SEED DISPERSAL BY WIND AND BIRDS IN A TALLGRASS PRAIRIE: IMPLICATIONS FOR PRAIRIE MANAGEMENT

A Thesis

Presented to the

Graduate Faculty of the Biology Department

and the

Faculty of the Graduate College

University of Nebraska

In Partial Fulfillment

of the Requirements for the Degree

Masters of Science

University of Nebraska at Kearney

By

Mark J. Morten

April 2011

THESIS ACCEPTANCE

SEED DISPERSAL BY WIND AND BIRDS IN A TALLGRASS PRAIRIE:

IMPLICATIONS FOR GRASSLAND MANAGEMENT

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Acceptance for the faculty of the Graduate College, University of Nebraska, in partial fulfillment of the requirements for the degree Master of Science, University of Nebraska at Kearney.

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Supervisory Committee

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Supervisory Committee Chair

Date

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ABSTRACT

Tallgrass prairies currently occupy less than 2% of their original area in Nebraska, and land management activities emphasize restoring and managing these remaining prairies. My study focused on two methods involved with management of tallgrass prairies and was conducted along the Platte River in central Nebraska. First, I quantified the number of seeds dispersed from established prairies into simulated restoration sites to determine whether enough seeds are dispersed by wind to reduce the costs of restoring prairies manually. I measured the dispersal of seeds 0-100 m into simulated restoration sites, focusing on dominant species of grass: big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium),* Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and tall fescue (*Festuca arundinacea*). I discovered that the species composition of these dominant grasses dictates how many seed structures are produced and whether those seed structures have an embryo or are empty. In this system, the seeds dispersed were mostly empty, making them unsuitable for replacing planting.

Second, I quantified the number of tree and shrub seeds deposited around wooden and steel t-posts in bird feces to measure the impact of artificial perches on the establishment of trees and shrubs on the prairie. I discovered that birds deposited a large number of tree and shrub seeds around fence posts, with the season dictating bird activity and which species of seed were deposited. Due to the loss of historical grazing and fire regimes and the introduction of artificial perches in the form of fences, windmills, and other structures, maintenance of prairie ecosystems requires proper management practices, such as periodic burning and rotational grazing, to combat establishment of woody species around artificial perches.

ACKNOWLEDGEMENTS

I first would like to thank The Platte River Whooping Crane Maintenance Trust, Inc., for funding and assistance from its staff during the many situations I encountered in the field. In particular, I thank Luis Ramirez for assistance coordinating land management to help me reach my study goals; Travis Dessinger for assistance with the machinery and cattle chasing; Dr. Felipe Chavez-Ramirez for advice about the initial study design; and Chuck Cooper for support and advice through the final steps of my degree.

Secondly, I thank all the volunteers who assisted me in building traps, sorting seeds, setting traps, and the occasional cow chase: Coyde Fickle, Alexandra Frohberg, Jennifer Merlino, Tony Bridger, Aric Buerer, Jessie Morten, and students from the Autonomous University of Nuevo León: Homero Alejandro Gárate Escamilla, Ana Cecilia Espronceda Almaguer, Oscar Oswaldo Rodríguez, José Fermin Loera García, José Ignacio Galván, Jonathan Marroquin Castillo, and Andrés Solorio Pulido.

Thank you to my committee members, Drs. Mary Harner, Keith Geluso, Letty Reichart, and Jeremy White, for your advice and leadership throughout my project. To my advisor Dr. Mary Harner, without your help, support, and personal friendship none of this would have been possible. You not only helped me achieve a Masters of Science degree but also the next hardest thing, acquire the job of a lifetime, and for that I am forever indebted to you.

Lastly I want to thank my wife, daughter, and parents for all of your emotional and physical support. I know without a doubt that I would not have achieved this accomplishment without all of you at my side and sometimes behind me pushing.

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Chapter 1: Overview of Thesis

Prairies were once the most abundant ecosystem in central Nebraska, but they now cover an area of less than 1% of their original size. Therefore, research on prairie management and restoration is greatly needed to help preserve the natural functions of the few remaining native areas, as well as to reestablish others. A common restoration technique involves adding high diversity seed mixes of native species to accelerate recovery of plant diversity. Seeds from different prairie plants are harvested, by hand or machine, to create seed mixtures that are representative of historical species abundances. These seed mixtures are then spread over targeted areas by with seeding rates that vary with different mixtures and the vegetative goals of the particular restoration. Due to the manpower required to harvest, sort, and plant seeds, restorations are costly. Therefore, techniques to reduce restoration costs are constantly being researched.

I was asked by The Platte River Whooping Crane Maintenance Trust (the Crane Trust) to conduct a study to determine whether established prairies located next to proposed restoration units (e.g., crop fields and other areas) have enough seed dispersed by wind into the restoration unit to replace some of the planting. I conducted a pilot study in the summer of 2009 in which seed traps were placed in various management units managed by the Crane Trust, spanning a distance of 0 - 200 m from a seed source. Analyses of preliminary data indicated that seeds were distributed > 10 m from a seed source, with a strong negative correlation between number of seeds caught and distance from seed source. I also detected a trend for greater seed dispersal from a burned site compared to an unburned site. Therefore, I expanded this study in 2010 to collect seeds at varying distances from five different seed sources on Crane Trust properties to determine whether seed dispersal by wind could replace mechanical seed planting as a restoration tool.

In addition, an unexpected pattern emerged from the pilot study. I had used steel fence posts to make exclosures to prevent cattle from disturbing seed traps, and birds landed on these posts. As a result, I collected a total of 178 large, bird-deposited tree/shrub seeds in traps with exclosures surrounding them and no large seeds in traps without exclosures, suggesting that presence of exclosures created artificial perches for birds that then deposited seeds into traps via feces. This led me to question the impact of all artificial perches on prairies and their effect on tree and shrub establishment. In 2010, I measured this by placing 20 artificial perches (steel t-posts and wooden posts) in the prairie and quantified the number of tree and shrub seeds deposited around them, as well as monitored bird use of the two perch types.

Combined, my results will guide land managers as they plan for the future of their properties. With better understanding of how to use established grasslands and reduce the costs of restoration, planning can be implemented to ensure optimal seed productivity and species content of a seed source. In addition, knowing the potential for tree and shrub establishment around fence posts will give incentive for removal of unnecessary perches and proper management practices around existing ones.

CHAPTER 2

GRASS SEED DISPERSAL AND ITS USE AS A REPLACEMENT FOR PLANTING IN PRAIRIE RESTORATIONS

Abstract

The Great Plains region of the central United States was once one of the largest prairies in the world, but most of this prairie has been converted to agricultural lands. Many conservationists and land managers seek to restore portions of native prairies to their original diversity, but at a cost of ~$280/acre and approximately 5 years for a restored area to establish, land managers are constantly searching for ways to reduce these costs. I investigated the potential of wind-dispersed seeds from an adjacent established prairie to replace planting efforts and reduce associated costs in prairie restorations on tallgrass prairies in central Nebraska. Five sites were chosen in which an established prairie site was located next to a simulated restoration site (grazed prairie). Seeds dispersed by wind from established prairies into simulated restoration sites were collected, quantified, and tested for viability. I discovered that the ability of the adjacent prairies to replace artificial plantings depends on the species of grass within the prairie. I observed that up to 20 m from the edge of the established grassland, equal or more seeds were dispersed than in plantings. However for tall, warm season grasses (*Andropogon gerardii*, *Schizachyrium scoparium, Sorghastrum nutans*, and *Panicum virgatum*), most seeds did not contain endosperm, and thus, not enough viable seeds were dispersed to significantly reduce restoration costs. My research generally shows that due to the lack of diversity of species actively dispersed by wind, restorations using diverse seed mixes may be the best method to reestablish prairies. However, in plantings where high species diversity is not an objective, such as grass pastures, certain species of wind dispersed grass seeds, like *Festuca arundinacea* and *Panicum virgatum*, could greatly reduce the

amount of planting required. In addition, the seed dispersal data I collected are the first field-collected data in this region, and they will be valuable for testing the accuracy of seed dispersal models.

