The Influence of Environmental Settings on the Distribution of Invasive Species

David Bercaw, Nora Dougherty and William Sees

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Abstract

Invasive plants can cause negative effects to vegetation and wildlife in an area. We studied invasive plants in the Gordon Natural Area of West Chester University in Chester County, Pennsylvania. We looked at past and present land uses, an old woodlot and an old orchard, to find relationships with two types of invasive plants. We studied Amur Honeysuckle (*Lonicera maackii*) and Norway Maple (*Acer platanoides*). Studies took place in November 2010. We used a randomly selected transect and set up plots every fifty meters. Results show some correlations between past land uses and different analytical variables. Further research is necessary to gain a full understanding of invasives in the area. Bigger plots and a larger frequency of total plots would help generate more accurate results in an invasive species study.

Introduction

One of the main threats to ecosystems and biological diversity within them is the invasion of an exotic plant, which often leads to the displacement of native species (Lundgren & Small, 2004). The introduction of an exotic invasive plant to a region can have detrimental effects on surrounding vegetation and wildlife in the area. When several invasives are introduced, the negative effects can be compounded and lead to larger scale problems. If left unattended or allowed to spread, exotic invasives can take over entire forest plots, potentially changing ecosystems. In order to manage and predict these invasive species, it is crucial to gain an understanding of the mechanisms which caused the initial invasions (Ren & Zhang, 2009).

The topic of invasive plants and their environmental setting, in a local natural area, is the basis for our research. The need to better comprehend why invasive plants have been successful has been strengthened by the ecological dangers associated with them (Eschtruth and Battles, 2009). We are concerned that invasive plants have begun to attack the Gordon Natural Area (GNA) in West Goshen, Pennsylvania. We assume that the environmental setting has something to do with the location and propagation of the invasives. In order to determine how disturbances affect invasions, we chose to look at past and present land use patterns (Lundgren & Small, 2004.)

The purpose of our research is to gain an understanding of the two most prominent woody invasives in the GNA. It is also our goal to recognize a pattern in past and present land uses in order to predict future invasions. After taking a few initial walkthroughs of the GNA, we chose to focus our research on woody invasive species because of their prominence in the area and their easily identifiable traits. The invasive species that we chose to focus on are Amur Honeysuckle (*Lonicera maackii*) and Norway Maple (*Acer platanoides*). During our field work we also observed a large amount of viney invasive species but excluded them from the research due to differences in the methodology of DBH measurement.

Our studies in the field took place during November 2010 in West Chester, PA. The area, located in southern Chester County, is in the humid subtropical climate zone. The Gordon Natural Area contains about forty hectares of protected woodlands and is located on the South campus of West Chester University. The area is comprised of many different land uses and soil types. Major landmarks within the GNA include; Tigue Road, a portion of Plum Run Creek, an old orchard, and several walking trails. Several tree species appear to dominate the Gordon Natural area; beeches, maples, poplars and oaks. Also notable were stands of maples which we speculated to be of the invasive variety.

There have been many previous studies done on the subject of invasive plants. Several peer-reviewed scientific articles were referenced when performing our research. This literature proved very helpful to us and we were able to gain knowledge of many aspects of invasive plants and characteristics surrounding them.

One of the most useful articles dealt with land use and site characteristics of invasive plants. *Influence of Land Use and Site Characteristics on Invasive Plant Abundances in the Quinebaug Highlands of Southern New England* was written by Marjorie R. Lundgren, Christine J. Small and Glenn D. Dreyer and published in <u>Northeastern Naturalist</u> in 2004. Their study examined distribution and abundance of invasive species in northern Connecticut and southern Massachusetts. Historical land use and site conditions were the main factors examined in their research. This study measured both past and present land uses and past and present soil conditions in the site. They also studied the influence of roads, land development and other environmental variables on invasives. We modeled our study after the Lundgren et al research, using a study area, several invasive species, map analysis and data analysis.

