Project Title

Modeling the historic range and habitat of American chestnut in Georgia circa 1804-1832; a guide for restoration efforts.

Summary

The return of American chestnut to its native range is the mission of TACF but without a better understanding of the historic range and habitat requirements of American chestnut, restoration efforts are likely to experience failures. We digitized and georeferenced historic Georgia Land Lottery maps from the early 1800's and used them to precisely locate 16,000+ historic American chestnut trees. Using these locations, we will develop chestnut habitat suitability models that identify important abiotic factors relevant to historic chestnut distribution, and create a map predicting current suitable habitat that can be used to guide restoration efforts.

Principal Investigators

Joyce Klaus, Ph.D., Conservation Biologist, Terra-Ignea Enterprises, Culloden, GA

Nathan Klaus, Senior Wildlife Biologist, Wildlife Conservation Section, Georgia Department of Natural Resources, Forsyth Georgia

Duration of project

9 months

Total anticipated cost

$4700

Previous project match-

Match	Type	Amount	Source	Comment
GA DNR	Cash	$4700	GA DNR	Contract to digitize/georeferenced land lot maps
N. Klaus	In kind	$3,600	GA DNR	Data collection from digitized maps
USFS	In kind		USFS	Locating and appending GIS layers to our dataset
J. Klaus	In kind	$1,600	Terra-Ignea Enterprises	Data cleanup and initial analysis

Short and long-term goals

This project should yield one significant peer-reviewed article (target journals include Castanea, Ecological Restoration, Forest Ecology and Management or Journal of Biogeography), as well as a dataset and habitat models that will be published on the Georgia GIS clearinghouse (https://www.georgiaspatial.org/) and would be available free of charge to other researchers, agencies, and land managers.

Long-term, these models would be used by those planning to restore American chestnut. This would yield many benefits including helping secure funding for reintroduction of American chestnut, inclusion of reintroduction into planning documents such as the 10-year management plan for the Chattahoochee-Oconee National Forest and Georgia State Wildlife Action plan, assurance that American chestnut was restored to a greater span of appropriate ecosystems, greater credibility of these efforts, and fewer planting failures. Our data should help predict the success of chestnut restoration projects throughout the state and the Southeast, making restoration more likely to succeed and improving the efficiency of restoration efforts.

Narrative

The Georgia Land Lotteries were a series of state-sponsored surveys conducted between 1804 and 1832. These surveys were primarily used to facilitate the transfer of Native American lands to private ownership after the removal of Native Americans. Most surveys delineated 202.5 acre lots and identified 12 corner trees to species (witness trees) for each lot. Though unintentional, surveyors effectively designed a systematic survey of Georgia's historic forests, documenting the location and species of about 650,000 trees prior to most European settlement, and creating a snapshot of forest composition prior to logging and introduced pests and diseases.

In 2005 the value of these maps for ecological studies was recognized by the Georgia Department of Natural Resources (GADNR). Working with the Georgia State Archives we funded the digitizing and georeferencing of all 421 known maps, covering approximately two-thirds of Georgia. Since that time we manually searched each of the 421 digitized maps to find and record the latitude and longitude of all 16,162 chestnuts noted in the land lottery surveys (Fig. 1). Today we can identify the location of each historic tree to within approximately 15 meters on the ground.

