ANALYZING FLORISTIC QUALITY ASSESSMENT SCORES FOR RESTORED AND REMNANT NATIVE PRAIRIE AT THE THEODORE ROOSEVELT PRESIDENTIAL LIBRARY: A LOCAL PROVENANCE APPROACH

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ABSTRACT

Prairie restoration plays a critical role in conserving biodiversity and enhancing carbon sequestration, contributing to climate adaptation. This study evaluates the effectiveness of restoration efforts at the Theodore Roosevelt Presidential Library in Medora, North Dakota, by comparing Floristic Quality Assessment (FQA) scores between remnant and restored prairie sites. A key challenge in this region is the limited availability of locally sourced native seeds, which are essential for promoting genetic diversity, ecological resilience, and long-term sustainability.

FQA provides a standardized method for assessing habitat quality, identifying conservation priorities, and guiding restoration by emphasizing species with high conservation value. This research employs a mixed-methods approach, combining ecological baseline assessments across 8.09 hectares (20 acres) with qualitative input from landscape architects, ecologists, volunteers, and seed cultivators. Species were evaluated using USGS-assigned coefficients of conservatism (C-values), which reflect their sensitivity to disturbance and ecological fidelity.

Findings highlight the complexities of seed-based restoration, particularly for species with high C-values. While some native species exhibit strong establishment and adaptability, others pose challenges that necessitate strategic planning. Ongoing efforts include cleaning and verifying bulk seed, continued site monitoring, and developing a KMZ file to document seed collection locations, particularly for the 2023 layer. These activities support iterative improvements to seed mixes and restoration protocols, with a comprehensive update expected by February 2024. By incorporating site-specific conditions and C values, the study sets a foundation for long-term prairie resilience. It highlights the importance of continuous monitoring, adaptive management, and local seed use to ensure ecological success. The restored site will provide important habitat and serve as a model for future restoration efforts across disciplines. This work contributes to more effective prairie restoration practices and is poised to help address critical gaps in native seed availability across North Dakota and the Upper Great Plains.

Keywords

Prairie Restoration, Floristic Quality Assessment (FQA), Ecosystem Resilience, Native Seeds

1 INTRODUCTION

The Theodore Roosevelt Presidential Library (TRPL), slated to open on July 4th, 2026, and the Theodore Roosevelt National Park (TRLNP), nestled amidst the breathtaking landscapes of Medora, North Dakota, are a testament to the enduring legacy of the 26th President of the United States. Roosevelt, a renowned conservationist and advocate for the American West, was deeply passionate about preserving the beauty and ecological richness of the prairie ecosystem. Today, the TRPL carries this torch by actively participating in the crucial endeavor of prairie restoration. The competitively awarded library design was completed by the internationally acclaimed design firm Snøhetta, in collaboration with local landscape architecture firm Confluence and local architecture firm JLG, which served as the landscape architect and architect of record, respectively. The TRPL also sponsors the Native Plant Project to help restore native plants in the library's varied outdoor spaces. As part of those efforts, the TRPL is sponsoring a notable Native Plant Project in partnership with Resource Environmental Solutions (RES) and North Dakota State University (NDSU) to help restore indigenous plants to the library's outdoor spaces, which cover nearly 8 hectares. Prairies, once vast and vibrant grasslands that stretched across North America, have undergone a dramatic decline due to human activities such as agriculture and urbanization (Samson & Knopf, 1994). This loss has had a devastating impact on biodiversity, as native plant and animal species that rely on these ecosystems for survival have faced significant population declines. Prairie restoration offers a beacon of hope, aiming to recreate these lost landscapes and restore the ecological balance they provide. The Theodore Roosevelt Presidential Library (TRPL) site is undergoing both preservation of remnant prairies and active restoration of disturbed areas. This study analyzes floristic quality assessment (FQA) metrics to evaluate the effectiveness of prairie restoration using local provenance plantings and native species richness of plugs grown from locally collected seeds of native plants.