Another noteworthy article, *The Relative Generality of Plant Invasion Mechanisms and Predicting Future Invasive Plants,* was written by M–X Ren and Q-G Zhang and published in <u>Weed Research</u> in 2009. Although dealing more with the specific mechanisms of invasive plants rather than the environmental setting of the study area, it was nevertheless useful. Their research on adaptation to the physical environment was a valuable resource and helped us to develop our ideas about geographic locations more cohesively.

Anne K. Eschtruth and John J. Battles published *Assessing the relative importance of disturbance, herbivory, diversity, and propagule pressure in exotic plant invasion* in <u>Ecological Science</u>, in 2009. This article explored ecological threats of invasive plants and determining factors of invasion success. The authors developed ideas about which specific factors were the main reasons for invasions and why they are so successful. They also agreed with many other scientists in the determination that the current rate of invasions is alarming and worth further investigation.

Patrick Martin and Peter Marks authored *Intact forests provide only weak resistance to a shade tolerant invasive Norway Maple (Acer platanoides L.)* in 2006 and was published in The Journal of Ecology. This study was focused on determining if undisturbed, close canopied forests were resistant to invasive plant species. The authors introduced Norway Maple seedlings to five forests in New York and Connecticut that were previously undisturbed by any invasive species. This study was unique for that reason. The existing research regarding invasive plant species is dominated by studies that are performed on forests where invasives are already present.

Martin and Mark's research took place over five years and included several important environmental variables: soil type, soil moisture, light levels, elevation, hardiness zone, slope, and dominant tree species. The propagules that resulted from seed introduction were measured for emergence, survivorship and height growth. The data that were collected were subjected to two types of data analysis: Manova (multivariate analysis of variance), and the Shapiro-Wilk Goodness of Fit test. The authors hypothesized that the intact forests would be highly resistant to the invasion of Noway Maple seedlings, even in deeply shaded areas. The results of the data analysis suggested that the opposite was true. The authors found that undisturbed forests are vulnerable to Norway Maple invasion over long periods of time.

Methods

We established a randomly located study transect in the Gordon Natural Area that was approximately 670 meters in length. The transect runs from west to east in the northeastern section of the Gordon Natural Area. Along the transect we located twelve plots with a five meter radius that were approximately fifty meters apart. As we were setting up our plots, we came across a deeply thicketed area which was impassable. In order to maintain random plot locations along a transect, we took a south-eastern azimuth to avoid the heavy brush. Using a Garmin

ETREX GPS unit, we determined the longitude and latitude of each plot and placed a white flag in the center. Since we would be returning to the plots several times, the flags helped us locate our sites with relative ease among the many other study sites present in the GNA. Within each plot, we identified all tree species with a tree diameter at breast height (DBH) greater than five centimeters and also included two invasive woody species: Amur Honeysuckle (*Lonicera maackii*) and Norway Maple (*Acer platanoides*). Since Amur Honeysuckle (*Lonicera maackii*) is a shrub with many small stems, it is necessary to take the DBH of any stem larger than one centimeter and to take the square root of the sum in order to find average DBH. Norway Maple (*Acer planatoides*) is a classic shade tree which is typically dense and invasive over much of the northeast USA (Sibley, 2009).

Using Geographic Information Systems (GIS), we mapped the location of each plot using ArcMap 9.3 (ESRI, 2008) and the coordinates that we gathered in the field with aerial photography of the Gordon Natural Area. Also included in the mapping process were attribute data indicating past land use, and relevant spatial data including: existing trails, streams, roads, and forest boundaries. Using the GIS, we measured each plot's distance to the closest trail, stream, road, and forest boundary.

The mean basal area of the tree species and invasive species were calculated for each of the study plots. Non-metric multidimensional scaling (NMS) was performed on the entire dataset including; vegetation, distance to trail, distance to the road, distance to the stream, distance to the forest edge, and past land use. In order to ensure a consistent result, we ran the NMS six times with PC-ORD version 5 using Sørenson's distance measure and two hundred and fifty iterations of the data. The non-metric multidimensional scaling yielded ordination graphs that would help us gain an understanding of the impact of the environmental setting on the invasive species and make correlations between past and present land use variables and their effects on the species.

