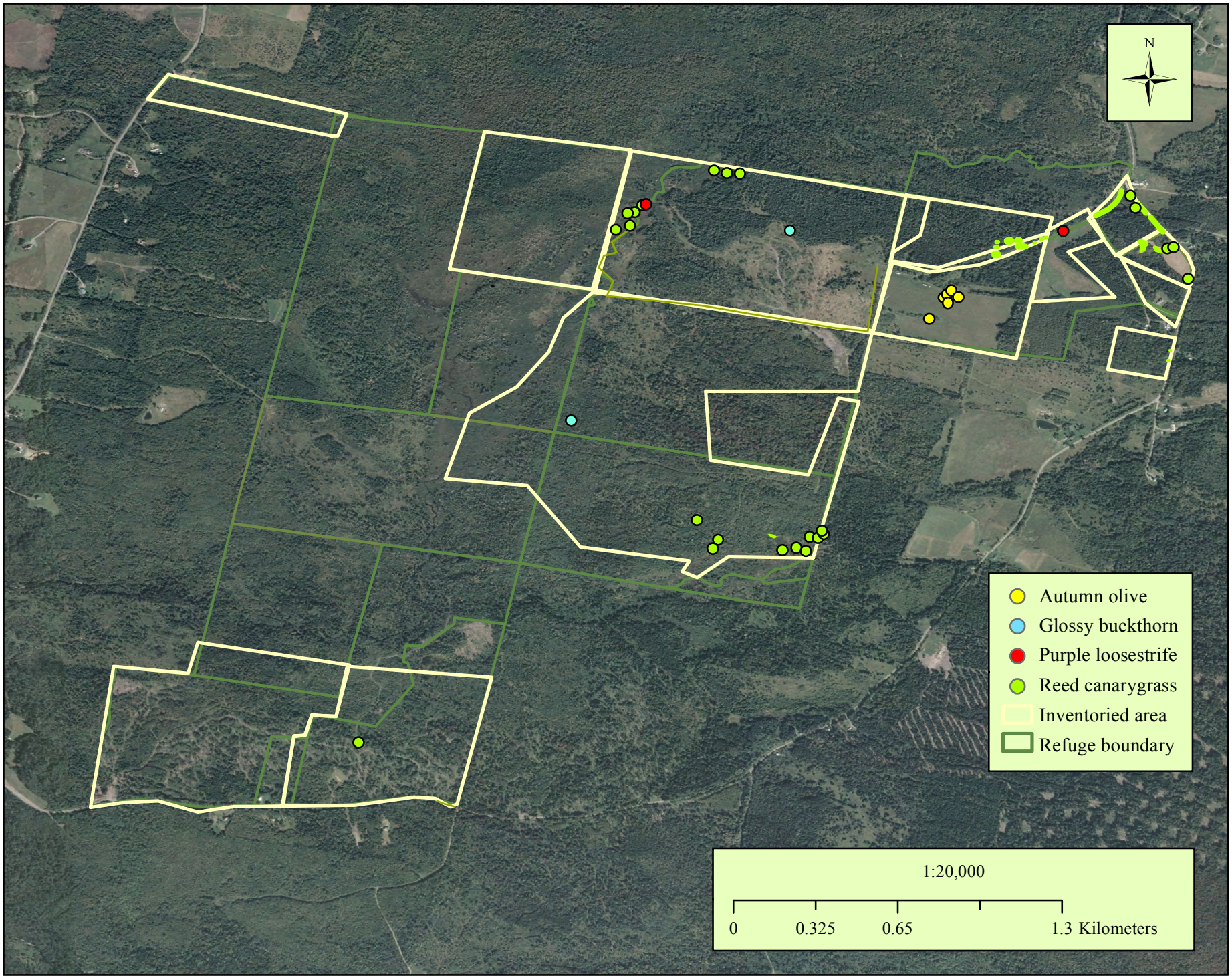

Figure 7. Targeted invasive non-native species detected on the Mohawk River Division of the Silvio O. Conte National Fish and Wildlife Refuge, August 2 - 18, 2011.

