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# LANDSCAPE ECOLOGY OF HEDGEROWS AND FENCEROWS IN PANAMA TOWNSHIP, LANCASTER COUNTY, NEBRASKA

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**Abstract.** *This study investigated woody plant composition, structure, and biomass of hedgerows and fencerows, and for effects between human attitudes and management practices. Fencerows arise as narrow strips of woody and herbaceous plants at field margins and property boundaries. Hedgerows grow from intentional linear plantings. Exotic species were more important in fencerow composition. Hackberry, Missouri gooseberry, American plum, and white mulberry readily inhabited both fencerows and hedgerows. Woody plants exhibited clumped distribution in both hedgerows and fencerows. A moisture gradient emerged as a factor in distribution of species. Management caused a significant difference in species richness and biomass in both hedgerows and fencerows. Hedgerows (discounting basal area of Osage-orange) had less tree biomass than fencerows and were more evenly distributed between center and margin. For all hedgerows, there was a significant difference between management schemes based on preservation-removal attitude scores.*

Landscape, like the mythical Greek characters Satyr, Centaur, and Harpy, springs from the synthesis of humans and nature. Landscape ecology tries to understand the reality of a landscape as determined by the human-nature interaction (Golley 1987; Zonneveld 1989; Golley 1990). Landscape as a coherent unit often results from the directed self-conscious or repetitive unconscious endeavors of humans and nature.

This study investigated a domain of rural landscape for evidence of such interaction (Spirn 1988; Haber 1990). The objective was to analyze and interpret landscape form as result of human activity (regulatory and control domain) within the context of natural parameters (process domain). The study can be seen as a snapshot of larger, complex events in which humans create landscape out of nature. At a less general level it investigated conscious or unconscious mental states leading to technical practices or rituals which may directly affect a plant community. Finally, at the specific and measurable level, it sought to link the prevalent human attitudes described in specific regulatory and control (disturbance) routines and to further tie those management activities concretely to plant composition and structure. The study's assumptions were: 1) humans act upon their attitudes; 2) repetitive minor disturbances of nature equate with cultural disturbances; 3) plant composition and structure are artifacts of landscape.

Hedgerows and fencerows are distinctive landscape features both within and between agricultural landholdings in the eastern Great Plains and elsewhere. The composition, form, size, location, and age of hedgerows have always reflected both social and natural events. For example the enclosure landscape of England dates from Parliament's enclosure acts of the nineteenth century (Pollard et al. 1974), yet many hedgerows there originated in Anglo-Saxon times and are contemporaneous to those of Normandy in France. In America, the geometry of the public land survey system that had been etched onto the Prairie Peninsula of Illinois and Indiana landscape was later adopted along the pre-barbed wire frontier of the 1850's, 1860's and 1870's. Hedgerows have become an important ecological and cultural artifact in the landscape of southeastern Nebraska (Baltensperger 1987). For this study "fencerows" were defined as containing spontaneously arising plants, that is, plants arriving as propagules through the agency of wind or animals and becoming established along uncultivated field verges or property boundaries. Fencerows predominate in the rural Great Plains, and because they often contain a fence as the most dominant human feature, the term "fencerow" is used. "Hedgerow" refers to man-planted rows of Osage-orange (*Maclura pomifera*) that are also found as field and property dividers and less often along rural road frontages. Purposefully laid out by pioneers, these lines served primarily to demarcate property boundaries, and enclose livestock (Hewes and Jung 1981; Sutton 1985).

Understanding the structure and function of hedgerows has recently gained the attention of European and North American researchers working in the area of landscape ecology (Forman and Baudry 1984; Forman and Godron 1986; Burel and Baudry 1990; Barrett and Bohlen 1991; Fritz 1991a; 1991b). Petrides (1943) was one of the first in North America to discern the interaction between hedgerows as wildlife habitat. Hedgerows have been studied for decades by European ecologists as unique anthropogenic communities (Bates 1937; Moore et al. 1967; Pollard and Relton 1970; Pollard et al. 1974; Hooper 1976; Willmot 1987). Hedgerow community composition has been both anthropogenic and adventive, drawing indigenous and naturalized species from the surrounding landscape. Community represents a powerful ecological concept because plant communities provide structure, often control ecological functions, reflect gradient changes in the environment, and provide habitat for animals (including people). The concept of community is basic to future probing of landscape structure and function and eventually should lead to more integrated management of landscapes.

Forman and Godron (1986:135) have noted, "Hedgerow vegetation is exceptionally varied, primarily because of differences in hedgerow origin and management." They have also determined other factors come into play such as: 1) the relative importance of trees and shrubs, 2) species present, 3) Species dominance and co-dominance, 4) thorniness, 5) physical dimensions 6) presence of human artifacts as swales, walls or fences.

Natural fencerows and purposefully planted hedgerows appear to harbor amalgams of native and naturalized woody plants. Yet, because the local biological, edaphic and climatic regime with its restrictive moisture gradient disfavors ready growth of woody plants, hedgerows and fencerows are an excellent place to study changes in woody plant composition and distribution at the margin of their viability. Closely allied and maybe inseparable from these ecological factors are those of human actions and interactions within their "agro-cultural" context. For example, the once fire-dominated prairie now converted to cropland, isolates woody plant groups. Management practices such as cutting, mowing, burning, herbicide application, or pruning should radically alter hedgerows and fencerows. Hedgerows and fencerows are strikingly visible plant masses in the space of Great Plains and therefore provide a dominant visual entity for the study of anthropogenic links between landscape, culture, and structure.

## Study Objectives

This study had several objectives in order to quantify some parameters of the proposed general verbal landscape model. They were to:

1) describe, interpret and discuss the woody plant composition and structure patterns, as influenced by ecological and anthropogenic factors.

2) assess manager/owner attitudes toward the hedgerow/fence landscape as the wider socio-cultural context for ecological and anthropogenic factors.

3) examine possible links from attitude to management and plant composition and
4) establish a baseline record in time and space of the woody species within several hedgerows and fencerows for future research.

I hypothesized that now, approximately 100-130 years after their establishment, woody plant species present, their density, and arrangement would be different in hedgerows and fencerows. For example, Osage-orange influences microclimate differently from fencerows; I predicted more mesic species and a greater number of interior woodland species associated with it. However, an older, established fencerow of various trees and shrubs may also provide similar microenvironment. Because many of the naturalized and native woody shrubs vigorously regenerate, the eventual loss of Osage orange protection may lead a hedgerow to the same species composition and structure as that of a fencerow. However, this last question would need years of plant succession to become more clearly measurable. I further hypothesized differing management practices between owners in the case of hedges would result in differences in woody plant structure and composition, and that any management differences may be linked to the owner's attitude toward hedges.

**Study Area**

For this study I chose to analyze the hedged, rural landscape in a small, relatively homogeneous portion of southeastern Nebraska. Fencerows and hedgerows studied were in contiguous Sections 9, 10, 11, 14, 15, and 16, Panama Township, Lancaster County, Nebraska (Figs. 1a-f). With elevation ranging from 433 m (1300 ft) to 483 m (1450 ft), it is a high point in southeastern Nebraska. The headwaters of the South Fork of the Little Nemaha River, North Fork of the Big Nemaha River, and the Hickman Branch of Salt Creek are in the study area. Soils are relatively homogeneous and predominantly of two upland associations: the Wymore-Pawnee, deep, moderately well drained, silty soils formed in loess and loamy parent material from glacial till, the Pawnee-Burchard, deep, well to moderately well drained loamy and clayey soils formed from glacial till (Soil Conservation Service 1977). A third lowland soil association, Kennebec-Nodaway-Zook, underlayed only a few hundred meters of sampled hedgerow or fencerow. These soils were ranked by the Soil Conservation Service for suitability for tree growth.

The ranking values were collapsed into three groups and used to gauge woody plant establishment and growth.

