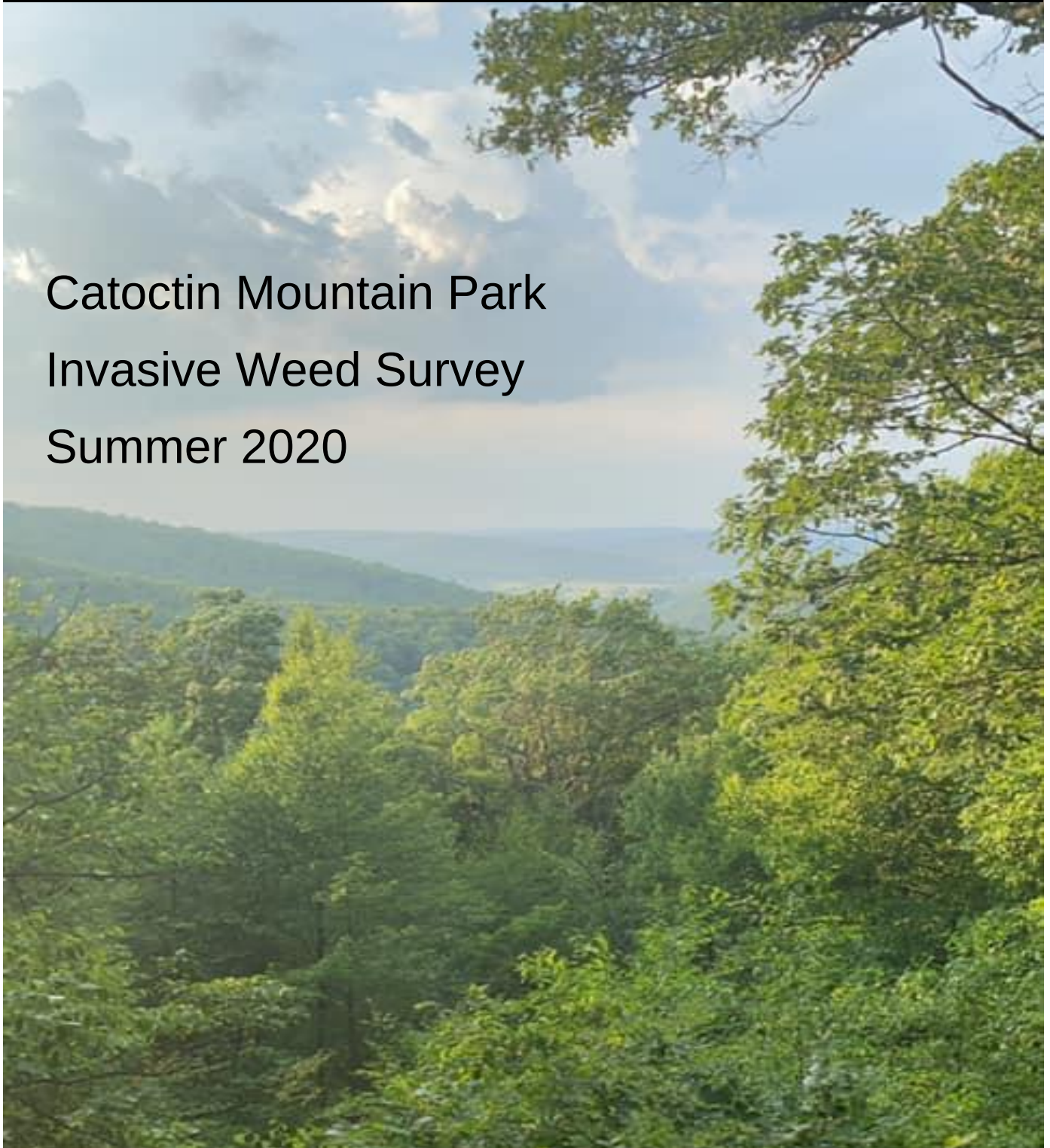




Catoctin Mountain Park Invasive Weed Survey Summer 2020



Landscape photo of Catoctin National Park from Thurmont Vista NPS. Shane Colgan

This report is available in digital format from the Urban Ecology Research Learning Alliance. To receive a copy of this report, please email ann_gallagher@nps.gov. Please cite this publication as: J. Taylor and S. Colgan 2020. UERLA Report: *Catoctin Mountain Park Invasive Weed Survey*.



Executive Summary of UERLA Report: *Catoctin Mountain Park Invasive Weed Survey*

National Parks are experiencing an increase in the prevalence of exotic invasive plant species. These Invasive plants can alter the function of natural ecosystems by outcompeting native plants. Since park managers are often limited by funding and man-hour resources, they must make decisions on what areas are most in need of attention. We have developed a technique for surveying invasive species that we believe will allow surveys to be completed quickly while also maintaining enough detail to document the locations and prevalence of target invasive plant species.

The survey was intended as a pilot study for other parks in the eastern region to follow; therefore, this report contains a detailed explanation of the methods and their justification, and a discussion section about how the techniques could be improved. Since this report was also intended to inform the decisions of the Natural Resource Management Department at Catoctin Mountain Park, we have included written descriptions of the patterns noted in the maps and through personal observation and offered management suggestions.

Methods

We designed our methods with the following goals in mind: 1) The final maps should be easy to visualize and intuitive for park managers to interpret for making management decisions. 2) The maps should contain enough detail that plant management teams can easily return to the locations of the target invasive species for removal. 3) The survey technique should minimize the use of manhour resources by narrowing the scope and level of detail where possible. 4) The survey should be completable by two interns over a period of 12 weeks.

Species that were ubiquitous or that park managers had no plans of treating were excluded:

<i>Microstegium vimineum</i> (Japanese Stiltgrass)	<i>Chelidonium majus</i> (Greater Celandine)	<i>Glechoma hederacea</i> (Ground Ivy)
<i>Rumex crispus</i> (Curly Dock)	<i>Epipactis helleborine</i> (Broadleaf Helleborine)	<i>Linaria vulgaris</i> (Yellow Toadflax)
<i>Verbascum thapsus</i> (Common Mullein)	<i>Polygonum Sachalinensis</i> (Giant Knotweed)	<i>Mollugo verticillata</i> (Carpetweed)
<i>Perilla frutescens</i> (Beefsteak Plant)	<i>Phalaris arundinacea</i> (reed canarygrass)	<i>Setaria faberi</i> (Chinese foxtail)
<i>Persicaria cespitosa</i> (Oriental Lady's Thumb)	<i>Prunus avium</i> (bird cherry)	<i>Taraxacum officinale</i> (Dandelion)
<i>Arthraxon hispidus</i> (Small Carpetgrass)	<i>Wisteria sinensis</i> (Chinese Wisteria)	<i>Ficaria verna</i> (Fig Buttercup)

Focused on recording the following species that were determined by park resource staff to be of high concern:

<i>Ailanthus altissima</i> (Tree-of-Heaven)	<i>Cirsium arvensis</i> (Canada Thistle)	<i>Persicaria perfoliata</i> (Mile-a-Minute)
<i>Aralia elata</i> (Japanese Angelica Tree)	<i>Berberis thunbergii</i> (Japanese Barberry)	<i>Rosa multiflora</i> (Multiflowered Rose)
<i>Elaeagnus umbellata</i> (Autumn Olive)	<i>Celastrus orbiculatus</i> (Oriental Bittersweet)	<i>Rubus phoenicolasius</i> (Wine Raspberry)
<i>Oplismenus hirtellus</i> (Wavyleaf Basketgrass)	<i>Lonicera japonica</i> (Japanese Honeysuckle)	<i>Lonicera mackii/ tatarica/ standishii/ corniculatus</i> (collectively recorded as Bush Honeysuckles)
<i>Alliaria petiolata</i> (Garlic Mustard)		

Surveyors were on the lookout for these species during the survey but did not note any in the park:

<i>Ampelopsis brevipedunculata</i> (Porcelain Berry),	<i>Cynanchum louiseae</i> (Black Swallowwort)	<i>Morus alba</i> (White Mulberry)
	<i>Euonymus fortunei</i> (Winter Creeper)	<i>Rhodotypos scandens</i> (Jetbead)
		<i>Humulus japonicus</i> (Japanese Hops)

Species that were not on our original target list that we ended up recording anyway, since they were few in number and therefore easy to record and potentially easy to eradicate, or because they dominated certain areas enough to draw concern:

<i>Cirsium vulgare</i> (Bull Thistle)	<i>Paulownia tomentosa</i> (Princess Tree)	<i>Acer ginnala</i> (Amur Maple)
<i>Acer platanoides</i> (Norway Maple)	<i>Securigera varia</i> (Crownvetch)	<i>Buxus microphylla</i> (Small-leaf Boxwood)
<i>Aesculus flava</i> (Yellow Buckeye)	<i>Spiraea japonica</i> (Japanese Spiraea)	
<i>Euonymus alatus</i> (Burning Bush)	<i>Vinca minor/major</i> (Periwinkle)	

Survey Equipment:

- Preferred: Trimble R1 GNSS Receiver unit connected to a sensor which was placed at the top of a baseball hat connected to the Apple iPad via Bluetooth - provide up to 1-foot accuracy and needed almost no standstill time

- Not Preferred: Bad Elf GNSS surveyor unit connected to the Apple iPad via Bluetooth - required a standstill of up to one minute or more in densely forested areas, and rarely achieved accuracy below 10 feet at Catoctin Mountain Park.

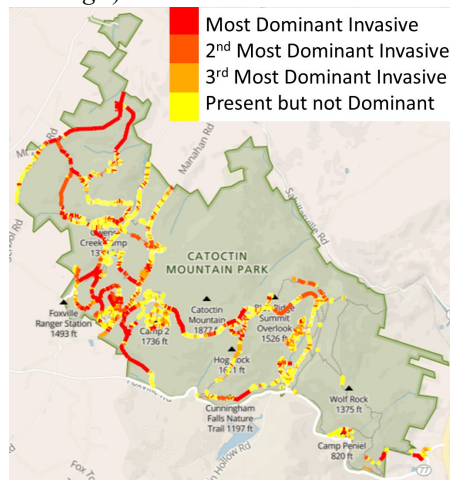
Survey Protocol:

The location of invasive plants was documented by placing either a point or line or polygon where species are found. At each location capture the relative abundance of the invasive species using a drop-down menu.

Results

Using ArcMap Desktop map for each species, that displayed the lines and polygons where that species was present, we created heatmaps which can be found on the NPS ArcGIS Online server.

Example: Japanese Barberry (*Berberis thunbergii*)



Recommendations (Discussion)

1. The prevalence of invasive species at Catoctin Mountain Park is severe enough that the manhour resources currently available to invasive plant mitigation are not sufficient to make headway against all invasive species in all areas of the park.
2. Highest priority should be given to the uncommon invasive species that are only beginning to invade the park especially for species that have been noted as pernicious at other parks.
 - a. Wavyleaf Basketgrass was only observed at Camp Misty Mount was removed by hand by a team of four within less than an hour
 - b. Princess Tree was similarly found only at one location on the trail east of the visitor's center where one mature tree was producing a progeny of small seedlings.
 - c. Amur maple, found at that same location
3. The park could track eradication by listing of plants for eradication. The list could be small enough that all known individuals could be treated in a single year allowing for follow up the following year to ensure that treatment is effective and could start with:

a. Tree-of-Heaven	d. Norway Maple	g. Crown Vetch
b. Japanese Angelica Tree	e. Periwinkle	h. Burning Bush
c. Bush Clover	f. Japanese Spiraea	
4. Next highest priority would be the most pernicious shrubby species: Barberry and Multiflora Rose. We suggest designating a target area small enough . to treat in a single year and then growing that target area outward each year.
5. Oriental Bittersweet and Japanese Honeysuckle tend to do well growing amongst shrubby invasives and native vines especially in areas dominated by Multiflora Rose. We suspect that these invasive vines could be reduced in number by removing the primary shrubby invasives.
6. Mile-a-Minute and Garlic Mustard formed large monocultures in more open areas. Therefore planting native plants following the spraying of herbicide may be effective by competing for understory space.
7. Garlic Mustard has been treated for years in the park. New approaches might be required. We propose experimenting with techniques.

8. Bull Thistle and Canada Thistle, only, showed up along roadsides and developed areas possibly because they need access to full sun to survive. We do not feel that any particular focus needs to be placed on mitigating these shade intolerant species since it seems unlikely that they will become invaders deeper into established forests.
9. We suggest planting trees to restore the forest cover in the open spaces may be an effective means of reducing the prevalence of almost all invasives. Invasives appear to do better when tree cover is missing.

Future survey suggestions:

1. Our survey protocols efficiently and accurately captured most woody species, and any species that are large in size, have distinct boundaries, and are discernable at a distance. It worked less well for forbs and grasses, especially those that are too small, exist in high numbers, are difficult to see at a distance, grow underneath other plants, and have indistinct boundaries at the edge of patches. We recommend subsampling areas throughout the park at given intervals to make the forbs survey more manageable.
2. The invasion intensity of garlic mustard, thistle species, and crown vetch is significantly higher in reality than it appears on our map.
3. We recommend quick surveys at the park become a regular event to identify new patches of infrequent invaders to stop new species from entering the park.
4. More intensive studies like our own could be conducted every 5-10 years to monitor the spread of the invaders already present.
5. Twelve weeks with two surveyors, can survey near campgrounds, roads, and trails which left areas away from human development unsurveyed.
6. Maintaining a contact with ESRI support would help with troubleshooting technological issues.
7. Future studies could incorporate analyses of species in reference to soil type, moisture content, elevation, slope and other factors to determine possible reasons why certain plants are more successful in certain areas than others.
8. A base station located in the park could potentially make the survey run faster, allowing more time to access other areas of the park and increase accuracy.

Introduction

Many National Parks are experiencing an increase in the prevalence of exotic invasive plant species. These invasive plants can alter the function of natural ecosystems by outcompeting native plants. This often leads to a reduction in biodiversity and can threaten rare and endangered species. Invasives usually provide poor forage and habitat space for native wildlife and can cause pest species such as ticks to increase. Since many native trees struggle to establish under invasive plant cover the prevalence of invasives may lead to forest decline as old trees die and are not replaced by young saplings. For these reasons the park service often uses mitigation efforts such as herbicides or mechanical removal to reduce, or optimally, eradicate invasive plants. These mitigation efforts can be daunting since parks cover large tracts of land that can be heavily invaded. Since park managers are often limited by funding and man-hour resources, they must make decisions on what areas are most in need of attention. These decisions can be difficult to make since the location and prevalence of invasives is often unknown. Surveys can be conducted to monitor the spread of invasives and create maps that inform park managers so they can make better decisions about how to direct mitigation efforts. However these surveys require an additional input of man-hour resources that can be expensive and time consuming. We have developed a technique for surveying invasive species that we believe will allow surveys to be completed quickly while also maintaining enough detail to document the locations and prevalence of target invasive plant species.