1.1 Significance of Prairie Restoration

Prairie restoration is vital for biodiversity conservation, as native prairies sustain diverse species of plants, insects, birds, and mammals adapted specifically to prairie ecosystems (Smith, 2010; Lortie & Hierro, 2022). Restoration helps reverse habitat loss, protects threatened species, and significantly contributes to carbon sequestration, aiding efforts against climate change. A cornerstone of successful prairie restoration lies in utilizing local seeds derived from native plant populations (McCormick et al., 2021; Pizza et al., 2023). These populations, having adapted to the specific environmental conditions of the restoration site, offer several advantages.

Sourcing seeds locally promotes genetic diversity within the restored habitat, fostering a more resilient plant community (Smith, 2010; Doll et al., 2011; Rodrigues & Loures, 2017). Furthermore, local seed use enhances ecological suitability, ensuring the plants thrive in their restored environment (Stromberg et al., 2007; Pizza et al., 2023). Ultimately, this approach promotes the long-term sustainability of restored prairie ecosystems (Martin & Wilsey, 2006). This necessitates the development of a standardized monitoring approach to track restoration progress over time. Such an approach should be able to pinpoint potential problems, assess the effectiveness of implemented management strategies, and evaluate the overall quality of the restored habitat (Herman et al., 1997; Freyman et al., 2016). The FQA, developed by Taft and collaborators (1997) offers a standardized framework for evaluating a site's natural quality. Initially implemented in the Chicago region, the FQA methodology has since been adapted for use in various regions, including North Dakota, by the Northern Great Plains Floristic Quality Assessment Panel.

1.2 Importance of Local Seed Sourcing in Restoration

A key principle in successful prairie restoration is the use of local seeds, which enhances the ecological suitability and resilience of restored habitats. Seeds sourced from local populations carry genetic traits that have evolved to thrive in specific environmental conditions. The advantages of using local seeds have been highlighted in restoration research, which emphasizes how genetic diversity and ecological compatibility promote long-term sustainability (McCormick et al., 2021; Pizza et al., 2023). Local seeds not only support biodiversity but also foster plant communities that are more resilient to environmental stresses, such as drought and extreme weather, which are increasingly common due to climate change (Rodrigues & Loures, 2017; Doll et al., 2011).

Moreover, research shows that seeding methods can significantly impact restoration outcomes. For instance, Applestein et al. (2018) found that broadcasting, as a seeding method, is both effective and costefficient for large-scale restoration, as it eliminates the need for expensive alternatives like hydroseeding. This finding aligns with restoration goals at TRLNP, where maximizing coverage while managing costs is crucial for scaling up restoration efforts.

1.3 Study Location and Context

This study was conducted at the Theodore Roosevelt Presidential Library site in Billings County, near the city of Medora, North Dakota (46°54′44″N, 103°31′31″W), a small historic town founded in 1883 along the Northern Pacific Railway, with a current population of approximately 200. The research area spans approximately 28.33 hectares and includes multiple ecotones, such as a 3.24-hectares firebreak scar, 6.81 hectares of blufftop, 4.05 hectares of wood draw, and a 3.85-hectares remnant (unplowed) prairie owned by the U.S. Forest Service. A wildfire event in 2021 affected parts of the site, leaving a visible firebreak scar where subsequent observations revealed the natural regrowth of several native species, including some that were not part of the restoration seed mix. This suggests the presence of a persistent native seed bank in the soil, activated by the fire disturbance, and highlights the ecological role of fire in promoting native species recovery in prairie ecosystems. The site lies within a culturally and ecologically rich landscape adjacent to Theodore Roosevelt National Park and the Little Missouri River valley (Figure 1). The design of the Library, led by the renowned architecture firm Snøhetta, is inspired by Roosevelt's reflections on nature, environmental stewardship, and civic engagement. Emphasizing minimal disturbance to the land, the project integrates a network of small pavilions throughout the native landscape, with the main building's sloped roof oriented northeast, framing views toward historic landmarks and the distant Elkhorn Ranch, creating a powerful connection between place, memory and legacy.

