

The Abundance and Spatial Distribution of Herbaceous and Woody Vegetation Along Old Field Margins in Three Upstate New York Fields

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Abandoned agricultural fields are a prominent landscape feature of the Great Lakes region of North America. When fields are abandoned, species are influenced by the nature of the surrounding landscape. This study examined the abundance and spatial distribution of woody and herbaceous vegetation species along old field margins (within 25 m of field edge or hedgerow) and the structure and composition of adjacent hedgerows. Ordination and regression analysis examined the preference of certain species, both herbaceous and woody, for either edge or field interior environments. No herbaceous species were found to decrease significantly with distance from the field edge. Two groups of species were easily identified; a group of field species found occurring with greater frequency in the last ten meters of transects, away from the field edge, and a group of edge species occurring with greater abundance in the first ten meters of transects. In general, total tree seedling densities significantly decreased with distance from the edge, but this study found no correlation between woody species establishment and species composition of hedgerows, except for sugar maple. Since this study was able to quantify an edge community for both herbaceous and woody species, given time, the edge communities may be used as a possible indicator of vegetation change for the old field community.

Keywords: Old field succession, edges, hedgerows, ordination

Agricultural fields are common elements in the diverse landscape mosaic of the northeastern United States and southeastern Canada. This fragmented landscape mosaic is composed of agricultural fields, post-agricultural fields, hedgerows, edges (borders), forests, and human habitations (McDonnell 1988). When fields are abandoned, the species composition of these successional communities is influenced by the nature of the surrounding landscape as adjacent vegetation acts as a seed source, varying from edge to edge for any given field.

The physical properties of the environment being colonized, coupled with varying seed inputs and survivorship, result in a heterogeneous pattern of vegetation composition and abundance (Armesto and Pickett 1986; Kelly and Canham 1992; Cogliastro et al. 1997).

Interaction between old field vegetation and adjacent vegetation can influence the rate and direction of vegetation change within an old field (McDonnell 1988). Trees along fences (such as hedgerows) and secondary woodlots (or plantations) serve as seed sources for the invasion of woody plants (McQuilkin 1940; Golley and Gentry 1965; Buell et al. 1971; McDonnell and Stiles 1983; Gill 1987; Rankin and Pickett 1989; Armesto et al. 1991; Gill and Marks 1991; Goldblum 1998). This edge effect may result in more seedlings and saplings of woody species along edges (McCormick and Buell 1957; McDonnell and Stiles 1983; Meiners et al. 2002) and variations in the herbaceous flora in terms of species composition and abundances with distance from the field edge (Whitford and Whitford 1978; Forman and Godron 1981; Meiners and Pickett 1999). As a result of species patterning edge environments have the potential to control the direction of plant community change in fragmented systems (Meiners et al. 2002).

The distribution of species and their relative abundances may result from variation in seed input as a result of proximity to source, yearly variation in seed production and survivorship, mode of dispersal, and predation (Gill 1987; Gill and Marks 1991; Schupp 1995; Meiners et al. 2000). In general, wind-dispersed seeds have been found to establish sooner after abandonment than animal-dispersed seeds (Buell et al. 1971) and the distribution of animal-dispersed species does not seem to be as clearly related to distance as wind-dispersed seeds (Gill 1987). The behavior of the dispersal agent (for animal dispersed seeds) is influenced by the availability of perch sites, availability of food, low apparency to predators and exposure (McDonnell 1988).

The emphasis of this study is the change in old-field vegetation with increasing distance from the field margin or edge. The main research question examined was; how do species composition, abundance and associations change from the field edge towards the center of the field for both herbaceous and woody species?

Study Area

This study was conducted at the E.N. Huyck Preserve (established in 1931), located in Albany County, New York State (42° 31' N, 74° 09' W) (Figure 1). The elevation of the area is between 425 and 500 m (1400 to 1700 ft ASL) (Odum 1943), on top of the Helderberg Plateau with an underlying geology of alternating sandstone and shale layers resulting in generally thin and rocky soils (Odum 1943; Russell 1958). The climate is primarily continental in character with an annual mean temperature of 6.7 °C (Berne, NY, 550 m ASL). The highest mean monthly temperature occurs in July (19.9 °C) and the lowest in January (-6.4 °C) (Thaler 1992). The annual precipitation totals, based on averages from 1963 to 1991, is 1287.1 mm.

During the 19th century and early 20th century most of the area was cleared and under agricultural use, such as hay fields and grazing. Today, *Acer saccharum* (sugar maple), *Tsuga canadensis* (hemlock), and *Fagus grandifolia* (beech) are the dominate canopy species in the forest, while the dominant sub-canopy species are *Fraxinus americana* (american ash), *Betula papyrifera* (white birch), and *Ostrya virginiana* (hop hornbeam) (Beatty 1984, 1991).