The technique was implemented at Catoclin Mountain Park in the summer of 2020 to map the current distribution of invasive plants along the park's trails, roads, and developed areas. The survey was intended as a pilot study for other parks in the eastern region to follow; therefore, this report contains a detailed explanation of the methods and their justification, and a discussion section about how the techniques could be improved. The maps created from the survey can be seen in the results section. Since this report was also intended to inform the decisions of the Natural Resource Management Department at Catoclin Mountain Park, we have included written descriptions of the patterns noted in the maps and through personal observation and offered management suggestions. We are confident that this report will be beneficial in planning the management of invasive plants at Catoclin Mountain Park, and that the use of the techniques described will be beneficial to national park managers as they plan their own efforts to evaluate the state of invasives within their respective parks.

Methods

We designed our methods with the following goals in mind: 1) The final maps should be easy to visualize and intuitive for park managers to interpret for making management decisions. 2) The maps should contain enough detail that plant management teams can easily return to the locations of the target invasive species for removal. 3) The survey technique should minimize the use of manhour resources by narrowing the scope and level of detail where possible. 4)The survey should be completable by two interns over a period of 12 weeks.

Location

The first step was to determine which areas of Catoclin Mountain Park we were going to survey. The park covers 5,770 acres, an area too large to survey completely in any detail. For this reason we chose to limit the scope of our efforts to the following areas of concern: trailsides, roadsides, and near developed areas such as buildings, parking lots, and campgrounds. We felt that focusing on these areas was appropriate since the conventional wisdom indicated that invasives tend to be the most dense and diverse in areas where humans have disturbed the soil. Humans are often a vector for new species of invasive plants to enter a landscape through the accidental dispersal of seeds attached to shoes, clothing, and vehicles, therefore early detection and eradication of new invaders should be accomplished

by surveying the areas where these new invaders are most likely to appear. Additionally these areas are what park guests see, making them of the highest priority to maintain in their natural condition for the enjoyment of future generations.

Plant Species

Catoctin Mountain Park contains 30+ species of invasive plants. Given the amount of manhour resources available to the project we felt it appropriate to reduce the scope of the survey to the invasive species of highest concern. The survey team consulted closely with park managers to compile a list of target species while omitting species that were ubiquitous or that park managers had no plans of treating. For example, *Microstegium vimineum* (Japanese Stiltgrass) was not included in the survey since a previous survey conducted in 2003 indicated that it was already prevalent throughout all corners of the park and eradication and management was no longer considered feasible. Recording it would have been time consuming and not of significant utility.

Other plants were not included in the scope of the survey because they have been present in the park for a number of years and do not appear to be spreading, dominating any one area, nor causing significant ecological damage. These low-priority exotic plants include: *Rumex crispus* (Curly Dock), *Verbascum thapsus* (Common Mullein), *Perilla frutescens* (Beefsteak Plant), *Persicaria cespitosa* (Oriental Lady's Thumb), *Arthraxon hispidus* (Small Carpetgrass), *Chelidonium majus* (Greater Celandine), *Epipactis helleborine* (Broadleaf Helleborine), *Polygonum Sachalinensis* (Giant Knotweed), *Phalaris arundinacea* (reed canarygrass), *Prunus avium* (bird cherry), *Wisteria sinensis* (Chinese Wisteria), *Glechoma hederacea* (Ground Ivy), *Linaria vulgaris* (Yellow Toadflax), *Mollugo verticillata* (Carpetweed), *Setaria faberi* (Chinese foxtail), *Taraxacum officinale* (Dandelion), and *Ficaria verna* (Fig Buttercup).

By omitting the species of low concern we were able to focus our time on recording the following species that were determined by park resource staff to be of high concern: *Ailanthus altissima* (Tree-of-Heaven), *Aralia elata* (Japanese Angelica Tree), *Elaeagnus umbellata* (Autumn Olive), *Oplismenus hirtellus* (Wavyleaf Basketgrass), *Alliaria petiolata* (Garlic Mustard), *Cirsium arvensis* (Canada Thistle), *Berberis thunbergii* (Japanese Barberry), *Celastrus orbiculatus* (Oriental Bittersweet), *Lonicera japonica* (Japanese Honeysuckle), *Lonicera maackii/ tatarica/ standishii/ corniculatus* (collectively recorded as Bush Honeysuckles), *Persicaria perfoliata* (Mile-a-Minute), *Rosa multiflora* (Multiflowered Rose), and *Rubus phoenicolasius* (Wine Raspberry). These species were already known to be in the park, and were either observed to be pernicious here at Catoctin or had seriously invaded other parks in the region

Surveyors were trained by park resource staff on the identification of pernicious weed species that had not yet been observed in the park. Surveyors were on the lookout for these species during the survey but did not note any in the park: *Ampelopsis brevipedunculata* (Porcelain Berry), *Cynanchum louiseae* (Black Swallow-wort), *Euonymus fortunei* (Winter Creeper), *Morus alba* (White Mulberry), *Rhodotypos scandens* (Jetbead), and *Humulus japonicus* (Japanese Hops).

There were a number of species that were not on our original target list that we ended up recording anyway, since they were few in number and therefore easy to record and potentially easy to eradicate, or because they dominated certain areas enough to draw concern: *Cirsium vulgare* (Bull Thistle), *Acer platanoides* (Norway Maple), *Aesculus flava* (Yellow Buckeye), *Euonymus alatus* (Burning Bush), *Paulownia tomentosa* (Princess Tree), *Securigera varia* (Crownvetch), *Spiraea japonica* (Japanese Spiraea), *Vinca minor/major* (Periwinkle), *Acer ginnala* (Amur Maple), and *Buxus microphylla* (Small-leaf Boxwood).

Survey Equipment

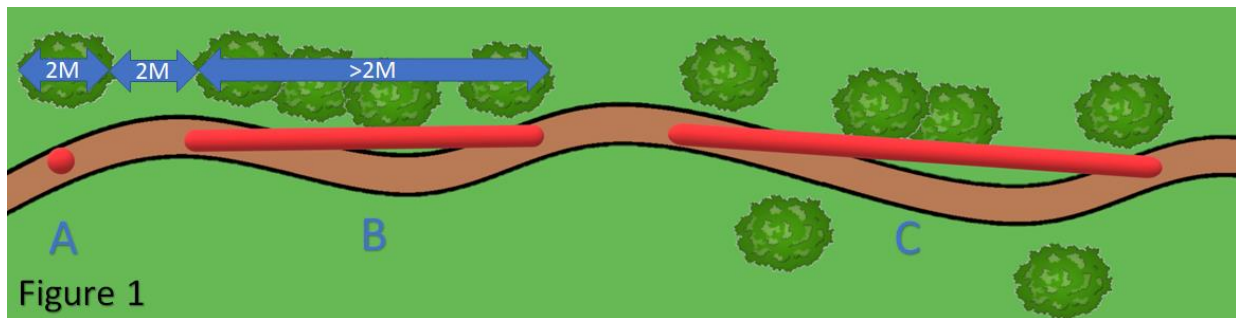
Invasive plant locations were recorded as vector points, lines, and polygons within the mobile geographic information system (GIS) application Collector by ESRI using an iPad tablet. To maximize accuracy, the tablet was connected via Bluetooth to a global navigation satellite system (GNSS). The vector shapes were regularly backed up and synced to an ArcGIS Online account where they were saved to the cloud and accessible for editing and sharing.

At the beginning of the survey a Bad Elf GNSS surveyor unit was used in connection with the Apple iPad via Bluetooth. The Bad Elf provides real-time 1-meter accuracy and is particularly useful for mapping, agriculture, and other surveying activities. An advantage to using the Bad Elf is a battery life of up to 35 hours. However, the Bad Elf required a standstill of up to one minute or more in densely forested areas, and rarely achieved accuracy below 10 feet at Catoctin Mountain Park. Therefore early on in the survey we decided to explore other options for a GPS device with less standstill time and improved accuracy. We recommend the Bad Elf device only for surveys of areas with flat topography and low tree cover.

The second GPS device at our location was the Trimble R1 GNSS Receiver unit. It was most effective. This particular device was connected to a sensor which was placed at the top of a baseball hat. This device was able to provide up to 1 foot accuracy and needed almost no standstill time at all. This allowed the survey to be conducted at a much faster pace with much greater accuracy than the Bad Elf. The Trimble unit was connected to the Apple iPad via Bluetooth in the same manner as the Bad Elf unit. An issue we encountered with the Trimble R1 unit, in the beginning, was the interface to control the device which consisted of only one button for all commands. We found this interface difficult to learn and the instruction manual non-intuitive. For this reason we have included in the appendix of this report a how-to guide for the Trimble R1. Similar Guides can be found in the appendix for Collector and ArcGIS Online.

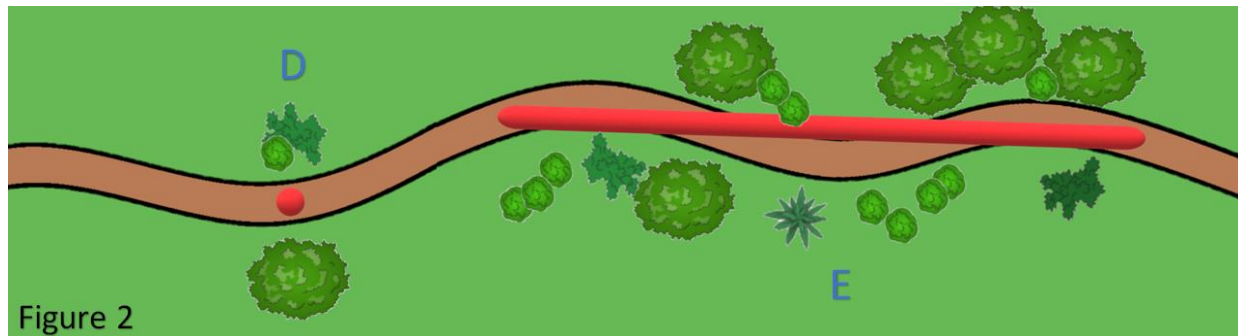
Survey Protocol: Trailsides

The location of invasive plants near trails was documented by placing either a point or line along the trail using the iPad/GPS unit and Collector. If a small patch of invasive plants was found, it was marked with a single point (see region A of figure 1). Points were used only if the patch of invasive plants occupies a space along the trail that is less than 2 meters wide. To maximize survey speed if the patch was longer than 2 meters it was marked instead with a line rather than marking each individual plant (see region B of figure 1).

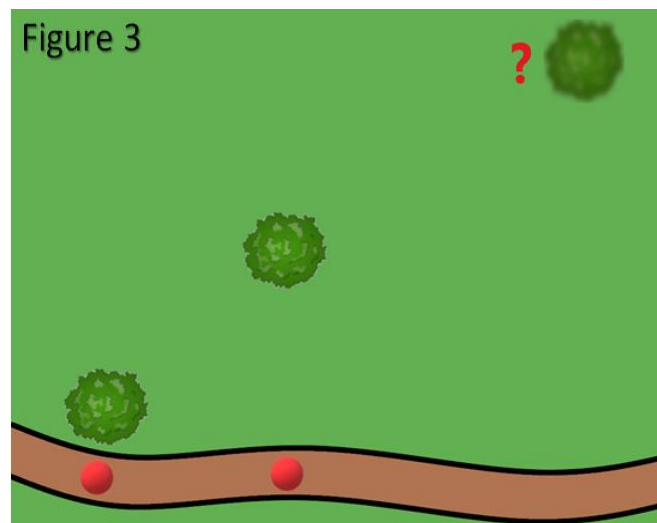


If a patch contained gaps between plants that were all smaller than 2 meters wide the plants were considered a single patch and were marked with a single continuous line. If the gaps between plants were greater than 2 meters the patches were considered separate and were marked with separate lines or points. In areas where invasive plants occupy both sides of the trail they were considered a single patch and marked with a single line so long as a plant occupied one side of the trail or the other without a gap greater than 2 meters (see region C of figure 1). This increased survey speed as we could characterize

both sides of the trail with a single pass. The invasive plants present within a patch and associated with a given point or line were recorded to a data table by filling a dropdown field in Collector.



In areas where there was more than one species of invasive plant, the methodology was similar except that a series of different species were marked as a single patch with one continuous line. The 2 meter rule continued to apply for marking small patches as dots (see region D of figure 2), and long patches as lines (See region E of figure 2). The data table was filled to record all species that were present within each patch, and also ranked each species from most dominant to least dominant based on the percent of aerial area that each species covered. For example in region D of figure 2 there are three species (species x, species y, and species z). These species occupy a space less than 2 meters wide and were therefore marked with a single point. Species x covers the greatest amount of area at that point and is therefore noted in the data table as the dominant invader. Species z covers the next highest



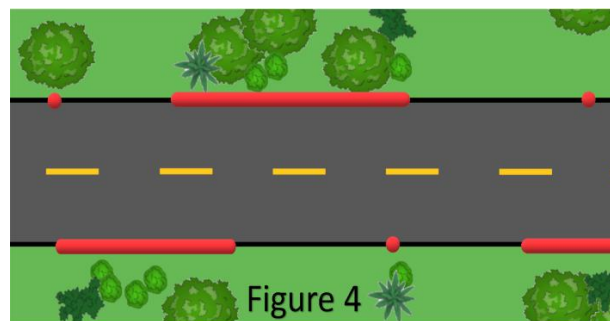
amount of area and species y covers the least; therefore, species z is recorded as the 2nd most dominant invader and species y is recorded as the 3rd most dominant invader. This ranking system was also used for lines on larger patches. In region E of figure 2 there are four invasive species of plants (x, y, z, and w), therefore there are four ranks assigned in order of dominance. In this instance species x still covers the most area and is given the 1st rank, followed by species y 2nd, then species z 3rd, and species w 4th. These rankings allow us to cover large invaded patches quickly while still recording some degree of relative invasion intensity that is easy to estimate, ocularly, without being overly affected by observer bias.