There are less that 100 acres (40 hectares) of extant woodland in these six square miles (1154 hectares). From quick observation it apparently did not predate settlement, because of topographic position, species,composition and specimen size. However, the lower reaches of the area could have supported prairie gallery forest and possibly bur oaks. The proportion of land use is approximately 75% row crops and 25% pasture. Twenty-three farmsteads are uniformly spaced in the study area. Only half are working farms; the rest, along with a half dozen other dwellings are rural residences. Two major cultural features are the sewage lagoons for the village of Panama and a ten acre cemetery (half of which is still virgin prairie).

Within the six section (1554 hectare) study area there was a total of 27, 898 meters of hedgerow and fencerow, of which 11, 575 meters of hedgerow and 6368 meters of fencerow were studied (Figs. 1a-f). Sampling on both sides of a hedgerow or fence yield nearly 22 miles of features studied. All fencerows sampled were relatively narrow, about 7 to 8 meters while the hedgerows were wider, up to 14 meters.

## Method

The sampling method was simple though exhaustive. The hedgerows and fencerows inherently divided into sample units of unequal length based on their known soil type, management type, or aspect. Woody plant species were counted as the hedgerow or fencerow was walked with a rotating measuring wheel (Fig. 2). The location of each was recorded as distance along the length of the hedgerow or fencerow (variable X) perpendicular distance to the center of the hedgerow or fencerow (variable Y) both to 0.1 meter. For clonal shrubs the center of the clone was estimated and used as a location. Additionally, each tree species size was estimated as the diameter at the ground level so saplings down to 2 cm could be identified. Two measures of distance to nearest neighbor were defined as that to any species and that to the same species. Total basal area for each tree species in the sample was calculated. These values were standardized for each species as number of species per meter of hedgerow.

The three observed variables in the field were: location, diameter and species of trees. Locating the position of each discrete woody plant allowed calculation of nearest neighbor (DNAS) and nearest neighbor of same species (DNSS) which are indicators of density, especially (DNSS). Both

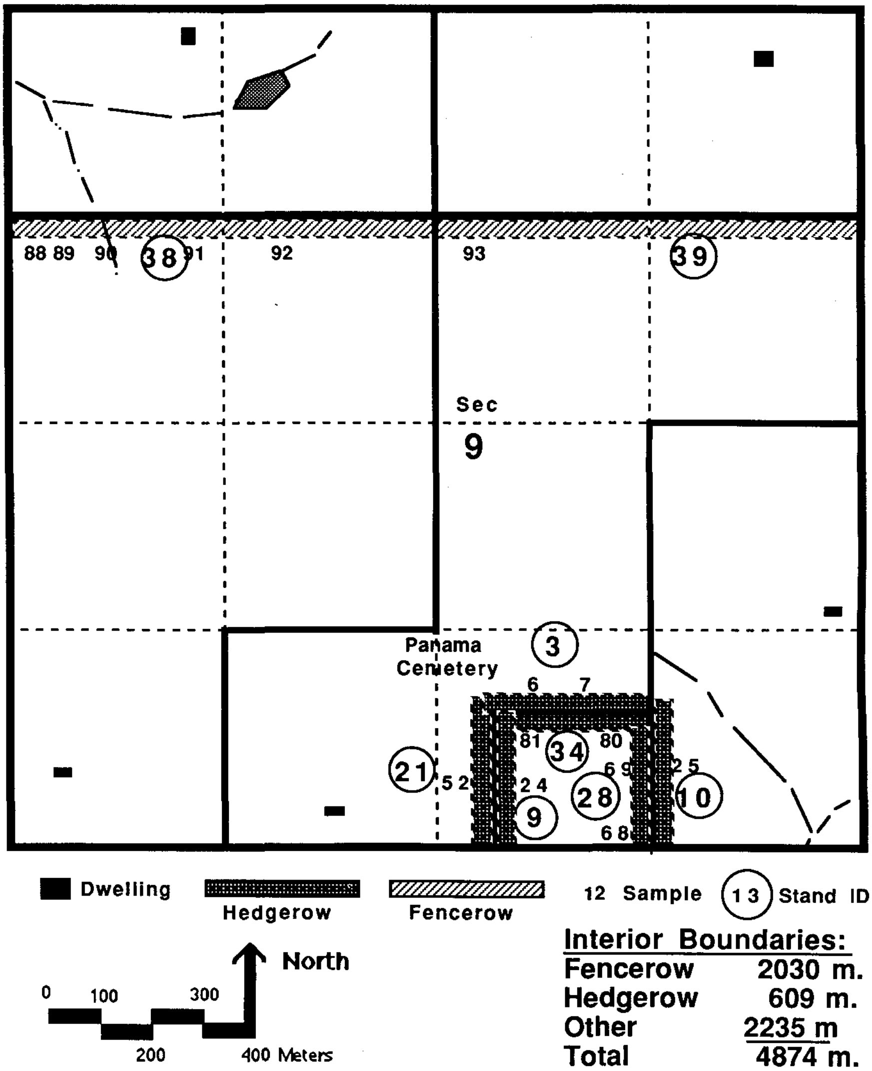



Figure 1a. Hedgerows and fencerows sampled in Section 9 Panama Township.

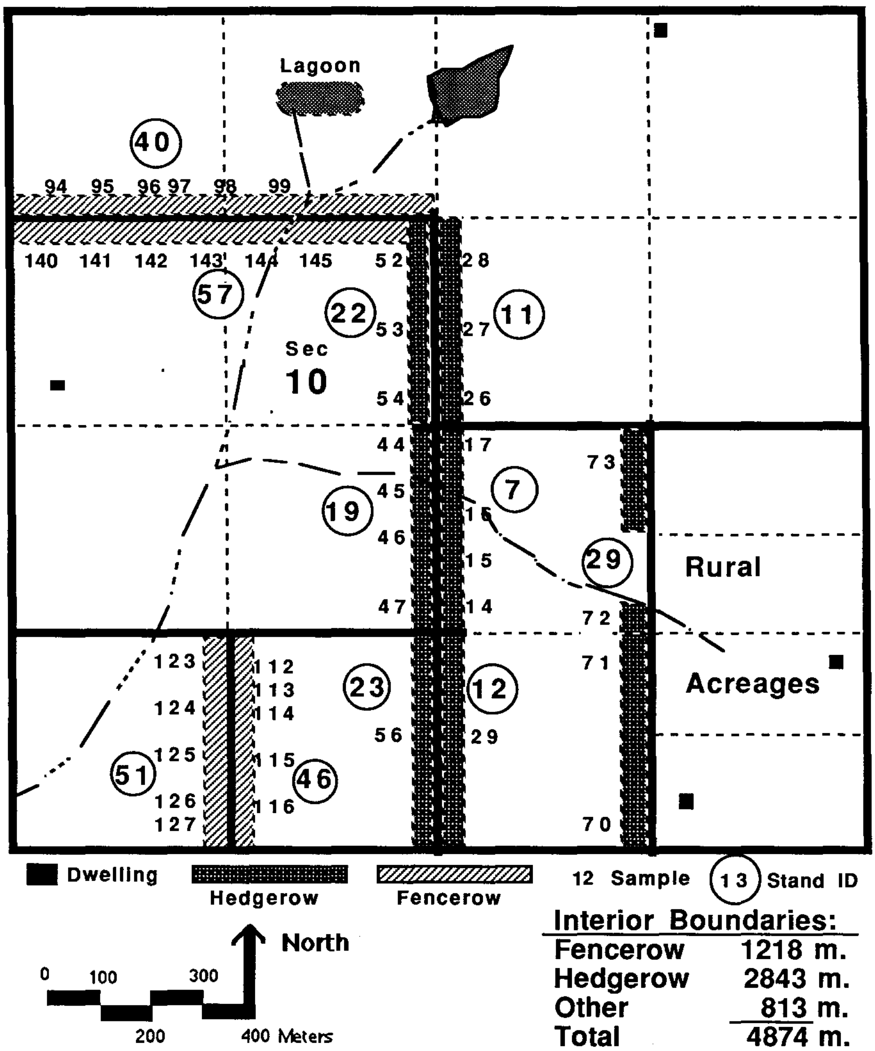



Figure 1b. Hedgerows and fencerows sampled in Section 10 Panama Township.

