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## **Introduction:**

Many of the hybrid seeds available to the farmers for purchase can only be used for one season and do not produce a good yield if used for a second crop. Native seeds, on the other hand, can be harvested each year and used again the following year or stored for many years. Native seeds will keep their strength of germination for decades. Because farmers were spending so much money buying hybrid seeds, many native varieties had been lost, so Anisha began to start a seed bank.

The seed bank provides native seeds to farmers free of charge or in exchange for manure or compost. At the end of the growing season, the farmers give back seeds to Anisha from their harvest. In order to have seeds available when needed, some farmers have also started their own small collections of seeds at home and trade these with their neighbours.

Anisha's seed bank keeps more than 400 varieties. These include multiple varieties of millet, rice and lentils as well as vegetables such as tomatoes, squash and beans, various gourds. Annually, Anisha distributes thousands of seeds to residents in the Martalli region. In 2017, Anisha started to accept mailorders for seeds.

This annotated bibliography aims to assist the Environment and Life Sciences Research Center ELRSC, mainly the Desert Agriculture and Ecosystems Program (DAE) program, by providing articles examining develops local strategies to oversee the implementation of plans to repair environmental damage with the goal of conserving biodiversity and enhancing greenery sustainably.

This annotated bibliography contains articles abstracts from 2019-2023.

E-resources used: Scopus, ProQuest and Web of Science.

**Contact NSTIC to request full-text articles**

### Articles Abstracts:

- 1- Anderson, T. (2023). Development, Environment, Community: A Q&A with Stantec President and CEO Gord Johnston. *Alaska Business Monthly*, 39(2), 48-51.

**Abstract:** The company grew across Canada, and then in the early '90s we moved into the United States and acquired our first company in Phoenix, which was a land development company. PG&E Pacific Gas and Electric Company] and other clients there, because of the wildfires that have been sparked by vegetation touching the power lines, want to bury some of the above-ground power lines. ...]a company that we just acquired there, called Cardno, was involved in helping create the specifications for mine closure in Australia and then secured the first major mine closure project there. ...]when staff approach me sometimes and say, "We have to get off fossil fuels," I reply, "Okay, but that's not something we can do in the short term."

- 2- Berto, B., Erickson, T. E., & Ritchie, A. L. (2023). Improving Seed Morphology and Germination Potential in Australian Native Grasses Using Seed Enhancement Technologies. *Plants*, 12(13), 2432.

**Abstract:** Difficult to handle seed material and poor germination commonly limit the uptake of native grasses in restoration and commercial-scale seeding efforts. Seed enhancement technologies (SETs) offer valuable solutions for improving the handling of seed material and optimising germination. This study considered eight widespread Australian native grasses; two representative of Mediterranean to temperate climates ('cool-climate' species) and six representative of arid to subtropical climates ('warm-climate' species). Through a series of experiments, this study logically selected and applied SET treatments to improve seed handling and germination for each study species. Seed handling was prioritised and addressed using flash flaming and/or acid digestion, while hydropriming was used following seed-handling treatments to enhance germination. Flash flaming and acid digestion were both applied to successfully reduce or remove bulky floret structures while maintaining or improving germination. Flaming at  $110 \pm 10$  °C with continuous exposure for 10 min and acid digestion concentrations of 75–80% with exposure times of 1–2.5 min were generally successful. Sub-optimal concentrations of sulphuric acid often compromised germination. Hydropriming did not improve germination outcomes when applied following flaming or acid digestion. Optimising SETs for germination, emergence and establishment in different environments, and

the viability and costs of application on larger seed batches are key considerations for the implementation and upscaling of SETs in the future.