Early in the development of our protocol we had to decide how far out from the trail we were going to survey. The farther out from the trail we included the more plants we were going to find and the longer the survey would take. We originally considered a buffer distance around the trails of 10 meters but this proved to be tedious as we had to make a decision with each plant whether it was inside or outside our buffer zone, and measuring each plant's distance from the trail was too time consuming to

consider given the size and time constraints of our survey. We decided to use line of sight from the trail as our buffer distance. If we could see a plant while standing at a trail, we recorded it. This allowed us to record plants quickly without leaving the trail. Plants right at the trail edge were recorded the same as plants far from the trail with a mark over the trail itself rather than over the plant (See Figure 3). Plants that were too far away from the trail to properly identify as an invasive species at that distance were not recorded.

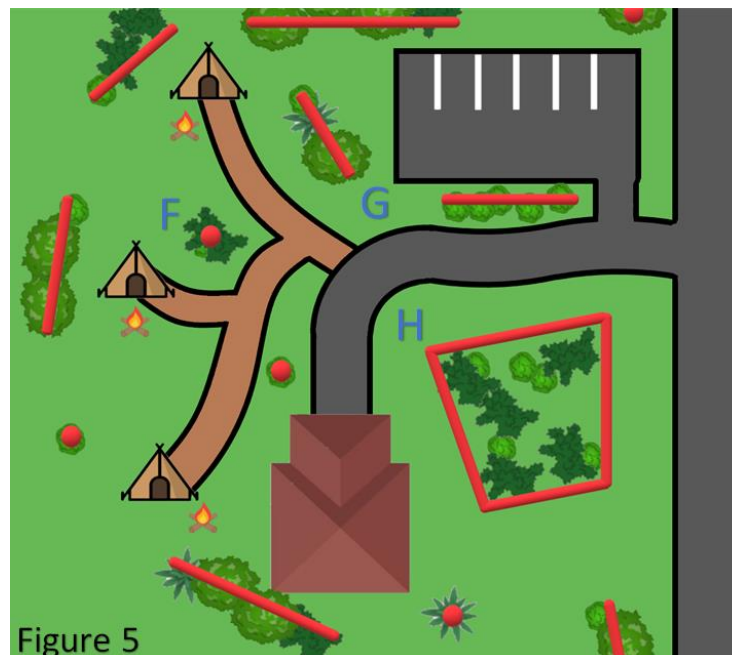
Survey Protocol: Roadside

Invaded patches along roadsides were marked in the same manner as described for trails above with the single difference being that both sides of the road were recorded independently rather than at the same time (See figure 4). Because the sides of the road are too far apart, we found it too difficult to try and survey both sides of the road with a single pass as we had done for trails. This has the added benefit that when teams go out to remove the invasives they will be able to tell which side of the road the target plant was on.



Survey Protocol: Developed Areas

Measuring invasive plants around buildings, parking lots and within campgrounds is inherently more complex than measuring invasive plants along roads and trails because the distribution of invasive plants is multidimensional, the areas are much larger, and the plant patches can have less distinct boundaries. However, we attempted to follow similar methods to that of roads and trails with the following differences.



We started by recording the invasive plants along the outside border of the developed area following the same protocol used for roadsides (see figure 5). After recording the perimeter, the internal area was combed for patches of invasive plants. Internal patches were marked by a point if they were less than 2 meters wide in all dimensions (see region F), or a line if they were longer than 2 meters wide in only one dimension (see region G). For patches of plants that were greater than 2 meters wide in both dimensions a polygon was drawn around the patch (See region H). All points, lines and polygons were georeferenced with species present and the relative dominance as was done along trails and roadsides. Similarly, gaps between plants must be greater than 2 meters in order for them to be recorded as separate patches.

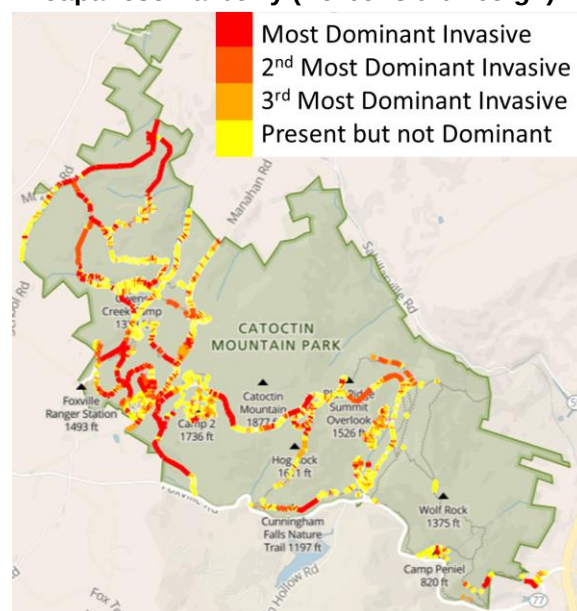
Data Processing/Map Making

All points, lines, and polygons that were captured with Collector during field surveys were uploaded to a feature layer on ArcGIS online. The data tables of this feature layer contained the information on what species were associated with each point, line, and polygon and the relative dominance of each species. Due to the sheer number of points recorded each day it was inevitable that small errors would occur in this dataset, for example a point might be missing its associated species information, or the species may have accidentally been recorded on the wrong column. For this reason, the data table on ArcGIS Online was curated after each day of fieldwork to correct these errors while the survey was fresh in our minds. Errors that could not be corrected from memory occasionally warranted returning to the field site. Regular curation allowed us to maintain an accurate dataset that was organized in a manner suitable for final processing.

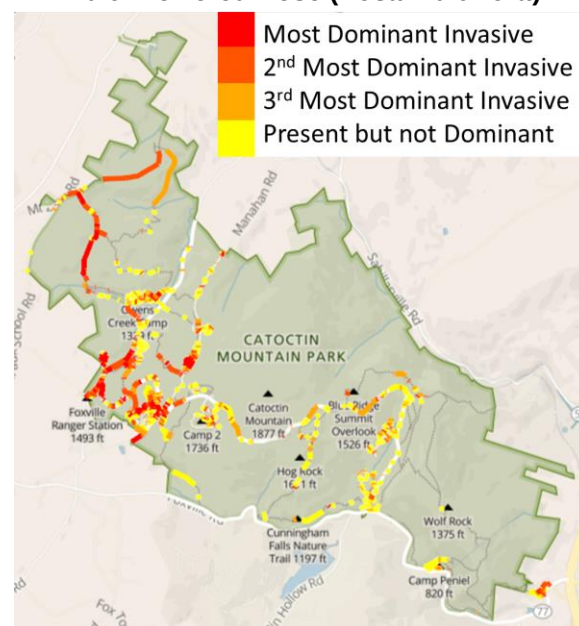
Results

Once surveys were completed the feature layer was downloaded to ArcMap Desktop to create the final maps. We created a map for each species that displayed the lines and polygons where that species was most dominant in red, 2nd most dominant in dark orange, 3rd most dominant in light orange, and all other lines, polygons, and points in yellow. This created a gradient from red to yellow showing areas where that species has taken over in red, and areas of low invasion in yellow. These maps have been uploaded to the NPS ArcGIS Online server. Most maps in this report show the full extent of the park; the online maps permit you to zoom in and see higher levels of detail for specific areas within the park.

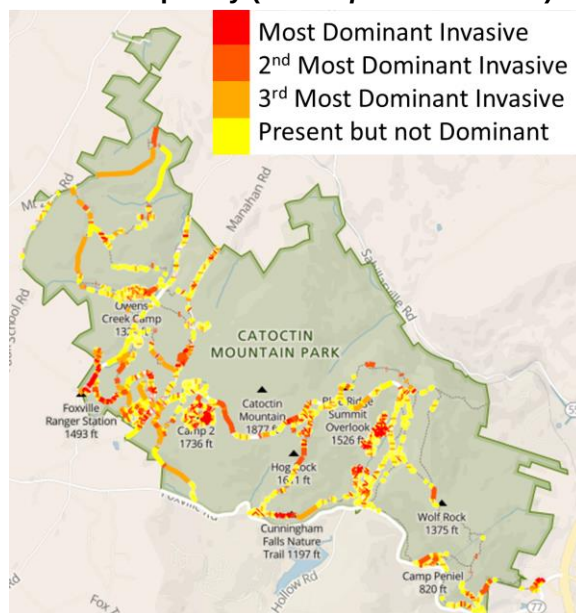
Japanese Barberry (*Berberis thunbergii*)



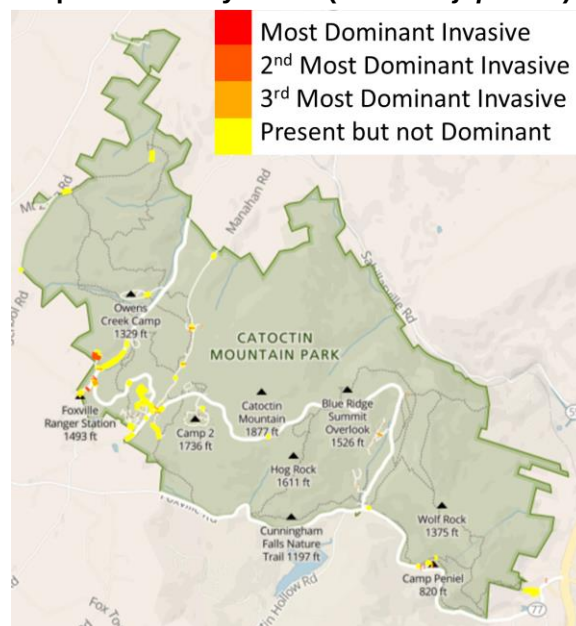
Multi Flowered Rose (*Rosa multiflora*)



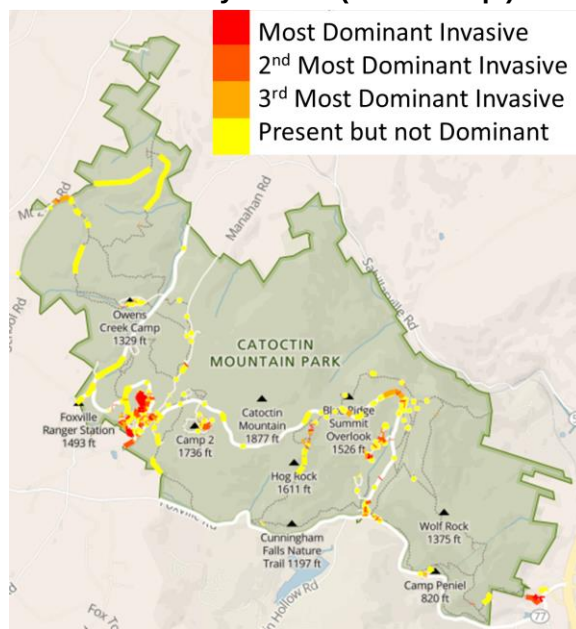
Wine Raspberry (*Rubus phoenicolasius*)



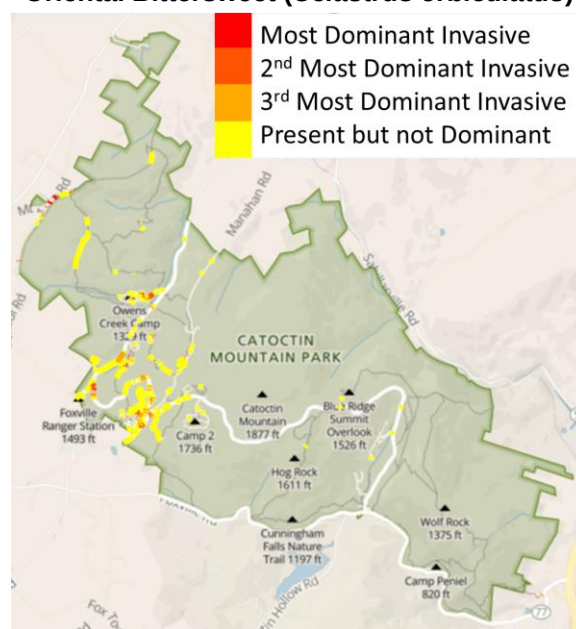
Japanese Honeysuckle (*Lonicera japonica*)



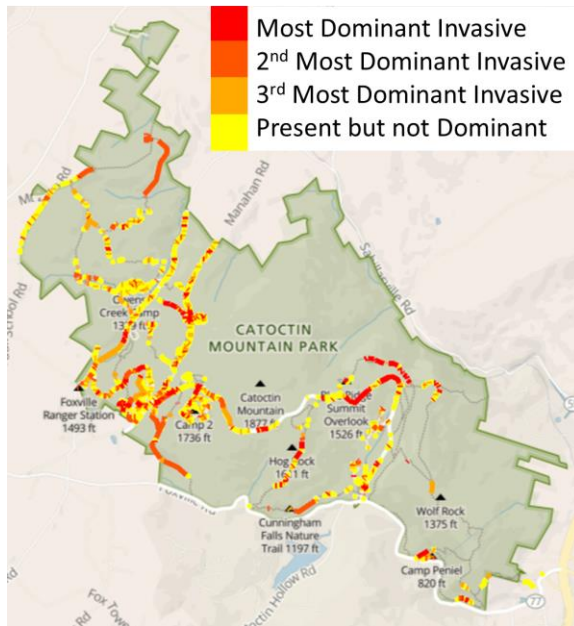
Bush Honeysuckles (*Lonicera* sp.)



