LOWER GREY CLOUD ISLAND FOREST PATCH: A 20 YEAR RECLAMATION MONITORING STUDY[1]

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Abstract. Reclamation specialists are constantly searching for efficient and effective revegetation methods upon xeric sites. In our investigation, we created a small forest patch, densely packed with woody plants and observed the development (expansion and mortality) of individual plants and groups of plants in the patch for the last 20 years. The patch has expanded from about 0.11 acres to about 1 acre in area; while the inner core of trees has only slightly expanded from 0.08 acres to 0.10 acres in size. The collective basal area of most tree species has increased but is now spread across many individuals. The basal area growth of some of the inner individuals has nearly halted (less then 0.1 inches in dbh over 5 years). In contrast, many surviving edge trees have increased their basal area with some individuals growing more than 0.5 dbh inches per year. Box elder (*Acer negundo* L.) is the only species that has greatly increased in the number of individual trees (dbh $\geq$ 10 cm). Siouxland Eastern Cottonwood (*Populus deltoides* Bart. Ex Marsh. "Siouxland") has gone extinct. Woody plant seedling recruitment continues to occur for northern red oak (*Quercus rubra* L.), woodbine (*Pathenocissus quniquefolia* (L.) Planch), riverbank grape (*Vitis riparia* Michx.), Eastern red cedar (*Juniperus viginiana* L.), grey dogwood (*Cornus recemosa*), Norway maple (*Acer platanoides* L.), green ash (*Fraxinus pennsylvanica* (Marsh.), and common hackberry (*Celtis occidentalis* L.). A small stand of Kentucky Bluegrass (*Poa pratensis* L.) remains in the understory of the inner core of the stand and the wood chip mulch which was applied during installation has been consumed. The full extent of the stand has become unrecognizable, as the stand has now merged with naturalized stands of sumac (Rhus sp.). Our study indicates that such an approach can achieve 100% shrubland savanna cover in 20 years, by establishing patches over 10% of the Lower Grey Cloud Island landscape. In contrast, traditional landscape treatments applied on the site have not achieved such a rapid colonization rate ($p \leq 0.01$).

Additional Key Words: plant ecology, landscape ecology, landscape architecture, planting design, landscape horticulture, urban forestry, landscape planning

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Introduction

In 1983, we established a small forest patch resides on the Lower Grey Cloud Island, southeast of St. Paul, Minnesota (Fig. 1). This densely packed circular forest patch had been installed on a large xeric pile of excess sand resulting from sand and gravel mining (Sanders and Associates 1981, Sanders *et al*. 1982, Burley *et al*. 1998 and Burley *et al.* 2004). The surface mine operations continue to supply sand and gravel for road mixtures and concrete. Our study describes the recent development of this forest patch since the last time it was measured, in 1998.

Study Area and Methodology

Study Area

Over the first fifteen years of the stand, the patch expanded from about 0.11 acres to 0.58 acres in area; while the inner core of trees expanded slightly from 0.08 acres to 0.09 acres in size. The collective basal area of most tree species increased but was concentrated in fewer

Figure 1. View of the Lower Grey Cloud Island, Minnesota along the Mississippi River, looking towards the southwest in the spring of 2003.

individuals (Burley *et al.* 2004). The basal area growth of some of the inner individuals nearly halted (less then 0.25 cm in dbh over 5 years). In contrast, many surviving edge trees increased their basal area with some individuals growing more than 1.5 dbh cm per year. Box elder (*Acer negundo* L.) is the only species that had increased in the number of individual trees (dbh $\geq$ 10 cm). Siouxland Eastern Cottonwood (*Populus deltoides* Bart. Ex Marsh. "Siouxland") became extinct. Woody plant seedling recruitment occurred for northern red oak (*Quercus rubra* L.), woodbine (*Pathenocissus quniquefolia* (L.) Planch.), riverbank grape (*Vitis riparia* Michx.), Eastern red cedar (*Juniperus viginiana* L.), and common hackberry (*Celtis occidentalis* L.). Over the years, a small stand of Kentucky Bluegrass (*Poa pratensis* L.) formed in the understory of the inner core of the stand. Even though changes in the inner core have been slow, we expected the inner core of trees to expand in area and expected to observe tree recruitment and increased diversity over the study area.