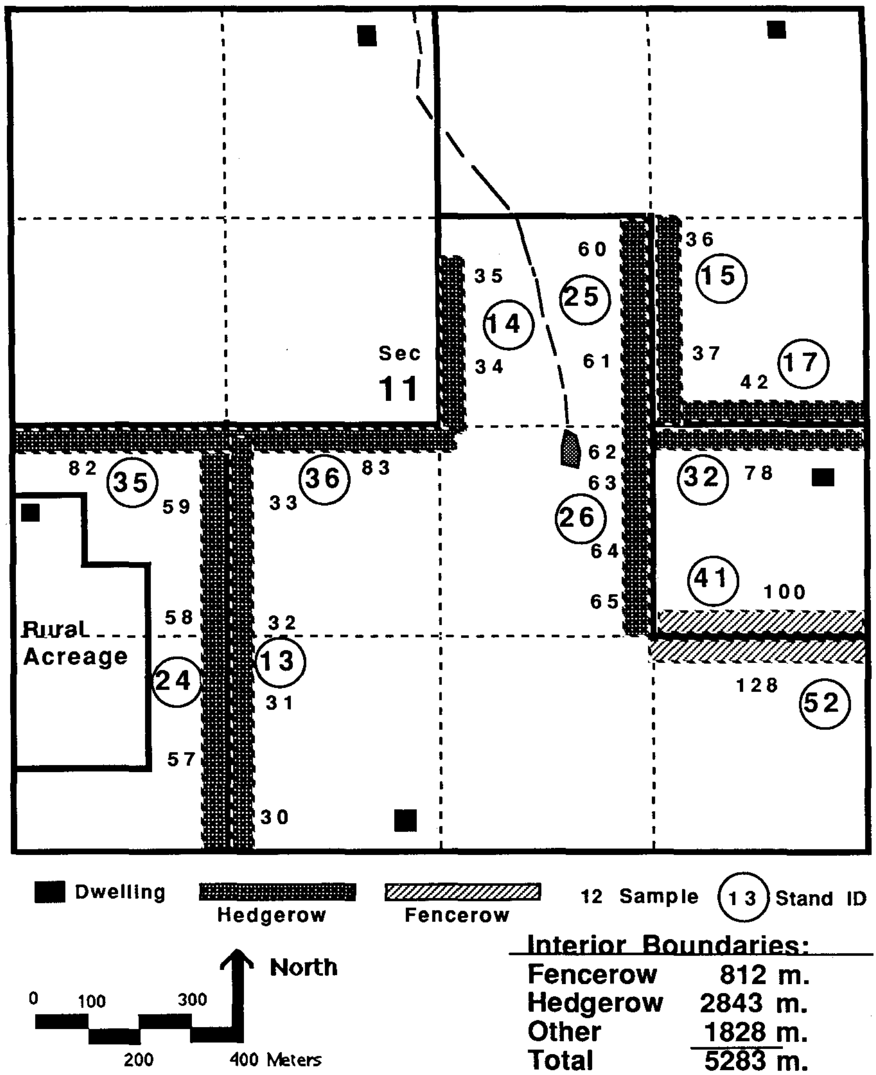



Figure 1c. Hedgerows and fencerows sampled in Section 11 Panama Township.

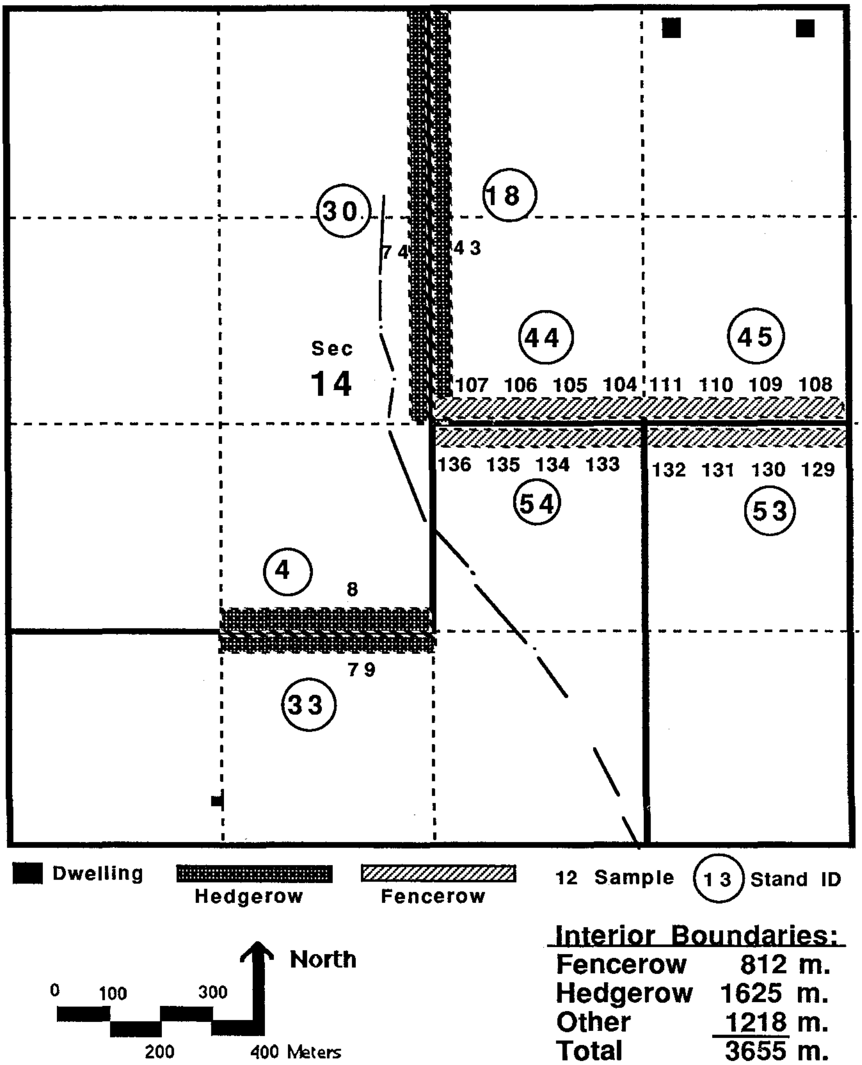



Figure 1d. Hedgerows and fencerows sampled in section 14 Panama Township.