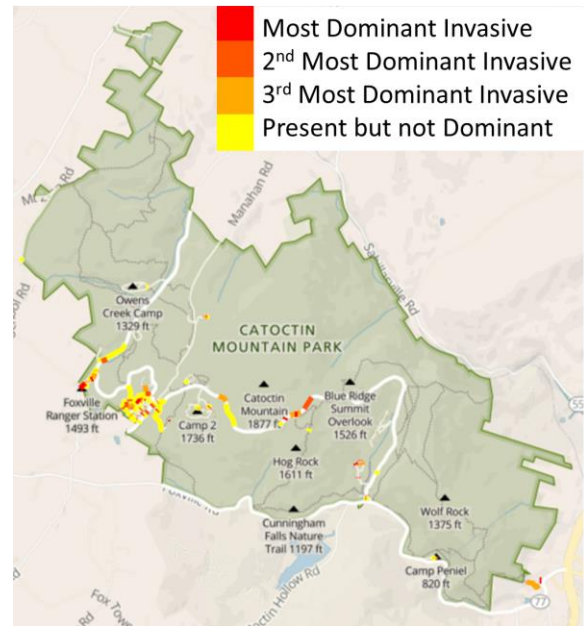
Oriental Bittersweet (*Celastrus orbiculatus*)



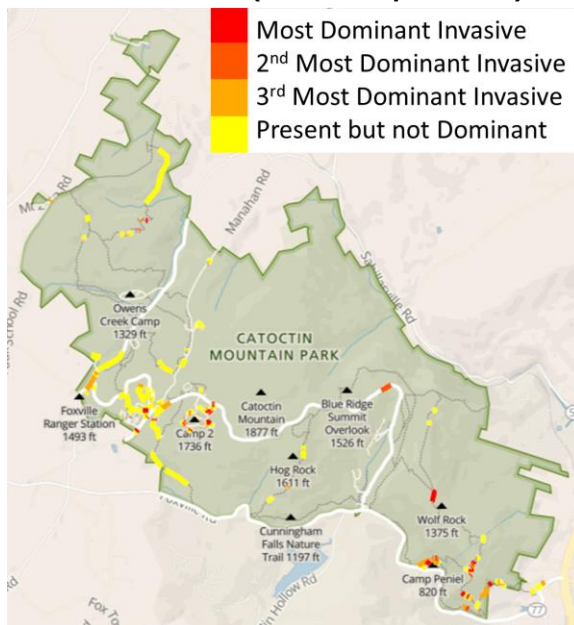
Garlic Mustard (*Alliaria petiolata*)



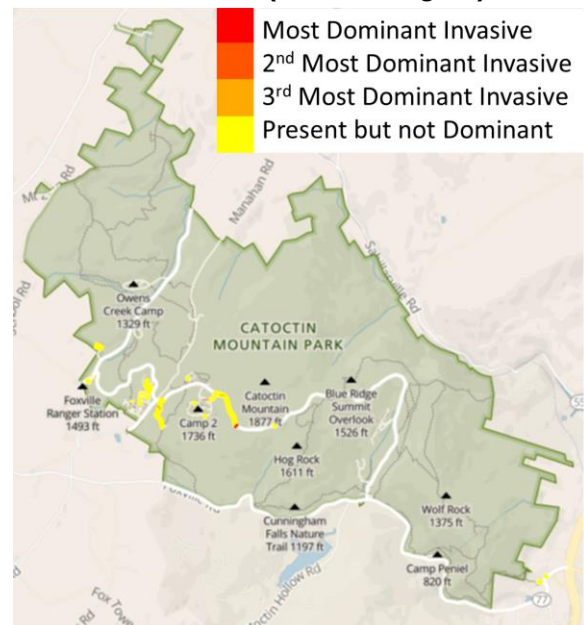
Canada Thistle (*Cirsium arvense*)



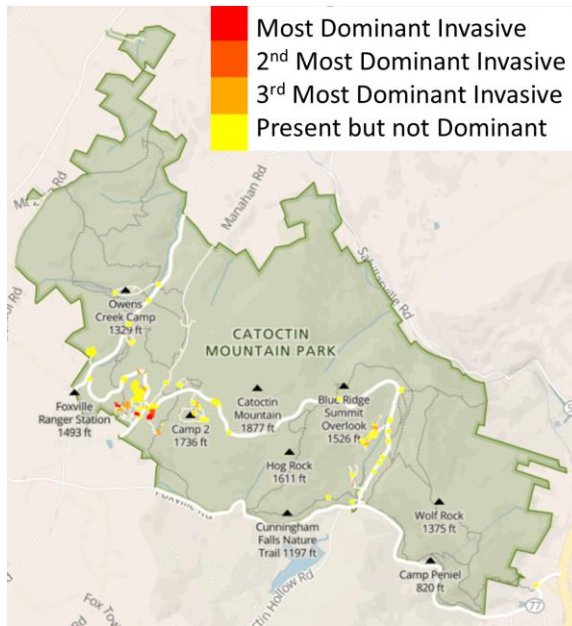
Mile-a- Minute (*Persicaria perfoliata*)



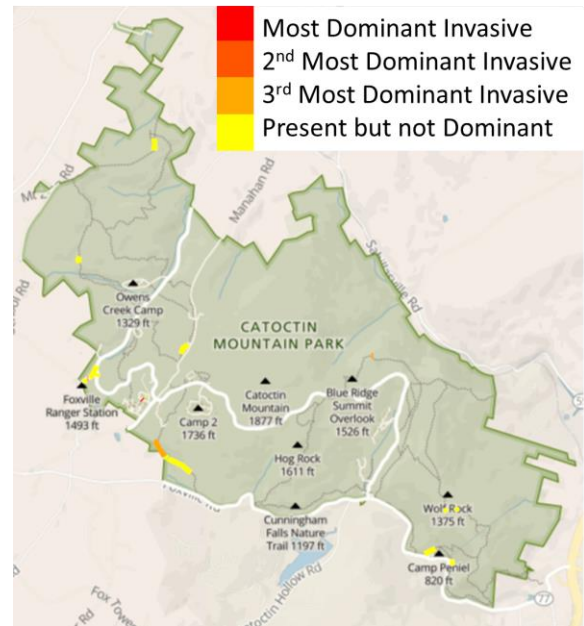
Bull Thistle (*Cirsium vulgare*)



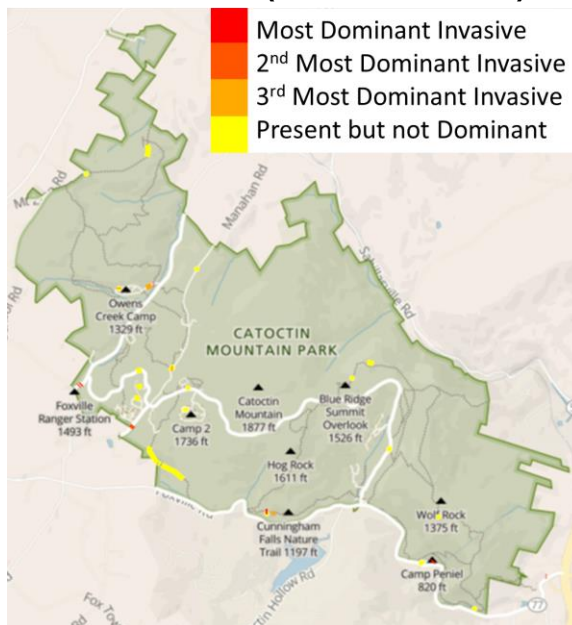
Autumn Olive (*Elaeagnus umbellata*)



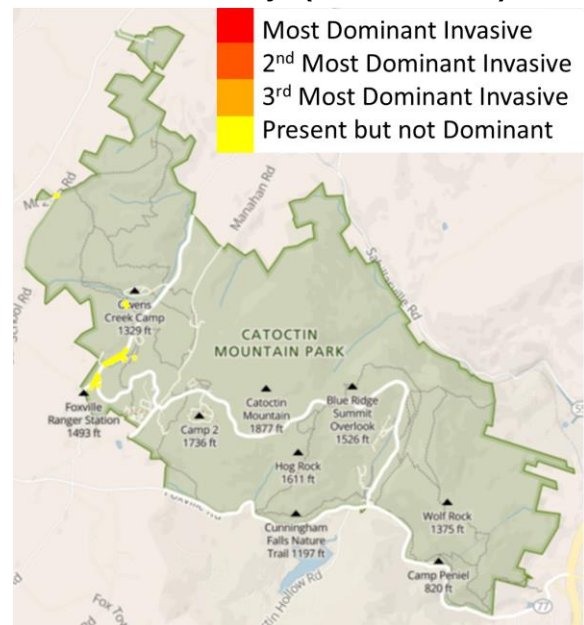
Japanese Angelica Tree (*Aralia elata*)



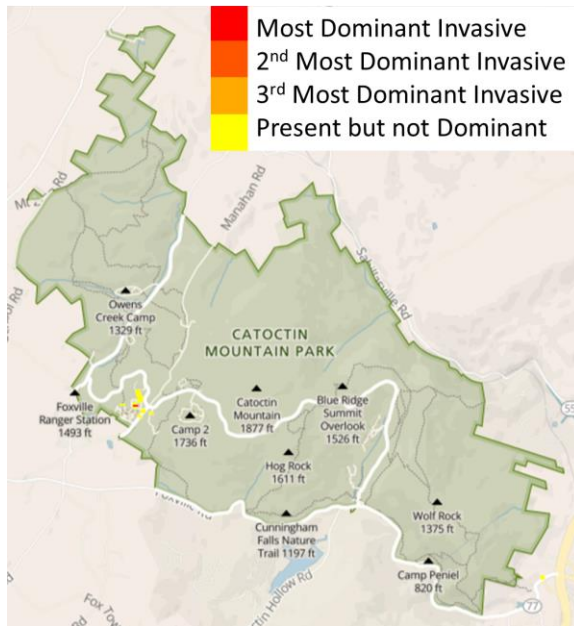
Tree-of-Heaven (*Ailanthus altissima*)



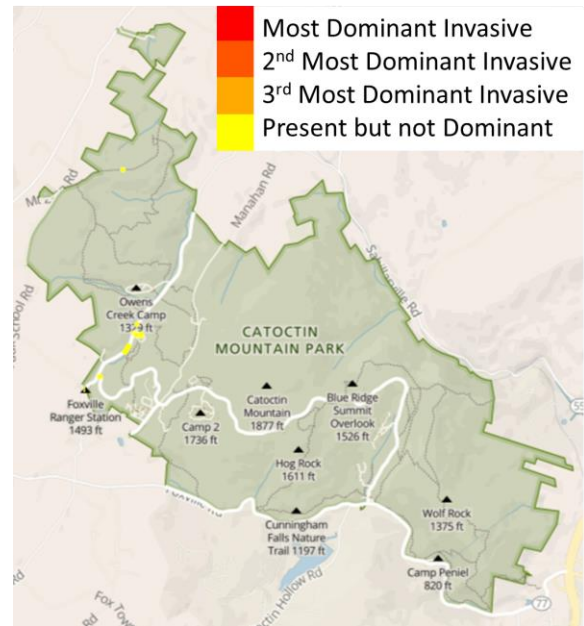
Yellow Buckeye (*Aesculus flava*)



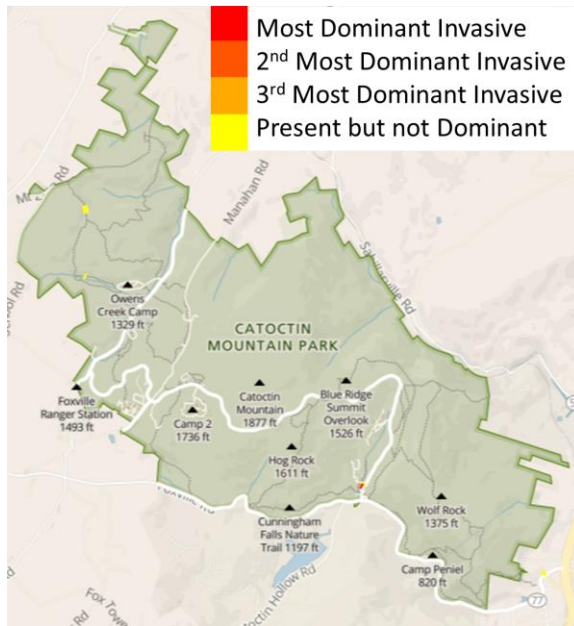
Crown Vetch (*Securigera varia*)



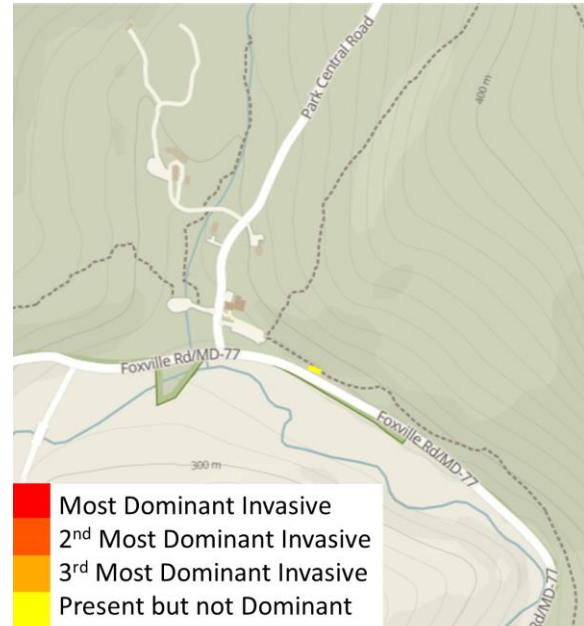
Burning Bush (*Euonymus alatus*)



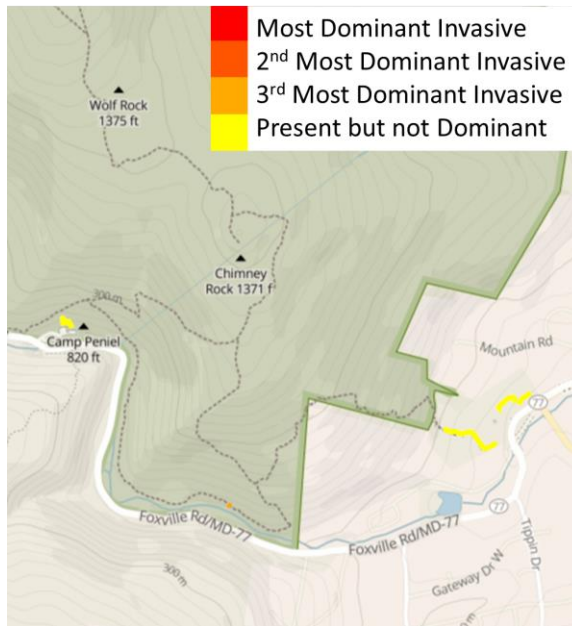
Periwinkle (*Vinca sp.*)