We also reported that during the first ten years, the green ash (*Fraxinus pennsylvanica* (Marsh.) trees and smooth sumac (*Rhus glabra* L.) shrubs planted outside the patch and placed in more typical planting spatial arrangements had a higher rate of mortality ($p \leq 0.01$) (Burley *et al*. 1998). We had also predicted that total area for the patch and rate of change for the patch could be expressed in equations 1 and 2, explaining 98 percent of the variance, with significant regressors (intercept and age of the stand in years squared) at $p \leq 0.001$.

$$\text{Area of Patch in Acres} = 0.121 + 0.001 * (\text{age of stand in years})^2 \quad \textbf{(1)}$$

$$\text{Rate of Change in Area of Patch} = 0.002 * (\text{age of stand in years}) \quad \textbf{(2)}$$

In addition we had reported that in the summer, surface soil temperatures could reach 24 degrees F. warmer outside the forest patch than within it and that the forest floor of the patch could be as dark as 125 foot candles on a bright summer day (Burley *et al*. 1998).

Methodology

Our methodology for the investigation is not too complex, but quite detailed, as we record the development of individual plants in the stand. For the first 10 years (to 1993) we measured the site every fall, then again five years later (1998), returning in 2004. We measured the diameter at breast height (dbh) of every tree on a measured map, locating each individual, recording the tree's basal area across the years. We have mapped the location of new seedlings (recruitment) and note the mortality of individual trees. In addition, we have mapped the extent of groundcover and dimension of the xeric clump. We intend to continue measuring the stand about every five years, providing the stand remains available for study.

Results

In 2004, we noted that the patch had expanded from its initial size of 0.11 acres to over one acre in extent and has merged with other stands of *Rhus* sp (Fig. 2). Nevertheless, the inner core of trees has expanded from 0.08 acres to only 0.1 acres in size (Fig. 3). The collective basal area of most tree species has increased but is concentrated in fewer individuals. The basal area growth of some of the inner individuals has nearly halted (less then 0.25 cm in dbh over 5 years).

Figure 2. View looking west of the stand illustrating the composition and structure of naturalized *Rhus* sp. and emerging saplings surrounding the stand.

In contrast, many surviving edge trees have increased their basal area with some individuals growing more than 1.25 dbh cm per year. The box elder (*Acer negundo* L.) trees decreased in the number of individual trees and saplings (dbh $\geq$ 2.54 cm) (Table 1). Woody plant seedling recruitment including tree seedlings (Table 2) has occurred for northern red oak (*Quercus rubra* L.), woodbine (*Parthenocissus quinquefolia* (L.) Planch.), riverbank grape (*Vitis riparia* Michx.), Eastern red cedar (*Juniperus viginiana* L.), honeysuckle (*Lonicera* sp.), grey dogwood (*Cornus recemosa* Lam.), Norway maple (*Acer platanoides* L.), northern prickly ash (*Zanthoxylum americanum* Mill.), *Salix* sp. (willow), *Rubus* sp. (raspberry/blackberry), green ash (*Fraxinus pennsylvanica* (Marsh.) and common hackberry (*Celtis occidentalis* L.). A small stand of Kentucky Bluegrass (*Poa pratensis* L.) has become less substantial (less area covered per square meter) within the inner core of the stand.

Table 1. Total number of trees and saplings ($\geq$2.54 cm dbh) by species within the patch.

Tree Name	1983	1988	1993	1998	2004
Acer negundo	0	1	21	30	19
Fraxinus pennsylvanica	11	11	11	11	10
Juniperus virginiana	7	7	7	7	7
Populus deltoides	15	8	1	0	0
Prunus maackii	15	13	13	12	2
Prunus serotina	0	0	8	7	7
Quercus rubra	10	5	2	7	4

