Program & Abstracts
22nd Biennial Southern Silvicultural Research Conference

Nacogdoches, TX
March 21 — 23, 2023

Conference Chairs

Brian Oswald & Don Bragg

Hosted by

Stephen F. Austin State University

Supported by

USDA Forest Service, Southern Research Station

Preface

The 22nd Biennial Southern Silvicultural Research Conference (BSSRC) is being held March 21—23, 2023 at the Fredonia Hotel in Nacogdoches, TX. This conference is the latest in a series of meetings designed to provide a forum for the exchange of research information among silviculturist, researchers, and managers. Presentations will emphasize research in artificial and natural hardwood regeneration, fire, intermediate management and stand development, forest measurements and modeling, longleaf pine, shortleaf pine, and vegetation management. In addition to an opening morning plenary session, six sessions including 68 oral and 46 poster presentations will be offered on March 21 and 22 (see pages 13-57. An online General Technical Report (e-GTR-SRS) will be compiled by the Chairs for publication by the Southern Research Station to document the proceedings.

Unlike recent BSSRCs, only one field tour will be offered on Thursday, March 23. This tour will visit several sites in eastern Texas to look at management on the Boggy Slough Conservation Area, research at a carbon afforestation project of SFA's Arthur Temple College of Forestry and Agriculture, and the I.E. Fairchild State Forest.

In addition to the regular program, a couple "bonus" items will also be available. A fertilizer application in forestry panel hosted by Dr. Cristian Montes (UGA) will held on Wednesday from 4:30-6:30 p.m. and an optional ethics training session (to help with those needing SAF certification) will be offered by Dr. Brian Lockhart on Wednesday from 5:30-6:30 p.m.; both of these are free and open to all interested registrants.

As part of the registration, attendees will be provided a continental breakfast, breaks, and some refreshments for the evening social on March 21 and 22 in Ballroom B. Because we will be near the restaurants of downtown Nacogdoches (including the one at the Fredonia), a longer block of time will be provided to attendees and lunch will be on your own both days. During the poster session on Tuesday evening in the Ballroom, a reception with a buffet and drinks provided will be held from 6:00 to 8:00 p.m. A social at the nearby Fredonia Brewery (walking distance from the hotel) will be held from 7:00 to 10:00 p.m. on Wednesday evening. Thursday field tour attendees will be offered breakfast and lunch, and transportation to the field sites will be provided.

Finally, we are grateful to the staff of the Arthur Temple College of Forestry and Agriculture, SFASU for their diligence in handling the fiscal responsibilities of the meeting and for helping with the registration process. We would like to recognize the following for their support: In addition, we would like to recognize the 22nd BSSRC's steering committee for devoting numerous hours to reviewing abstracts, establishing the program for oral and poster, developing field tours and presentations, and making all the other necessary arrangements to ensure a successful conference. Steering committee members include:

Universities

Brian Oswald (co-Chair & Registration & Reception & Moderators & Proceedings), SFASU, Nacogdoches, TX

Gordon Holley and Jon Gauntt (Web Site & Registration), Louisiana Tech University, Ruston, LA

Jeremy Stovall and Rebecca Kidd (Field Tours), SFASU, Nacogdoches, TX

Kyle Cunningham (Continuing Education Credits), University of Arkansas, Little Rock, AR

Eric Taylor (Technology Coordinator), Texas A&M Forest Service, College Station, TX

USDA Forest Service

Don Bragg (co-Chair & Print Materials & Proceedings), SRS, Monticello, AR

Nancy Koerth (Proceedings), SRS, Nacogdoches, TX

Callie Schweitzer (Student Scholarship/Student Helpers), SRS, Huntsville, AL

Industry and Associations

Conner Fristoe, Weyerhaeuser, Columbus, MS

Mickey Rachel, Roy O Martin Lumber Company, Alexandria, LA

Brian Lockhart (Student Paper/Poster Contests), Consulting Silviculturist, Gentry, AR

Respectfully, Brian Oswald, Professor, SFASU and Don Bragg, Project Leader, SRS
22nd BSSRC co-chairs

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None this time—but for the next BSSRC, you could be a contributor! See the planning committee for details!

Bronze Sponsors — $500

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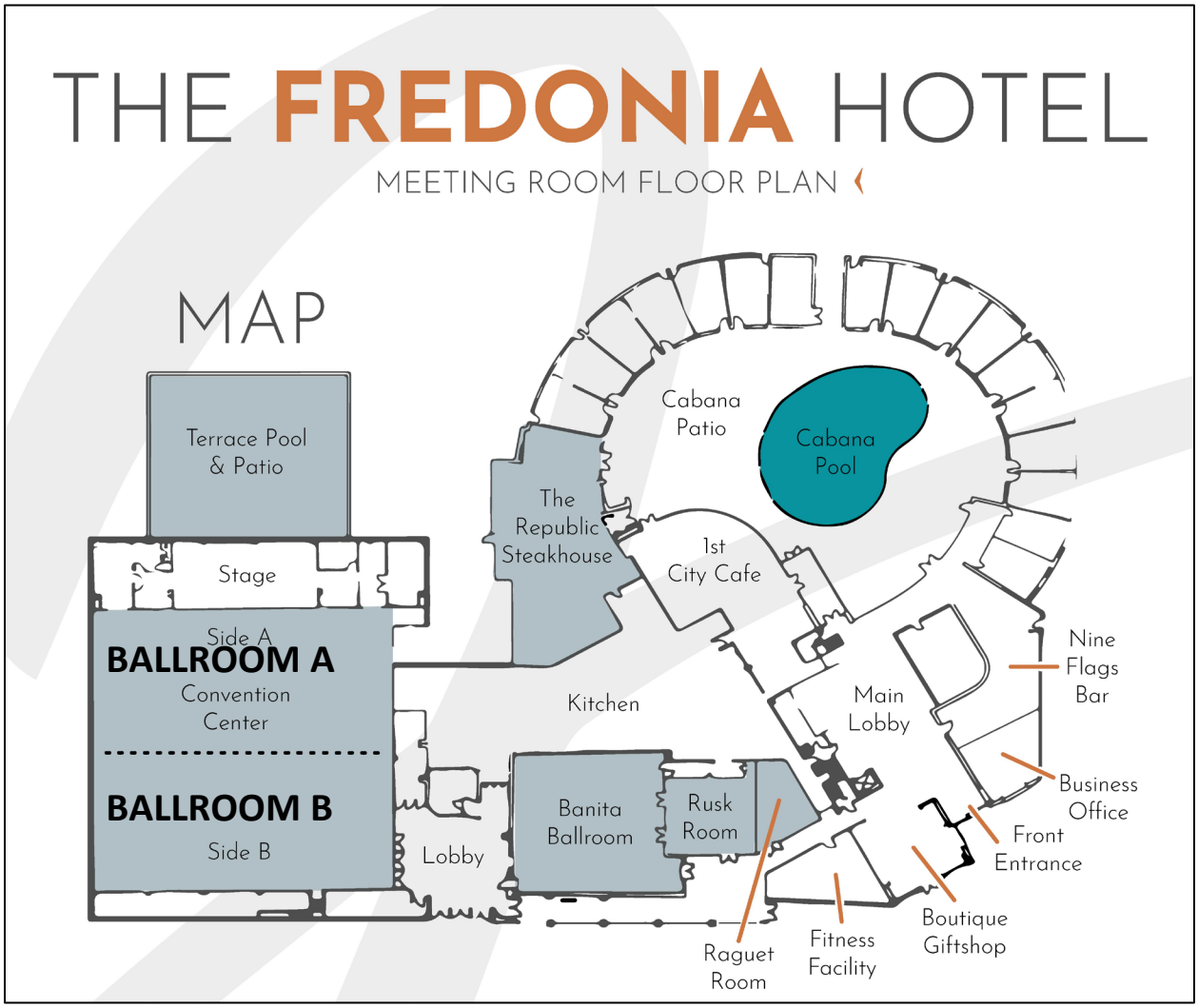
F&W Forestry	fwforestry.net

22nd Biennial Southern Silvicultural Research Conference

The Conference Venue: The Fredonia Hotel and Convention Center

200 North Fredonia Street, Nacogdoches, TX 75961



thefredonia.com

Book your hotel room through either the BSSRC website or call the hotel at: (936) 564-1234

Monday, March 20, 2023

Starting at 3:00 pm	Special lodging rates at the Fredonia Hotel for BSSRC participants begins
6:00 – 9:00 pm	**Registration — Raguet Room**
6:00 – 9:00 pm	**Poster set-up — Ballroom A**

22nd Biennual Southern Silvicultural Research Conference Program

Tuesday, March 21, 2023

7:00 – 8:00 am **Continental Breakfast – Ballroom B**

8:00 am – 8:00 pm **Poster visitation – Ballroom A**

Welcome Session — Ballroom B

8:00 – 9:30 am **Welcome and Plenary Session speakers:**

Brian Oswald, Co-chair, 22nd Biennial Southern Silvicultural Research Conference
Steve Westbrook, President, Stephen F. Austin State University (SFASU)
Hans Williams, Dean, Arthur Temple College of Foresty and Agriculture, SFASU, and Past President, Texas Forestry Association
Eric Taylor, Extension Specialist & Silviculturist IV, Texas A&M Forest Service

9:30 – 10:00 am **Break**

Concurrent Session 1 — Ballroom A

Field Trip Sites: Brian Oswald (moderator)

10:00 - 10:30 am Silviculture at the Boggy Slough Conservation Area – management to promote conservation and research. S. Jack, R. Sanders

10:30 - 11:00 am STMicroelectronics – SFASU carbon sequestration reforestation. J. Grogan, K. Farrish, H. Williams, B. Oswald

11:00 – 11:30 Shortleaf pine restoration project on the I.D. Fairchild State Forest, Texas A&M Forest Service. J. Ellis

11:30 – 1:30 pm **Lunch on your own**

Growth and Yield and Modeling 1: Eric Taylor (moderator)

1:30 - 2:00 pm An integrated system approach to model tree and stand growth. Q. Cao

2:00 - 2:30 pm A stand-level growth and yield model system for shortleaf pine plantations in the western half of the Southeastern United States. C. VanderSchaaf

2:30 - 3:00 pm A novel, single-tree measure of growing stock based on volume growth. T. Dean

3:00 – 3:30 pm **Break**

Growth and Yield and Modeling 2: Eric Taylor (moderator)

3:30 - 4:00 pm Biomass estimates for natural-origin hardwood saplings of southeastern Arkansas. M Bataineh

4:00 - 4:30 pm* A growth and yield system of differential equations for slash pine plantations including response to silvicultural treatments. L. Ramirez Quitero, M. Cubillos, C. Rodreigo, B. Bullock

4:30 - 5:00 pm* DBH estimation based on LiDAR point clouds at stand level of loblolly pine plantations. C. Talmage, Y. Weng, Y. Zhang, J. Grogan

5:00-5:30 pm* Quantifying aboveground biomass using remote sensing and ground measurements for mixed-hardwood forests. S. Jha, S. Yang, S. Hale, T. Johnson

** denotes student presenter*

Concurrent Session 2 — Ballroom B

Fire 1: Mohammad Bataineh (moderator)

10:00 - 10:30 am	Predicting fire intensity using vegetation, fuel, and weather variables on the William B. Bankhead National Forest, Alabama. J. Craycroft, C. Schweitzer
10:30 – 11:00 am	Future trends in dead fuels and implications for prescribed fire in the southern United States. Y. Liu, H. Tian, B. Tao, J. Yang
11:00 - 11:30 am	Prescribed fire barriers and solutions for managing sustainable forests: silvicultural cocktails. C. Schweitzer, D. Dey, A. Brandon.
11:30 – 1:30 pm	**Lunch on your own**

Fire 2: Callie Schweitzer (moderator)

1:30 - 2:00 pm	Linking fire behavior to effects - use of pyrometers and thermocouples. M. Bataineh, B. Portner, M. Pelkki, R. Ficklin
2:00 - 2:30 pm	A preliminary analysis of decomposition-driven changes in litter flammability. M. Varner, J. Kane, T., Shearman, J. Kreye, H. Alexander
2:30 - 3:00 pm*	Disturbing the peace: bringing back natural disturbance for oak woodlands and savannahs in the eastern US. M. Berry, P. Keyser, A. Vander Yacht, C. Henderson
3:00 – 3:30 pm	**Break**

Fire 2: Callie Schweitzer (moderator)

3:30 - 4:00 pm*	Influences of overstory pyrophytic and mesophytic trees and understory solar irradiance on leaf litter and woody debris fuel moisture retention. L. Goncalves Lazzaro, H. Alexander, J. Cannon, M. Aspinwall
4:00 - 4:30 pm	Spatial factors in post-fire tree mortality – a preliminary analysis. T. Shearman, M. Varner, J. Willis

Concurrent Session 3 — Banita Room

Hardwood 1: Brian Lockhart (moderator)

10:00 – 10:30 am	Advancing established white oak (*Quercus alba*) reproduction through a midstory removal. C. Dugger, W. Clatterbuck
10:30 - 11:00 am	Timing of dormant season inundation is crucial to flood effects on bottomland red oaks. B. Babst, R. Sample, J. Cook
11:00 - 11:30 am	The response of willow oak (*Quercus phellos*) seedling roots to fall environmental cues and winter flooding. B. Babst, J. Kressuk, T. Collins, E. Gardiner, M. Bataineh
11:30 – 1:00 pm	**Lunch on your own**

Concurrent Session 3 — Banita Room

Hardwood 2: Brian Lockhart (moderator)

1:30 - 2:00 pm*	Factors affecting oak regeneration in bottomland hardwood forests in northern Missouri. I. Hayford, B. Knapp.
2:00 - 2:30 pm*	Leaf area index (LAI) across eastern cottonwood and hybrid poplars and its relationships with productivity and water use efficiency under coppicing and non-coppicing management in the southeastern United States. J. Wang, H. Renninger
2:30 - 3:00 pm*	Characterization of community structure and structural diversity to assess evidence of forest type shifts prior to slough flow restoration treatments in the Apalachicola River floodplain. J. Tracy
3:00 – 3:30 pm	**Break**

Shortleaf Pine: Don Bragg (moderator)

3:30 - 4:00 pm	Site Preparation for shortleaf pine cluster planting and restoration of shortleaf pine-hardwood mixtures: First year results. D. Clabo, M. Hinson.
4:00 - 4:30 pm*	Sustainable pathways for shortleaf pine restoration in uncertain climates. C. Iwamoto, C. Seigert, J. Granger, K. Poudel, A. Polinko, Z. Freedman
4:30 – 5:00 pm*	Insight into the roles of prescribed fire and hardwood competition in the survival and growth of shortleaf pine throughout its early life. H. Filligim, B. Knapp, J. Kabrick
5:00 – 5:30 pm	Fuel load reduction and woodland restoration treatments in the Ouachita Region of Arkansas. K. Cunningham

Poster Session and Reception — Ballrooms and Banita Room

6:00 – 8:00 pm	**Poster Session and Reception: complementry hors d'oeuvres and cash bar**

Wednesday, March 22, 2023

7:00 – 8:00 am **Continental Breakfast – Ballroom B**

8:00 am – 4:00 pm **Poster visitation – Ballroom A**

Concurrent Session 4 — Ballroom A

Restoration and Reclamation: Conner Fristoe (moderator)

8:00 – 8:30 am Some silvicultural implications of updating the Southern Region's old-growth guidance. D. Bragg

8:30 – 9:00 am Reconstructing stand development patterns of oak-pine mixedwoods at Boggy Slough Conservation Area. B. Knapp, S. Jack

9:00 – 9:30 am* Evaluating the trajectory of secondary vegetational succession on clear-cut timber and strip mined sites. I. Kennedy, M. Mount, W. Clatterbuck, D. Buckley.

9:30 – 10:00 am **Break**

Loblolly Pine 1: Conner Fristoe (moderator)

10:00 – 10:30 am* Branch growth and mortality as influenced by light attenuation. A. Majekobaje, T. Dean

10:30 – 11:00 am* Characterizing spatial dependencies of competing vegetation in thinned loblolly pine stands. J. Young, B. Brunson, C. Montes, J. Rheney

11:00 – 11:30 am* Thinning and three genotypes effects on dbh, total height, and height to live crown, volume, and weight for loblolly pine. S. Flue, G. Holley, J. Adams, M Sayer, M. Tyree, M Blazier.

11:30 – 1:30 pm **Lunch on your own**

Loblolly Pine 2: Conner Fristoe (moderator)

1:30 - 2:00 pm Climate-smart forestry and its implication on southern silviculture. G. Wang

2:00 - 2:30 pm Thinned young *Pinus taeda* stands outperform thinned older stands. T. Albaugh, D. Carter, R. Cook, R. Rubilar, O. Campoe

2:30 - 3:00 pm* Height, diameter and volume comparison of three species of west gulf coastal plain provenance pines after seven growing seasons in East Texas. C. Carpenter, H. Williams, J. Gorgan, B. Oswald, J. Stovall, Y. Weng

3:00 - 3:30 pm **Break**

Hardwoods 3: Brian Lockhart (moderator)

3:30 – 4:00 pm Planted white oak (*Quercus alba*) respond to spacing density and orientation in gap openings in the Blue Ridge Mountains of North Carolina. S. Clark, T. Keyser, S. Schlarbaum, A. Saxton

4:00 - 4:30 pm Multi-phased shelterwood on the Daniel Boone National Forest, Kentucky, tests herculean effort to regenerate oak. C. Schweitzer, J. Calvert, S. Clark, J. Royse

4:30 - 5:00 pm A look back on 26-years of hardwood development after afforestation on flood-prone agriculture lands in the Louisiana delta. J. Adams, W. Patterson.

