

**Catskill Mountains Garlic Mustard
Trailhead/Trail Survey Report
January 20, 2007**



Garlic mustard adjacent to the Lost Clove trail in November 2006



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Executive Summary

Garlic mustard is an invasive herbaceous plant that displaces native plant species. To better determine its distribution in interior forest in the New York State (NYS) Catskill Park, volunteers surveyed 33 trailheads and the first ¼ mile of the associated trail in Forest Preserve and Wilderness areas. Garlic mustard was found at 20 of the 33 trailhead parking areas sampled (60%). Of the 32 trails sampled, it was found at nine trail locations (28%). Garlic mustard was found in moderate abundances at the trailhead parking areas and at the trails, with a majority of the sites estimated to have 100 to 999 plants. It was mostly found in large patches (> 20 ft²) at a low to moderate percent cover (0 – 25%). Garlic mustard was found well into interior forest areas with an average estimated distance from trail head parking areas and trails of 67 feet and 42 feet respectively.

Based on the limited data in this study, it is unclear what the primary vector of garlic mustard was on the sampled trails. A number of the trails in the study were observed to be old roads, and potential past disturbances (before the land was in a preserve status), such as logging operations, could have spread garlic mustard seed up the trail system. However, a number of weed managers have speculated that garlic mustard seed can be transported via the soles of muddy hiking boots.

Control efforts should focus on preventing garlic mustard from spreading into interior forest areas and eradicating existing trail side occurrences. Strategies to preventing garlic mustard from spreading into interior forest areas could include: 1) educating foresters on the potential for garlic mustard to spread during logging operations and 2) preventing large patches of garlic mustard from going to seed at the entrances to trails, intern stopping the potential spread of seed up the trail by hikers, bikers, and horseback riders. Eradicating the trail side garlic mustard occurrences should start with the patches that are farthest up the trail.

Further survey efforts are needed to gain a comprehensive view of the distribution of the species. The Catskills Regional Invasive Species Partnership (CRISP) should work with hiking clubs and natural resource managers to record the presence of the species in interior forest. This trail survey has shown that volunteers are an important resource for collecting invasive species distribution data and that garlic mustard is present in interior forest in NYS Forest Preserve and Wilderness in the Catskill Park. With sufficient detection and response, the threat of garlic mustard to forest systems in the Catskills can be abated.

Introduction

Garlic mustard possesses many properties that allow it to invade the forest understory and out-compete native vegetation. It is an herbaceous biennial that can tolerate a wide range of light and moisture levels (McCarthy 1997, Nuzzo 1999, Meekins and McCarthy 2002). Its growth and reproduction is greatest in areas with high soil moisture and high light levels (Meekins and McCarthy 2002). The rapid spread of garlic mustard is primarily associated with small scale disturbances that expose mineral soil. It has been found in high densities in floodplain ecosystems where disturbance from flooding is a frequent event (McCarthy 1997) and has the ability to spread through mature high quality upland forest (Nuzzo 1999).

Garlic mustard out-competes some native plant species (McCarthy 1997, Meekins and McCarthy 1999). In a greenhouse experiment, garlic mustard suppressed the growth of box elder (*Acer negundo*) and chestnut oak (*Quercus prinus*) at densities comparable to a typical invasion (Meekins and McCarthy 1999). A three-year removal experiment in a floodplain forest in Maryland found that species richness was significantly higher in removal areas compared to paired control areas (McCarthy 1997). Annual species, tree seedlings, and vines showed the greatest increase in the removal plots. The allelopathic properties of garlic mustard most likely add to its competitive abilities (Roberts and Anderson 2001, Stinson and Klironomos In review).

An invasive species road and trail survey in the Beaverkill and Panther Mountain Forest Matrix Blocks (FMB) (Figure 1) found that garlic mustard was widespread throughout the road system. It was the most frequently occurring invasive plant species, found in approximately 60% of the road transects sampled in the Beaverkill FMB and approximately 83% of the road transects sampled in the Panther Mountain FMB (Zimmerman *et al.* 2006). Additionally, it was the most frequent invasive plant species found in riparian areas in the Beaverkill FMB. Randomly placed transects along the trails in the Beaverkill and Panther Mountain FMBs found that the trails were relatively free of garlic mustard as it was only found in 2 of the 50 trail transects sampled. However, qualitative observations noted that garlic was present at a number of the trailhead parking areas and on portions of the trails that were not sampled. These results provided an indication that additional inventory effort was required to determine if garlic mustard was present on trails throughout the Catskill Park.

Objectives

This study aimed to determine:

1. If garlic mustard is present at trailhead parking areas and the first ¼ mile of trails.
2. The abundance, distribution, and percent cover at which garlic mustard occurs.
3. How far garlic mustard is found into interior forest areas from trailhead parking areas and trails.