3- Bowman, E. A., Plowes, R. M., & Gilbert, L. E. (2023). Evidence of plant-soil feedback in South Texas grasslands associated with invasive Guinea grass. *NeoBiota*, 81

**Abstract:** Plant-soil feedback (PSF) processes play an integral role in structuring plant communities. In native grasslands, PSF has a largely negative or stabilizing effect on plant growth contributing to species coexistence and succession, but perturbations to a system can alter PSF, leading to long-term changes. Through changes to soil abiotic and biotic properties, invasion by non-native plants has a strong impact on belowground processes with broad shifts in historical PSFs. Guinea grass, *Megathyrus maximus*, an emerging invasive in South Texas, can efficiently exclude native plants in part due to its fast growth rate and high biomass accumulation, but its impacts on belowground processes are unknown. Here, we provide a first look at PSF processes in South Texas savannas currently undergoing invasion by Guinea grass. In this pilot study, we addressed the question of how the presence of the invasive *M. maximus* may alter PSF compared to uninvaded grasslands. Under greenhouse conditions, we assessed germination and growth of Guinea grass and the seed bank in soil collected from grasslands invaded and uninvaded by Guinea grass. We found that Guinea grass grown in soil from invaded grasslands grew taller and accumulated higher biomass than in soil from uninvaded grasslands. Plants grown from the seed bank were more species rich and abundant in soil from uninvaded grasslands but had higher biomass in soil from invaded grasslands. In South Texas savannas, we found evidence to support shifts in the direction of PSF processes in the presence of Guinea grass with positive feedback processes appearing to reinforce invasion and negative feedback processes possibly contributing to species coexistence in uninvaded grasslands. Future work is needed to determine the mechanisms behind the observed shifts in PSF and further explore the role PSF has in Guinea grass invasion.

4- Byun, C. (2023). Role of priority effects in invasive plant species management: Early arrival of native seeds guarantees the containment of invasion by Giant ragweed. *Ecology and Evolution*, 13(3)

**Abstract:** Empirical evidence shows that early arrival of native species, which induces the priority effects, can contribute to invasive plant species containment. However, more systematic studies are required to test the applied relevance of the priority effect. This study

therefore aimed at testing the priority effects generated by different sowing times of seeds of nine native species on one target invasive plant species, that is, Giant ragweed (*Ambrosia trifida*). This study hypothesized that, when sown earlier, some native species will be able to substantially contain *A. trifida* through resource preemption. An additive competition design was used to test the competitive effects of native species on *A. trifida*. Depending on the sowing times of native and invasive plant species, three priority treatments were conducted: all species sown at the same time (T1); native species sown 3 weeks before *A. trifida* (T2); and native species sown 6 weeks before *A. trifida* (T3). Priority effects created by all nine native species significantly affected the invasibility of *A. trifida*. The average value of the relative competition index (RCI<sub>avg</sub>) of *A. trifida* was the highest when native seeds were sown 6 weeks early and decreased with decreasing early sowing time of native plants. The species identity effect was not significant on RCI<sub>avg</sub> if natives were sown at the same time or 3 weeks earlier than *A. trifida* invasion, but it was significant ( $p = .0123$ ) if they were sown 6 weeks earlier than *A. trifida*. Synthesis and applications. The findings of this study clearly show that native species, when sown early, provide strong competition and resist invasion through prior utilization of resources. The consideration of this knowledge might improve *A. trifida* invasion management practices.

5- Cordero, S., Gálvez, F., & Fontúrbel, F.,E. (2023). Ecological Impacts of Exotic Species on Native Seed Dispersal Systems: A Systematic Review. *Plants*, 12(2), 261.

**Abstract:** Exotic species are one of the main threats to biodiversity, leading to alterations in the structure and functioning of natural ecosystems. However, they can sometimes also provide ecological services, such as seed dispersal. Therefore, we assessed the ecological impacts of exotic species on native dispersal systems and the mechanisms underlying the disruption of mutualistic plant–disperser interactions. Exotic species negatively affect dispersal mutualisms by (i) altering dispersal behavior and visitation rates of native dispersers, (ii) predated native dispersers, (iii) transmitting forest pathogens, and (iv) predated seeds. Conversely, positive impacts include the dispersal of native plants, forest regeneration, and native habitat restoration via (i) increasing the visitation rates of frugivorous birds, (ii) facilitating the colonization and establishment of native forest trees, (iii) enhancing forest species seedling survival, and (iv) facilitating seed rain and seedling recruitment of early and late successional native plants. The reviewed studies provide similar results in some cases and opposite results in others, even within the same taxa. In almost all cases, exotic species cause negative impacts, although

sometimes they are necessary to ensure native species' persistence. Therefore, exotic species management requires a comprehensive understanding of their ecological roles, since the resulting effects rely on the complexity of native–exotic species interactions.

