Prairie Fork Conservation Area – Project Application

Project Title: Continued Evaluation of Restoration and Reconstruction Techniques in a Gradient of Natural Communities of Missouri – Prairies, Savannas, and Woodlands

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Relationship of the proposal to the long-term goals of PFCA:

The proposed project addresses management questions related to the restoration and/or reconstruction of prairie, savanna, and woodland natural communities. This project will build off the work initiated in 'Evaluation of Restoration and Reconstruction Techniques in a Gradient of Natural Communities of Missouri – Prairies, Savannas, and Woodlands', a three-year project funded from 2019-2022. Two key findings justify the need for continued monitoring and additional work: 1) treatment effects indicate further monitoring is needed to understand temporal trends over timeframes most meaningful to management decisions; and 2) additional treatment approaches or data collection, with minimal changes to the established study designs, can strengthen our understanding of the mechanisms for invasive plant management and community restoration. This proposal explicitly addresses Emphasis Area #1 (the control and management of exotic plant species presents an overwhelming annual workload

on PFCA. Assessment of efficacy of methods for control is desired.). Each study objective was developed in consultation with managers at PFCA to address relevant restoration questions and build on the findings from the original study in action-oriented ways.

Statement of overall and specific objectives (including hypotheses tested):

The overall objective of this project is to improve the efficiency of restoration management for prairie, savanna, and woodland ecosystems at PFCA. The specific needs within each of these ecosystems vary, so this project has three components, each of which was developed in consultation with PFCA management:

1. Prairie ecosystems – evaluating sericea lespedeza (*Lespedeza cuneata*) invasion without sustained herbicide control. This portion of the project will include continued sampling of the previous study and one new study component:
    a. Hypothesis 1: the cessation of herbicide control will continue to facilitate growth in sericea lespedeza populations, which is also related to prairie reconstruction age (continued measurement from original study)
    b. Hypothesis 2: the seedbank potential of sericea lespedeza is directly related to above-ground sericea lespedeza abundance and is related to prairie reconstruction age (new study question informed by original work)
2. Savanna ecosystems – evaluating management approaches for establishing trees within reconstructed prairies for savanna restoration. This portion of the project will introduce a new study component:
    a. Hypothesis 1: strategically placing fuel reduction treatments (e.g., mowing) provide local reduction in fire intensity to allow tree survival and reduce top-kill from prescribed burning
3. Woodland ecosystems – evaluating methods for establishing native ground flora during woodland restoration from closed-canopy forest. This portion of the project will continue sampling of the

original study, providing more time to observe plant community development following seeding in the original study and to track plant response to timber stand improvement (TSI) activities.

a. Hypothesis 1: effects of soil scarification (i.e., raking) on seeded plant community become more pronounced with time, demonstrating delay in plant community response following seeding

Project Justification:

The Prairie Fork landscape is a mosaic of prairie, savanna, and woodland natural communities, and each of these natural communities is targeted for restoration or reconstruction in the Prairie Fork Restoration Plan (website: http://prairiefork.missouri.edu/management/projects.asp?ID=39 accessed January 10 2022). These natural communities differ in the amount of associated tree cover, as well as characteristics of the disturbance regime (i.e., fire) and edaphic conditions (Nelson 2005). To date, considerable progress has been made in the reconstruction of prairie communities at PFCA, but challenges remain for savanna and woodland restoration efforts.

This project is designed to address specific challenges associated with restoration or reconstruction of each natural community, as expressed directly by managers at PFCA, and is indicative of a greater scientific need for natural community management in Missouri. For prairie reconstruction, PFCA is interested in determining the efficacy and effectiveness of current management practices on the control of the existing sericea lespedeza population. In sites where prairie plants have been restored but are ecologically classified as savannas, the establishment of widely dispersed and ecologically meaningful trees has remained a challenge. The woodland natural communities at PFCA have transitioned through time to closed canopy forests and lack the ground flora that would characterize this community type. Although thinning can reduce tree densities, managers lack information on how to restore or reconstruct woodland plant assemblages under existing tree canopies. We will continue sampling of the original study areas to extend our inference on temporal dynamics on management effects and introduce new study elements informed by findings from the original study.

Expected Benefits and Outcomes:

This research will generate actionable scientific information useful to land managers at PFCA, throughout Missouri, and within the central United States. Each component of the project addresses a specific question related to restoration or reconstruction of prairie, savanna, and woodland natural communities (respectively). Results from each component can be immediately incorporated into PFCA management; for example, evaluating the spread of sericea lespedeza without sustained herbicide treatment can inform managers as to the potential to modify current herbicide prescriptions while maintaining acceptable control. Likewise, protocols for establishing savanna trees within prairies or reconstructing ground flora via broadcast seeding do not exist for the region. Results from this work will be communicated to the scientific and management communities through peer-reviewed publication (at least one publication for each project component) and presentation at professional conferences. The study areas will also be suitable as demonstration sites for different restoration techniques, which may be incorporated into the outreach and education mission of PFCA.