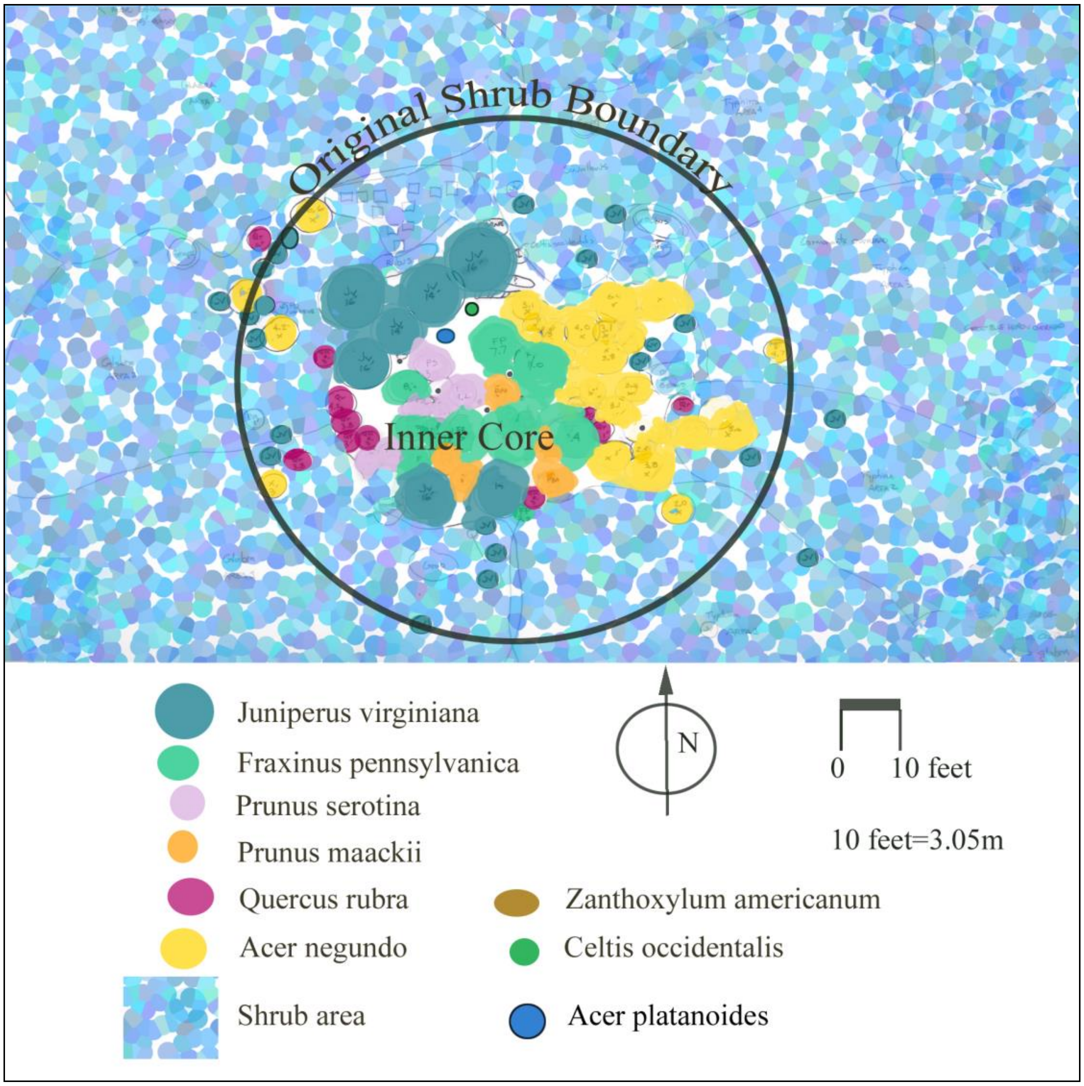

Figure 3. 2004 measured map of the inner core of trees and shrubs in the forest patch stand.

Table 2. Total number of tree seedlings (<u><</u>2.54 cm dbh) by species within the patch.