Figure 1: Project site and area key map (red line represents the TRPL property boundary and initial RES observation area, and the green line denotes the limits of work (LOW) for constructing the TRPL and grounds) 1. Blufftop/plateau (green) 2. Woody Draws (yellow) 3. Firebreak (orange) 4. Active construction area (brown) 5. SW corner of Medora city limits 6. Little Missouri River

1.4 Research Objectives

The research objectives of this study are to identify native plant species that demonstrate high success rates in seed-based restoration at the Theodore Roosevelt Library and National Park (TRLNP), compare species lists and Floristic Quality Index (FQI) values across different habitat types within the site, and assess restoration design effectiveness by employing comparative metrics derived from unique restoration plots. Additionally, the study evaluates the success rates of native seed collection and subsequent establishment in restored habitats. Finally, the research seeks to establish an evidence-based adaptive management framework by providing baseline data and methodologies for ongoing, long-term ecological monitoring and management strategies.

2 LITERATURE REVIEW

Historically, North American prairies, which extended from western Ohio to the Rocky Mountains and from southern Canada to Texas, represented vast and ecologically diverse grasslands that provided essential ecosystem services, including soil health, carbon sequestration, and water regulation (Samson & Knopf, 1994). Over the past two centuries, however, intensive agricultural development, urban expansion, and industrialization have severely reduced these prairies, causing significant habitat loss and fragmentation, especially in tallgrass regions (Link et al., 2017). Prairie restoration efforts have emerged in response, emphasizing the reintroduction of native species, local seed sourcing, and ecological integrity measurement through FQAs (Herman et al., 1997; Freyman et al., 2016), which quantify restoration success using species-specific Coefficients of Conservatism (C values) (Bauer et al., 2018; McCormick et al., 2021; Pizza et al., 2023; Taft et al., 1997).

Restoration techniques commonly employed include broadcasting, drilling, and hydroseeding, each chosen based on specific project goals and site conditions, complemented by essential long-term monitoring practices (Applestein et al., 2018). Despite these advances, restoration projects encounter multiple challenges, including environmental variability, high implementation costs, invasive species management, and difficulties in securing sustained community engagement and support (Green et al., 2021; Link et al., 2017; Rodrigues & Loures, 2017).

2.1 Floristic Quality Assessment (FQA)

FQA evaluates ecological integrity based on plant species composition by assigning each native species a "Coefficient of Conservatism" (C-value) ranging from 0 to 10, with higher numbers indicating stronger habitat specificity and lower disturbance tolerance (Freyman et al., 2016). C-values can vary significantly between states and ecoregions, reflecting distinct regional environmental conditions and scoring criteria. For this study, we used the 2001 U.S. Geological Survey Coefficients of conservatism for the vascular flora of the Dakotas and adjacent grasslands reports.

Thus, comparisons should only be made within the same state or ecoregion with similar plant material. For example, Big Bluestem (*Andropogon gerardii*) has a C-value of 6 in both North Dakota and Wisconsin. However, Prairie Dropseed (*Sporobolus heterolepis*) shows variation, scoring 8 in North Dakota but 10 in Wisconsin. In contrast, Western Wheatgrass (*Pascopyrum smithii*) scores 7 in North Dakota and only 4 in Wisconsin, illustrating regional differences in species conservatism. This tool aids prairie restoration by measuring restoration success, guiding native plant selection, and distinguishing invasive from native species.

3 METHODOLOGY

This study employed a collaborative, field-based ecological assessment approach that involved multiple stakeholders, integrating professional ecological assessments with academic fieldwork to ensure comprehensive and robust data collection. FQA conducted through the Universal FQA Calculator, served as the primary methodological framework, allowing standardized evaluation of plant community composition and ecological integrity within the project site.