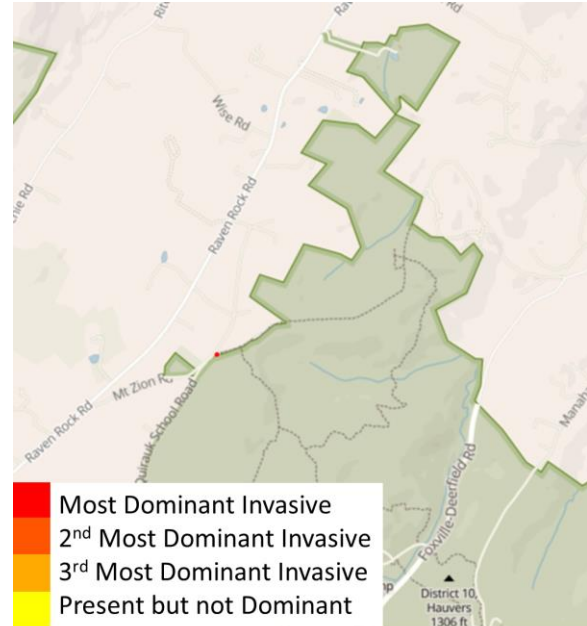
Amur Maple (*Acer ginnala*)



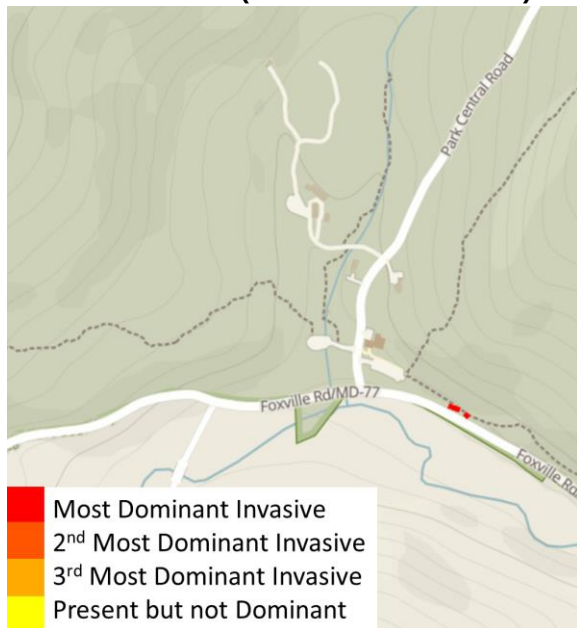
Japanese Spiraea (*Spiraea japonica*)



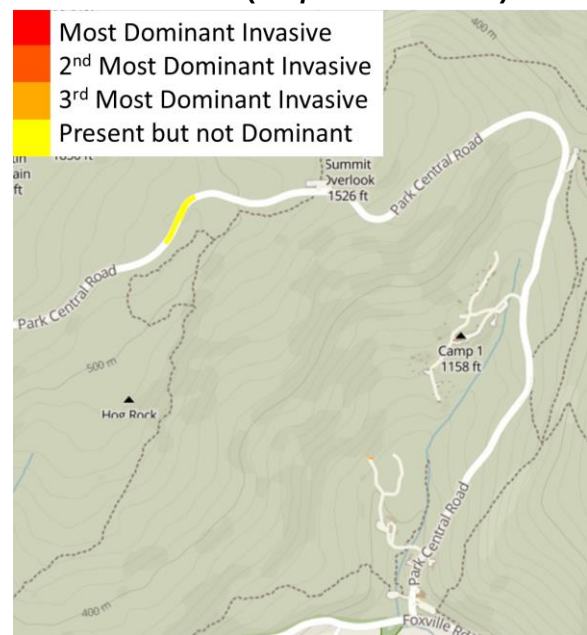
Norway Maple (*Acer platanoides*)



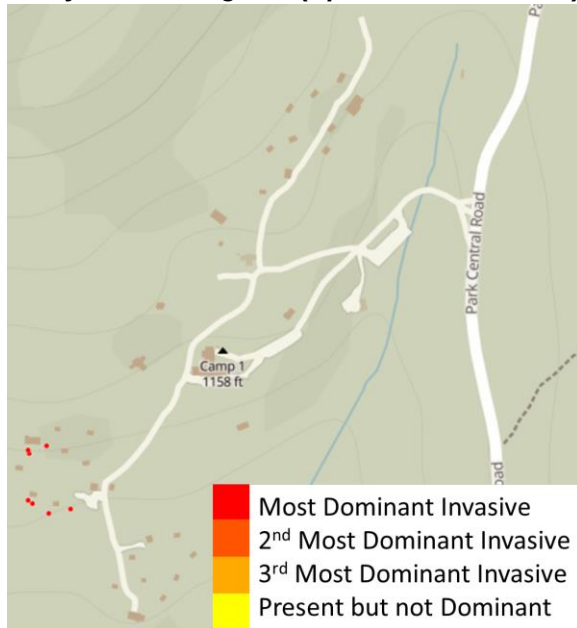
Princess Tree (*Paulownia tomentosa*)



Bushclover (*Lespedeza cuneata*)



Wavyleaf Basketgrass (*Oplismenus hirtellus*)



Discussion

Our survey maps reveal a diverse assortment of distribution patterns for the various invasive plant species found at Catoctin Mountain Park. Some invasives are uncommon or restricted to specific areas while others are found throughout the park and dominate large areas. These varying distribution patterns can be used to inform park management, so that they can make decisions that are tailored to each species. One of the first things that can be discerned from our maps is that the prevalence of invasive species at Catoctin Mountain Park is severe enough that the manhour resources currently available to invasive plant mitigation are not sufficient to make headway against all invasive species in all areas of the park. Therefore, priorities should be set to focus on the species and locations of highest concern.

We feel that the highest priority should be given to the uncommon invasive species that are only beginning to invade the park since their numbers are still small enough that eradication is feasible with minimal effort. This is especially true for species that have been noted as pernicious at other parks. For example Wavyleaf Basketgrass was only observed at Camp Misty Mount, and was removed by hand by a team of four within less than an hour. Princess Tree was similarly found only at one location on the trail east of the visitor's center where one mature tree was producing a progeny of small seedlings. Coincidentally a new invader previously unknown to the park, Amur maple, was found at that same location. Both of these species could be eradicated from the park with less than a day's worth of work. We recommend that the park resource management team maintain a list of plants that are marked for eradication. We recommend that this eradication list include the three species already mentioned as well as other species that are pernicious and few in number, such as Tree-of-Heaven and Japanese Angelica Tree, this list should be kept small enough that all known individuals can be treated in a single year, and follow up visits be conducted the following year to ensure that treatment is effective. Other species that are small enough in number to be considered for the eradication list include: Bush Clover, Norway Maple, Periwinkle, Japanese Spiraea, Crown Vetch, and Burning Bush, however many of these are not notably pernicious and could have their eradication deferred to future years at the discretion of the park resource managers. By eradicating uncommon species early the park's resource management team will minimize the number of problem species within the park and prevent the need for more intensive management of those species in the future.

Following the eradication of uncommon species we feel that the next highest priority would be to begin chipping away at the most pernicious shrubby species. One hope that we had at the beginning of this survey was that we could identify a leading edge between pristine areas and invaded areas. This leading edge could become a defensible space from which to focus mitigation efforts and move the line of invasives back each year. This technique would be advantageous since it places focus on preventing the spread of invasives into pristine areas. However, the maps of our most common invasive shrubs, Barberry and Multiflora Rose, show that the leading edge is not easily discernible because the density of these plants seems to decrease in a gradient. There is not really a line that could be drawn between invaded areas and pristine areas because the density of invaders thins out slowly across large distances. A leading edge would almost have to be created by designating a target area small enough to treat in a single year and then growing that target area outward each year. Since many of the prominent invasive shrubs grow together in and amongst each other, this enlarging target area could be used to combat all shrub species at once.

We observed that woody vines such as Oriental Bittersweet and Japanese Honeysuckle only occasionally occur alone and tend to do well growing amongst shrubby invasives and native vines. These two invaders appeared to do especially well in areas dominated by Multiflora Rose and were not frequently seen climbing native shrubs and trees where other invaders were absent. For this reason, we suspect that these invasive vines are secondary invaders and can be reduced in number by removing the primary shrubby invasives.

Mile-a-Minute and Garlic Mustard seemed to have the opposite pattern. While they were present in areas with other invasives they seemed to only dominate areas where woody species are thin or absent, oftentimes forming large monocultures in more open areas. Management of Mile-a-Minute through herbicide has been ongoing at the park for a number of years with only minimal success. New management strategies may need to be implemented to combat this species effectively. We observed that Mile-a-minute seems to do best in more open areas, therefore planting native plants following the spraying of herbicide may be effective by competing for understory space. The park has had less experience combating Garlic Mustard but given its similar propensity to invade areas with thin understory cover we feel it may react the same. It may be wise to pick a small location where Garlic Mustard is dominating and see how easy it is to defeat with herbicide, not necessarily because it is a high priority, but to gain experience in knowing how it responds to simple treatments; that way it can be determined if more integrated management techniques are needed in the future.

We noticed that the two thistle species, Bull Thistle and Canada Thistle, only showed up on our maps along roadsides and developed areas. From our anecdotal experience it seems that these species grow only where there is no longer tree cover, likely because they need access to full sun to survive. This may also be true of Crown Vetch and Bushclover although we saw these species too seldom to conclude that with the same degree of confidence. We do not feel that any particular focus needs to be placed on mitigating these shade intolerant species since it seems unlikely that they will become invaders deeper into established forests. However, planting trees to restore the forest cover in the open spaces where these invaders grow may be an effective means of reducing the prevalence of these species. In fact it seems that almost all invasives do better when tree cover is missing, therefore a management plan that places more focus on reforestation may see success greater than plans focused only on removal of invasive plants.

Future survey suggestions:

One of the purposes of this study was to serve as a pilot for future studies at Catoctin Mountain, and new survey programs at other parks in the eastern region. We have therefore provided the following critique of our methods and offer suggestions for future survey methods.

The survey protocols we chose seem to efficiently and accurately capture most woody species, and any species that are large in size, have distinct boundaries, and are discernable at a distance. The method seems to work less well for forbs and grasses, especially those that are too small, exist in high

numbers, are difficult to see at a distance, grow underneath other plants, and have indistinct boundaries at the edge of patches. For example, we included garlic mustard in this survey, and it was by far the most difficult plant to track using our methods for the above stated reasons. Trying to find satisfactory starting and stopping points for the lines that represented each patch was exceptionally difficult. We noticed how hard it would be early on and decided to change the survey method for just this plant. Because this plant is biennial, we decided to ignore the small 1st year plants that grow low to the ground and are hard to see. We instead only recorded the 2nd year plants that had bolted into a flowering stalk and produced seed pods. These Second year plants were slightly easier to perceive and were less numerous. This allowed us to speed up the survey speed while still capturing garlic mustard's prevalence on the landscape. It should be noted however that this tweak to the methods will underestimate the severity of the garlic mustard invasion. In the end we would recommend alternate methods for evaluating this species, and other forbs like it. Perhaps subsampling areas throughout the park at given intervals to make the survey more manageable. Mile a minute was another plant that may not be accurately evaluated by our methods. It simply hides too well in other vegetation and I'm certain that we missed small patches of it due to human error. Crownvetch was extremely visible and easy to record during the flowering season as the flowers are very showy, but became difficult later in the year as flowering faded. While we did not survey in the spring, we feel that surveying this plant prior to flowering would be difficult as well. The only other forbs we evaluated during the survey was Canada Thistle and Bush Thistle. These forbs were less problematic because they are larger, less common, clearly visible, and appeared to grow in patches with distinct boundaries. Therefore the method can reasonably be used for some forbs if their growth habit allows for it. We would like to note however that even these forbs became difficult to survey within developed areas. When we surveyed Foxville Plaza there were too many forbacious plants sparsely located throughout the field and many of them had just been mowed. In the interest of time we did not scour the mowed areas for forbs. We only recorded forbs tall enough to bear seed since these could be easily seen and located from a distance. For this reason, the invasion intensity of garlic mustard, thistle species, and crown vetch is significantly higher in reality than it appears on our map. We do not however want to cast doubt on the methods we chose. The technique was exceptionally effective at recording all tree, shrub, and woody vine species in a timely manner.

We recommend surveying at the park become more regular. Quick scans of the park to identify new patches of infrequent invaders could be conducted yearly to stop new species from entering the park. More intensive studies like our own could be conducted every 5-10 years to monitor the spread of the invaders already present. When these more intensive studies are conducted you may want to consider making the study itself longer. Currently with a survey period of 12 weeks with two surveyors, there is enough time to survey near campgrounds, roads, and trails which leaves areas away from human development unsurveyed. This could potentially be detrimental since surviving invaders in these more remote areas may reinfest to already treated areas of the park. More time would allow for a more comprehensive and detailed survey and a better understanding of the severity of invasive plants.

Due to the fact that this study relies heavily on ESRI products, maintaining a contact with someone at ESRI would be extremely helpful. We had many instances that were unsolved because we could not have ESRI troubleshoot the issues. Situations that occurred were as followed:

1. The new version of collector that was originally used was suddenly unable to load the line and polygon layer, which forced us to resort to collector classic (the older version). Although we were able to continue surveying, the time it would normally take was slowed down, and it required slight reworking for how we conducted our procedures.
2. Another issue we ran into during the study that caused more time to be used on the technical side was making domain lists. We could find no sources where we could effectively copy and paste similar domain lists to other fields within a feature layer. Writing the same domain list 32 times is very time consuming, and there was no support (that I could find) to make this process faster.

Considering this was the first survey, and we now have a better idea of where certain plants are in relation to the park spatially, perhaps future studies could incorporate analyses of invasions in

reference to soil type, moisture content, elevation, slope and other factors to determine possible reasons why certain plants are more successful in certain areas than others.

In order to maintain accuracy at Catoclin Mountain Park it could be wise to look into a potential base station. At times while surveying, the procedure was slowed down or came to a halt due to the receiver trying to obtain accuracy. A base station could potentially solve these issues and overall make the survey run faster, allowing more time to access other areas of the park and increase accuracy.

Acknowledgments

We would like to send our appreciation to the National Park Service for the accommodation we received while at Catoctin Mountain Park and the valuable information and resources that went a long way in conducting this project.

We would especially like to give thanks to:

Lindsay Donaldson (Chief of Resource Management Catoctin Mountain Park) for going above and beyond in accommodating us with housing and a vehicle to conduct the survey. Also for always being quick with responses to any issues or situations we encountered.

Rebecca Loncosky, Biologist Catoctin Mountain Park for teaching us the biology of plants at Catoctin Mountain Park, and how to identify native and invasive species.

Ann Gallagher, UERLA Science Education Coordinator for designing and funding both internships through agreements with the Geoscientist in the Parks program and Connect Parks, People, and Science with the University of Maryland. She provided assistance and feedback for the project and in the preparation of this report.