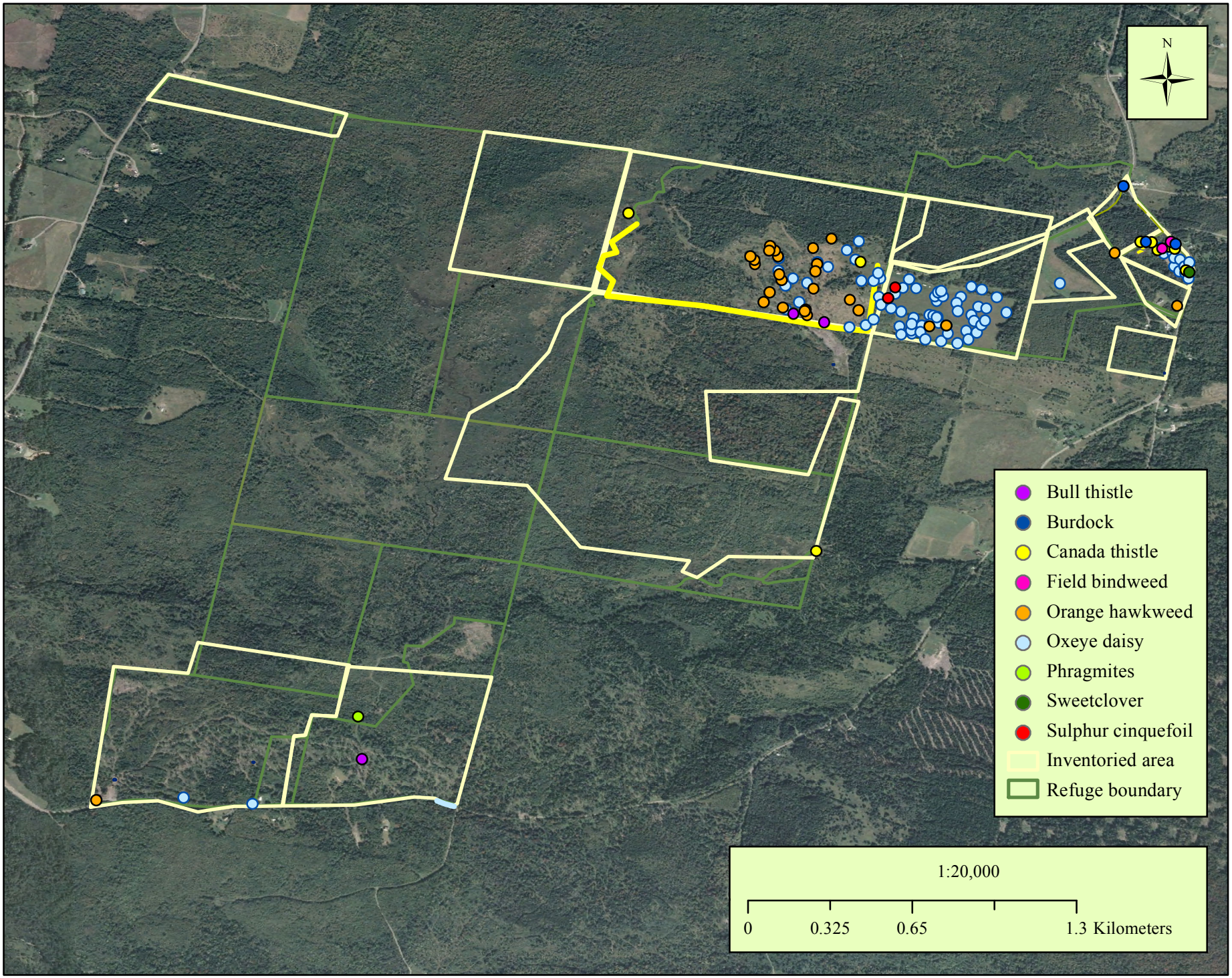

Figure 8. Non-target invasive non-native species detected on the Mohawk River Division of the Silvio O. Conte National Fish and Wildlife Refuge, August 2 - 18, 2011.