Tree Name	1998	2004
Acer negundo	5	1
Acer platanoides	0	1
Fraximus pennsylvanica	0	2
Juniperus virginiana	7	18
Prunus serotina	2	0
Quercus rubra	3	4
Salix sp.	0	1

Discussion

Forest Patch Expansion

Based upon predictions made from observations during the first 10 years of forest patch development, it was estimated that the forest patch in 2004 (21 years) would grow to 0.562 acres in size. However, the patch has now grown to over an acre in size and has merged with naturally occurring stands of *Rhus* sp. Nevertheless, the expansion has been primarily in the spread of shrubs and not the spread of trees. We still believe that the forest portion of the patch will begin expanding, but we find it interesting that the expansion has moved quite slowly. Thus we interpret the results of our study to mean that the stand withstood the ravages of establishing vegetation in a xeric environment (especially when compared to the mortality rates of traditional planting approaches) and that the stand was highly visible (noticeable) from the first day of planting. However, the woody forest patch core of the stand has not begun to highly influence the landscape beyond the borders of the initial planting. In our opinion, the stand looks less significant today as naturalized stands of shrubs and trees compete for visual attention.

Tree Recruitment and Mortality

We also find the dynamics of the tree recruitment and mortality interesting. *Acer negundo* (L.) decreased in abundance for the first time in the stand and *Prunus maackii* (Rupr.) is becoming nearly extinct, as only 2 of 15 trees remain. Small seedlings of *Celtis occidentialis* (L.), *Acer platanoides* (L.), *Fraxinus pennsylvanica* (Marsh.), *Quercus rubra* (L.), and *Juniperus virginiana* (L.) have been found within and near the core of the stand. Only a few *Juniperus virginiana* (L.) have been found residing beyond the general area of the core.

We expected to observe several species of woody plant seedlings from woody plants abundantly growing in the area nearby (within 1 kilometer) to colonize the patch, including: juneberry (*Amelanchier canadensis* L. Medic), and Chokecherry (*Prunus virginiana* L.), as these plants are often distributed in bird droppings. Especially when woodbine (*Pathenocissus quniquefolia* (L.) Planch.), riverbank grape (*Vitis riparia* Michx.), Eastern red cedar (*Juniperus viginiana* L.), and common hackberry (*Celtis occidentialis* L.), have probably colonized the site in this manner. In addition, red maple (*Acer rubrum* L.), sugar maple (*Acer sacharum* Marsh.), silver maple (*Acer saccharinum* L.), American basswood (*Tilia americana* L.), elm (*Ulmus* sp.) have not colonized the site; yet, *Acer platanoides* (L.) and *Fraxinus pennsylvanica* (Marsh.) have established themselves in very limited numbers on the site.

We are surprised to see *Quercus rubra* (L.) colonizing the site, because the acorns need to be relocated several hundred meters from acorn bearing trees to inhabit the site. There are other oaks and nut trees nearby that have not colonized the site including: white oak (*Quercus alba* L.), northenr pin oak (*Quercus ellopsoidalis* E.J. Hill), bur oak (*Quercus macropcara* Michx.), hickory (*Carya* sp.) and walnut (*Juglans* sp.). Other nearby tress that could colonize the site include cottonwood (*Populus deltoides* Bart. Ex Marsh.) and quaking aspen (*Populus tremloides* Michx.).

The *Fraxinus pennsylvanica* (Marsh.) planting has remained stable and accumulated biomass. The canopy of these trees, along with *Acer negundo* (L.) has started to noticeably increase, creating a closed canopy. We believe that this closed canopy has resulted in the lower abundance of *Poa pratensis* (L.) within the core. We believe that Prunus *maackii* (Rupr.) is not able to compete with these two trees (see Grime 1979 and Curtis 1959).

We have recorded data to assess plant diversity, importance values, and vegetation dominance in anticipation of studying the dynamics of the stand and the composition of the stand in relationship to related stands described by Curtis (1959). However, since so little change has taken place in the stand, we believe reporting such information is currently of only limited value.

Conclusion

We are still waiting for the core to expand and influence its borders. We were initially impressed with the establishment and visual impact of the clump. However, we are disappointed and maybe somewhat impatient for the clump to expand. Nevertheless we are encouraged by the development and expansion of the shrubland savanna. Our study suggests that a *Rhus* sp. shrubland savanna on the site can cover the upland landscape in 20 years by planting xeric clumps over 10% of the area. Since there are so few long-term studies observing the growth and development of individual plants, we are hopeful that we may observe future phenomena about the individual plants as they interact with the environment. Even though changes in the inner core have been slow, we have observed signs that the core may be beginning to expand and expect to observe tree recruitment and increased diversity over the next 20 years.

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