Methods

Sample Design

Trailhead parking areas and associated trails were sampled throughout the NYS Catskill Park in both Forest Preserve and Wilderness (Figure 1). A total of 33 trailhead parking areas and 32 trails were sampled. An attempt was made to obtain an even distribution of sample locations across the six forest matrix blocks, however for logical reasons only four forest matrix blocks were sampled.

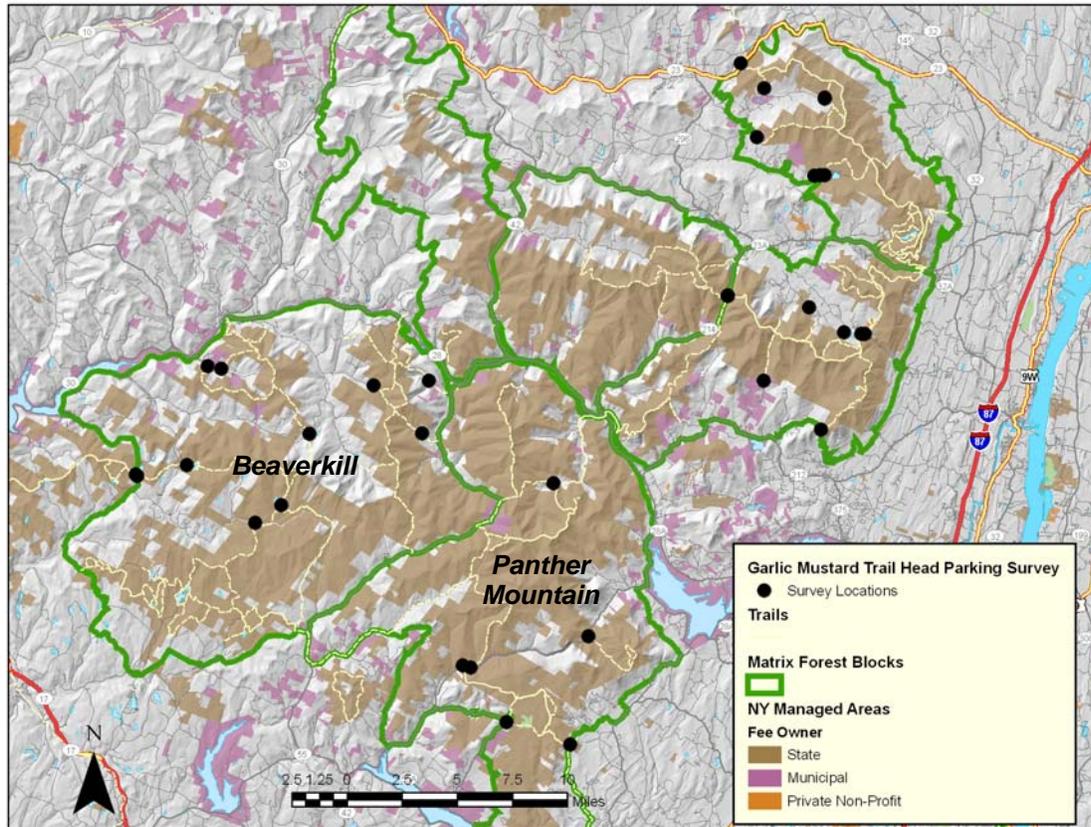


Figure 1. Location of the garlic mustard trail survey locations within the Catskills Mountain Forest Matrix Blocks in New York State.

Data Collection

Five groups of volunteers were utilized to collect garlic mustard distribution data at the trailhead parking areas and trails. Volunteers were trained in May on garlic mustard identification and the data collection protocol.

At trailhead parking areas field crews searched 20 feet from the edge of the parking areas for the presence of garlic mustard. For approximately $\frac{1}{4}$ mile up the trail from the trailhead (where the trail leaves the parking area/road), crews searched for garlic mustard within 20 feet of both sides of the trail. If garlic mustard was detected, its abundance, distribution, and percent cover (cover estimated in 10ft. x 10ft. plot at densest patch) was estimated (see Appendix B for data sheet and survey instructions). Additionally, the distance that garlic mustard was found from the trailhead parking area and/or trail and the distance that garlic mustard was found up the trail were estimated. At each trail and trailhead, the adjacent habitat type was also recorded.

Results

Garlic mustard was found at 20 of the 33 trailhead parking areas sampled (60%) (Figure 2). Of the 32 trails sampled, garlic mustard was found at nine trail locations (28%). At eight of the nine trails at which garlic mustard occurred, it was also found at the trailhead parking area.

Garlic mustard was found at a moderate abundance at the trailhead parking areas and trails where it occurred (Table 1). Thirty-five percent of the 20 trailhead parking areas with garlic mustard present were within the 100 to 999 plants abundance class. While, 56% of the 9 trails with garlic mustard present were within the 100 to 999 plants abundance class.