Concurrent Session 4 — Ballroom A

5:00 – 5:30 pm	An evaluation of species composition and stand structure on patch cut vs. larger clearcut stands after 30+ years at natchez trace state forest in West Tennessee. W. Clatterbuck, J. Biggerstaff
5:30 – 6:00 pm	White oak sustainability – what's the (under)story? L. Vickers, B. Knapp

Concurrent Session 5 — Ballroom B

Intermediate Treatments/Competition Control 1: Joshua Adams (moderator)

8:00 – 8:30 am	Aminocyclopyrachlor cut stem applications compared to standard herbicides for Eucalyptus control. P. Minogue, K. Lorentz
8:30 – 9:00 am	A comparison of Garlon 4, Garlon XRT, Vista, Vastlan, Chopper GEN2, and Terravue in site preparation applications. A. Self, J. Ezell, A. Ezell
9:00 – 9:30 am	A comparison of glufosinate products for the control of natural pines. J. Ezell, A. Self, A. Ezell.
9:30 – 10:00 am	**Break**

Intermediate Treatments/Competition Control 2: Wayne Clatterbuck (moderator)

10:00 – 10:30 am*	Seasonal light response curves of *Ligustrum sinense* (Chinese privet): a test of extended leaf phenology. T. Markus, L. Pile-Knapp, D. Cole, G. Wang
10:30 – 11:00 am	Mid-rotation brush control in a loblolly pine plantation using chopper GEN2 and selected glufosinate products. A. Ezell, J. Ezell, A. Self
11:00 – 11:30 am	Evaluating dormant-season herbicide applications for the control of Chinese privet (*Ligustrum sinense*). L. Pile-Knapp, K. Vaughn, G. Wang
11:30 – 1:30 pm	**Lunch on your own**

Intermediate Treatments/Competition Control 3: Andy Ezell (moderator)

1:30 - 2:00 pm	Effects of fertilization and vegetation control application under different thinning intensities in the southeast US. C. Montes, M. Wang, B. Bullock, D. Zhao
2:00 - 2:30 pm	Use of pre-emergent herbicides (clopyralid and imazamox) for seedling release in an oak shelterwood. S. Peairs
2:30 - 3:00 pm	Use of post-emergent herbicides (indaziflam, sulfometuron methyl, and flumioxazin) for seedling release in an oak shelterwood. S. Peairs
3:00 - 3:30 pm	**Break**

Management and Silvics: Andy Ezell (moderator)

3:30 – 4:00 pm	Role of root system structure in sustained growth among loblolly pine genotypes. M. Sayer, K. Wharton, M Tyree, M. Blazier, J. Adams, B Wolfe
4:00 - 4:30 pm	Managing feral hogs: perspectives of forest landowners in Arkansas, Louisiana, and East Texas. N. Tian, J. Gan, G. Holley
4:30 - 5:00 pm	Natural plant succession of a dozer line in Arkansas. V. McDaniel, G. De Jong
5:00 – 5:30 pm	Updating the Silvics of North America: progress, timeline, and involvement. S. McNulty, C. Stelly

Concurrent Session 6 — Banita Room

Ecosystem Services: Tom Dean (moderator)

8:00 – 8:30 am	Impact of pine species identity on woodland ecosystem services. J. Willis, M. Varner, J. Cannon, J., Puhlick, D. Bragg, C. Schalk
8:30 – 9:00 am*	Asssessment of trade offs among ecosystem services of wetland researve easements. T. Corbin, M. Bataineh, B. Babst, I. Hung.
9:00 – 9:30 am*	Evaluating stem and branch characteristics of five-year-old Sonderegger pine saplings. K. Shoemaker, D. Jackson, J. Adams
9:30 – 10:00 am	**Break**

Longleaf Pine 1: Brian Oswald (moderator)

10:00 – 10:30 am*	Spatial patterns of disturbance and intra-stand structure in a longleaf pine (*Pinus palustris*) woodland. D. Phillips, J. Goode, J. Hart
10:30 – 11:00 am*	Does longleaf pine cone production correlate with seed production, size, and germination rate? R. Nations, H. Alexander, J. Willis, M. Aspinwall, J. Cannon
11:00 – 11:30 am*	Effects of fertilization and endophyte application on growth of planted longleaf pine. B. Doughty, A. Polinko.
11:30 – 1:30 pm	**Lunch on your own**

Longleaf Pine 2: Pat Minogue (moderator)

1:30 - 2:00* pm	The influence of slash management practices on water and nutrient dynamics in longleaf pine forests. J. Murray, D. Hagan, P. Hiesl, R. Baldwin
2:00 - 2:30 pm	Silvicultural strategies for converting longleaf pine plantations to multi-aged longleaf pine stands. G. Nyen, A. Polinko, J. Puhlick.
2:30 - 3:00 pm	Tropical cyclones stimulate cone production in longleaf pine woodlands. J. Cannon, B. Rutledge, J. Puhlick, J. Willis, D. Brockway
3:00 - 3:30 pm	**Break**

Longleaf Pine 3: Pat Minogue (moderator)

3:30 – 4:00 pm	Silvicultural strategies for promoting longleaf pine recruitment in multi-aged stands. J. Puhlick, B. Knapp, I. Goldberg, B. Rutlendge, R. Taylor, J. Willis
4:00 - 4:30 pm	Is longleaf pine an intolerant species? It's comparison with other southern pines and southern hardwoods. A. Sharma, J. Willis
4:30 - 5:00 pm	Survival of longleaf pine seedlings planted under different canopy reduction treatments in a slash pine-turkey oak stand. J. Vogel, J. Shabaga, S. Lapalikar, A. Sharma
5:00 – 5:30 pm	Prescribed burning has little effect on longleaf pine wood quality. E. Andrews, J. Willis

Ethics training — Banita Room

5:30 – 6:30 pm **Ethics Training: Brian Lockhart (instructor)**

Fertilizer application in forestry panel — Rusk Room

4:30 – 6:30 pm **Panel discussion led by Cristian Montes, University of Georgia**

Wednesday evening social — Fredonia Brewery

7:00 – 10:00 pm **Social at Fredonia Brewery (138 North Mound Street, Nacogdoches)**

** denotes student presenter*

22nd BSSRC Poster Session and Reception
Tuesday, March 21, 2023

Poster #	Lead presenter	Poster title
1	Clifton Albrecht *	The interacting roles of hydrology and light in structuring regeneration of East Texas bottomland hardwood forests
2	Emily White *	Carbon sequestration potential of non-commercial tree species in the southeast
3	Joshua Everett *	The effects of eastern redcedar encroachment on soil saturated hydraulic conductivity in the Cross Timbers
4	Samantha Murray *	Drought effects on the relative importance of multiple stand attributes and site conditions on forest productivity
5	Sloane Scott *	Pollinator Habitat in Log Landings (PHiLL) project
6	Megan Van-Spanje *	Identifying applied isotopic nitrogen (15N) allocation in a mid-rotation pine plantation under varying herbicide regimes
7	Basanta Shrestha *	Carbon storage, fuel loading, and fire behavior consequences in hurricane-impacted, fire-dependent forests of the southeastern U.S.
8	Logan Ozment *	Drivers and projections of suitable ranges of major woody biofuel species under climate changes
9	James Borland *	Early detection of loblolly pine tree decline
10	Dinesh Upadhayay *	Effect of thinning on basal area growth among different diameter classes in natural-stand of shortleaf pine (*Pinus echinata* Mill.)
11	Gabriel Nyen *	Silvicultural strategies for converting longleaf pine plantations to multi-aged longleaf pine stands
12	Ryan Bohannon *	Developing successful management strategies for invasive plant species at Townsend Bombing Range, Georgia
13	Ian Goldberg *	Aging the grass stage from a known aged outplanting of longleaf pine using modern dendrochronological techniques
14	Trisha Markus *	Invasive plant impact of fuels: an implication to fire behavior
15	Baylor Doughty *	Stand dynamics of shortleaf pine-upland oak mixtures in northern Mississippi
16	Quentin Boccaleri *	Growth, yield, and carbon following thinning in loblolly pine
17	Noah Howie *	Prescribed fire effects on the spatial patterns of stand structure and fuel characteristics in a mixed oak-shortleaf pine forest
18	Katelyn BcBride *	Temperature adaptation and acclimation in southern pine species and populations
19	Samantha Luitjens *	Spatial patterns of species composition after catastrophic wind disturbance in a longleaf pine (*Pinus palustris* Mill.) woodland

22nd BSSRC Poster Session and Reception (continued)
Tuesday, March 21, 2023

Poster #	Lead presenter	Poster title
20	Andrew Arko *	The effects of a moderate severity hurricane on landscape-scale heterogeneity in a longleaf pine woodland
21	Cady Greenslit *	The effects of water availability and nutrient addition on resin duct production in loblolly pine (*Pinus taeda*) in southeastern Oklahoma
22	Kyle Dues *	A machine learning approach to stand dynamics in a threatened forest ecosystem
23	Jacob Lewis *	Productivity of hybrid sweetgum plantations in southeastern Oklahoma and northeastern Texas
24	Tian Zhang *	Interaction between climate change and increased tree canopy cover will reduce water yield
25	Maxwell Schrimpf *	Quantifying effects of initial spacing on corewood transition in loblolly pine using CT scanning.
26	Eamonn Thurmond *	Monitoring avifauna response to forestry wildlife treatments in bottomland hardwood forests
27	Gary White *	Loblolly pine and shortleaf pine hybridization spatially quantified using chromatography and GIS: an East Texas case study
28	Jacob Grochowski *	Evaluating restoration treatment effects on regeneration demographics in East Texas upland mixedwoods using a chronosequence
29	Alexandria Cook *	First year survival and growth of ponderosa pine (*Pinus ponderosa*) and Jeffrey pine (*Pinus jeffreyi*) in the East Texas Pineywoods
30	Austin Morrison *	Small NIPF landowner Landsat imagery survey
31	Simone Lim-Hing *	Improving fusiform rust hazard maps using machine learning and spatial interpolation
32	Chris Dempsey *	Vegetative analysis of three Gulf Coastal Plain vernal pools
33	William Henry McNab	Response of advance regeneration 20 years following three levels of commercial thinning in a 45-year-old eastern white pine plantation on a dry site in the southern Appalachians
34	Cason Brewster	Effectiveness of shelterwood and strip clearcuts for regenerating bottomland oaks in northeast Texas
35	Michael Crosby	Evaluating bias in tree-level measurements obtained with a backpack LIDAR unit
36	Brett Wolfe	Leaf turgor loss point among bottomland hardwood forest trees
37	Josh Pierce	Site selection for reintroduction of the federally threatened Louisiana Pinesnake (*Pituophis ruthveni*)

22nd BSSRC Poster Session and Reception (continued)
Tuesday, March 21, 2023

Poster #	Lead presenter	Poster title
38	Don Bragg	Correcting the erroneous geographic coordinates of the Southwide Pine Seed Source Study source areas
39	Curtis VanderSchaaf	Impacts of diesel and insurance costs on owner-operator log truck drivers in the Western Gulf
40	Curtis VanderSchaaf	Reforestation tax incentive impacts on financial returns of loblolly pine plantations for family forest landowners in Mississippi
41	Virginia McDaniel	Using fire and thinning to restore open woodlands in the Ouachita National Forest
42	Chris Schalk	Composition of the understory plant community at the Stephen F. Austin Experimental Forest prior to timber harvest and frequent fire
43	Chris Schalk	Food-webs, forest management, and resiliency of southern pine forests
44	Michaella Ivey	Modeling crown characteristics related to wind stability in slash pine (*Pinus elliottii*)
45	Daniel Saenz	Management of southern pine forests influences breeding bird communities
46	Kyle Cunningham	Individual tree response to commercial thinning in a mid-rotation red oak plantation in Arkansas

ALL PRESENTATION ABSTRACTS

Adams, J., and W. Patterson

A look back on 26-years of hardwood development after afforestation on flood-prone agriculture lands in the Louisiana delta (ORAL)

Thousands of acres of former agricultural lands have been afforested over the last four decades. In 1996, an 80-acre area of abandoned cropland was afforested after approximately 40-years of being cleared, land leveled, and farmed. The tract, composed of three soil series, is situated between the Boeuf and Ouachita Rivers in Catahoula Parish, Louisiana, and was planted with a variety of bottomland species. Twenty-six years after planting, the overall site has shifted toward a pre-dominant overcup oak or Nuttall oak stand dependent on the soil type. Most other species compose a minimal representation in the stand currently. Alternatively, several species not planted are now represented in the stand comparable to some species that were planted. Overall this assessment after nearly 30 years of afforestation points toward developing stands with only one to two primary species regardless of initial deployment.

Albaugh, T., D. Carter, R. Cook, R. Rubilar, and O. Campoe

Thinned young *Pinus taeda* stands outperform thinned older stands (ORAL)

There is a premium for larger stem sizes. For example, saw timber (>12 inches in diameter) stumpage prices can be 2-7 times more per ton than pulpwood (<6 inch diameter). Chip 'n' saw (CNS, between 8 and 12 inches in diameter) typically has an intermediate price. Stand density, which can be managed at planting and with thinning, influences diameter growth. Thinning to low stand density (100-200 trees ac^{-1}) has a large effect on diameter growth; however, there is uncertainty in response magnitude when thinning is completed at different stand ages. Our interest was quantifying the response to thinning stands from 500 to 200 trees ac^{-1} when stands were young (12-15 years old) compared to when they were old (18-24 years old). Old thins had more than two times the green weight removed as young thins. Old thin removals were mostly CNS whereas young thins were mostly pulpwood. Four year post young thin diameter growth was more than two times larger than post old thin diameter growth however, post-thin volume increment was about the same for young and old thins. Young thin trees reached saw timber size at age 21, 8 years post-thin. Old thin trees reached saw timber size at age 31, 10 years post-thin. Post thin older trees started out larger but grew slower in diameter than the young thin trees. If the goal is to reach saw timber size trees rapidly, our data suggest that young *Pinus taeda* stands accrue diameter more rapidly than old stands when thinned.

* Albrecht, C., K. Kidd, J. Stovall, B. Oswald, J. Van Kley, and S. Jack

The interacting roles of hydrology and light in structuring regeneration of East Texas bottomland hardwood forests (POSTER)

The composition of tree regeneration in bottomland hardwood (BLH) forests is strongly influenced by the light and hydrologic environment experienced by seedlings and saplings. An improved understanding of the effects of these factors, as well as possible interactions between them, may inform future management of BLH forests for increased regeneration of desirable trees, decreased regeneration of undesirable and invasive trees, or reforestation of land historically used for other purposes. In this study, tree regeneration dynamics were surveyed in naturally-occurring treefall gaps in BLH forests of the Neches River, Angelina River, and Attoyac Bayou floodplains in East Texas. Within each treefall gap, sample quadrats were arranged to capture the greatest possible variation in ground-level light environment. Variation in hydrology

was introduced by river basin-level differences in flood regime and differences in elevation among sites within each floodplain. The findings of this study will contribute to an understanding of the effects of light and flooding environment on the density and biomass of regeneration in bottomland hardwood forests. Additionally, findings will allow for an estimation of species' size-specific mortality risks at very young ages in a variety of environmental contexts. This study is a part of the continuing effort to understand the interacting roles of light and hydrology on the development of BLH forests.

Andrews, E., and J. Willis

Prescribed burning has little effect on longleaf pine wood quality (ORAL)

Longleaf pine (*Pinus palustris*) is a fire adapted species that is economically valued for the production of premium wood products. Yet surprisingly little is known about the effects of prescribed fire on wood quality. In this study, we examine the effects of fire seasonality (winter or spring), fire return interval (2, 3, 5 years), and tree canopy position (dominant, co-dominant, intermediate) on longleaf pine specific gravity and annual late-wood ring width in a long-term experiment conducted at the Escambia Experimental Forest in southern Alabama, USA. Results indicate that fire return interval (P = 0.5517), canopy position (P = 0.7130), fire seasonality (P = 0.1489), and the interaction between fire seasonality and burn interval (P = 0.4797) had negligible effects on wood specific gravity. Similarly, burn interval (P = 0.8408), fire seasonality (P = 0.5765), and the interaction between fire seasonality and burn interval (P = 0.8807) had no effect on latewood ring width. In contrast, canopy position significantly influenced latewood ring width (P = 0.0074), as dominant trees (2.78 mm) added statistically more latewood than co-dominant (2.23 mm) and intermediate trees (2.15 mm). Collectively, these results demonstrate that prescribed burning at frequent intervals in the spring and winter has little impact on longleaf pine wood quality.

*** Arko, A., J. Cannon, and A. Himes**

The effects of a moderate severity hurricane on landscape-scale heterogeneity in a longleaf pine woodland (POSTER)

Modern forest management emphasizes infusing practices with an understanding of natural disturbance regimes -- often called ecological forestry. Emulating aspects of natural disturbance regimes is considered an effective tool to balance silvicultural and ecological objectives. Wind disturbances, such as hurricanes or tornados, are a major disturbance affecting forests across the native range of longleaf pine (*Pinus palustris* Mill.). Wind damage can result in death of individual trees or numerous trees leading to complex patterns of gaps at the stand and landscape scale. Canopy gaps play an essential role in the regeneration patterns of longleaf pine because size and shape of overstory gaps influence regeneration and fire regimes. It is important to understand how hurricane damage influences the formation of gaps so that the process may be more effectively incorporated into restoration and management of longleaf pine forests. Canopy gaps were delineated using LiDAR derived canopy height models (CHM) before and after 2018 Hurricane Michael. We compared gap size, shape, and spatial pattern among landscape factors such as soil drainage class, forest species and size class. In total, 328 gaps were delineated. Excessively drained soils and stands of longleaf pine-dominated stands had greatest variability in gap sizes. Spatial patterns of gaps were observed to differ by forest species. Gaps displayed different spatial patterns depending on soil drainage. No differences were observed in gap shape. Understanding the patterns of gap formation following wind disturbances provides information for development of silvicultural prescriptions that better emulate natural distance regimes in longleaf pine.

Babst, B., J. Kressuk, T. Collins, E. Gardiner, and M. Bataineh

The response of willow oak (*Quercus phellos*) seedling roots to fall environmental cues and winter flooding (ORAL)

The timing of seasonal flooding in bottomlands relative to seedling dormancy is a crucial determinant of how flooding affects seedlings [1]. This study investigated whether cold soil temperatures and other environmental cues reduce root activity in willow oak (*Quercus phellos*) during winter, and whether reduced root activity increased root tolerance to winter soil flooding. We employed an experimental approach in a greenhouse, in which soil temperatures were manipulated, and a correlative approach in the field. In the greenhouse, low soil temperature reduced root growth and respiration. Temperature effects on root respiration were direct and reversible, not acclimation. Waterlogging to the root collar in December immediately halted root growth, but did not reduce root respiration. Survival and spring growth were high for seedlings in all treatments. Seedlings that experienced warmer winter temperatures had greater morphological stress responses to flood. Naturally seeded, 1-year-old willow oak seedlings sampled in the field had decreased root respiration following frost events, but respiration rebounded when air temperatures increased again. Root respiration was much more variable in the field than in the greenhouse, and was significantly correlated with both soil and air temperatures. Together our results indicate that root growth could continue during typical winter soil temperatures in the Lower Mississippi Alluvial Valley, but the stress of flooding may be reduced even when soil temperature is not low enough to stop root growth.

Babst, B., R. Sample, and J. Cook

Timing of dormant season inundation is crucial to flood effects on bottomland red oaks (ORAL)

Since flooding in winter and early spring is an integral part of bottomland hardwood ecosystems, moderately flood tolerant oaks, like Nuttall oak (*Quercus texana*), should be well adapted to flooding during these seasons. However, altered hydrology and unusual weather patterns are more frequently exposing bottomlands to flooding when trees are transitioning into or out of dormancy. Previously, we found that autumn flooding resulted in reduced fine roots, nutrient uptake, and survival overwinter in Nuttall oak. To determine what duration of winter-spring flooding would be damaging, dormant Nuttall oak seedlings were flooded for different durations, from zero to three months. Moderately flood intolerant Shumard oak (*Q. shumardii*) seedlings were also included for comparison. Flooding during winter dormancy had no effect on Nuttall oak, but Shumard oak seedlings had reduced growth in the spring. Flooding that extended beyond budbreak resulted in reduced leaf area and root biomass accumulation for both species, and reduced survival of Shumard oak seedlings. Given the rest of the growing season to recover, only those Nuttall oak seedlings that had been flooded into late spring had reduced biomass, especially taproot biomass, while even winter flooding reduced Shumard oak biomass. Overall, these results suggest that Shumard oak seedlings are intolerant of winter flooding. Nuttall oak seedlings may tolerate flooding during winter and early spring, but winter flooding that extends several months beyond budbreak can impact seedlings.

Bataineh, M.

Biomass estimates for natural-origin hardwood saplings of southeastern Arkansas (ORAL)

Biomass estimates are integral to the determination of carbon and feed stocks, fuel loads, and primary productivity. Understories of mature, natural-origin, pine and pine-hardwood stands in southeastern Arkansas are largely dominated by shade-tolerant hardwood species which are poorly represented by existing biomass equations. Destructive sampling of 120 saplings (dbh <

12.7 cm) was conducted to develop biomass models for winged elm, eastern hophornbeam, flowering dogwood, white ash, American holly, and blackgum. Linear and nonlinear models were constructed using diameter at breast height as the main predictor of total and component aboveground biomass (foliage, branch, and stem) and were compared to existing biomass models. Models indicated that blackgum stored the least total aboveground biomass, while dogwood and hophornbeam stored the most total aboveground biomass. A linear pooled biomass model provided a good fit to observed values (R^2=0.97) indicating the potential use of a general biomass model for multiple hardwood species in southeastern Arkansas.

Bataineh, M., B. Portner, M. Pelkki, and R. Ficklin

Linking fire behavior to effects - use of pyrometers and thermocouples (ORAL)

Thermocouples and pyrometers are routinely deployed to characterize fire in prescribed burning. Although thermocouples are more expensive and are cumbersome to deploy, they capture temperature changes over time. Pyrometers, on the other hand, provide easier deployment at the expense of sacrificing detail. In this paper, we compare thermocouple and pyrometer temperature readings above- and below-ground from four prescribed burns in a frequently (every 3 years) burned upland oak-hickory forest of the Ozark Mountains, Arkansas. Mean maximum temperature at 30 cm above-ground did not differ ($p = 0.32$) between thermocouples and pyrometers. At ground-level, mean maximum temperature also did not differ ($p = 0.94$) between thermocouples and pyrometers. Higher agreement occurred between temperature readings at 30 cm above- than at ground-level ($r = 0.78$; $p < 0.01$, and 0.30; $p = 0.03$, respectively). Fuel and weather conditions resulted in differences in mean maximum temperature among prescribed burns. Detectable below-ground pyrometer heating did not exceed 12 mm in depth and did not allow for a comparison with below-ground thermocouples. Pyrometers appear to provide reliable estimates of mean maximum temperature at 30 cm above-ground, and to a lesser degree, at ground-level in frequently burned oak-hickory forests. These findings agree with reports from similar forests but contradict reports from other forests, highlighting the importance of fuel and forest type when comparing techniques.

