ARTICLE

A Field Investigation into the Effects of Anthropogenic Disturbances on Biodiversity and Alien Invasions of Plant Communities

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Abstract: The importance of biodiversity to the health of our planet is increasingly being discussed, not only by scientists, but by the public at large. Therefore, an understanding of how human activities are affecting biodiversity is vital for informed participation in society, and thus it is an important topic for liberal arts education. Here, I present the protocol and results for a field activity that I have used in a non-majors' biology course to investigate the influence of anthropogenic disturbances on plant communities. Students surveyed plant-species abundances in five sites that had experienced a range of disturbance regimes, including protected nature trails, mowed fields, and a ruderal (waste) site. Disturbances had a negative impact on measures of species richness, evenness, and diversity; moreover, disturbances made the plant communities much more susceptible to invasion by alien species. While the approach taken in this study worked very well in my non-majors' course, it could easily be adapted and refined for use in ecology, conservation, and botany courses for biology majors.

Keywords: biodiversity, conservation, disturbance, evenness, invasive plants, Simpson's index, species richness

INTRODUCTION

The scientific focus of conservation biology is on principles related to the protection of biological diversity, or "biodiversity." Biodiversity can be studied on a wide range of scales, from genetic variation among individuals of a species to the diversity of biomes across the globe. A particularly important scale is the community level, or the mixture of individuals of different species that occur together in the same location. The identities and relative abundances of the species within a community define the community's "structure," and the co-occurring species plus the abiotic aspects of the location constitute an "ecosystem." This paper reports on a field study conducted by a non-majors' biology course in which students measured plant-community structures and investigated how biodiversity was related to anthropogenic activities.

Biodiversity is a central focus of conservation largely because of its influence on the processes needed to maintain ecosystems so that they can provide services necessary for human well-being (Sekercioglu, 2010; Cardinale et al., 2011; Hooper et al., 2012; Liu, 2016; Thom & Seidl, 2016). These ecosystem services include water purification, flood control, pest control, carbon sequestration, decomposition, and pollination. Ecosystems also provide goods to humans, such as food, timber, biofuels, and medicine. More abstractly, biodiversity in ecosystems provides aesthetic, recreational, cultural, and even spiritual value to humans. Because biodiversity affects so many different aspects of our lives, even students with minimal interest in biology can find some reason to care about biodiversity.

Foremost among the factors believed to drive changes in biodiversity are what ecologists call "disturbances," which are defined as events that cause abrupt changes in the physical and biotic characteristics of an ecosystem, displacing or killing some or all of the individuals of some species and creating new opportunities for others (Sousa, 1984; Pickett & White, 1985; van der Maarel, 1993). Disturbances can be natural in origin (e.g., winds, floods, fires, waves, ungulate browsing, and pest outbreaks) or anthropogenic (e.g., logging, mining, agriculture, fires, dredging, and pollution). In addition, anthropogenic changes to the environment are increasing the frequency and severity of some natural disturbances, such as hurricanes, floods, and extreme-temperature events (Turner, 2010; Banks et al., 2013; Altman et al., 2016).

The ecological literature abounds with studies investigating the effect of disturbances on the diversity of a wide variety of taxa, including bacteria (Galand et al., 2016), insects (Yujie & Jindong, 2015), mollusks (Armenteros et al., 2016), fish (Partasasmita et al., 2015), plankton (De Backer et al., 2014), and plants in all sorts of environments (Radford, 2013; Clarke et al., 2015; Nylén & Luoto, 2015; Ripplinger et al., 2015; Baker et al., 2016; Tenzin & Hasenauer, 2016). Interestingly, disturbance seems to be as likely to increase the biodiversity of a community as it is to decrease it. Some of this variation in effects is predicted by the intermediate disturbance hypothesis, which posits that a moderate level of disturbance is necessary to maintain the greatest diversity in a community (Grime, 1973; Connell, 1978). While this hypothesis is still highly cited, many empirical results do not fit its predictions (Fox, 2013). Nevertheless, there is broad consensus that disturbances can have severe negative effects on the biodiversity of communities, and that anthropogenic disturbances can be particularly harmful (Kumar & Ram, 2005; Ripplinger et al., 2015; Tenzin & Hasenauer, 2016). Even so, there is still much to learn about why some disturbance regimes can be beneficial and others detrimental to the biodiversity of a community (Mackey & Currie, 2001; Kershaw & Mallik, 2013).

