Restoration Seed Reserves for Assisted Gene Flow Within Seed Orchards[1]

C.S. Echt[2] and B.S. Crane[3]

Changing climate and declining forest populations imperil the future of certain forest tree species. To complement forest management and genetic conservation plans, we propose a new paradigm for seedling seed orchards: foster genetic mixing among a variety of seed sources to increase genetic diversity and adaptive potential of seed supplies used for forest restoration. This new type of seed orchard, a restoration seed reserve (RSR) targeting imperiled species, would incorporate into seed production the seed transfer concepts of assisted gene flow and composite provenancing (Aitken and Bemmels 2016, Broadhurst et al. 2008). The RSRs can be considered a secondary restoration gene pool under the restoration gene pool concept (Jones 2003). They are a hedge against future climate uncertainty by providing seed that minimizes adaptive constraints by maximizing genotypic diversity within restored stands (Lefèvre et al. 2014). While this approach may appear risky, we view it as a responsible strategy to augment, not replace, ongoing National Forest seed programs. The goal of RSRs is to provide range-wide, restoration-ready, seed that has increased adaptive diversity beyond what is available from native local seed sources.

Operationally, RSRs differ from standard seed orchards because no attempt would be made to select for production forestry traits, surmise which adaptive traits are needed, or adhere to strict seed zones, although options remain flexible with respect to policy arising from newly drawn seed zones. At production age, a properly designed RSR would contain about 200 trees grown from seed collected from 20 or more distinct populations across the species' range. RSRs avoid inbreeding by retaining no related individuals (no clones or family structure) and containing accessions selected only for seed production traits (by rouging an initial planting of 2000 to 2400 seedlings). Such a design assures gene flow among genotypes sampled from dispersed populations. For most tree species, especially those in the southern United States, outbreeding depression from intercrossing among diverse provenances would not be an issue (Frankham et al. 2011).

While not all RSR seed is expected to be fully adapted to any particular restoration site, the idea is that, as a restoration stand becomes established, a high enough proportion of individuals will be naturally selected to survive and successfully reproduce; any maladapted offspring would be selected against or comprise a low fraction of a restored stand. RSRs obviously do not follow the "local is best" approach to genetic conservation. When a species' local seed sources are from small, isolated, or inbred populations, however, their genetic diversity may be insufficient for future restoration needs (Jones 2013). Because gene flow can promote adaption and not degrade local adaption that may exist in neighboring populations (Tigano and Friesen 2016), RSRs can redress genetically depauperate local seed sources and provide supplemental material for forest restoration of sensitive species. Further, the RSR design is economically feasible for seed collection and orchard management, and can capitalize on the range-wide collections done to date.

RSRs would be established on current National Forest System seed orchard property to produce seed in support of restoration activities. Alternatively, for arboretums, botanical gardens, and other organizations with a restricted land base, there are opportunities to meet their species conservation goals, with RSRs or other strategies, by partnering with U.S. Department of Agriculture Forest Service geneticists to share expertise and gain access to seed orchard and experimental forest resources.

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[1] A version of this paper was presented at the Gene Conservation of Tree Species – Banking on the Future Workshop, May 16-19, 2016, Chicago, IL.

[2] USDA FS, Southern Research Station, 23332 Success Road, Saucier, MS 39574.
[3] USDA FS, Southern Region, RO Forest Management, 1720 Peachtree NW, Suite 816N, Atlanta, GA 30309.
Corresponding author: cecht@fs.fed.us.

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