Results

The non-metric multidimensional scaling yielded ordination graphs. Upon analyzing the graphs developed by the NMS, several variables seemed to play considerable roles. Meanwhile, other variables seemed to not affect the distribution of invasive species in any way. The NMS graph of the relationship between all plots between two axes showed that there were some common characteristics between some of the plots. The cluster of six plots, including four from the old wood lot and two from the old orchard, shows that they are more strongly correlated than other plots not included in the cluster.

Another NMS graph that showed a strong relationship is that of the stream distance in relation to the location of the plots. This graph shows that four of six plots in the cluster and one other plot are influenced by stream distance. The graph showing the relationship between Tulip Poplars and the plots also shows a strong correlation. This graph shows that the Tulip Poplar may be the influencing factor that made the cluster of plots on the main graph. All six plots in the cluster show similarities in size and location between the 2 axes. These graphs were helpful in some ways but our lack of data became obvious after running it through NMS.

Discussion

After analyzing the data recorded and the ordination graphs developed from Non-metric Multidimensional Scaling, the results show some relationship between plots and invasive species. The most apparent relationship is that of the Amur Honeysuckle (*Lonicera macckii)*, which was found in four of twelve plots. Interestingly, three of the four plots were located in the old orchard area of the GNA. This proves a strong correlation between the exotic invasive Amur

Honeysuckle and past land use. Individual species showed more patterns in response to past land use than current land use (Lundgren & Small, 2004).

It is apparent that to successfully analyze the threat of invasives on the GNA, more data needs to be collected. This can be done in several ways, including making more plots. The plots for this article were set on a transect in the northern section of the GNA. We randomly chose to start from the western border and continue to the eastern border. However, after analyzing the data, we determined that a transect may not be the most encompassing method for analyzing invasives. It may be necessary to locate random plots differently. This can be done by locating several plots in each type of relevant spatial data and each type of past land use. One option would be to set up a larger number of plots in two specific areas; the old woodlot and the old orchard. The other alternative would be to select more random plots throughout the entire GNA for successful data analysis. Seeing as how Amur Honeysuckles (*Lonicera maackii*) was most prominent in the old orchard section of the GNA, locating plots by past land use would be most effective for analysis. By finding patterns in the generalities of invasive mechanisms, we can advance our capability of predicting and monitoring invasions (Eschtruth & Battles, 2009).

Another option for collecting more data would be to expand the plot radius. The five meter radius used in this study may not be quite large enough. As is obvious in our data, some plots do not contain a large quantity of trees. An increase in the plot radius could help solve this problem and give a much larger sample to work with. This may even allow for an expansion of the amount of invasives studied in the GNA. We came up with several different options to expand our plots in different areas. Along roads and trails, we would consider having 10 m x 5 m rectangular plots (Lundgren & Small, 2004). Within the old woodlot and the new orchard, we thought that increasing the plot radius to 10 m would provide better results. Lastly, in areas along a stream, we would consider changing the plot sizes similarly to the way plots by roads and trails were. Through making these changes, we really think we would see more correlations between past and present land uses and their effect on woody invasives.

Table 1: Species Matrix

TOTAL BASAL AREA (cm^2)