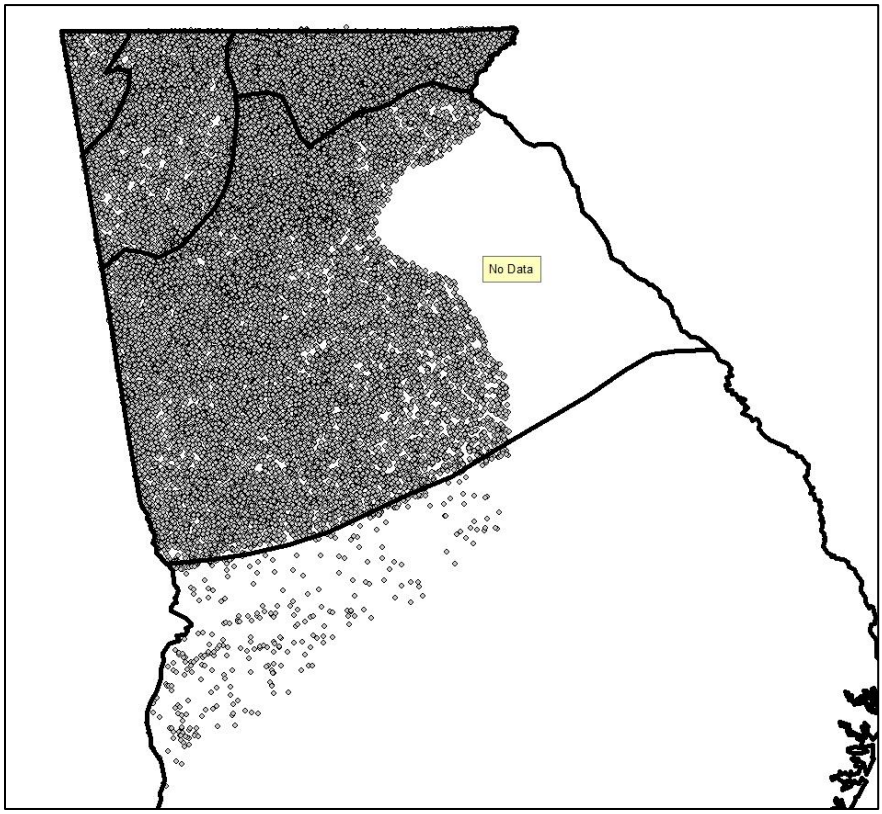

Figure 1. Locations of American chestnut trees in Georgia circa 1804-1832 as noted by state surveyors. Land lottery surveys covered approximately 2/3 of the state, excepting areas already settled along the coast and along the Savanna River. Black lines represent physiographic provinces. Note the heavy density of American chestnuts documented in the Piedmont as well as numerous trees found in the upper Coastal Plain; both constitute a departure from commonly accepted range maps used today.

Using the location dataset just described, we conducted a GIS 'neighborhood analysis' (ArcView 3.2 – Spatial Analyst Extension) to map the relative density of American chestnut (Fig. 2). This work has revealed many interesting facets of the habitat and range of American chestnut. Particularly interesting is the very high density of this species found in the upper Piedmont physiographic province, higher than what was found across much of Appalachia. This is a departure

from the current understanding of this species, which is often viewed as an Appalachian species in Georgia. We have also documented American chestnut in forest communities that are not known to include this species, such as many ecosystems restricted to the upper Fall Line. Notice also the relationship of American chestnut with landform or some correlate (i.e. the distribution of this species in the Ridge and Valley physiographic province of extreme northwest Georgia). Abiotic factors such as elevation, soils, and landform played a significant role in the distribution of this species in its historic range (e.g. Fei et al 2007). These habitat qualities will likely continue to play a role in the success or failure of restoration efforts as restorationists begin outplanting blight-resistant trees.