Methodology

Three abandoned fields were sampled in 1992 and 1993 (Figure 1). Fields 1 (2.4 ha) and 2 (2.0 ha) were contract hayed until approximately 1972, and field 3 (3.7ha) was abandoned in 1968 (Figure 1). All three fields were originally plowed and planted with two species of hay, *Phleum pratense* (timothy) and *Lotus corniculatus* (Birdsfoot-trefoil) (Dr. R. Wyman and Mr. L. Bryan, pers. comm.). In air photos from the early 1960's, cows are evident in field 3. The eastern edge of field 3 was abandoned several years prior to the rest of the field, due to the steep slope (Mr. L. Bryan pers. com.).

Line transects, 25 meters in length extending from the field edge towards the field interior were used for vegetation surveys with any species touching the line included. The field edge was defined as the point at which tree stems greater than 10 cm dbh occurred. Two transects were placed along each field edge at 1/3 and 2/3 the length of the field, with 24 transects established in three fields. None of the transects overlapped at any point. Along each transect all species were identified (nomenclature follows Gleason and Cronquist 1991) and the vegetation cover was

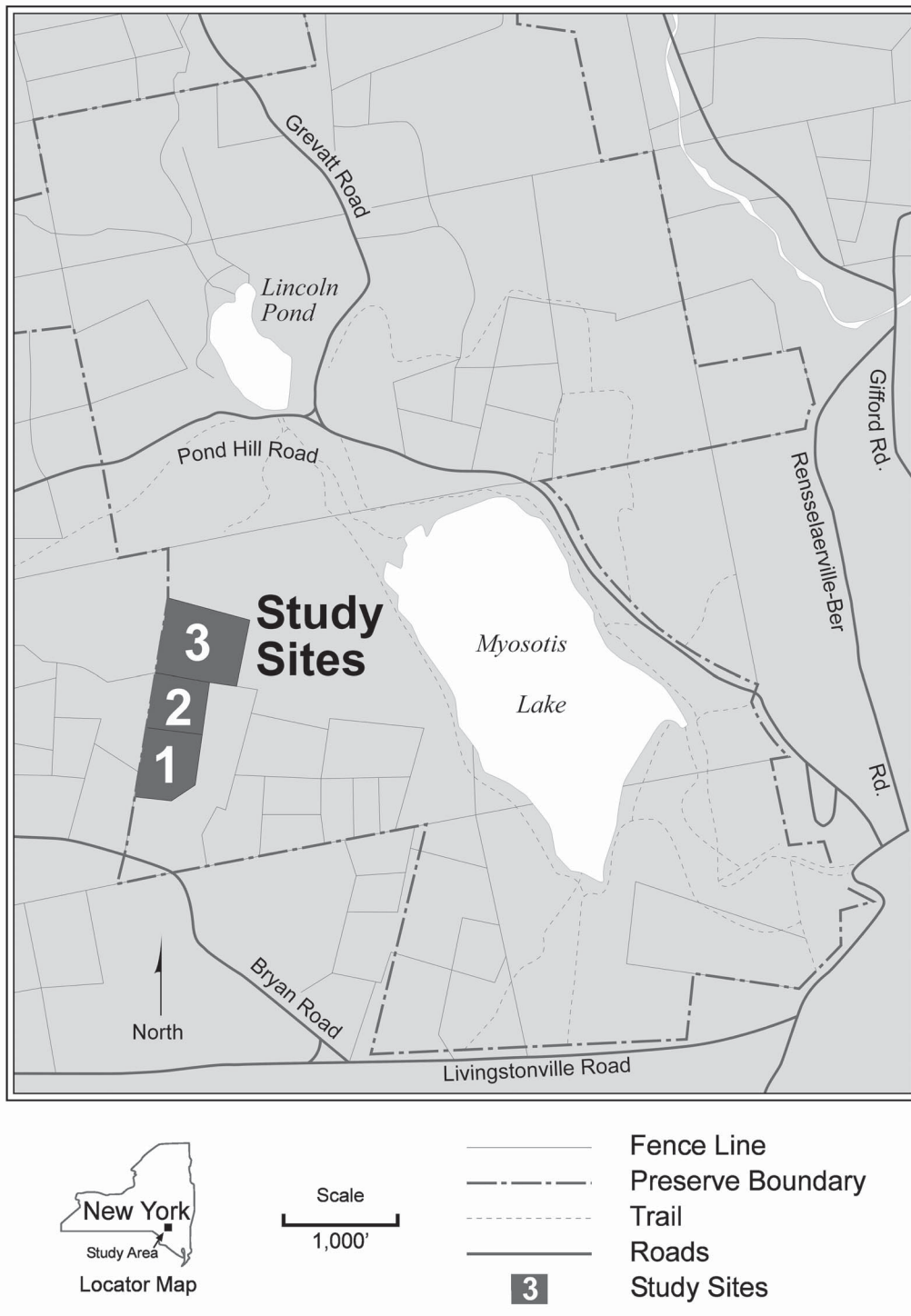


Figure 1: Map of a portion of the E.N. Huyck Preserve showing the relationship of the three study sites (F1, F2, and F3) to each other.

Source: E.N. Huyck Preserve Information Pamphlet.

estimated using the line intercept method every meter. Litter cover was also estimated. For each one meter section of the line the total percent cover for all species can be greater than 100%, since the vegetation was layered.