Introduction

Prairies once covered > 95% of Nebraska, with the eastern third of the state dominated by tallgrass species and the remainder with mixed grass and Sandhill species (Smith 1990, Steinauer et al. 2003, Tunnel 2008). Natural disturbances, especially wildfires and bison grazing, formally maintained prairies by resetting succession so that woody vegetation did not encroach upon and degrade prairies (Abrams et al. 1986, Collins 1987, Fitch et al. 2001). Wildfires maintain prairie health by removing dead biomass, increasing soil irradiance, and stimulating soil microbial activity, which combined, support vigorous growth of grasses and herbaceous plants (Collins 1987, Hulbert 1988, Masters et al. 1993, Mitchell et al. 1996) and suppress tree establishment (Briggs and Gibson 1992, Briggs et al. 2002a,b). Grazing by large bison herds remove standing vegetation, create areas of disturbance by hoof action and wallowing, allow seasonal re-growth by constant herd movement, and shape fire patterns by creating grazed fire barriers within prairies (Knapp et al. 1999, Helzer and Stueter 2005). Semi-arid conditions with periods of severe drought (7-10 years) favor establishment of plants that can undergo periodic dormancy while enduring fire and grazing (Knapp 1984, Knapp 1985, Briggs and Knapp 1995). Combined, these disturbances create a diverse ecosystem that supports numerous species of animals reliant upon the different habitats and processes that originally maintained prairies.

Today less than 2% of Nebraska's original tallgrass prairies remain (Steinauer et al. 2003). European settlement led to eradication of bison herds, introduction of domestic cattle (*Bos taurus*), suppression of wildfires, and conversion of prairies to croplands

(Smith 1990, Knapp et al. 1999). After bison were eradicated from prairies, cattle were grazed in fenced pastures continuously throughout the year. Such areas often were overstocked and damaged by effects of continuous grazing rather than periodic grazing with which prairies evolved (Samson and Knopf 1994, Packard and Mutel 1997). In addition, wildfires were suppressed to protect forage, homesteads, and other property (Steinauer et al. 2003). Row crop agriculture was introduced around 1880, and since then almost all farmable ground has been converted to crops, leaving only small fragments of prairie remaining (Smith 1990). Combined, these processes reduced the overall amount of tallgrass prairie, the diversity it once supported, and its value as habitat for prairie wildlife.

In efforts to save existing prairies and restore degraded ones, organizations and programs have been established with the purpose of prairie management and restoration. Prescribed burning is used to replicate wildfires and cattle grazing is used to replicate grazing by bison (Helzer and Steuter 2005). Programs such as the Conservation Reserve Program (CRP) pay landowners to reestablish prairies by replanting crop fields with native grasses and forbs and aid landowners with their management. Some landowners replant their fields to grass pastures with the knowledge that they are more valuable for grazing than crop production (Mitchell et al 2005). When reestablishing prairie, a common practice is to collect seeds from different prairie plants, by hand or machine, to create seed mixes representative of historical species abundances and then disperse these seeds over targeted areas for restoration (Packard and Mutel 1997, Steinauer et al. 2003, Tunnel 2008). Due to the intensive manpower required, restorations are costly. According to Prairie Plains Resource Institute, the current cost of planting a high diversity (>75 plant species) upland mix is $280/acre (B. Krohn, pers comm.). Hence, restoring a 32.4 ha field (80 acres), a common size of crop field, costs $22,400.

My research examined the effectiveness of using established prairies adjacent to restoration sites as natural seed sources via wind dispersed seeds to reduce costs and manpower needed to restore prairies. Specifically, I addressed the following question: Do established tallgrass prairies disperse an equal quantity of seeds to replace artificial planting conducted in restorations, and if so, how much area of restorations can this replace? I predicted that established prairies disperse an equal quantity of seeds to replace planting within a certain distance of the seed source. My study aids in improving restoration techniques so that prairies can be restored for less cost per area. In addition, this is one of the first papers to present seed dispersal data collected in the field as opposed to data generated from simulation models (Jongejans and Schippers 1999, Bullock and Clarke 2000) or in controlled environments (Jongejans and Schippers 1999). My data will be valuable for testing the accuracy of such seed dispersal models.

Study site

In summer and autumn 2010, I conducted research on lands managed by the Platte River Whooping Crane Maintenance Trust (hereafter, The Crane Trust) near Grand Island in Hall County, Nebraska (Fig.1). The Crane Trust's properties consist of native and restored tallgrass prairies located in the Platte River valley. The land type is different than that of typical tallgrass prairies in that it has a high water table and is intertwined with sloughs (linear, wet depressions) and wetlands (Meyer et al. 2008).

Figure 1. State of Nebraska with location of the Crane Trust indicated with a star (source: blogs.westword.com).

Prairie vegetation in drier areas is dominated by grasses, including big bluestem (*Andropogon gerardii*), little blustem (*Schizachyrium scoparium*), and switchgrass (*Panicum virgatum*), whereas wet areas, such as sloughs, are dominated by species like prairie cordgrass (*Spartina pectinata*), softstem bulrush (*Schoenoplectus tabernaemontani*), and Emory's sedge (*Crex emoryi*) (Meyer et al. 2010).

Much of the property is managed on a four-year rotation of cattle grazing, prescribed burning, and resting. In year one of the rotation, a unit is burned in March or April and then grazed at a rate of 1.85 animal units (AU)/ha for four months (May-June and September-October). In year two, the unit is grazed for two months (July-August) at a rate of 1.85 AU/ha. In years three and four, the unit is rested (no grazing or burning), and then the rotation is repeated.

Methods

To determine whether established tallgrass prairies disperse enough seed into restoration areas to replace mechanical planting, I quantified the amount of seeds dispersed from five ungrazed areas (source sites) into five adjacent grazed management units (simulated restoration sites). The grazed units were devoid of most standing vegetation and thus simulated areas prepped for restoration. The amount of seeds dispersed by wind into grazed units was compared to the amount of seeds recently used for planting in nearby prairie restorations. Source sites included four burned areas and one unburned area (Fig. 2), and cattle were not grazed within source sites.

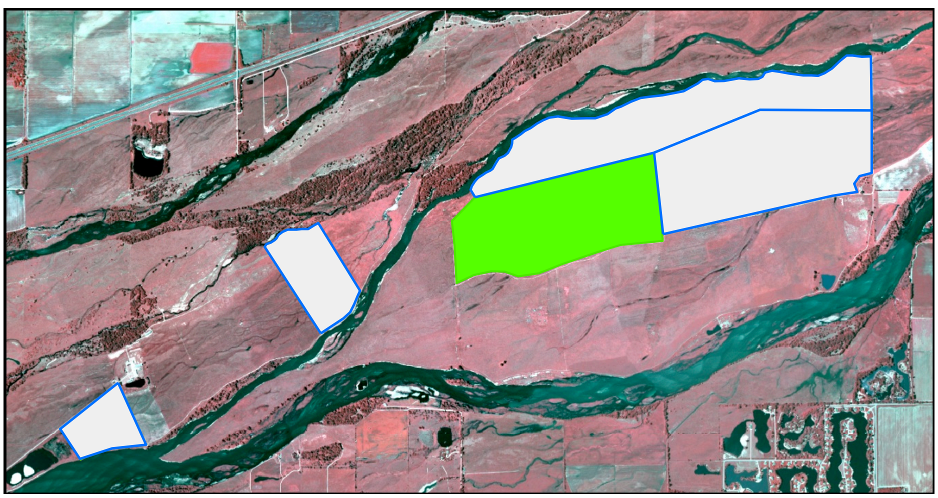

Figure 2. Grazed management units (simulated restoration sites) are outlined in blue and established seed sources are shaded with green. Aerial photo was taken in June 2010. Note that all grazed sites lie east of seed sources to take advantage of prevailing westerly and southerly winds.