Disturbances are also believed to be major factors leading communities to be susceptible to colonization by alien (i.e., non-native, non-indigenous, or exotic) species (Larson et al., 2001; Rodgers & Parker, 2003; Paiaro et al., 2007; Eschtruth & Battles, 2009; Torbick et al., 2010). The introduction of alien species, in turn, is one of most significant factors reducing the biodiversity of communities (Lodge, 1993; Vitousek et al., 1996; Lonsdale, 1999; Cameron et al., 2016). If alien species become so abundant in a community that they force out native species or disrupt the normal functioning of the ecosystem, then they are considered "invasive" species. Invasive species have been found to be responsible for negative impacts on a variety of ecosystems (Ehrenfeld, 2010; Simberloff, 2011), as well as for tremendous economic losses (Pimentel et al., 2005; Marbuah et al., 2014). As is the case for the disturbance-diversity relationship, the nature of the relationship between invasive species and the biodiversity of communities is not always clear-cut (Dukes & Mooney, 1999; Davis et al., 2000; Parker et al., 2006; van Kleunen et al., 2010; Bennett et al., 2011; Radford, 2013).

The field study described in this paper examined the relationships among biodiversity, disturbance, and invasive species. The study included plant communities in five fields covering a range of disturbance regimes. This study served as a final project for a non-majors' course in global-change biology, and it comprised four main learning outcomes: At the end of the project, students should be able to 1) communicate the importance of biodiversity; 2) explain the connections between biodiversity, disturbance, and invasive species; 3) demonstrate proficiency using the scientific method to address an important question in conservation biology; and 4) use

Excel to calculate a variety of diversity-related metrics and construct graphs. Achievement of these learning outcomes was assessed through a comprehensive lab report, which was written in a standard style for a journal article in ecology. In their papers, students were required to include the following components: 1) introduction of the questions and hypotheses addressed in the study, citing relevant articles; 2) clear explanation of the methods; 3) correct analysis of data; 4) professional-quality graphs; and 5) clear interpretation and communication of the results and their broader implications.

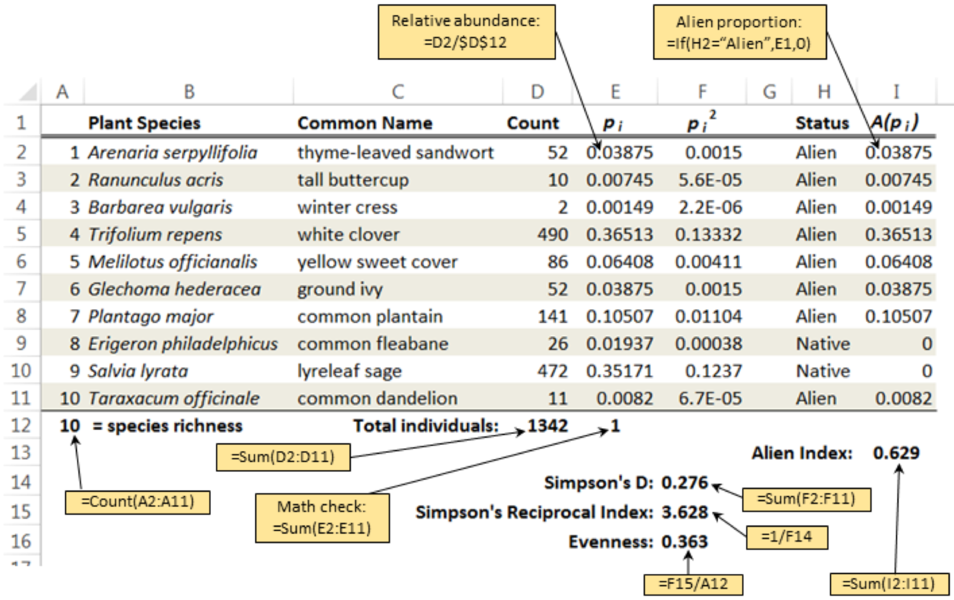
METHODS

The field activity described in this paper was designed for the course INQ 250: Biology on a Changing Planet. This is a non-science majors' course in the general education, or "Inquiry," curriculum at Roanoke College, a selective liberal arts college of ~2000 students in Salem, VA, USA. The focus of the course was how technological innovations and environmental changes affect humans and non-human life across the globe. The general requirements for an INQ 250 course include a quantitative aspect, reading of scientific literature, and a writing assignment in the format of a scientific study (i.e., a lab report or journal article). The Biology on a Changing Planet section of INQ 250 was taught in the spring semesters of 2011, 2012 and 2014, and each section contained 24 students. The class met for three one-hour "lecture" periods and for one three-hour lab period per week.

