Ecoregions and Endemism to define Gene Conservation Guidelines for Longleaf Pine Ground-layer Restoration

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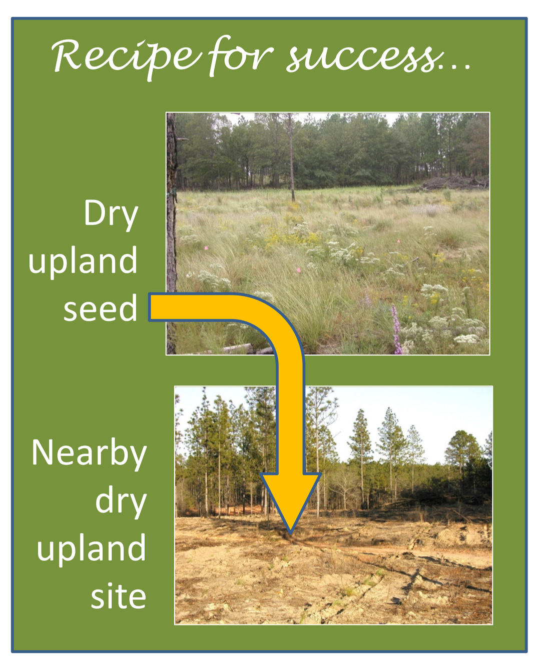
The lack of ecologically suitable plant materials for restoration represents a formidable barrier to achieving range-wide restoration goals for longleaf pine. There is a clear need for developing sources for plant materials that will survive and thrive in the restored setting. In addition to selecting the "right" species for a project, it is also important to consider the source of materials. Botanists, foresters, and geneticists recognize variations within a species. Variation can be associated with the source location and related to adaptations for success in different conditions. A key to selecting suitable plant material lies in understanding the species' genetics through common garden studies. However, managers often must collect seed or purchase whatever seed is available from commercial sources, and deploy seed of species for which there are no research based guideline.

What do you do if no seed transfer guidelines have been established by genetics research?

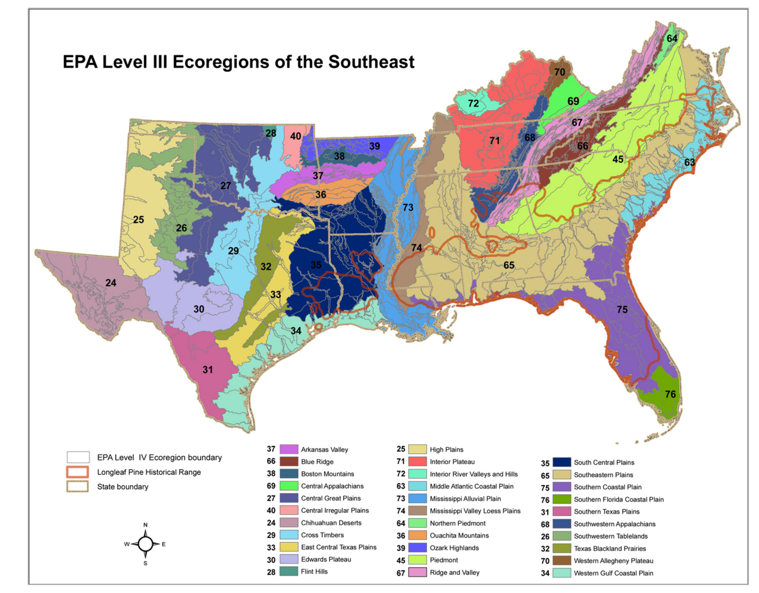
THE SAFE SOLUTION

Select seed sources from the closest possible location and collect from a site that physically matches the target site. This may minimize risks of getting individuals maladapted to the restoration site, but provides no guidance for seed sources for wider distribution.



ECOREGIONS FOR GUIDANCE

Level III ecoregions define areas with repeating patterns of vegetation and landforms. They are defined by geology, soils, physiography, and to some degree major vegetation types. Ecoregions DO NOT consider within-species genetic variability. However, some studies have shown genetic patterns correllate with ecoregions in the Pacific Northwest.