Cynthia Wanschura, Regional GIS Coordinator Region 1 - National Capital Area for providing additional support with GIS and lending us the Trimble R1.

Aleksandra Voznitza, NCA IPMT Liaison for providing guidance and feedback on our procedures and methods to make the project more successful.

Rick C. Slade, Superintendent Catoctin Mountain Park for providing a warm welcome to Catoctin mountain park and approving all of our activities from the top level.

We would also like thank the Geologic Society of America, Geoscientists-in-the-Parks program, AmeriCorps, Conservation Legacy , the University of Maryland, and UERLA for sponsoring our internships.

Appendix

Resource for creating and sharing map, collecting data, setting up to go online.
<https://doc.arcgis.com/en/collector-classic/>

R1 Troubleshooting Guide

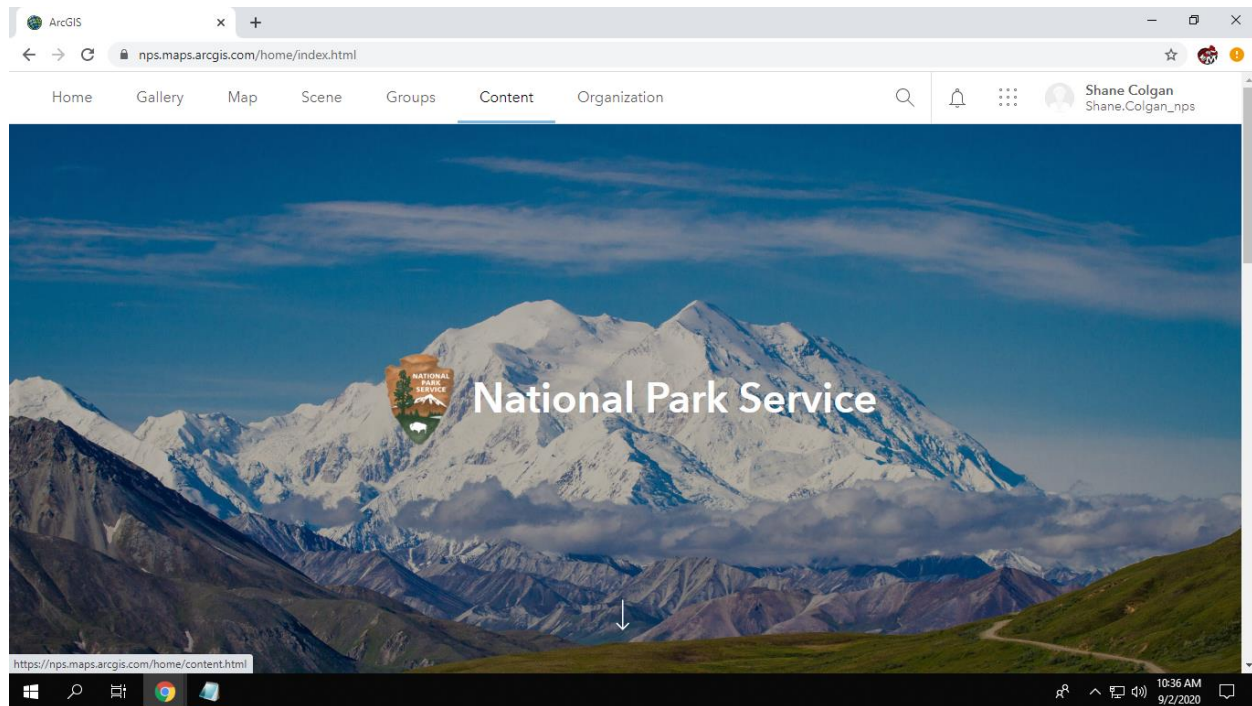
For future surveyors I have listed simple instructions and also an instruction manual on how to properly use the Trimble R1:

1. When facing the front of the GNSS Receiver you will notice two LED's located directly above the central button. The left LED represents the Bluetooth and the right LED represents the battery life. Hold the power button until both of these lights turn green and then release the button.
2. *Battery LED will display green when fully charged, yellow when below half-life, and red when it is low and needs to be charged.*
3. At this point you should see the LED for Bluetooth on the left begin to blink alternating between blue and amber. This means the device is attempting to connect to a Bluetooth device.
4. Now you need to go to the settings option on the iPad, go to Bluetooth, and connect to the option that shows the GNSS Trimble Receiver. Once connected the LED Bluetooth should light green to confirm it is at maximum accuracy. If not fully connected to the satellite's the amber light will continue to blink as mentioned in step 2.
5. When you're finished surveying, make sure to hold the power button on the receiver until both LEDs turn Red and then continue to hold until the LED light for the Bluetooth turns off. At this point the receiver is turned off unless connected to a charging station, at which point the power LED will either be green for fully charged, yellow for halfway charged, or red for low battery.
6. It is important to always remember to turn off the receiver when you're finished using it, and to make sure the battery is fully charged before continuing to survey later on or the following day.

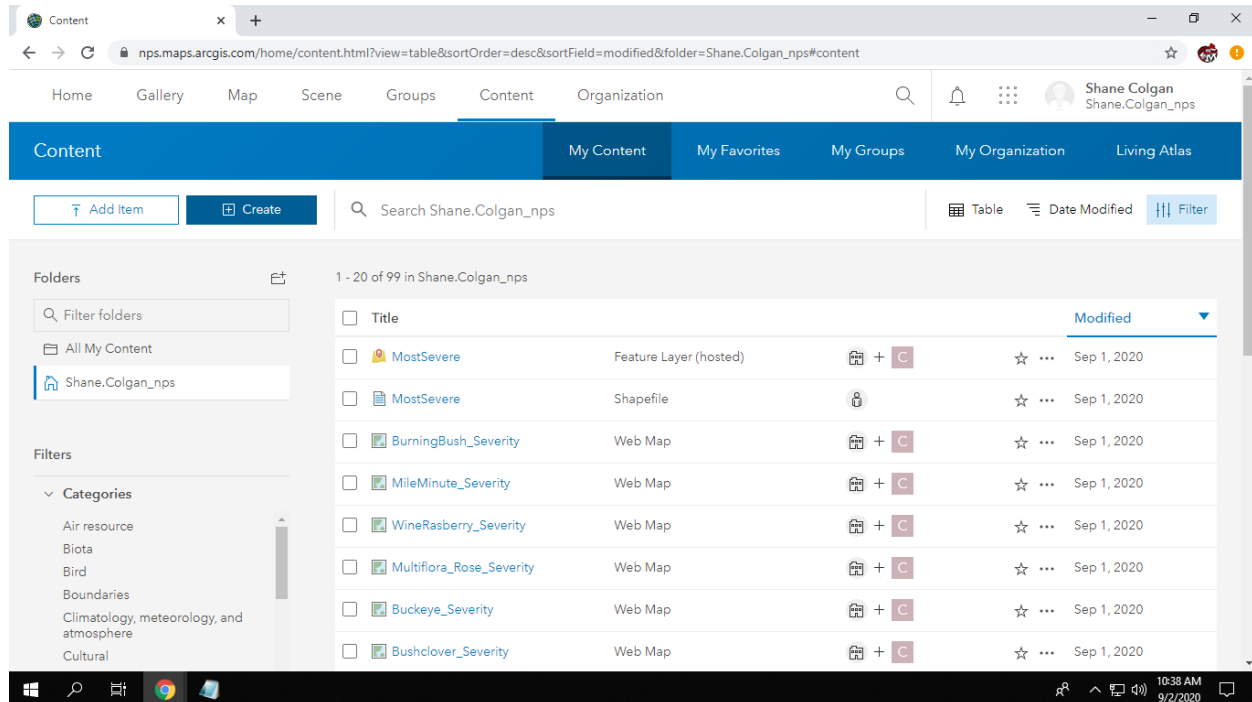


Creating Feature Layer in AGOL for Surveying

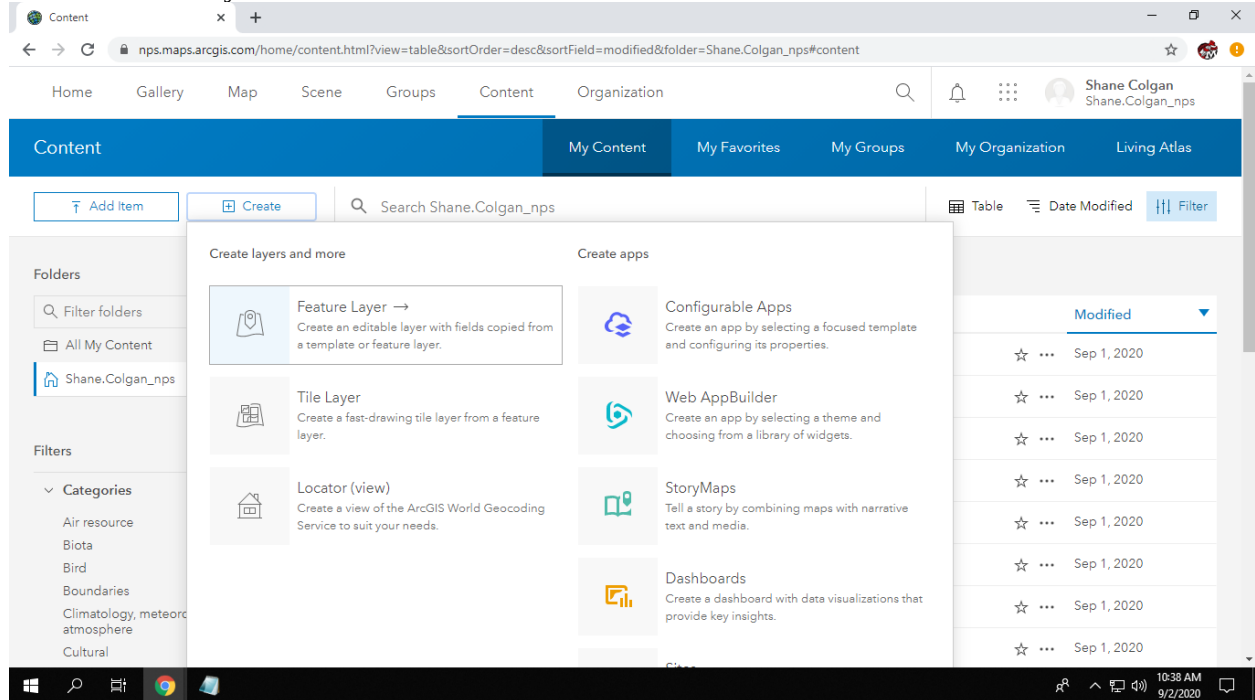
First go to content after signing into AGOL