My preparation for the activity mainly involved reconnaissance work to locate suitable field sites. These sites had to be close to campus, publicly accessible, and encompass a range of disturbance levels. Each site had to contain a community of plants that were easily counted and could be recognized by non-experts. Mid-April worked well for data-collection in southwestern Virginia, as many of the spring-ephemeral wildflowers were in bloom. With a field guide in hand, I surveyed the sites and made a list of the plant species I found. For simplicity, I did not include grasses, trees, or shrubs. I thus only considered forbs, or broad-leaved, herbaceous angiosperms.

I settled on five field sites within two larger locations near the Roanoke College campus—a public park in Roanoke County (Green Hill Park, or "GHP") and a Nature Conservancy-owned preserve in Montgomery County (Falls Ridge Preserve, or "FRP"). I chose three sites within ~0.5 km of each other at GHP: 1) a section of a nature trail within but near the edge of a wooded area; 2) an open field that is mowed or hayed approximately bimonthly during the summer and fall; and 3) a waste area that serves as a location for dirt to be used for fills or construction. The soil in the waste area is plowed into new piles annually, which completely removes most of the existing vegetation. I refer to these three sites as "protected," "mowed," and "ruderal," respectively. I chose two sites within ~0.1 km of each other at FRP that were very similar in ecology and disturbance regime to the first two sites at GHP, and I also refer to them as "protected" and "mowed."

For illustration, I will describe the methods and results from 2012 only. I took half of the class to GHP during our lab meeting on April 10, and the other half of the class to FRP on April 17. Upon reaching a site, I kept the students together as a group to point out the boundaries of the site and discuss the type and frequencies of disturbances the site had undergone. As we stood together, I asked students to look around and point out a plant as they noticed it. A few students were familiar with some plants, so I made sure to give them an opportunity to demonstrate their knowledge before I spoke up. Once we had found and discussed all the species on my list, each student (or pair of students) was assigned to be responsible for one or more plant species.



	A	B	C	D	E	F	G	H	I
1		**Plant Species**	**Common Name**	**Count**	p_i	p_i^2		**Status**	$A(p_i)$
2	1	*Arenaria serpyllifolia*	thyme-leaved sandwort	52	0.03875	0.0015		Alien	0.03875
3	2	*Ranunculus acris*	tall buttercup	10	0.00745	5.6E-05		Alien	0.00745
4	3	*Barbarea vulgaris*	winter cress	2	0.00149	2.2E-06		Alien	0.00149
5	4	*Trifolium repens*	white clover	490	0.36513	0.13332		Alien	0.36513
6	5	*Melilotus officianalis*	yellow sweet cover	86	0.06408	0.00411		Alien	0.06408
7	6	*Glechoma hederacea*	ground ivy	52	0.03875	0.0015		Alien	0.03875
8	7	*Plantago major*	common plantain	141	0.10507	0.01104		Alien	0.10507
9	8	*Erigeron philadelphicus*	common fleabane	26	0.01937	0.00038		Native	0
10	9	*Salvia lyrata*	lyreleaf sage	472	0.35171	0.1237		Native	0
11	10	*Taraxacum officinale*	common dandelion	11	0.0082	6.7E-05		Alien	0.0082
12	**10**	**= species richness**	**Total individuals:**	**1342**	**1**				
13								**Alien Index:**	**0.629**
14					**Simpson's D: 0.276**				
15					**Simpson's Reciprocal Index: 3.628**				
16					**Evenness: 0.363**				

Fig. 1. Excerpt of Excel file used to calculate diversity metrics. Data shown are for the mowed site at Falls Ridge Park. Yellow callouts indicate formulas typed into the cells. If the "Math check" cell does not equal 1, then there has been an error in data entry or in a formula.