6- de Oliveira Araújo, J., Daniel, T. P., Geovana, B. Q., Júlia, M. S., Hoshide, A. K., Vicente Toledo Machado de, Morais Junior, Samuel José Silva Soares, da Rocha, & Denise Cunha Fernandes dos, Santos Dias. (2023). Selection of Superior *Senna macranthera* Seeds, Carbon Stock, and Seedling Survival, and Costs for Habitat Restoration. *Sustainability*, 15(13), 9875.

**Abstract:** Conservation and recovery of degraded areas generate great demand for seeds of native tree species. The development and/or improvement of efficient techniques for the evaluation of forest-seed quality is important for the production and establishment of high-quality seedlings for restoration. In this study, the tissue density of radiographic images of *Senna macranthera* seeds was related to their physiological quality. Moreover, biomass, carbon stock, seedling survival, and X-ray technique costs were estimated for *S. macranthera*. Collected seeds were analyzed using digital radiography to measure relative and integrated density. The physical integrity of seed tissues was visually evaluated. Seeds were then germination tested to assess seedling development-related traits. Semiautomated radiography allowed for visualizing internal seed structures and observing their density and physical-integrity differences as well as physiological quality. Moreover, seed lots with lower relative and integrated densities had more physical damage and/or malformation, thus producing less vigorous seedlings. The average carbon stock was 21.42 kg per tree. The seed selection cost was USD 0.0132/seed at an 81% germination rate. The annual cost of planting *S. macranthera* seedlings was USD 7500 per hectare during the establishment year and averaged USD 1562 per year for replanting lost transplants over the eight years after initial planting. Applying these techniques may enhance the seedling production of this species, contributing to reforestation programs in Brazil.

7- Fortier, J. (2023). RESTORATION: Harnessing technology to improve revegetation outcomes. *Canadian Mining Journal*, 144(5), 13-15.

**Abstract:** In the experiment, a coated black-eyed susan seed was applied to a challenging site with drought conditions and heavy clay, credit:chase beaudoin northern wildflowers,sudbury,ont.i The deep and fibrous roots of native grasses, wildflowers, and shrubs

are the best natural tool against soil erosion and sedimentation. ...]for over 100 years, farmers have been coating their own seed to increase yields and shelf-life and improve handling, using natural minerals like clay or lime. The coating recipe might include the following: lime, which is a natural mineral with the ability to buffer acidic conditions; gibberellic acid, which is a natural plant growth hormone that will encourage seeds to break dormancy and germinate soon after spring application; and a thick, heavy encrusting layer of natural minerals which will make the seed heavier, making them less likely to be blown away, which will also increase the ease of handling and broadcasting. ...]Canada and the world have embarked on an ambitious journey towards revegetation, recognizing the crucial role of restoring and preserving our natural ecosystems.

- 8- Juan Camilo Fontalvo-Buelvas, Eugenio-Gozalbo, M., Yadeneyro de la Cruz-Elizondo, & Escalona-Aguilar, M. (2023). Evaluating University Gardens as Innovative Practice in Education for Sustainability: A Latin-American Case Study. *Sustainability*, 15(5), 3975.