Primary ecological data were gathered by Resource Environmental Solutions (RES), whose team of experienced ecologists and environmental specialists conducted systematic field surveys. These surveys included detailed plant species identification, habitat condition assessments and comprehensive ecological evaluations, with findings documented in a series of technical memoranda. Additional environmental insights were sourced from a report prepared by KLJ Engineering (Kadrmas, Lee, & Jackson, 2021) and submitted to JLG Architects, which further enriched the dataset and provided critical context for understanding the site's ecological characteristics.

Additionally, faculty members and students from the Landscape Architecture program at North Dakota State University (NDSU) actively contributed to field research activities. Their involvement included mapping invasive species, collecting and cataloging native plant seeds, and participating in initial planting operations. They will continue to assist in monitoring the success of plant establishment and ecological restoration outcomes, ensuring an adaptive approach to long-term management.

Seed collected by dry weight needed to be cleaned and refined and yield rates were low. The seed was then taken to greenhouses in North Dakota and Wisconsin and grown into plugs, which were later delivered to the NDSU extension plots located approximately 75 miles from the rural site in Medora. The data (Table 1) presents 2023 seed collection information for various plant species, detailing bulk seed collected in ounces, refined seed quantities in ounces and bulk seed collected in pounds. Species such as *Symphyotrichum laeve, Symphyotrichum ericoides, Ratibida columnifera, Plantago patagonica, and Heterotheca villosa* show the highest bulk collection values, with some reaching up to 95 ounces. Refined seed quantities are consistently lower across species, indicating a reduction during the processing stage. Several species, including *Linum rigidum, Linum lewisii* and Achillea millefolium, have minimal collection and refinement quantities, reflecting limited seed availability or collection effort.

Table 1: 2023 Seed Collection and Refinement Data by Species

Species	2023 Bulk Collected (oz)	2023 Refined Seed (oz)	2023 Bulk Collected (lb)
Symphyotrichum oblongifolium	3	0.2	0.1
Symphyotrichum laeve	95	10	20
Symphyotrichum ericoides	75	5	20
Ratibida columnifera	70	10	10
Plantago patagonica	70	15	0
Muhlenbergia cuspidata	45	0.2	0
Linum rigidum	1	0	0
Linum lewisii	3	0	0
Heterotheca villosa	70	20	5
Dalea purpurea	2	0.3	1
Bouteloua gracilis	40	3	0.2
Bouteloua curtipendula	30	10	0.5
Achillea millefolium	2	0.2	0.8

The integration of these multiple data sources and collaborative efforts enabled a comprehensive ecological baseline assessment, supporting informed decision-making for restoration planning and ecological management strategies.

4 RESULTS

The total number of plant species observed across six site types distinguishes between total species, native species, and non-native species (Figure 2). The site observed by RES exhibited the highest species richness, with 114 total species, comprising 103 native and 11 non-native species. Both the Initial Proposed and NDSU Seed Plots contained exclusively native species, with counts of 57 and 32, respectively, and no non-native presence. In contrast, the Disturbed/Firebreak area recorded the lowest species richness, with only 8 species (5 native, 3 non-native), indicating reduced ecological quality. The Blufftop/Plateau and Woody Draw sites demonstrated moderate species diversity, with 32 total species (26 native, 6 non-native) and 14 total species (12 native, 2 non-native), respectively.