Using the cover data for all herbaceous species, community patterns were assessed using ordination analysis. For analysis purposes the cover data was summed every five meters with infrequent species (species occurring in only one transect) excluded. Ordination serves the purpose of reducing multidimensional data into a low-dimensional representation that can be related to community gradients (Gauch 1982). This study analyzed community data, utilizing the ordination procedure Detrended Correspondence Analysis (DCA), to determine if species associations existed with distance from the field margins. The program PC-ORD (Version 4, McCune and Mefford 1999) was used to perform DCA on the cover data. DCA provides a multi-dimensional spatial arrangement of the vegetation data (sites and species), such that points close together in ordination space reflect similarity within the data and allows for the dominant gradients of change in species composition to be identified (Gauch 1982; Peet et al. 1988; Kent and Coker 1992). DCA generates scaled axes with units reflecting the mean rate of species turnover, such that an axis length of 400 (i.e. four standard deviation units) represents, on average, a complete turnover of species composition in the samples (Kent and Coker 1992).

Based upon the results from the ordination procedure, cover data for all species (herbaceous and woody) were then examined using both linear and exponential regression models (Zar 1999) to determine which individual species increased or decreased with distance from the field margin. Values were regarded as significant where probabilities were $< p = 0.1$ following Hughes and Fahey (1988), and Myster and Pickett (1992). To determine if a species increased or decreased consistently, the homogeneity of slope test was applied if greater than four of eight transects in each field showed a significant regression (following Hughes and Fahey 1988). For species that did not show a significant trend with regression analysis, t-tests were performed comparing summed seedling densities and/or species cover in the first ten versus the last ten meters of the 25 meter transect. Using the five meter distance class data from the ordination analysis, chi-square analysis (χ^2) was used to determine species associations

along the 25 meter transects. The direction of the relationship was calculated using the Cole Index (Whittaker 1975).

To sample woody seedling densities two belt transects (25 meters long and one meter wide) were established along each edge using the same line transects from the herbaceous sampling described above. Seedling densities for each species were recorded every square meter. Perpendicular to and centered on the belt transects another set of transects, measuring 50 meters by four meters, were established to sample the hedgerow vegetation. The diameter at breast height (dbh) (1.37 m above ground) for all trees $>$ ten cm dbh were measured. Trees $>$ ten cm dbh are assumed to be capable of producing seeds and therefore would be sources for the establishment of tree seedlings (Beatty 1984). To estimate the minimum age of establishment (based on oldest tree found), the five largest trees in each hedgerow were cored ($n=50$) as close to the base as was possible. The cores were later dried, mounted, sanded, and rings counted using a microscope. Ring counts were assumed to be the *minimum* date of tree establishment in the hedgerow and not the exact age of the tree as many of the cores did not intersect the pith and the oldest tree may not have been among the five largest.

Simple regression analysis was used to determine if seedling densities decreased or increased with distance from the field edge for each transect and species. Both linear and exponential models (using the log values for seedling densities) were utilized to see which, if any, relationship explained the most density variance with distance, with the methodology and justification the same as for the herbaceous analysis. Regression analysis was also performed to analyze the relationship between hedgerow tree species and tree seedling densities. The tree species abundance measure used in the regression analysis was basal area (m^2ha^{-1}).

Results

Herbaceous Species Distribution

There were 126 species found in the sampled areas, with 74, 77, and 73 species found in Field 1 (F1), Field 2 (F2), and Field 3 (F3), respectively. The three fields shared 54 species of herbs, grasses, vines, shrubs, and trees with *Galium mollugo* and *Origanum vulgare* being the dominant species.