The students were charged with counting as many individuals of their species as they were able across the site, being careful to stay within the designated boundaries of the site. I used the opportunity to discuss the distinction between a genet (a genetic individual) and a ramet (a physically distinct plant with its own main stem). For example, a patch of ten trillium ramets could be descended from ten different seeds, or they could all be clonal copies of a single genet, originating from a single seed. For the purpose of assessing community-level diversity, we were interested in how many stems of a species occupied the space. Therefore, we defined an individual plant as a separate main stem, and thus students counted ramets irrespective of genets.

Once all species were assigned, students were released simultaneously to count their plants as quickly, but carefully, as they could. During the counting period, I circulated among students to answer questions and help with identifications. I stopped the counting period once students began to exhaust their counting (which ranged from 4-11 minutes per site). This sampling scheme was not intended to provide a precise count of the total number of plants. However, assuming the students worked with comparable diligence, the data should represent reliable estimates of the relative numbers of individual plants for each species (Appendix 1).

All of the analyses were performed using Excel. We met in a computer lab during class so that I could assist students with the analyses. Students were provided with a spreadsheet with five groups of rows—one group for each site (Figure 1). Within each site was a list of the species' names and the number of individuals counted. Students first had to calculate the relative abundance (p_i) for each of the species, which is defined as the proportion of the total number of individuals counted in a site that is made up of each species. (The subscript, *i*, is used to designate that there is a separate value for each species.)

Students then made rank-abundance graphs, which are used to visualize several aspects of a community's structure. Within a site, the species are first ranked according to relative abundance, with the most abundant species ranked "1." Then the relative abundances are graphed (on the y-axis) against the rankings (on the x-axis). In Excel, a good choice for the "chart" type is "scatter with straight lines and markers." It is standard for a rank-abundance graph to display the Y-axis on a logarithmic scale, which can be accomplished in Excel by choosing the "logarithmic axis" button on the format axis menu. The default option of "base 10" for the logarithm is most straightforward and easy to explain to students. While students can make separate graphs for each site, they should eventually make a single graph containing separate curves for all the sites (Fig. 2).

The most basic descriptor for community structure is the number of different species present, which is called the species richness (*S*). The species richness for a site can be quickly read from a rank-abundance graph by looking at the rank number on the x-axis that is associated with (i.e., is directly below) the rightmost point on the curve for that site.

While species richness is consistent with our notion of the diversity of a community, it does not tell the whole story. Specifically, richness gives no insight into another fundamental aspect of diversity—how "even" the relative abundances are among species. For instance, consider two communities that each contains 10 different species. The individuals of the first community may be composed of 99.1% members of just one species, and 0.1% of each of the other nine. In contrast, the species in the second community might each make up 10% of the total community. While both communities have the same richness, the second is more diverse because it has a much greater evenness.

Ecologists have devised a variety of diversity metrics that incorporate both richness and evenness. One such metric is the Simpson's reciprocal index, which can be calculated with the following formula:

$$1/D = 1 \div \sum_{i=1}^{S} (p_i^2)$$

Where Σ indicates the sum across all species, p_i is the proportion of a sample that is made up species i, and S is species richness. The larger the value of *1/D*, the greater the diversity of the community. The Simpson's reciprocal index can conveniently be calculated from the same spreadsheet as the relative abundances. A column can be added to the right of the p_i column to calculate the squares of the p_i values (see

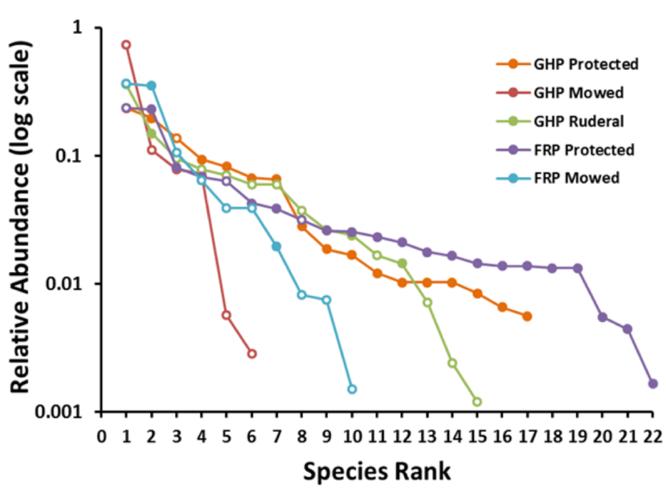


Fig. 2. Rank-abundance graph for plant communities in the five field sites. Filled circles represent native species, and open circles represent alien species