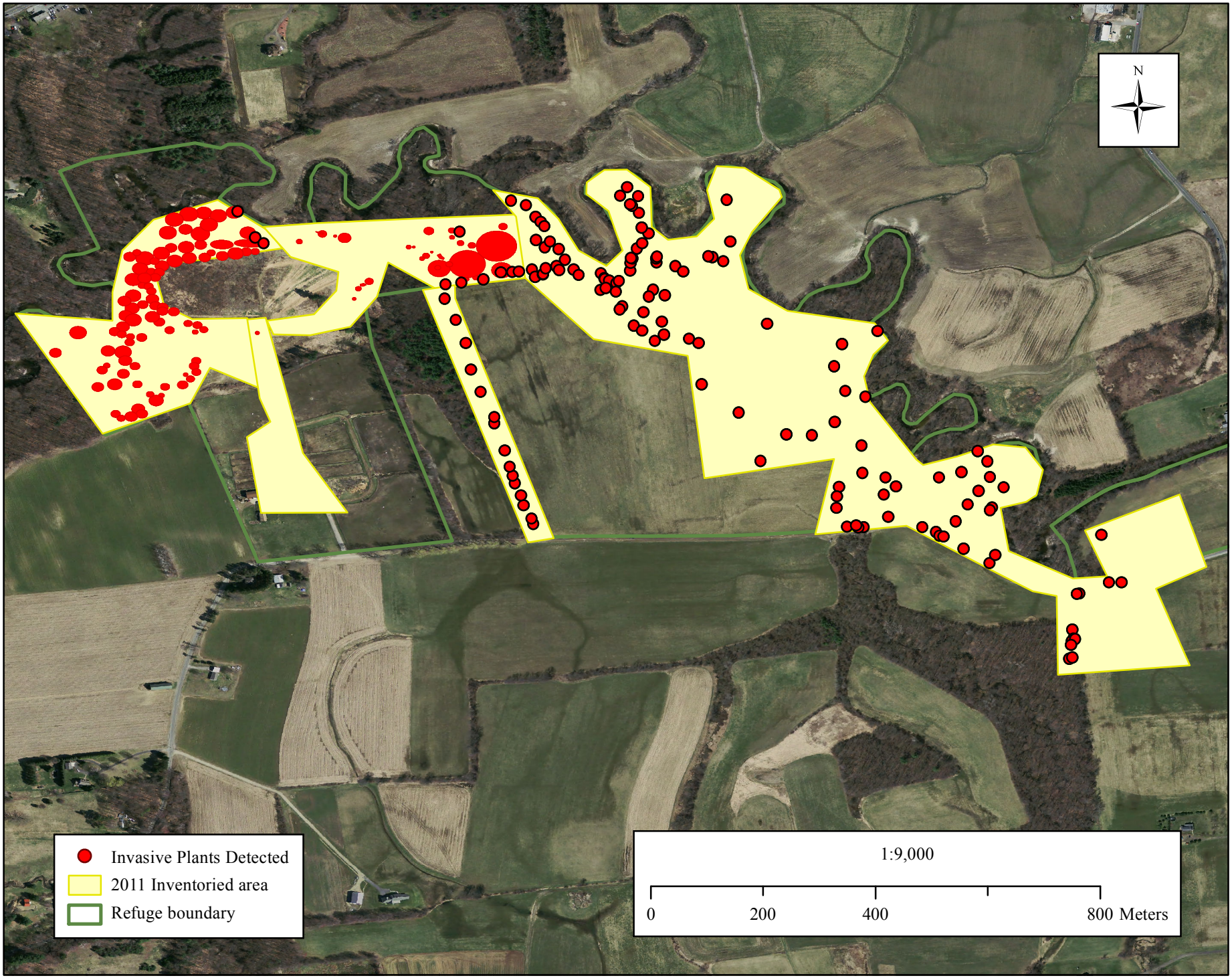

Figure 9. Lands inventoried for invasive non-native plants on the Fort River Division of Silvio O. Conte National Fish and Wildlife Refuge, August 2 - 18, 2011.

