American chestnut in flower, Pilot Mountain State Park, N.C.

Tools for Factoring Climate Change into American Chestnut Restoration Efforts

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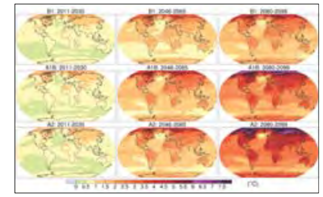


International Panel on Climate Change (IPCC) Fourth Assessment Report (2007)

Introduction

The American Chestnut Foundation's breeding program will allow for the widespread reintroduction of blight-resistant American chestnut trees. While the program will breed regionally adapted genotypes, long-term adaptability will present an important challenge to reintroduction.

Specifically, changing climate conditions will complicate efforts to match resistant chestnuts with appropriate locations **(Inset 1)**, because chestnuts containing genes from a given location may not be best adapted to altered local environmental conditions. We provide two mapping tools to assist American chestnut restoration efforts in light of climate change.

Tool 1: Forecasts of Climate-Associated Shifts in Tree Species (ForeCASTS)

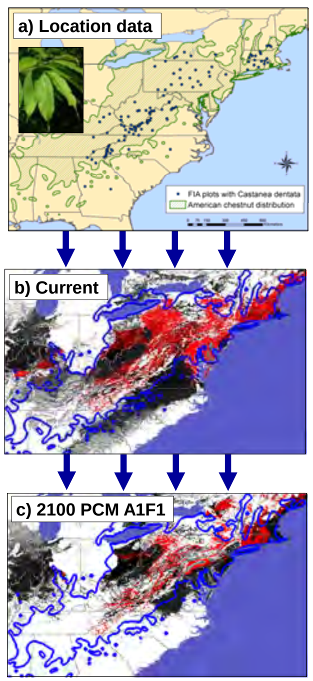


Figure 2: Results for American chestnut: a) FIA data, b) current habitat prediction, c) 2100 PCM A1F1 high emissions prediction

❖ **Product 1:** Maps that forecast location and quality of habitat under multiple global circulation models/emission scenario combinations

❖ *Method:* Multivariate Spatio-Temporal Clustering (MTC) (Hargrove and Hoffman 2005)

- Classifies 4-km² pixels into 30,000 unique "ecoregions" using 16 environmental variables
- Variables include soils, temperature, precipitation, topography, growing season
- Species occurrence data: 121 Forest Inventory and Analysis (FIA) plots **(Figure 1a)**
- Creates map of current potentially suitable habitat based on existing occurrence data **(Figure 1b)**
- Tracks current habitat into future in 2050 and 2100 under Hadley and PCM models, high (A1F1) and low (B1) emissions scenarios **(Figure 1c)**
- Maps available online at *www.geobabble.org/~hnw/global/treeranges3/climate_change*

Inset 1: American chestnut restoration and climate change

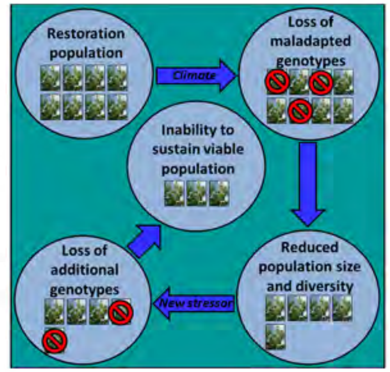
❖ Restoration efforts should account for climate change

- Portions of historic range may become unsuitable in the future
- Other locations may not be most suitable for local genotypes

❖ Maladapted genotypes may be more susceptible to stressors such as drought and pests

- Loss of any genotypes reduces already low genetic variation and small population size, lowering the likelihood of sustaining a viable population (Inset Figure 1)

❖ Without extensive provenance tests, indirect approaches using environmental variables may be best for matching plants with appropriate locations



Inset Figure 1: Loss of genotypes reduces genetic variation, decreasing the likelihood that a restored population will persist.