ENDEMISM IN THE SOUTHEASTERN COASTAL PLAIN

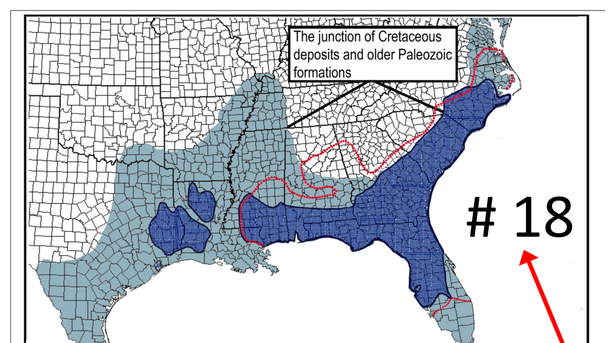


Figure 8. Phytogeographic pattern #18. Dark blue stippled area: core region of longleaf pine (*Pinus palustris*). Red dotted line: area of discontinuous or disjunct occurrences of longleaf pine. After Ware, Frost, and Doerr (1993). Light blue: Atlantic Coastal Plain, Gulf Coastal Plain, including the entire Mississippi Embayment. Adapted from Sorrie & Weakley (2001).

About 27% of the about 6100 taxa native to the Coastal Plain, are endemic to the region. Sorrie and Weakley (2001, 2006) examined distributions of >1000 coastal plain endemic species [> 90% of known locations in the coastal plain] and described common distribution patterns (with ≥ 8 taxa) as centers of endemism.

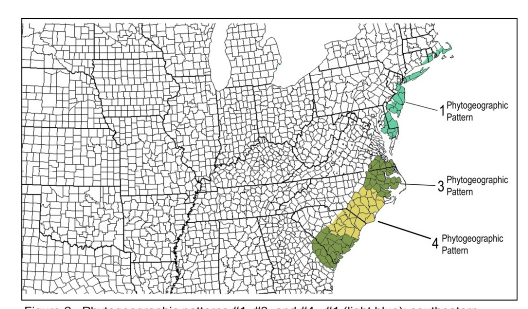


Figure 2. Phytogeographic patterns #1, #3, and #4. #1 (light blue): southeatern Massachuestts to southern New Jersey and adjacent Delmarva Peninsula. #3 (green): southeastern Virginia to southeastern Georgia. #4 (tan): southeastern North Carolina to northeastern South Carolina. Adapted from Sorrie & Weakley (2001).

Pattern #18 nearly coincides with the range of longleaf pine in the coastal plains. It includes at least 440 taxa (not counting regional subsets), 15 endemic genera. Within this core area, subsets were recognized (see Figures 2-5; not shown is a West Gulf Coast center). Although some of the endemics are considered rare, many are distributed broadly within pattern #18.

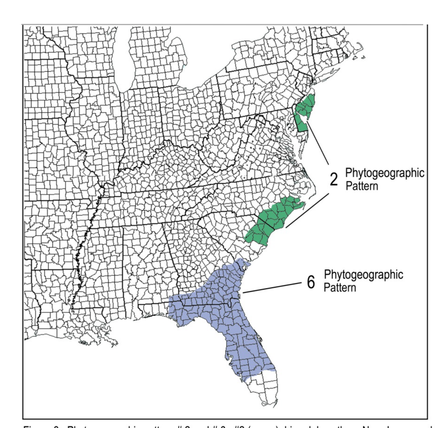


Figure 3. Phytogeographic pattern # 2 and # 6. #2 (green): bimodal southern New Jersey and Delaware/eastern North and South Carolina. #6 (blue): southern South Carolina to peninsular Florida westard to the central panhandle of Florida and southeastern Alabama. Adapted from Sorrie & Weakley (2001).