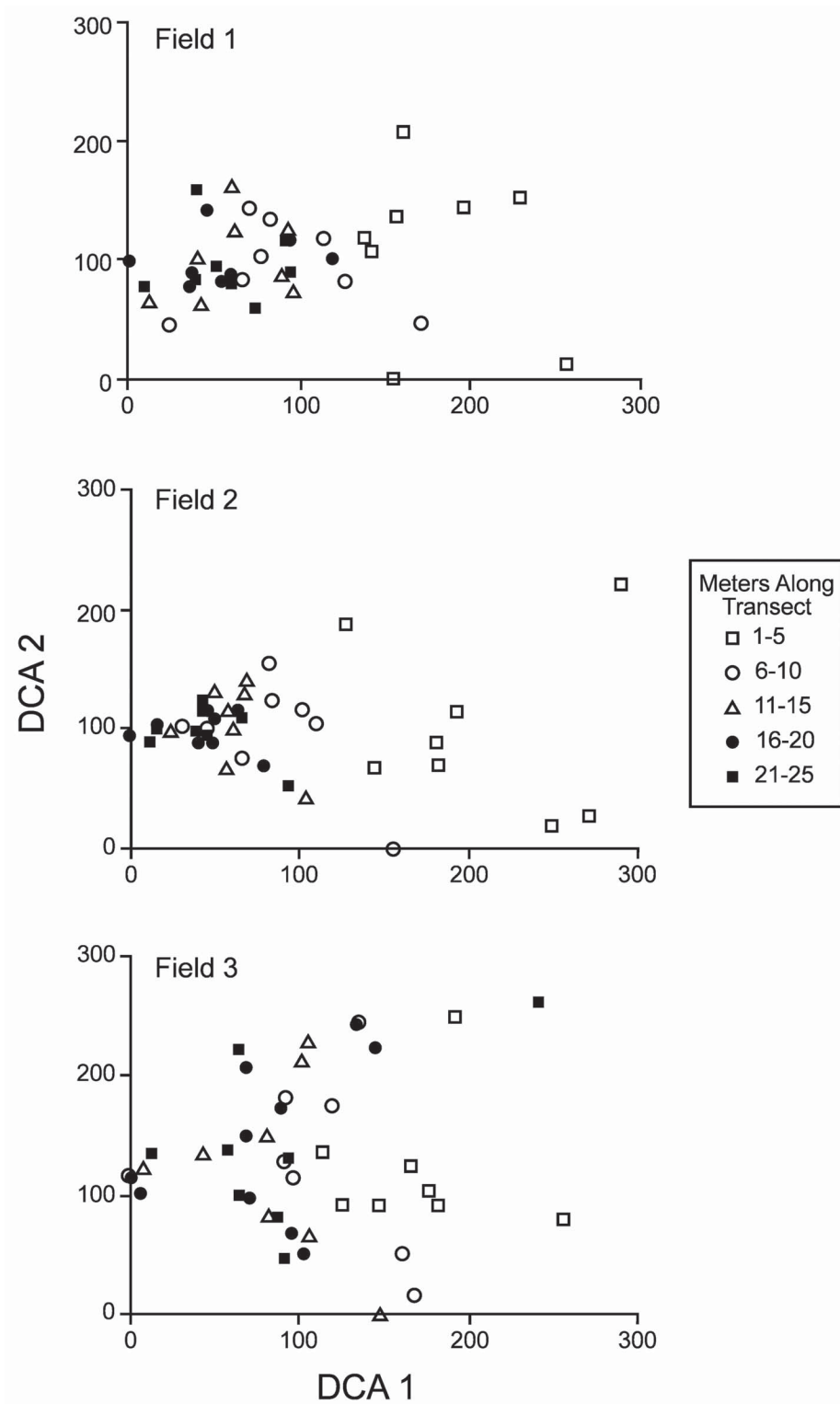


Figure 2: Ordination of field transects showing variation in vegetation cover and composition with distance from the field edge, categorized into 5 meter blocks.

Table 1: Spatial distribution of selected herbaceous and woody species along 25 meter transects. Categories “increasers” and “decreasers” based on regression analysis ($p < 0.1$). Categories “interior” and “edge” are based on results from T-tests ($p < 0.05$) comparing the first 10 meters (edge) with the last 10 meters (interior) of each transect.

Increasesers		Decreasers	
<i>Galium mollugo</i> *	[1,2,3]	<i>Rubus spp.</i>	[3#]
<i>Origanum vulgare</i>	[1,2]	<i>Acer saccharum</i>	[1#,2#]
<i>Vicia spp.</i>	[2#]**	(seedling densities)	
<i>Hieracium caespitosum</i>	[2#]	Total seedling densities (woody)	[1#,2#]
		Litter cover	[1#,2#]
Interior		Edge	
<i>Chrysanthemum leucanthemum</i>	[2]	<i>Rubus spp.</i>	[3]
<i>Fragaria virginiana</i>	[2]	<i>Epipactus helleborine</i>	[2]
<i>Galium mollugo</i>	[1,2,3]	<i>Aster divaricatus</i>	[2]
<i>Stellaria graminea</i>	[1,2]	<i>Prunus virginiana</i>	[1,2]
<i>Vicia spp.</i>	[2]	<i>Viburnum alnifolium</i>	[2]
<i>Hieracium caespitosum</i>	[2]	<i>Prunus serotina</i>	[2]
		<i>Acer saccharum</i> (% cover)	[3]
		<i>taraxacum officinale</i>	[2]
		<i>Ranunculus acris</i>	[1,2]
Species which do not occur in first 10 meters (interior)		Species which only occur in first 10 meters (edge)	
<u>Woody</u>		<u>Woody</u>	
<i>Rosa spp.</i>	[1,2,3]	<i>Prunus virginiana</i>	[1]
<i>Malus spp.</i>	[2]	<i>Viburnum alnifolium</i>	[1,3]
		<i>Ribes spp.</i>	[1,2]
		<i>Quercus rubra</i>	[1,3]
		<i>Prunus serotina</i>	[1,3]
<u>Herbaceous</u>		<u>Herbaceous</u>	
<i>Prunella vulgaris</i>	[2]	<i>Rumex acetosella</i>	[2]
<i>Oxalis stricta</i>	[2]	<i>Smilacina racemosa</i>	[1,2,3]
<i>Aster divaricatus</i>	[3]	<i>Epipactus helleborine</i>	[1,2,3]
<i>Aster lanceolatus</i>	[2]		
<i>Centaurea spp.</i>	[2]		
<i>Trifolium hybridum</i>	[2]		
<i>Geum aleppicum</i>	[1]		
<i>Trifolium aureum</i>	[3]		

* For each species at least 4 out of 8 transects must have a significant increase or decrease in the regression analysis ($p < .1$) to be considered an increaser or decreaser, respectively. Only species which meet this qualification are listed here.** 1, 2, or 3, indicate respective field numbers for which a species had the indicated distribution. # indicates homogeneity of slope ($p < .05$) for regressions from all transects within that field.

