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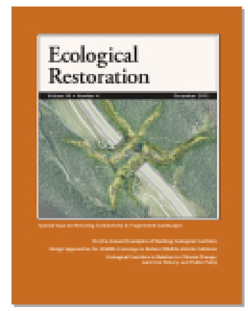

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Connecting Fragments of the Pine Rockland Ecosystem of South Florida: The Connect to Protect Network

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Globally, critically imperiled pine rockland ecosystems occur only in south Florida, USA and the Bahamas (Snyder et al. 1990). Once encompassing 51,193 ha along the Miami Rock Ridge in south Florida, today Everglades National Park protects 8,029 ha, while outside the park approximately 920 ha remain as small fragments within the dense urban matrix of Miami-Dade County, FL (Bradley 2005, Florida Natural Areas Inventory 2010; Figure 1). Since the late 19th century, pine rocklands have been cleared for timber, agriculture, and urban development. This unique ecosystem evolved with a diverse mix of temperate and tropical plant and animal species. Of the 432 native plant species found within pine rocklands, 31 are endemic to Florida, 5 are federally endangered, and 5 are candidates for federal listing (Gann et al. 2002, Florida Natural Areas Inventory 2010). Realizing a sense of urgency in 1990, Miami-Dade County voters approved a property tax that created the Environmentally Endangered Lands Program (EEL), which has purchased 242 ha of pine rockland forest fragments for protection. On private lands small pine rockland parcels still exist in various stages of health.

Because the ability to move successfully from fragment to fragment and find new patches to colonize is critical for a species' persistence (Kindlmann et al. 2008), corridors and stepping stones can potentially connect isolated populations, increase seed dispersal, and provide areas for new colonization. In this spirit, Fairchild Tropical Botanic

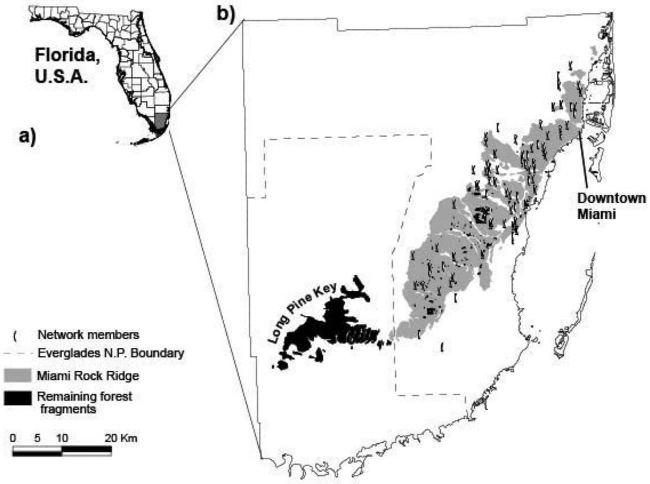

Figure 1. Original and current extent of pine rockland in Miami-Dade County, Florida, U.S. a) Location within Florida. b) Original extent of pine rockland occurred on the Miami Rock Ridge, a limestone ridge (80 km × 14 km) with elevation of 2–7 m above sea level (dark grey). Pine rockland fragments (black) are located on Long Pine Key within the boundary of Everglades National Park, while outside the park approximately 2% of the former extent remains. Connect To Protect Network (CTPN) stepping stone gardens are indicated as white dots, which are enlarged to make the locations visible at this scale.

Figure 2. Connect to Protect Network (CTPN) volunteers creating pine rockland habitat at West Miami Middle School, Miami, FL, September 2007. Known as Project Pride, this pine rockalnd stepping stone garden provides habitat for the federally endangered lead plant (*Amorpha herbacea var. crenulata*) and has become a focal point of the environmental science curriculum at the school.

Garden founded the Connect to Protect Network (CTPN), a corridor program that uses public outreach, education, and restoration support to help establish healthy native pine rockland corridors and stepping stone gardens on both public and private properties. Initially we used GIS data to locate and prioritize potential areas for corridor and stepping stone development. Quickly realizing that physical connections between existing pine rocklands were nearly impossible to accomplish in the urban matrix and that few intact tracts ≥2 ha existed, we sought residential, school, and business areas of any size in close proximity to natural forest fragments as potential natural or restored stepping stones (Figure 1). Although stepping stones do not physically connect natural forest patches, they may be able to facilitate seed and pollen dispersal between fragments. There is great capacity to create planted and managed stepping stone gardens within the urban patchwork, especially on private lands.