Table 1. Percent of garlic mustard occurrences by abundance classes for trailhead parking areas and the first ¼ mile of trails.

# of plants	Trailhead Parking Areas	Trail
Single plant	0%	0%
Under 20 plants	15%	11%
20 to 99 plants	30%	11%
100 to 999 plants	35%	56%
Over 1000 plants	20%	22%

The distribution of garlic mustard at a majority of the trailhead parking areas and trails was spotty (Table 2). A spotty distribution was defined as few scattered individuals. However, there were a few garlic mustard occurrences at trailhead parking areas and trails that were determine to be dense continuous patches.

Table 2. Percent of garlic mustard occurrences by distribution classes for trailhead parking areas and the first ¼ mile of trails.

	Trailhead Parking Areas	Trail
Spotty	45%	44%
Light continuous	20%	33%
Dense pockets	20%	11%
Dense continuous	15%	11%

The densest patches of garlic mustard at a majority of the trails and trailhead parking areas were found to have a low percent cover (1 to 25%) within a 10ft.x10ft. area (Table 3). However, there were a few occurrences at both trailhead parking areas and trails that had a moderate to high percent cover of garlic mustard (25 – 75%).

Table 3. Percent of garlic mustard occurrences by percent cover classes for trailhead parking areas and the first ¼ mile of trails. Percent cover was estimated in a 10x10 foot area within the densest patch of garlic mustard.

Percent cover	Trailhead Parking	Trail
1 to 5%	40%	22%
6 to 25%	15%	44%
26 to 50%	25%	22%
51-75%	20%	11%
76-100%	0%	0%

The size of garlic mustard patches at trailhead parking areas and trails were relatively evenly distributed among the six patch size classes (Table 4 and 5). A patch was defined as continuous individuals with no more than 20 feet between stems, with the potential for more than one patch to be present at a trailhead/trail sample site. The >20x20 foot patch size class was the most frequent at the trailhead parking areas and trail sample locations.

Table 4. Total number of patches by size class at trailhead parking areas.

	Patch Size (feet)					
	1	2x2	5x5	10x10	20x20	>20x20
Sum of patches	10	4	9	4	1	12
Percent of patches	25%	10%	23%	10%	3%	30%

Table 5. Total number of patches by size class at trail sample locations.

	Patch Size (feet)					
	1	2x2	5x5	10x10	20x20	>20x20
Sum of patches	4	4	5	2	1	6
Percent of patches	18%	18%	23%	9%	5%	27%

The average estimated distance that garlic mustard was found from the trailhead parking areas into interior forest areas was 67 feet, with a maximum distance of 500 feet. The average distance that garlic mustard was found from the trail samples was 42 feet, with a maximum estimated distance of 100 feet. The average distance that garlic mustard was found up the trail from the trailhead parking area was 500 feet.