Seed sources for research objectives were established in one of three ways. Two were 50 m x 150 m fenced exclosures located on the western end of a year one management unit. Two were created in cooperation with another study by fencing off the western half of two, year one management units, with the fenced off area measuring approximately 400 m x 300 m. One was created by using a year three management unit, 1600 m x 750 m, that was located on the western edge of a year one management unit (Fig. 2).

To simulate a restoration area, year one management units were used because they were grazed, which kept local vegetation trimmed off near ground level, thus minimizing contamination. A tractor with a mowing attachment also was used to mow grasses during the months of July and August when the cattle were rotated out of the management units. Mowing also was conducted when traps were first installed in June.

Figure 3. Seed trap made from a plastic funnel and PVC pipe.

I captured seeds in funnel traps, based on a modification of a design in Cottrel (2004). Each funnel trap consisted of a plastic funnel, cloth bag, and PVC pipe (Fig. 3). Funnels had a 15 cm diameter mouth with the neck cut off to leave a 5 cm opening at the narrow end of the funnel. A cloth soil-sample bag was attached to the narrow end of each funnel to collect seeds. The funnel and bag were placed in the PVC pipe measuring 7 cm in diameter and 20 cm tall. The PVC pipe was used as a stand to hold the funnel upright and to protect the collection bag from rodents and other elements. Once in place funnels were secured to pipe stands by a piece of wire, and the open end of each pipe was sealed with

Figure 4. Welded wire exclosure used to keep trap from being disturbed by cattle.

duct tape and wire mesh and then punctured to drain rainwater. The whole assembly was buried so that the lip of the funnel was ~ 5 cm above ground level (Fig. 3). All traps had welded wire exclosures placed over them to eliminate disturbance by cattle. Welded wire exclosures consisted of a 20 cm by 20 cm piece of 4 in/10.16cm welded wire fence staked to the ground directly over funnels (Fig. 4).

At each site I placed three lines of funnel traps leading from the edge of the ungrazed source site into the grazed simulated restoration site. Each line consisted of 13 funnel traps arranged from west to east and spaced at 0, 1, 2, 3, 4, 5, 10, 15, 20, 25, 50, 75, and 100 m from the edge of the ungrazed grassland (Fig. 5). Within each site, each line of traps was no closer than 20 m to other traps lines.

Figure 5. Seed traps leading away from source into grazed management unit.

I collected and replaced cloth bags beneath the funnel traps approximately bimonthly from July to December. After collection, bags were dried at 40ºC for 48 hrs and transported to the University of Nebraska at Kearney where they were stored at room temperature in until processing. From each bag, all materials were emptied, and seeds were separated from other contents. I counted and categorized seeds into those of grasses and forbs. Subsequently, big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium),* Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and tall fescue (*Festuca* *arundinacea*) seeds were separated and quantified for the individual trap in which they were caught (see Data analysis). Once separated by species, seeds from all sites were combined by trap number for viability testing. Seeds were sent to the Nebraska Crop Improvement Association for viability testing with a TZ test, following methods of Patil and Dadlani (2009).

Data analysis

To describe the absolute number of forb and grass seeds captured during the study, I calculated the total number of grass and forb seeds collected over the season for each trap (# seeds/177 cm^2, i.e. surface area of my funnel trap). I then extrapolated this number to seeds/m^2 for each site for both forbs and grasses. From field observations, I observed that several grass species collected in traps were unlikely dispersed from seed sources, but rather from areas directly around my seed traps. These species were unaffected by grazing and mowing, and plants released seeds close to the ground/trap surface. Species identified as potential contaminators included side-oats gramma (*Bouteloua curtipendula*), blue gramma (*Bouteloua gracilis*), sand lovegrass (*Eragrostis trichodes*), and dropseed species (*Sporobolus spp.*)

Therefore, I focused and limited my subsequent analyses to the five species of grasses with the capacity for wind dispersal that resided in seed source sites. These species were big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and tall fescue (*Festuca arundinacea*). I recalculated the density of grass seeds captured per site based on only these focal species, both averaged across all distances and for each distance from seed sources. I also described densities of the five focal species at the seed source (0 m trap distance) to characterize the seed source. I assumed that seeds from the five focal species captured at 75 and 100 m distances were more likely from local contamination (low-growing individuals dropping seeds into traps) than from wind dispersal (based on personal observations in the field). Therefore, I determined the average number seeds caught at 75 and 100 m for each species. I used that average value as a correction factor, and subtracted that number for each of the five focal species from the number of seeds in each trap.

I then determined what proportion of seeds captured (across all distances) were likely viable, based on species-specific viability results from the TZ tests conducted at the Nebraska Crop Improvement Association. I used each species' individual viability % to determine the total number of viable seeds for each of the 5 species at each distance for each site and divided that number by trap area (0.0177 m^2) to get # viable seeds/m^2 at each distance per site.

I compared my final densities of grass seeds to a density of 136 seeds/m^2, which is the density of grass seeds used in a recent, nearby restoration (C. Helzer, personal communication). Data were summarized in Excel, plotted in SigmaPlot (version 11.0), and analyzed in SPSS (version 18).

Results

Many grass seeds were deposited by wind into simulated restoration sites, with four of five sites averaging hundreds of grass seeds/m^2 and one site averaging thousands of grass seeds/m^2 (Table 1). Densities of forb seeds were relatively low compared to grass seeds and were highly variable among sites (Table 1). Less than 20 species of grass were dispersed across sites. Removal of the low-growing species (possible contaminating species) and a focus on the five focal grass species (see Methods) more accurately reflected the dispersal capabilities of seed sources, especially for site F2 (Table 1). These numbers, however, are high, as they do not factor in local contamination or seed viability (see below).

For the five focal grass species (big bluestem, little bluestem, Indian grass, switchgrass, and tall fescue), I detected within-site variability in the absolute amount of seeds produced at the source, estimated from the number of seeds captured in the 0 m traps. Three of the four sites burned the previous spring produced similar densities of seeds: HQ = 2279 ± 1013 seeds/m^2 MID = 2806 ± 913 seeds/m^2; MNE = 2184 ± 1161 seeds/m^2 (mean ± SD). One additional burned site produced nearly four times as many seeds as the other burned sites: F2: 8060 ± 6545 seeds/m^2, but this site was exceptionally variable. The one unburned site produced the fewest seeds: UB = 1243 ± 170 seeds/m^2. Statistical differences among sites were not detected (Kruskal Wallis test: $p = 0.395$). Grass species abundances also varied among sites (Table 2). Notably, big bluestem and little bluestem dominated the productive site, F2, and were mostly absent in the other sites; tall fescue was present in the unburned (UB) site, but not the neighboring burned (MNE) site; and switchgrass was most abundant at MNE (Table 2).