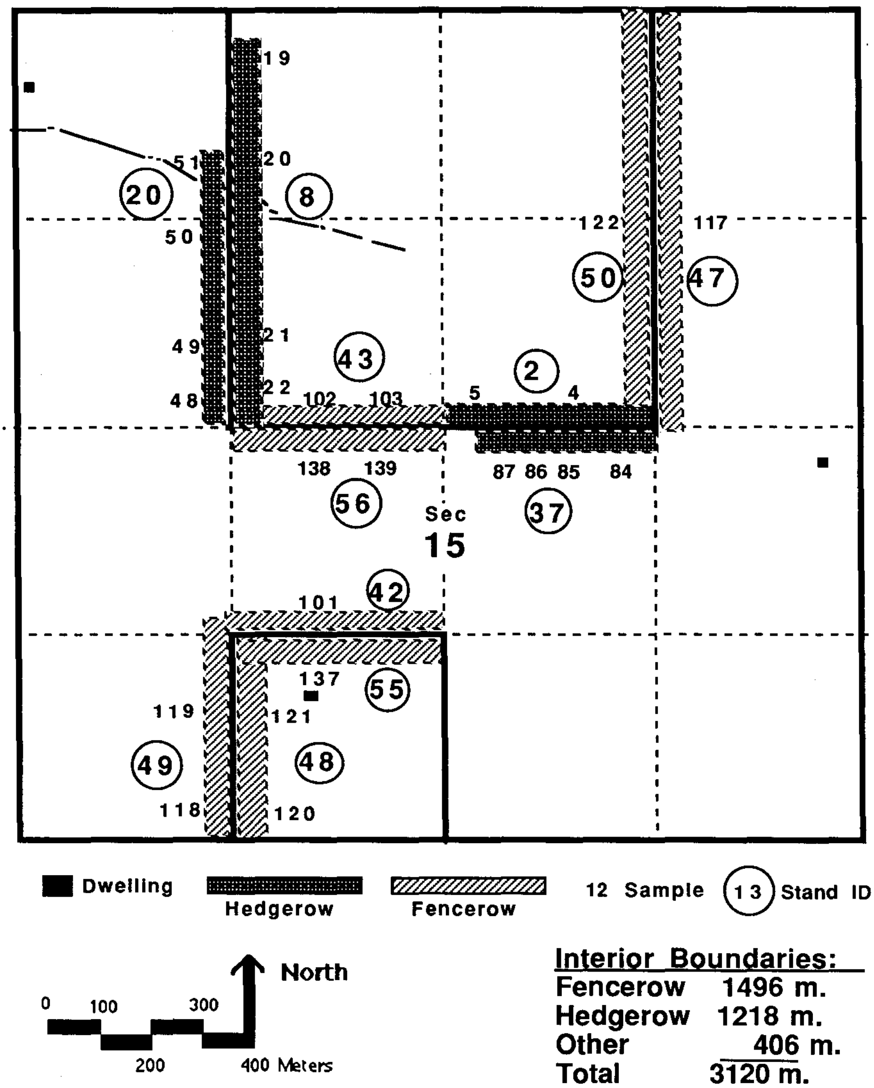
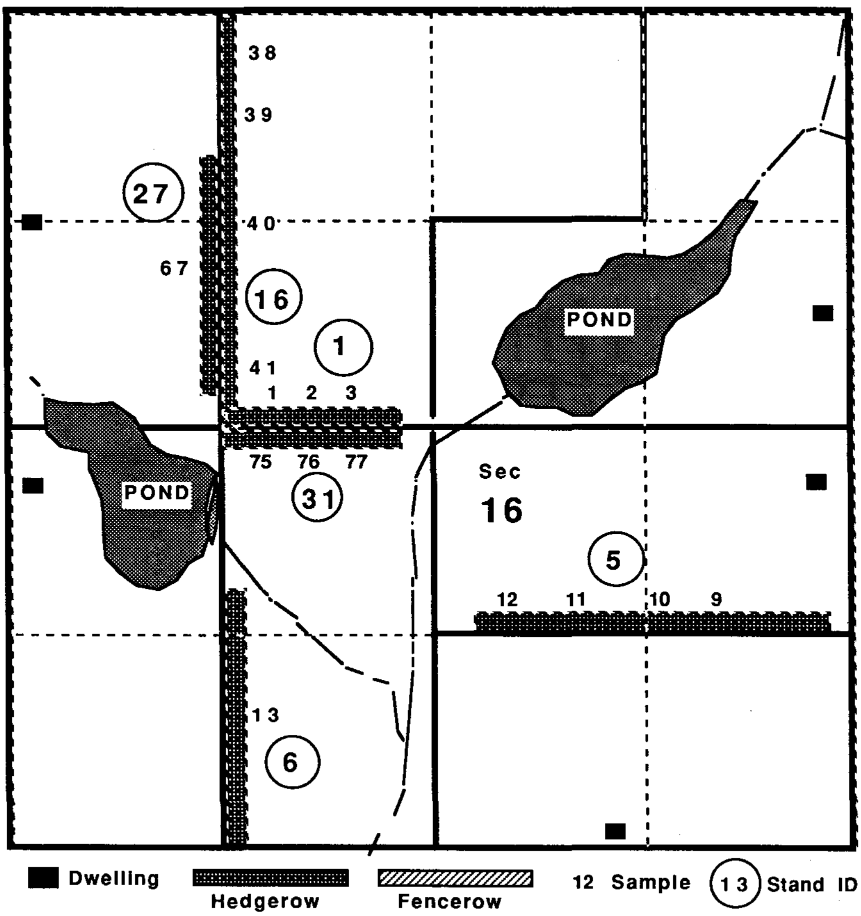
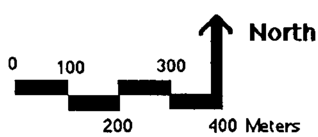



Figure 1e. Hedgerows and fencerows sampled in section 15 Panama Township.




| Interior Boundaries | |
|---|---|
| Fencerow | 0 m |
| Hedgerow | 2437 m |
| Other | 3655 m |
| Total | 6092 m |

Figure 1f. Hedgerows and fencerows sampled in Section 16 Panama Township.

Figure 2. Measuring wheel used to locate specimens along fencerows and hedgerows. Note the cut Siberian elm. Fencerow are easily patrolled by the land manager and removal of woody plants quickly accomplished. This may mean fencerows are more frequently disturbed.

DNSS and DNAS for each species were used as input values for the reciprocal averaging and PCA ordinations.

Before ordination, statistical sample outliers were deleted through use of box an whisker plots based on the two distance measures and the basal area. Nine of 87 hedgerow sample units and 14 of 58 fencerow sample units were deleted (of these, 12 had only one woody species). To further normalize the data, distance measures were transformed by square root transformation. Several data sets were created by using the reciprocal averaging option to group samples of similar species for closer examination. The computer program, "Ordiflex" Release B, (Gauch 1977), was used for reciprocal averaging, ordinating and plotting the results. In addition to comparing the composition and density between hedgerows and between hedgerows and fencerows the internal structure of each was investigated in relation to management. To do this the basal areas for all tree species were summed for each 0.5 meter increment of width [variable Y] within 1) unmanaged hedges 2) managed hedges 3) unmanaged fencerows 4) managed fencerows.

Figure 3. Cutting Osage-orange for fence-posts opens the hedge to light. This disturbance is ephemeral because established tree rootstocks quickly regrow. Note the management of this hedgerow differs across property boundaries.

The owner-manager of each hedgerow and fencerow was surveyed either by telephone interview or mailed questionnaire using the same questions. Two types of information were gathered. First, historical information about the past management practices on a particular hedgerow or fencerow was recorded. Second, the owner-manager was asked to respond to a series of questions to gauge their attitude toward care and preservation of hedgerows and fencerows. The attitude survey was constructed in such a manner that the lower the score the less favorable the manager's view of hedgerows. It was assumed that an attitude of less concern over the preservation of hedgerows would translate into more and intense disturbance. These included cultural and regulatory practices such as burning, clear-cutting allowing sprouting (Figure 3), grubbing, selective removal, top pruning, root pruning, herbicide application, planting trees or shrubs, mowing, grazing or other. Managed sample units contain any one or combination of those practices, while unmanaged sample units have been left untouched.

Each adjacent owner along a boundary hedgerow or fencerow was also surveyed as to management practices previously employed. To this end, each segment of hedgerow with similar adjacent owners becomes a sample even if it is only a portion of a larger hedgerow. For example a 440 meter (1/4 mile) N-S hedgerow on the same soil type may have one owner on the west but two sequential owners on the east (each 220 meters), thus yielding two sample units on the east and one on the west.

The fine-grained data collection allowed use of several analysis strategies to illuminate the composition and structure of hedgerows and fencerows, as well as possible relationships with human activities. Two distance to nearest neighbor measures were used to create 8 groups of like species composition based on reciprocal averaging. The groups were: fencerows using distance to nearest neighbor of any species (FEDNAS1, FEDNAS2) and nearest distance to neighbor of same species (FEDNSS1, FEDNSS2), and hedgerows using nearest distance to nearest neighbor of any species (HEDNAS3, HEDNAS4) and nearest distance to neighbor of same species (HEDNSS1, HEDNSS2). The 8 groups were then subjected to Principal Components Analysis in the Ordiflex program to view their relative positions in species space by variable. It was hypothesized that their relationship would be based on the known factors of soil, aspect and management. The eight hedgerow and fencerow data sets were subjected to Analysis of Variance using the independent variables richness (R) and sample total basal area for tree species (TBAS). It was hypothesized that richness, the total number of species per sample, and the sum of the basal areas for trees would be greater in hedgerows.