Background and Rationale:

This project will focus on three natural community types at PFCA, each representing a different stage in a restoration management trajectory:

1. Prairie communities that have undergone plant reconstruction with the successful establishment of a diversity of native species. However, continued management of sericea lespedeza at low population levels requires frequent herbicide treatment and may constrain resources for other activities.

2. Savannas at PFCA that have undergone prairie plant reconstruction. However, there has been limited success in establishing savanna trees while maintaining the reconstructed plant community with frequent prescribed fire.

3. Woodlands at PFCA that have recently been thinned to reduce the density of trees, thereby opening the forest canopy and providing light to the ground flora. However, as is similar in other areas with intensive agricultural land use histories, woodland indicator species may no longer exist in the soil

seed bank or seed rain, requiring active restoration efforts. Further, the recent TSI (winter 2021-2022) within the woodland study area will provide additional information regarding seeding response.

1. The Prairie Community

Invasive plant species can affect restoration outcomes by competing with desired species and thus are commonly controlled with intensive management. Invasive species management can defer resources available for restoration projects and can have deleterious impacts on native populations from disturbance and non-target applications. Sericea lespedeza is a non-native, invasive legume species that commonly invades disturbed habitats, including open fields and pastures, and threatens the integrity of tallgrass prairies (Eddy and Moore 1998, Silliman and Maccarone 2005). In the 1990s sericea lespedeza was widespread and dominant across the property. Current prairie management at PFCA includes active prairie reconstruction through round-up ready cropping, native seeding and establishment, and annual sericea lespedeza herbicide applications. Based on our preliminary findings from monitoring sericea lespedeza across prairie reconstruction ages, without control, sericea lespedeza populations continue to increase but increases are more profound in younger reconstructions (Figure 1). Based on study observations, sericea lespedeza populations and their response to management may be related to both the resident above-ground and below-ground abundance of sericea on a given site. For example, some young reconstructions lack sericea lespedeza and do not have concomitant increases in sericea

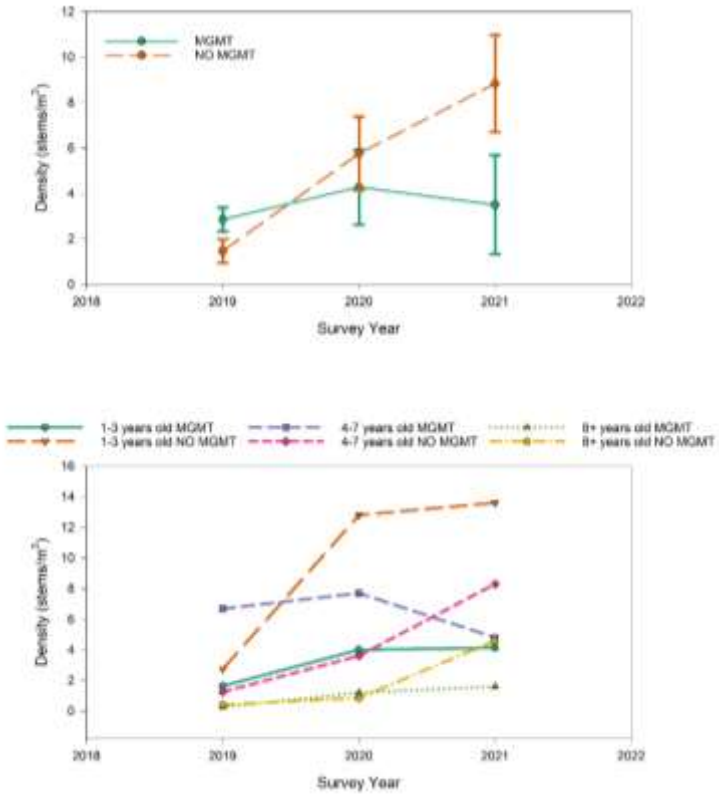

Figure 1. Changes in sericea lespedeza density (stems per m^2) by management approach (upper panel) and the interaction of reconstruction age by management approach (lower panel).

abundance with herbicide exclusion although they lack the compositional and functional diversity of older reconstructions. However, where sericea is present, the exclusion of control increases sericea abundance. Additionally, older reconstructions that have been intensively managed for long periods of time are not as responsive to exclusion from herbicide treatment and 1) may lack sericea in the soil seed bank or 2) the resident community impedes invasion if sericea seed is in the soil seed bank, or 3) a combination of both. Quantifying the sericea seed bank potential across our study plots will help to inform management of the species in prairie reconstructions.