I observed seeds in traps at all distances from the seed source (Fig. 6). Overall, site F2 deposited more seeds over all distances compared to the other sites (Fig. 6A). When F2 was removed, seed dispersal followed a declining pattern with distance, tapering off about 20 m from the seed source (Fig. 6B). Despite producing more seeds at the 0 m distance, the burned site (MNE) did not appear to produce more seeds than the neighboring unburned site (UB) across distances from the seed source (Fig. 6B).

These initial estimates of dispersal included potential contaminating (low-growing) grass species and did not account for whether seeds were full, alive, or viable. After subtracting the possible contaminating species (seeds captured at 75 and 100 m distances; Fig. 6), I examined laboratory data that indicated that many of the seeds were empty (ranging from 27-92%; Table 3). Of the full seeds, some were dead, notably 69% of switchgrass seeds (Table 3). Overall viability of seeds was extremely low, ranging from 4-46% (Table 3). Dispersal distances corrected for contamination and viability indicated that much less viable grass seed was distributed from source areas into pastures (Fig. 7) than I had originally estimated. As a result, densities of seeds similar to those used in restorations only reached about 2 m into neighboring pastures (Fig. 7).

Table 1. Number of forb and grass seeds deposited in pastures over the entire study period (July-December 2010) at the Crane Trust. These values represent all seeds collected and are not corrected for viability or local contamination.

Site	**Forb seeds (#/m²)**	**All grass seeds[1] (#/m²)**	**Five focal grass seeds[2] (#/m²)**
F2	146	4815	1633
HQ	3	462	406
MID	33	610	390
MNE	485	730	414
UB	187	692	471

[1]Represents all species of grass seeds captured.

[2]Represents the sum of five focal grass species (big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium),* Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and tall fescue (*Festuca arundinacea*)).

Table 2: Density of seeds (#/m^2) at 0 m trap distance (an estimate of relative abundance of five focal grass species) collected over the entire study period (July-December 2010) at the Crane Trust.

Site	Big bluestem	Little bluestem	Tall fescue	Indiangrass	Swtichgrass
F2	2806	4426	19	377	433
HQ	697	19	1224	0	339
MID	0	0	2203	19	584
MNE	19	0	0	132	2034
UB	0	0	1168	0	75

Table 3: Percentage of viable, dead, and empty seeds for the five focal grass species.

Species	Viable (%)	Dead (%)	Empty (%)
Big bluestem	6	2	92
Tall fescue	46	12	42
Switchgrass	4	69	27
Little bluestem	14	4	82
Indiangrass	21	4	75

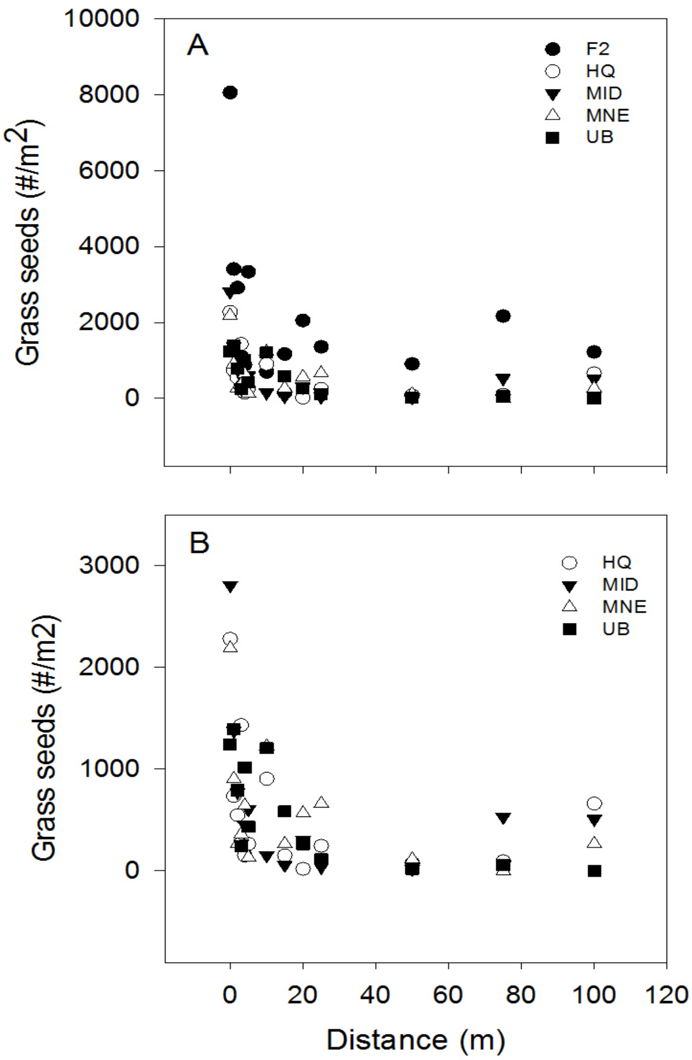

Figure 6. Number of grass seeds per area (not corrected for contamination or viability) representing five focal species (big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium),* Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and tall fescue (*Festuca arundinacea*)) at different distances from a seed source, collected in summer 2010 at the Crane Trust. Each symbol represents a different sampling site. (A) Represents all five sampling sites; (B) Excludes productive site F2.

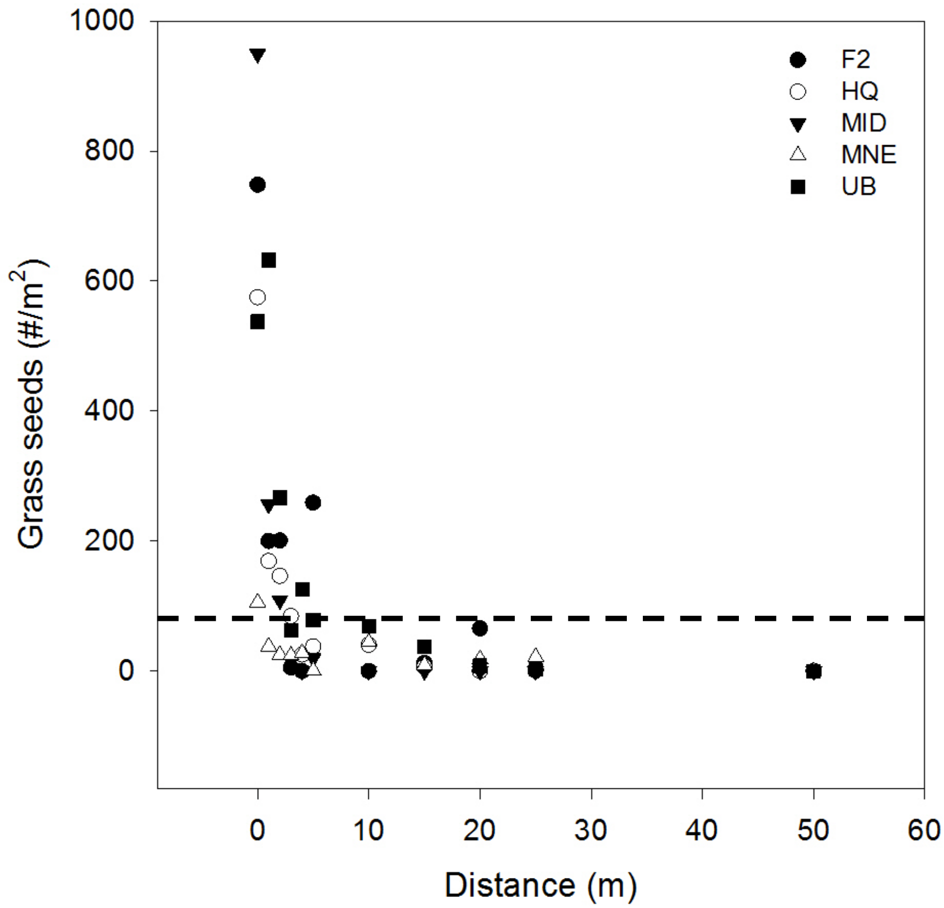

Figure 7. Estimate of number of grass seeds deposited at each distance per site after correcting for contamination and using viability estimates based on laboratory analysis. Dashed line indicates the number of viable grass seeds used in a nearby restoration (136 seeds/m^2; C. Helzer, pers. comm.), the threshold for the amount of seed required for a restoration in central Nebraska.