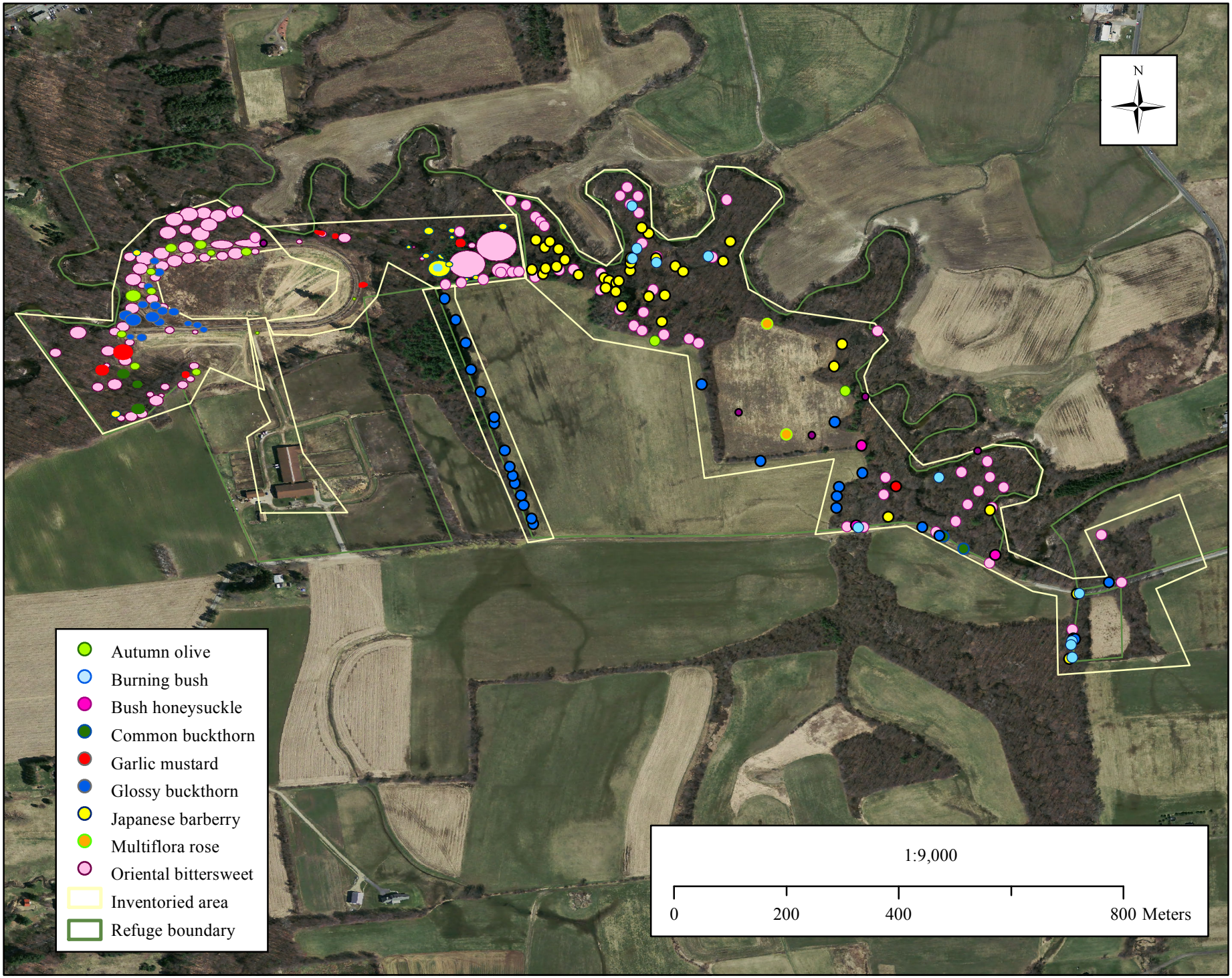

Figure 10. Targeted invasive non-native species detected on the Fort River Division of Silvio O. Conte National Fish and Wildlife Refuge, August 2 - 18, 2011.

Figure 11. Non-target invasive non-native species detected on the Fort River Division of Silvio O. Conte National Fish and Wildlife Refuge, August 2 - 18, 2011.

Table 1 **List of invasive non-native plant species targeted for inventory by Utah State University at the Salmon River Division of the Silvio O. Conte National Fish and Wildlife Refuge, August 2 – 18, 2011.**

Species	Common name	Species Category	State Noxious Species
Allaria petiolata	Garlic mustard	1st Priority	X
Cynanchum nigrum	Black swallowwort	1st Priority	X
Cynanchum rossicum	Pale swallowwort	1st Priority	X
Microstegium vimineum	Japanese stiltgrass	1st Priority	X
Berberis thunbergii	Japanese barberry	2nd Priority	X
Celastrus orbiculatus	Oriental bittersweet	2nd Priority	X
Euonymus alatus	Burning bush	2nd Priority	X
Lonicera japonica	Japanese honeysuckle	2nd Priority	X
Lonicera sp.	Bush honeysuckles	2nd Priority	X
Lythrum salicaria	Purple loosestrife	2nd Priority	X
Phragmites sp.	Phragmites	2nd Priority	X
Polygonum cuspidatum	Japanese knotweed	2nd Priority	X
Acer plantanoides	Norway maple	3rd Priority	X
Rosa multiflora	Multiflora rose	3rd Priority	X

Table 2 **List of invasive non-native plant species targeted for inventory by Utah State University at the Mohawk River Division of the Silvio O. Conte National Fish and Wildlife Refuge, August 2 – 18, 2011.**

Species	Common name	Species Category	State Noxious Species
Allaria petiolata	Garlic mustard	1st Priority	X
Berberis thunbergii	Japanese barberry	1st Priority	X
Celastrus orbiculatus	Oriental bittersweet	1st Priority	X
Elaeagnus umbellate	Autumn olive	1st Priority	X
Lonicera sp.	Bush honeysuckles	1st Priority	X
Rosa multiflora	Multiflora rose	1st Priority	X
Lythrum salicaria	Purple loosestrife	2nd Priority	--
Polygonum cuspidatum	Japanese knotweed	2nd Priority	X
Rhamnus frangula	Glossy buckthorn	2nd Priority	X
Centaurea maculosa	Spotted knapweed	3rd Priority	--
Phalaris arundinacea	Reed canarygrass	3rd Priority	--

Table 3 List of invasive non-native plant species targeted for inventory by Utah State University at the Fort River Division of the Silvio O. Conte National Fish and Wildlife Refuge, August 2 – 18, 2011.