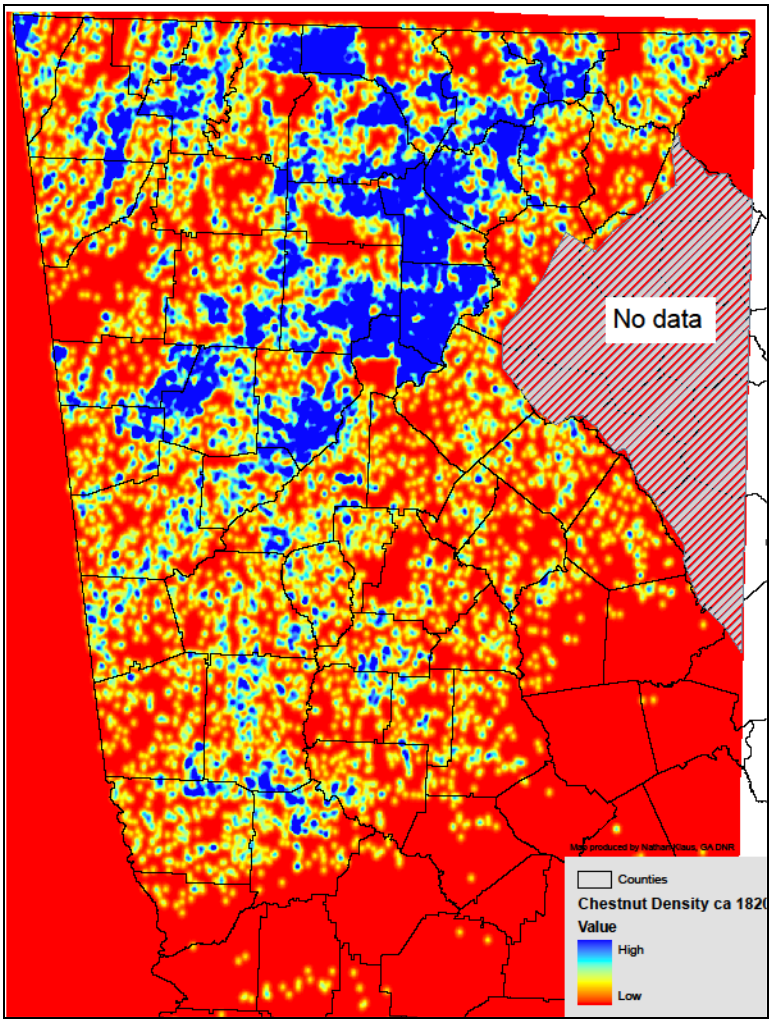

Figure 2. Density of American chestnut according to state land lottery surveys, circa 1804-1832. Note the significant differentiation of density throughout its Georgia range. While a few of these distinctions are an artifact of the surveyor most appear to be related to landform, soil type or other site attributes. With further analysis these relationships could be discovered and used to guide restoration efforts of American chestnut in Georgia.

Maps of historic locations can only tell us where chestnut *actually* occurred *and* was documented. Historic maps cannot tell us where chestnut potentially occurred (i.e. occurred but was not documented or could have occurred but did not

due to random factors) or the full span of where future outplantings are likely to be successful. Such information can be generated with predictive geospatial models based on a variety of biotic and abiotic factors (e.g. Fei et al. 2012). To do this, we would need to examine environmental factors of historic chestnut locations and a number of random locations to determine which factors most likely influenced historic chestnut distribution. We would then map those factors across the state to determine the full range of chestnut habitat suitability.

To this end, we surveyed relevant literature, both modern and historic (e.g. Society of American Foresters 1926, Woods and Shanks 1959, Good 1968, Stephenson 1974, Karban 1978, Johnson et al. 1982, McEwan et al. 2005, Fei et al. 2007, Rhoades et al. 2009, Fei et al 2012) and queried experts at meetings of the Georgia Chapter of the American Chestnut Foundation to identify significant abiotic variables which might influence American chestnut distribution. After careful selection of variables (e.g. elevation, soil properties, physiographic province, etc.), we generated a geospatial database of those variables for each chestnut location and for an equal number of random locations throughout the state. We propose to use that database to create a chestnut habitat suitability model (Philips et al. 2018) and map the distribution of suitable American chestnut habitat in Georgia that will predict where chestnut potentially occurred and is most likely to be successful in future outplantings.

To disseminate the results of our analysis, we plan to publish in a peer-reviewed scientific journal (e.g. Castanea, Ecological Restoration, Forest Ecology and Management or Southeastern Naturalist). We will make data and models available to the public via Georgia GIS Clearinghouse. We would also like to make our results available through The American Chestnut Foundation website.

Citations:

Fei, S., J. Schibig and M. Vance. 2007. Spatial habitat modeling of American chestnut at Mammoth Cave National Park. Forest Ecology and Management. 252:201-207.

Fei, S., L. Liang, F.L. Paillet, K.C. Steiner, J. Fang, Z. Shen, Z. Wang and F.V. Hebard. 2012. Modeling chestnut biogeography for American chestnut restoration. Diversity and Distributions. 18:754-768.Georgia Land Lottery Maps,

Georgia Archives, 5800 Jonesboro Road, Morrow, GA 30260 U.S.A.