12 plots

11 species

	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
	Amer. Sycam.	Amur Honey.	Sugar Maple	Amer. Beech	Norway Maple	Tulip Poplar	White Oak	Red Oak	Red Maple	Black Cherry	White Ash
Plot1	528.12	6.40	893.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plot2	0.00	0.00	0.00	576.50	343.06	2266.24	0.00	0.00	0.00	0.00	0.00
Plot3	0.00	0.00	0.00	53.06	154.28	1929.66	1392.04	0.00	0.00	0.00	0.00
Plot4	0.00	0.00	0.00	1323.50	0.00	44.10	0.00	1395.35	0.00	0.00	0.00
Plot5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2777.51	230.73	0.00	0.00
Plot6	0.00	0.00	0.00	1470.44	455.54	86.59	0.00	0.00	0.00	0.00	0.00
Plot7	0.00	0.00	0.00	2508.27	501.99	1378.85	0.00	0.00	0.00	0.00	0.00
Plot8	0.00	0.00	0.00	0.00	0.00	4566.62	0.00	0.00	550.19	0.00	0.00
Plot9	0.00	0.00	0.00	0.00	0.00	3201.92	1302.91	0.00	0.00	183.25	918.08
Plot10	0.00	11.90	0.00	0.00	834.68	3654.23	0.00	0.00	0.00	0.00	0.00
Plot11	0.00	15.85	0.00	0.00	0.00	3804.59	0.00	0.00	0.00	322.69	0.00
Plot12	0.00	4.76	0.00	0.00	0.00	295.59	0.00	0.00	0.00	540.33	0.00
Total	**528.12**	**38.91**	**893.97**	**5931.77**	**2289.55**	**21228.39**	**2694.95**	**4172.86**	**780.92**	**1046.27**	**918.08**

Table 2: Environmental Matrix

DATA ANALYSIS (m)

12 plots

1: Old Wood Lot
2: Old Orchard

5 efactors

	Q	Q	Q	Q	C
	Dist. To road	Dist. To stream	Dist. To forest edge	Dist. To trail	Past Land Use
Plot1	249.9	2.49	17.13	31.73	2
Plot2	224.08	35.1	56.58	3.42	2
Plot3	180.77	80.34	100.59	52.54	2
Plot4	148.82	126.8	145.93	98.59	2
Plot5	120.86	171.87	91.72	82.11	2
Plot6	96.05	218.41	91.81	40.29	2
Plot7	71.88	264.29	111.51	7.71	2
Plot8	45.79	308.94	139.42	2.57	2
Plot9	18.65	371.22	144.67	32	2
Plot10	22.3	427.36	120.54	67.2	1
Plot11	76.55	459.38	163.07	67.73	1
Plot12	125.64	495.66	138.98	105.5	1
Total	**1381.29**	**2961.86**	**1321.95**	**591.39**	