Species	Common name	Species Category	State Noxious Species
Allaria petiolata	Garlic mustard	1st Priority	X
Cynanchum nigrum	Black swallowwort	1st Priority	X
Cynanchum rossicum	Pale swallowwort	1st Priority	X
Microstegium vimineum	Japanese stiltgrass	1st Priority	X
Berberis thunbergii	Japanese barberry	2nd Priority	X
Celastrus orbiculatus	Oriental bittersweet	2nd Priority	X
Elaeagnus umbellate	Autumn olive	2nd Priority	X
Euonymus alatus	Burning bush	2nd Priority	X
Lonicera japonica	Japanese honeysuckle	2nd Priority	X
Lonicera sp.	Bush honeysuckles	2nd Priority	X
Lythrum salicaria	Purple loosestrife	2nd Priority	X
Polygonum cuspidatum	Japanese knotweed	2nd Priority	X
Acer plantanoides	Norway maple	3rd Priority	X
Rhamnus cathartica	Common buckthorn	3rd Priority	X
Rhamnus frangula	Glossy buckthorn	3rd Priority	X
Rosa multiflora	Multiflora rose	3rd Priority	X

Table 4 **Invasive plant inventory areas, inventory dates, personnel involved, and acres inventoried during the 2011 Invasive Non-native Plant Inventory for Silvio O. Conte National Fish and Wildlife Refuge, August 2 - 18, 2011.**

RLGIS	Division Name	Search Area	Origin	Date	Acres
{945ECC56-910A-4DD8-85E1-830B30D17063}	SMN	Salmon River, Pine Brook	C. Chapple	8/3/2011	48.5
{20B5636F-F63C-4822-A264-52FA7B796CF6}	SMN	Pine Brook	USU Multiple*	8/3/2011	223.0
{F1130D87-6377-42B3-96C0-3F3C23193A54}	SMN	Pine Brook, 117 Pine Brook Rd	P. Chapple	8/3/2011	31.2
{F84667DF-06A2-409D-B82B-3DE67F03A21C}	MKR	Blueberry Swamp	USU Multiple*	8/8/2011	13.7
{647FD63D-1960-42ED-8A2E-63C8453C38FF}	MKR	Blueberry Swamp	P. Chapple	8/8/2011	6.9
{B2B25784-8611-4803-A23B-3E59FECA37B7}	MKR	Blueberry Swamp	USU Multiple*	8/8/2011	37.2
{95B3086A-F9BB-496E-B366-07FCE22EE4EC}	MKR	Blueberry Swamp	K. Edvarchuk	8/8/2011	23.0
{0BDEF842-E80F-48B5-A1B3-9CAE073ACD7C}	MKR	Blueberry Swamp	K. Edvarchuk	8/9/2011	7.6
{BD46D57D-06BE-4841-A829-215E37EA275F}	MKR	Blueberry Swamp	USU Multiple*	8/9/2011	112.7
{14506148-E9BA-49BC-A8B5-3DF1991D1E7B}	MKR	Blueberry Swamp	USU Multiple*	8/9/2011	11.6
{EF5721C5-DD87-441C-A9CB-EB6DE20F1151}	MKR	Blueberry Swamp	USU Multiple*	8/10/2011	57.2
{6598FA1C-EAA4-46FE-A7A0-34B119B87168}	MKR	Blueberry Swamp	K. Edvarchuk	8/10/2011	6.0
{5F19E093-D8C9-4F51-8D13-44E2C7499203}	MKR	Blueberry Swamp	D. Harker	8/10/2011	5.2
{6541C9ED-15E9-4C0E-9180-027A2A6DEE93}	MKR	Blueberry Swamp	USU Multiple*	8/11/2011	59.8
{2D297B5E-881B-4B7C-A90B-68F405F6A850}	MKR	Blueberry Swamp	USU Multiple*	8/11/2011	199.1
{EE49B558-9F23-42C6-9773-C10393E13C90}	MKR	Blueberry Swamp	USU Multiple*	8/12/2011	84.6