**Abstract:** The aim of this study was to define a protocol for evaluating university gardens as innovative practice in Education for Sustainability and to apply it to a Latin-American study case, that of the Agroecological Garden in the Faculty of Biology at the Veracruzana University (Mexico). A comparative evaluation was conducted between two different moments (December 2018 and January 2021) based on sustainability indicators that were adapted from the SAEMETH-G methodology, using three levels of increasing complexity. These levels were the selection of sustainability dimensions, the individuation of the components, and the selection of the appropriate indicators. At the beginning of 2021, the selected Agroecological Garden showed high sustainability, with an accumulated score of 84.04 out of a total of 100 points, with the agro-environmental dimension being the best positioned (93.74), followed by the socio-educational (91.99) and the economic-administrative (66.4) domains. A significant robustness at the socio-environmental level was evidenced. However, it is necessary to address the substantial deficiencies evidenced at the economic-administrative level, especially in relation to financing and institutionalization, in order to make this innovative didactic resource sustainable and thus contribute to education for sustainability among university students.



9- Davis, R. (2022). *Fruits of Our Labor: Exploring the Impacts of a Nonprofit Seed Bank on Indigenous Communities in the Southwestern United States* (Order No. 29061639). Available from Publicly Available Content Database. (2682199947).

**Abstract:** This thesis explores the ways that the nonprofit Native Seeds/SEARCH, of Tucson, Arizona interfaces with Indigenous communities and the local seed and food systems in the Southwest United States. The thesis argues that Native seed and food sovereignty have different meanings for different Indigenous people, and that nonprofits working with Indigenous communities need to consider input from them when deciding how to catalogue, regenerate and sustain healthy grow outs for the future, especially in the light of climate change and drought.

10- Guidetti, B. Y., Dardanelli, S., Miño, F. M. L., & Amico, G. C. (2022). Artificial perches for birds in deforested areas favour a seed rain similar to woodland remnants. *Plant Ecology*, 223(10-12), 1261-1274.

**Abstract:** The lack of seeds represents one of the highest difficulties to overcome for the ecological restoration of areas that have been deforested. This study evaluates the effectiveness of artificial perches in increasing the abundance and species richness of bird-dispersed seeds and the similarity of seed rain composition of deforested areas with and without artificial perches in relation to woodland remnants that serve as seeds source. We also tested for differences in seed abundance and species richness with different origins (native or non-native) as well as different type of habits (woody and non-woody). The experiment took place in two sites of the Espinal ecoregion, Argentina. We found that in deforested areas, perches increased seed abundance and species richness in the seed rain in comparison with deforested areas without artificial perches. The species composition under artificial perches was similar to the seed rain dispersed in the woodland. However, there was a decrease in the abundance and richness of native species under artificial perches, probably due to behavioral differences between opportunistic and obligate frugivorous. Seed of trees and shrubs species that can act as natural perches and nurses were well represented in the seed rain under artificial perches. We recommend using artificial perches in deforested areas with potential for recovery because it is an efficient technique to promote the entry of birds and increase seed rain, preserving features of the original environment. In places where native and non-native species show different fructification peaks, artificial perches could be used in certain periods of the year.

- 11- Lacoretz, M. V., Malavert, C., Madanes, N., Cristiano, P., & Tognetti, P. M. (2022). Seed dormancy and germination of native and invasive alien woody species of an endangered temperate forest in the Argentine Pampas. *Forest Ecology and Management*, 526 p.120577-

**Abstract:** Forest restoration plans can benefit from knowledge of seed ecophysiology. Naturally, seeds respond to environmental clues to trigger germination or persist in the seed bank. Controlling dormancy and germination moment in native species will allow more efficient seed management, both for direct seeding (in situ restoration) and for native plant cultivation in nurseries (ex situ restoration). In addition, the differences in germination conditions of native and alien invasive trees can be used as control windows of the alien species in the seed bank. The aim of this study was to identify the environmental factors regulating seed dormancy and germination of native and alien trees of the Talares, an endangered temperate forest of the Argentine Pampas region. Seeds of the native trees *Schinus longifolius*, *Jodina rhombifolia*, *Celtis tala* and the alien trees, *Ligustrum lucidum*, *Ligustrum sinense* and *Gleditsia triacanthos* were collected and the presence of dormancy was determined exposing the seeds to standard germination protocols. In case of dormancy presence, a post-maturation experiment was carried out in two conditions: i) cold and wet (stratification) and ii) dry and warm (after-ripening). The native species *J. rhombifolia* and *C. tala* showed seed dormancy but *S. longifolius* did not. For *C. tala* germination it was necessary a previous post-maturing process; however, environmental conditions for *J. rhombifolia* germination were not attained. Alien species showed a high germination, reaching up to 100% in at least one of the evaluated conditions, and displayed different emergence windows compare to natives. Since alien species germinated at lower temperatures than natives, a temporal window for chemical or mechanical control is proposed. Ecophysiology of seed dormancy and germination facilitates strategies for decision makers, as it can make native seeds use and aliens control more efficient to meet global restoration goals.