Two-way ANOVAS between management (managed or unmanaged) and between type (hedgerow or fencerow) were performed on the entire data set for each of three transformed (square-root) and standardized (per meter) variables. The variables were distance to nearest neighbor of same species (DNSS), total basal area for trees (TBAS) and richness (R). It was hypothesized that unmanaged hedgerows and fencerows would show greater density, richness and tree biomass. Finally, attitude scores based on the landowner/manager survey and management were subjected to a 2-way analysis of variance for DNSS, TBAS and R to detect differences in density, structure, and composition of hedgerows only. It was hypothesized that attitudes would lead to differences in management history and thus affect density, richness, and basal area.

With regards to structure, hedgerows only and fencerows only were first analyzed to determine random or clumped dispersion. Second, their structure was examined further by comparing the distribution of total basal area for all tree species in relation to the center of the hedgerow and fencerow. This was accomplished for managed and unmanaged hedgerows and fencerow by summing the basal areas for each 0.5 meter of width.

## Results

Reciprocal averaging allowed the separation of the fencerow and hedgerow samples into groups of more or less like species. There was, however, much overlap between the species complement for several of the groups (Table 1).

Generally, fences seemed more open to colonization by naturalized species; however, there was a group of 10 fencerow samples which contained only one woody species. These samples were not used in any analysis. This "null" group was entirely a managed one. It should be noted that except for two elm species, green ash and moisture-loving cottonwood and willow, the woody species composition are characterized by either thorns or fleshy fruits.

Because hackberry and Missouri gooseberry were found in nearly every hedgerow and often were the only two woody plants besides Osage-orange that occurred, ordinations of HEDNSS 1, HEDNSS 2 HEDNAS 3 and HEDNSS 4 did not use them.

Hackberry, Missouri gooseberry, American plum and white mulberry seem to readily inhabit both fencerows and hedgerows. On the other hand, there was an association of understory shrubs and vines: buckthorn, poison ivy, golden currant, wild raspberry greenbriar and woodbine exclusive to hedgerows. Similarly, gray dogwood and multiflora rose were exclusive to fencerows. Most interesting for future investigation would be the dispersion or loss of several species which occur as one or two individuals. These species were Kentucky coffeetree (*Gymnocladus dioica*), matrimony vine (*Lycium halmifolium*), moonseed (*Menispermum canadense*), apricot (*Prunus armenica*), smooth sumac (*Rhus glabra*), buckbrush (*Symphoricarpos orbiculatus*), and Tartarian honeysuckle (*Lonicera tartarica*).

The hedgerows as a group and fencerows as a group were each analyzed to gauge whether species in them were random or clumped. Computer programs "Poisson.Bas" and "Negbinom.Bas" (Ludwig and Reynolds 1988) computed various indices based on the frequency distribution of species per 100 meters in each sample unit. To determine the patterning several hypotheses were tested for hedgerows and fencerows:

## TABLE 1
## HEDGEROW AND FENCEROW SPECIES COMPOSITION BY GROUPS USED IN ANALYSES

| | | N=35<br>HEDNSS1 | N=34<br>HEDNSS2 | N=33<br>HEDNAS3 | N=42<br>HEDNAS4 | N= 24<br>FEDNAS1 | N= 21<br>FEDNAS2 | N= 24<br>FEDNSS1 | N=20<br>FEDNSS2 |
|---|---|---|---|---|---|---|---|---|---|
| Hackberry | *Celtis occidentalis* L. | + | + | + | + | + | + | + | . |
| Mo. Gooseberry | *Ribes missouriensis* Nutt. | + | + | + | + | . | + | + | |
| *White Mulberry | *Morus alba* L. | . | + | + | + | + | + | + | . |
| American Plum | *Prunus americana* Marsh. | + | | + | + | + | + | + | . |
| American Elm | *Ulmus americana* L. | + | | + | + | . | | | |
| Chokecherry | *Prunus virginiana* L. | + | | + | + | | . | | |
| Green Ash | *Fraxinus pennsylvanica* Marsh. | + | | . | + | | . | | |
| Honey-locust | *Gleditsia triacanthos* L. | . | + | . | + | + | | | . |
| Poison Ivy | *Toxicodendron radicans*(L.) O. Ktze. | + | | + | . | | | | |
| Greenbriar | *Smilax hispida* L. | . | | + | . | | | | |
| E. Redcedar | *Juniperus virginiana* L. | . | + | . | . | + | | | + |
| *Siberian Elm | *Ulmus pumila* L. | . | | . | + | + | + | + | + |
| Golden Currant | *Ribes aureum* Wendl. | | | . | + | | | | |
| Woodbine | *Parthenocissus vitacea* (Knerr)Hitch. | . | | + | | | | | |
| Wild Raspberry | *Rubus ideaus* L. | . | | + | | | | | |
| River Grape | *Vitis riparia* Michx. | | . | . | . | + | | | |
| Black Willow | *Salix nigra* Marsh. | | . | . | . | . | | | . |
| Prairie Rose | *Rosa arkansana* Porter | | | . | | . | + | | + |
| *Buckthorn | *Rhamnus cathartica* L. | . | | . | | | | | |
| Boxelder | *Acer negundo* L. | | | . | | . | | . | |
| Elderberry | *Sambucus canadensis* L. | | | . | | | | . | |
| Gray Dogwood | *Cornus foemina* P. Mill. | | | | | | . | | |
| *Osage Orange | *Maclura pomifera* (Raf.) Schneid. | | | | | + | + | + | . |
| *Black Locust | *Robinia pseudo-acacia* L. | | | | | . | | . | . |
| *Multiflora rose | *Rosa multiflora* Thunb. | | | | | . | | | + |
| Cottonwood | *Populus deltoides* Marsh. | | | | | . | | | . |

*Non-native species +Major species . minor species

All nomenclature follows the *Flora of the Great Plains* ( Great Plains Flora Association 1986).

1) The number of plants/100 meters were from a Poisson distribution and hence randomly patterned by using the number of woody plants per 100 meters, for 83 hedgerow and 58 fencerow samples. A total number of 3068 individuals per hedgerow and 696 per fencerow gave a Variance/Mean Ratio (Index of Dispersion) of 14.18 and 9.4 respectively. For hedgerows the $\chi^2$ value with 11 df is 151.8 ($p<.0001$), hence the hypothesis that woody plants were randomly patterned was rejected. For fencerows the $\chi^2$ value with 7 df is 110 ($p<.0001$), hence the hypothesis that woody plants in fencerows are randomly patterned was rejected.
2) The number of plants/100 meters were from a Negative Binomial distribution and hence clustered by using the number of woody plants per 100 meters for hedgerows and fencerows. A total number of 79 individuals per hedgerow and 103 per fencerow give a Variance/Mean Ratio (Index of Dispersion) of 1.17 and 2.77 respectively. For hedgerows the $\chi^2$ value with 1 df is 0.26 ($p<0.46$), hence the hypothesis that woody plants were randomly patterned was not rejected. For fencerows the $\chi^2$ value with 1 df is 1.73 ($p<0.72$), hence the hypothesis that woody plants in fencerows are randomly patterned was not rejected.

Principal Components Analysis (PCA) was performed on the eight groups of hedgerow and fencerow samples suggested by reciprocal averaging and allowing a focus on a smaller selection of samples. Inputs into the PCA were both nearest neighbor values (DNAS and DNSS) per species. In each case the major axes examined were 1 and 2, each accounting for the maximum portion of the variation within the samples (Table 2). Interpretation of the variation accounted for by the axes was difficult because of tight sample clusters. Generally, sample unit patterning did not correspond in any strong way to a definable axis based on the environmental variables of soil, aspect or management, with the following exceptions:

1) FEDNSS1: Sample units from the same fencerow showed a strong tendency to cluster (Figure 4).
2) FEDNSS 2 and FEDNAS 1: Some sample units from the same fencerow clustered.
3) HEDNSS 1: About 20% of the sample units with the greatest distance from the cluster center shared the characteristic of being unmanaged.