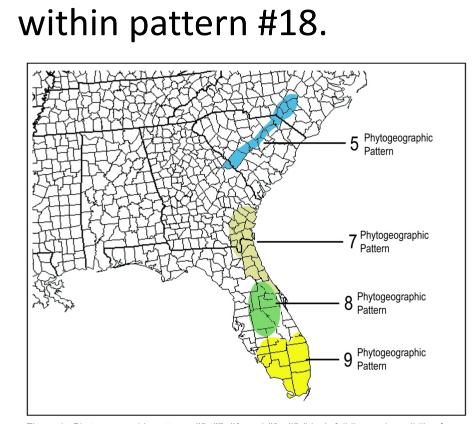


Figure 4. Phytogeographic patterns #5, #7, #8, and #9. #5 (blue): fall-line and sandhills of the Carolinas and east-central Georgia. #7 (tan): southeastern Georgia to northeastern Georgia to northeastern Florida. #8 (green): Lake Wales Ridge. #9 (yellow): subtropical Florida. Adapted from Sorrie & Weakley (2001).

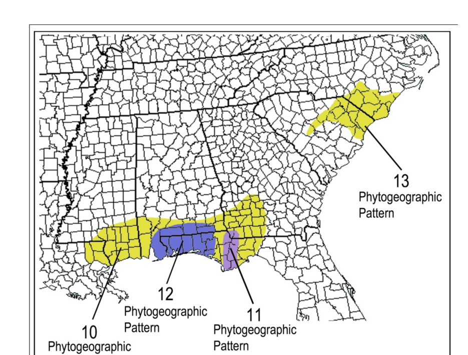
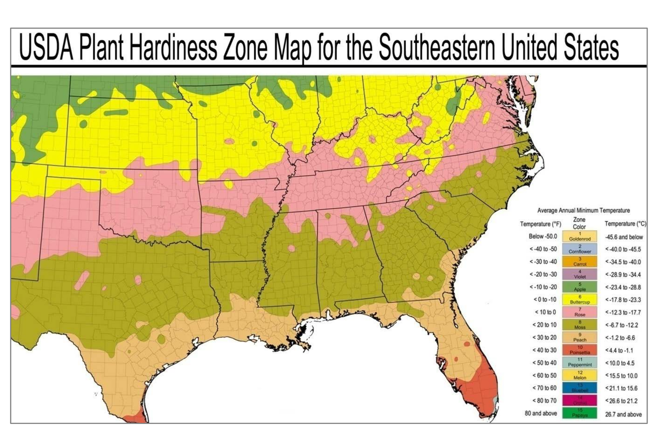


Figure 5. Phytogeographic patterns #10, #11, #12, and #13. #10 (yellow): East Gulf Coastal Plain. #11(violet): central panhandle of Florida. #12 (blue): western panhandle of Florida. #13 (yellow): wide spread on East Gulf Coastal Plain disjunct to the Carolinas. Adapted from Sorrie & Weakley (2001).