Discussion

My research demonstrated that highly productive, established tallgrass prairies did not have enough viable, wind-dispersed seeds moving into adjacent plots of land (i.e. simulated restoration sites) to reduce the costs and efforts of manually restoring prairies. At first, my data suggested that adequate numbers of seeds reached or could reach ≥ 20 m into adjacent sites, which potentially could save thousands of dollars in restorations, but the amount of empty seeds (seeds without an embryo; Willan 1985) greatly compromised the potential to replace seeding in restoration sites. Distances adequately seeded by established prairies only reached, at most, 2 m beyond the prairie edges for most grass species. My results indicated that, due to the lack of diversity of species and the short dispersal distances, restorations using diverse seed mixes are a better method to reestablish prairies; however, in plantings where high species diversity is not an objective, certain species of wind-dispersed grass seeds could greatly reduce the amount of planting required.

Seed sources in my study contained different relative abundances of the five focal species, with some sites containing all five focal grass species, and others only two (Table 2). Differences in species content likely reflected local-scale variation in topography, soil texture, soil moisture, and history of land use in this region, as described by Nagel (1981) and Henszey et al. (2004). Site F2 was the only site to contain all five focal species in its seed source (Table 2), and it produced as much 10 times the number of seeds as other sites (Fig. 7). The high productivity of site F2 also was observed in companion studies demonstrating higher numbers of birds (Frohberg et al. in prep.), small mammals (Wills et al. in prep), and herpetofauna (Harner and Geluso in prep.). F2 contained grass biomass averaging 800 g/m^2 (Harner and Geluso in prep.), which is higher than any biomass reading (178.5 g/m^2 – 755.5 g/m^2) taken in studies conducted from 1975 to 1993 by Briggs and Knapp (1995) and Abrams et al. (1986) on tallgrass prairie sites in the Flint Hills region of northeast Kansas. The reasons behind F2's high production are unknown and will be the focus of future research at The Crane Trust.

An additional interesting finding among sites was the difference in the amount of tall fescue and switchgrass seeds dispersed at sites MNE and UB (Table 2). Seed sources for both sites were part of the same prairie type (wetland range site; Nagel 1981), and were within 300 m of one another (Fig. 8), so theoretically they should have produced similar amounts of both species, but they did not. One explanation for variation between sites is that site MNE was burned in April 2010, which suppressed production of the cool season grass, tall fescue (Tunnel 2008), and increased production of the warm season grass, switchgrass (Mitchell et al. 1996).

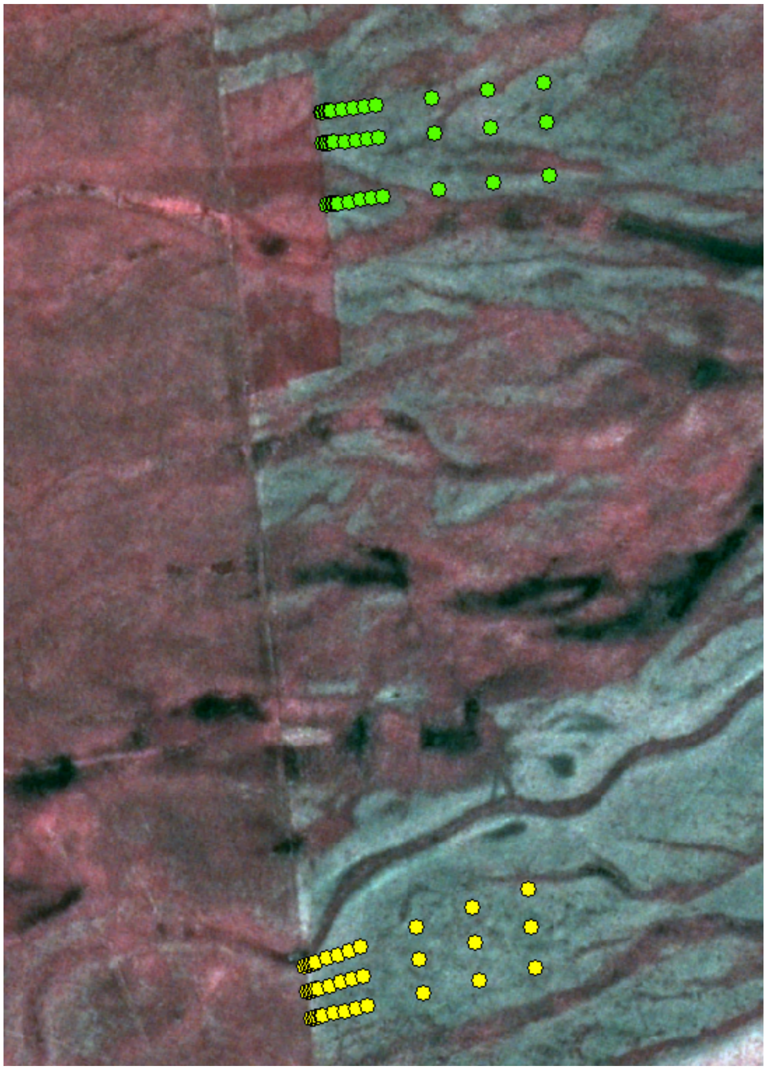

Figure 8. Sites MNE (top) and UB (bottom) were part of the same prairie unit and vegetation type with the only difference being MNE was burned in the spring and UB was not.

Seed dispersal in my study generally followed a negative exponential pattern (Fig. 6) similar to theoretical models and field-collected data of wind-dispersed seeds (Ernst et al. 1992, Jongejans and Schippers 1999, Bullock and Clarke 2000). In studies conducted by Bullock and Clarke (2000) and Jongejans and Schippers (1999), over 90% of seeds were dispersed within 5 m of the seed source, with the other 10% distributed across other distances, as far as 80 m. This also was the case with my data, where approximately 90% of seeds were deposited within 5 m of the seed source.

At first, even with the majority of seeds being dispersed within the first 5 m, my data appeared to demonstrate that an adequate quantity of seeds dispersed ~20 m into adjacent simulated restoration sites to equal planting. However, after adjusting the seed totals to count only viable seeds for each distance and to remove local contamination (Fig. 7), this number drastically decreased. My study shows that accounting for viability is absolutely necessary when estimating the overall potential of a seed source as a tool for replacing planting in a prairie restoration. For example, even a site that dispersed > 12 times the quantity of seeds used in a local restoration (F2), the quantity of non-viable seeds (30-90%) greatly reduced the distance of adequate simulated planting to only 2 m from seed sources.

The large quantity of non-viable seeds dispersed from seed sources in my study was likely associated with species composition. According to a study by Cornelius (1950), four of my warm-season, focal species (big bluestem, little bluestem, Indian grass, and switchgrass) commonly contain non-viable seeds in seed heads (Table 4). Moreover, such an observation is well known by land managers who harvest seeds to sell as seed mixes (Chris Helzer, personal communication). Seed sources containing these species will not produce enough viable seeds to equal the amount used in restorations, making the distance the seeds disperse irrelevant. My data are the first seed-dispersal data obtained in a field situation in this region, and they demonstrated that seed viability is just as important as distance of dispersal when estimating the potential of a seed source as an aid for planting in a prairie restoration.