TABLE 2
SUMMARY OF VARIATION ACCOUNTED FOR BY AXIS 1 AND AXIS 2
OF PRINCIPAL COMPONENTS ANALYSIS
FOR FENCEROW AND HEDGEROW GROUPS

| Group | Variation accounted for by: Axis 1 | Axis 2 | Total |
|---|---|---|---|
| FEDNAS 1 | 16.6% | 15.7% | 32.2% |
| FEDNAS 2 | 24.6% | 19.7% | 44.3% |
| FEDNSS 1 | 22% | 20% | 42% |
| FEDNSS2 | 22.2% | 18.1% | 40.3% |
| HEDNSS1 | 24.7% | 15.5% | 40.2% |
| HEDNSS2 | 27.5% | 23.9% | 51.4% |
| HEDNAS3 | 19.8% | 15.9% | 35.7% |
| HEDNAS4 | 27.9% | 20.9% | 48.8% |

4) HEDNSS 2: About 25% of the sample units that were well-separated shared the characteristic of being unmanaged. In addition, Axis 1 appears to be related to a moisture gradient with moisture increasing left to right (Figure 5). This can be surmised by looking at the species, willow, grape and chokecherry, which make up significant portions of those samples.

In order to further assess the groups suggested by reciprocal averaging, they were subjected to two, two-way analyses of variance using total basal area of all tree species (TBAS) per meter per sample and the number of species (richness) per meter per sample as dependent variables, comparing

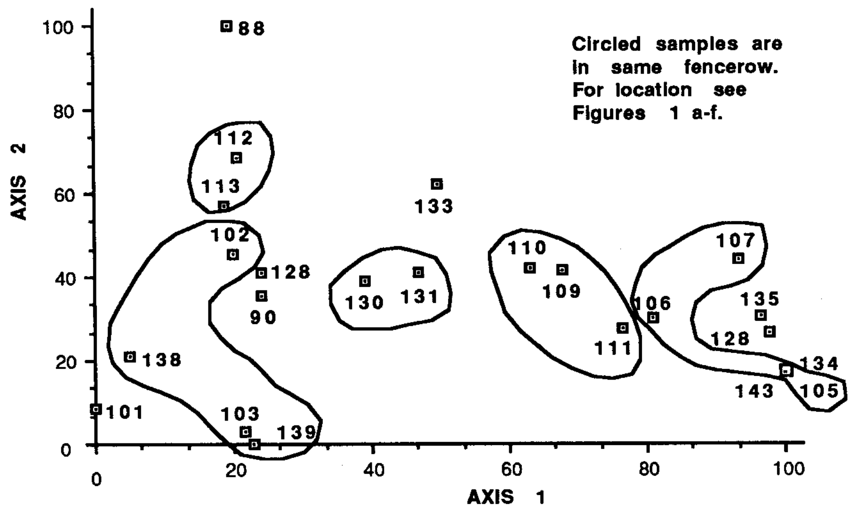



Figure 4. Principal components analysis for fencerow group FEDNSS 1.

them with type (hedgerows vs. fencerows) and management (managed vs. unmanaged). Both richness and basal area show a significant difference at the 5% level between hedges and fences for the factor of management (managed or unmanaged) (prob.>F-value=.023 and .022 respectively). For Richness, there is also a significant difference at the 5% level between type (fencerows and hedgerows) (prob.>F-value=0.02). The interaction for basal area was not significant (prob.>F-value=0.111). The interaction for richness (prob.>F-value of 0.929) was also not significant suggesting a lack of interaction between type and management.

One-way analysis of variance was run on all 8 groups with no significant differences between managed and unmanaged samples for basal area and richness except one. Using the variable of richness only the group, HEDNSS1 showed a significant difference at the 5% level for managed versus unmanaged hedgerow sample units (prob.F-value=0.028).

There was no significant difference between the total biomass expressed as total basal for hedgerows and fencerows and there was also no significant

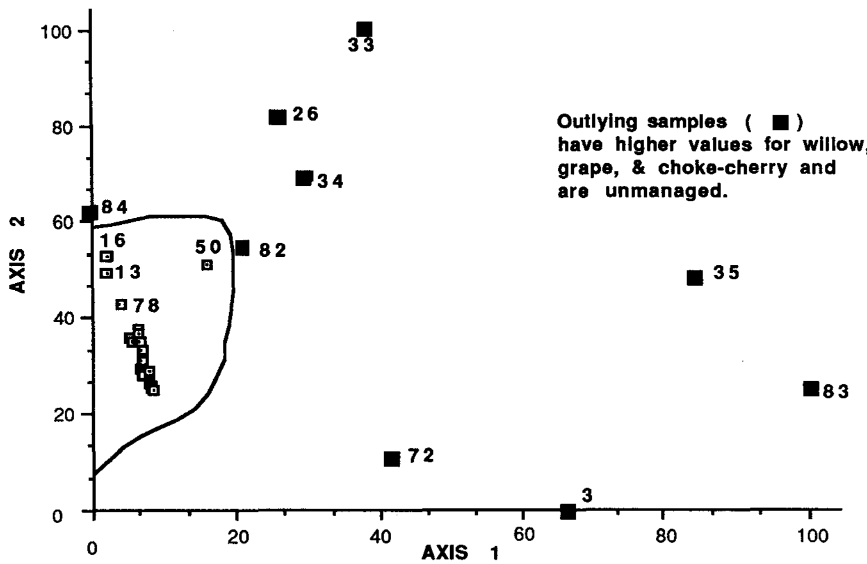



Figure 5. Principal components analysis for hedgerow group HEDNSS 2.

difference for it between managed and unmanaged hedgerows and fencerows. Apparently, the tree basal area is not a good indicator of differences between hedgerows and fencerows. This variable was, however, examined further to help understand hedgerow and fencerow structure by comparing the horizontal (width-wise) location of tree biomass for managed and unmanaged hedgerows and fencerows (Fig. 6).

The distribution and structure of the tree biomass is different (Fig. 7-8) for each type. Fencerows are narrower and have trees in closer proximity to the fence, while hedgerows spread trees out. The 0 to 0.5 meter range is critical in hedgerows because this location in unmanaged samples was the most shady and dry and the place competition with the Osage-orange most intense (Fig. 9). It must also be noted that the basal area for the Osage-orange trees gained from quick counts of stems and diameters is about 20 times greater than the other trees residing among them.

Finally, the attitudes of the landowner/manager were surveyed and linkages assessed between those attitudes as they impinged on hedgerows

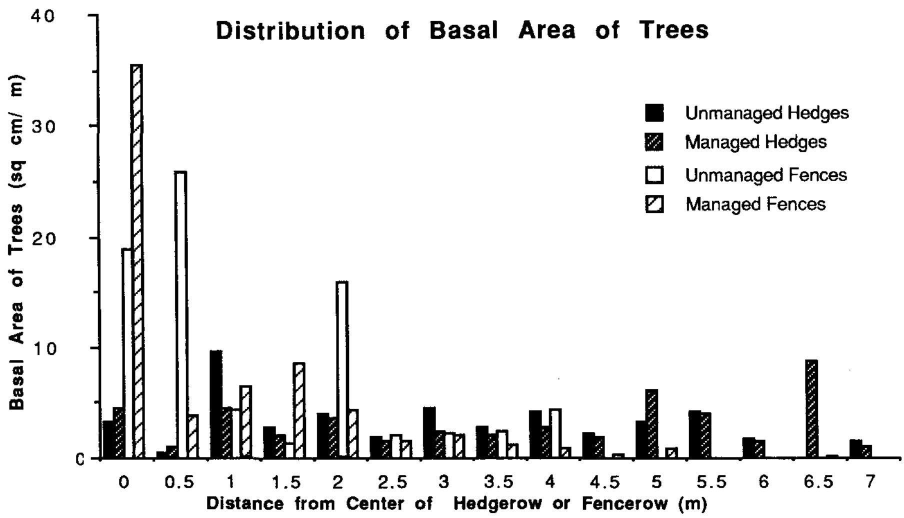



Figure 6. Comparison of basal area per meter of a sample v. 0.5 meter class distance from center of hedgerow or fencerow for all hedgerows and fencerows.