Good, N.F. 1968. A study of natural replacement of chestnut in six stands in the highlands of New Jersey. Bulletin of the Torrey Botanical Club. 95:240-253.

Johnson, G.G., S. Ware and G.C. Johnson. 1982. Post-chestnut forests in the central Blue Ridge of Virginia. Castanea. 47:329-343.

Karban, R. 1978. Changes in an oak-chestnut forest since the chestnut blight. Castanea. 43:221-228.

McEwan, R.W., C. Rhoades and S Beiting. 2005 American chestnut (*Castanea dentata*) in the pre-settlement vegetation of Mammoth Cave National Park, central Kentucky, USA. Natural Areas Journal. 25:275-281.

Philips, S.J., M. Dudik and R.E. Schapire. [Internet] Maxent software for modeling species niches and distributions (Version 3.4.1). Available from url: http://biodiversityinformatics.amnh.org/open_source/maxent/. Accessed on 2018-8-13.

Rhoades, C., D. Loftis, J. Lewis and S. Clark. 2009. The influence of silvicultural treatments and site conditions on American chestnut (*Castenea dentata*) seedling establishment in eastern Kentucky, USA. Forest Ecology and Management. 258:1211-1218.

Stephenson, S.L. 1974. Ecological composition of some former oak-chestnut communities in western Virginia. Castanea. 39:278-286.

Society of American Foresters, Committee of the Southern Appalachian Section. 1926. A forest type classification for the southern Appalachian Mountains and the adjacent Plateau and Coastal Plain regions. Journal of Forestry. 24:673-684.

Woods, F.W. and R.E. Shanks. 1959. Natural replacement of chestnut by other species in the Great Smoky Mountains National Park. Ecology. 40:349-361.

Timeline

2005 -- Digitize and georeferenced land lottery maps

2007-2015 -- Identify all American chestnut locations on land lottery maps and create a GIS layer of this information

2016 -- Query literature and local expertise on likely variables that influenced historic American chestnut distribution

2016-2017 -- Assemble GIS datasets of predictive variables, create dataset upon which to base models, several rounds of quality control/data cleanup

November 2021-July 2022 -- Data analysis, modeling, mapping

August 2022 -- Draft and submit publication, tentative publication by end of 2022. Dataset and models will be made available via GIS clearinghouse after publication.

Results and reporting

Several benchmarks will be reached throughout this project; these can be reported as they are reached: (1) completion of analysis, (2) submission of a draft manuscript for publication, (3) acceptance and publication of the manuscript, and (4) online publication of dataset and models in Georgia GIS Clearinghouse.

Breakdown of how and when funds will be spent

Expense	Amount	Timeline
Data analysis & publication including required software such as Microsoft Excel and ArcGIS	$4700	November 2021-August 2021

A Conflict of Interest or Commitment (COI or COC) statement. If a COI or COC is known, please document them here. If there is no known COI or COC, please certify as such with a statement in this section:

There is no known COI or COC for either investigator.

CURRICULUM VITAE

Joyce Marie Klaus, Ph.D.
Conservation Biologist

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Education

Ph.D. Conservation Biology, GPA 4.0 **2013**
University of Central Florida, Orlando, Florida
Research interests included amphibian ecology, the role of fire in wetland community dynamics, and restoration ecology especially in fire-maintained ecosystems

B.A. Biology (Environmental Studies minor), GPA 3.6 **2003**
College of Charleston, Charleston, South Carolina
Interests included vertebrate biology, botany, ecology, and sustainability

Publications

Klaus, J. M. and R. F. Noss. 2016. Specialist and generalist amphibians respond to wetland restoration treatments. The Journal of Wildlife Management 80:1106-1119.

Klaus, N. A., A. Isler, and J. M. Klaus. 2015. Is your site prep helping or hurting your longleaf restoration? The Longleaf Leader, Spring 2015.

Klaus, N. A., and J. M. Klaus. 2011. Evaluating tolerance of herbicide and transplantation by cane (a native bamboo) for canebrake restoration. Restoration Ecology 19:344-350.