The ordination for all three fields (Figure 2) shows meters one through five from the transects with high scores on the first axis and distances greater than five meters from the margin tend to be clumped with low scores. The length of the first axis is about three standard deviations meaning that there is considerable, but not complete, turnover of species among the samples on this axis. Spearman's rank correlation coefficients were calculated for distance from field edge versus the ordination value for the first axis (DCA 1) and the results showed a significant ($p=0.00001$) negative relationship for all three fields. Variation along the second axis (DCA 2) does not seem to be related to distance from the field margin, with species responding to other environmental variables not measured (Figure 2).

Since the ordination analysis showed a clear separation of plots within the first five to ten meters, regression analysis of cover versus distance from edge was performed for each species on a transect-by-transect basis. "Increasers" were species that increased in cover with distance from field edge; "decreasers" were species that show the opposite trend. *Galium mollugo*, *Origanum vulgare*, *Vicia* spp., and *Hieracium caespitosum* were all found to increase significantly ($p < 0.01$) with distance from the field edge, in at least one field (Table 1). *Galium mollugo* increased significantly ($p < 0.01$) in all three fields, though the rate of increase was not found to be consistent from transect to transect according to the homogeneity of slope test. Both *Vicia* spp. and *Hieracium caespitosum* only increased in F2, however they both increased consistently for all transects and edges in that field (Table 1).

No herbaceous species were found to decrease significantly with distance from the field edge, although many species occurred with significantly greater ($p < 0.05$) coverage in the first ten meters of transects. In F1, *Ranunculus acris* was the only herb found to be an "edge" species (Table 1). In F2, *Epipactus helleborine*, *Aster divaricatus*, *Taraxacum officinale*, and *Ranunculus acris* had significantly ($p < 0.05$) greater cover in the first ten meters than in the last ten meters along the transect (Table 1). No herbs were found to be "edge" species in F3.

Several herbaceous species, but no woody species, were found to occur with significantly greater ($p < 0.05$) cover in the last ten meters of transect (interior) than in the first ten meters (edge) (Table 1). *Chrysanthemum leucanthemum*, *Fragaria virginiana*,

Stellaria graminea, *Vicia* spp., and *Hieracium caespitosum* had significantly greater ($p < 0.05$) cover as "interior" species in F2 (Table 2). *Stellaria graminea* also occurred as an "interior" species in F1, while *Galium mullogo* was a significant "interior" species in all three fields (Table 1).

Where herbaceous species occurred only in the first ten meters or last ten meters, statistical analysis was not possible, but these species were clearly "edge" or "interior" species, respectively. *Smilacina racemosa* and *Epipactus helleborine* were only found within the first ten meters in all three fields and *Rumex acetosella* was only found within the first ten meters in F2 (Table 1). In F1, *Geum aleppicum* was the only herbaceous species that did not occur within the first ten meters. In F2, five species were not found within the first ten meters: *Prunella vulgaris*, *Oxalis stricta*, *Aster lanceolatus*, *Centaurea* spp., and *Trifolium hybridum*. In F3, *Trifolium aureum* and *Aster divaricatus* were not found within the first ten meters of transects sampled.

When examined using chi-square analysis 25 species pairs showed significant associations ($p \leq 0.05$) within five meter distance classes. *Stellaria graminea* and *Fragaria virginiana* were both positively associated ($p \leq 0.05$) with *Vicia* spp. and with each other in F2. All of the significant associations between *Solidago rugosa* and other species were negative, such as; *Potentilla recta* (F3), *Dactylis glomerata* (F3), *Fraxinus americana* (F2), *Anthoxanthum* spp. (F3), and *Festuca rubra* (F3). *Potentilla recta* was negatively associated with *Potentilla simplex* in F1, *Solidago gigantea* in F1 and F3 and *Muhlenbergia* sp. in F3. *Fraxinus americana* was negatively associated with grass species (*Muhlenbergia* spp.) in F2 and *Festuca rubra* in F3. *Solidago gigantea* was positively associated with two grass species (*Muhlenbergia* spp.) in F3 and *Anthoxanthum* sp. in F2. *Taraxacum officinale* and *Ranunculus acris* were positively associated in F1, while *Trifolium pratense* was positively associated with *Bromus* sp. in F3 and *Chrysanthemum leucanthemum* in F2.