Connect to Protect Network Framework

Integrating conservation gardens as high-quality islands within the urban matrix may be the solution to conserving this rare ecosystem (Janzen 1999). Since 2007, CTPN has grown to 47 homeowners, 46 schools, and 5 institutions, who have voluntarily enlisted (Figure 1). We recruit new members via presentations throughout the community, brochures, and promotions on our institution's website (www.fairchildgarden.org/centerfortropicalplantconservation/connecttoprotect/). Our goals to educate members about issues surrounding pine rockland conservation and to encourage an interactive network are accomplished through biannual meetings and newsletters where information about growing pine rockland species and managing invasive plants are enthusiastically shared. CTPN is connecting natural and human communities.

Providing restoration support to members is critical to meeting CTPN goals. We organize volunteer workdays and provide native pine rockland plants free of charge (Figure 2). Workdays may comprise invasive removal or plantings that help members maintain their pine rockland habitats. Drawing upon Fairchild's extensive volunteer network and competitive education program, The Fairchild Challenge, we have engaged over 400 community members in restoration projects on public and private lands since 2007. All CTPN members are eligible to receive a pine rockland starter kit of 7–10 pine rockland plant species that is intended to help new members establish pine rockland gardens or increase diversity of existing sites. To receive the starter kit, members must be willing to collect data on the distributed plants. We created a simple datasheet where members are asked to observe and document plant health, phenology, and pollinator presence monthly. Some members elect to be rare plant foster gardeners, where they cultivate and collect data on 10 plants of a rare species. The data contribute to the growing information about changes in plant phenology across time with climate change (Table 1), whether pollination is occurring to produce fruits, and whether pine rockland plants can be sustained in these urban gardens.

Since fragmentation limits dispersal and makes isolated populations more susceptible to extinction (Kirchner et al. 2003), distributing plants throughout the community not only increases the number of possible dispersing individuals, but it expands the spatial footprint of the species. Our

Table 1. Phenology of 17 pine rockland species growing in Connect to Protect Network gardens, Florida, 2009–2010. Shaded areas indicate months when flowers were observed. Data is voluntarily supplied by 20 members. Legal status: FLE = Florida Endangered; FLT = Florida Threatened; USC1 = United States federal candidate; USLE = United States listed endangered.

	Legal	2009											2010											
SPECIES	**Status**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Abildgaardia ovata								■	■	■	■	■					■	■						
Alvaradoa amorphoides	FLE					■	■						■	■	■	■								
Angadenia berteroi	FLT					■	■	■		■						■	■	■	■	■	■	■	■	
Brickellia mosieri	USC1, FLE					■		■	■	■		■						■	■	■				
Chamaecrista nictitans var. aspera										■	■	■	■											
Eragrostis elliottii								■	■	■	■						■	■	■	■				
Echites umbellata								■	■							■								
Galactia smallii	USLE			■	■	■		■						■	■	■								
Ipomoea microdactyla	FLE																							
Jacquemontia curtisii	FLT									■	■	■	■	■	■	■	■	■	■	■				
Liatris chapmanii								■	■										■	■				
Mimosa quadrivalvis var. angustata																								
Schizachyrium sanguineum			■	■								■	■											
Senna ligustrina			■	■	■				■	■														
Tephrosia angustissima var. corallicola	FLE			■	■			■	■	■	■				■	■	■	■	■					
Trichostema dichotomum								■	■	■	■							■	■	■				
Zornia bracteata													■	■	■		■	■						

horticultural research identifies cultivation and storage requirements of pine rockland taxa that are not commercially available and allows us to distribute uncommon species (Maschinski et al. 2009).