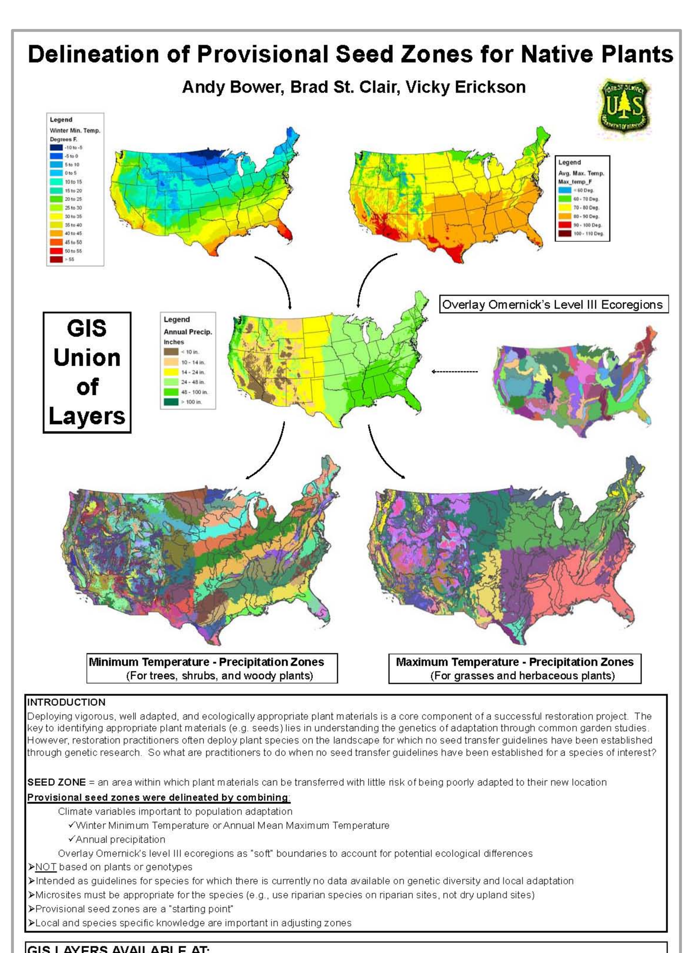
CLIMATE BASED MODELS



Plant distributions are generally limited by climate, so it is not surprising that seed transfer guidelines based on climate patterns have proved useful, especially for trees. Gardeners recognize the USDA Plant Hardiness Zones, which are based on this principle. Seed transfer recommendations for loblollly pine have been based on a climate model (Schmidtling 2003) and are available for all southern pines.

ANOTHER CLIMATE-BASED MODEL

Bower, St. Clair, and Erickson used **climate data coupled with EPA Level III ecoregions** to develop 2 models for native plants. The model for trees, shrubs, and woody vegetation was based on minimum winter temperature and annual precipitation. The herbaceous species model was based on average maximum temperature and annual precipitation, climatic factors that affect herbaceous species viability. They suggested that Level III ecoregions could be used to guide transfer decisions within climate defined zones. Note the large zone for southeastern grasses and forbs.



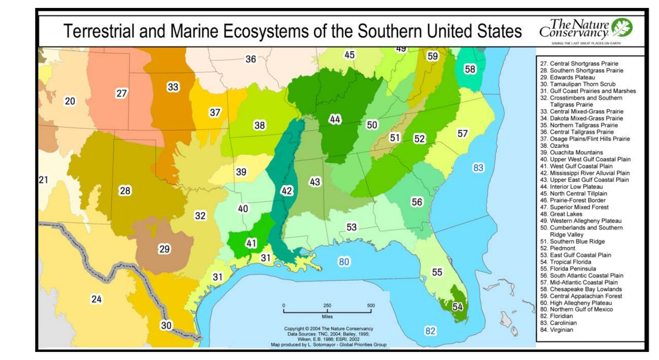
ENDEMISM--INDICATOR OF GENETIC STRUCTURE?

Endemic taxa arise through speciation via the development of altered gene combinations leading to isolation and further genetic change. Speciation may be associated with adaptations to local conditions, result from long-distance dispersal events, follow from isolation during periods of major climate changes. Processes resulting in speciation, may also lead to intraspecific genetic shifts that are not sufficient for reproductive isolation, but nevertheless lead to differentiation among populations. Genetic structure within a widespread species may lead to differences in traits associated with successful establishment and growth when introduced into a restoration setting. Intraspecific variation may be continuous & gradual (clinal) or local & abrupt, associated with habitat variability (ecotypic variation). Both kinds of variation may affect planting success.