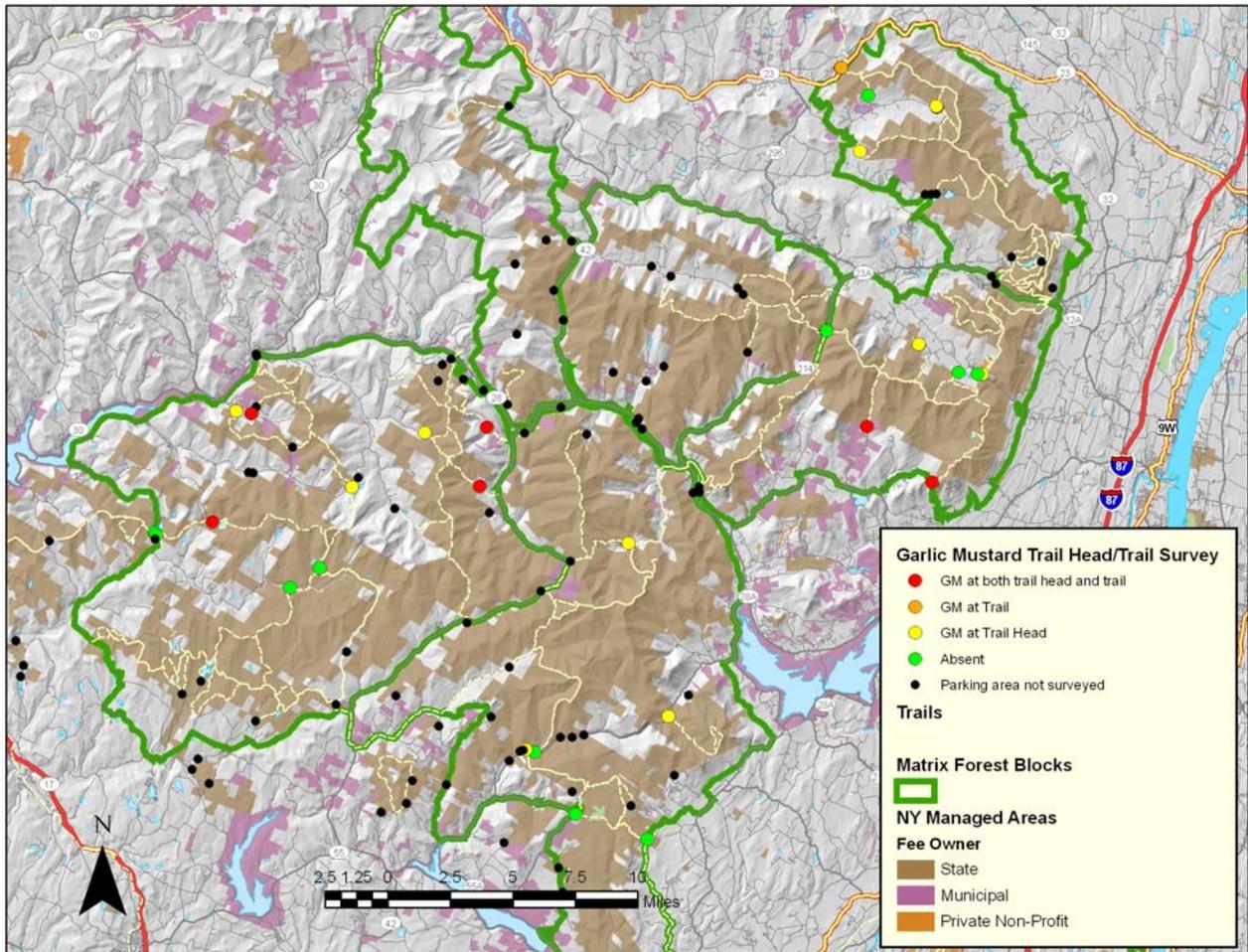


Figure 2. Location of garlic mustard occurrences at trailhead parking areas and trails within the Forest Matrix Blocks in the Catskill Mountains.

Discussion

Garlic mustard was detected at more than half of the trailhead parking areas sampled. This result aligns with the invasive plant species road inventory, which found that garlic mustard was widespread throughout the road system in the Beaverkill and Panther Mountain FMBs (Figure 3). The parking area at most of the trailheads sampled was directly adjacent to the road corridor, intern in most cases directly associated with a garlic mustard seed source. In some instances garlic mustard was found spreading well into interior forest from the edge of the trailhead parking areas.

Approximately, 25% of the trails sampled had garlic mustard present, with an average distance up the trail of 500 feet. From these trail side occurrences it appears to have spread into the forest interior with an average distance into the interior of 42 feet. Qualitative observations from the survey suggest that a number of the trail side occurrences are on trails that appeared to be old roads or are adjacent to the road. Based on this limited dataset it is unclear what the primary vector of garlic mustard was on these trails. Potential past disturbances, such as logging operations, could have spread garlic mustard seed up the trail system. However, garlic mustard seed could have been transported via the soles of muddy

hiking boots or wildlife. Depending on the environmental conditions at these sites, garlic mustard will most likely continue to spread at these locations.

Seventy-five percent of the 20 trailhead garlic mustard occurrences and 80% of the nine trail garlic mustard occurrences were found within a stream corridor. This result corresponds to a study in the Midwest that found that garlic mustard has significantly high survival and reproduction rates in mesic habitats (Meekins and McCarthy 2002). Additionally, flooding events often disturb the soil and spread garlic mustard seed, opening an opportunity for further expansion of the population. Due to the high frequency of old roads (currently trails) in mesic forests in the Catskills, garlic mustard is a high threat to these mesic forest plant communities.

Management Implications

The high frequency of garlic mustard along road sides precludes eradication of the species in the Catskills. However, efforts should focus on preventing garlic mustard from spreading into interior forest areas and eradicating trail side occurrences. Strategies to preventing garlic mustard from spreading into interior forest areas could include: 1) educating foresters on the potential for garlic mustard to spread during logging operations and 2) preventing large patches of garlic mustard from going to seed at the entrances to trails, thereby stopping the potential spread of seed up the trail by hikers, bikers, and horseback riders. Eradicating the trail side garlic mustard occurrences should start with the patches that were detected the farthest up the trail. Potential manual or mechanical control options include pulling or cutting the flower heads off (preventing seed set) in early May. To eliminate the seed bank, follow up management would be required for up to seven years.