Awards

Gordon State College Faculty Development Grant, Spring 2018
TERN Grant 2017-2018 (In conjunction with GA DNR Nongame Conservation Section)
Gordon State College Faculty Development Grant, Spring 2016
Recognition for service to the Gordon State College African American Male Initiative 2014-2015
EPA STAR Fellowship 2005
USDA FS Herp Conservation Challenge Grant 2004

Related Work Experience

Conservation Scientist **2018-present Terra-Ignea Enterprises, LLC**
Owner/scientist of consulting business specializing in applied ecological and conservation services including botanical and wildlife surveys, prescribed fire, ecological and fire effects monitoring, baseline surveys, land management and restoration plans, data analysis, GIS, and writing for grants, reports and publications.

Assistant Professor **2015-2018** **Gordon State College**
Tenure-track biology professor teaching Introductory Biology I & II, Principles of Biology I & II, Plant Biology, Ecology, Special Research Topics, and Undergraduate Research Biology

Assistant Professor **2014-2015** **Gordon State College**
Non-tenure track biology professor teaching Introductory Biology I & II and Principles of Biology I & II.

Technician – Biologist **2013-2015** **Georgia DNR Nongame Conservation Section**
Habitat mapping, surveying, and population estimation of gopher tortoises on state-owned lands.

Contractor – Herpetologist **2010** **USDA Forest Service**
Surveyed for *Ambystoma cingulatum* on Francis Marion National Forest.

Technical Specialist – Biologist **2010** **US Fish and Wildlife Service**
Worked on Deepwater Horizon incident surveying for and transporting sick, oiled and injured wildlife.

Prescribed Fire Technician **2008-present** **US Fish and Wildlife Service**
NWCG certified Fire Fighter Type 2 assisting with all aspects of prescribed fire on Piedmont NWR.

Presentations

Edwards, S. and J. M. Klaus. 2018. Exploring seed scarification techniques for pineywoods legumes. Poster presentation for Gordon State College Undergraduate Research Symposium, Barnesville, GA.

Rogers, P. and J. M. Klaus. 2018. Saving square-heads. Poster presentation for Gordon State College Undergraduate Research Symposium, Barnesville, GA.

Klaus, J. M. 2017. Pine Mountain and western Sandhills native plant propagation. Oral presentation for Georgia Plant Conservation Alliance.

Dean, A. W., J. M. Klaus, M. J. Gray, D. L. Miller, and A. L. J. Duffus. 2015. Distributions of known *Ranavirus* infections in southeastern amphibians and reptiles. Poster presentation for Southeastern Partners in Amphibian and Reptile Conservation Annual Meeting, Covington. LA.

Gladden, B., M. J. Bender, and J. M. Klaus. 2015. Influence of mycorrhizal fungi on cowpea growth. Poster presentation for Georgia Academy of Science Annual Meeting, Georgia College and State University, Milledgeville, GA.

Klaus, J. M. 2014. Amphibian responses vary in response to fire and a fire surrogate. Poster presentation for Southeastern Partners on Amphibian and Reptile Conservation Annual Meeting, Lake Cumberland State Park, Jamestown, KY.

Klaus, J. M. 2013. Effects of fire and a fire surrogate on wetland vegetation and larval treefrog survival. Oral presentation for Southeastern Partners on Amphibian and Reptile Conservation Annual Meeting, Hickory Knob State Park, McCormick, SC.

Klaus, J. M. 2010. Of frogs and fire. Oral presentation for Land Grant/Sea Grant National Water Conference, Hilton Head, SC.

Klaus, J. M. 2008. Prescribed fire as a tool for amphibian habitat restoration. Oral presentation for Southeastern Partners on Amphibian and Reptile Conservation Annual Meeting, University of Georgia, Athens, GA.