2. The Savanna Community

Savannas are characterized by widely spaced, open-grown trees interspersed within grasslands dominated by prairie grass and forb species. In essence, these communities are grasslands with scattered trees, and were historically abundant throughout northern Missouri (McCarty 1998, Hanberry and Abrams 2018). Given the land use practices of the past few centuries, savannas have been replaced by agriculture or closed-canopy forests. At PFCA, savannas may be appropriate in areas targeted for prairie reconstruction, with the added challenge of establishing trees within a reconstructed prairie. To maintain the prairie condition, repeated frequent fire would be necessary but would likely top-kill planted tree seedlings (Arthur et al. 2012, Dey et al. 2017, Knapp et al. 2017), requiring some protection for seedlings during burning. In addition, competition from grasses and forbs reduce establishment success of planted oaks in afforestation plantings, requiring some form of competition control (Dey et al. 2008). Currently, there are no management guidelines for efficient tree establishment within a savanna restoration context in mid-Missouri. The original study found differences in tree survival based on species but had found minimal effects of fuel reduction treatments applied at the tree-level. However, patterns at the broader scale suggested that more continuous fuel reduction treatments (e.g., mowed strips), rather than scattered fuel reduction at the individual tree level, may be more effective at reducing top-kill.

3. The Woodland Community

Several areas at PFCA are delineated as woodland natural communities, with greater canopy cover and slightly incised surface features. Woodland restoration has recently become a fairly common

management objective in Missouri, typically involving thinning and burning treatments (McCarty 1998, Dey et al. 2017). Several studies from Missouri demonstrate that these treatments can result in increased abundance of woodland indicator plants (Kinkead et al. 2012, Knapp et al. 2015, Maginel 2015). However, many of these restoration efforts differ from PFCA in that the sites likely did not experience heavy agriculture (soil tillage) to completely deplete the seed bank. Consequently, it is unlikely that thinning and burning alone will result in the response of woodland indicator species at PFCA due to the effects of the agricultural legacy (Brudvig et al. 2013). In this region, it is uncommon for woodland restoration efforts to include broadcast seeding of native ground flora species, although this approach has been practiced in other regions (Glitzenstein et al. 2001, Reinhardt et al. 2017). To effectively restore woodland communities, managers require information on how to efficiently establish ground flora plants under existing tree canopies. The original study had limited short-term success at establishing native woodland flora. However, following two years post-seeding, seeded species are beginning to respond, suggesting that additional monitoring is warranted. Further, thinning and TSI will increase available light to the woodland understory, likely increasing the germination and establishment of seeded species response.

Methods:

1. The Prairie Community

To evaluate the effectiveness of current control methods and the influence of reconstruction age on sericea lespedeza, in 2019 we established 49 pairs of 5 x 5 m experimental units (EU) across prairie reconstruction ages PFCA (98 EUs total). One of the paired EUs represents the 'control' (management as usual) and the partner EU serves as the 'treatment', which in this scenario, is untreated. The untreated EUs have been excluded from sericea lespedeza herbicide applications.

Within each paired plot, we have recorded visual cover by functional group and sericea lespedeza using a modified Daubenmire scale (Abrams and Hulbert 1987) across each 25 m^2 plot. In each of the four plot corners, a 1 x 1 m subplot was established to quantify the number (density) of lespedeza stems and the cover class of functional groups, recorded on an annual basis.

We propose to continue monitoring the 49 paired plots from 2022-2023 resulting in a 5-year dataset. In addition, we will evaluate the seedbank of each plot in 2023 to assess the presence and abundance of sericea lespedeza in the soil. In late winter (February/March) 2023, we will take 5 soil cores (203 cm^3; 5 cm H x 7.23 cm W) from the soil surface per plot. The samples will be aggregated to the plot level and spread across plant flats (27.8 cm W x 54.5 cm L x 6.2 cm D) filled with potting soil. The flats will be grown in a greenhouse until December 2023. The trays will be monitored weekly and sericea lespedeza germinates counted and removed with positive ID.