Field Site	Species Richness	Species Evenness	Simpson's Recip. Ind.	Alien Index
GHP Protected	17	0.43	7.25	0.14
GHP Mowed	6	0.30	1.79	1.00
GHP Ruderal	15	0.37	5.51	0.81
FRP Protected	22	0.34	7.56	0.33
FRP Mowed	10	0.36	3.63	0.63

Table 1: Summary of biodiversity metrics for the five sites at Green Hill Park (GHP) and Falls Ridge Preserve (FRP).

Column F in Fig. 1). The sum of these squares can be calculated in a cell at the bottom of the column, and the reciprocal of these squares can be calculated in a separate cell. This value is the Simpson's reciprocal index for the site.

The relative evenness of different communities can be observed on a rank-abundance graph, where a steeper slope generally indicates a lower relative evenness. The evenness (E) can also be quantified by factoring the richness component out of the diversity index. Specifically, a community's evenness is calculated by dividing the Simpson's reciprocal index by species richness: $E = 1/(DS)$. (See Cell F16 in Fig. 1.)

A final goal was to quantify the relative influence of alien species on the plant communities. Rather than just counting the number of alien species present, I desired a metric that gave a better sense of the proportion of the total community made up by alien individuals. Two additional columns were required in the Excel spreadsheet. Cells in the first column simply indicate whether the species was "Alien" or "Native" (Column H in Fig. 1). If a species was alien, then the relative abundance of the species would be copied into the next column (Column I in Fig. 1). The sum of the values in the second column was called the "alien index," and it could range from 0 if there were no alien species in the community, to 1 if every individual plant was of an alien species.

RESULTS AND DISCUSSION

Students counted 4776 individual plants representing 49 different species (Appendix 1). The species richness of the forb communities varied more than threefold across the five sites, from a low of 6 in the GHP mowed site to a high of 22 in the FRP protected site (Fig. 2; Table 1). Disturbance had a negative effect on species richness, with the two low-disturbance, protected sites having the greatest richness, and the two mowed sites having the lowest richness. While the ruderal site at GHP had the most severe disturbance, this site had an intermediate richness value—closer to the protected than the mowed site at GHP. Notably, the complete clearing of the land in the ruderal site opened up opportunities for many species that were good dispersers to colonize the site. In contrast, the more-frequent but less-severe disturbance of mowing encouraged the establishment of competitive grass species, leaving less open space for colonization by forb species.

Disturbance had a less-consistent effect on species evenness of the forb communities. Nevertheless, the community with the lowest evenness was at a mowed site, and the community with the highest evenness was at a protected site (Table 1). These patterns can be seen on the rank-abundance graph, as the GHP mowed site had the curve with the steepest slope, and the GHP protected site had the curve with the most-gentle slope (Fig. 2). Low values of evenness are generally associated with community structure being dominated by one or a small number of species. For instance, the GHP mowed site was dominated by common buttercup, which made up 73% of the total number of individuals of forbs (Appendix 1). In contrast, the most abundant species in the GHP protected site (large-flowered trillium) made up just 23% of the total number of individual forbs.

The Simpson's reciprocal index gives a more complete story of diversity because it incorporates both richness and evenness. The two protected sites had similarly high diversity indices ($1/D > 7.0$), while the two mowed sites had much lower diversity indices ($1/D = 1.8$ and 3.6). The ruderal site had an intermediate diversity index of 5.5 (Table 1).

The effects of disturbance on invasibility were even more striking. In particular, 16 of the 17 forb species in the protected site at GHP were native, and 19 of the 22 forb species at the protected site at FRP were native (Appendix 1). In contrast, all six of the forb species in the mowed site at GHP were alien, eight of the 11 forb species in the mowed site at FRP were alien, and 12 of the 15 species in the ruderal site at GHP were alien. Thus disturbance, regardless of the frequency or severity, seemed to open up a site to colonization by non-native species.