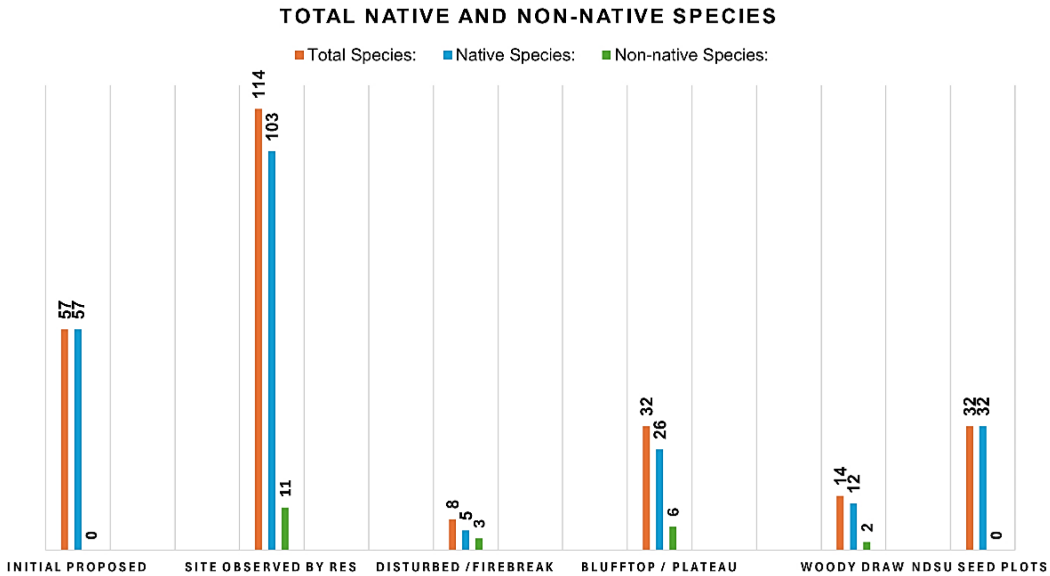

Figure 2: Total Number of Native and Non-native Plant Species Across Different Site Types

These findings highlight variation in species composition and the degree of non-native species across the landscape.

The floristic quality index (FQI) across six site types (Figure 3) compares Adjusted FQI, Native FQI, and Total FQI to evaluate ecological integrity based on plant species composition. The Initial Proposed site and NDSU Seed Plots exhibit the highest Adjusted FQI values (57 and 56, respectively), suggesting strong restoration potential and a predominance of native species. The Full Site Observed by RES also performs well across all FQI measures, indicating high overall ecological quality. In contrast, the Disturbed/Firebreak site records the lowest scores, particularly in Native and Total FQI, reflecting degraded conditions and reduced native species presence. These findings reveal marked differences in floristic quality across the landscape, shaped by varying levels of disturbance and restoration influence.

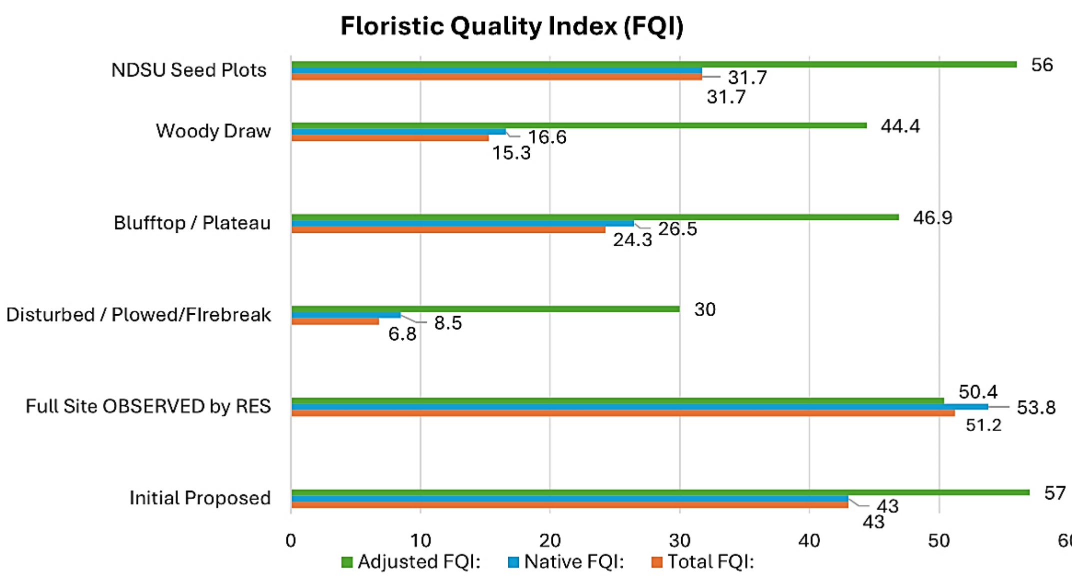

Figure 3: Floristic quality index (FQI) scores by site type, highlighting variations in ecological condition and restoration potential.