* Boccaleri, Q., A. Polinko, and B. Kanieski da Silva

Growth, yield, and carbon following thinning in loblolly pine (POSTER)

Carbon-based management is an emerging objective of the forest industry, worldwide. In the world of southern forestry, the primary challenge comes from incorporating management for carbon within the traditional management plan of a yellow pine plantation. Meanwhile, thinning can be considered one of the major silvicultural activities conducted in southern forestry. Additionally, thinning has a major impact on the merchantable yield produced by a stand throughout its lifetime. Understanding the impacts that thinning has on growth and yield, in relation to age, density, and site conditions, is vital for the management of carbon. An optimized thinning regime, which produces the most for carbon-based management while also providing significant timber yield, would be helpful to the overall southern market. For these reasons, this project seeks to analyze the relationship between different thinning regimes and carbon yield. Specifically, it will be examining even age rotation regimes of loblolly pine (*Pinus taeda*). To achieve this, the following was conducted: 1) a literature review on the known impacts of thinning on stand yield and its relationship with carbon yield. 2) A meta-analysis, where data form different thinning regime trials was analyzed to understand the direct impacts of thinning on carbon yield. 3) Analyze the tradeoffs of carbon management within in thinning-based management plan.

*** Bohannon, R., T. Markus, Y. Tang, and G. Wang**

Developing successful management strategies for invasive plant species at Townsend Bombing Range, Georgia (POSTER)

Non-native, invasive plant species threaten the ecosystem functions and services of forests throughout the southern United States. On installations such as Townsend Bombing Range (TBR) in southeastern Georgia, invasive plants can also interfere with land management for military training. To sustain the ecological and military values provided by forests at TBR, this project was initiated to inventory and manage invasive plant species on this land. Transect surveys were conducted across the installation to determine the presence and distribution of invasive species in different vegetation types, including planted pine stands and hardwood stands. The survey results were then used to identify the highest-priority species for control and develop targeted management strategies. The control methods developed for each target species will be experimentally tested in the field to determine their effectiveness. The results of this study will inform the sustained, successful management of invasive plants in forests at TBR.

*** Borland, J., and M. Bataineh**

Early detection of loblolly pine tree decline (POSTER)

Early detection of tree decline is critical for effective forest management. High resolution spectral reflectance provides a mean for early decline stage identification. This study seeks to develop decline stage specific spectral signatures that reflect early, green stage attack of bark beetles. Reflectance values were collected from 46 loblolly pines (*Pinus taeda*) that represented progressively declining pines (n = 12 for each of three classes) within a plantation under an active bark beetle attack. Mean spectral reflectance of healthy trees was 19.36% higher in the 650 -700 nm range and 6.68% lower in the 700 – 900 nm range than declining or dying trees. Preliminary single factor analysis of variance at specific intervals of 700, 720, and 750 nm, as well as broader ranges of 550 to 800 and 500 to 800 nm found no significant difference in decline class mean reflectance ($P > 0.05$).

Bragg, D.

Some silvicultural implications of updating the Southern Region's old-growth guidance (ORAL)

The USDA Forest Service's Southern Region (R8), in conjunction with the Southern Research Station, have chartered a formal team of managers, planners, and scientists to update R8's 1997 guidance document on old-growth management and restoration. There are a number of silvicultural implications associated with old-growth management and restoration for the Region's national forests. For example, recent regional-scale restoration initiatives have been established for several important but declining species, including longleaf (*Pinus palustris*) and shortleaf (*Pinus echinata*) pines and white oak (*Quercus alba*). Historically, open pine- and oak-dominated old-growth forests were very common across the region, so restoration efforts for these ecosystems have focused on thinning overstories, greatly reducing midstories, and the application of frequent prescribed fire to help maintain these stands. These treatments are usually designed to reduce arboreal richness, encourage certain early successional overstory species, and lessen stand densities to the point of allowing for grass- and forb-dominated understories. However, these treatments also inherently diminish certain stand attributes some mistakenly assign to all old-growth forests (for example, well-stocked, high biomass, arboreally rich stands). Other questions related to silvicultural practices in old stands, from determining the degree of maturity for candidate patches and patch size to allowable treatments and the long-term sustainability of this resource will be addressed by this update. Ultimately, the team's goal

is to produce updated old-growth guidance by FY2024, thereby providing R8 managers and planners better, more scientifically robust information.

Bragg, D., and S. Reid

Correcting the erroneous geographic coordinates of the Southwide Pine Seed Source Study source areas (POSTER)

The Southwide Pine Seed Source Study (SPSSS) was the first major large-scale study of southern pine tree improvement and provided a tremendous amount of information from its inception in the early 1950s until its conclusion decades later. The silvicultural value of this early study, even given some design weaknesses and other limitations, continues to this day and these data will soon be available for further analysis through the USDA Forest Service's Research Data Archive. However, in the process of preparing this information, we discovered that many of the geographic coordinates provided for the seed sources were erroneous in the original study plan documentation. While some errors are very minor, others represent departures of many miles and significantly different latitudes/longitudes. Such departure errors would probably have had little to no impact on the earlier interpretations of seed source performance; however, they may prove to be problems if used in modern geographic analyses that require much more precise locations. We demonstrate a number of these errors and present a series of species-based maps and a table with improved coordinates for future researchers to use.

Brewster, C., R. Hurliman, R. Holeman, C. Meek, K. Anderson, and J. Everett

Effectiveness of shelterwood and strip clearcuts for regenerating bottomland oaks in northeast Texas (POSTER)

Oaks are usually the most valuable bottomland species, but often hard to regenerate. Operational shelterwoods, cut to 50% canopy cover, and strip clearcuts were established in 2014 to test their effectiveness for establishing oak regeneration. The previously unmanaged site (93.6 ft^2/acre BA) was located in Morris County, Texas and dominated by overcup oak (*Quercus lyrata*) 31%, willow oak (*Q. phellos*) 29%, water oak (*Q. nigra*) 11%, and sweetgum (*Liquidambar styraciflua*) 9%. Before treatment, there were 1965 seedlings per acre with willow oak most abundant (38%). By 2022, BA of the shelterwood areas recovered to 96.2 ft^2/acre and the sapling size class (DBH < 5cm) increased from an initial 270 trees per acre (TPA) to 580 TPA with 26% *Quercus* spp. The seedling layer increased to 7371 TPA with 67% willow oak, 10% overcup oak, 9% water oak, 5% *Ulmus* spp., 3% cherrybark oak (*Q. pagoda*), and 3% sweetgum. Average seedling height was ~10". In the strip clearcuts, no seedlings occurred in the sampling plots. However, there were 961 TPA in the sapling size class with 62% *Quercus* spp. (41% willow oak, 10% water oak, 6% overcup oak, and 5% cherrybark oak). These results indicate both techniques successfully enhanced oak regeneration. The strip clearcut produced ~600 oaks per acre between 0.1 and 5.0 cm DBH that likely will contribute to the next stand, especially with targeted control of less desirable species. The shelterwood increased seedlings 3.75x with the majority comprised of oaks. However, overstory reduction is needed to release this regeneration.

Cannon, J., B. Rutledge, J. Puhlick, J. Willis, and D. Brockway

Tropical cyclones stimulate cone production in longleaf pine woodlands (ORAL)

In the southeastern U.S., longleaf pine (*Pinus palustris*) is a primary focus for restoration efforts, as the species is expected to be resilient to future climate changes such as increased drought and tropical cyclone intensity. Formulating silvicultural prescriptions that account for climatic threats will be critical for adapting to these changes. Longleaf pine is a weakly masting species with

sporadic seed production, posing challenges for silvicultural planning. Disturbances from tropical cyclones may increase cone production by increasing precipitation, freeing up resources from competing vegetation, or by stimulating reproduction via stress mechanisms. Alternatively, tropical cyclones could decrease cone production by causing mechanical damage to branches or conelets. Using a long-term data set (1965-2022) of longleaf pine cone counts from 13 sites across the southeastern U.S., we examined whether occurrence of tropical cyclones altered cone production. We identified 50 unique tropical cyclones impacting the sites over the study period. We found that tropical cyclones significantly increased cone production by ~80% in the second year after storm events before returning to pre-storm levels in year four. Interestingly, we only observed this increase in lower intensity storms—those generating winds < 72 km h^{-1} at the site—whereas higher intensity storms showed no such increase. This pattern is inconsistent with the hypothesis that cyclone-caused mortality may free up resources for residual trees. Further observation and experimentation can help determine the extent to which increased precipitation or stress mechanisms may play a role in stimulating cone production in longleaf pine.

Cao, Q.

An integrated system approach to model tree and stand growth (ORAL)

An integrated system, as envisioned by Daniels and Burkhart (1988), contains a unified mathematical structure for modeling tree and stand growth that can be applied at any level of resolution. In this talk, I will outline the recent progresses that make this concept a reality:

(1) The integrated system is based on a whole-stand growth model.
(2) Given a tree list, an individual-tree growth model can be derived from the stand model.
(3) A diameter distribution (e.g., Weibull) can be partitioned into individual trees, which can be grown according to the tree growth model from (2) above.
(4) A stand table can be converted into a tree list, which can be used to derive a tree growth model by use of the technique from (2) above.

This integrated system can provide growth predictions for a current stand. The inputs can be a plot summary, a tree list, a stand table, or a diameter distribution. The outputs are constrained to have numerical consistency at all levels of resolution.

*** Carpenter, C., H. Williams, J. Gorgan, B. Oswald, J. Stovall, Y. Weng**

Height, diameter and volume comparison of three species of West Gulf Coastal Plain provenance pines after seven growing seasons in East Texas (ORAL)

Seedlings of west gulf coastal plain provenance loblolly (*Pinus taeda*), slash (*P. palustris*), and shortleaf (*P. echinata*) pines were planted in December of 2015 on three east Texas sites to compare initial survival and growth of these species on three different drainage class sites. Feral hogs and Texas leafcutter ants caused significant damage to seedlings between establishment and January of 2019. Loblolly and slash pines had the greatest heights, and loblolly pine had the greatest basal diameters. In January 2023 the plots were remeasured for stocking, height and diameter and volumes calculated, the differences between species compared. The presentation provides these results.

Clabo, D., M. Hinson, and M. Hinson

ORAL: Site preparation for shortleaf pine cluster planting and restoration of shortleaf pine-hardwood mixtures: first year results (ORAL)

Shortleaf pine (*Pinus echinata*)-hardwood restoration continues to be a management goal throughout the interior South. Cluster or group planting involves placing groups of tightly spaced

trees (often 3x3 to 6x6 ft spacing) on favorable microsites in clearcut or partially harvested stands. Site preparation or release operations for cluster planting may be focused on smaller areas reducing costs and improving access on sites with steep topography. The objective of this study was to investigate site preparation methods to establish a shortleaf pine component using cluster planting in an upland mixed hardwood stand that had a minor overstory shortleaf pine component at the time of study establishment. The study area was located in Dade County, Georgia near the summit of Sand Mountain in a stand that had received a two-aged harvest five years prior. The stand averaged 21 ft^2 ac^{-1} overstory basal and had approximately 2,000 to 5,000 naturally regenerating hardwood stems per acre in the understory. Four treatments were installed as three replications on 60 x 60 ft experimental units. All site preparation treatments included felling of understory hardwoods during late summer 2021. Treatments included: 1.) fell only (control), 2.) fell and burn, 3.) fell-herbicide-burn, and 4.) fell and herbicide. Bareroot 1-0 stock shortleaf pine seedlings were planted December 27, 2021 at a 5 x 5 ft spacing. Survival 2.5 months after planting averaged 96.6 percent across all treatments. End of first growing season shortleaf pine survival and growth along with woody regeneration species composition and height will be reported.

Clark, S., T. Keyser, S. Schlarbaum, and A. Saxton

Planted white oak (*Quercus alba*) respond to spacing density and orientation in gap openings in the Blue Ridge Mountains of North Carolina (ORAL)

White oak (*Quercus alba* L.) is difficult to sustain in many stands across the eastern United States because natural processes are failing to establish advanced reproduction. A study was implemented in the Blue Ridge ecoregion on the Pisgah National Forest in NC to examine artificial regeneration response to a relatively novel silvicultural treatment, the uneven-aged irregular shelterwood. The shelterwood was implemented as 0.25- and 1.0-acre gaps that will later be expanded over time on an area basis to create multiple age classes (i.e., Femelschlag). Planted seedlings were bareroot (1-0) from 10 pedigreed sources and were planted at two densities (2 by 2 ft or 12 by 12 ft) in the 0.25-acre gaps, while the 1.0-acre gaps were not utilized for this study. Each planting density was replicated three times, resulting in planting within 6 gaps. Within a single gap, groups of 10-30 trees were planted along the north or south axis extending from gap center at three distinct locations: center (2-13 ft from the gap center), edge (6 feet inside and outside the edge of the gap), and forest matrix (20-30 ft outside the gap edge). Seedling quality was relatively low but considered standard for southern commercial hardwood nurseries. Trees averaged 13.1 inches in height at the time of planting, ranging from 6 inches to 34 inches. First and second-year survival was 96 and 83 percent, respectively. Effects of spacing and orientation within the gap will be discussed within the broader framework of oak silviculture and regeneration processes.

Clatterbuck, W., and J. Biggerstaff

An evaluation of species composition and stand structure on patch cut vs. larger clearcut stands after 30+ years at Natchez Trace State Forest in West Tennessee (ORAL)

Few references are available examining the long-term effects of patch cutting in eastern hardwood forests. Patch cutting is defined as a small-scale clearcut of 2- to 5-acres, and it is generally prescribed to lessen the aesthetic impact of harvesting in highly visible areas. This study examines a change in the harvesting from clearcutting to patch cutting that occurred at Natchez Trace State Forest, located in the Coastal Plain of west Tennessee, in the 1990s. The objective of the study was to determine the regenerative effects (species composition and stand structure) of the patch cuts after 25-30 years compared to larger stand clearcuts conducted previously in the 1980s using the same sampling procedures. The patch-cut areas were hypothesized to have a

greater prevalence of shade-tolerant species and oak species (*Quercus*) than the clearcut areas. Data were compiled from both types of regenerated stands and compared. The areas that were previously patch cut are dominated by yellow-poplar (*Liriodendron tulipifera*) and have little to no oak species present. Poplar is dominant throughout the sampled patches, even along the edge. The areas that were previously clearcut had a much more diverse species composition, with total oak species being the most prevalent in those areas by both trees per acre and basal area per acre. The results from this study indicate that patch cutting is not an effective method for oak regeneration and development especially when yellow-poplar is present. Larger clearcuts to ensure stands at each stage of succession will enhance species and landscape diversity.

*** Cook, A., B. Oswald, H. Williams, K. Kidd, A. Shrestha, and J. Grogan**

First year survival and growth of ponderosa pine (*Pinus ponderosa*) and Jeffrey pine (*Pinus jeffreyi*) in the East Texas Pineywoods (POSTER)

Since the arrival of Euromericans in the United States, landscape conversion and changing climate have contributed to dramatic changes in species presence in the Pineywoods of East Texas. Current species may not be well adapted to future climatic conditions. Many western pine species such as ponderosa pine (*Pinus ponderosa*) and Jeffrey pine (*Pinus jeffreyi*) are often found on more xeric soils and reduced precipitation patterns, but which might reflect future conditions in this region. To evaluate the efficacy of western species as possible future species in this region, in November of 2021 we planted over 2,900 containerized seedings of two New Mexico sources of ponderosa pine, one source of Jeffrey pine, and western gulf coast genetically improved loblolly pine (*Pinus taeda*) seedlings on three site-prepared sites. Initial heights and root collar diameters measurements were made in January of 2022, and first year measurements of survival and growth were made in January of 2023. And analyses made to determine how the species performed after the first year, and how their responses compared to loblolly pine.

*** Corbin, T., M. Bataineh, B. Babst, and I. Hung**

Assessment of trade offs among ecosystem services of wetland reserve easements (ORAL)

The Wetlands Reserve Program aims to restore farmed wetlands through financial incentives to landowners. Establishment of easements includes taking a number of restoration measures to establish ecosystem processes that will ideally allow for the recovery of wetland functions. In this study, carbon storage and potential merchantable timber volume from ground-based inventory data collected from 30 easements in Arkansas were quantified. This data was then used to evaluate potential trade offs among wildlife habitat suitability, carbon storage, and timber production services. Higher carbon storage and merchantable yield values were associated with stands with relatively higher stocking. However, Forest Vegetation Simulator (FVS) projections illustrated a deviation from desired forest conditions for wildlife habitat for stands with relatively higher stocking values. It is likely that management intervention will be required to meet tree density-centric desired conditions, with the proportion of sampled stands expected to be within desired forest conditions dropping to 4% by 2054. Trade offs between carbon storage and timber yield will likely materialize in order to achieve desired habitat conditions for wildlife, with the maintenance of structural diversity resulting in initial losses of carbon storage and reduced timber yields. Despite these inherent trade offs, management techniques may be adopted for plantations on wetland reserve easements to meet forest structural habitat conditions for wildlife, while optimizing carbon storage and producing merchantable timber to mitigate management costs.

Craycroft, J., and C. Schweitzer

Predicting fire intensity using vegetation, fuel, and weather variables on the William B.

Bankhead National Forest, Alabama (ORAL)

When applying the tool of prescribed fire to achieve various goals, forest managers benefit from being able to accurately predict fire behavior with site- and time-specific data. At the William B. Bankhead National Forest in northcentral Alabama we are using three levels of thinning (none, light, heavy) and three fire return intervals (no fire, 9-year return, 3-year return) in mixed *Pinus-Quercus* stands to move stands towards more desirable structures. After 56 fires over 11 years, we have amassed a significant store of data related to fire temperatures and burn conditions. In this work, we model maximum fire temperature as a surrogate of fire intensity by using a mixed effects model that incorporates stand and vegetation variables, fuel loading measurements, and weather data. The random portion of our model estimates low correlation (est. rho = 0.21) of maximum temperatures within stand, but moderate (est. rho = 0.41) correlation within plots (plots are nested within stands). The fixed effects portion of our model reveals associations of maximum temperature with several vegetation (importance values of oaks and conifers, seedling counts of conifers and other species), fuels (loadings of both bark and duff), and weather variables (average ambient temperature and relative humidity over the 24 hours leading up to the burn start time; fuel temperature and fuel moisture). This presentation will detail the design and results of the model and highlight implications.

Crosby, M., and J. Adams

Evaluating bias in tree-level measurements obtained with a backpack LIDAR unit (POSTER)

The ability to rapidly acquire biometric data in forests will allow for timely decisions to be made regarding harvest, fertilization, prescribed fire, or other silvicultural treatment. High resolution tree-level data can be used in assessing tree conditions and in calculating tree- or stand-level volume estimates. Using mobile, terrestrial LIDAR (Light Detection and Ranging) units, such data collection is possible and provides an archive of present stand conditions. This study seeks to apply a mobile backpack LiDAR unit to assess an outplanting of American sycamore (*Platanus occidentalis*) in northern Louisiana. The objective of the present study is to compare LiDAR-derived measurements with in situ measures for height and ground-line diameter.

Cunningham, K.

Fuel load reduction and woodland restoration treatments in the Ouachita region of Arkansas (ORAL)

Natural shortleaf pine stands have historically occupied forest sites in the Ouachita Region. These forests have been maintained through time by combination of disturbances and fire. Through incomplete regeneration harvests and extended fire return intervals, some stands have developed dense vegetation at the ground to mid-canopy levels. This study explored combinations of chemical, mechanical and prescribed fire treatments to address heavy vegetation loads in a natural shortleaf stand located in the Ouachita Region of west Arkansas. Initial downed woody debris levels were 8.4 tons per acre across treatments. Mid-story trees averaged 1,070 stems per acre. Impact of treatments on downed woody debris tonnage, mid-story and understory stems per acre, fuel depth, duff depth and vegetation group presence will be presented. Response of shortleaf pine, oak and hickory reproduction to treatments will be included. Seventh year results will be provided.

Cunningham, K.

Individual tree response to commercial thinning in a mid-rotation red oak plantation in Arkansas (POSTER)

Negative consequences to stem quality following disturbance in young oak stands have been well documented. A primary response variable has been propensity for epicormic branching following stand disturbance across many hardwood species. Many hardwood plantations established over the past 30 years are nearing or in a condition warranting thinning. A study was conducted in White County, AR exploring combinative thinning methods in a 29-year-old oak (*Quercus* spp.) planting consisting of red oak group species. Initial stands were classified as overstocked with basal area per acre (BA/A) of 140 ft2 (472 TPA) acre. Fully stocked, post thinning target BA/A was 60-65 ft2 (180 TPA). A combination of fifth row thinning, plus selective thinning provided three treatments: selective thinned outside row, selective thinned inside row, and non-harvest control. Two-hundred and forty stems were marked for analysis, with 20 trees per plot and 4 plots per treatment in a randomized complete block design. Pre- and post-harvest relationships between stem, crown size, and epicormic branching response will be given. Year 4 repeated measures analysis for annual epicormic sprouting by treatment will also be presented.

Dean, T.