Table 4. Percentage of full seed in a 1937 native prairie harvest reported by Cornelius (1950).

Species	Full seed (%)
Big bluestem	32.5
Little bluestem	13.1
Switchgrass	0.8
Indian grass	0.8
Tall dropseed	5
Side-oats gramma	trace
Total grass seed	52.4
Inert material (empty glumes, broken stems, leaves, etc.)	47.6

My observation on the lack of diversity (< 20 species) of seeds dispersed from the seed source into the adjacent fields also supported the need for using manually collected, high diversity seed mixes in prairie restorations (Steinauer et al. 2003, Tunnel 2008). However, if diversity is not needed in a planting, then certain species of wind dispersed seeds from species that produce full seeds have the potential to reduce the amount of planting needed. My study contained two species that fit this criteria, tall fescue and switchgrass, both of which produced >50 % full seeds and dispersed seeds > 20 m. Crop fields planted to grass pastures contain only a few different species of grass (Mitchell et al 2005) and could be a possible target for this type of application. For example, if I wanted to plant a wheat field back to grass for grazing and save on cost, I could plant a ¼ of the field to tall fescue and leave the rest to wheat. Once the tall fescue established it could disperse enough seed to plant back the rest of my field to tall fescue approximately 20 m a year, reducing the overall costs of planting my field to ¼ of what it would have cost.

My research generally showed that as a tool for prairie restoration, species of grass seed dispersed by wind from an established tallgrass prairie are too low in diversity and percentage of viability to adequately replace planting. Despite the high costs to acquire the amount and diversity of seeds used in seed mixes along with the cost of planting via hand and machine, establishment via these means will reach the goals of prairie restoration in a quicker and more effective manner. Although found to not be useful for prairie restorations, the data produced by this study provided field data to be used in future dispersal studies, something that is nonexistent for this region and this species type. In addition these data will be valuable for comparison with seed dispersal simulation models to test the accuracy of these models.

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CHAPTER 3

ARTIFICIAL PERCHES IN TALLGRASS PRAIRIES INCREASE AND CONCENTRATE BIRDS-DISPERSED SEEDS OF SHRUBS AND TREES

Abstract

Tree and shrub encroachment on prairies has been an ever-growing problem since European settlement. Tree establishment is now so severe that great expense is required to remove and prevent establishment of woody vegetation. Birds play a significant role in dispersing seeds, and I sought to determine how the presence of artificial perches (fence posts) affects the distribution of tree and shrub seeds by birds on tallgrass prairies in central Nebraska. I placed wooden and steel posts in prairies, captured seeds beneath them, and visually examined birds perching. I discovered that overall, more seeds tended to be deposited around wooden posts than steel posts, and there was a trend for birds to more often land and spend more time on wooden posts than steel posts. I found that different species of birds used one post type over another, and this may have influenced the species of seed deposited around each perch type. Red mulberry (*Morus rubra*) and dogwood (*Cornus sericea* and *Cornus drummondii*) were the most abundant seeds deposited, and both are managed to prevent their establishment in prairies. Results of this study show the impact of artificial perches on seed dispersal by birds and the importance of maintaining disturbance by fire and grazing to minimize establishment of woody plants on the prairie.

Introduction

Trees and shrubs were once rare on the Great Plains of North America because wildfires, disturbance by large herds of grazing ungulates, and a semi-arid climate kept woody vegetation from establishing (Knapp et al. 1999, Grace et al. 2002, Steinauer et al. 2003). The few trees and shrubs that did establish generally were located near river banks and in protected areas, such as canyon slopes, rock outcroppings, and small islands, where plant litter was insufficient to sustain fire (Gibson et al. 1990, Briggs and Gibson 1992). The scarcity of trees across prairies probably limited a large-scale seed dispersal of such woody vegetation due to lack of a nearby seed source, thus further contributing to a paucity of woody vegetation (Holthuijzen and Sharik 1984, Holthuijzen et al. 1986, Briggs et al. 2002, Horncastle et al. 2004).

Following European settlement, trees and shrubs came to dominate areas of prairies that historically lacked woody species (Rodgers and Anderson 1979, Packard and Mutel 1997). Settlers suppressed wildfires and altered ungulate grazing, thereby diminishing disturbances that once kept these species at bay (Smith 1990, Sampson and Knopf 1994, Fitch et al. 2001). People also helped establish seed sources by planting trees and shrubs for wind breaks, aesthetic value, shade, and wildlife habitat (Baer 1989, Cable 1999, Gardner 2009). Due to these processes, woody plants now are common in many prairies where, historically they were very rare. As a result, a larger seed source is available for dispersal, which facilitates establishment of new individuals at a potentially much faster rate (Chambers and Macmahon 1994, Fitch et al. 2001).

Trees and shrubs have several methods of seed dispersal (Primack and Miao 1992, Chambers and McMahon 1994, Vander Wall et al. 2005); one of which is to produce fruit that is consumed by an animal and then deposited elsewhere via the animals' feces (Myster and Pickett 1993, Wang and Smith 2002). Birds are the most prolific seed dispersers, due to their mobility, and they easily move large numbers of seeds across landscapes (Chavez-Ramirez and Slack 1994, Horncastle et al. 2004). Birds are commonly observed on man-made structures, such as fence posts and windmills in prairies (McClanahan and Wolfe 1993, Scott et al. 2000). This observation led me to address the question of whether the presence of artificial structures contributes to the establishment of woody species on the prairie.

In this study, I examined the dispersal of tree and shrub seeds by birds in a tallgrass prairie associated with the Platte River in central Nebraska, where patches of woody vegetation exist near river channels. I quantified the amount of seeds deposited by birds around two types of artificial perches, steel t-posts and wooden posts, both commonly used in prairies. I expected to find several species of large, bird-dispersed seeds deposited beneath these perches, possibly with more seeds beneath wooden posts because of their larger surface area and natural construction. Results of my study will show the impact of artificial perches on the dispersal of woody species on the prairie and the importance of maintaining disturbance by fire and grazing to minimize establishment of these woody plants.

Study Site

This study was conducted on lands managed by the Platte River Whooping Crane Maintenance Trust near Grand Island in Hall County, Nebraska (Fig. 1), in summer and autumn 2010. The Crane Trust properties consist of native and restored tallgrass prairies and riparian areas located in the Platte River valley. The land type is different than that of typical tallgrass prairie in that it has a very high water table and is intertwined with sloughs (linear, wet depressions) and wetlands (Meyer et al. 2008). Prairie vegetation in the higher elevations is dominated by grass species like big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and switchgrass (*Panicum virgatum*), while lower areas, such as sloughs, are dominated by species such as prairie cordgrass (*Spartina pectinata*), softstem bulrush (*Schoenoplectus tabernaemontani*), and Emory's sedge (*Carex emoryi*) (Meyer et al. 2010).

Figure 1. State of Nebraska with location of the Crane Trust indicated with a star (source: blogs.westword.com).

The property is managed on a four-year rotation of prescribed burning, cattle grazing, and resting. In year one of the rotation, a unit is burned in March or April and then grazed at a rate of 1.85 AU/ha for four months (May-June and September-October). In year two, the unit is grazed for two months (July-August) at a rate of 1.85 AU/ha. In years three and four, the unit is rested (no grazing or burning), and then the rotation is repeated.