The Mean Coefficient of Conservatism (Mean C) across six different areas, comparing Total Mean C (blue) and Native Mean C (green), assesses ecological integrity based on plant species composition (Figure 4). The Initial Proposed site and NDSU Seed Plots display the highest Mean C values (5.7 and 5.6, respectively), reflecting strong native species communities and minimal disturbance. Moderately high Mean C values occur in the Full Site Observed by RES and Blufftop/Plateau (5.3 and 5.2 Native Mean C, respectively), indicating relatively intact native vegetation. Woody Draw shows a lower Total Mean C (4.1) compared to its Native Mean C (4.8), suggesting some influence of non-native species. In contrast, the Disturbed/Firebreak area has the lowest Mean C values (2.4 Total and 3.8 Native), reflecting significant ecological disturbance and reduced presence of conservative species.

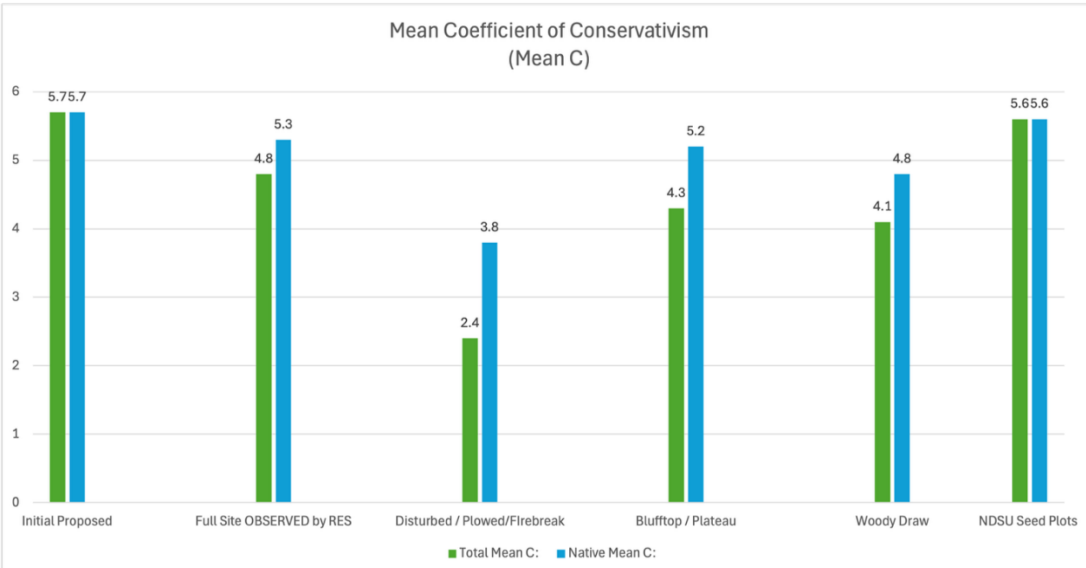

Figure 4: Mean Coefficient of Conservatism (Mean C) by Site.