A novel, single-tree measure of growing stock based on volume growth (ORAL)

Silviculturists have a long history of using various metrics of tree dimensions to gauge potential growth rate relative to other trees. Single-tree measures of tree occupancy based on crown area and leaf area per tree are useful for judging trees to leave after a thinning. A potentially better measure of tree occupancy may be marginal height cost (MHC), i.e., stem volume added per unit height growth. Past results suggest that this measure of growth potential seems to be independent of site quality, age, and stand density unlike crown width and leaf area. Plot sums of MHC have been shown to be linearly related to a power of quadratic mean diameter (Dqx) times trees per hectare, the same mathematic form for total basal area per hectare (x=2) and Reineke's stand density index (SDI, x=1.6). I tested the hypothesis that MHC is a measure of individual-tree occupancy by fitting MHC to a power function of DBH for trees within a plot. The data for the test came from a thinning study installed in a 15-year slash pine plantation in central Louisiana. Plots were thinned at age 17 to 35% relative SDI, and residual tree growth followed for 5 years. Marginal height cost calculated for residual trees was shown to be proportional to DBH1.45 and the fits were unbiased across the range of DBH. I will demonstrate how this equation can be used to evenly distribute growing stock among diameter classes in a hypothetical uneven-aged stand for slash pine stand.

*** Dempsey, C., and M. McBroom**

Vegetative Analysis of Three Gulf Coastal Plains Vernal Pools (ORAL)

The unique hydroperiods of vernal pools provide important habitat for flora and fauna while at the same time providing hydrologic functions similar to jurisdictional wetlands including flood mitigation, groundwater recharge, and pollutant uptake and transformation. There is a lack of scientific literature available regarding vernal pools of the Gulf Coastal plains. This project characterized the hydrologic function and vegetation communities of three vernal pools that have not been significantly impacted by anthropogenic activities. Groundwater levels were monitored using a network of ten wells across the three wetlands. Soil moisture was measured using a series of probes within each wetland. Overstory and midstory species were inventoried on 1/20th acre plots based on diameter class. Percent coverage of ground cover was recorded within overstory/midstory species on 1/1000th acre plots, four plots per overstory/midstory plot. Inundation or saturated conditions persisted for as much as 359 days out of the year and 244 days during the 245 day growing season. The dominant overstory species consisted primarily of *Fraxinus caroliniana* and *Cephalanthus occidentalis* comprised the majority of the midstory, both

obligate species. Groundcover was predominantly grass. Of note is two of the vernal pools where prolonged periods of dry conditions (greater than two months) occurred had a substantial component of *Triadica sebifera*. The ecologic services and hydrological functions these features provide warrant additional research in order to facilitate increased conservation and restoration efforts.

*** Doughty, B., and A. Polinko**

Effects of fertilization and endophyte application on growth of planted longleaf pine (ORAL)

Longleaf pine (*Pinus palustris*) is an ecologically important pine species in the southern United States. Changes in fire regimes in the US South along with increased attention in more productive commercial species has resulted in a reduction in the native range of longleaf pine over the last century. There has been an extensive amount of research investigating the establishment and growth of longleaf pine. Longleaf pine has a unique characteristic grass stage that can last from 2 to 10 years and reducing the time in the grass stage may be solution for reducing the length of the rotation as well as restoring longleaf pine across its native range. Improving nutrient content through fertilization reduces the time of the grass stage, particularly when combined with herbaceous vegetation control. However, much of the fertilization research has been concerned with broadcast applications and little attention has been paid to directed controlled release fertilizers, which may reduce the cost of application in addition to reducing the time in the grass stage. In addition, information regarding the application of bacterial endophytes in Southern pines remains limited. This research explores contemporary techniques to improve the establishment of longleaf pine in a production setting. Specifically, the objective is to evaluate the role of controlled release fertilizer or endophytic bacteria on the establishment and growth of planted longleaf pine.

*** Doughty, B., A. Polinko, and J. Granger**

Stand dynamics of shortleaf pine-upland oak mixtures in northern Mississippi (POSTER)

Shortleaf pine (*Pinus echinata*) and upland hardwoods (white oak *Quercus alba*, black oak *Q. velutina*, and scarlet oak *Q. coccinea*) once dominated northern Mississippi. However, fire suppression as well as a preference for faster growing loblolly pine has resulted in a decrease in dominance of this forest type across the landscape. Much of the research regarding stand development in upland systems relates to single species stands while research on stand development in mixed-stands still remains limited. This study investigates stand development patterns in mixed shortleaf pine upland hardwood forests. A series of upland sites were selected across a gradient of site quality and species composition on both federal and private land. Overstory and midstory tree measurements including height, diameter, and status (live or dead) were recorded along with two increment cores per tree. Understory trees were destructively sampled to determine establishment age. Stand age structure will be quantified in the context of disturbance history, stand structure and species composition. We will present preliminary results, compare the results of modelled and current stand conditions, and discuss management implications.

*** Dues, K., A. Polinko, and J. Willis**

A machine learning approach to stand dynamics in a threatened forest ecosystem (POSTER)

Longleaf pine (*Pinus palustris*) plays a major role in the economic sustainability and ecosystem diversity of Southeastern forests. Longleaf pine had a historic range of 91 million acres; yet the current range of longleaf pine forests sits around 4.5 million acres. Many longleaf pine sites were

converted to faster growing competitive loblolly pine following harvest in the late 19th and early 20th centuries. The high ecologically diverse of longleaf pine sites leads to the existence of key habitat for several threatened or endangered species, including gopher tortoise and red-cockaded woodpecker. The reduction in range of longleaf pine, combined with a preference for faster growing species has led to a gap in quantifying individual tree growth in longleaf pine forests. As an ecologically important species, longleaf pine provides a unique opportunity to evaluate artificial intelligence in predicting individual tree growth in complex stand structures. Artificial neural networks act similarly to biological neural networks by creating artificial neurons (or decisions) that can be weighted for varying importance. We used increment core data collected across a range of sites and stand structures to predict basal area increment using a recurrent neural network. Developing a machine learning model to predict future growth and stand dynamics in longleaf pine systems will help quantify individual tree growth across a range of management objectives, ultimately expanding the use of computer science by forest researchers aiming to model forests.

*** Dugger, C., and W. Clatterbuck**

Advancing Established white oak (*Quercus alba*) reproduction through a midstory removal (ORAL)

White oak is a most difficult species to naturally regenerate, yet it is one of the most valuable and keystone species in the hardwood forest from wildlife and timber perspectives. Bumper acorn crops that exceed animal predation only occur every 5 to 8 years. The new, white oak germinants are one of the slowest growing species, often outgrown and suppressed by faster-growing competitor species unless actions are taken to give the germinants more growth resources, primarily an addition of sunlight. White oak requires an intermediate amount of sunlight, too much sunlight favors faster-growing intolerant species such as yellow-poplar and cherry, while not enough sunlight favors shade-tolerant species such as maples, beech, and many midstory species (sourwood, dogwood, and blackgum). This study capitalizes on a bumper white oak acorn crop during the fall of 2018 near Oak Ridge, TN and evaluates the release of 2nd-year white oak germinants through a midstory control treatment compared to uncut controls after 2.5 growing seasons to enhance size of white oak advance reproduction (compared to other species). Preliminary results indicate that the filtered sunlight received in the released plots are favoring height growth of white oak and limiting growth of other species (both intolerant and tolerant species), while the white oak seedlings in the closed-canopy control mostly maintained themselves or diminished with marginal height growth and increased mortality. The enhanced growth and size of white oak advance reproduction is projected to give them a greater competitive advantage once the overstory is removed.

Ellis, J.

Shortleaf pine restoration project on the I.D. Fairchild State Forest Texas A&M Forest Service (ORAL)

In 2008, the Texas A&M Forest Service (TAMFS) received a Shortleaf Restoration Grant from the USDA Forest Service to conduct shortleaf pine restoration management activities on the I.D. Fairchild State Forest. The dominant forest type on this 2083-acre state forest is mature, mixed loblolly and shortleaf pine and includes several bird foraging areas hosting a small population of the endangered red-cockaded woodpecker. TAMFS has several ongoing projects that focus on shortleaf restoration and conservation. We have used several different silvicultural practices in these projects including understory control via mechanical, herbicide, and prescription burning; artificial regeneration with shortleaf pine bare-root and containerized seedlings; and natural

regeneration of shortleaf pine using the seedtree and shelterwood methods. During this presentation, we will discuss the details of these projects, the knowledge gained from our efforts, and the questions that have yet to be answered. We will discuss the successful establishment and maintenance of our seedtree, shelterwood, and plantation stands in which shortleaf is the primary crop species. We will also present the results from our prescription burn activities in young, immature shortleaf pine stands in both the naturally and artificially regenerated stands. And lastly, we will present our outreach and education efforts towards, forest landowners, consulting foresters, and natural resource professionals in the management of the shortleaf pine ecosystem.

*** Everett, J.**

The effects of eastern redcedar encroachment on soil saturated hydraulic conductivity in the Cross Timbers (POSTER)

Agricultural abandonment and the exclusion of fire have led to increasing woody plant encroachment around the globe. In the Cross Timbers region of the south-central USA, eastern redcedar (*Juniperus virginiana*) encroachment has been increasing since the 1970s. With the continuing transition to eastern redcedar dominance in the region, we investigated the impact these novel forest systems have on the hydrological cycle. Using previously created random points within four paired watersheds in north-central Oklahoma, located at the Cross Timbers Experimental Range, we compared saturated hydraulic conductivity (Ksat) between two post oak (*Quercus stellata*) dominated woodlands and two novel eastern redcedar woodland systems. Additionally, we measured species diversity and richness using Daubenmire sampling at the same points to determine whether diversity and richness in the understory influenced Ksat. Using a Saturo (Meter Group) to measure Ksat, we determined that eastern redcedar woodlands had greater Ksat (approximately 9% greater) than nearby post oak forests with Ksat values of 15.58cm/h^{-1} and 15.90cm/h^{-1}, respectively. Shannon diversity index and species richness, however, showed little to no difference between the different forest cover types even though the post oak forests had much greater understory biomass. As eastern redcedar continues to become a more dominant component in the Cross Timbers region, this may accelerate hydraulic conductivity and reduce runoff, an important consideration in more water-limited regions of the south-central USA.

Ezell, J., A. Self, and A. Ezell

A comparison of glufosinate products for the control of natural pines (ORAL)

The availability and use of genetically improved pine seedlings has resulted in the need to control naturally occurring loblolly pine seedlings in areas to be planted. Seedlings from natural regeneration sources often occur in thousands or tens of thousands per acre. The recent concern over using glyphosate has prompted the search for an effective alternative for controlling this vegetation. A total of 15 treatments (including an untreated check) were applied to field sites in northern Mississippi which were well stocked with natural loblolly pines. The treatments included five glufosinate products applied alone and in mixtures with other herbicides. All treatments were replicated three times. Plots were evaluated at 14 DAT, 28 DAT, 56 DAT and 1 YAT. Results indicate that glufosinate is very effective at controlling loblolly pine.

Ezell, A., J. Ezell, and A. Self

Mid-rotation brush control in a loblolly pine plantation using Chopper GEN2 and selected glufosinate products (ORAL)

Mid-rotation brush control (MRBC) has been shown to be an effective part of pine plantation management in the South. Different formulations of imazapyr have been used for these applications depending on whether the application was completed aerially or by using ground equipment. However, there are situations in which additional herbicides may be needed to achieve the desired level of control. In this study, a total of 17 treatments were applied to the understory vegetation in a pine plantation that had been thinned. All treatments were applied in August, 2021 and replicated three times. Plots were evaluated at 30 DAT, 60 DAT, 90 DAT, 120 DAT, and 1 YAT. Treatments with glufosinate had rapid brownout. Control of hardwoods varied by treatment and results raise concerns over the efficacy of adding glufosinate to imazapyr for such applications.

*** Fillingim, H., B. Knapp, and J. Kabrick**

Insight into the roles of prescribed fire and hardwood competition in the survival and growth of shortleaf pine throughout its early life (ORAL)

Shortleaf pine is an economically and ecologically important species that was once prevalent across the southeastern United States, and there is growing interest in its restoration throughout its former range. One challenge with restoring shortleaf pine is competition from hardwoods. In Missouri specifically, many sites formerly occupied by shortleaf pine are now dominated by oak species with established, highly competitive advanced regeneration. This presentation incorporates results from three studies on the early life stages of shortleaf pine in the Missouri Ozarks. The first study focuses on the growth and survival of planted shortleaf pine seedlings over a 10-year period and highlights the importance of release from hardwood competition for the survival of shortleaf pine during this period. The second study focuses on survival, sprouting, and growth following prescribed burning of shortleaf pine and oak seedlings and saplings of various sizes (0-15 cm basal diameter). Results from this study suggest that properly timed fire can top-kill hardwoods without top-killing shortleaf pine, thus releasing shortleaf pine from the hardwood competition. The third study uses tree-ring analysis to study growth responses of shortleaf pine planted following a 2002 tornado in two stands with different known histories of management activities, specifically prescribed burning and mechanical release, across a range of competition levels. Taken together these findings provide insight into the roles of prescribed fire and hardwood competition in the survival and growth of shortleaf pine throughout its early life.

*** Goldberg, I., B. Knapp, and M. Stambaugh**

Aging the grass stage from a known aged outplanting of longleaf pine using modern dendrochronological techniques (POSTER)

Longleaf pine (*Pinus palustris*) is a foundation species of biologically diverse ecosystems throughout the southeastern United States. Unlike other species of southern pine, longleaf pine has a unique life history of producing little aboveground growth for the first few years of its life, developing a long taproot followed afterward by vertical height growth. Longleaf pine seedlings have been observed to stay within this “grass stage” for as short as two years to longer than a decade. Because of this, we do not know the true age of seedlings unless they were tracked from germination. There has been little published research on aging longleaf juveniles, with Pessin (1934) reporting that annual growth rings cannot be measured for “grass stage” longleaf pine. The objective of this research is to use modern techniques in quantitative wood anatomy to determine if longleaf pine seedings can be correctly aged. In 2017, we destructively sampled longleaf pine saplings that were planted as container-grown seedlings in 2003. Sections were taken just below the root collar, at the root collar, and just above the root collar in order to observe both belowground and aboveground annual growth. Each sample was sanded with

progressively finer grit to reveal cellular structure under microscope. This poster will describe the methodology used and report initial results. Accurately aging longleaf pine juveniles can reveal new research questions about longleaf demography and dendrochronology.

*** Goncalves Lazzaro, L., H. Alexander, J. Cannon, and M. Aspinwall**

Influences of overstory pyrophytic and mesophytic trees and understory solar irradiance on leaf litter and woody debris fuel moisture retention (ORAL)

Following decades of fire exclusion, open-canopied, pyrophytic oak and pine landscapes across the central and eastern U.S. are shifting to closed-canopied forests with a dense midstory occupied by shade-tolerant, often fire-sensitive species (i.e., mesophytes). As these encroaching species move into historically pyrophytic landscapes, changes in crown traits and microclimate may impact fuel bed moisture, and further alter fire frequency. Thus, changes in overstory conditions may impact fuel bed drying rates, which affects fire ignition, prescribed burns, and wildfires. The primary objective of this study was to understand how fine fuel moisture dynamics beneath overstory trees vary by the functional groups: fire-tolerant longleaf pine, fire-tolerant upland oak (*Quercus margaretta* and *Quercus laevis*), and fire-intolerant oak (*Quercus laurifolia*) to better understand potential impacts on prescribed fire effectiveness in systems with varying levels of mesophyte encroachment. The study was conducted at the Jones Center at Ichauway, Georgia, where 15 trees were selected, representing the functional groups. In summer 2022, we implemented a fuel drying experiment, in which 60 fully hydrated bags with leaf litter and fine woody fuels were placed under each tree and weighed every two hours. Based on preliminary data, we found that fuels tended to dry faster beneath pines and more slowly beneath mesophytic oaks. Also, woody fuels dried slower than leaf litter fuels, and pine needles dried faster than hardwood leaf litter. Better understanding the relationship between overstory, fuels and microclimate can lead to a better conservation management.

*** Greenslit, C., L. Peach, H. Adams, and R. Will**

The effects of water availability and nutrient addition on resin duct production in loblolly pine (*Pinus taeda*) in southeastern Oklahoma (POSTER)

Pine species produce resin as a defense against bark beetle infestation. Our study determined the impacts of water availability (ambient vs 30% reduction) and fertilization on resin duct production in *Pinus taeda* plantations in southeastern Oklahoma. We collected ten cores per plot from a factorial combination of plots with throughfall excluders established year 5 and fertilization applied years 5 and 10 (n=4). We measured resin ducts and tree ring areas using ImageJ. Average duct size was smaller (p=0.023) for trees grown with throughfall excluders (0.66 mm^2) than those without (0.61 mm^2). Fertilization increased duct count (p=0.045) (ducts per ring), but this effect was strongest the year after fertilization and was related to radial growth. Duct density (ducts/mm^2 ring) was greater for trees with simulated drought (p=0.027) with 0.44 ducts mm^{-2} for trees with excluders and 0.41 ducts mm^{-2} for trees without. Fertilized trees had larger relative duct area (duct area per ring area) (1.73%) than non-fertilized trees (1.61%) (p=0.002) and the wet, fertilized trees had the greatest (1.80%) while wet, non-fertilized trees the lowest (1.57%) (p = 0.001 fertilization x water). Overall, the effects of reduced water availability had mixed effects because while excluders increased duct density, the average duct size was reduced resulting in similar duct relative areas and reduced absolute duct area per ring (due to reduced radial growth). Fertilization increased duct relative area and ducts per ring. These results indicate that resource availability affects resin duct formation and potential resistance to bark beetle infestation.

*** Grochowski, J., B. Knapp, and S. Jack**

Evaluating restoration treatment effects on regeneration demographics in East Texas upland

mixedwoods using a chronosequence (POSTER)

Pre-settlement upland forests in East Texas were characterized by fire-driven woodland structure and dominated by pines and oaks. Fire suppression and conversion to plantation silviculture reduced the extent of this community type and allowed species typical of drainages and bottomlands, particularly sweetgum and yaupon holly, to colonize uplands. Upland forests with relict pine and oak overstories and dense midstories of yaupon and sweetgum have poor pine and oak regeneration, lack historically available wildlife habitat, and have reduced floristic diversity, so restoring upland stand structure and composition is of interest. At Boggy Slough Conservation Area, a restoration prescription consists of a sequence of treatments: harvest, dormant season prescribed burning, herbicide application, and growing season prescribed burning. We constructed a chronosequence of seedling demographics by collecting data in stands at each stage of the restoration prescription to evaluate the effects of each treatment on the abundance of competitors and desired species. Initial analyses show a promising reduction in yaupon abundance in the largest height class across the sequence of treatments, and further analyses will address the effects of treatments on desired pine and oak species. Reducing the abundance of large, overtopping yaupon holly may improve the competitive position of pine and oak seedlings. Knowledge about the effects of these treatments on regeneration demographics will help land managers select best practices for control of aggressive competitors and promotion of pine and oak species to restore mixed pine-oak uplands.

Grogan, J., K. Farrish, H. Williams, and B. Oswald

STMicroelectronics – SFASU Carbon Sequestration Reforestation Project (ORAL)

In 2000, STMicroelectronics, in partnership with the Arthur Temple College of Forestry and Agriculture at SFASU, began a carbon sequestration reforestation project which ultimately led to the reforestation of 3449 acres of marginal pastureland. From 2001 to 2004, pastureland was acquired, site prepared and planting using first-generation improved “drought-hardy” loblolly pine. Properties were subsequently donated to SFA with STMicroelectronics retaining the carbon rights. Site x genetic interactions have resulted in a plethora of timber quality issues on the resulting stands, necessitation early regeneration of many of these stands. Despite early difficulties with tree quality, stand volume growth/carbon sequestration has substantially exceeded expectations and numerous silvicultural research opportunities have resulted. Research has included carbon sequestration both above- and below-ground, thinning studies, comparisons of various southern pine and hardwood species, herbicide studies, site preparation/tillage treatment comparisons, and most recently, Nantucket pine tipmoth damage assessment. The project has resulted in substantial increases in forestry scholarships through timber revenue, provided a broad range of educational and long-term research opportunities, while meeting the original intent of the properties; carbon sequestration. A brief overview of project and numerous challenges encountered along the way, will be presented.