Future Inventory/Research

The distribution of garlic mustard in forest interior areas in the Catskills is still relatively uncertain. Results from this survey effort indicate garlic mustard was present along 28% of the trails sampled and in some cases has spread into the adjacent forest interior. Additionally, qualitative observations indicate that garlic mustard is present along old logging roads in Lost Cove and McKinley Hollow (locations not capture in either survey effort). Future inventory efforts should focus on gaining a better understanding of the distribution of garlic mustard in forest interior areas in the Catskills. The Catskill Regional Invasive Species Partnership should work with hiking clubs and natural resource managers to record the present of the species in interior forests in the Catskills. Additionally, initiating a pilot study to determine if remote sensing can be used to detect garlic mustard at the landscape scale will aid in determine its distribution.

The vectors for garlic mustard seed dispersal in forests interior areas in the Catskills are unclear. The results from the trail survey provide no clear explanation for how garlic mustard was spread from road edges into the forest interior adjacent to the trails. Garlic mustard seed dispersal and establishment are thought to be associated with events that disturb the forest soils. In riparian areas, flooding events are believed to be one of the primary vectors of garlic mustard seed dispersal. In upland mesic forest, activities such timber management operations may facilitate the spread of garlic mustard seed along skid trails and the associated soil disturbance may lead establishment of the species. Some weed managers have speculated that garlic mustard seed maybe spread along trails by mud that collects in ATV tires and soles of hiking boots. In addition, wildlife may spread the seed. Although further research is required to substantiate these hypotheses, prevented measures should be taken to limit the spread of the species.

Conclusion

This trail survey has shown that garlic mustard is present in interior forests in NYS Forest Preserve and Wilderness in the Catskill Park and that volunteers are an important resource for collecting invasive species distribution data. With sufficient detection and response, the threat of garlic mustard to forest systems in the Catskills can be abated.