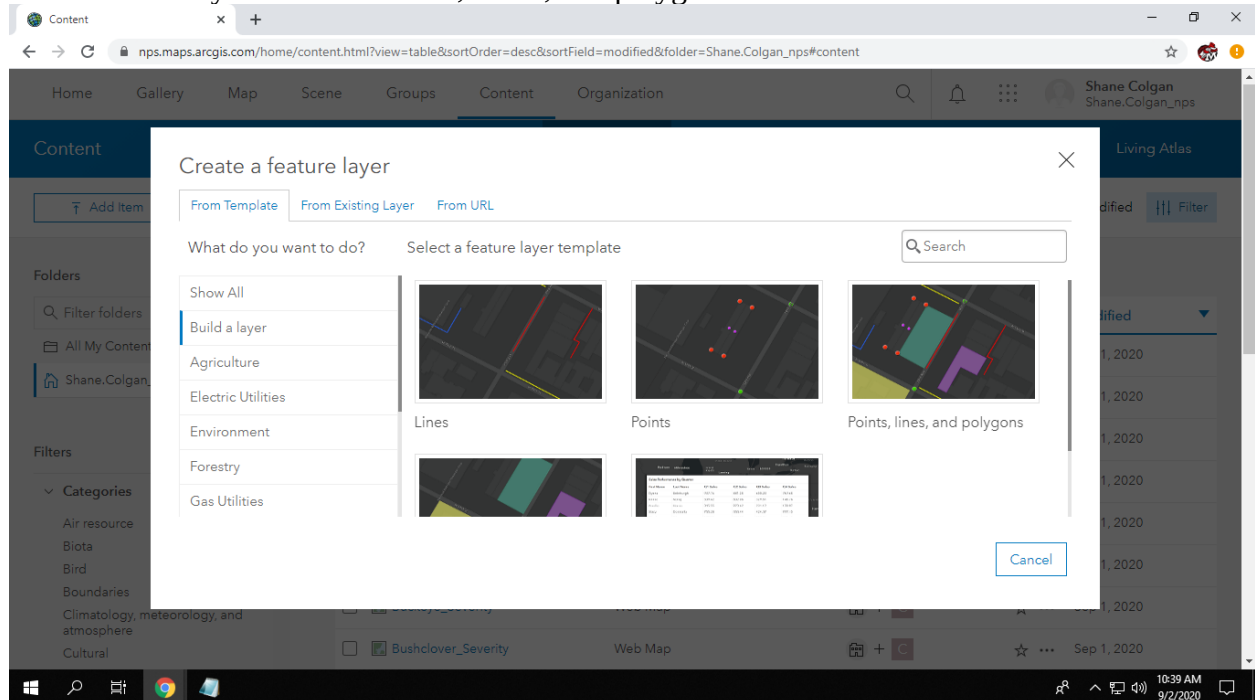
Click on the create button



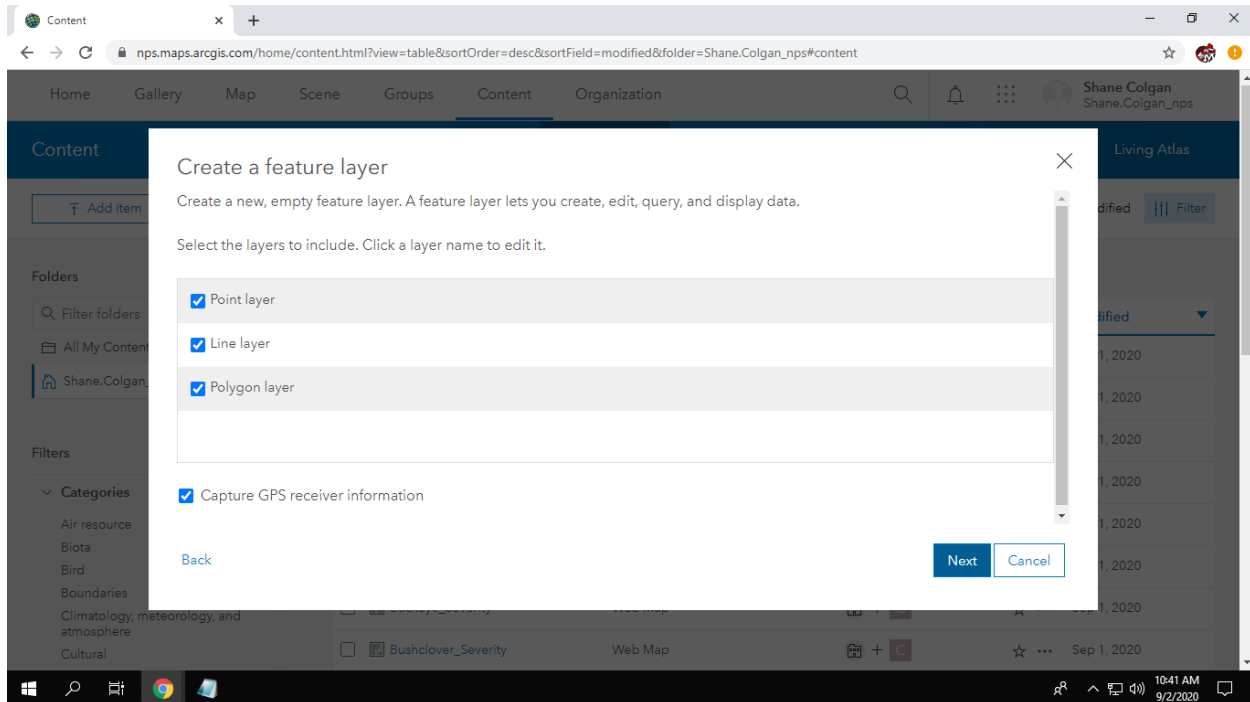
Click Feature Layer



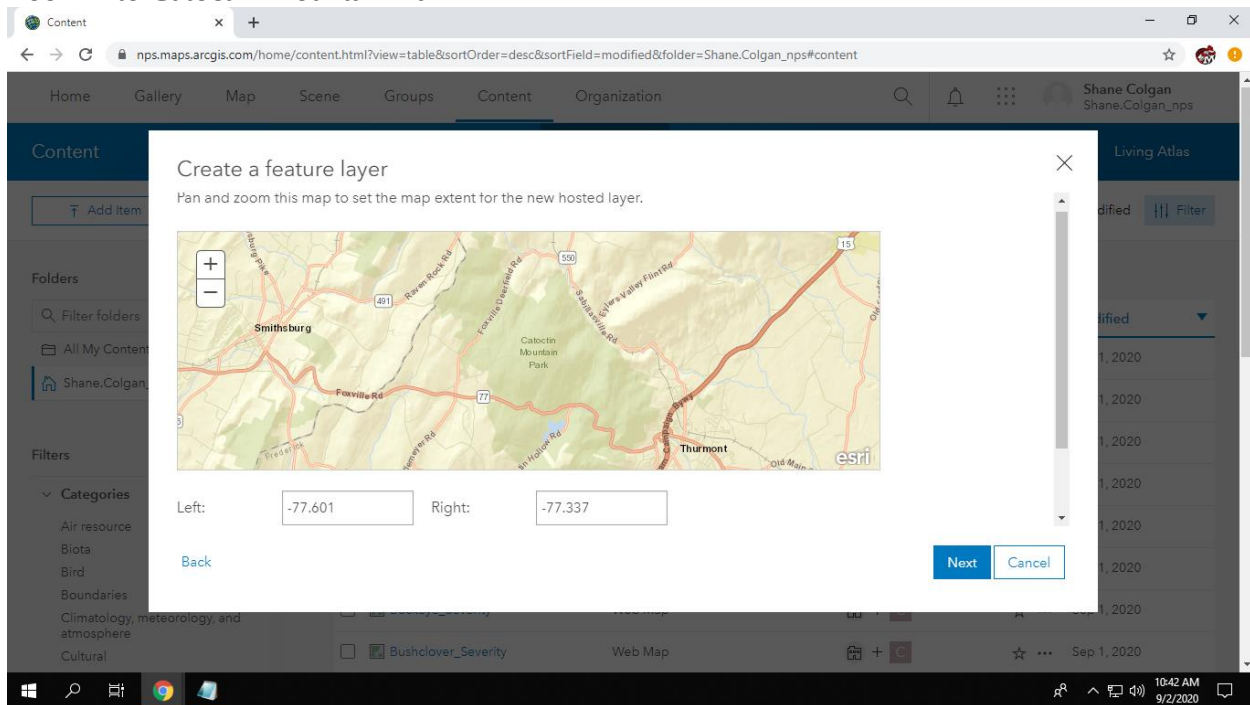
Click Build a layer and then Points, Lines, and polygons



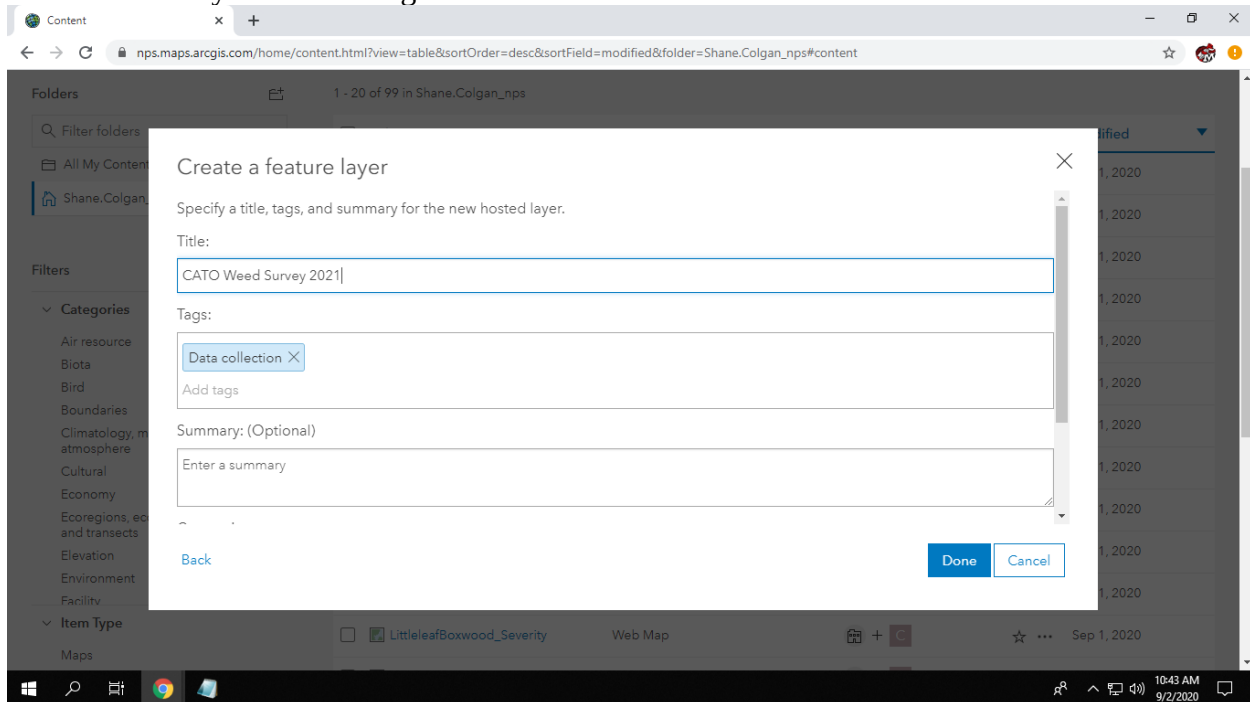
Make sure all boxes are checked and then click next.



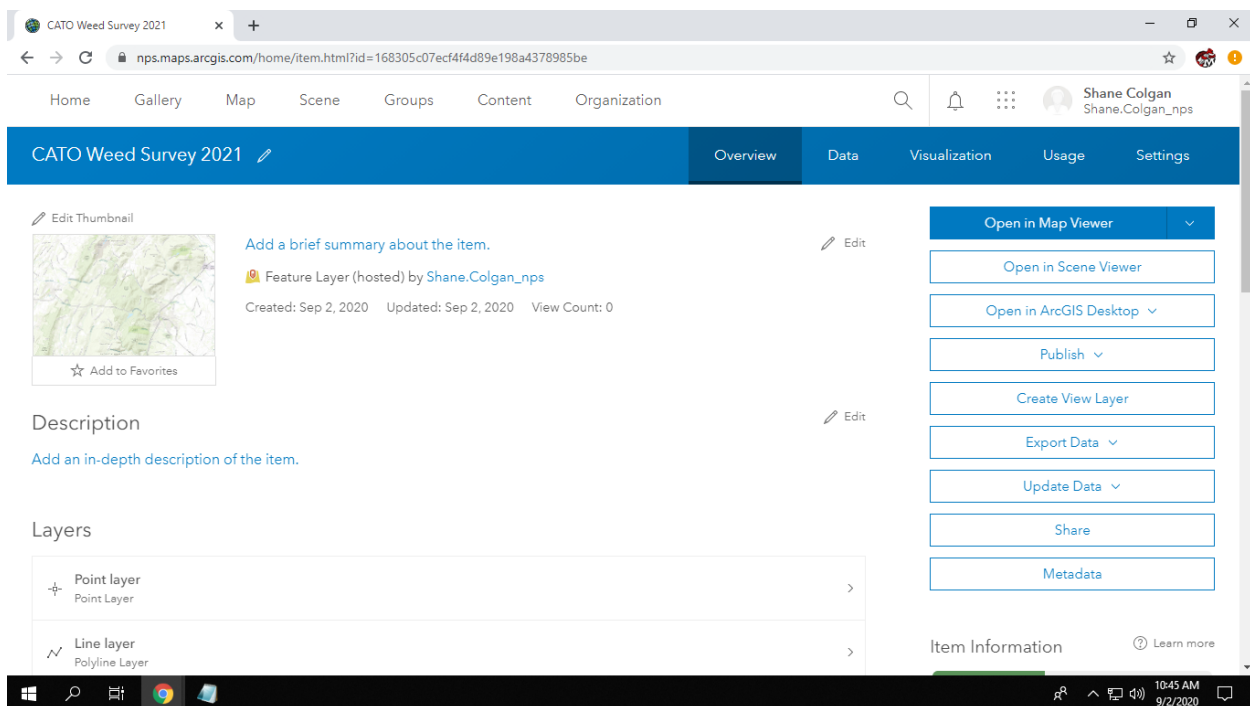
Zoom into Catoclin Mountain Park



Name feature layer than add tags



Add summary and description of Feature Layer



Click on data than fields to create layers

The screenshot shows the ArcGIS Maps web interface for the 'CATO Weed Survey 2021' item. The 'Data' tab is active, and the 'Point layer' is selected. The table view displays 'No Data Found'. The interface includes a navigation bar with 'Home', 'Gallery', 'Map', 'Scene', 'Groups', 'Content', and 'Organization'. The user profile 'Shane Colgan' is visible in the top right corner. The data last updated timestamp is 'Sep 2, 2020, 10:45:02 AM'.

Layer: Point layer

Table Fields

Double-click a value in the table to change it. Data Last Updated: Sep 2, 2020, 10:45:02 AM

Point layer (Features: 0, Selected: 0)

Speed (km/h)	Direction of t...	Compass rea...	Position sour...	Receiver Name	Horizontal A...	Vertical Accu...	Latitude	Longituc
No Data Found								

Layers OBJECTID and GLOBALID must stay but all other layers for each point, line, and polygon can be deleted at user's discrepancy.

The screenshot shows the ArcGIS Maps web interface for the 'CATO Weed Survey 2021' item. The 'Data' tab is active, and the 'Point layer' is selected. The 'Fields' tab is active, showing a list of fields. The interface includes a navigation bar with 'Home', 'Gallery', 'Map', 'Scene', 'Groups', 'Content', and 'Organization'. The user profile 'Shane Colgan' is visible in the top right corner. The data last updated timestamp is 'Sep 2, 2020, 10:45:02 AM'.

Layer: Point layer

Table Fields

+ Add Search Fields

Table Order in Table Filter

Filters

29 of 29

Display Name	Field Name	Type
☐ OBJECTID	OBJECTID	ObjectID
☐ Speed (km/h)	esrignss_speed	Double
☐ Direction of travel (°)	esrignss_direction	Double
☐ Compass reading (°)	esrignss_azimuth	Double
☐ Position source type	esrignss_positionsourcetype	Integer
☐ Receiver Name	esrignss_receiver	String

Add new layer

The screenshot shows the ArcGIS Maps web interface for the 'CATO Weed Survey 2021' dataset. The 'Data' tab is selected, and the 'Fields' sub-tab is active. A list of 29 fields is displayed, including 'OBJECTID', 'Speed (km/h)', 'Direction of travel (*)', 'Compass reading (*)', 'Position source type', and 'Receiver Name'. The 'Add' button is located at the top left of the fields list.