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RECENT WORK EXPERIENCE

Senior Wildlife Biologist
Georgia DNR, Nongame Endangered Wildlife Program
Forsyth, GA
May1999- Present

- Administer and coordinate numerous grants from State Wildlife Grants, National Fish and Wildlife Foundation Grants, Knobloch Family Foundation and others for the restoration of longleaf/wiregrass, longleaf/bluestem, open oak woodland and other endangered ecosystems on state lands.
- Supervise a workgroup conducting restoration using ecological forestry, herbicides, planting, fire and other treatments on state and private lands.
- Supervise approximately 15,000 acres of prescribed fires annually on state, private and federal lands for ecosystem restoration and management of endangered species and rare communities.
- Supervise 4-6 permanent positions, also a six-person seasonal fire crew
- Research habitat management and restoration of grassland and longleaf pine systems, also birds of high conservation priority including Swainson's Warbler, Cerulean Warbler, Southeastern American Kestrel, Golden-winged Warbler, Appalachian Yellow-bellied Sapsucker**.**

RECENT GRANTS RECEIVED

- June, 2021 National Fish and Wildlife Foundation – Longleaf Landscape Stewardship Fund
- January, 2021 The Environmental Resources Network (small grants)
- October, 2020 State Wildlife Grant-Habitat Restoration on State Lands
- November, 2020 Knobloch Family Foundation
- June, 2020 National Fish and Wildlife Foundation – Longleaf Landscape Stewardship Fund

EDUCATION

- Master of Science, Forestry, Wildlife, and Fisheries; University of Tennessee, minor in statistics
- Bachelor of Science in Biology; University of Iowa

SELECT PUBLICATIONS

- Klaus, N. A., S. Rush, S. Weitzel, M. Holdrege. 2020. Changes in tree canopy, groundcover, and avian community following restoration of a montane longleaf pine woodland. Amer. Midl. Nat. 184:163-176.

- Klaus, N. A. 2019. Fire history of a Georgia Montane Longleaf Pine (*Pinus palustris*) Community. Georgia Journal of Science, vol 77, No 2, Article 5.

- Rush, S., N. Klaus, T. Keyes, J. Petrick and R. Cooper. 2012. Fire severity has mixed benefits to breeding bird species in the southern Appalachians. Forest Ecology and Management, 263:94-100.

- Klaus, N. A., and J. M. Klaus. 2009. Evaluating tolerance of herbicide and transplantation by cane (a native bamboo) for canebrake restoration. Restoration Ecology, 19(3): 344-350.

- Schneider, T., G. Beaton, T. Keyes, and N. Klaus eds. 2009. The breeding bird atlas (Georgia), 520 pp. University of Georgia Press, Athens, GA.

- Klaus, N. A. and T. Keyes. 2007. Effect of two native invasive tree species on upland pine breeding bird communities in Georgia. Wilson Bulletin 119(4)737-741.

- Klaus, N. A., D. A. Buehler, and A. M. Saxton. 2005. Forest management alternatives and songbird breeding habitat on the Cherokee National Forest, Tennessee. Journal of Wildlife Management 69:222-234.

- Klaus, N. A. 2004. Status of the golden-winged warbler in North Georgia with a nesting record of the Lawrence's warbler. Oriole 69(1):1-7.

- Klaus, N. A. 2004. Appalachian yellow-bellied sapsucker sightings on the Tellico District, Cherokee National Forest, with a 1995 nesting record. Migrant. 75(1)1-5.

- Linder, E. T., N. A. Klaus, and D. A. Buehler. 2003. Population viability as a measure of forest sustainability. In Southern Forest Science. Past, present, and future. M. Rauscher, ed.

- Klaus, N. A. and D. A. Buehler. 2001. Golden-winged warbler breeding habitat characteristics and nest success in clearcuts in the Southern Appalachian mountains. Wilson Bulletin 113(3) 297-301

- Dettmers, R., D. A. Buehler, N. Klaus, J. G. Bartlett. 2000. Influence of point-count length on bird-habitat models. J. Wildl. Manage 63(3)815-823

PROFESSION AFFILIATIONS

- The Wildlife Society (past officer), American Chestnut Foundation (GA chapter board member), Society of American Foresters, American Ornithologists Union, Ocmulgee Audubon Society, Cooper Ornithological Society, Wilson Ornithological Society, Partners in Flight (treasurer), Georgia Ornithological Society