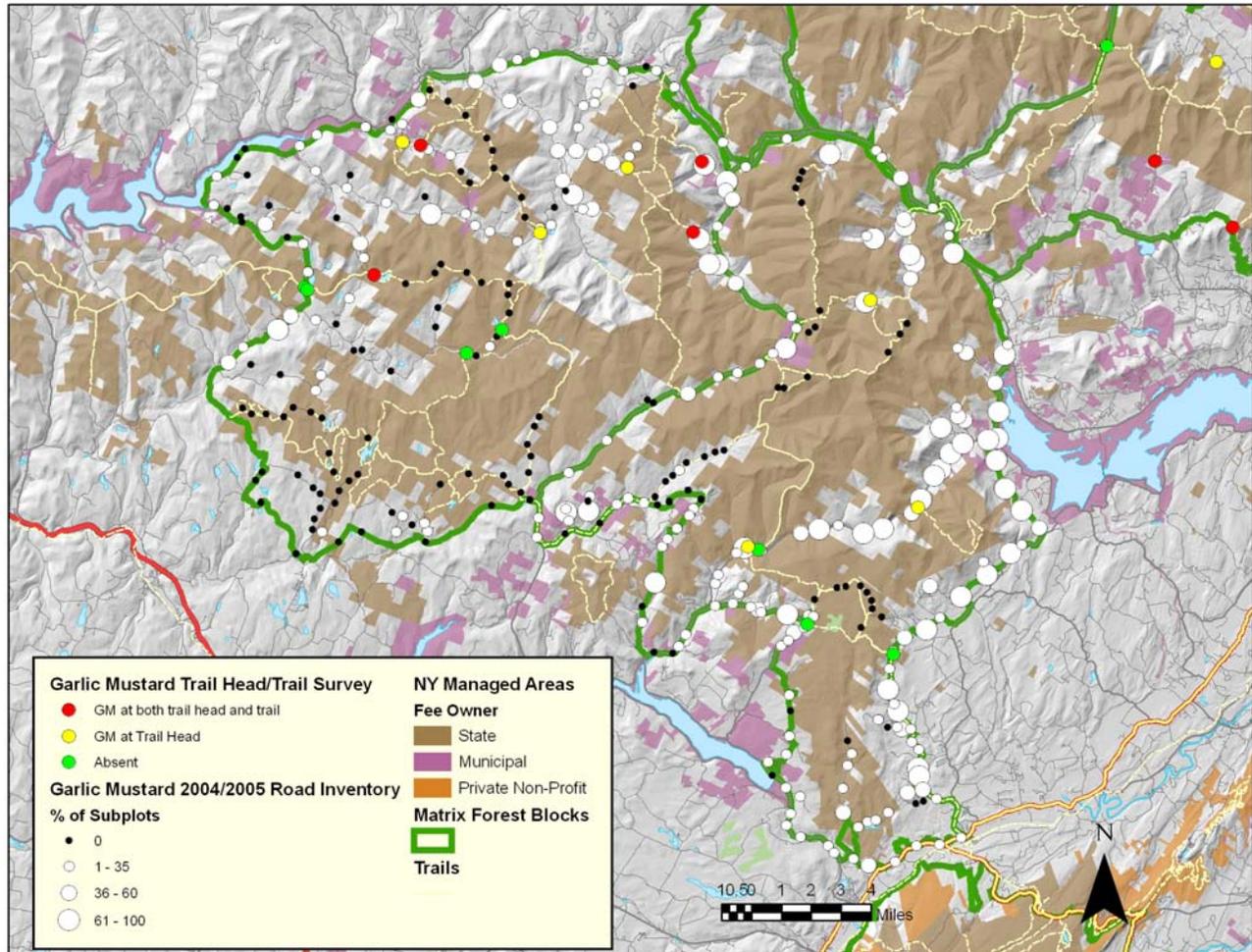


Figure 3. Location of garlic mustard trailhead parking area, trail, road occurrences within the Beaverkill and Panther Mountain Forest Matrix Blocks in the Catskill Mountains.

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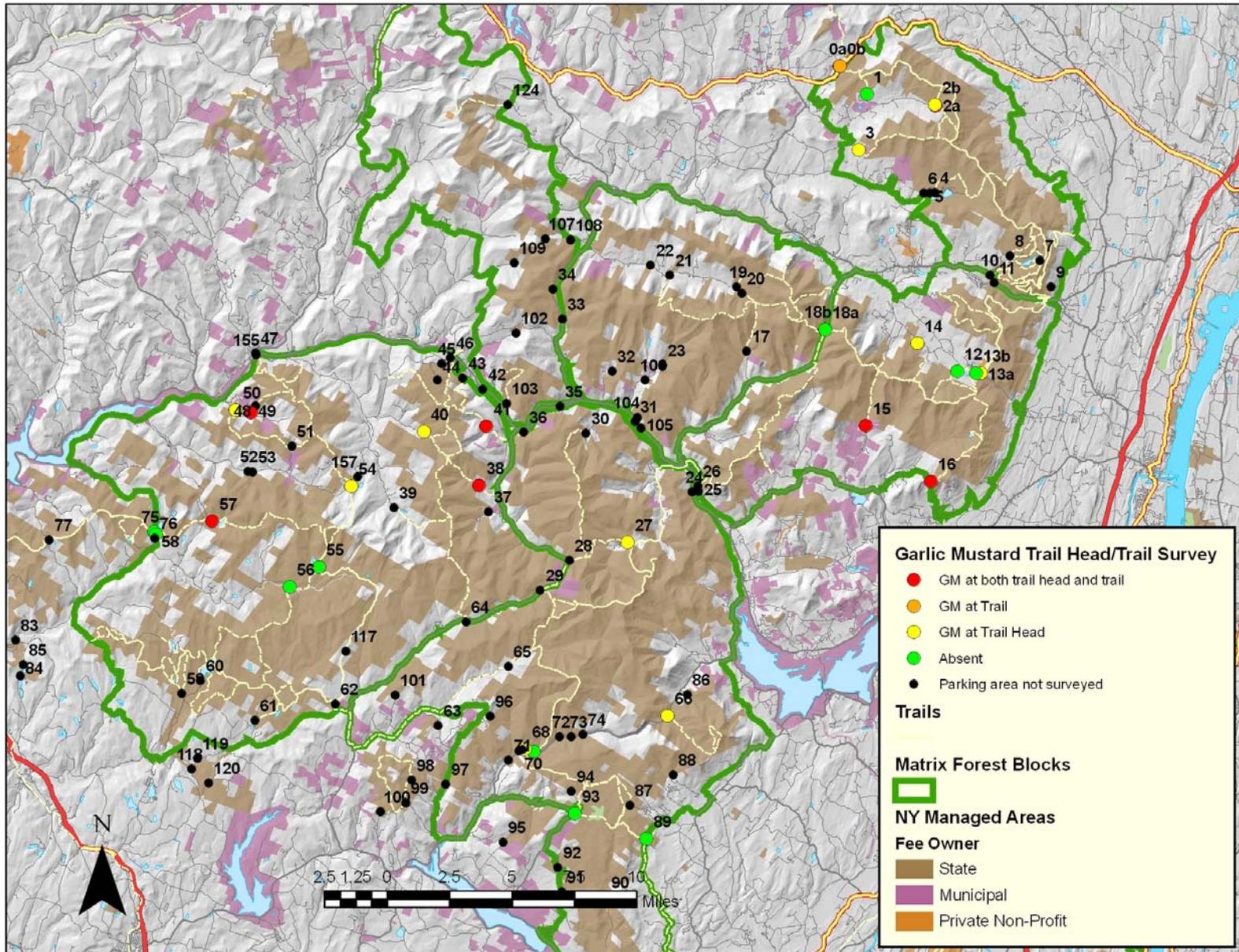
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Acknowledgements

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Appendix A. Distribution of trailhead parking areas and trails, and associated codes.



Appendix B. Garlic mustard trailhead and trail survey locations. Abundance and % cover number correspond to classes on data form.