Moreover, some of the alien species tended to be inordinately abundant, as reflected in the alien-indices. In the ruderal and the two mowed sites, respectively, 81%, 63%, and 100% of the individual ramets were of alien species (Table 1). It was quite clear that disturbance made the sites more susceptible to invasive alien species, including white clover, winter cress, common buttercup, spring vetch, and common plantain. The low-disturbance sites were not immune to invasive species, however, with purple dead-nettle and stinging nettle combining to make up ~30% of the individuals in the FRP protected site, and garlic mustard making up ~14% of the individuals in the GHP protected site (Appendix 1).

The effect of disturbance on biodiversity is very much scale-dependent (van der Maarel, 1993; Hamer & Hill, 2000; Woods et al., 2016). Specifically, at the within-site scale in this study, disturbance had a negative impact on plant-community diversity. However, if one looks at a larger scale, then disturbance can be interpreted to have increased plant-community diversity. For example, consider what the forb community would look like if the entire land area of Green Hill Park had been left undisturbed. The community composition for the whole park would likely be very similar to what was found in just the protected site. Different disturbance regimes created more habitat types and new niches that could be filled by a wider variety of species. Thus, an important lesson is that disturbance can have one effect on biodiversity when considered on a local scale, and an opposite effect when considered on a regional scale. Whether disturbance is "good" or "bad" for conservation is largely determined by the perspective and goals of the observer.

CONCLUSION

All factors considered, this field activity was a resounding success. I believe that the feature that most contributed to the success was the method used to collect field data. Although our quick-and-dirty counting method did not provide the most precise data, I am confident that the results were representative of reality. Moreover, the results were interpretable by the students, who were thus able to tell a coherent and compelling story in their reports. Because we used real-world data, the results were not trivial or obvious in advance—a feature that increased the students' interest in their data. Furthermore, the students seemed to have a lot of fun with the activity. Rather than the tedium often associated with data collection, the technique we used came across more like a scavenger hunt. Most of the students enjoyed a chance to spend the lab outside, and several seemed to appreciate learning to identify some flowering plants—a skill that they will be able to build upon and show off long after the end of this course.

Although this activity worked very well as the final lab project for a spring-semester course in southwestern Virginia, it might be problematic for use in more northern areas, where not many plants will be in flower until after the spring semester ends. However, the activity should be easily adaptable for a course in May or June. I expect it would work in the fall as long as data are collected early in the semester. Certainly, the set of plant species will be different, but plenty of species flower in autumn. Furthermore, earlier-flowering species may still be identifiable from their fruits or leaves.

While this activity was designed for a non-science majors' course, it could be refined for upper-level biology courses. For instance, an ecology class might be interested in employing more-precise sampling techniques (e.g., quadrats or transects), including more quantitative measures (e.g., Sorensen's coefficient of community, percent similarity, and gamma diversity), and analyzing data with statistical tests. A conservation-biology class might be interested in a wider range of disturbance regimes, including looking at restoration sites. Students in a field botany class could be given more autonomy by choosing their own sites and doing their own plant identifications.

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Appendix 1. Summary of plant counts for the five field sites. The counts were numbers of individual ramets (or separate stems) of plant species found at the sites within a specified timeframe.

Green Hill Park - Protected Site
(1075 individuals counted in 7 minutes)

Plant Species	Common Name	Status	Count	Relative Abund.
Uvularia perfoliata	perfoliate bellwort	native	7	0.65%
Polygonatum biflorum	Solomon's seal	native	11	1.02%
Trillium grandiflorum	large-flowered trillium	native	252	23.44%
Asarum canadense	wild ginger	native	18	1.67%
Caulophyllum thalictroides	blue cohosh	native	9	0.84%
Jeffersonia diphylla	twinleaf	native	20	1.86%
Podophyllum peltatum	may-apple	native	211	19.63%
Sanguinaria canadensis	bloodroot	native	88	8.19%
Alliaria officinalis	garlic mustard	alien	146	13.58%
Dentaria laciniata	cut-leaved toothwort	native	11	1.02%
Fragaria virginiana	common strawberry	native	30	2.79%
Toxicodendron radicans	poison ivy	native	6	0.56%
Viola papilionacea	common blue violet	native	100	9.30%
Viola canadensis	Canada violet	native	70	6.51%
Osmorhiza longistylis	anise-root	native	72	6.70%
Galium aparine	cleavers	native	13	1.21%
Erigeron pulchellus	robin's plantain	native	11	1.02%