The study site was located mainly along the southern edge of Mormon Island (Fig. 2) and encompassed three different management units. The management units were in year three or four of the management rotation to avoid interactions with cattle.

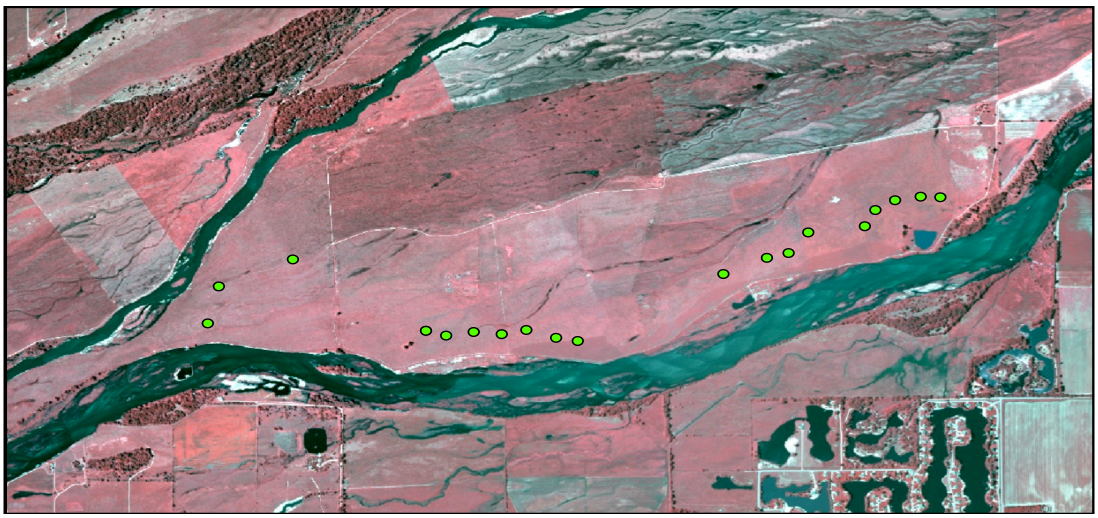

Figure 2. Perch locations in three separate ungrazed (years 3 and 4) management units on Mormon Island, southwest of Grand Island, NE.

Methods

To quantify seed deposition by birds at artificial perches, I placed 10 steel t-posts and 10 wooden posts, alternating ever other post type, throughout three management units. Each post was placed at least 100 m from other perches at the site. Perches were defined as any object other than grass taller than 1 m. At the base of each post, I installed a collection tray that were 1 m in diameter and 30 cm tall, constructed from children's plastic swimming pools (Fig. 3). I placed 13 mm wire mesh over the top of each tray to reduce secondary dispersal and/or removal of seeds by other organisms. Bottoms of trays were lined with black landscaping fabric to cover up the blue plastic of the swimming pool. Perches and trays were installed from 8 June 2010 to 9 October 2010. Collection trays were checked twice a month, and all seeds/fecal deposits were removed. Seeds were air dried, sorted, and identified to genus and/or species. I compared the number of seeds deposited around wooden posts and steel t-posts with nonparametric Mann-Whitney U tests and Chi-square tests. I also conducted visual surveys of birds one hour per week throughout the field season to record species of birds using perches and duration of use. I compared frequency of post use by birds (number of times birds landed on posts (strikes) and time perched) with Chi-square tests. Statistical tests were run in PAWS (version 18.0).

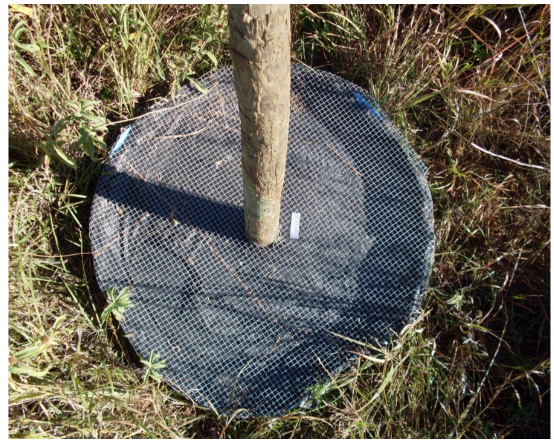

Figure 3. Bird-dispersed seed collection tray constructed from a children's swimming pool, landscaping fabric, and wire mesh placed at the base of a wooden post perch.

Results

The number of seeds captured beneath perches varied widely (Table 1). Wooden posts captured a range of 0-807 seeds/perch, and steel posts captured a range of 13-159 seeds/perch over the duration of study. Differences in total numbers of seeds deposited were not detected between perch types (Mann Whitney U test: $p = 0.41$), due to the high variability among posts, when individual posts were considered the unit of replication. However, when all seeds captured were summed across traps, more seeds were captured beneath wooden posts (total = 1274 seeds) than steel t-posts (528 seeds) ($X^2 = 309$, df = 1, $p < 0.001$).

Most seeds captured were mulberry (*Morus rubra*), followed by dogwood (*Cornus sericea* and *Cornus drummondii*) (Table 1). The number of mulberry seeds did not differ statistically between perch types (Mann Whitney U test: $p = 0.60$), but significantly more dogwood seeds were captured beneath steel posts (Mann Whitney U test: $p = 0.012$). Mulberry seeds were captured earlier in the season than dogwood seeds (Fig. 4).

Table 1. Number of seeds per perch captured beneath steel and wooden posts over 6 sampling dates in 2010 at the Crane Trust. Values represent mean ± standard deviation for a sample size of 10 posts.

Perch Type	Total Seeds	Mulberry	Dogwood	Other
Steel t-post	53 ± 46	38 ± 51	14 ± 11	1 ± 2
Wooden post	127 ± 258	122 ± 257	4 ± 6	2 ± 3

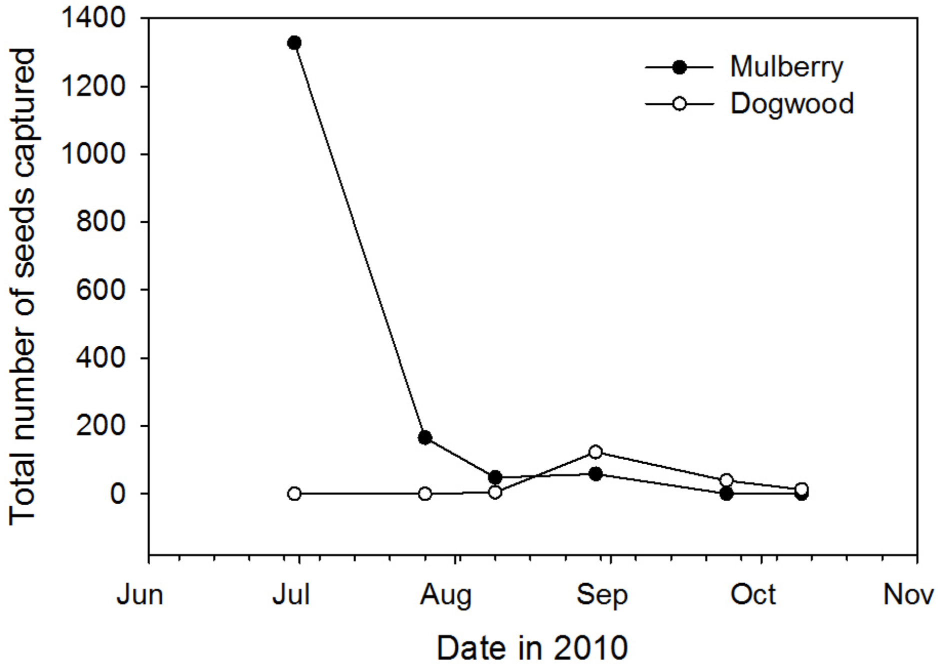

Figure 4. Total number of mulberry (*Morus rubra*) and dogwood (*Cornus sericea* and *Cornus drummodii*) seeds captured during study under both steel t-posts and wooden posts.