- 12- Lamb, N., Havens, K., Holloway, J., Steffen, J. F., Zeldin, J., & Kramer, A. T. (2022). Low passive restoration potential following invasive woody species removal in oak woodlands. *Restoration Ecology*, 30(4)

**Abstract:** The restoration of oak woodlands often requires removal and management of woody invasive plants. This can trigger germination of the soil seed bank, which can alter restoration trajectories. In degraded deciduous woodlands generally, it is unclear whether the soil seed

bank will contribute native plant material in sufficient quantities to help achieve restoration goals and allow practitioners to rely on passive restoration without supplemental seeding. To support restoration decision-making around passive or active restoration in three *Rhamnus cathartica*-invaded forest preserves in the Chicago region, we asked: (1) Does the soil seed bank differ from standing aboveground vegetation at reference and unrestored sites? and (2) Can the species richness, Shannon diversity, floristic quality (measured by abundance-weighted mean coefficients of conservatism), or density of germinable seeds of native species in the soil seed bank be predicted by a site's restoration status (reference or unrestored)? We found that species composition differed significantly between aboveground vegetation and the soil seed bank at reference and unrestored sites, with a significant interaction between restoration status and location. Despite high variation among the three forest preserves, restoration status also predicted native species richness, diversity, floristic quality, and seed density in the soil seed bank, with unrestored sites significantly lower than reference sites in all measures. Results suggest that reintroduction of native seeds will be necessary to fully restore desired native plant communities in oak woodlands following the removal of invasive woody plants.

13- Anna Kövendi-Jakó, Szitár, K., Halassy, M., Halász, K., Mojzes, A., & Török, K. (2021). Effect of seed storing duration and sowing year on the seedling establishment of grassland species in xeric environments. *Restoration Ecology*, 29

**Abstract:** The availability of seeds of native species in many countries for grassland restoration is limited; therefore, ex situ seed banks can gain importance as a source of germplasm in the future. We tested the usability of seed accessions of the Pannon Seed Bank for reintroduction with the aim to restore sandy grassland in Hungary. Seeds of 10 native sandy grassland species were seeded in the year of collection and after one or two years of storage. The establishment was estimated by counting seedlings along seeded transects for two vegetation seasons. This study produced the first numerical estimate we know about of native sand grassland species emergence in the field. A low establishment of the tested species was found, ranging from 0.002 to 8%. Within this range, *Dianthus serotinus* had the highest establishment, while *Festuca vaginata*, which was sown as matrix species, performed only medium establishment. The short-term storage (1 or 2 years) of seeds had no significant effect, except for *F. vaginata*, where seed storage had a positive effect on reintroduction success. The year of seeding had the highest influence on recruitment. Four species were found to emerge over two years instead of only the

first year. Based on our results, the weak seed yield of certain years and the low supply of native seeds in the market can be mitigated by using stored seeds. It is recommended to use multi-year, scheduled seeding to reduce the negative impacts of particularly dry years and to increase the restoration success.