Green Hill Park - Mowed Site
(706 individuals counted in 4 minutes)

Plant Species	Common Name	Status	Count	Relative Abund.
Spergularia rubra	sand spurrey	alien	55	7.79%
Arenaria serpyllifolia	thyme-leaved sandwort	alien	2	0.28%
Ranunculus acris	tall buttercup	alien	516	73.09%
Vicia sativa	spring vetch	alien	78	11.05%
Veronica serpyllifolia	thyme-leaved speedwell	alien	4	0.57%
Plantago major	common plantain	alien	51	7.22%

Green Hill Park - Ruderal Site
(836 individuals counted in 10 minutes)

Plant Species	Common Name	Status	Count	Relative Abund.
Rumex crispus	curled dock	alien	6	0.72%
Phytolacca americana	pokeweed	native	20	2.39%
Ranunculus acris	tall buttercup	alien	1	0.12%
Alliaria officinalis	garlic mustard	alien	50	5.98%
Brassica rapa	field mustard	alien	2	0.24%
Barbarea verna	early winter cress	alien	50	5.98%
Barbarea vulgaris	winter cress	alien	300	35.89%
Vicia sativa	spring vetch	alien	65	7.78%
Asclepias syriaca	common milkweed	native	12	1.44%
Glechoma hederacea	ground ivy	alien	14	1.67%
Lamium purpureum	purple dead nettle	alien	79	9.45%
Datura stramonium	jimsonweed	alien	22	2.63%
Veronica serpyllifolia	thyme-leaved speedwell	alien	31	3.71%
Solidago gigantea	late goldenrod	native	125	14.95%
Taraxacum officinale	common dandelion	alien	59	7.06%

Falls Ridge Preserve - Protected Site
(817 individuals counted in 11 minutes)

Plant Species	Common Name	Status	Count	Relative Abund.
Arisaema triphyllum	Jack-in-the-pulpit	native	38	2.09%
Smilacina racemosa	Solomon' plume	native	3	0.17%
Trillium grandiflorum	large-flowered trillium	native	25	1.38%
Urtica dioica	stinging nettle	alien	114	6.27%
Asarum canadense	wild ginger	native	70	3.85%
Ranunculus abortivus	kidneyleaf buttercup	native	10	0.55%
Thalictrum dioicum	early meadow rue	native	8	0.44%
Aquilegia canadensis	columbine	native	24	1.32%
Actaea pachypoda	white baneberry	native	124	6.82%
Jeffersonia diphylla	twinleaf	native	30	1.65%
Podophyllum peltatum	may-apple	native	147	8.09%
Corydalis flavula	yellow corydalis	native	24	1.32%
Dentaria laciniata	cut-leaved toothwort	native	77	4.24%
Mitella diphylla	miterwort	native	47	2.59%
Viola papilionacea	common blue violet	native	42	2.31%
Viola striata	pale violet	native	417	22.95%
Glechoma hederacea	gill-over-the-ground	alien	57	3.14%
Lamium purpureum	purple dead nettle	alien	431	23.72%
Galium aparine	cleavers	native	32	1.76%
Solidago gigantea	late goldenrod	native	46	2.53%
Erigeron pulchellus	robin's plantain	native	26	1.43%
Actinomeris alternifolia	wingstem	native	25	1.38%

Falls Ridge Preserve - Mowed Site
(1342 individuals counted in 8 minutes)

Plant Species	Common Name	Status	Count	Relative Abund.
Arenaria serpyllifolia	thyme-leaved sandwort	alien	52	3.87%
Ranunculus acris	tall buttercup	alien	10	0.75%
Barbarea vulgaris	winter cress	alien	2	0.15%
Trifolium repens	white clover	alien	490	36.51%
Melilotus officianalis	yellow sweet cover	alien	86	6.41%
Glechoma hederacea	ground ivy	alien	52	3.87%
Plantago major	common plantain	alien	141	10.51%
Salvia lyrata	lyreleaf sage	native	472	35.17%
Erigeron philadelphicus	common fleabane	native	26	1.94%
Taraxacum officinale	common dandelion	alien	11	0.82%