RLGIS	Division Name	Search Area	Origin	Date	Acres
{E3A159DC-04FC-4617-AEB2-2CE421B4DE2F}	SMN	Pine Brook Road	USU Multiple*	8/16/2011	29.6
{5B8E75CF-B98B-42D5-BB45-390AD8F7E323}	SMN	Quarry Hill Road	USU Multiple*	8/16/2011	54.0
{9B05A420-3CC3-41F9-9935-C05F6BE2A674}	SMN	34 Cover Road	USU Multiple*	8/16/2011	64.3
{2BAD8FC6-848C-42EA-8EAD-C264A8A79256}	SMN	52 Wentworth Road	USU Multiple*	8/16/2011	34.8
{0A900B40-2149-4322-A7ED-8A933AD4F395}	SMN	Pine Brook Falls, Pine Brook Legacy Preserve	USU Multiple*	8/17/2011	159.7
{53C11526-C6BD-4A9D-BEB2-7F64CB074909}	FRG	Fort River Division	P. Chapple	8/18/2011	15.6
{392E1EB3-67A3-43FC-BB9E-E4554D33FE53}	FRG	Fort River Division	C. Chapple	8/18/2011	4.7
{56CCF5FF-5962-4A45-92D4-40F3DACD5334}	FRG	Fort River Division	C. Chapple	8/18/2011	9.7
{E6D3F167-2280-4623-9FF7-97BC48E853C9}	FRG	Fort River Division	D. Harker	8/18/2011	53.8
{926DA782-04DE-440C-AD44-E0B9F5683690}	FRG	Fort River Division	D. Butler	8/18/2011	4.1
TOTAL					**1357.6**

* USU Multiple indicates more than one crew member participated in the search of this area.

Table 5 The number of populations and acres infested of targeted and non-target invasive non-native plant species detected within inventoried areas of Silvio O. Conte National Fish and Wildlife Refuge, August 2 - 18, 2011.

Species	Common name	# Features	Acres Infested
Ailanthus altissima	Tree of heaven	18	0.17
Allaria petiolata	Garlic mustard	14	0.25
Arctium minus	Burdock	5	0.01
Berberis thunbergii	Japanese barberry	424	5.12
Celastrus obiculatus	Oriental bittersweet	282	7.07
Cirsium arvense	Canada thistle	14	0.91
Cirsium vulgare	Bull thistle	10	0.04
Convolvulus arvensis	Field bindweed	2	0.01
Cynanchum rossicum	Pale swallowwort	2	0.50
Elaeagnus umbellata	Autumn olive	22	0.39
Euonymus alatus	Burning bush	46	0.13
Lonicera morrowii	Bush honeysuckle	19	0.09
Lythrum salicaria	Purple loosestrife	8	0.08
Microstegium vimineum	Japanese stiltgrass	150	4.88
Phalaris arundinacea	Reed canarygrass	48	4.35
Phragmites australis	Common reed	1	0.01
Rhamnus cathartica	Common buckthorn	5	0.13
Rhamnus frangula	Glossy buckthorn	44	0.74
Rosa multiflora	Multiflora rose	106	2.07
Rubus phoenicolasius	Wineberry	2	0.04
	Subtotal	**1,222**	**26.99**
Non-target Species			
Catalpa speciosa	Catalpa	2	0.004
Hieracium aurantiacum	Orange hawkweed	29	0.06
Leucanthemum vulgare	Oxeye daisy	89	0.11
Linaria vulgaris	Yellow toadflax	2	0.07
Melilotus officinalis	Yellow sweetclover	1	0.0005
Potentilla recta	Sulfur cinquefoil	2	0.00005
Pueraria montana	Kudzu	1	0.20
Robinia pseudoacacia	Black locust	5	0.23
	Subtotal	**131**	**0.67**
	TOTAL	**1,353**	**27.66**

Table 6 **The number of populations and acres infested of targeted and non-targeted invasive non-native plant species detected within inventoried areas of the Salmon River Division of Silvio O. Conte National Fish and Wildlife Refuge, August 2 - 18, 2011.**