Table 3: Main NMS Results

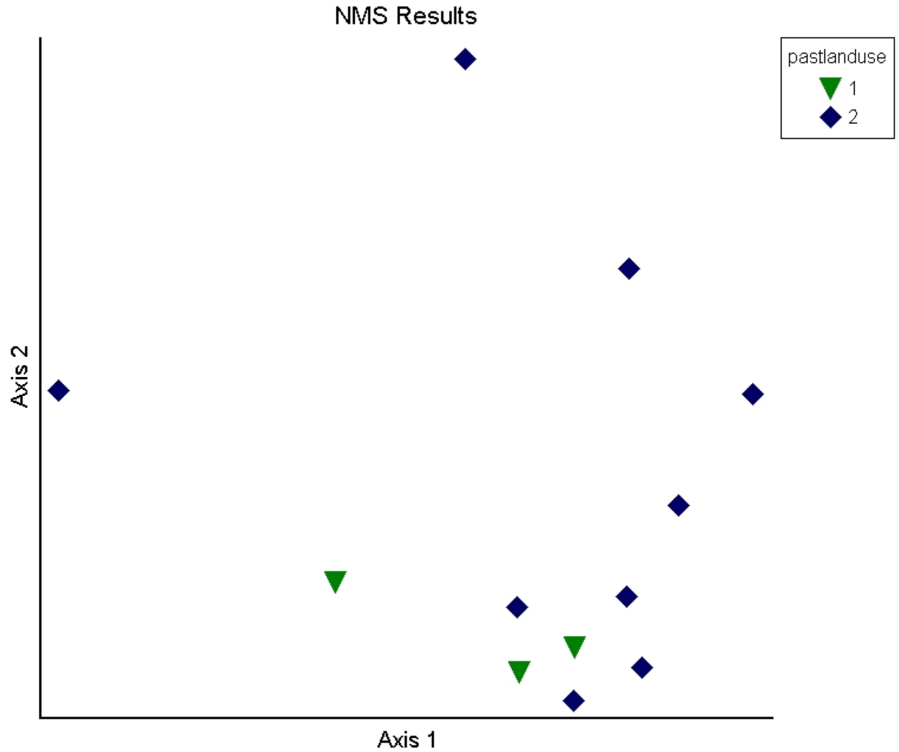


Table 4: Amur Honeysuckle Relationships to Past Land Use

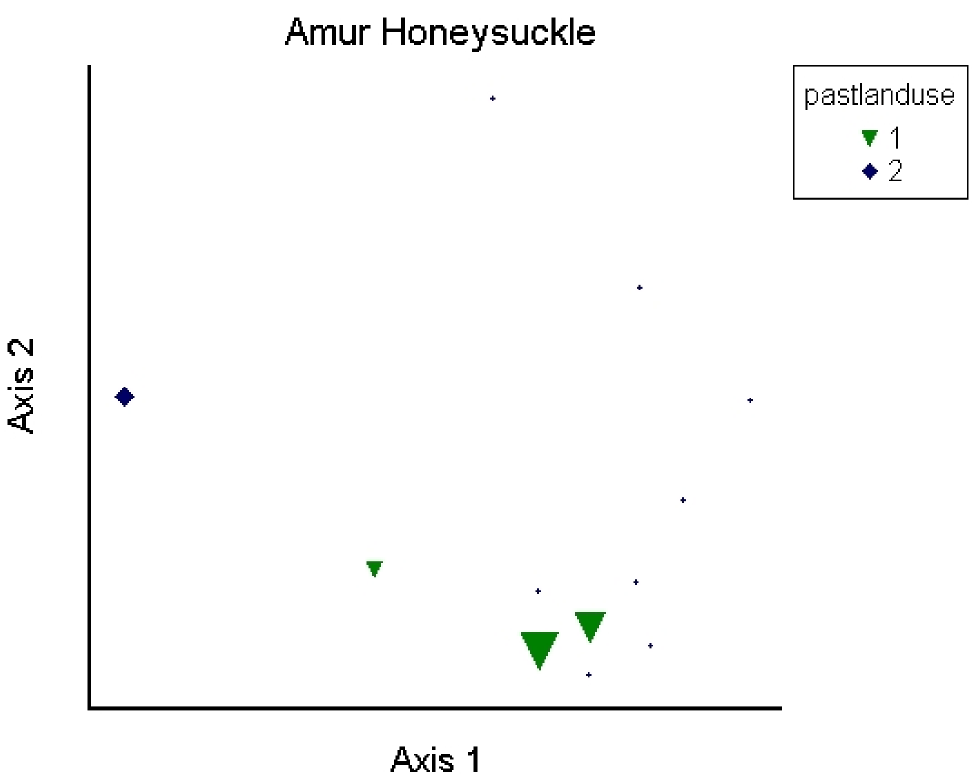


