GLOBAL RE-INTRODUCTION PERSPECTIVES

Re-introduction case-studies from around the globe

Edited by

Pritpal S. Soorae

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Cover photo: Clockwise starting from top-left:

- Formosan salmon stream, Taiwan
- Students in Madagascar with tree seedlings
- Virgin Islands boa

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Contact Details: Pritpal S. Soorae, Editor & RSG Program Officer
E-mail: ***psoorae@ead.ae***

Experimental introductions of Florida ziziphus on Florida's Lake Wales Ridge, USA

Carl W. Weekley[1] & Eric S. Menges[2]

[1] - Research Assistant V, Plant Ecology Lab, Archbold Biological Station, P.O. Box 2057, Lake Placid, FL 33862, USA (*cweekley@archbold-station.org*)
[2] - Senior Research Biologist, Plant Ecology Lab, Archbold Biological Station, P.O. Box 2057, Lake Placid, FL 33862, USA (*emenges@archbold-station.org*)

Introduction

Florida ziziphus, ***Ziziphus celata*** (Rhamnaceae) Judd and D. Hall, is listed as VU -D1 (vulnerable to extinction due to a population <1,000 mature individuals) by the IUCN (World Conservation Monitoring Center, 1998). It is also listed as Endangered by the US Fish and Wildlife Service (USFWS, 1999) and by the state of Florida (Coile & Garland, 2003). A thorny, multi-stemmed clonal shrub to 2 m in height, Florida ziziphus is known from fewer than a dozen populations along a 45 km stretch of the Lake Wales Ridge, an area renowned for its many narrowly endemic plants. All known populations occur in pyrogenic xeric uplands, but most of these sites have been converted to cattle pastures.

Only two populations are publicly protected. Florida ziziphus is self-incompatible (Weekley & Race, 2001) and genetically depauperate (Godt ***et al.***, 1997 & Weekley ***et al.***, 2002). Most populations consist of a single genotype. Altogether, wild populations comprise <30 genotypes and only two mating types. Due to its incompatibility system and the distance between populations, most populations are self-sterile. Historic Bok Sanctuary, an affiliate of the Center for Plant Conservation, maintains a multi-genotype ***ex situ*** population that has produced several thousand fruits since its establishment in 1989.

Florida ziziphus (*Ziziphus celata*)

Goals

- Goal 1: Establish demographically viable, genetically diverse, and sexually reproducing populations in appropriate habitat on protected sites.
- Goal 2: Increase understanding of the microhabitat requirements and autecology (e.g. fire ecology).
- Goal 3: Maintain and strengthen collaborations with Historic Bok Sanctuary (***ex situ*** population is source of propagules for introductions), Florida Museum of Natural History's Laboratory of

Molecular Systematics and Evolutionary Genetics (genetic analysis is critical component of introductions), other researchers who contribute to our understanding of the biology of Florida ziziphus, and private and government agency land managers.

Planting Florida ziziphus

Success Indicators

- Indicator 1: Transplant survival rates >70% for introduced potted plants.
- Indicator 2: Seed germination rates >10% for introduced seeds.
- Indicator 3: Flowering by individuals of multiple mating types.
- Indicator 4: Production of viable fruits within introduced population.

Project Summary

Feasibility: Florida ziziphus is known exclusively from pyrogenic xeric upland sites that historically supported longleaf pine (***Pinus palustris***)-wiregrass (***Aristida stricta*** var. ***beyrichiana***) sandhills. Most of the endemic-rich sandhill habitat on the Lake Wales Ridge was lost to citrus and cattle ranching decades ago and the remainder has been degraded by decades of fire suppression. Genetically depauperate remnant populations of Florida ziziphus occur primarily in privately owned cattle pastures. Restoration of viable populations requires the introduction of genetically diverse cross-compatible mating types to protected sites containing fire-maintained sandhill habitat. Since 2002, we have carried out two major introductions, comprising 430 potted transplants and 4,728 seeds.

Each introduction was designed as an experiment to evaluate the relative efficacy of transplants vs. seeds in the establishment of new populations, to investigate the microhabitat requirements of transplants, seeds and seedlings, and to explore the performance of propagules representing different maternal lineages. Here we compare 1) the establishment rates of transplants vs. on-site seedlings in the two introduction sites, and 2) the vital rates of transplants and seedlings in the two sites.