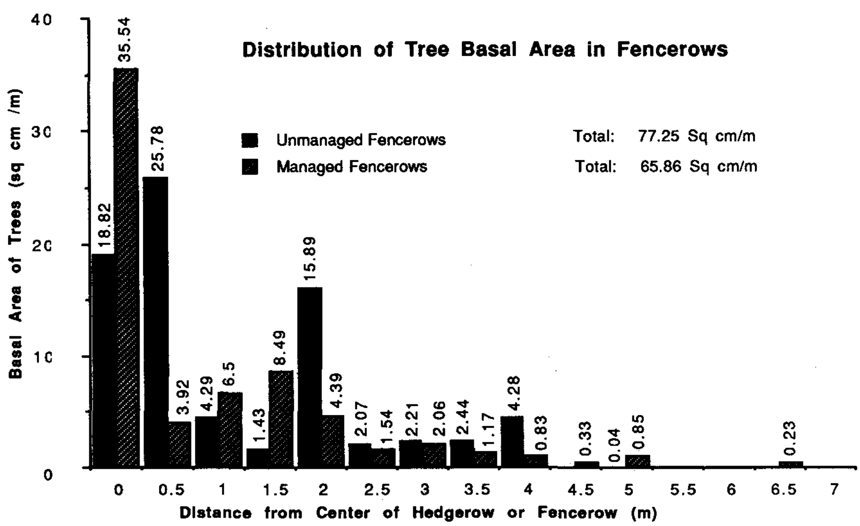



Figure 7. Comparison of basal area per meter of sample unit v. 0.5 meter class distance from center of fencerow for managed and unmanaged types.

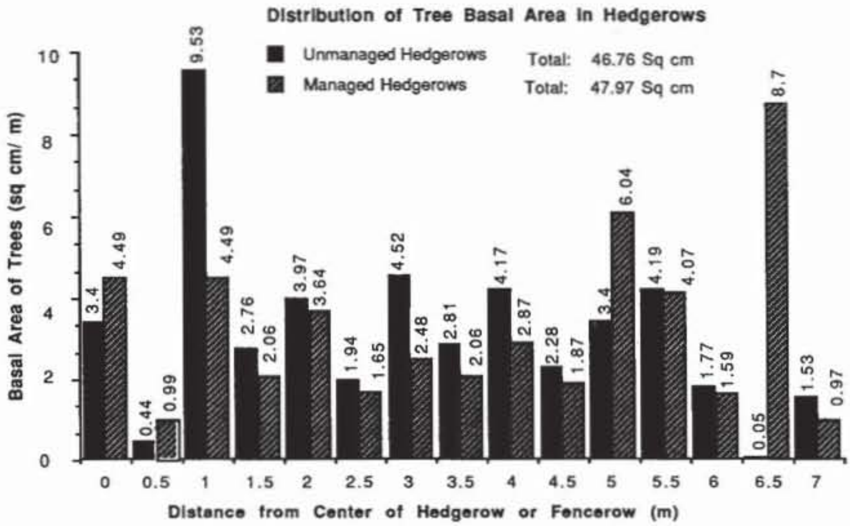



Figure 8. Comparison of basal area per meter of sample unit v. 0.5 meter class distance from center of hedgerow for managed and unmanaged types.

Figure 9. The interior of an unmanaged Osage-orange hedgerow. Note the edge effects from lessening competition between Osage-orange at right and hackberries on left.

only. Two-way ANOVA's were run on all hedges and the most representative groups, HEDNSS1 and HEDNSS2. In these groups, there was no significant, detectable direct linkages at the 5% level based on the dependent variables tree basal area or richness (prob.>F-value=0.054). However, if one considers "management" as a variable dependent on the attitudes of the owner or manager and compares it for all hedges, there is a significant difference at the 1% level (prob.>F-value=0.001) between management schemes based on Preservation/Removal class attitude scores derived form the survey.

Hackberry was found in almost all samples, while this lessens it usefulness in the PCA because it tends to obscure differences between samples; hackberry can be thought of as a broad gauge of the impact of human management activity. Therefore its existence became an indication of the relationship with management practice in hedgerows. An ANOVA examining the management versus number of hackberries per meter of hedgerow showed a significant relationship at the 1% level (prob.>F-value =0.01). Total numbers of individual hackberry are greater in unmanaged samples.

**Discussion/Summary**

Fencerows are spontaneous and visually patchy; and, based on observations in the study area and elsewhere, fencerows may be more susceptible to ongoing, casual woody plant removal (Fig. 2). Still, the dominance of Osage-orange tends to make the hedgerow appear more homogeneous. Results showed different densities, and species composition in fencerows and hedgerows. As might be expected, there was a wide variation as the species became rarer. Four rather important species are noted with asterisks as exotics, now naturalized in the rural landscape (Table 1). Many of the species in both hedgerows and fencerows are members of the deciduous woodland and reside both as understory and transition between woodland and prairie or as old-field succession constituents (Bazzaz 1968). Weaver (1965) lists Eastern redcedar and honey-locust as members of the deciduous woodland accompanying shrubs into open areas. Missouri gooseberry and wild raspberry, along with woodbine, poison-ivy, riverbank grape, American plum and chokecherry readily inhabit both hedgerows and fencerows. The upland hedgerows of Panama Township, however are devoid of about half of the typical shrub complement of the deciduous forest. One specimen of coralberry (*Symphoricarpos orbiculatus*), was found, while none were found of Bittersweet (*Celastrus scandens*), and prickly-ash (*Zanthozylum americanum*).

Bittersweet has been nearly extirpated from many cropland borders because of its susceptibility to the herbicide, 2-4D.

Weaver (1965:36) also gives an account of the typical successional stage of woody plant communities in eastern Nebraska:

> Summarizing, pioneer trees at stream sources are those with light, wind blown seeds, such as the willow. They usually appear soon after the prairie sod is weakened by erosion. Boxelder, elms, and ash, all with windblown seeds, occur as soon as there is favorable habitat. Pioneer shrubs and vines like elder[berry] and bittersweet and grapes have showy, edible fruits carried by birds. This early stage in woodland development is represented for considerable distance along nearly all small tributaries. When a stream develops a floodplain with wide protecting banks, large fruits such as those of walnut, hazel, bur oak, etc. are carried up stream by various animals, especially timber squirrels.

There are similarities to the linear hedgerow and fencerows due to lack of a continual supply of moisture. Because the hedgerow and fencerow create snowdrifts, excess moisture is deposited in and along them (Jenson 1954; Frank et al. 1976; Lyles 1976; Rollin 1983). This, however, is short-lived, intermittent and more than offset by evapotranspiration. Still, the blockage of wind and disturbance of a dense sod layer consequently by shade particularly in hedgerows offers the chance for initial stages of the successional scenario described by Weaver to occur. Animal vectors of fruits and seeds, especially squirrels were numerous in hedgerows but because no ready source of large fruits is widely available, these plants (bur oak) have not appeared. An exception was sample unit 42 (Fencerow stand I D 17, Fig. 1c) where three mature, human-planted walnuts along a hedge have not spread, probably because of unfavorable growing conditions. Many of the less easily dispersed species, large-fruited autochores, could not be found. This also points to the young successional stage of hedgerows and fencerows because these types of fruit are not usually associated with pioneers species (Huston and Smith 1987). The opposite is true of Osage-orange; since its introduction, squirrels and gravity keep new seedlings in close proximity to fruiting trees. A large number of constituent anemochores would be expected because prairie or open environments favor wind seed dispersion. This does not seem true for woody plants dispersed by wind; the study found only 6 of 33 species total. At points where hedgerows or fencerows intersect drainages, the groupings of plants more closely fit Weaver's description.