ID	ROAD	TRAIL	TH GM	TH Abund	TH %	TH Dist	T GM	T Abund	T%	T Dist Up	T Dist From
0a	State Route 23	Escarpment N	na				yes	3	2	20	20
0b	State Route 23	Escarpment S	no				yes	4	4	500	50
1	Peck	Elm Ridge	no				no				
2a	County 56 - Big Hollow	Batavia Kill	yes		1	10	yes	2	1	50	5
2b	County 56 - Big Hollow	Batavia Kill	yes	2	1	0	no				
3	Barnum	Black Dome Range	yes	4	2	10	no				
4a	County 78	Colgate Lake	yes	4	1	100	na				
4b	County 78	Colgate Lake	no				no				
4c	County 78	Colgate Lake	yes	3	3	30	na				
12	Prediger - County 16	Devil's Path	no				no				
13a	Platt Cove	Long Path North	yes	2	1	10	no				
13b	Platt Cove	Long Path South	no				no				
14	Elka Park	Roaring Kill	yes	3	1	10	no				
15	Mink Hollow	Mink Hollow	yes	4	3	70	yes	4	2	70	10
16	Meads Mountain	Overlook	yes	3	1	5	yes	5	3	1300	20
18a	State Route 214	Devil's Path E	no				no				
18b	State Route 214	Devil's Path W	yes	4	3	80	no				
27	Woodland Valley	Woodland Valley	yes	5	4	50	no				
38	Mckinley Hollow	Rider Hollow	yes	3	1	20	yes	4	1	800	100
40	Rider Hollow	Rider Hollow	yes	3	1	16	no				
41	Lost Cove	Lost Cove	yes	5	3	500	yes	4	2	50	100
49	Huckleberry Brook Spur	Huckleberry Loop2	yes	4	3	35	yes	5	3	1300	35
50	Huckleberry Brook Spur	Huckleberry Loop1	yes	3	2	21	no				
54	Mill Brook Road	Dry Brook Ridge	yes	5	4	200	no				
55	Beverkill	Balsam Lake Mountain	no				no				
56	Beaverkill	Monquap - Hardenburg	no				no				
57	Alder Rd.	Big Pond - Alder Lake	yes	4	2	50	yes	4	2	500	40
58	Barkaboom	Big Pond - Touch-me-not	no				no				
66	Peekamoose	Knape Brook - High Point	yes	4	4	75	no				
67	Peekamoose	Peekamoose - Table Mountain	no				no				
68	Peekamoose	Long Path	yes	5	4	50	no				
75	Barkaboom	Big Pond - Alder Lake	no				no				
89	Upper Cherry Town	Snow ID 24	no				no				
93	Yaegerville	Snow ID 1	no				no				

Catskill Mountains Weed Watchers Invasive Species Trailhead/Trail Inventory Reporting Form

Observation Date: _____

Invasive Plant Species: _____

Observer's Name: _____

Observer's Phone and/or Email: _____

Trail Name: _____ Trail #: _____

Trail Head Parking Area

Adjacent Habitat: Forest Stream Wetland Field Pond Other _____

Invasive Plant Present: _____ Time to Complete: _____

(IF Yes) Population Size (ft.):

1	#		10x10	#	
2x2	#		20x20	#	
5x5	#		>20x20	#	

Abundance (# of plants)

- _____ Single Plant
- _____ Under 20 plants
- _____ 20 to 99 plants
- _____ 100 to 999 plants
- _____ Over 1000 plants

Distribution

- _____ Spotty
- _____ Light continuous
- _____ Dense pockets
- _____ Dense continuous

Percent Cover (10 ft x 10 ft plot)

- _____ 1 to 5%
- _____ 6 to 25%
- _____ 26 to 50%
- _____ 51 to 75%
- _____ 76 to 100%

Furthest distance from the trail head parking into the interior habitat: _____

Comments: _____

Trail (first 1/4 mile)

Adjacent Habitat: Forest Stream Wetland Field Pond Other _____

Invasive Plant Present: _____ Time to Complete: _____

(IF Yes) Population Size (ft.):

1	#		10x10	#	
2x2	#		20x20	#	
5x5	#		>20x20	#	

Abundance (# of plants)

- _____ Single Plant
- _____ Under 20 plants
- _____ 20 to 99 plants
- _____ 100 to 999 plants
- _____ Over 1000 plants

Distribution

- _____ Spotty
- _____ Light Continuous
- _____ Dense pockets
- _____ Dense Continuous

Percent Cover (10 ft x 10 ft plot)

- _____ 1 to 5%
- _____ 6 to 25%
- _____ 26 to 50%
- _____ 51 to 75%
- _____ 76 to 100%

Furthest Distance up the Trail: _____ Furthest Distance from Trail: _____

Comments: _____

Mail Form by June 30th to: Chris Zimmerman, The Nature Conservancy
195 New Karner Rd. Suite 201 Albany, New York 12205

Invasive Species Trailhead/Trail Inventory Reporting Form Directions

General Information

1. Observation date – date of site visit
2. Invasive plant species – name of plant
3. Observer's name – name/names of inventory crew members
4. Observer telephone/email – contact information
5. Trail name – name of trail from provided map/list
6. Trail number – number of trail from provided map

Trailhead Inventory – Search 20 ft. from the edge of the trailhead parking area.