2. The Savanna Community

During the previous study, we planted oak seedlings in three areas classified as savanna natural communities that have undergone prairie restoration. The study design compared seedling establishment of five oak species (*Quercus bicolor*, *Q. macrocarpa*, *Q. muehlenbergii*, *Q. stellata*, and *Q. velutina*), two production methods (bareroot and "root production method" or RPM), and three cultural treatments (control, mechanical fuel removal, and weed cloth). The control treatment evaluated survival and growth of seedlings planted directly into the reconstructed prairie without additional treatment. Results showed that species was an important factor for seedling survival and that the fuel reduction treatment resulted in a minor increase in seedling survival. However, most trees were top-killed from the prescribed burn, suggesting the fuel reduction treatments were not adequate to protect the planted seedlings.

We will establish new fuel reduction treatments to refine the approach for establishing savanna trees in reconstructed prairie. The new treatments will be three levels of fuel reduction applied as mowed strips that vary in width from one mower pass to three mower passes (1 pass = 150 cm, 2 passes = 300 cm, and 3 passes = 450 cm). Fuel will be removed using a bagger attachment. The fuel reduction treatment will occur just prior to prescribed burning and oriented perpendicular to the direction of fire spread. We believe that the trees adjacent to the fuel reduction strips will have a higher probability of survival than those farther away. We also believe that the wider strips will provide positive outcomes for the trees at farther distances from the fuel reduction strips. Trees will be reassessed for diameter, height, and mortality, and distance of each tree to the fuel reduction strip will be recorded.

3. The Woodland Community

The woodland area used for the first study recently received a timber stand improvement (TSI) treatment, reducing the overall basal area to 14 m^2/ha and will be treated to control invasive shrubs such as multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*) and bush honeysuckle (*Lonicera maackii*). These management actions will likely address two of the challenges we faced in the previous study, in which stand density was generally high and the abundance of invasive shrubs were likely competing heavily with the ground flora community. With the reduction of basal area and the removal of invasive shrubs, we will be able to monitor the effects of the previous study with regard to the original treatments of scarification through raking and seeding of native plants.

The sampling will remain the same as the previous study in order to preserve continuity. Overstory trees will be sampled within a 0.05-hectare plot, identifying each tree and measuring diameter. The midstory will be sampled using a stem count of each stem over 1 meter tall and less than 3 cm in diameter within a 2.5 meter radius from plot center. All stems between 3 and 9.9 cm will have diameter at breast height recorded. The understory ground flora will be monitored using four 1x1 meter quadrats, identifying each plant to the species level and recording the percent cover of each individual species.

Budget:

The project will last two years (May 2022 – May 2024). In Year 1, we request from PFCA $8,134 and in Year 2, we request $9,850. The total project cost is $17,984.

	Year		
CATEGORY	2022	2023	TOTAL
Salary (student technician; $12/hr)	$3,840	$4,320	$8,160
Benefits (7.65%)	$294	$330	$624
Greenhouse rental		$4,700	$4,700
Supplies	$4,000	$500	$4,500
TOTAL REQUESTED	$8,134	$9,850	$17,984

The budget includes labor for student technician support ($12/hour; 2022 – 40 hours per week for 8 weeks; 2023 – 10 hours per week for 36 weeks) and associated benefits. In 2023, the prairie work will

require renting greenhouse space at MU ($4,700). Field supplies include a bagger for the mower in 2022 ($3,500) and general field supplies ($500) in both 2022 and 2023.

Other Funding:

This project has considerable cost savings through in-kind contributions from the USDA Forest Service – Northern Research Station. In-kind contribution will be provided by salary including USDA Forest Service scientist support (Lauren Pile, Research Ecologist, $6,300 per year; Dan Dey, Research Forester, $1,935 per year; and John Kabrick, Research Forester, $1,780 per year) and forest research technician support (Dacoda Maddox, $5,000 per year). Total in-kind contribution is $30,030. Field travel costs and conference attendance (Missouri Natural Resources Conference) will be provided by USDA Forest Service and/or University of Missouri School of Natural Resources.

Schedule and Duration:

The proposed project is a two-year project (May 2022 – May 2024). The table below provides a detailed schedule of treatments and surveys.

		2022				2023				2024	
Component	Task	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun
Prairie	Field plot survey			■				■	■		
	Soil seed collection					■					
	Seed trials						■	■	■		
	Report					■				■	■
Savanna	Mowing strips			■							
	Prescribed burning			■							
	Measurement				■	■	■	■			
	Report					■				■	■
Woodland	TSI/invasive control	■	■	■							
	Measurement						■	■			
	Report									■	■

Information Transfer:

Annual progress reports will be submitted to the PFCA Trustee by December 31st. Presentations on portions of the project will be given annually at Missouri Natural Resources Conference from 2023 to 2024. Each portion of the project will result in a peer-reviewed publication in an international journal and presented at a national conference.

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