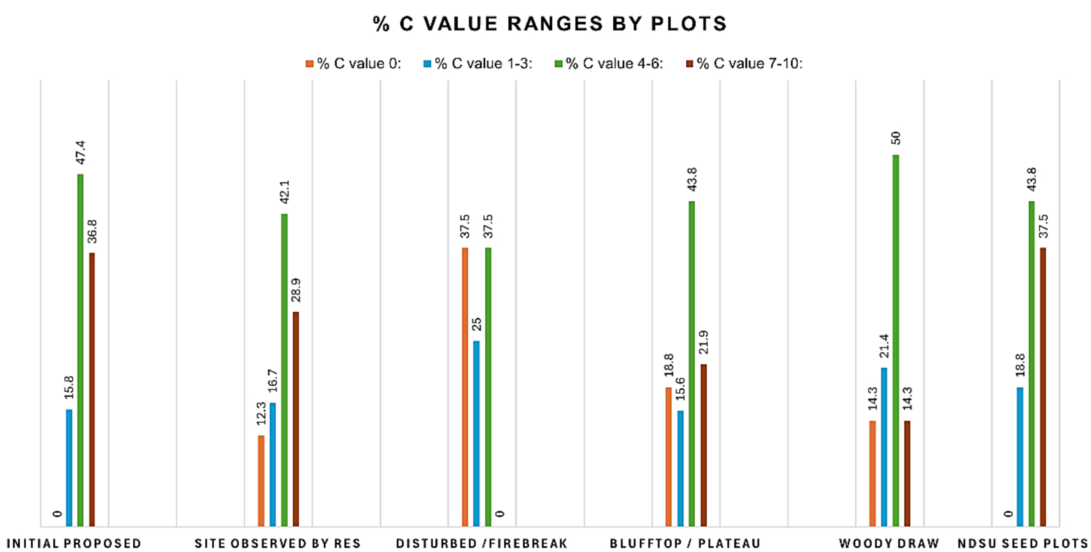

Figure 5: Percentage of Species by Coefficient of Conservatism (C Value) Ranges for Each Plot.

The percentage distribution of plant species by Coefficient of Conservatism (C value) ranges 0 (orange), 1 to 3 (blue), 4 to 6 (green), and 7 to 10 (brown) varies across the six site types (Figure 5). The Initial Proposed and NDSU Seed Plots exhibit the highest proportions of conservative species, with 36.8 percent and 37.5 percent of species falling within the 7 to 10 range and over 43 percent in the 4 to 6 range, indicating high ecological integrity. In contrast, the Disturbed or Firebreak plot is dominated by species with lower C values, with 37.5 percent in both the 0 and 1 to 3 categories and no species in the 7 to 10 range, reflecting degraded conditions. The Site Observed by RES and Blufftop or Plateau plots presents a more balanced distribution across categories, with moderate representation of higher C-value species. Woody Draw shows a concentration in the 4 to 6 range (50 percent) but lower proportions in the 7 to 10 range, suggesting a moderately intact native plant community with some disturbance.

The first-year survival rates of propagated plugs grown from locally collected seeds are presented in Table 2, showing variable success across species. *Carex filifolia* exhibited the highest survival at 100%, followed by *Bouteloua curtipendula* (98%), *Muhlenbergia cuspidata* (97%), *Koeleria macrantha* and *Elymus lanceolatus* (95%), and *Bouteloua gracilis* (94%). High survival rates were also recorded for *Symphyotrichum laeve* (94%), *Plantago patagonica* (88%), *Symphyotrichum ericoides* (88%), *Artemisia frigida* (90%), and *Heterotheca villosa* (83%). In contrast, some species showed very low survival, including *Thermopsis rhombifolia* (2%), *Oxytropis lambertii* (3%), *Pediomelum esculentum* (6%) and *Astragalus laxmannii-robustus* (6%). Species such as *Vicia americana* (60%), *Packera plattensis* (47%), *Geum triflorum* (43%) and *Linum rigidum* (43%) exhibited moderate success, while *Phlox hoodii* (20%) and *Penstemon albidus* (18%) had more limited survival. These outcomes suggest that while many native species establish successfully under current restoration conditions, others may require tailored propagation techniques or site-specific strategies to improve establishment rates.