Tree Seedling Densities and Woody Species Analysis

Tree seedling densities were found to decrease with distance from the field margin in F1 and F2, but not in F3 (Figure 3). Regression analysis (performed on each transect) showed that in F1 and F2, total tree seedling densities significantly decreased ($p < 0.05$)

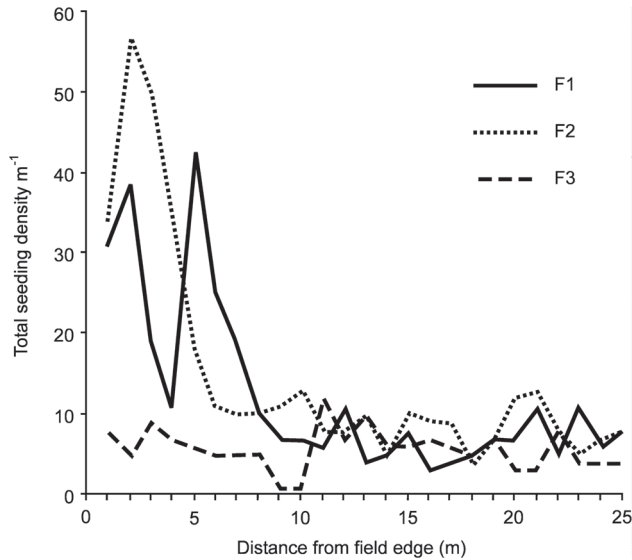


Figure 3: Total tree seedling densities with distance from the field edge for all three fields. Totals are cumulative for the eight transects in each field.

exponentially with distance from the edge. The rate that tree seedlings decrease with distance from one field edge to another was found to be consistent (based on homogeneity of slope test, $p < 0.05$) (Table 1).

Regression analysis for each species showed that only *Acer saccharum* seedling densities decreased significantly ($p < 0.1$) with

distance from the field margin in F1 and F2 (Table 1). The decrease in *Acer saccharum* with distance from the field edge was consistent for all transects from all three fields based upon homogeneity of slope analysis ($p < 0.05$). No woody species had a significantly ($p < 0.05$) greater percent cover in the last ten meters than in the first ten meters, although when species only occurred in the last ten meters of the transects statistical analysis was not possible (Table 1). There were a number of woody species which were categorized as “edge” species; *Rubus* spp., *Prunus virginiana*, *Viburnum alnifolium*, *Prunus serotina*, and *Acer saccharum* all occurred more frequently ($p < 0.05$) in the first ten meters of at least one of the three fields (Table 1). *Rubus* spp. and *Acer saccharum* showed this pattern in F3, while the other species showed this pattern in F2. *Prunus virginiana* occurred as an edge species in both F1 and F2 (Table 1).

Where woody species occurred only in the first ten or last ten meters statistical analysis was not possible, but these species were clearly “edge” or “interior” species, respectively. *Prunus virginiana*, *Viburnum alnifolium*, *Ribes* spp., *Quercus rubra* and *Prunus serotina* all occurred exclusively in the first ten meters of F1 (Table 1). *Viburnum alnifolium*, *Quercus rubra* and *Prunus serotina* also occurred exclusively in the first ten meters of F3, while *Ribes* spp. had a similar distribution in F1 and F2 (Table 1). *Rosa* spp. did not occur within the first ten meters along the field margin in any of transects in all three fields, while *Malus* spp. did not occur

Table 2: Basal Area (m² ha⁻¹) for hedgerow trees >10 cm dbh and the minimum age of hedgerow trees. Field edges face approximatel South (S), West (W), North (N), East (E).

	Field 1				Field 2				Field 3			
	S	W	N	E	S	W	N	E	S	W	N	E
<i>Acer saccharum</i>	21.9	2.2	72.7	23.4	72.7	34.9	39.3	31.0	39.3	2.4	24.3	0
<i>Fraxinus americana</i>	8.7	0	2.37	4.6	2.37	0	0.8	6.4	0.8	1.8	2.1	3.0
<i>Malus</i> sp.	0.7	0	0	0.8	0	0	1.7	1.1	0	0	0	0
<i>Prunus serotina</i>	3.5	9.7	23.2	5.8	23.2	8.4	12.3	5.5	12.3	0.2	3.7	0.3
<i>Quercus rubra</i>	16.9	69.4	16.6	0	16.6	0	0	1.7	0	0	14.6	0
<i>Tilia americana</i>	0	0.1	15.7	0	15.7	6.9	4.0	2.9	4.0	0	0	0
Total for all species	51.7	81.4	130.6	34.6	130.6	50.2	58.0	48.7	56.4	4.4	44.7	3.3
Min. hedgerow age*	48	62	84	32	84	46	40	58	40	53	103	20

Table 3: Stem Density (stems ha⁻¹) for all hedgerow tree > 10 cm dbh. Field edges face approximately South (S), West (W), North (N), and East (E).