Table 5: Stream Distance Relationships to Past Land Use

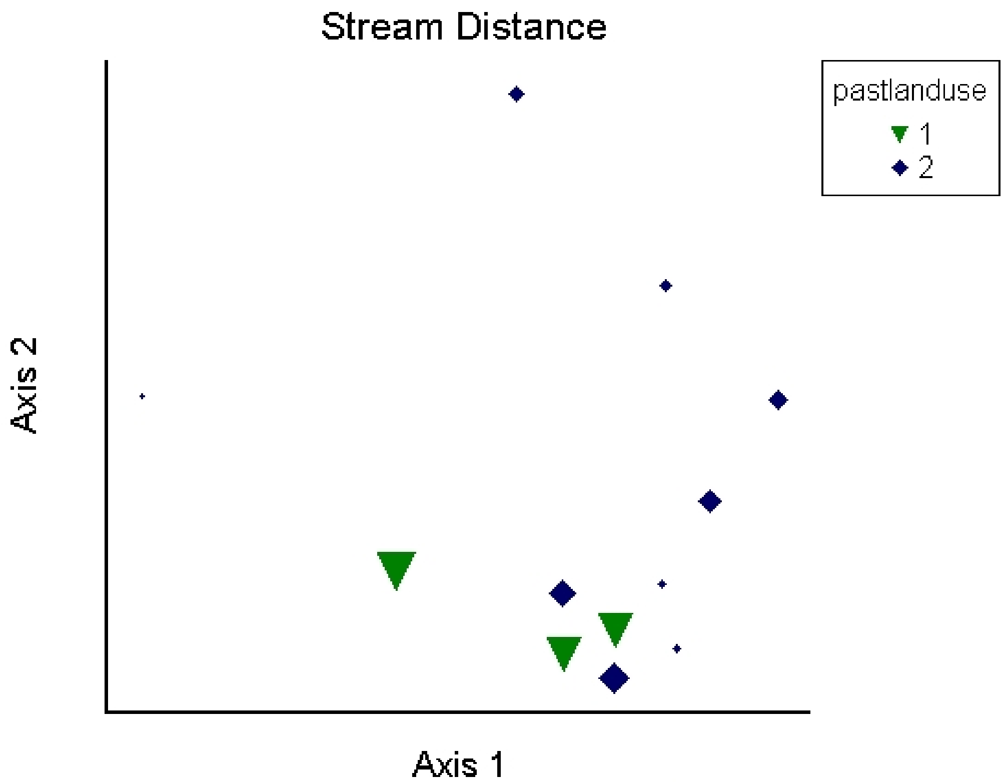


Table 6: Tulip Poplar Relationships to Past Land Use