Measuring Success

To determine whether the CTPN is connecting pine rockland fragments and preserving native pine rockland plant species, in 2012 we surveyed 20 CTPN stepping stone gardens to count the total common and endangered species present and measure the distance to the nearest protected fragment. The gardens contained 64% of species (217 total species) known from pine rocklands. On average, in areas ≤0.4 ha, private homes and schoolyards supported 42 and 10.8 species/garden, respectively, while one commercial property grew 20 species. In comparison, 20 randomly sampled EEL pine rocklands harbored 38 species/ha. Four CTPN gardens had >50 native pine rockland species, and 15 gardens supported at least 1 state or federally listed endangered species. The majority of gardens (17) were located ≤10 km from a pine rockland fragment and 3 gardens occurred >10 km from the nearest fragment.

Future steps for the CTPN include developing more stepping stones close to forest fragments, encouraging planting greater diversity of both common and rare species, and engaging CTPN members in research on seeds, dispersal, and restoration. Because shortening distances between fragments may increase dispersal opportunities for poor dispersers and increase population survival (Fahrig and Merriam 1994, Bailey 2007), we expect that increasing the number of stepping stones between fragments will promote gene exchange. Documenting the degree of dispersal across the CTPN will require controlled genetic experiments. The relatively uniform topography and stratigraphy of the Miami Rock Ridge enables reintegration of the former biodiversity components of the pine rockland ecosystem into the urban matrix, albeit in small, numerous patches. Accomplishing this to the extent where dispersal can be effective for genetic and evolutionary sustainability of the rare plant populations growing in pine rocklands will require much more participation in the CTPN, but we are encouraged by the enthusiasm and dedication of members willing to take immediate action to prevent further loss of biodiversity.

Acknowledgements

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The Potential for Agroecosystems to Restore Ecological Corridors and Sustain Farmer Livelihoods: Evidence from Brazil

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The Atlantic Forest is a highly diverse biome, extending from the northeast to the south of Brazil. The diversity of elevation and climate of this biome allows for extraordinary biodiversity with high levels of endemism (Tabarelli et al. 2005). The original territory of the Atlantic Forest contains 65% of the Brazilian population, providing fundamental ecosystem goods and services, such as climate regulation, water supply, erosion control, and pollination (Ditt et al. 2008). An estimated 100 million people in Brazil depend on the water provided by Atlantic Forest rivers and streams. Despite its importance, the Atlantic Forest is one of the most threatened and fragmented biomes worldwide (Myers 1988, Tabarelli et al. 2005). Slightly over 11% of the original forest remains, mostly remnants (83%) smaller than 50 ha and within 100 m from forest edges, revealing high levels of fragmentation.

Reconnecting forest fragments became a national policy at the end of the 1990s through the Pilot Program for the Tropical Forest Protection (PP-G7), financed by the World Bank. This program has resulted in both the establishment of protected areas and some small functional corridors between them in high priority areas, particularly in the Amazon region. In addition to the PP-G7 program, Brazil's main Forest Act of 1965 mandates permanent preservation areas (PPA or in Brazil, APP) along rivers and streams in an effort to provide natural ecological corridors for fauna and flora outside protected areas. According to the Forest Act, hilltops, springs, and areas with slopes greater than 45 degrees must be set aside for conservation purposes. The Forest Act also requires farmers to maintain Legal Reserves (LR or in Brazil, RL) on their farms, characterized by sustainable use of natural resources, conservation and restoration of ecological processes, conservation of biodiversity, and the protection of native flora and fauna (Ditt et al. 2008). The minimum area of LR required in the Atlantic Forest is 20% of the total area of each farm.

Theoretically, the Forest Act and programs like the PP-G7 should guarantee connectivity and forest conservation within the Brazilian territory. Nevertheless, because the enforcement of the Forest Act is weak, the PP-G7 program has brought results only at a small scale, and they are predominantly restricted to the Amazon region. Approximately 16% of the required LR and 42% of PPAs show severe deforestation, representing 87 million ha to be restored in private areas (Sparovek et al. 2011).

Santa Catarina State offers an interesting case study. It holds the highest relative forest coverage (23%) among the Brazilian states, although most of them are secondary forests (Tabarelli et al. 2005), but it also experiences the most rapid deforestation (Meister & Salviati 2009). According to the Brazilian Institute of Geography and Statistics, small family farms encompass 87% of all properties and 44% of the land in the State, a much greater proportion than in other States.