Five species of birds were observed on steel posts, and seven on wooden posts (Table 2). Birds more frequently landed on wooden posts (32 strikes) than steel posts (24 strikes), but these strike frequencies were statistically indistinguishable ($X^2 = 1.14$, df =1, $P > 0.05$). Birds also tended to spend more time on wooden posts (95 min total) than steel posts (78 min total), but again these differences were statistically indistinguishable ($X^2 = 1.67$, df = 1, $p > 0.05$; Table 3). Post usage differed for two species: Brown Headed Cowbirds more often landed on wooden posts and spent more time on them, whereas Dickcissels more commonly landed on steel posts and spent more time on them (Tables 2 and 3). Birds were observed on perches primarily in June and July, with Brown Headed

Cowbirds most commonly striking posts in June, Dickcissels in July, and Field Sparrows in early August. I did not observe any birds landing on perches during observation dates between 29 August and 8 October 2010 (7 total).

Table 2. Number of times birds landed on posts (strikes) during 13 hours of observation between 28 June and 8 October 2010.

Species	**Steel t-Posts**	**Wooden Posts**
Brown Headed Cowbird	5	10
Dickcissel	13	7
Field Sparrow	4	7
Redwing Blackbird	1	3
Western Kingbird	1	1
Western Meadowlark	0	3
Northern Flicker	0	1
Total	*24*	*32*

Table 3. Total number of minutes birds were observed sitting on posts during 13 hours of observation between 28 June and 8 October 2010.

Species	**Steel t-Posts**	**Wooden Posts**
Brown Headed Cowbird	6	32
Dickcissel	44	26
Field Sparrow	14	21
Redwing Blackbird	5	5
Western Kingbird	9	2
Western Meadowlark	0	8
Northern Flicker	0	1
Total	*78*	*95*

Discussion

My study demonstrated that birds deposited a large number of tree and shrub seeds around artificial perches (wooden and steel fence posts) in this mesic grassland surrounding the Platte River (Table 1). Results were inconclusive regarding whether birds preferred one perch type or the other due to high variability among perches, but I detected a trend for greater seed deposition around wooden posts. Birds may have been attracted to wooden posts because they are more similar to natural features on the landscape, such as tree branches, or simply because wooden posts had a larger surface area on which to perch. Castrale (1983) monitored perch use by four species of sagebrush-grassland birds and found that 97 % of time birds used shrubs as perches and <3 % of the time used fence posts, suggesting that when given a choice the more natural structure may be selected. Encroachment of woody vegetation is actively managed against on prairies (Steinauer et al. 2003, Tunnel 2008), and at this site, such artificial perches are common landscape features. Given that birds target these perches and concentrate seeds around them, managers should prioritize tree and shrub eradication around fence posts.

Most bird deposited seeds were from white mulberry (*Morus alba*) and two species of dogwood (*Cornus sericea* or *Cornus drummondii*) trees, species that have high germination rates (mulberry: 23-44% (Barnea et al. 1991) and dogwood: 41-65% (Acharya et al. 1991)), and are therefore managed against on the prairie. The number and species of seeds deposited coincided with seasonal patterns of fruit ripening. White mulberry trees produce fruit from June-July and dogwood from Sep-Oct (Kaul et al. 2006). Mulberry species produce an aggregate fruit that contains 10- 32 seeds (Stapanian

1982), while dogwood fruits contain only a single seed per fruit (M. Morten, pers. observation). This may explain why a greater number of mulberry seeds were deposited around perches than dogwood seeds; if a bird ate one fruit from each species of tree then it would subsequently deposit several mulberry seeds and only one dogwood seed.

Distance to a seed source also likely contributed to variability in seed deposition, as has been shown in other studies, such as by Sooty-headed Bobuls (*Pycnonotus aurigaster*) and 12 species of forest seeds (Scott et al. 2000) and by McCay et al. (2008) in a study of ornithochorous seed dispersal into a fragmented landscape. Mulberry and dogwood trees occurred on the perimeter of my study site, near the southern river channel (Fig. 2), and near some of my artificial perches (M. Morten, pers. observation). If I had located perches at other locations on the island, such as by riparian woodlands with a different species composition, I may have observed different patterns of seed dispersal. This study could be expanded by increasing the number of perches examined and placing pairs of perches at fixed distances from known seed sources, as done by McClanahan and Wolfe (1993).

I also detected patterns in perch use by different species of birds that could be associated with the type of seeds deposited and the seasonality of seed deposition. Seasonality dictated the species of bird in the area, with Brown Headed Cowbirds (*Molothrus ater*) (June) and Dickcissels (*Spiza americana*) (July) being the most observed. Dickcissels and Brown Headed Cowbirds simultaneously occur in prairie sites (Zimmerman et al 1983), with Dickcissels nesting in grasslands and foraging on grass seeds and insects (Zimmerman 1965, Winter 1999), and Brown Headed Cowbirds parasitizing nests of grassland nesting birds. Cowbirds are known to utilize perches to locate nests of grassland nesting birds, including Dickcissels, to parasitize (Hauber and Russo 2000, Shaffer et al. 2003, Jensen and Cully 2005). This contributes to the impact of artificial perches on prairie ecosystems in that these perches also may be altering the distribution of Cowbird parasitism outside what would occur in areas without artificial perches. Additionally, one could speculate that because birds were observed using perches in the area at the same time as fruiting (Cowbirds-mulberries and Dickcissels-dogwood), the amount and species of seeds deposited around each perch type (wooden vs. steel post) was influenced by perch use of these species. Ankey and Scott (1980) show Brown Headed Cowbirds being partially frugivorous (eating both insects and fruits) in the summer months, which combined with the fact that they were observed using perches during the same time as mulberry fruit ripening, led me to speculate that they were responsible for most of the mulberry seed dispersal. The same explanation seems plausible for Dickcissels and dogwood seed dispersal, but I found no documentation of Dickcissels eating dogwood fruits. Dickcissels are granivorous/insectivorous, eating mostly grass seeds or insects depending on availability (Wiens and Rotenberry 1979). More detailed observations of birds, both on the artificial perches and within nearby woodlands, would help clarify whether Brown Headed Cowbird and Dickcissels are dispersing mulberry and dogwood seeds, respectively.

In conclusion, this study showed that artificial perches are altering some of the natural processes in prairie ecosystems by concentrating tree seeds and creating a perch for brood parasites, Brown Headed Cowbirds. The widespread use of posts for fence is unlikely to decrease anytime soon, so other solutions must be found to reverse their effects. To combat increased probability of tree establishment around fence posts, proper management rotations of burning, grazing, and periodic herbicide application are needed. In addition, to decrease parasitism rates by Cowbirds, larger pasture units are needed to help reduce the amount of perches relative to nesting area (Hauber and Russo 2000). This study provided insight into artificial perch use by grassland birds as well as demonstrated that artificial perches create areas with high concentrations of bird-dispersed seed. In the future managers can also use this information to target areas for prevention of tree establishment (Horncastle et al. 2004). Knowing perch use and relative seed abundance by perch type may lead to the use of less herbicide and other tree control methods in prairie management areas, as well as provide incentive for removal of all unnecessary artificial perches.

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