- 14- Barga, S. C., Olwell, P., Edwards, F., Prescott, L., & Leger, E. A. (2020). Seeds of Success: A conservation and restoration investment in the future of U.S. lands. *Conservation Science and Practice*, 2(7)

**Abstract:** Seeds of Success (SOS) is a national seed collection program led by the Bureau of Land Management. SOS represents the most comprehensive native seed repository in the United States, supporting native plant restoration, management, and research. Since inception in 2000, SOS has collected seeds from over 24,400 native plant populations from ~5,600 taxa from 43 states. Collections include species important to wildlife, pollinators, and indigenous people, and over 10,000 collections have been shared for restoration and research use. We asked how many SOS sites have burned since collection, and identified 662 fires at 631 sites. If fire continues at the pace observed since 2011, an estimated 14% of collection sites will burn by 2050 and over 24% by 2080, putting genetic diversity at risk in areas where fire is linked with invasion. Analysis of 14 native forb species from the western United States found that many collections were from the warmest and driest portions of their range, areas at the highest risk of wildfire, subsequent invasion, and local extinction. SOS provides an opportunity to understand change in natural populations, and represents a critical repository of native plant genetic resources for conservation and future use.

- 15- Cecco, V. D., Musciano, M. D., D'Archivio, A.A., Frattaroli, A. R., & Martino, L. D. (2019). Analysis of intraspecific seed diversity in *Astragalus aquilanus* (Fabaceae), an endemic species of Central Apennine. *Plant Biology*, 21(3), 507-514.

**Abstract:** This work aims to study seeds of the endemic species *Astragalus aquilanus* from four different populations of central Italy. We investigated seed morpho-colorimetric features (shape and size) and chemical differences (through infrared spectroscopy) among populations and between dark and light seeds. Seed morpho-colorimetric quantitative variables, describing shape, size and colour traits, were measured using image analysis techniques. Fourier transform infrared (FT-IR) spectroscopy was used to attempt seed chemical characterisation. The measured data were analysed by step-wise linear discriminant analysis (LDA). Moreover, we

analysed the correlation between the four most important traits and six climatic variables extracted from WorldClim 2.0. The LDA on seeds traits shows clear differentiation of the four populations, which can be attributed to different chemical composition, as confirmed by Wilk's lambda test ( $P < 0.001$ ). A strong correlation between morphometric traits and temperature (annual mean temperature, mean temperature of the warmest and coolest quarter), colorimetric traits and precipitation (annual precipitation, precipitation of wettest and driest quarter) was observed. The characterisation of *A. aquilanus* seeds shows large intraspecific plasticity both in morpho-colorimetric and chemical composition. These results confirm the strong relationship between the type of seed produced and the climatic variables.

16- Devenish, A. J. M., Gomez, C., Bridle, J. R., Newton, R. J., & Sumner, S. (2019). Invasive ants take and squander native seeds: implications for native plant communities. *Biological Invasions*, 21(2), 451-466.

**Abstract:** Seed dispersal is a fundamental process in the lifecycle of all flowering plants. Many plant species have evolved specialist associations with biotic vectors to facilitate dispersal. Such specialised interactions mean that these associations are potentially highly sensitive to disruption, e.g. from invasive species. However, despite this threat we still understand remarkably little about how such perturbations affect the dynamics and efficiency of the seed-dispersal process. In this study we quantify the impacts of an invasive ant across three key phases of the seed dispersal process: seed removal, distribution and placement, in order to determine the stages of seed dispersal most vulnerable to disruption by invaders. Using the Argentine ant (*Linepithema humile*) as a model, we show that invaded sites exhibited a significant decrease in seed dispersal services across all three phases of the dispersal process, relative to non-invaded sites. Seeds dispersed in invaded sites were: (a) less likely to be transported; (b) potentially distributed over a smaller spatial area, and (c) less likely to be placed at soil depths favourable for germination and establishment compared to those dispersed in non-invaded sites. These results reveal that ant-mediated seed dispersal services are significantly reduced by an invasive species at multiple stages in the dispersal process. Reductions in the efficacy of seed dispersal, combined with shifts in the ecological and geographical patterns of dispersal, may lead to cascading impacts on plant species composition and community structure. This study shows how an invasive ant can affect seed dispersal at several stages in the dispersal process.

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