Implementation: In June 2002, we introduced 144 two to three year old potted plants and 1,728 seeds to the Lake Wales Ridge National Wildlife Refuge (Carter Creek). Equal numbers of transplants and seeds were introduced into each of 36, 5 m radius plots representing three experimental treatments: burn-only, chainsaw felling of subcanopy followed by burning (saw-and-burn), and an untreated control. Thus, introduction plots contained a range of microhabitat conditions defined by the percentage of subcanopy shade, litter, bare sand, and co-occurring

shrub cover. The second experimental introduction was carried out in June 2005 at The Nature Conservancy's Tiger Creek Preserve. Into five sandhill sites representing a range of habitat quality from "good" to "poor", we transplanted 286 1 - 2 year old potted plants and sowed 3,000 seeds. Habitat quality was defined by TNC land managers based on widely used criteria for sandhill restoration, including an open subcanopy, low shrub cover, extensive graminoid cover, and high herb diversity.

Post-introduction monitoring: Introduced transplants were monitored at least quarterly for the first year and at least annually thereafter; seed arrays, each containing 24 seeds, were monitored at least monthly for four to six months for seedling emergence.

Transplants vs. seeds as effective propagules for introduction: Transplants outperformed seeds as effective propagules in both the Carter Creek and the Tiger Creek introductions. At Carter Creek, cumulative transplant survival 4.5 years post-introduction stood at 76.4%, while the 1,728 introduced seeds resulted in only three surviving seedlings, an establishment rate of 0.17%. At Tiger Creek, two years post-introduction, cumulative transplant survival was 72.4%. The 3,000 seeds yielded 47 seedling survivors, a 1.57% establishment rate. Thus, despite the greater expenditure of time and effort required to produce transplants, their greater survival rates make them the propagule of choice in introductions. However, direct seeding is still important because seeds are easy to introduce and they may provide critical data on the germination ecology of Florida ziziphus. Raising seedlings ***ex situ*** is troublesome, despite higher germination rates, because nursery-grown seedlings suffer high mortality.

Vital rates of transplants and seedlings in contrasting sites and microsites: Cumulative transplant survival was higher at Carter Creek after 4.5 years (76.4%) than at Tiger Creek after two years (72.4). Annual transplant survival also differed dramatically at the two sites, averaging 94.8 ± 3.3% Carter Creek, and 74.1± 4.5% at Tiger Creek. However, transplants at Tiger Creek experienced greater growth than those at Carter Creek. Surviving Tiger Creek transplants gained a median of 3.25 cm in height, a 40.8% increase in <2 years, while growth a Carter Creek was negligible (median of 0.5 cm, a 1.6% increase) after 4.5 years. However, cumulative transplant survival has been >60% in all sites, suggesting that Florida ziziphus has broader habitat tolerances than previously thought. Seed germination percentages differed only marginally at the two sites ($\chi^2 = 4.062$, df = 1, $p = 0.044$). It was slightly higher at Tiger Creek (4.8%) than at Carter Creek (3.6%). Seedling survival at the two sites differed significantly two years post-sowing ($\chi^2 = 15.766$, df = 1, $p < 0.001$), however; it was almost five times greater at Tiger Creek (32.4%) than at Carter Creek (6.5%). Tiger Creek seedlings averaged 6.2 ± 3.9 cm in height 15 - 18 months post-germination (range 1.4-20.5 cm), while after 4.5 years Carter Creek seedlings averaged 9.0 ± 2.0 cm (range 1.0-11.0 cm). Thus, while transplant survival was higher at Carter Creek, both seed germination and particularly seedling survival were higher at Tiger Creek. In addition, both transplant and seedling growth at Carter Creek were negligible compared to Tiger Creek. These differences may reflect difference in the quality

of available propagules or of difference in the quality of introduction microsites.

Major difficulties faced

- Paucity of genetic variability and mating types within extant populations may constrain seed production and subsequent seedling recruitment.
- Propagating new genotypes from seeds is slow and uncertain due to low rates of seed germination and high rates of seedling mortality.
- Transplant shock and animal disturbance are threats to introduced plants.

Major lessons learned

- Transplants are more successful than seeds as introduction propagules because of high transplant survival rates (>75% one year post-introduction), low seed germination rates (<5%), and low seedling survival rates (<35%).
- High rates of transplant survival in a range of microhabitats suggest that Florida ziziphus is more tolerant of shade and competition than previously thought.
- Multi-disciplinary collaboration among conservation ecologists, geneticists, and land managers is critical in ensuring a scientifically sound and successfully implemented introduction strategy.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reasons for success/failure:

- Transplant survival >70%, but 4.5-year old transplants have not grown.
- Seed germination and seedling survival have been lower than projected, but most surviving seedlings have shown steady growth.
- Introductions have increased our understanding of microhabitat requirements and autecology of Florida ziziphus.
- Introduced plants have not yet flowered, so we cannot assess whether populations are reproductively viable.

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