* Hayford, I., and B. Knapp

Factors affecting oak regeneration in bottomland hardwood forests in northern Missouri (ORAL)

Successful oak regeneration in bottomland forests can be limited by several factors, including number of seeds produced and viability, acorn predation, microsite conditions for germination and seedling establishment, poor seedling growth due to high shade, and herbivory of established seedlings. These factors interfere with developing large oak advance reproduction needed for successful oak regeneration and subsequent recruitment. Two studies were designed to test the importance of these factors on oak regeneration in bottomland forests in northern Missouri. The specific objectives were to test the effects of: 1) acorn predator exclosures on acorn removal; 2)

light gradients on acorn germination; 3) overstory and midstory release on survival and growth of oak seedlings; and 4) herbivory on survival of oak seedlings. Study 1 used a factorial design involving three levels of acorn predator exclosures established within three light levels. We found that poor seed crops and acorn predation were prevalent; however, germination of acorns was unaffected by light availability. Study 2 used a completely randomized split-plot design, with main-plot treatments being previous overstory harvest and the split-plot treatments including levels of midstory release. Midstory release increased light availability and improved development of underplanted oaks. Herbivory reduced survival of oak advance reproduction. Our findings suggest that natural regeneration is limited by acorn establishment, and subsequent seedling growth is limited by shade. Timely release of natural regeneration would be important following bumper crops. Alternatively, underplanting and midstory release may be used to provide sufficient large oak advance reproduction prior to an overstory harvest.

* Howie, N., J. Hart, and D. Goode

Prescribed fire effects on the spatial patterns of stand structure and fuel characteristics in a mixed oak-shortleaf pine forest (POSTER)

Prescribed fire is increasingly used as a forest management tool to restore and maintain fire-adapted ecosystems. Fire-adapted species produce pyrophytic fuels, which increases fire intensity, and in turn can inhibit the growth of fire-sensitive species. These vegetation-fuels-fire feedbacks influence, and are influenced by, intra-stand spatial patterns of biophysical elements. Alterations in forest composition and structure directly influence these biophysical elements, making our understanding of these feedback systems imperative to achieving long-term management objectives. We analyzed the effects of prescribed fire on the spatial characteristics of biophysical elements in a mixed oak-shortleaf pine stand in the Savage Gulf Natural Area, located on the Cumberland Plateau, Tennessee, USA. We monitored two 1-ha plots to investigate the impacts of fire reintroduction in a stand that has gone long unburned. A burned and unburned treatment were used to quantify species composition and fuel characteristics, analyze fuel and plant spatial distribution patterns, and illustrate their interactions. Inter-plot comparisons revealed that overstory tree density was comparable between burned and unburned plots, with no significant difference ($p < 0.05$) between the two. After two prescribed fires, mean density of saplings and seedlings were significantly reduced in the burned treatment when compared to the unburned treatment. Additionally, the spatial distribution of shortleaf pine and oak species were significantly clustered within both plots, indicating that localized canopy disturbances may have been influential in their current distribution.

Ivey, M., and J. Cannon

Modeling crown characteristics related to wind stability in slash pine (*Pinus elliottii*) (POSTER)

Slash Pine (*Pinus elliottii*) is an ecologically and economically important tree species dominant throughout much of the US Gulf Coastal Plain. Evidence suggests that slash pine is relatively wind resistant compared to many other southern pines. However, tree winching experiments suggest that trunk and root strength are similar among many species in dry soils. The higher wind susceptibility of slash pine, therefore, could be due to differences in canopy architecture, but it is unknown how canopy traits in slash pine vary with size and stand density. To address this knowledge gap, we scanned 12.2 ha across 3 slash pine stands using a terrestrial LiDAR scanner. The stands spanned a gradient of tree sizes (7-31 cm) and planting densities (4-62 m^2ha^{-1} basal area). We extracted point clouds of individual trees and derived crown attributes including height, canopy base height, live crown ratio, crown volume and area, and porosity. We assessed how each crown attribute varied with tree size, local density, and a size x density interaction using

multiple regression. As expected, larger trees were taller and had larger crown area. Lower planting densities produced trees that were taller for a given diameter, with raised canopies. This would contribute to higher torque from wind, contributing to windfall susceptibility. Comparisons of canopy traits across species can provide useful knowledge of how wind susceptibility changes during stand development as well as inform management strategies to minimize wind risk.

*** Iwamoto, C., C. Siegert, J. Granger, K. Poudel, A. Polinko, and Z. Freedman**

Sustainable pathways for shortleaf pine restoration in uncertain climates (ORAL)

Strip mining has left degraded soils throughout the southeastern US. To enhance the probability of success in forest restoration, combinations of organic (OA) and microbial (MA) soil amendments can be utilized to increase carbon sequestration and water availability. However, precipitation uncertainty due to climate change may challenge the effectiveness of our existing restoration techniques. This study represents a comprehensive greenhouse experiment to inform future reforestation efforts using shortleaf pine with consideration to climate change under different moisture regimes: dry, average, and wet. In a greenhouse, shortleaf pine seedlings were planted in replicates across moisture treatments receiving the following amendments: OA, MA, OA+MA, unamended control, or control with no trees. Tree growth parameters (survival, ground line diameter, height, root-to-shoot ratio), soil-water fluxes (dissolved organic carbon, specific ultraviolet absorbance at 254 nm), and soil health indicators (pH, carbon and nitrogen content) were measured throughout the study. After four months, survival was 62% across treatments. For the dry, average, and wet water regimes, the unamended control, OA+MA, and OA soil amendments saw the largest increase in height respectively. In the dry water regime, the increase was from 20.01 ± 1.57 to 27.33 ± 1.52 cm, 22.37 ± 0.67 to 28.37 ± 3.61 cm in the average water regime, and 22.14 ± 0.43 to 30.17 ± 1.37cm for the wet water regime. Further tree growth, soil-water flux, and soil indicator results are pending. Results from this greenhouse experiment will inform current restoration techniques using OA and MA soil amendments.

Jack, S., and R. Sanders

Silviculture at the Boggy Slough Conservation Area – management to promote conservation and research (ORAL)

The Boggy Slough Conservation Area (BSCA), located west of Lufkin, TX, is a 19,055-acre property with a mix of upland and bottomland forested ecosystems and a long history of management for conservation values. Since the early 20th Century the property has been under private ownership, first by the Temple family and then their namesake forest products corporation. The T.L.L. Temple Foundation purchased the property in 2013 to honor the Temple family, the corporate history, and their combined legacy in East Texas, and to demonstrate and promote forest conservation in the region. The mission of BSCA is to "serve as a model of excellence for East Texas through ecological research and outreach to promote conservation, management, and stewardship of natural resources." To pursue this mission, bottomland forest management focuses on regenerating desired species and controlling invasive species; upland management works to restore and maintain an open pine or pine-hardwood canopy, promote native ground cover species, and favor shortleaf and longleaf pine where appropriate. Primary silvicultural treatments in the uplands include selection-based harvests, frequent prescribed fire, and targeted use of herbicides. Case studies illustrate progress in the uplands after seven years of management – the open canopy forest condition is now more prevalent on the property, and wildlife community responses to changing habitat are documented. Research is conducted via collaborations and a new visiting scholar program, and the property is frequently used for outreach events by BSCA and partners to show conservation-oriented alternatives to the dominant forest management regimes in East Texas.

*** Jha, S., S. Yang, S. Hale, and T. Johnson**

Quantifying aboveground biomass using remote sensing and ground measurements for mixed-hardwood forests (ORAL)

Accurately predicting forest aboveground biomass (AGB) is essential to estimate forest productivity and monitor forest carbon dynamics. The objective of this study was to quantify forest AGB using remote sensing and ground measurements. Specifically, Shuttle Radar Topography Mission Digital Elevation Model (SRTM-DEM), Landsat-8 and Sentinel-2 images were used to derive 122 remotely sensed variables (60 from each satellite image) (e.g., raw spectral bands, vegetation indices, texture indices and terrain metrics). Three ground-based variables computed from forest inventory data were examined, which included, mean stand height, trees per ha, and basal area per ha. Random forest algorithm with recursive feature elimination (RFE) method was used for model fitting and variable selection. A pilot study was conducted using carbon inventory data collected from three sites in eastern Tennessee. The forests are dominated by oaks, hickories, maples and yellow poplar. Results show that models with both remotely-sensed and ground-based variables produced more accurate predictions than those with only remotely-sensed variables. In general, models with variables computed from Landsat-8 yielded lower RMSE and greater R^2 than from Sentinel-2. The number of important predictors selected varied among models, but the ground-based variables ranked higher than remotely-sensed ones. Among all remotely-sensed variables, texture metrics explained more variability of AGB than other variables. Formal analyses will be made by including more sites in the region. The results of this work will provide additional insights on applying remote sensing information in forest modeling.

*** Kennedy, I., M. Mount, W. Clatterbuck, J. Franklin, and D. Buckley**

Evaluating the trajectory of secondary vegetational succession on clear-cut timber and strip mined sites (ORAL)

Rates and pathways of secondary succession were investigated and compared between clear-cut and strip mine sites in east Tennessee using chrono sequence techniques. Plots were established at 5-year age intervals ranging to 30 years after the disturbances on sites with similar productivities. Clear-cut sites were hypothesized to undergo vegetative succession more rapidly than strip mine sites due to the intensity and impact of disturbance on the substrate. A control site for each type of disturbance was also evaluated as a metric for the expected pathway of succession, community structure, and species composition (forest type). These sites were selected for their lack of human disturbance and proximity to disturbed areas. Preliminary results suggest that clear-cut sites are progressing away from their previous oak-hickory type at a more rapid successional rate as hypothesized. If an oak-hickory species composition is to be maintained after these stand initiation disturbances, silvicultural practices to encourage these species are recommended.

Knapp, B., and S. Jack

Reconstructing stand development patterns of oak-pine mixedwoods at Boggy Slough Conservation Area (ORAL)

Upland forests of east Texas were historically comprised of varying mixtures of pine and hardwood species, with local composition driven by site characteristics and fire regime. Many previous natural forests in the region were converted to agriculture or plantation forests of loblolly pine, and an extended period of fire exclusion resulted in the densification of other forestlands. The restoration of natural communities, including upland woodlands with mixtures

of shortleaf pine and oak species (e.g., post oak, white oak, southern red oak) provide conservation benefit, but we lack information on optimal silvicultural practices for their management. Examples of mature upland pine-oak stands are legacies of past land management, representing a target that may be difficult to regenerate with current approaches. We examined contemporary and past stand structure/composition and stand dynamics of mature upland pine-oak forests of Boggy Slough Conservation Area (BSCA) near Lufkin, TX, using dendrochronological stand reconstruction approaches. We sampled nine mature pine-oak stands across the property, primarily from upland sites with ecological site classifications of shortleaf pine-post oak or shortleaf pine-southern red oak communities. Within each stand, up to 60 trees (30 pines and 30 oaks) were cored to determine age of establishment and growth patterns. Initial analyses indicate that shortleaf pine and oaks were primarily restricted to larger diameter classes. Loblolly pines occurred across all diameter classes, while non-oak hardwoods were primarily in small diameter classes. Results suggest current challenges with regenerating shortleaf pine and oak species may shift these communities away from historical condition without additional management.

*** Lewis, J., O. Joshi, L. Zhai, and R. Will**

Productivity of hybrid sweetgum plantations in southeastern Oklahoma and northeastern Texas (POSTER)

The pulp and paper industry of the south-central U.S., which relies partially on hardwood timber, has faced supply chain issues due to excessive mortality in hardwood stands, harvesting/ transportation challenges, and heightened demand in the oil and gas industries for hardwood-based products. Further, demand is rising for wood-based renewable energy. Dedicated, dual-purpose plantations are a solution, utilizing highly productive and site-tolerant species. Sweetgum (*Liquidambar styraciflua*) is an ideal hardwood candidate, but recent findings suggest that hybrid sweetgum (*Liquidambar formosana* x *styraciflua*) exhibits superior growth under highly controlled conditions. Our study, spanning southeastern Oklahoma and northeastern Texas, explored this at an operational scale by comparing plantations of various ages across a range of site conditions. Thirty-four plantations were sampled, 10 with half-sib families of sweetgum and 24 with hybrid clones. Planting densities and management intensity were similar across plantations. Ages ranged from 6-11 years for half-sib families and 5-8 years for hybrid clones. In general, we found hybrids had greater stem biomass and volume than half-sibs for a given DBH due to greater specific gravity and decreased stem taper. Wood specific gravity was significantly greater for hybrids (0.49 vs 0.46 g/cm^3), as was stem bulk density (58.7 vs 54.5 lbs/ft^3). Based on the stand age-biomass relationships, hybrids also exhibited accelerated growth (9.4 vs 6.1 green tons/acre/year), though current annual increments will be calculated after the 2022 growing season. We conclude that hybrid sweetgum is superior to sweetgum in terms of productivity and could serve as an important biomass species in the future.

Liu, Y., H. Tian, B. Tao, and J. Yang

Future trends in dead fuels and implications for prescribed fire in the southern United States (ORAL)

Prescribed fire as a forest management tool for forest health and wildfire risk reduction treats more than 6 million acres of forestry and rangeland each year in the southern US, accounting for about 60% of total treated area in the US. Research has suggested an increasing need in prescribed fire under changing climate due to faster ecosystem cycling and more intense wildfires. This study analyzes this need for the southern US by projecting future trends of various components of forest fuels. Current and future fore fuels were simulated using a dynamical global vegetation model, the Dynamical Land Ecosystem Model (DLEM). The DLEM carbon pools include

litter and duff (1-hour and 10-hour dead fuels), herb / grass, shrub, and coarse woody debris (100-hour and longer lag fuels). The regional climate change scenarios were obtained from the dynamical downscaling of the North American Regional Climate Change Assessment Program. The DLEM projection shows that, while shrub and live herb are likely to increase, the dead fuels that are subject to be removed by prescribed fire are likely to decrease. The decreasing trend is clearer in the areas where prescribed fire is used more extensively at present. The result suggests that the need in increasing prescribed fire under changing climate would be eased in some areas of the southern US if removing accumulated dead fuels is a primary goal of the burning.

*** Luitjens, S., J. Hart, and J. Goode**

Spatial patterns of species composition after catastrophic wind disturbance in a longleaf pine (*Pinus palustris* Mill.) woodland (POSTER)

Spatial patterns of mortality and tree survival influence post-disturbance succession and development through tree establishment, growth, and neighborhood effects. Biological legacies are components of ecological memory and their spatial arrangements may influence the regeneration patterns, composition, and resiliency. Our goal was to quantify intra-stand spatial patterns of woody plant composition in a catastrophically-wind disturbed and fire-maintained *Pinus palustris* woodland and infer the drivers of these patterns. We georeferenced all trees in a 1.6-hectare plot to investigate uni- and bivariate spatial point patterns. To create an inferential model for stem density, we used site factors, such as slope, as predictor variables. Significant aggregation within species and litter flammability-class types was observed, implying a positive feedback loop from residual stems. Significant repulsion between species and aggregation within species was observed, indicating species-specific neighborhood patterns. The spatial pattern of flammability classes exhibited significant repulsion, which can result in patchy fires, as intensity of fire may not be uniform. Bare soil, canopy cover, slope, and slope position elevation were significant predictors of stem density. Through an inferential model, this study enhances our understanding of the spatial patterns and drivers of post-disturbance regeneration which may inform future silvicultural decisions. Understanding spatially-explicit species interactions in catastrophically-disturbed stands provides valuable information on succession, development, and resiliency.

*** Majekobaje, A., and T. Dean**

Branch growth and mortality as influenced by light attenuation (ORAL)

Mechanisms of branch mortality remain poorly understood, hindering our ability to predict where the base of live crown is, and to understand how different stressors affect canopy dynamics and why some species are able to retain more branches than others. Carbon starvation and hydraulic failure are two leading hypotheses formulated to explain tree mortality. Here, we set up an experiment to understand the conditions that lead to the death of lower branches under shade conditions, and this paper presents the preliminary result from this study. In the spring of 2022, prior to bud burst, shade structures (consisting of 0%, 30%, and 60% shade clothes) were installed on one branch each of 30 seven-year-old loblolly pine trees at Lee Memorial Forest, Franklinton, Louisiana. Initial measurements of branch length, diameter at the base of branch, length of terminal leader, and diameter of terminal leader were carried out for all branches at the beginning of the study. Subsequent measurements were then carried out weekly until growth slowed down in August 2022. The slowest growth rate and indication of mortality were observed in the branches growing under the deepest shade. This result helps improve our prediction of where the base of live crown is, hence, crown size. Growth and biomass of other parts of a tree are a function of its crown size. Thus, crown dimensions often serve as predictors in process-based forest growth

models. Improved prediction of crown size will ultimately lead to improved process-based models predicting stem growth and mortality.

*** Markus, T., L. Pile-Knapp, D. Coyle, and G. Wang**

Seasonal light response curves of *Ligustrum sinense* (Chinese privet): a test of extended leaf phenology (ORAL)

Chinese privet (*Ligustrum sinense* Lour.) is an invasive shrub common throughout the southeastern U.S. The foremost concern of Chinese privet (CP) is its highly competitive nature, displacing native plants, pollinators, and wildlife communities. Understanding invasive species' physiology will help determine how it competes with native species and improve management decisions. Extended leaf phenology (ELP) is an adaptation in which understory plants in deciduous forests take advantage of higher sunlight levels during the dormant season when canopy foliage is absent. CP is semi-evergreen to evergreen, which may allow it to use ELP to gain carbon and use soil resources during canopy leaf-off enabling a competitive advantage over native species. Determining the amount of carbon gain due to ELP requires measuring photosynthetic activity during the dormant season. A gas exchange analyzer, CIRAS-2 with the PLC-6 cuvette (P.P. Systems), was used to create light response curves for CP occupying forest edge and interior habitats. We found that CP actively photosynthesizes during native canopy absence, and carbon assimilation rates depend on whether the shrub is in the forest edge vs. the interior. We observed habitat and seasonal variability in leaf shedding or leaf replacement. CP in both habitats retained leaves throughout the winter of 2019-2020, but it shed leaves in the edge habitat during the winter of 2020-2021, likely due to interannual climate and variation and microclimate conditions. Our results provide evidence of the competitive ELP potential of CP. However, winter leaf senescence variability may pose management difficulties for planning foliar herbicide applications.

*** Markus, T., L. Pile-Knapp, C. Oswalt, W. Bridges, and G. Wang**

Invasive plant impact of fuels: an implication to fire behavior (POSTER)

Invasive plants are increasingly changing the composition and structures of the forests in the southern region of the US, which may have significant implications for fire behavior. The purpose of this project is to use the US Forest Service's most recent Forest Inventory and Analysis (FIA) plot data (2015-2019) and forest health variables (2014-2018) in the Southern Region of the US to determine if invasive plants alter fire behavior. The FIA invasive species subplot data will be used to rank invasion severity, high, low, or none, using species cover percentages with the most common invasive species identified by forest type. The extrinsic fuel properties (e.g., down woody debris, depth of fuel bed, litter, duff, and percent of coverage of herbaceous and woody species) will be compared between invasion severity and forest types. It is expected that the most significant impact on changing extrinsic fuel properties, which may potentially alter fire behavior, may be caused by the most frequently occurring invasive species. This project aims to identify the potential for invasive plants to change fire ecology in the southern US and to help land managers, wildland firefighters, and policymakers better predict fire behavior in forests with different degrees of invasion.

Matthews, J.

Current trends in timber sale receipt utilization within the USDA Forest Service (ORAL)

Congress has granted the USDA Forest Service authority to retain timber sale receipts and utilize them for numerous land management purposes. Over the last 10 years new authorities have been granted to broaden the range of timber sale receipt utilization. These new authorities have shifted

how national forests are approaching portfolio management to determine the best ways to utilize the timber sale receipts. Historically, authorities utilized included Knutson-Vandenberg for sale area improvements, Salvage Sale Funds, and Stewardship Authority. More recently the Good Neighbor Authority and Knutson-Vandenberg for use outside the sale area authority have opened up many new opportunities for funding projects which would previously not have had funding. Fund collections and accomplishment reporting highlight the increasing shift towards utilization of these new authorities as well as a continued increase in the use of stewardship contracting authorities. Congress has entrusted the USDA Forest Service to manage these funds wisely and it is imperative that funds are used appropriately for priority projects.