Species	Common name	# Features	Acres Infested
Refuge Lands			
Alliaria petiolata	Garlic mustard	3	0.07
Berberis thunbergii	Japanese barberry	110	0.90
Celastrus obiculatus	Oriental bittersweet	41	1.00
Euonymus alatus	Burning bush	16	0.04
Lythrum salicaria	Purple loosestrife	1	0.02
Microstegium vimineum	Japanese stiltgrass	26	1.11
Rosa multiflora	Multiflora rose	15	0.18
Non-target species:*			
Ailanthus altissima	Tree of heaven	1	0.003
Linaria vulgare	Yellow toadflax	1	0.07
	Subtotal	**214**	**3.41**
Partner Lands			
Alliaria petiolata	Garlic mustard	3	0.02
Berberis thunbergii	Japanese barberry	262	3.70
Celastrus obiculatus	Oriental bittersweet	123	1.47
Cynanchum rossicum	Pale swallowwort	2	0.50
Euonymus alatus	Burning bush	18	0.05
Lonicera morrowii	Bush honeysuckle	16	0.08
Lythrum salicaria	Purple loosestrife	5	0.06
Microstegium vimineum	Japanese stiltgrass	124	3.77
Rose multiflora	Multiflora rose	89	1.65
Phalaris arundinacea	Phragmites	7	2.69
Non-target species:*			
Ailanthus altissima	Tree of heaven	15	0.13
Arctium minus	Burdock	2	0.01
Cirsium vulgare	Bull thistle	5	0.02

Species	Common name	# Features	Acres Infested
Elaeagnus umbellate	Autumn olive	2	0.01
Linaria vulgare	Yellow toadflax	1	0.003
Pueraria Montana	Kudzu	1	0.02
Rubus phoenicolasius	Wineberry	2	0.04
	Subtotal	**677**	**14.39**
	TOTAL	**891**	**17.79**

* Non-target species are nonnative species that were noted by the survey crew to be present but were not targeted for this inventory.

Table 7 The number of populations and acres infested of targeted and non-targeted invasive non-native plant species detected within inventoried areas of the Mohawk River Division of Silvio O. Conte National Fish and Wildlife Refuge, August 2 - 18, 2011

Species	Common name	# Features	Acres Infested
Elaeagnus umbellata	Autumn olive	6	0.003
Lythrum salicaria	Purple loosestrife	2	0.001
Phalaris arundinacea	Reed canarygrass	41	1.66
Rhamnus frangula	Glossy buckthorn	2	0.005
	Subtotal	**51**	**1.669**
Non-target Species:			
Arctium minus	Burdock	3	0.0007
Cirsium arvense	Canada thistle	14	0.91
Cirsium vulgare	Bull thistle	3	0.0007
Convolvulus arvensis	Field bindweed	2	0.01
Hieracium aurantiacum	Orange hawkweed	29	0.06
Leucanthemum vulgare	Oxeye daisy	89	0.11
Melilotus officinalis	Yellow sweetclover	1	0.0005
Phragmites australis	Common reed	1	0.01
Potentilla recta	Sulfur cinquefoil	2	0.00005
	Subtotal	**144**	**1.102**
	TOTAL	**195**	**2.77**

Table 8 **The number of populations and acres infested of targeted and non-targeted invasive non-native plant species detected within inventoried areas of the Fort River Division of Silvio O. Conte National Fish and Wildlife Refuge, August 2 - 18, 2011.**

Species	Common name	# Features	Acres Infested
Alliaria petiolata	Garlic mustard	8	0.16
Berberis thunbergii	Japanese barberry	52	0.52
Celastrus obiculatus	Oriental bittersweet	118	4.60
Elaeagnus umbellata	Autumn olive	14	0.38
Euonymus alatus	Burning bush	12	0.04
Lonicera morrowii	Bush honeysuckle	3	0.01
Rhamnus cathartica	Common buckthorn	5	0.13
Rhamnus frangula	Glossy buckthorn	42	0.73
Rosa multiflora	Multiflora rose	2	0.24
	Subtotal	**256**	**6.81**
Non-target Species:			
Ailanthus altissima	Tree of heaven	2	0.04
Catalpa speciosa	Catalpa	2	0.004
Cirsium vulgare	Bull thistle	2	0.02
Robinia pseudoacacia	Black locust	5	0.23
	Subtotal	**11**	**0.29**
	TOTAL	**267**	**7.10**

Table 9. Species and infestation canopy cover classes within the Salmon River Division and partner lands at Silvio O. Conte National Fish and Wildlife Refuge, August 2 – 18, 2011.