❖ Possible bet-hedging strategy: Use local sources and sources from locations with current conditions similar to those expected at the restoration site

❖ **Product 2:** Maps of change in areas of suitability **(Figure 2)**

- Define currently acceptable locations expected to remain suitable or to become unsuitable in 2050 based on Hadley B1, as well as potentially newly suitable areas **(Figure 2c)**
- Measure distance between current and nearest 2050 expected suitable habitat, identifying areas that may be at greatest vulnerability **(Figure 2d)**

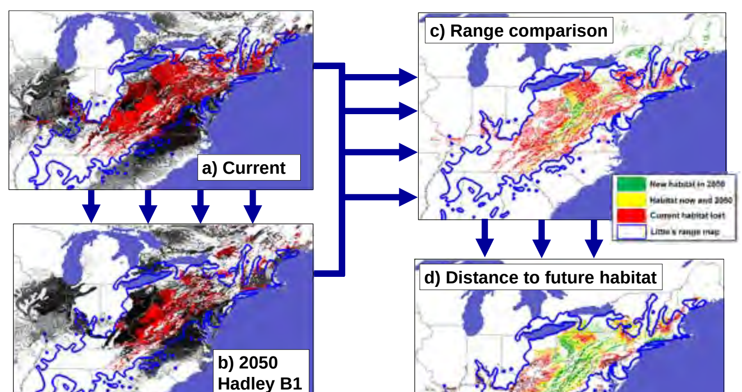


Figure 2: American chestnut a) current habitat and b) Hadley B1 2050 habitat prediction results are used to determine c) range comparison over time and d) distance to future habitat

Tool 2: Quantitative Seed-Transfer Zones

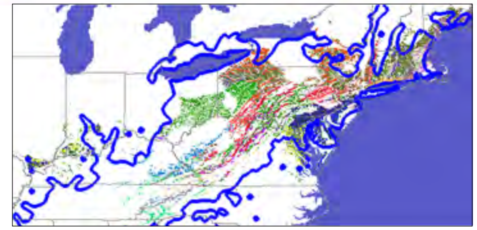


Figure 3: Quantitatively defined seed-transfer zones for American chestnut (current); each color denotes a different zone.

❖ Quantitatively defined seed-transfer zones could assist selection of suitable restoration sites and chestnut sources

❖ MSTC approach delineates "ecoregions" with approximately equal environmental variance **(Figure 3)**, which can serve as seed transfer zones (Potter and Hargrove 2012)

- Uses 16 environmental variables and 121 FIA plot locations
- Tracks zone shifts in response to climate change

❖ **Product 3:** Seed zones projected forward in time **(Figure 4)**:

"Where should I plant trees from a given location to best ensure they will be well-adapted in the future?"

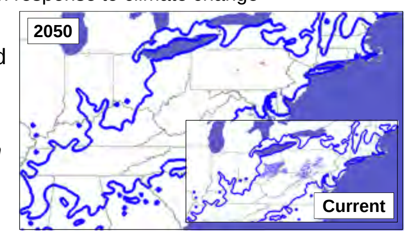


Figure 4: Current zone (inset) projected forward to 2050 under Hadley B1

❖ **Product 4:** Seed zones projected backward in time **(Figure 5)**:

"If I want to plant trees in a given location and best ensure they will be well-adapted in the future, where do I collect them today?"

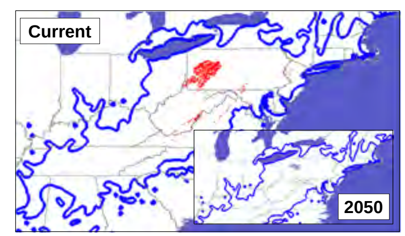


Figure 5: Hadley 2050 (B1) zone (inset) projected backward to current conditions

Citations

Hargrove, W.W.; Hoffman, F.M. 2005. Potential of multivariate quantitative methods for delineation and visualization of ecoregions. *Environmental Management.* 34((Suppl. 1)):S39-S60.

Potter, K.M.; Hargrove, W.W. 2012. Determining suitable locations for seed transfer under climate change: A global quantitative method *New Forests*. 43(5-6):581-599.

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