* McBride, K., M. Aspinwall, and H. Alexander

Temperature adaptation and acclimation in southern pine species and populations (POSTER)

Warmer and more variable temperatures have the potential to alter the health, function, and sustainability of southern pine forests, as well as the economic and ecological benefits they provide. Tree responses to warming and temperature variability likely differ among pine species and populations, as each may possess different physiological adaptations and temperature tolerances. Despite a rich history of research on southern pines, our basic understanding of temperature adaptation and genetic variation in temperature acclimation in southern pine species remains limited. To address this, we conducted a common garden experiment with loblolly (*Pinus taeda*), longleaf (*Pinus palustris*), shortleaf (*Pinus echinata*) and slash pine (*Pinus elliottii*). Seedlings were selected from three or more geographically distinct populations for each species, allowing us to explore genetic differentiation in temperature adaptation within species. We tested the hypothesis that species and populations from cooler and more seasonal climates will generally show a lower photosynthetic temperature optimum, higher basal rates of leaf respiration, and a greater capacity for seasonal temperature acclimation of photosynthesis and respiration in comparison to species and populations from warmer and less seasonal climates. As an extension of this hypothesis, we tested the extent to which temperature adaptation influences the ability of southern pine species and populations to acclimate to temperature variation. This study's advances in quantifying the photosynthetic and respiratory responses of southern pine species to temperature variation can inform models of vegetation responses to climate change and management decisions aimed at sustaining or improving southern pine forest productivity into the future.

McDaniel, V., and G. De Jong

Natural plant succession of a dozer line in Arkansas (ORAL)

Silviculture operations require the construction of miles of temporary roads to extract timber and dozers lines are routinely created to suppress fires on National Forest lands across the US. It is well-known that such disturbances can be gateways for non-native invasive plants to spread into native ecosystems. Also, managers often seed these temporary roads with annual fast-growing non-native species to control soil erosion. The recolonization process of these disturbed landscapes is not well-studied and differs from region to region. In the spring of 2021, a dozer line was built through a botanically diverse, high quality shale glade and woodland ecosystem on the Ouachita National Forest in Arkansas. All vegetation was removed along the 300-m dozer line with a width that varied from 5 to 30 meters. The area was not reseeded. We installed 60 one-m^2 quadrats at 5-m intervals along the center of the dozer line and measured them 3 and 6 months after the disturbance. We identified each plant to species and gave it a cover class. Vegetation recovered quickly and covered most of the disturbed area within the first growing season. While most species were native, several non-native species increased in frequency. Monitoring these

disturbed areas is important because early detection and treatment is key for success and less costly in the long run. The need to seed dozer lines and temporary roads in certain forest types may not be necessary, as the seed bank and bud banks are sufficient to colonize and prevent erosion.

McDaniel, V., G. De Jong, D. Zollner, S. Hooks, T. Keyser, and D. Bragg

Using fire and thinning to restore open woodlands in the Ouachita National Forest (POSTER)

Restoration of the once-open canopy forests of the southern US is now a common goal of many resource management agencies. For instance, the Ouachita National Forest uses both midstory thinning and prescribed burning in the shortleaf pine-dominated forests of Arkansas and Oklahoma to reduce tree density and increase diversity of ground flora and associated fauna. For the last 10 years, the USDA Forest Service has worked with The Nature Conservancy on a Collaborative Forest Landscape Restoration Project to monitor progress toward a desired future condition in these shortleaf pine-dominated woodlands. Desired future condition is a summary of the desired structural and composition changes to a forest after management is implemented. Since 2012, three measurements were taken three years apart on 100 ten-meter radius plots to evaluate the effectiveness of restoration treatments on stand basal area, tree stem density, species richness, native species richness, and FQI (Floristic Quality Index). Plots managed with fire and thinning had significantly lower basal area and stem densities, and significantly higher species richness, ground layer species richness per plot, ground layer cover, and average FQI than unmanaged plots. Fire alone or in conjunction with thinning moved plots toward the desired future condition.

McNab, W.H.

Response of advance regeneration 20 years following three levels of commercial thinning in a 45-year-old eastern white pine plantation on a dry site in the southern Appalachians (POSTER)

During the 1960s and 1970s, low quality sites in national forests of the southern Appalachian Mountains were typically regenerated by clearcutting and planting eastern white pine seedlings (*Pinus strobus*) to increase productivity. Following later changes in management objectives, those stands are now being targeted for partial or complete harvest and restoration of natural communities. Because pine seedlings were planted densely to exclude hardwood competition, basal area in mature pine stands can be high (>200 sq. ft/ac). A management question is composition of advance regeneration in relation to desirable species (oaks and hickories). The purpose of this nonreplicated case study was to determine the composition and response to three levels of white pine partial harvest treatments, which consisted of reducing stand basal area from below by either 0 percent (control), 33 percent, or 66 percent. Mean oak site index of a mature adjacent stand was 72 feet at 50 years and 99 feet for white pines. After 20 years of response following thinning species composition did not differ among the three treatments. Preliminary inventory data indicated stocking of approximately five thousand hardwood stems per acre of which about 20 percent were white oaks (*Quercus alba*). Unanticipated was the presence of yellow-poplar (*Liriodendron tulipifera*) saplings on the heavily thinned (66 percent) treatment, which were not present in the control. Results from this study suggest that adequate advance regeneration of desirable species may be present in harvested white pine plantations and can respond to release without the need for artificial regeneration.

McNulty, S., and C. Stelly

Updating the Silvics of North America: progress, timeline, and involvement (ORAL)

Last published in 1990, The Silvics of North America (SNA) is the most used silvics guide in the world. However, being over 30 years out of date has caused the manual to fall behind in critical topics such as climate change impacts and species range mapping. Moreover, with less than 200 species included the guide does not fully represent tree species throughout North America. Therefore, the Updated Silvics of North America Project (USNAP) was launched by the U.S. Forest Service as a collaborative effort with Canada and Mexico to revise this manual. This revision will include an expanded species list especially as it relates to Canada and Mexico, new range and projection maps, and more information on important topics such as disturbances and goods and services. Additionally, the USNAP is developing a new digital platform to host the SNA that will allow for easier and more efficient access through electronic media (e.g., tablets, cell phones, laptops). The SNA will also be available in Spanish and French for the first time. This presentation will give an overview of the current progress and timeline, and conclude with an invitation to apply for a lead author position on any of the available species chapters. If selected, submitted chapters will go through a formal peer review process before being published in the new SNA with proper credit given to all associated authors and review members.

Minogue, P., and K. Lorentz

Aminocyclopyrachlor cut stem applications compared to standard herbicides for Eucalyptus control (ORAL)

Eucalyptus plantations are grown for fiber, fuel, and other uses on more than 17.8 million ha world-wide, yet some species are considered invasive and have adverse environmental or social impacts. A new herbicide, aminocyclopyrachlor (AMCP) was evaluated to determine rate response for control of planted eucalyptus trees by cut stem treatment and compared to standard applications of imazapyr and triclopyr herbicides. Using a AMCP product containing 120 g acid equivalent per liter, the lowest rate tested, 12.5% in water, resulted in 100% eucalyptus crown reduction and greater control than the standard aqueous preparations of 8% imazapyr product (460 g acid equivalent per liter) or 50% triclopyr amine product (360 g acid equivalent per liter) at 6 and 12 months after treatment, for all diameter classes. Increases in stem height and diameter at 24 months after treatment suggest that control obtained using imazapyr cut stem treatment may be impermanent. AMCP treated trees did not have regrowth by 24 months after treatment.

Montes, C., M. Wang, B. Bullock, and D. Zhao

Effects of fertilization and vegetation control application under different thinning intensities in the southeast US (ORAL)

Fertilization and competing vegetation are two practices to improve loblolly pine stand productivity and carbon acquisition in the southeast US. To evaluate the interactions between these silvicultural treatments and thinning effects, a region-wide trial was established by the plantation management research cooperative back in 2012. Three levels of thinning intensity after the first or second thin interventions, plus four silvicultural treatments (Control, Fertilization, Competition release, and Fertilization plus competition release), were established over a wide range of sites with different soil and climatic conditions in the southeast US. Six years after treatment, our results show more significant responses to fertilization than competition release treatments when treatments were applied after the first thin on the lower coastal plain, upper coastal plain, and piedmont sites. The same pattern was observed eight years after on the second thin in sites of the lower coastal plain areas. Responses to competition release were larger than fertilization responses when applied in combination with a second thinning on upper coastal plain and piedmont sites. Our results highlight the importance of timing activity for thinning opportunity.

*** Morrison, A., D. Unger, D. Kulhavy, I. Hung, and Y. Zhang**

Small NIPF landowner Landsat imagery survey (POSTER)

Assessment and quantification of NIPF landowners that own 50 acres or less of forestlands across east Texas using Landsat imagery and county appraisal district parcel data. NLCD (National Land Cover Dataset) data, derived from Landsat data, proved to be especially useful in understanding the diversity of forested lands and cover type in each of the 43 counties of East Texas. In conclusion, Landsat imagery has proven to be immensely helpful in identifying areas of manageable forestland across East Texas.

*** Murray, J., D. Hagan, P. Hiesl, and R. Baldwin**

The influence of slash management practices on water and nutrient dynamics in longleaf pine forests (ORAL)

(1) Silvicultural applications that manipulate woody debris loading and the structural composition of a forest can have both short and long-term effects on biogeochemical cycling. Longleaf pine forests have been the historically dominant community types throughout much of the Southeastern United States. Fire exclusion, hardwood encroachment, and resource exploitation have severely reduced the amount of remaining longleaf pine habitats, making ecological restoration necessary. The silvicultural treatments used to reestablish these communities have been widespread, leading to some skepticism regarding the sustainability of certain restoration practices. (2) This study aimed to understand how overstory manipulation and woody debris management affected soil water retention rates and nutrient availability. Using a randomized complete block design, abiotic responses to biomass harvesting, conventional harvesting, and mastication treatments were measured across a soil moisture gradient in the South Carolina sandhills. (3) Our findings indicate that mastication increased soil moisture retention rates by 37% and 41%, on average, compared to conventional harvesting and biomass harvesting, respectively. (4) Additionally, soil nutrient stocks did not decline following any management practice, indicating that both biomass harvesting and mastication treatments may not necessarily impact site productivity in a negative manner. These findings imply that mastication treatments keep moisture retention high and do not immediately change soil nutrient availability in longleaf pine forests. Long-term vegetation response studies should continue to document successional trends in conjunction with moisture retention rates and long-term nutrient pulsing.

*** Murray, S., L. Zhai, R. Will, and H. Gholizadeh**

Drought effects on the relative importance of multiple stand attributes and site conditions on forest productivity (POSTER)

Under the threat of increasing drought, previous studies showed that changes in key stand attributes and site conditions could alleviate drought impacts on forest productivity. However, there is a lack of comprehensive comparison to determine the relative importance of key factors or their interactive effects with drought in forest responses for efficient adaptation strategies. To address this knowledge gap, we compiled U.S. Forest Service Forest Inventory and Analysis (FIA) data from 2295 plots across southcentral U.S. forests, stressed by a serious drought from 2010-2015. With the repeated survey of the FIA plots, we calculated forest productivity given ingrowth of new trees, growth of existing trees, and net change after accounting for mortality. Using 'random forest' statistical models, we quantified the interactive effects of 15 factors (eight stand attributes and seven site conditions) with drought on forest productivity. Our results showed that: (1) stand age and functional identity characterized by leaf C:N showed stronger interactive effects on the ingrowth, growth, and net change but basal area and species richness only showed

moderate interactive effect with drought; (2) soil nutrient availability showed the greatest interactive effect on ingrowth, but the most important interactive factors with drought on growth and net change were temperature and aspect, respectively. Managing for younger stands by reducing rotation length potentially alleviates drought impacts, leaf C:N could be considered to select species in drought adaptation strategies, e.g., planting and selective thinning, and soil nutrient availability and aspect could inform site selection and preparation to sustain productivity under drought.

*** Nation, R., H. Alexander, J. Willis, M. Aspinwall, and J. Cannon**

Does longleaf pine cone production correlate with seed production, size, and germination rate? (ORAL)

Fire-dependent longleaf pine (*Pinus palustris* Mill.) ecosystems in the southeastern U.S. require viable seed sources for successful natural regeneration. Most studies focus on cone production, but there is little understanding of whether seed production and viability mirror cone production, which may be decoupled at high cone production levels. To better understand longleaf pine cone-seed relationships, we conducted two rounds of longleaf seed collection from trees representing a gradient of cone production during seedfall (mid-October to early December). In 2021, we collected seeds from 10 trees in a longleaf pine stand in southwest Georgia, U.S.A., using 10 0.25-m^2 seed traps placed under each tree. In 2022, we collected seeds in the same stand in southwest Georgia and in two stands in northwest Florida, U.S.A., with 10 trees in each stand and three 3-m^2 seed traps placed under each tree. We tallied seeds to determine seed production and measured seed length, width, and mass to explore seed size trends and their relationship with cone production and seed viability. We also conducted germination trials with the collected seeds in a growth chamber under controlled conditions (20 °C, 16:8 hr light:dark). Preliminary results indicate that seed production increases linearly with cone production ($R^2 = 0.82$, $P < 0.001$), with 0.37 fully developed seeds (wing with seed present) collected per cone. Identifying relationships between cone production, seed production, seed size, and germination rate will provide managers and landowners with a better method of predicting success of natural regeneration efforts in their longleaf pine stands.

*** Nyen, G., A. Polinko, and J. Puhlick**

Silvicultural strategies for converting longleaf pine plantations to multi-aged longleaf pine stands (ORAL)

In the late 1990s and early 2000s, incentives for planting longleaf pine resulted in thousands of hectares of mostly marginal agricultural lands being converted to longleaf pine plantations. For plantations that have been commercially thinned, ecosystem services like improved wildlife habitat and carbon sequestration could lead some landowners to convert plantations to multi-aged stands. However, silvicultural strategies for converting longleaf pine plantations to multi-aged stands need to be developed for local site conditions. The overall goal of our project is to develop silvicultural strategies for converting longleaf pine plantations to multi-aged longleaf pine stands. Our first objective is to determine the number of gaps and range of gap sizes created by Hurricane Michael (October 2018) in longleaf pine plantations that were commercially thinned for the first time in 2014. These metrics could be a natural analogue for converting plantations to multi-aged longleaf pine stands. Our second objective is to develop guidelines for restoring native grasses and forbs after the first commercial thinning of planted pines. These guidelines will be based on actual plantings of native groundcover after commercial thinning in longleaf pine plantations at the Jones Center at Ichauway in southwestern Georgia. The relative success of groundcover restoration will be based on aboveground biomass of individual species of native

grasses and forbs. We will also determine the influence of canopy openness and soils on average planted grass and forb biomass within plantations. Finally, we will document recruitment of new cohorts of pine within canopy gaps created during Hurricane Michael.

*** Ozment, L., L. Zhai, B. Murray, R. Will, and O. Joshi**

Drivers and projections of suitable ranges of major woody biofuel species under climate changes (POSTER)

Woody species have been proposed for biofuel production given their advantages over non-woody species. However, effects of climate change on the suitable ranges of woody biofuel species are still largely unknown, creating critical knowledge gaps in woody biofuel development. For eight potential woody biofuel species, we obtained species presence data from plots across the contiguous U.S. surveyed by the U.S. Forest Service Forest Inventory and Analysis (FIA) program. We used multiple algorithms to model climate impacts on distributions of these species given the effects of soil, forest structure, and elevation. Moreover, suitable ranges of the species were projected in low and high carbon emission scenarios. Our results showed that 1) Accuracy of our models were relatively high for most species studied (AUC > 0.8), except for Acer rubrum with AUC < 0.7; 2) All species were more sensitive to variation in precipitation and soil water availability than the other factors used; 3) Compared between current and future climate scenarios, half of the species (*Juniperus virginiana, Liquidambar styraciflua, Liriodendron tulipifera,* and *Pinus taeda*) were projected to expand their suitable ranges, but the others (*Acer rubrum, Populus deltoides, Platanus occidentalis*, and *Quercus velutina*) reduced their suitable ranges. We conclude that selections of species and sites based on predicted climate changes are critical to building plantations of woody biofuel species, and the integration of species distribution models and large-scale forest surveys could inform natural climate solutions, such as biofuel production.

Peairs, S.

Use of post-emergent herbicides (clopyralid and imazamox) for seedling release in an oak shelterwood (ORAL)

Land managers have a limited selection of post-emergent herbicides that can be used for oak seedling release. Post-emergent herbicides may be more effective (compared to pre-emergent options) at controlling non-oak, woody species which may be problematic in post-disturbed, regenerating hardwood stands. This study was conducted on the Clemson Experimental Forest within an upland hardwood stand that had recently received a shelterwood harvest. Clopyralid and imazamox herbicides were applied singly and in combination as individual treatments. Treatments were applied on June 27 & 28 and July 6, 2022 as foliar broadcast sprays using a pressurized backpack sprayer. Individual white and red oak seedlings were marked with florescent flagging prior to spray applications. The herbicide damage to the seedlings was evaluated approximately 90 days after treatment (DAT). Results indicate that both clopyralid and imazamox (alone or used in combination) are safe options to apply over oak reproduction and will provide acceptable competition control for the remainder of the initial growing season. Findings also suggest that imazamox may provide some limited inhibition of yellow-poplar.

Peairs, S.

Use of pre-emergent herbicides (indaziflam, sulfometuron methyl, and flumioxazin) for seedling release in an oak shelterwood (ORAL)

Silvicultural researchers have sought practices to encourage natural oak regeneration by

suppressing competing vegetation for decades. The use of shelterwoods is a commonly used practice to promote oak regeneration in upland hardwood stands containing an adequate oak component. The use of prescribed fire within shelterwoods has been suggested to have mixed results in controlling both woody and herbaceous competitors. This study incorporated the use of pre-emergent herbicides to create bare ground conditions around existing advanced oak reproduction in a post-harvested (shelterwood) stand. Chemical applications using sulfometuron and indaziflam were conducted approximately 45 days (May 1 & 6, 2022) after completion of logging activity. A second treatment of flumioxazin was performed on June 3, 2022. Individual white and red oak seedlings were marked with florescent flagging prior to spray applications. The herbicide damage to the seedlings was evaluated approximately 90 days after treatment (DAT) for sulfometuron and indaziflam treatments; and 60 DAT for the flumioxazin treatment. Results indicate that both sulfometuron and indaziflam (alone or used in combination) are safe options to apply atop oak and will provide acceptable competition control for the majority of the initial growing season. In addition, indaziflam also provides some limited suppression of yellow-poplar.

*** Phillips, D., J. Goode, and J. Hart**

Spatial patterns of disturbance and intra-stand structure in a longleaf pine (*Pinus palustris*) woodland (ORAL)

All stands experience disturbance events that impact plant species composition and drive development patterns. Observed contemporary disturbances (such as prescribed fire) and reconstructed canopy disturbances (based on dendroecological techniques) provide insight into past and current stand conditions, and help explain observed spatial patterns of intra-stand structure. Our goal for this study was to connect disturbance with observed patterns of vegetation organization in a fire-maintained, longleaf pine woodland. Within a 1-ha plot in the Oakmulgee Ranger District of the Talladega National Forest, Alabama, we recorded location, species, height, and dbh of all trees and longleaf pine saplings. Additionally, we recorded the species and sub-quadrat location for any non-longleaf pine sapling. We used standard dendroecological techniques to reconstruct canopy disturbance history. Of the 189 overstory individuals analyzed for disturbance history, 86% exhibited at least one release event, and 52% exhibited multiple release events. To capture disturbance types more fully within the stand, we recorded char height and mortality approximately six months after a prescribed burn. We observed mortality in 9 of the 394 trees and 12 of the 57 longleaf pine saplings. Using the R package comspat, we intend to quantify spatial patterns of vegetation structure at the sub-quadrat level. Further, we hope to elucidate disturbance-driven causes for the observed spatial patterns.

Pierce, J., D. Castellanos, C. Schalk, and R. Schaefer

Site selection for reintroduction of the federally threatened Louisiana Pinesnake (*Pituophis ruthveni*) (POSTER)

As part of the recovery plan for the Louisiana Pinesnake, a federally threatened species, individuals would be reintroduced in eastern Texas and western Louisiana. Since 2010, snakes have been released on a single reintroduction site in western Louisiana (Catahoula District of the Kisatchie National Forest). Participating zoos are reaching holding capacity of Louisiana Pinesnakes and need to export offspring that were bred with the intent to release. Given 291 snakes have been released to date, a second reintroduction site will be warranted soon. Using ArcGIS, 6 polygons will be delineated onto aerial photographs using the criteria of suitable soils, USFS ownership, and lack of major barriers, in an attempt to choose areas that best represent current and future habitat. Using ArcGIS, each site will be evaluated for percent of suitable soils, percent of suitable habitat, road density, and potential for population expansion. From these

results, USFWS will select the two best sites for further data collection. To rank the final two sites, we will evaluate finer scale habitat characteristics: midstory height and density, herbaceous cover, hardwood basal area (BA), pine BA, and pocket gopher mound presence. Field locations to perform the habitat analysis will be randomly chosen by placing a gridline over the polygons. The distance between the grid points (n = 30 at each site) will be appropriately determined based on the size and shape of the polygons. Data will be analyzed, and a spreadsheet of habitat variables will be presented to USFWS for a final site selection.