Scientific Name	Common Name	Total Infestations	Canopy Cover Class Number of Infestations				
			<1%	1-10%	10-25%	25-60%	>60%
Refuge lands							
Alliaria petiolata	Garlic mustard	3	0	0	2	1	0
Berberis thunbergii	Japanese barberry	110	2	45	22	36	5
Celastrus obiculatus	Oriental bittersweet	41	1	8	7	24	1
Euonymus alatus	Burning bush	16	0	6	0	10	0
Lythrum salicaria	Purple loosestrife	1	0	1	0	0	0
Microstegium vimineum	Japanese stiltgrass	26	2	2	9	8	5
Rosa multiflora	Multiflora rose	15	2	11	2	0	0
Non-target species:							
Ailanthus altissima	Tree of heaven	1	0	0	0	1	0
Linaria vulgare	Yellow toadflax	1	0	0	1	0	0
	Subtotal	**214**	**7**	**73**	**43**	**80**	**11**
Partner Lands							
Alliaria petiolata	Garlic mustard	3	2	0	1	0	0
Berberis thunbergii	Japanese barberry	262	7	50	89	105	11
Celastrus obiculatus	Oriental bittersweet	123	0	47	23	45	8
Cynanchum rossicum	Pale swallowwort	2	0	1	1	0	0
Euonymus alatus	Burning bush	18	0	7	3	8	0
Lonicera morrowii	Bush honeysuckle	16	0	7	5	3	1
Lythrum salicaria	Purple loosestrife	5	0	1	2	1	1
Microstegium vimineum	Japanese stiltgrass	124	2	17	10	74	21
Rose multiflora	Multiflora rose	89	1	24	21	25	18
Phalaris arundinacea	Phragmites	7	0	2	3	0	2
Non-target species:							
Ailanthus altissima	Tree of heaven	15	0	1	10	1	3
Arctium minus	Burdock	2	0	2	0	0	0
Cirsium vulgare	Bull thistle	5	0	1	2	0	2
Elaeagnus umbellate	Autumn olive	2	0	0	2	0	0
Linaria vulgare	Yellow toadflax	1	0	0	1	0	0
Pueraria Montana	Kudzu	1	0	0	0	1	0
Rubus phoenicolasius	Wineberry	2	0	0	1	1	0
	Subtotal	**677**	**12**	**160**	**174**	**264**	**67**
	Total	**891**	**19**	**233**	**217**	**344**	**78**

Table 10. Species and infestation canopy cover classes within the Mohawk River Division at Silvio O. Conte National Fish and Wildlife Refuge, August 2 – 18, 2011.

Scientific Name	Common Name	Total Infestations	Canopy Cover Classes Number of Infestations				
			<1%	1-10%	10-25%	25-60%	>60%
Elaeagnus umbellata	Autumn olive	6	2	3	1	0	0
Lythrum salicaria	Purple loosestrife	2	0	0	1	0	1
Phalaris arundinacea	Reed canarygrass	41	0	8	8	21	4
Rhamnus frangula	Glossy buckthorn	2	0	0	0	1	1
Non-target Species:							
Arctium minus	Burdock	3	0	2	0	1	0
Cirsium arvense	Canada thistle	14	1	11	1	1	0
Cirsium vulgare	Bull thistle	3	0	1	1	1	0
Convolvulus arvensis	Field bindweed	2	0	1	1	0	0
Hieracium aurantiacum	Orange hawkweed	29	0	20	5	3	1
Leucanthemum vulgare	Oxeye daisy	89	30	33	14	9	3
Melilotus officinalis	Yellow sweetclover	1	0	0	1	0	0
Phragmites australis	Common reed	1	0	0	0	1	0
Potentilla recta	Sulfur cinquefoil	2	0	0	0	0	2
	Total	**195**	**33**	**79**	**33**	**38**	**12**

Table 11. Species and infestation canopy cover classes within the Fort River Division at Silvio O. Conte National Fish and Wildlife Refuge, August 2 – 18, 2011.

Scientific Name	Common Name	Total Infestations	Canopy Cover Classes Number of Infestations				
			<1%	1-10%	10-25%	25-60%	>60%
Alliaria petiolata	Garlic mustard	8	0	1	2	1	4
Berberis thunbergii	Japanese barberry	52	0	5	6	34	7
Celastrus obiculatus	Oriental bittersweet	118	0	22	20	67	9
Elaeagnus umbellata	Autumn olive	14	0	8	2	2	2
Euonymus alatus	Burning bush	12	0	0	1	10	1
Lonicera morrowii	Bush honeysuckle	3	0	0	0	3	0
Rhamnus cathartica	Common buckthorn	5	0	3	0	2	0
Rhamnus frangula	Glossy buckthorn	42	1	11	4	25	1
Rosa multiflora	Multiflora rose	2	0	2	0	0	0
Non-target Species:							
Ailanthus altissima	Tree of heaven	2	0	0	1	0	1
Catalpa speciosa	Catalpa	2	0	1	0	1	0
Cirsium vulgare	Bull thistle	2	0	1	1	0	0
Robinia pseudoacacia	Black locust	5	0	2	1	1	1
	Total	**267**	**1**	**56**	**38**	**146**	**26**