Table 2: First-Year Survival Rates of Propagated Plugs Grown from Local Seed Collection

Species	1st Year Survival Rate (%)
Vicia americana	60
Thermopsis rhombifolia	2
Symphyotrichum oblongifolium	75
Symphyotrichum laeve	94
Symphyotrichum ericoides	88
Ratibida columnifera	85
Plantago patagonica	88
Phlox hoodii	20
Penstemon albidus	18
Pediomelum esculentum	6
Packera plattensis	47
Oxytropis lambertii	3
Nassella viridula	68
Muhlenbergia cuspidata	97
Linum rigidum	43
Linum lewisii	81
Koeleria macrantha	95
Heterotheca villosa	83
Hesperostipa comata	50
Geum triflorum	43
Galium boreale	75
Elymus lanceolatus	95
Dalea purpurea	58
+Carex filifolia	100
Calylophus serrulatus	67
Bouteloua gracilis	94
Bouteloua curtipendula	98
Astragalus laxmannii-robustus	6
Artemisia frigida	90
Antennaria rosea	77
Achillea millefolium	75

5 DISCUSSION

This study underscores the complexities inherent in seed-based restoration efforts at Theodore Roosevelt National Park (TRLNP), particularly concerning the propagation of native plant species with varying Coefficients of Conservatism (C-values). Species with higher C-values, such as Astragalus laxmannii var. robustior (C=9) and Pediomelum esculentum (C=8), exhibited lower first-year survival rates, indicating challenges in establishing these species from seed. Conversely, species with moderate to low C-values, including Achillea millefolium (C=3) and Artemisia frigida (C=4), demonstrated higher survival rates, suggesting they are more adaptable to restoration efforts. These findings highlight the importance of selecting appropriate species based on their ecological characteristics and adaptability to ensure successful restoration outcomes.

Restoration experts suggest that a phased approach may improve restoration success in such cases. Packard and Mutel (2005) recommend beginning with less conservative species that can tolerate disturbed conditions and help stabilize the site. Over time, more conservative species with higher C-values can be introduced as the site's ecological conditions improve and can better support these sensitive species. This strategy may help address some of the challenges observed in establishing high C-value species at the TRPL site. The ongoing restoration is guided by the Adaptive Land Management Plan developed by Resource Environmental Solutions (RES), which provides recommendations on species selection, invasive species control, and site monitoring.

The research also involved a comparative analysis of species lists and FQI scores across different habitat types within TRLNP, showing a higher coefficient of conservatism for remnant habitat on the blufftop/plateau and lower coefficients on the steeper and woodier draws. This analysis provided insights into the ecological integrity of various habitats and informed restoration design by identifying areas with higher conservation value. Unique plots were assessed using comparative metrics, allowing for the evaluation of restoration strategies and the identification of best practices for future projects. However, the study faced challenges, including the presence of non-native or unrecognized species lacking assigned C-values, which complicated assessments of ecological suitability. Additionally, the wild-harvest list included species not currently incorporated into seed mixes or plug propagation protocols, highlighting the need for ongoing evaluation and adaptation of restoration practices, as argued by Lortie & Hierro (2022).

Finally, this initial research is limited to what was observed onsite and what is proposed for the restoration planting. The amount of data collected was insufficient to establish a probability value for hypothesis testing; however, it provided baseline data for long-term monitoring and management strategies, which are still being developed and documented. We anticipate repeating plant surveys and calculations to do a statistical comparison of C and FQI over time.

6 CONCLUSION

The findings of this study emphasize the complexity of seed-based restoration, particularly when involving species with high C-values. While particular native species demonstrate high survival rates and adaptability, others present challenges that require careful consideration in restoration planning. Ongoing efforts, including the cleaning and verification of approximately 1,200 pounds of bulk seed material and the planned continuation of site visits by NDSU students and faculty, are essential for refining restoration strategies. The development of a KMZ file to track collection sites, with a focus on the 2023 layer, enhances the accuracy of field activity documentation. As the seed cleaning and verification process progresses, internal documentation will be updated, and seed mixes will be revised accordingly. A comprehensive 2024 update is anticipated by late February. These efforts will contribute to more effective restoration practices at the Theodore Roosevelt Presidential Library and help fill gaps in native prairie seed sources for future projects in an area of the United States that lacks local native seed sources.

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