1. Invasive plant present – is species present adjacent to trailhead? Yes/no
2. Time to complete – total time it took to inventory trailhead.
3. Adjacent habitats – check the box of adjacent habitats – if more than one habitat type is present, check all applicable boxes and circle the dominant habitat type.
4. Size of population – estimate square footage of population – a population is defined as continuous individuals with no more than 20 ft. between stems. More than one population may be present at a site. Record number of populations in each size category.
5. Abundance – estimate total number of individuals in all populations for the entire trailhead parking area.
6. Distribution – estimate the distribution over the entire trailhead parking area. (Spotty = few scattered individuals, Light continuous = uninterrupted light population surrounding trailhead parking, Dense pockets = thick patches scattered adjacent to trailhead parking, Dense continuous = uninterrupted dense population surrounding trailhead parking).
7. Percent cover – estimate the percent cover of the species in a 10x10 ft. plot in the densest population
8. Distance from trailhead parking area – estimate the furthest distance that individuals occur from the edge of the parking lot into the adjacent interior habitat. Measure to nearest foot within first 20 ft. If greater than 20 ft. then estimate >20 ft., >50, >100, >200, >300, etc.
9. Comments – Note any recent disturbances or any other observations

Trail Inventory – Search .25 miles up the trail and 20 ft. from trail's edge.

1. Invasive plant present – is species present adjacent to trail? Yes/no
2. Time to complete – total time it took to inventory trail.
3. Adjacent habitats – check the box of adjacent habitats – if more than one habitat type is present, check all applicable boxes and circle the dominant habitat type.
4. Size of population – estimate square footage of population – a population is defined as continuous individuals with no more than 20 feet between stems. More than one population may be present at a site. Record number of populations in each size category.
5. Abundance – estimate total number of individuals in all populations for the entire trail.
6. Distribution – estimate the distribution along the entire trail. (Spotty = few scattered individuals, Light continuous = uninterrupted light population surrounding trail, Dense pockets = thick patches scattered adjacent to trail, Dense continuous = uninterrupted dense population surrounding trail).
7. Percent cover – estimate the percent cover of the species in a 10x10 ft. plot in the densest population
8. Furthest distance up the trail – record the furthest distance up the trail that individuals occur from the start of the trail.
9. Furthest distance from the trail – estimate the furthest distance that individuals occur from the edge of trail into the adjacent interior habitat. Measure to nearest foot within first 20 ft. If greater than 20 ft. then estimate >20 ft., >50, >100, >200, >300, etc.
10. Comments – Note any recent disturbances or any other observations

Nature Needs You!

Invasive Species Trail Head Inventory Volunteer Opportunity

Join the Catskill Mountain Weed Watchers

Help The Nature Conservancy in partnership with the Catskill Center, Catskill Mountain Club, and Department of Environmental Conservation determine the distribution of the invasive, non-native plant Garlic Mustard along trails and at trail heads throughout the Catskill Mountains. Garlic Mustard poses a high threat to the native forest ecosystems in the Catskills. It has the ability to invade natural areas and out-compete native plant species. Garlic Mustard is difficult to eradicate once established, so early detection of its presence is essential to limiting its invasion.

Current Distribution

Garlic Mustard is widespread along roads in the southern Catskills. Its distribution along trails and in forest interior areas is currently unknown. We need volunteer Weed Watchers to visit these unsurveyed trails to find out if garlic mustard is present.



Garlic Mustard (*Alliaria petiolata*)

What We Will Do

Each Weed Watcher will visit up to five trail heads within close proximity of each other between late April & early June, 2006. Volunteers will go out independently to fill out a short form recording the presence/ absence of garlic mustard at each trail head and along the first part of the trails.

When and Where

Earth Day, Sat. April 22nd 9am-12noon Catskill Center, Arkville, NY

We will have a brief Weed Watchers training and then travel to a nearby trail head to pull garlic mustard. **Sign-up by Thursday, April 20th.** Field guide and inventory equipment will be provided. Bring work gloves and a GPS unit if you own one.



Interested? Contact:

Chris Zimmerman, Ecological Management Coordinator

czimmerman@tnc.org 518-272-0195 ext. 21 or 518-690-7878

195 New Karner Rd., Suite 201, Albany, NY 12205