	Field 1				Field 2				Field 3			
	S	W	N	E	S	W	N	E	S	W	N	E
<i>Acer saccharum</i>	857	175	2258	325	2258	1950	2325	1277	2325	50	265	0
<i>Fraxinus americana</i>	214	0	108	175	108	0	100	163	100	75	212	100
<i>Malus sp.</i>	48	0	0	75	0	0	100	109	100	0	0	0
<i>Prunus serotina</i>	143	250	699	75	699	200	650	272	650	25	213	25
<i>Quercus rubra</i>	214	950	323	0	323	0	0	54	0	0	425	0
<i>Tilia americana</i>	0	25	161	0	161	225	250	54	250	0	0	0
Total stem density	1476	1400	3549	650	3549	2375	3425	1929	3425	150	1115	125

within the first ten meters sampled in F2 (Table 1).

Hedgerows

The main tree species (stems > ten cm dbh) represented in the hedgerows of these three fields were *Acer saccharum*, *Quercus rubra*, *Prunus serotina*, *Tilia Americana*, *Fraxinus americana*, and *Malus spp.* (Table 2). *Acer saccharum*, *Prunus serotina*, and *Quercus rubra* made up 88 % of the basal area from all the ten hedgerows sampled. The dominant hedgerow tree species over ten cm dbh was *Acer saccharum*, with a total basal area generally exceeding 20 m² ha⁻¹ and values ranging from 0 to 72.7 m² ha⁻¹ (Table 2). *Quercus rubra* was generally less than 20 m²ha⁻¹, with one hedgerow the exception (69.4 m²ha⁻¹). *Prunus serotina* was the only tree species to occur in all ten hedgerows with basal areas ranging between 0.2 and 23.2 m² ha⁻¹ (Tables 2 and 3).

Stem densities (stems > ten cm dbh) were very high for all hedgerows (greater than 650 stems ha⁻¹), except two adjacent to F3 (Table 3). *Acer saccharum* had the greatest stem densities overall, with several hedgerows exceeding 2000 stems ha⁻¹, while *Quercus rubra* and *Prunus serotina* both had densities consistently less than 1000 stems ha⁻¹ (Table 3). The hedgerows surrounding F3 had abundant stems < ten cm dbh and very few stems > ten cm dbh when compared with F1 and F2. In general the hedgerows surrounding F3 were comprised of many smaller trees (including *Pinus strobus*) with only the occasional very large tree (Tables 2 and 3).

The oldest tree cored was an *Acer saccharum* which was at least 103 years old and it was found in the hedgerow along the northern edge of F3. Tree establishment began in these hedgerows approximately 40+ years ago with the age of establishment of the eastern hedgerow in F3 the only exception. The age of the eastern edge of F3 is complicated by the fact that it was abandoned earlier than the rest of the field making the edge and resulting hedgerow as defined in this study (see methodology) by default younger than the others (Table 2). The northern edge of F1 and the southern edge of F2 both have tree establishment in the hedgerows starting greater than 80 years ago (Table 2).

In general the three oldest species in the hedgerows were *Acer saccharum*, *Quercus rubra* L. and *Tilia americana*. Of the trees cored, *Acer saccharum* was on average 47 ± 25 yrs, while *Quercus rubra* and *Tilia americana* were more consistent at 43 ± 9 and 44 ± 10, respectively.

Regression analysis was performed to compare the basal area of tree species > ten cm dbh with seedling densities for transects. *Acer saccharum* was the only woody species which seedling densities were found to be significantly related ($r^2 = 0.49$; $p = 0.0001$) to the basal area of individual in the hedgerow. Regression analysis using exponential, log-linear, and log-log models did not improve the relationship found for *Acer saccharum*. None of the other hedgerow species were significantly correlated with the density of seedlings in the fields, but there were very few seedlings of these species present, compared to *Acer saccharum* densities.

Discussion

Old field vegetation communities are influenced by the nature of the surrounding landscape. Adjacent vegetation, such as hedgerows and neighboring fields act as a seed source for the colonization of woody and herbaceous species. The pattern of species colonization will in turn affect the pattern and direction of vegetation change over time (McDonnell 1988; Meiners et al. 2002). As stated previously, this study aimed to examine how species composition, abundance, and species associations change from the field edge towards the center of the field for both herbaceous and woody species.

In this study certain herbaceous species showed an affinity for edges (the first ten meters) within fields. Forman and Godron (1981) noted that some herbaceous species may be sensitive to edge environments, but few studies document which herbaceous species could be characterized as “edge” species (Whitford and Whitford 1978). Meiners and Pickett (1999) found that the dominant environmental variable in herbaceous species patterning in old field communities was distance from field edges. Several species in this study were found to occur with significantly greater cover within the first ten meters, or only occurred in the first ten meters from field edges. Some of these “edge species” are typically considered forest herbs, while others would be considered field species, some are introduced exotics and others are native, with no pattern statistically obvious. Some of the species which showed the greatest degree of edge affinity were *Aster divaricatus* (a native forest herb), *Taraxacum officinale* (a weedy exotic), and *Ranunculus acris* (an exotic field herb). *Rumex acetosella* (also an exotic field herb) was only found within the first ten meters in F1 and *Smilacina racemosa* (a native forest herb), and *Epipactus helleborine* (a native forest herb) only occurred within the first ten meters of all three fields sampled. The mixing of both woodland and field herbs within the edge environment may suggest these areas are undergoing a shift from field to forest in terms of species composition. No clear pattern in terms of exotics and native species abundances was evident in this study. Meiners and Pickett (1999) found that exotic herbaceous species peaked within 20 m of an edge within forests and were essentially restricted to edge environments.