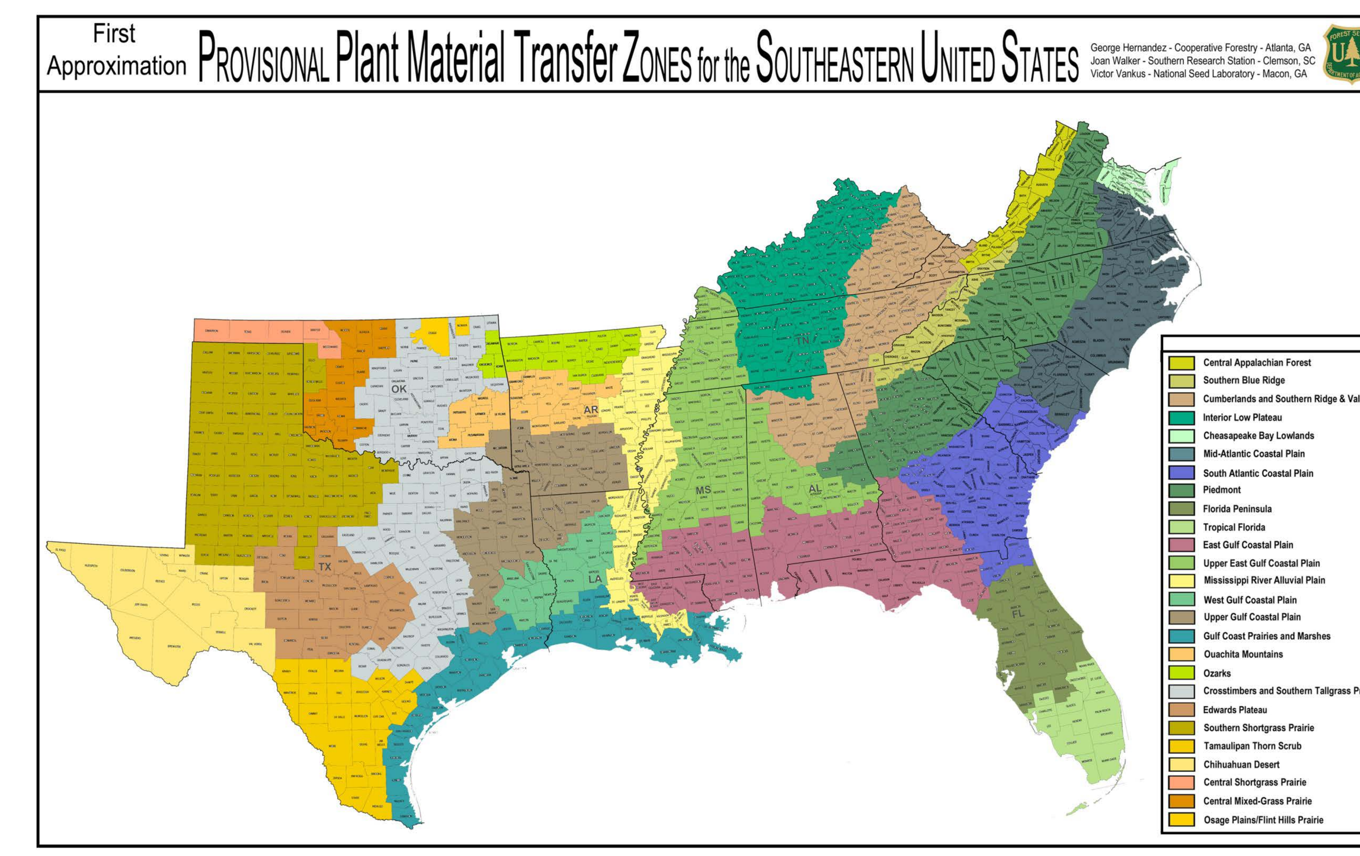
Hypothesis: Centers of endemism are indicators for potentially significant genetic structure within widespread species

Proposal: Incorporate the distribution of endemics in the delineation of provisional plant material transfer zones. This approach may conserve genetic diversity within widespread species, and help ensure the establishment of new populations.

FIRST APPROXIMATION



We examined available ecoregion models, USFS, EPA, NRCS, and The Nature Conservancy models. The TNC model was designed to (1) reflect the distribution of conservation targets at large scales and (2) to be implementable for conservation planning. TNC developers modified EPA Level III Ecoregions and to meet thei rdual objectives. Modifications accommodated recognized pyhtogeographic patterns , e.g. in the decision to split South Carolina. The TNC foci of **conservation and implementation** paralleled the needs for delimiting plant material transfer guidelines, specifically zones within which plant materials (seed or others) might be conservatively moved. We modified the TNC ecoregion model to follow county lines, in order to support implementation of county administered land owner support programs.



PROVISIONAL ZONES WITH CAVEATS

- **They are not species specific.** Individual species must be evaluated to determine suitability.
- **They are large**, and therefore are applicable for species that are naturally distributed across several zones.
- **The zones are ecologically heterogeneous**, with a range of habit conditions embedded. Within a zone, plant materials should be placed in habitat conditions that match their origins. For example, sites from well-drained sands will be most suitable for well-drained sandy sites within the same zone.
- **The zones are provisional.** Zones are expected to change with research. And as noted, transfer rules for individual species are likely to be developed for important restoration species.