Pile-Knapp, L., K. Vaughn, and G. Wang

Evaluating dormant-season herbicide applications for the control of Chinese privet (*Ligustrum sinense*) (ORAL)

Chinese privet is an aggressive, non-native shrub of the southeastern US, particularly in bottomland and mesic forests. However, its evergreen leaves allow for herbicide treatment in the dormant season when the impact to native species can be minimized. Complicating control efforts are the tall and dense monocultures this shrub can create; greatly limiting the effectiveness of management. The purpose of this study was to determine which combination of chemical herbicide (glyphosate, metasulfuron, or a mixture of both) and application method (backpack sprayer or mistblower) applied during the dormant season would result in the greatest control of Chinese privet with minimal non-target impacts. Study results suggest that herbicide, regardless of the chemical formulation, will kill more than 50% of the basal area of Chinese privet in a heavily invaded, bottomland forest. However, glyphosate did impact native species that remained green during the dormant season, including sedges and wintergreens. Across size classes, mistblowers were more effective at controlling Chinese privet than backpack sprayers regardless of herbicide. Although no treatments impacted native species richness, mistblowers also had fewer impacts to native flora including tree and shrub reproduction than backpack sprayers. Mistblowers are not commonly used for controlling invasive shrubs, however as this study demonstrates, their utility for controlling large and tall shrub infestations should be considered.

Puhlick, J., B. Knapp, I. Goldberg, B. Rutledge, R. Taylor, and J. Willis

Silvicultural strategies for promoting longleaf pine recruitment in multi-aged stands (ORAL)

In longleaf pine ecosystems, an objective of some landowners is to develop multi-aged stands with a component of large longleaf pine trees. As large trees are harvested or die from other causes, ingrowth of trees into upper canopy positions and larger diameter classes can be problematic if stocking deficiencies of longleaf pine occur within certain size classes. A potential strategy to accelerate recruitment of trees to larger size classes is to purposefully release saplings within dense patches of longleaf pine. At the Jones Center at Ichauway in southwestern Georgia, we applied treatments to patches of sapling-sized trees within mature stands to compare: (1) thinning of trees within the patch, and (2) no thinning of trees within the patch. Before treatment, patches often contained over 1,200 trees per acre. In patches that were thinned, we retained dominant and codominant saplings of good form and with robust crowns. In these same patches, we cut most of the intermediate and suppressed saplings to reduce belowground competition for soil nutrients and water. During marking, we also considered spacing of residual trees, based on the average height of dominant trees within patches. To evaluate treatment outcomes, we plotted the positions of patches over time on a density management diagram for longleaf pine. We plan to monitor residual tree growth and mortality over time. Precommercial thinning of trees in dense sapling thickets may also enhance forest carbon accumulation, increase native ground cover, and benefit longleaf pine associated wildlife species.

*** Ramirez Quintero, L., C. Montes Cubillos, and B. Bullock**

A growth and yield system of differential equations for slash pine plantations including response to silvicultural treatments (ORAL)

Slash pine is the second most important commercial species in the southeastern United States, it is usually established in poorly drained flatwoods where it outperforms other common commercial pine species. Modeling slash pine growth and how it responds to silvicultural treatments is of interest to forest managers wanting to maximize their investments in the region. In this research, a system of differential equations is proposed to model slash pine growth including the effect of silvicultural treatments (i.e., bedding, and vegetation control). Data for this model came from a long-term study (30 years) established by the Plantation Management Research Cooperative (PMRC) across Georgia, Florida, and South Carolina. The model system describes the trajectory of three state variables (dominant height, mortality, and basal area). The three models were estimated simultaneously using maximum likelihood and the variance/covariance was modeled within the system. The proposed system was compared to other traditional model systems and the advantages/disadvantages of the proposed methodology are discussed.

Saenz, D., J. Reid, C. Adams, and J. Childress

Management of southern pine forests influences breeding bird communities (POSTER)

Avian community composition is driven by habitat, particularly vegetation structure. Forests in the southeastern United States have experienced extensive habitat alteration due to decades of short-rotation management and fire suppression. Recent efforts to restore historical forest conditions have been conducted using prescribed fire and other silvicultural practices aimed at manipulating the forest vegetation structure and composition. To evaluate the breeding bird response to habitat restoration management, we sampled breeding bird communities using automated audio recorders and measured vegetation structure at 22 sites in shortleaf pine dominated ecosystems, under different management regimes and seral stages over a broad geographic area in the Pineywoods Ecoregion of eastern Texas. Bird calls were identified to species and forest vegetation strata were characterized at each site. Treatment sites that were frequently burned tended to have lower hardwood midstory density and basal area and a greater proportion of grassy understory vegetation than unburned sites. Several bird species were exclusive to either the burned or unburned sites. In general, recently burned and thinned forested sites tended to have greater species richness than untreated sites. Our preliminary analyses indicated that avian communities were more similar to each other within a management treatment than between treatments, suggesting that restoration efforts influenced changes in bird assemblages within pine forests. Understanding how wildlife communities respond to restoration efforts will help inform management decisions.

Sayer, M., K. Wharton, M. Tyree, M. Blazier, J. Adams, and B. Wolfe

Role of root system structure in sustained growth among loblolly pine genotypes (ORAL)

An assessment of above- and belowground responses to release by thinning and throughfall exclusion (TFE) is underway in a north-central Louisiana loblolly pine plantation. Twelve 4-tree experimental units (EU) of three genotypes from the eastern (756, C93) or western (LA) loblolly pine range were established in 2018 at age 13 years. The 36 EU were partitioned into three blocks of four EU by genotype and two levels each of thinning (no thinning, two of four trees harvested) and throughfall exclusion (no TFE, TFE) were applied in 2018-2019. Relative basal area growth (RG) indicated an immediate and sustained positive response to thinning in two genotypes. By

year 3 after thinning, a significant increase in RG was observed for 756 (126%) and LA (55%) but not for C93. Early analyses indicated fascicle gas exchange was more sensitive to water availability in C93 compared to 756. During severe water deficit at age 5 years, C93 had 72% less tree leaf area compared to 756. In the parish where our study is located, 11 of the 17 years between 2005 and 2021 were characterized by less than average precipitation. Perhaps poor drought tolerance contributed to absence of a RG response to thinning in C93. There is value in knowing why C93 fascicle gas exchange and tree leaf area were sensitive to water deficit. Root system excavations of 756, LA, and C93 are allowing additional assessments to determine the role of root system architecture, biomass allocation, and hydraulic function in drought tolerance and RG.

Schalk, C., V. McDaniel, and J. Pierce

Composition of the understory plant community at the Stephen F. Austin Experimental Forest prior to timber harvest and frequent fire (POSTER)

Using prescribed fire and timber harvest to manage forests in the southeastern U.S. can help restore open canopy structure and herbaceous plant diversity. The Stephen F. Austin Experimental Forest has been historically managed for silvicultural research, but management implementation has been infrequent (i.e., 5–8 year fire return intervals, ~30 years since last timber harvest). However, management including a timber harvest and shorter fire return interval (2-3 years) is planned for this site over the next few years. We plan to study the shifts in understory plant diversity in response to these management actions. We collected pre-treatment data in summer 2022 by measuring the vegetative structure (e.g., basal area) as well as understory species composition (seedling and ground layer species/cover) across 6 sites with 18 subplots (3.6 m radius) of which each had two nested 1 m^2 quadrats (36 total). All seedlings/woody vegetation > 1 m in height in each subplot and plants within each quadrat were identified to species. Basal area ranged from 15 to 35.5 ft^2. The most frequently observed species in the quadrats were *Chasmanthium sessilifolium* (61%), *Dichanthelium laxiflorum* (44%), *Callicarpa americana*, *Ilex vomitoria*, *Rubus* sp., and *Vitis rotundifolia* (all 39%) and the most frequently observed woody species in the subplots were *Callicarpa americana* (67%) and *Liquidambar styraciflua* (33%). Total vegetative cover ranged from 2-95% while detritus cover ranged from 50-100%. These results will serve as a baseline to track shifts in understory plant community composition resulting from the upcoming forest management.

Schalk, C., C. Adams, R. Kidd, D. Saenz, and S. Mullin

Food-webs, forest management, and resiliency of southern pine forests (POSTER)

Forest management has the potential to alter ecological gradients (e.g., habitat and resource availability) that structure species' assemblages in these systems. The application of management strategies has been shown to alter forest structure in pine ecosystems, less is known about how these efforts influence pathways of energy flow and the consumer-resource relationships therein. Recent evidence produced across a variety of study systems underlines the idea that food-webs are fundamental to informing ecological restoration efforts. In this study, we examined how differences in forest management practice frequency (e.g., prescribed fire, thinning) affected the food-web structure in southern pine forests. We sampled consumers and dominant basal under high and low management practice frequencies. We compared community-wide metrics of trophic structure inferred from stable isotope patterns. We found that the high-frequency treatment supported a greater diversity of consumers with increased trophic redundancy. The low-frequency treatment supported fewer consumers which were supported by a wider range of resources and occupied a wider range of relative tropic positions. Restoration efforts that mimic natural disturbances can drive food-web structure in these forest ecosystems. Frequent forest

management practices (e.g., prescribed fires and thinning operations) could be implemented to support increased consumer diversity while also increasing trophic redundancy, leading to greater stability and resilience in pine-forest ecosystems.

*** Schrimpf, M., A. Polinko, R. Thirumalai, A. Himes, and H. Renninger**

Quantifying effects of initial spacing on corewood transition in loblolly pine using CT scanning (POSTER)

A limited knowledge of wood formation and its properties remains a question to producers in maximizing wood quality for final products. Properties associated with juvenile and mature wood (corewood and outerwood respectively) are important to the strength and viability of the lumber. Despite the important of corewood and outerwood, the properties and mechanisms involved in the transition are not fully understood. This study explores how stand density influenced the transition between corewood and outerwood, using contemporary methodologies for quantifying wood density. Specifically, we evaluate the role of the live crown transition between juvenile and mature wood. Unmodified tree cores were taken from 179 plantation grown loblolly pine (*Pinus taeda*) which were planted at three different initial spacings of 5, 8, and 10 feet (435, 680, and 1742 TPA respectively). We create an analysis methodology which allows for large quantity data analysis while minimizing core preparation. Using 3-dimensional greyscale images obtained using an industrial computed tomography (CT) scanner. We will present results and discuss management implications. Understanding the role of initial spacing and the live crown on radial variation of specific gravity allows silviculturists to develop silvicultural prescriptions that target desired end wood products.

Schweitzer, C., J. Calvert, S. Clark, and J. Royse

Multi-phased shelterwood on the Daniel Boone National Forest, Kentucky, tests herculean effort to regenerate oak (ORAL)

The Heathy Forests Restoration Act of 2003 spurred a long-term study in the Cold Hill area of the London Ranger District on the Daniel Boone National Forest (DBNF), KY. This study included regeneration and intermediate stand treatments to assess silvicultural treatments that can be used to curtail susceptibility and vulnerability of oak-dominated stands from gypsy moth and oak decline. One treatment targeted recruitment of oak reproduction using a multi-phased shelterwood. In 2006, midstory stems of non-desirable species in six stands (20-25 acres each) were deadened with an herbicide to improve understory light conditions for oak growth. Ten-years post-treatment, competitive oaks, those 4 feet tall up to 1.5 inches DBH, increased to 200 stems per acre. In this same size class red maple, a less-desirable species, increased to over 1600 stems per acre. We did a pre-harvest "site preparation for natural regeneration" treatment in 2019 (cut-surface herbicide treatment of red maple stems) prior to a commercial harvest in 2020 that retained 10-15 square feet of basal area per acre. We will discuss the silviculture prescription, challenges, and preliminary reproduction response post-harvest.

Schweitzer, C., D. Dey, and A. Brandon

Prescribed fire barriers and solutions for managing sustainable forests: silvicultural cocktails (ORAL)

A virtual forum for land managers to provide feedback on barriers to, and opportunities for, increased use of prescribed fire in the U.S. was held in June 2021. Managers from over 20 diverse agencies and organizations were selected to contribute their knowledge as related to four key questions. Questions addressed delineating the barriers to planning, implementation, and

monitoring the use of prescribed fire at the desired pace, scale, and seasonality; proposed solutions to the identified barriers; additional information needed to implement proposed solutions; and new barriers likely to arise to proposed solutions. Some key barriers to increased use of prescribed fire included narrow burn windows, limited resources, and capacity (both for planning and implementation), and the complexity associated with large-scale burning. Less commonly identified barriers varied among regions and land ownership and included air quality restrictions, lack of confidence in consistent leadership support, social license, suppression culture, and conflicts with timber and other resources. Opportunities to overcome these barriers include resource sharing and leveraging multi-stakeholder partnerships, the potential to create larger scale prescribed burning organizations, and building trusted relationships among practitioners and the public. We will highlight themes from managers and suggest silvicultural solutions to addressing perceived conflicting objectives among timber, wildlife, and fire suppression.

*** Scott, S., L. Knapp, B. Knapp, and A. Chapman**

Pollinator habitat in log landings (PHiLL) project (POSTER)

Habitat loss and degradation are among the greatest threats to wild bee populations. Since pollinators are keystone species for agricultural and forested ecosystems, pollinator habitat restoration is critical to ecosystem health and stability worldwide. Boosting the abundance, richness, and diversity of floral resources and bee nesting sites may assist in this goal. Log landings (areas where harvested timber is loaded for transport) are challenged with soil compaction, erosion, residual mulch and logging debris, and invasive species. This makes them unique areas to study the establishment of ephemeral pollinator habitat. The Pollinator Habitat in Log Landings (PHiLL) project was designed to investigate this establishment across the Hoosier, Shawnee, and Mark Twain National Forests of Indiana, Illinois, and Missouri. Three soil treatments and a control were applied across five landings in each National Forest to improve soil conditions, along with the seeding of a range of competitive, pollinator-friendly native plants. Study treatments included biochar amendment to the soil, soil ripping to reduce compaction, a combination of ripping and biochar, and a control treatment. Each treatment was split into subplots to be seeded and left unseeded. We have results of treatment effects on plant diversity, richness, and abundance for the first two years of this three-year study. Results may influence the management practices of foresters, landowners, agriculturalists, and others concerned with the restoration and support of pollinator communities globally.

Self, A., J. Ezell, and A. Ezell

A comparison of Garlon 4, Garlon XRT, Vista, Vastlan, Chopper GEN2, and Terravue in site preparation applications (ORAL)

Site preparation continues to be a major focus of vegetation management programs in pine plantation management in the South. Evaluation of new products applied alone or in mixtures must be completed to test cost-efficacy. In this study, a total of eight treatments (including an untreated control) were applied to a recent cutover area in northern Mississippi. All treatments were replicated three times in the October, 2021 application. Plots were evaluated at 1 MAT, 4 MAT, 8 MAT, and 1 YAT. Treatment effectiveness for all major species on the site will be presented.

Sharma, A., and J. Willis

Is longleaf pine an intolerant species? It's comparison with other southern pines and southern hardwoods (ORAL)

Longleaf pine is widely perceived as a shade intolerant species; however, there are few studies that have evaluated its shade tolerance traits. We planted one-year old seedlings of longleaf pine along with two other southern pines (loblolly and shortleaf) and three southern hardwoods species (southern red oak, mockernut hickory, and yellow poplar) at four levels of light (full, 40, 20, and 10%). After eight months of growth, we obtained their light response curves and specific leaf area (SLA) and leaf dry matter content (LDMC). Our observations suggest that longleaf pine is relatively less intolerant than both shortleaf and loblolly pines and is better able to maintain its photosynthetic rate at increasingly lower light levels. Loblolly pine appears to be the most shade intolerant southern pine. Among hardwood species, mockernut hickory appears to be more shade tolerant and yellow poplar the more intolerant species. While all species showed lower photosynthesis rate with increasing shade, southern red oak exhibited a unique photosynthetic response, with high net photosynthetic rates at either moderate light levels or very high light levels. In all the species, SLA increased with increasing shade level but the variation of SLA in longleaf pine was lower than other species. LDMC values were more variable across the species than SLA. The light response and SLA dynamics observed in longleaf pine suggest it is a relatively less intolerant species than other southern pines, and thus may be able to regenerate under its own canopy and managed as multi-aged stands for multiple benefits.

Shearman, T., J. Varner, and J. Willis

Spatial factors in post-fire tree mortality – a preliminary analysis (ORAL)

Accurate prediction of post-fire tree mortality is essential for management of forest resources. Fire-caused injuries to tree crowns are consistently found to be the best predictors of survival or mortality but spatial factors are likely also important predictors that are rarely used in mortality models. We stem-mapped the locations of over 1200 individual trees (longleaf, shortleaf, and loblolly pine) across 13 stands and measured tree characteristics (height, diameter, crown height) as well as fire injury (crown volume scorched, bark char height, scorch height) after prescribed fire. Using the spatial positions of the trees, we calculated local basal area within a 10 m radius of each tree as well as the Hegyi competition index. Average scorch across stands ranged from 20 to 80 percent for trees ranging from 20 cm to 70.7 cm DBH. We used a random forest model to identify which tree and neighborhood characteristics were associated with increased crown scorch by classifying them into three broad classes: no scorch, some scorch, or complete scorch. The model had an overall accuracy of 60.7% in predicting test data but was better at predicting no scorch (78.3% accuracy) than either some (57.7%) or all scorch (58.8%). Plot location was also an important predictor, possibly due to differences in fuel loading or weather conditions among fires. Initial post-fire tree mortality ranged widely across the sites, from 0 – 19%. This research contributes to the need to build better models to predict fire-caused mortality in ecologically and economically important southern pines.

*** Shoemaker, K., D. Jackson, and J. Adams**

Evaluating stem and branch characteristics of five-year-old Sonderegger pine saplings (ORAL)

Sonderegger pine (*Pinus* x *sondereggeri* H.H. Chapm.), the natural hybrid of longleaf (*P. palustris* Mill.) and loblolly pine (*P. taeda* L.), is historically described as having stem and branch deformities at maturity that may lead to poor wood quality. For this reason, Sonderegger pine seedlings are traditionally culled from southern forest tree nurseries to assure only pure longleaf pine seedlings are outplanted to meet landowner objectives. The general acceptance of Sonderegger pine as an inferior tree has led to an absence of research to determine its morphological development from the seedling to mature stand management phases. In 2018, 400 Sonderegger pine seedlings were operationally detected in the nursery and outplanted on the Catahoula Ranger District of Kisatchie

National Forest (Pollock, LA) with the main objective to evaluate and describe their morphological development over time. Before planting, seedling height to the terminal bud and root collar diameter were measured. In the field, tree height and diameter at breast height measurements were recorded, and evaluations for stem straightness, forking defects, ramicorn branches, and disease occurrence have been made. These observations along with ongoing assessments of branch angle, diameter, and height along the bole may give insight on Sonderegger pine morphology at age five as it relates to long-term wood quality and utilization.

*** Shrestha, B., H. Alexander, and Y. Olshansky**

Carbon storage, fuel loading, and fire behavior consequences in hurricane-impacted, fire-dependent forests of the southeastern U.S. (POSTER)

Intense hurricanes occur two out of three years across southeastern US, where forests are managed with prescribed fire. Combinations of such disturbances (hurricane followed by prescribed burn) are expected to gradually decline the capacity of southeastern U.S. forests to act as carbon sinks. Primary goal of this study is to understand hurricane impacts on fuel loading, fire behavior, and carbon sequestration capacity of such forests impacted by recent hurricanes. We hypothesize that fire managed forests store most carbon in stabilized soil organic matter and live vegetation, and hurricanes will convert them into dead woody and leaf litter C pools, resulting in increased fuel load, leading to severe prescribed fire; and reducing C pools in vegetation. We also hypothesize that recovery of carbon depends on severity of hurricane damage. We are currently sampling sites with recent hurricane damage to quantify above- and below ground carbon pools and fuel loading prior to fire (<1 month), immediately after fire (within 1 week), and 1 year after a prescribed fire. We independently evaluate each sites for fire behavior in relation to fuel loading. Ultimately, our goal is to determine carbon recovery rates to establish imperative correlation between hurricane, fire and carbon dynamics in forest ecosystems. Understanding the response of forest carbon pools to disturbances (hurricane-prescribed fire) will improve understanding of hurricane impacts on fire behavior and carbon dynamics in fire managed forests, which helps to predict the role of southeastern U.S. forests in climate mitigation.