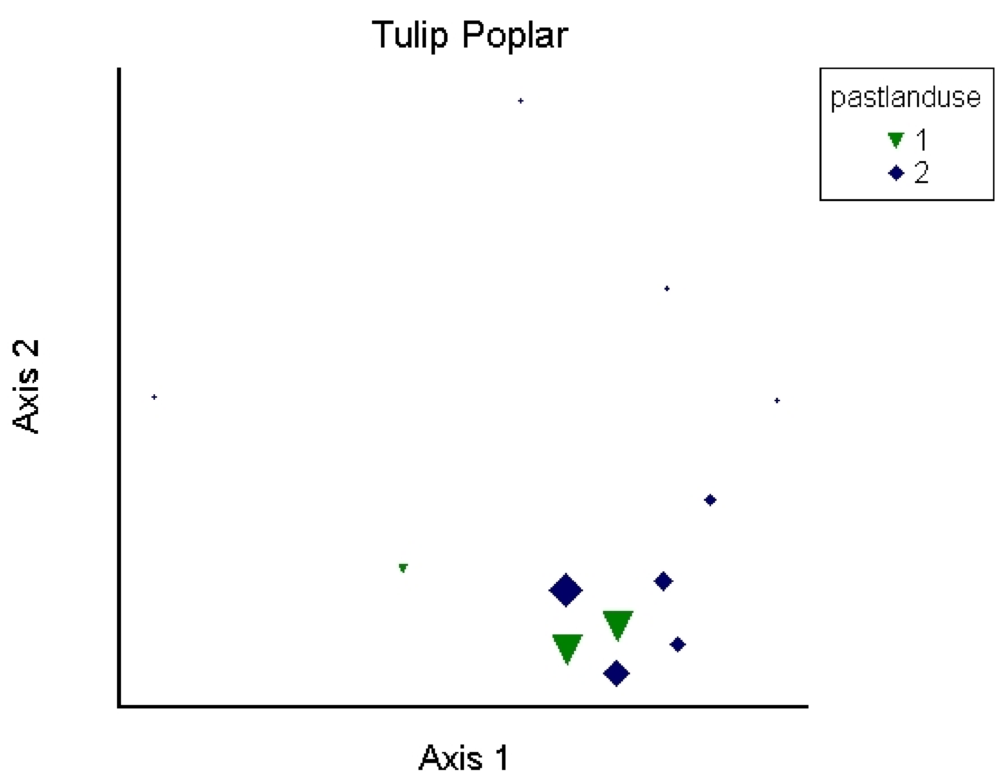
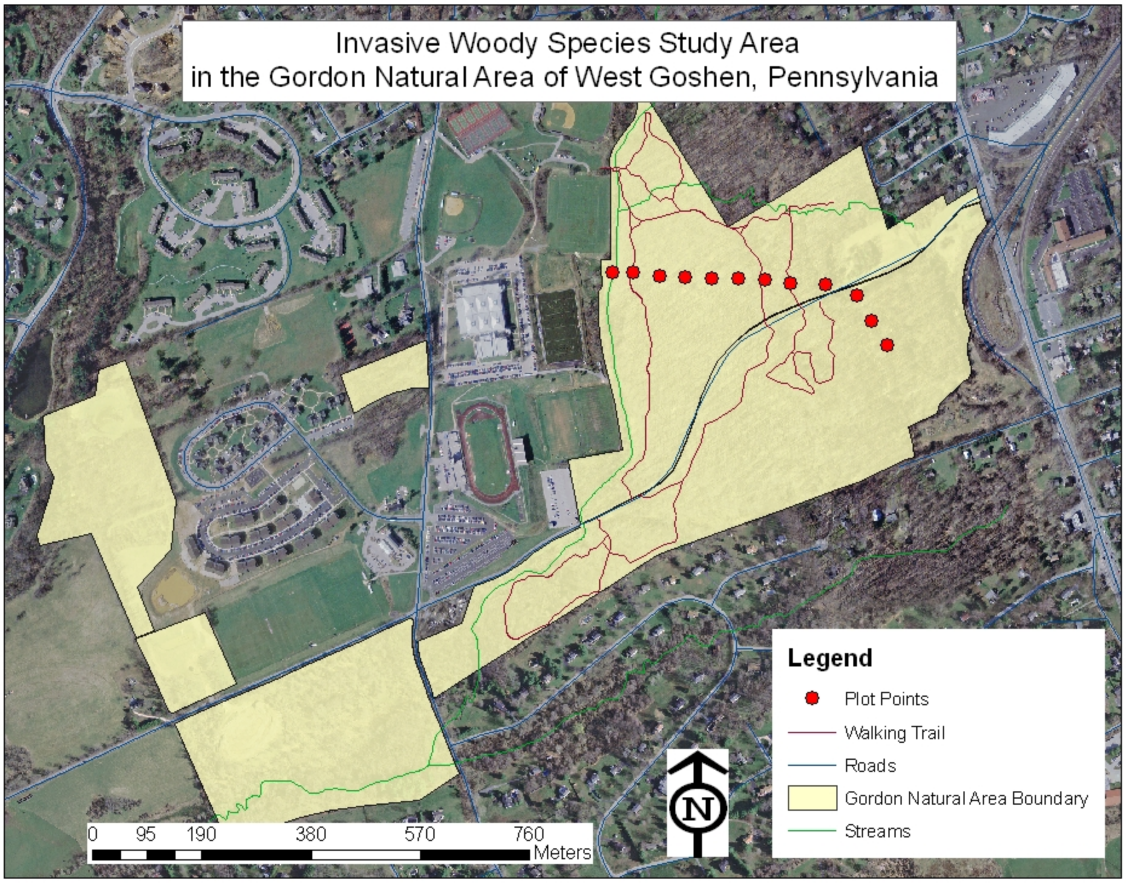


Table 7: Base map of Study Area



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