Myster and Pickett (1992) suggested the level of species interactions during succession decrease with time and studies should concentrate on those species which are most strongly associated with one-another. Although the only association between herbaceous species which occurred within the categories of “edge” or “interior” for this study was a positive association between *Taraxacum officinale* and *Ranunculus acris*, the results did show a strong degree of affinity by certain species to establish in “edge” or field “interior” environments. Approximately half of the species labeled as “edge” species in this study were found within nearby forests in a survey by Beatty (1984).

Studies have noted woody seedling establishment is greater along edges of old fields, or other abandoned agricultural areas (McDonnell and Stiles 1983; Armesto et al. 1991). This study did show that there was a greater density of woody species close to field edges since total tree seedling densities, regardless of species, were found to decrease with distance from field margins. Most tree species seedlings were concentrated within the first ten meters of field edges in F1 and F2. In an experimental forest clearing Hughes and Fahey (1988) found no appreciable colonization of three common tree species, including *Acer saccharum*, beyond 15 m from the edge. This study used similar methods of regression analysis to those used by Hughes and Fahey (1988), with results showing several woody species having a significantly greater occurrence within the first ten meters of fields. In all three fields; *Acer saccharum*, *Viburnum alnifolium* and *Prunus serotina* were the woody species which occurred significantly more within the first ten meters along edges than further into fields. Certain woody species displayed the opposite trend, not occurring within the first ten meters along field edges. *Rosa* spp. did not occur within the first ten meters in any field, while *Malus* spp. did not occur along the edge in F2. Both species (*Rosa* and *Malus*) are animal dispersed and therefore their distribution is not expected to be related to distance.

Many studies have shown the rate of invasion, relative abundance, and the resulting spatial distribution of woody species in abandoned agricultural fields depends upon the proximity of trees and shrubs in adjacent hedgerows and forests (Forman and Godron 1981; McDonnell and Stiles 1983; McDonnell 1988; Armesto et al. 1991; Gill and Marks 1991). In this study only *Acer saccharum* showed a positive correlation between seedling

densities and basal area in the hedgerow. Other wind-dispersed species, such as *Tilia americana* (Basswood) and *Pinus strobus* (white pine) did not occur with enough frequency to perform a valid regression. If the timing of a mast seeding of a species such as *Acer saccharum* corresponds with the abandonment of a field, then that species may be able to dominate the site during the initial stages of succession (Stover and Marks 1998).

If variation in seed input is a result of proximity to seed source and mode of dispersal, then there should be a difference in seedling establishment patterns if species are wind-dispersed or animal-dispersed. Gill (1987) suggested wind-dispersed seeds of species such as *Fraxinus*, *Tilia*, *Pinus* and *Acer* were found at distances > 25 meters from seed sources, while animal-dispersed seeds were found < 25 meters from seed sources. In this study seedlings of both animal- and wind-dispersed species were more abundant within the first ten meters of transects except a few smaller stems of *Malus* and *Rosa* which are both animal dispersed. *Fraxinus americana* (wind dispersed) seedling densities were negatively correlated with basal areas of hedgerow trees in this study, although this relationship was not significant. In general the mode of dispersal was not found to be a factor in the pattern of species establishment in the three fields.

This current study suggests that proximity to seed source may not be a controlling factor in the pattern of establishment of woody species in old field communities. The fact that woody species seedling densities are greatest along edges may be due in part to seed source proximity, but other factors such as light levels, soil moisture, litter cover, seedling predation and other environmental variables may be the controlling factors. Since vegetation change occurs over time, this relationship between hedgerow species and seedling densities may also change with time. Fields in this study were relatively young, between 20 and 25 years old, and with time further establishment of woody species and patterns of vegetation composition within the fields may begin to reflect seed source proximity. Armesto et al. (1991) have suggested that over the course of vegetation change, physical heterogeneity decreases, which may change the controlling factors of seedling establishment.

Conclusion

This study concentrated on the spatial patterns of both herbaceous and woody species along a 25 meter margin for three fields. The existence of an identifiable edge community has been shown for both herbaceous and woody species. Several herbaceous species occurred more frequently within the first ten meters of old field communities sampled. Woody seedling establishment was concentrated along field margins, but the relationship between hedgerow species and seedling establishment is still unclear. Gill and Marks (1991) suggested that the colonization of vegetation within the edge community is stochastic depending on the proximity and fecundity of woody seed sources. They suggest this creates difficulty in using edge communities for the prediction of successional pathways. In this study, the edge community has been quantified for both herbaceous and woody species and therefore, given time, the edge communities may be used as a possible indicator of vegetation change for an old field community surrounded by hedgerows. Meiners et al. (2002) suggested that little is known of the role edges play in regulating forest regeneration. The ability to quantify and identify species patterning within an edge community in time and space will allow for assessment of the role edges play in forest establishment within fragmented landscapes.

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