Display Name	Field Name	Type
☐	OBJECTID	ObjectID
☐	Speed (km/h)	Double
☐	Direction of travel (*)	Double
☐	Compass reading (*)	Double
☐	Position source type	Integer
☐	Receiver Name	String

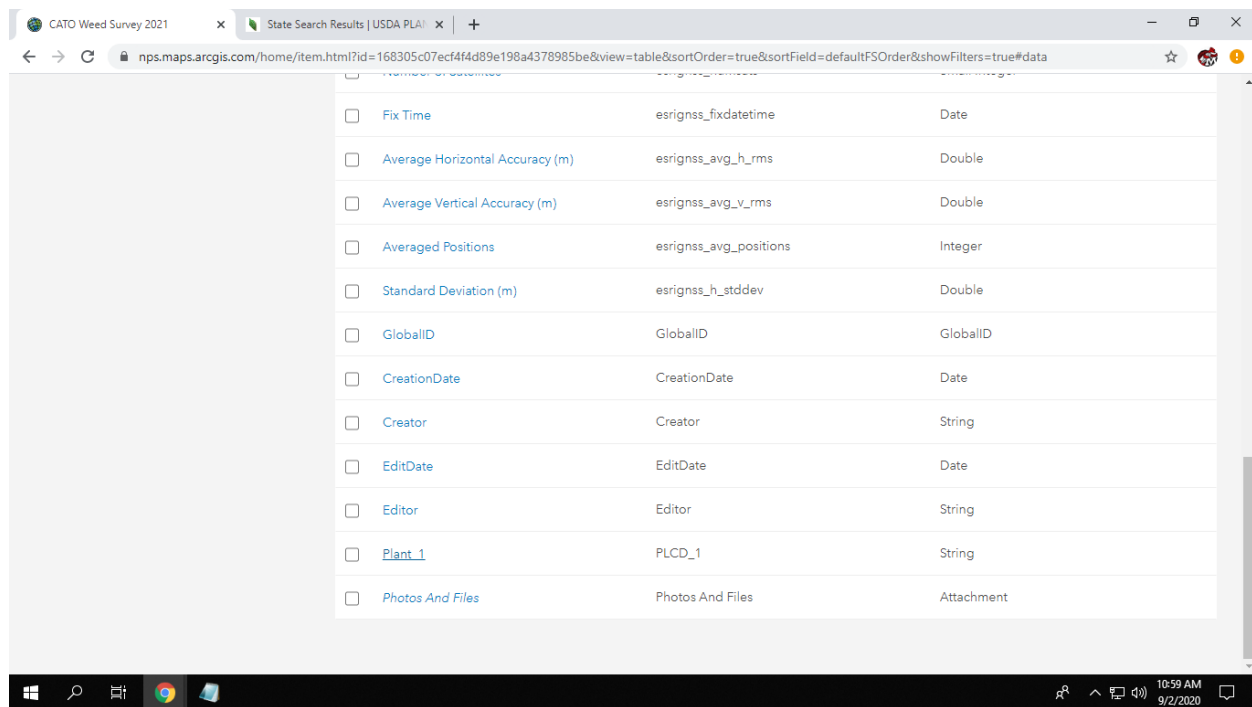
Field name cannot be changed once created; Display name can be changed. We made 10 separate fields for point, line, and polygon, but this may not be necessary.

The screenshot shows the 'Add Field' dialog box open in the ArcGIS Maps web interface. The dialog box contains the following information:

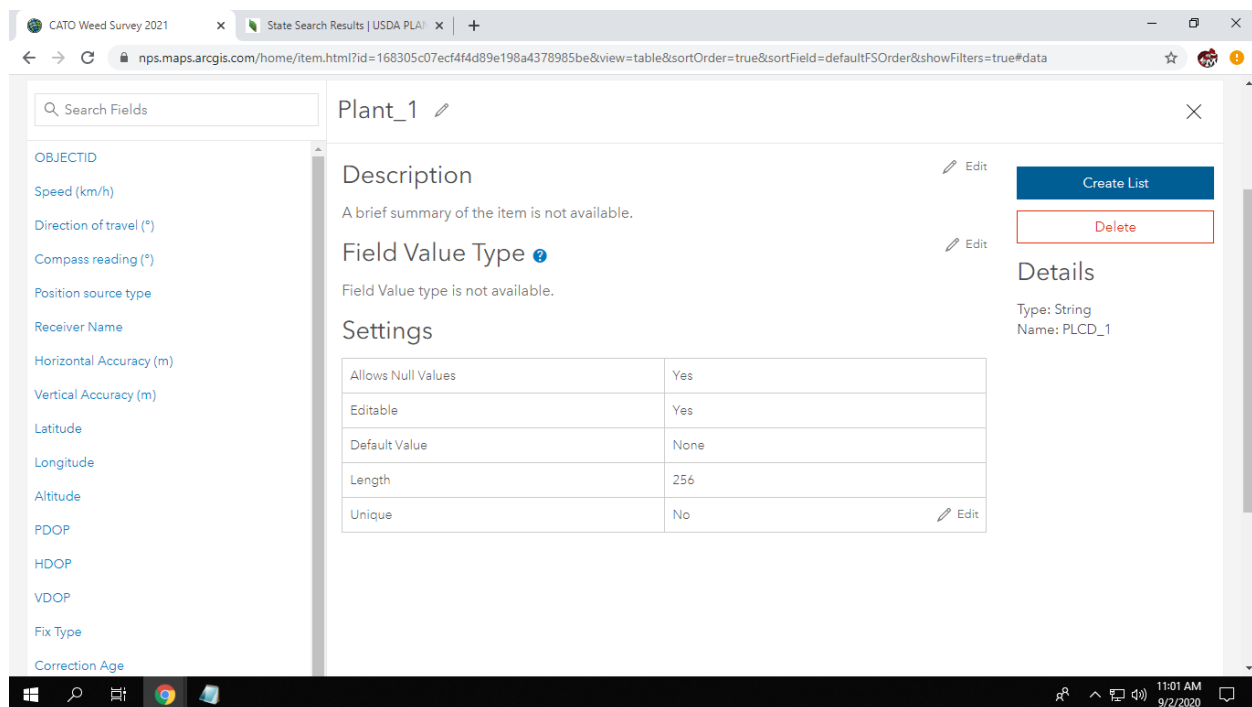
- Field Name: PLCD_1
- Display Name: Plant_1
- Type: String
- Length: 256
- Default Value: (Optional)
- Allow Null Values: ☒

The 'Add New Field' button is highlighted in blue.

Now the newly created layer will appear, click on it to make a drop down menu of plant names



Click on create list



This screen is where you will put the drop down list for each plant layer you can find plant species and their respective code on <https://plants.sc.egov.usda.gov/java/stateSearch>

Label Code

Displayed Value Stored Value

+ Add

Create the list of values for this field by entering attribute values one at a time or by generating the list from the current attribute values in the layer.

Add, edit, reorder, and delete items in the list. The Label is the displayed value and can be any text. The Code is the value stored in the database and must match the field type.

Generate List Save Cancel

11:02 AM 9/2/2020

Use plus sign to add more plant species, and then click generate list

Label Code

Plant1 PL1

+ Add

Create the list of values for this field by entering attribute values one at a time or by generating the list from the current attribute values in the layer.

Add, edit, reorder, and delete items in the list. The Label is the displayed value and can be any text. The Code is the value stored in the database and must match the field type.

Generate List Save Cancel

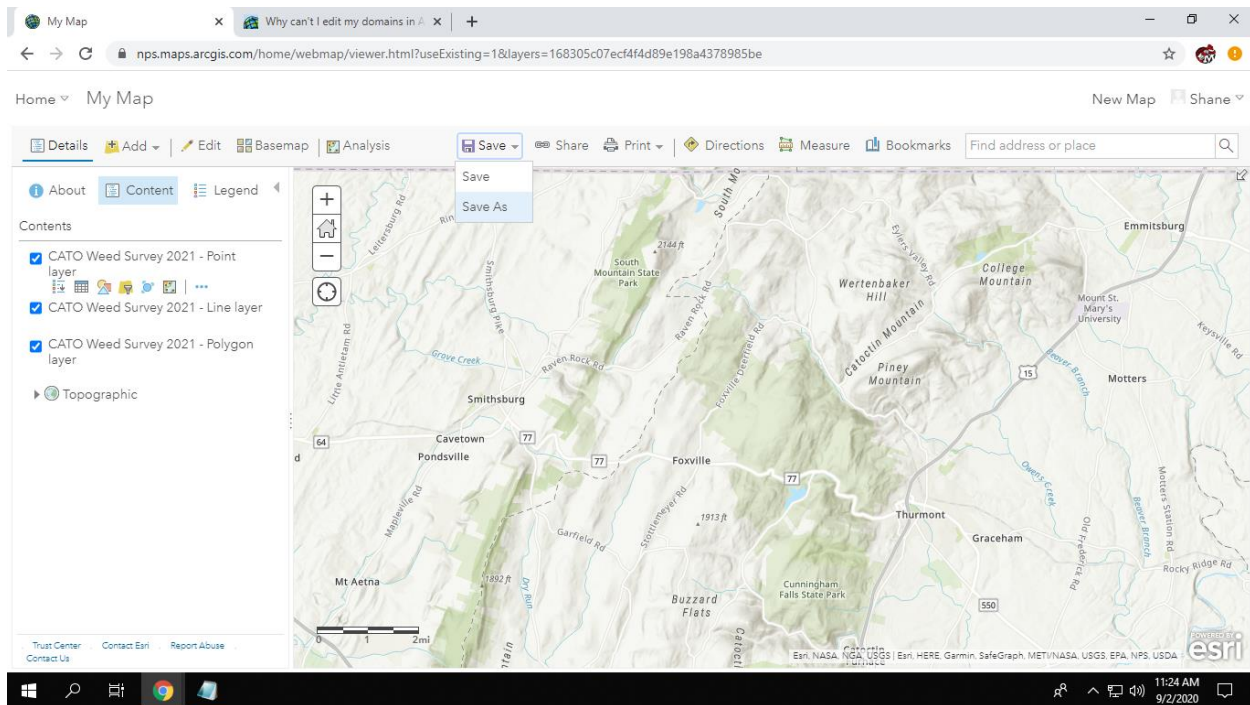
11:04 AM 9/2/2020

Click on overview and then share

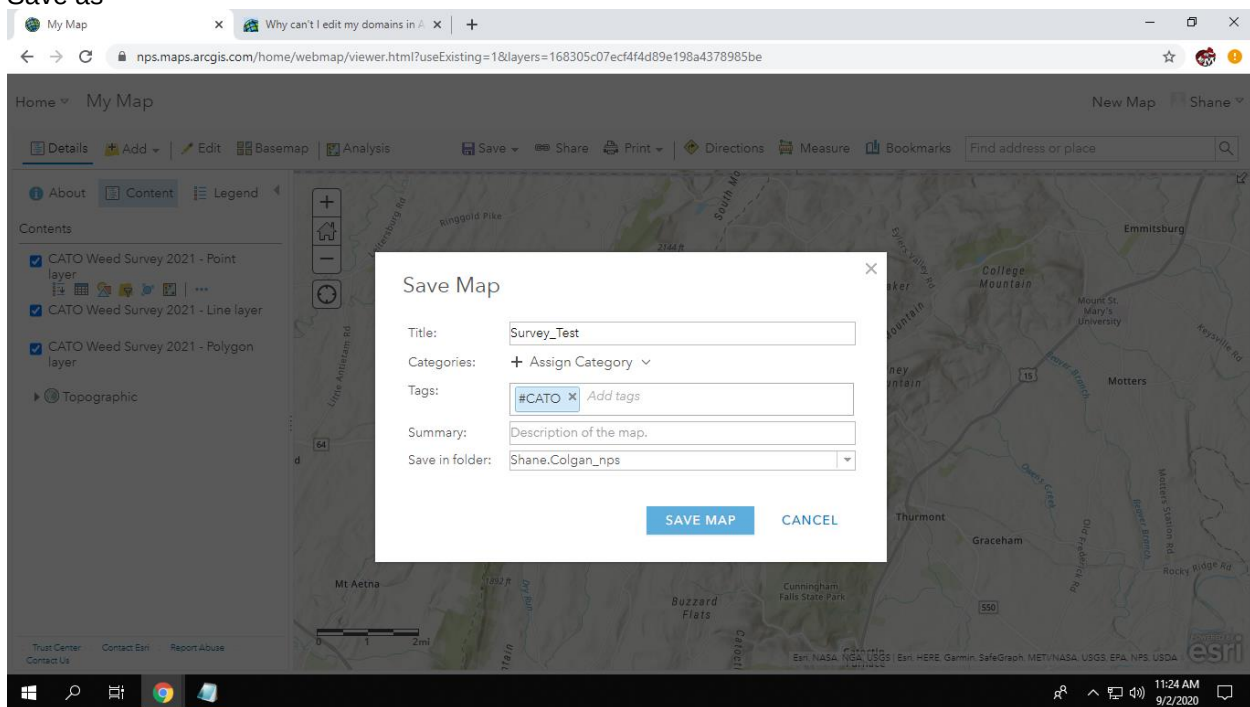
The screenshot shows the ArcGIS Online interface for a map item titled "CATO Weed Survey 2021". The browser address bar shows the URL: nps.maps.arcgis.com/home/item.html?id=168305c07ecf4f4d89e198a4378985be. The top navigation bar includes links for Home, Gallery, Map, Scene, Groups, Content, and Organization. The main content area has a blue header with the item name and tabs for Overview, Data, Visualization, Usage, and Settings. The Overview tab is active, displaying a thumbnail map, a brief summary, and a description. The Layers section lists two layers: "Point layer" (Point Layer) and "Line layer" (Polyline Layer). On the right side, there is a vertical menu with buttons for "Open in Map Viewer", "Open in Scene Viewer", "Open in ArcGIS Desktop", "Publish", "Create View Layer", "Export Data", "Update Data", "Share", and "Metadata". The "Share" button is highlighted in blue. At the bottom, the Windows taskbar shows the time as 11:13 AM on 9/2/2020.

Click on Organization and also edit group sharing (if you choose), to let it be available to others. If you want to keep it for yourself simply don't share

Save layer in web map using save as



Save as



Allow map to be shared so person using collector can access

Content

Why can't I edit my domains in ...

nps.maps.arcgis.com/home/content.html?view=table&sortOrder=desc&sortField=modified&folder=Shane.Colgan_nps#content

Home Gallery Map Scene Groups Content Organization

Shane Colgan
Shane.Colgan_nps

Content My Content My Favorites My Groups My Organization Living Atlas

Add Item Create Search Shane.Colgan_nps Table Date Modified Filter

Folders

Filter folders

All My Content

Shane.Colgan_nps

Filters

Categories

- Air resource
- Biota
- Bird
- Boundaries
- Climatology, meteorology, and atmosphere
- Cultural

1 - 20 of 101 in Shane.Colgan_nps

Title	Modified
☐ Survey_Test Web Map   ... Sep 2, 2020	
☐ CATO Weed Survey 2021 Feature Layer (hosted)   ... Sep 2, 2020	
☐ MostSevere Feature Layer (hosted)  +  ... Sep 2, 2020	
☐ MostSevere Shapefile   ... Sep 1, 2020	
☐ BurningBush_Severity Web Map  +  ... Sep 1, 2020	
☐ MileMinute_Severity Web Map  +  ... Sep 1, 2020	
☐ WineRaspberry_Severity Web Map  +  ... Sep 1, 2020	
☐ Multiflora_Rose_Severity Web Map  +  ... Sep 1, 2020	

Sharing level: Owner

11:26 AM 9/2/2020