While it is not surprising that fencerows and hedgerows are somewhat different with regards to species composition, density, and structure, it is interesting that PCA relationships indicate strong similarities with a few noted exceptions. Hedgerow- and fencerow-woodly plant distribution patterns are both clustered. This can be explained given the biology of major portion of the woody plants. One would expect fruit dispersal by birds (Smith 1975) to be clustered closely with parent-food source. McDonnell and Stiles (1983) noted what they called "recruitment foci," which received significantly more seed input and thus lead to a clustered or nucleated spatial structure (Yarranton and Morrison 1974).

Each environment, hedgerow or fencerow, can be thought to be limited in biomass by competition for scarce water resources. The relatively high stress environment, and young age (100-130 years) of Great Plains hedgerows would also account for some variance in associated species. Each hedgerow or fencerow has its own similar developmental and environmental histories and hence are more similar within themselves (Fig. 4).

Only 5 hedgerow species were wind dispersed, and they represented a small fraction of the total number of individuals. This is somewhat different than Weaver's stream scenario, and also the dispersal findings of Dutch plant geographers (Nip-van der Voort et al. 1979). Their research on newly created land in three Dutch polders showed anemochores being most prevalent and autochores least so on new road verges. This changed on older roads with autochores gaining importance and implying a successional shift. Dispersal of plants in Great Plains hedgerows may be subject to rates more in line with that of English snails (Cammeron, Down and Pannett 1980), because of a severe stress gradient. Nebraska hedgerows also seems to match the successional models of Huston and Smith (1987), where "the effect of water stress, modeled . . . is to slow growth rates and overall rate of successional replacement." They also noted on their computer simulations, "slower build up of biomass . . . and higher species diversity."

Several authors studying birds have made reference to the importance not only of plant composition and structure, but also management of the hedgerow (Linehan 1957; Moore, Hooper and Davis 1967; Murton and Westwood 1974; Wilmot 1980; Arnold 1983; Best 1983; Rands 1983; Shalaway 1983). Management practices can radically alter structure and species composition in hedgerows and fencerows (Helliwell 1975). Consideration of management practices, or the lack of them, immediately brings us face to face with the impact of human beings. Since hedgerows are anthropogenic, one can approach the concept of plant community where "man [is] a maker of plant communities" (Whitney and Adams 1980). Whitney and Adams used several community descriptors such as species diversity and dominance (importance value) in concert with socio-economic factors to define clear anthropogenic plant communities in Akron, Ohio.

Management activities clearly have created differing assemblages and structure in hedgerows. The unusual results, indicating little interaction between management and vegetation type (hedgerow or fencerow), when examining species richness can be explained by the large number of managed hedgerows being grazed and thus reducing wood species through trampling or browsing. Management is most likely a disturbance of some type and may be a primary cause of differences in species composition (Denslow 1980; Noble and Slayter 1980), between hedgerows and fencerows. The degree and type of change brought about by differing management activities can not be addressed in this study because all types of management were pooled. Still, there is a noticeable difference between grazed hedgerows and those harvested for posts.

The composition, form, size, location, age and management of hedges reflect both social and natural events. Hedgerows occur in the landscape **because of** human activity, but are subject to natural and social forces (Fig. 10). Humans and human interactions (communities or neighborhoods (Palmer 1984), economic activity and so forth) are conversely affected by the structure of the landscape. Allen (1989) has argued for using management units as investigative units, herein represented by boundary fencerows and hedgerows. One could consider the interaction of humans in the origin and maintenance of the hedgerow as still another higher order interaction. Nassauer (1988) has studied rural landscapes in the upper Mid-west and has found that "neatness" is an attribute toward which managers move. Timing, placement and type of management add other factors which impact the plant abundance and content of a hedgerow. Where management is cyclic, however, and more or less predictable, one would expect the hedgerow to more closely resemble natural communities, particularly one with periodic disturbance, such as the Vijfheerenlanden willow coppice community in Holland (Dijst et al. 1981). Landscapes and the plant communities of which they are comprised, are either natural or anthropogenic. The differences are often subtle but are strongly influenced by management of organisms over space and time (Fig. 11).

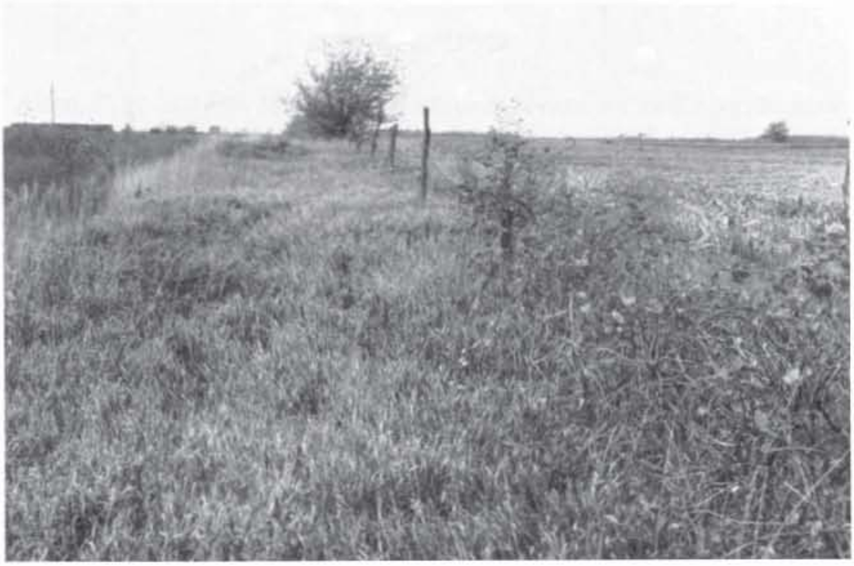


Figure 10. An open fencerow with a complement of river grape in foreground and white

This study showed a weak but persistent linkage between attitude, management, and woody plant community structure in a rural landscape. More study material from a wider area could help to strengthen our understanding. That humans have an impact on their surroundings is not doubted, but the quantity and quality of that impact is largely unknown. This study has a number of assumptions and the conclusions are most likely valid for a small segment of a rural landscape. However, it has attempted to quantify a much proclaimed but poorly documented area of landscape ecology, namely humans and culture as an ecological force in making landscape. Frequent, repetitive management activities regulate nature into stable or more predictable landscape than might have been predicted. This study has shown, in a specific instance, that a seminal relationship is already present within a predominantly human-created plant community. This relationship can lead us to design more sustainable plant communities, on the one hand, and more sensitive sustainable management of natural plant communities on the other.

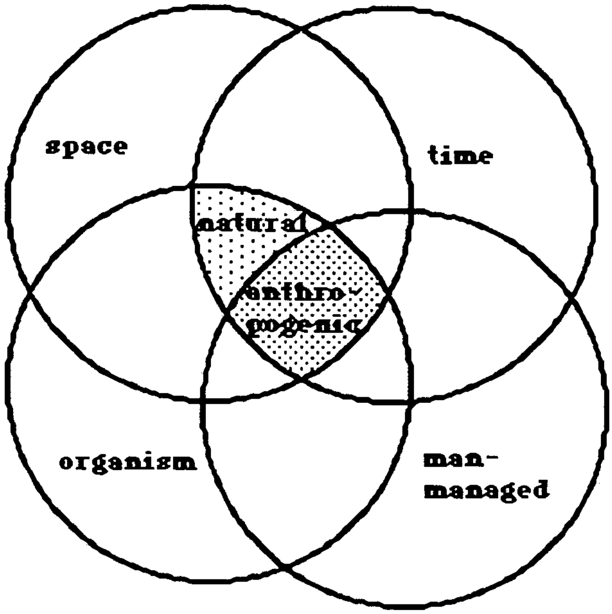



Figure 11. The anthropogenic plant community.

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