*** Talmage, C., Y. Weng, Y. Zhang, and J. Grogan**

DBH estimation based on LiDAR point clouds at stand level of loblolly pine plantations (ORAL)

Stand variables such as average tree diameter at breast height (dbh) and height are important stand characteristics for forest management. Conventionally, tree dbh are measured, while tree height is often estimated based on tree dbh, due to the difficulty in field measuring tree height. Recent development in remote sensing techniques, in particular in the application of Light Detection and Ranging (LiDAR) to forestry, provides a reversing alternative. LiDAR point clouds can be used to accurately estimate tree height and crown size, which can be used to calculate number of trees per unit area. Foresters are very interested in if dbh can be derived from LiDAR data. This study used LiDAR data collected from the permanent plots established in loblolly pine plantations in east Texas and developed alternative models to estimate stand average dbh from LiDAR derived stand variables including total height, crown size, and the number of trees per acre at the stand level. The models were evaluated based on the mean difference between observed and predicted dbh, mean absolute difference, and root mean square error, respectively. Results were encouraging that stand-level dbh could be accurately estimated using LiDAR data-derived stand variables. The estimated stand dbh, paired with LiDAR-derived height and number of trees per acre can then be employed to estimate stand volume/ acre for the stand.

*** Thurmond, E., K. Kidd, D. Saenz, C. Shackelford, and J. Childress**

Monitoring avifauna response to forestry wildlife treatments in bottomland hardwood forests (POSTER)

Bottomland hardwood forest habitat loss within the Lower Mississippi Alluvial Valley has contributed to the decline of forest bird species. There are ongoing efforts to restore bottomland hardwood forests through conservation programs to achieve desired forest conditions for wildlife. Monitoring of treatment effectiveness and need of intermediate treatments (e.g., thinning, patch cuts, variable retention harvests) in restored bottomland hardwood forests is critical. This study collected a baseline inventory of bird species through the deployment of autonomous recording units at 150 sites at varied successional stages over two breeding seasons. Bird vocalizations were identified to species via Kaleidoscope™ software. Habitat variables (e.g., basal area, canopy cover, foliage density, ground cover) were measured to provide a quantitative representation of forest structure at each site. Baseline data were compared to avian community metrics captured in bottomland hardwood forests at different successional stages to identify influential forest wildlife treatments. The percentage of overstory canopy cover was found to have the greatest influence on avian community composition. Sites with forest wildlife treatments within the last four years had the greatest species richness, but lacked priority-species such as prothonotary warbler (*Protonotaria citrea*). Increased canopy cover reduced species richness, but increased occupancy by species of conservation concern. Maintaining a mosaic of habitat conditions on the landscape should be a management consideration to increase overall species richness and retain target species.

Tian, N., J. Gan, and G. Holley

Managing feral hogs: perspectives of forest landowners in Arkansas, Louisiana, and East Texas (ORAL)

Feral hogs (FHs) (*Sus scrofa*) are an invasive species that has spread widely across the southern United States and, with their rapidly increasing population, have caused severe damage to row crops, livestock, water quality, forest regeneration, and infrastructure. As a result, controlling FHs is an urgent issue for farmers, rural landowners, and natural resource managers. We conducted three-state mail surveys in 2021 to elicit feral hog damage and landowners' attitudes toward managing FHs in Arkansas, Louisiana, and East Texas in the West Gulf region. We found that feral hog activities like rooting and wallowing caused severe and widespread damage to both agriculture and forestry. Average economic loss inflicted by feral hogs was estimated at $67.13/ha and $42.96/ha for landowners in the region who owned cropland and forestland, respectively. Through further data analysis, we anticipate to gain knowledge on whether and why landowners have taken actions to control FHs as well as the drivers and barriers for these landowners to control FHs on their land. Those findings will help both landowners and other stakeholders understand the negative societal impact of FHs and landowners concerns and motivation for FH control, leading to the development and deployment of more effective policies and educational programs for controlling/managing FHs in the study area.

*** Tracy, J.**

Characterization of community structure and structural diversity to assess evidence of forest type shifts prior to slough flow restoration treatments in the Apalachicola River floodplain (ORAL)

The Apalachicola River floodplain in Florida's panhandle has experienced significant alterations to its hydrologic regime since the 1950s. A combination of anthropogenic and climatic variables have

impacted flow of the river and led to increased durations of low flow and drought periods that impact health and survival of alluvial swamp tree species. Past research in the floodplain has determined a 37% decrease in swamp tree species density between 1976 and 2004 and suggests that low bottomland hardwood forest distribution may be expanding into areas that were a swamp forest type prior to alterations in flood regime. Here, we present an analysis of floodplain forest vegetation community structure in an area that is in the pre-treatment phase of a slough flow restoration project. Analyses of relative trees per acre, relative basal area, species diversity, and physical health characteristics are assessed at the overstory, midstory, and understory levels across an elevation gradient that includes low bottomland and swamp forest types. We aim to determine how elevation impacts community structure in this project site and whether there are signals of forest type change at low elevations prior to restoration. These initial analyses set a baseline from which to determine future success of the project in supplying more water to low elevation swamp environments during low-flow periods and improving health and productivity of flood tolerant swamp forest communities. Considering the shade tolerance of swamp tree species, our results inform the potential need for addition of canopy gaps in restoration efforts to supplement hydrologic improvements.

*** Upadhayay, D., P. Saud, M. Bataineh, T. Lynch, and D. Bragg**

POSTER: Effect of thinning on basal area growth among different diameter classes in natural-stand of shortleaf pine (*Pinus echinata* Mill.)

Long-term monitoring of natural stands can help managers understand the role of stand productivity on desired forest conditions. This research project considered the effects of thinning from below on basal area growth using repeated measurements among different diameter classes of naturally occurring shortleaf pine stands on Ozark and Ouachita National Forests in Arkansas and Oklahoma. The permanent research plots were established in 1985-1987 and were remeasured about once every five years until 2012-2014, with a single thinning in 1996 to restore the initial stand basal area. We used generalized linear mixed model to evaluate the multiple treatment effects on basal area growth response considering the three different diameter classes (small < 7 inches, medium = 7-14 inches, big >14 inches), the initial stock level (low ≤ 30 ft^2/ac, average = 30-60 ft^2/ac; moderate = 60-90 ft^2/ac; high > 90 ft^2/ac) and thinning intensity (low ≤ 21.8 ft^2/ac removed; high >21.8 ft^2/ac removed). A preliminary analysis found that big-diameter class trees show better basal area growth followed by medium and small-diameter class. The result also indicated that basal area growth is significantly affected by relative spacing, stand age, initial stand basal area, and crown condition. This study will help increase our understanding of the long-term effect of density management on the regulation of the stand dynamics, growth, and yield, and provides information to the forest manager about the application of the thinning treatment among the different diameter classes of the stand.

VanderSchaaf, C.

A stand-level growth and yield model system for shortleaf pine plantations in the western half of the southeastern United States (ORAL)

A system of growth and yield equations for shortleaf pine (*Pinus echinata* Mill.) plantations using data from across the western half of the southeastern United States is presented. Data used in model fitting were obtained from Arkansas, Mississippi, Oklahoma, and Tennessee (n = 168). Site index ranged from 45 to 68 feet (base age 25), planting densities ranged from 194 to 1,742 seedlings per acre, and measurement ages ranged from 1 to 30 years. The majority of the measurement ages were 16 years of age or less (n = 148). A mix of cutover and old-field sites were in the model fitting dataset. Predictions of trees per acre, basal area per acre, and total volume

per acre can be obtained directly. Quadratic mean diameter can be mathematically derived from the trees and basal area per acre estimates. A simple validation analysis using published data from three studies established prior to 1959 showed that the model system produced reasonable predictions for planting densities less than 1,210 seedlings per acre. For higher planting densities, survival at younger ages was overpredicted, and hence overall stand development was overpredicted through time. However, for higher planting densities, the carrying capacity of sites may be accurately predicted. Perhaps this initial modeling effort will create an interest in obtaining a more complete dataset. Hopefully, the dataset will greatly consist of more recently established plantations, that eventually a thinning component can be added, and that a more sophisticated validation analysis can be conducted.

VanderSchaaf, C.

Impacts of diesel and insurance costs on owner-operator log truck drivers in the Western Gulf (POSTER)

Forest harvesting, or logging, is extremely important to the fiber supply chain, allowing landowners to conduct management on their property and to receive financial compensation for their capital investment. After the felling, skidding, delimbing and often topping, and merchandizing of trees, the logs must be loaded onto a truck for the hauling or transport of that raw woody resource to a mill. Mills commonly pay for hauling with a haul rate that is calculated per ton per loaded mile ($/ton/loaded mile). This analysis is focused on owner-operator truck drivers, or independent contract drivers, and hence drivers that are self-employed. These drivers pay for the truck and trailer (and other necessary accessories such as straps or chains, etc.), insurance for the truck and trailer, licensing, maintenance, fuel, mandatory professional training, salary, fringe benefits such as health insurance, retirement, etc. This analysis looks at the impacts of different costs of diesel per gallon ($3, $4, $5, and $6 per gallon), different logging truck annual insurance rates ($8,000, $11,000, and $14,000), along with basic assumptions about hauling conditions and maintenance costs, and varying rates of salary received per load ($/ton/loaded mile of $0.13 to $0.23 by two cents), on the annual salary of an average logging truck driver. Silviculturists, foresters, and forest landowners should be extremely concerned about adequate salaries to log truck drivers; especially given inflation, high insurance costs, and rising diesel prices. Without these drivers, forest management options become minimal.

VanderSchaaf, C.

Reforestation tax incentive impacts on financial returns of loblolly pine plantations for family forest landowners in Mississippi (POSTER)

Rates of return from forest plantation investments depend on survival and growth rates, but also costs and revenues associated with various practices. Beyond that, tax related issues are another important consideration that are often not addressed in forest financial assessments. Many financial assessments can be defined as “before-tax.” Forest landowners within Mississippi have the potential to reduce reforestation cost burdens through two important tax-related opportunities. The first being the Federal reforestation deduction and amortization incentives and the second being the state-based reforestation tax credit. An overabundant supply of wood in Mississippi has resulted in fairly poor market conditions, particularly for pulpwood stumpage. This has resulted in the likelihood of marginal returns for many landowners without some type of assistance. Beyond that, substantial inflation and rising fuel costs have resulted in greater reforestation costs plus additional reductions in stumpage values due to factors such as greater costs for loggers during forest harvesting operations. The impacts of these two income tax reduction opportunities on loblolly pine plantation financial returns were examined.

*** Van-Spanje, M.**

Identifying applied isotopic nitrogen (15N) allocation in a mid-rotation pine plantation under varying herbicide regimes (POSTER)

The efficacies of collective fertilizer and herbicide treatments in pine plantations tend to vary, and direct causalities are unknown. Independently, these mid-rotation treatments result in a growth response of the crop species, but combined, the response is expected to be additive. This study aims to identify fertilizer 15N acquisition levels at mid-rotation under varying competing vegetation control regimes. The study site, located within the Appomattox-Buckingham State Forest in Virginia, has a gradient of competing vegetation in the understory as a result of a previous chemical site-preparation study. Treatments were assigned using random stratification to assure each new treatment reflected the gradient of existing understory competition. The Treatments include fertilizer applied stand-wide with (A) herbicide applied pre-fertilization, (B) herbicide applied post-fertilization, and (C) no chemical control applied. Objectives of the study are to (1) estimate the quantity of nitrogen fertilizer (isotopic nitrogen, 15N) sequestered by crop loblolly pine trees (i.e., assimilated into plant tissues) at mid-rotation, (2) measure variability in crop tree 15N sequestration between different chemical control regimes, (3) measure the effect of competing vegetation aboveground biomass quantity on crop tree 15N capture, (4) estimate the "competitiveness" of competing vegetation by species. We found pine 15N acquisition to be greatest in Treatment A plots where the vegetative competition was chemically controlled before fertilizer was applied. Additionally, lessened competing vegetation basal area leads to greater pine 15N retention.

Varner, M., J. Kane, T. Shearman, J. Kreye, and H. Alexander

A preliminary analysis of decomposition-driven changes in litter flammability (ORAL)

Senesced litter drives fire behavior across most southeastern forests and woodlands. Substantial research over the last decade has revealed strong differences in litter flammability across tree species. In this study, we collected litter from 12 native southeastern tree species soon after senescence in north Florida. We deployed 15 gram samples in mesh litter bags beginning in February and then collected samples at one, two, three, five, and eight months. We calculated decomposition rates for all species and used collected litter in laboratory combustion experiments. In the lab, we burned four to five oven-dry samples of each species for each collection date (including the zero-month samples at collection). We measured flame heights, flaming duration, smoldering duration, and percent fuel consumed. All species' litter lost mass via decomposition, with the most loss in *Oxydendrum arboreum* and *Quercus nigra* and the least loss in three pines (*Pinus palustris*, *P. echinata*, and *P. taeda*) and two oaks (*Quercus laevis* and *Q. falcata*). The collected litter burned in diverse ways, with most species declining in flammability, while four oaks either showed no decline or were more flammable with decomposition. The unique patterns of flammability caused by decomposition reveal nuanced relationships among southeastern species that deserve additional research attention.

Vickers, L., and B. Knapp

White oak sustainability – what's the (under)story? (ORAL)

White oak is an important species with a broad range, spanning more than 100 million acres of forestland. About three-quarters of the white oak forests are mature, and in those forests, oaks tend to be prevalent as large trees, scarce as saplings, and highly variable as advance reproduction. The difficulties of regenerating oak forests are well-known. More recently, however, concern over the scarcity of small diameter white oaks has spurred great interest in the

long-term sustainability of this important resource among stakeholders. In this presentation, we distill results from several broad-scale analyses to highlight factors limiting white oak regeneration and canopy recruitment at the local, regional, and range-wide scales. We discuss the implications of those results and the questions they raise for future research and management.

Vogel, J., J. Shabaga, S. Lapalikar, and A. Sharma

Survival of longleaf pine seedlings planted under different canopy reduction treatments in a slash pine-turkey oak stand (ORAL)

Longleaf pine (*Pinus palustris*) naturally establishes in excessively drained sandy soils, but when planted as seedlings in clearcuts, high mortality rates often occur. We planted containerized longleaf pine under different levels of artificial canopy opening to test whether leaving residual trees during harvest would increase survival. In a 65-year-old slash pine (*Pinus elliottii*) plantation that had been overgrown with turkey oak (*Quercus laevis*), we harvested either slash pine or turkey oak, or both, and planted seedlings within four 1/3 acre plots per treatment. An unharvested area was also planted. Before harvest, stand basal area ranged from 8.2-12.9 ft^2/ac of slash pine and 25.6-27.2 ft^2/ac for turkey oak. The removed basal area of turkey oak was matched within a treatment to the pine basal area, resulting in 8.2-12.9 ft^2/ac of residual basal area in NoPine and NoOak plots, 33.8-40.1 ft^2/ac in NoHarvest plots, and no residual basal area in NoTree treatments. Seedlings were planted at 3.6 m x 3.6 m spacing. A planting in 2020 resulted in significantly higher ($p<0.05$) mortality rates in the NoTree (88±8%) than the NoHarvest treatment (75±8%) after 18 months. The two treatments with residuals trees were intermediate in mortality (NoPine=78±8%, NoOak=80±8%); not differing from the other treatments. A second planting in 2021 again resulted in the highest mortality in NoTree treatments (70±7%) after six months, which was significantly greater than the NoHarvest (44±3%), NoPine (45±5%), and NoOak (50±5%) treatments. In extremely xeric soils, longleaf pine survival is increased when planted under a canopy rather than in gaps.

Wang, G.

Climate-smart forestry and its implication on southern silviculture (ORAL)

Climate change is happening today and will continue in the future, producing many unexpected effects on our forests. In recent years, climate change has become the most critical driver for forest management, altering how we practice forestry. Climate-smart forestry is an emerging approach to sustainable forest management, with specific strategies and proactive practices aimed at promoting climate change adaptation to improve forest resilience for the benefits of neutralizing carbon emissions, increasing productivity and provision of ecosystem service, and harmonizing environmental, social, and economic well-being. This new forestry paradigm will have significant implications for southern silviculture. In this paper, I first described the recent rise of climate-smart forestry. I then explored significant stressors associated with climate change in southern forests. Finally, I discussed major silvicultural systems currently practiced in the southern US (e.g., loblolly pine plantation management, longleaf pine restoration, and oak regeneration) in the context of climate-smart forestry.

* Wang, J., and H. Renninger

Leaf area index (LAI) across eastern cottonwood and hybrid poplars and its relationships with productivity and water use efficiency under coppicing and non-coppicing management in the southeastern United States (ORAL)

Populus is a promising genus for bioenergy production due to its fast-growth. To estimate eastern

cottonwood and hybrid poplar growth performance, we planted 167 unique clones from eastern cottonwood (*Populus deltoides*) and five taxa of hybrid poplars at two sites in the southeastern United States. Leaf area index (LAI), leaf gas exchange, tree height, and diameter at breast height (DBH) were measured. Backpack light detection and ranging (LiDAR) was used to estimate crown volume at the same time as LAI (LiCOR 2200). We used ANOVA, linear regression, and machine learning models to explore the difference between taxa and relationships between LAI, photosynthetic capacity, intrinsic water use efficiency (WUE), and productivity (yearly added biomass). LAI varied significantly across different months and taxa. *P. trichocarpa* × *P. maximowiczii* (T×M) genotypes had significantly higher LAI than other taxa. *P. deltoides* × *P. maximowiczii* (D×M) genotypes had the lowest LAI but showed the highest photosynthetic capacity, while eastern cottonwood had the lowest photosynthetic capacity but significantly higher LAI. T×M showed the highest WUE, while eastern cottonwood showed the lowest WUE. Eastern cottonwood had the highest productivity, and T×M had the lowest productivity. Coppicing management significantly reduced LAI, photosynthetic capacity, and productivity. Linear regression models and machine learning models suggested that LAI, leaf conductance, photosynthetic capacity, and crown volume can explain over 84% of the variance of productivity in non-coppiced management and over 74% in coppiced management. These findings are useful for selecting *Populus* taxa and genotypes for efficient bioenergy production in the southeastern US.

*** White, E., C. Siegert, J. Granger, and D. Williams**

Carbon sequestration potential of non-commercial tree species in the Southeast (POSTER)

Landowner participation in carbon exchange markets has become increasingly popular in the southeastern U.S. Advances in the knowledge of species-specific carbon storage are critical for development of accurate carbon quantification. Woody debris is a major component of the global carbon cycle, and the decomposition of wood is affected by the quality of substrate, climate, and the type and abundance of decomposer organisms. However, variation among tree species is a major factor affecting decomposition and long-term carbon storage that is not well known. To address this knowledge gap, a field experiment was initiated in 2021 to test the decomposition rates across several common, but silviculturally unimportant, species that exist on the landscape, with the goal of identifying species with desirable traits to facilitate long term carbon storage. Preliminary analysis found that wood density could be an indicator of sequestered carbon. Species density ranges from hickory, the densest with 0.939 g/cm^3 on average, to eastern redcedar, the least dense with 0.465 g/cm^3 on average. However, the species that has the highest percent density loss after 6 months of decomposition was white oak (15%) while the species with the least change in density was loblolly pine (3.5%). Carbon loss data are pending, along with 12-month decomposition data. Results from this study could offer species-specific area options for optimizing carbon sequestration in managed forest.

*** White, Jr., G., B. Oswald, K. Kidd, I. Hung, and B. Sengupta**

Loblolly pine and shortleaf pine hybridization spatially quantified using chromatography and GIS: an East Texas case study (POSTER)

Loblolly (*Pinus taeda*) and shortleaf (*Pinus echinata*) pines are known to hybridize under suitable site and weather conditions in East Texas. Spatial quantification of such hybridization has become a growing concern as southeastern United States pine forests are increasingly influenced by improved pine genetics and warmer, drier conditions from climate change. High Performance Liquid Chromatography (HPLC) and Inverse Distance Weighted spatial interpolation were conducted using terpenes extracted from shortleaf, loblolly pine, and putative hybrid needles

sampled in Atlanta State Park, Tyler State Park, and Mission Tejas State Park (n = 24, 14 overstory, 10 advance regeneration individuals), representing a north-to-south transect in East Texas. The intensities of 14 chromatogram peaks representing terpene expression were identified and measured. T-tests at each site indicated no significant differences for peak intensity between overstory and advance regeneration forest strata. Two-way ANOVA indicated significance of six peaks for differences in the site variable (n = 3), five peaks for differences in the species class variable (n = 3), and one peak for their interaction. Tukey HSD tests indicated that the shortleaf pine-to-shortleaf x loblolly pine comparison was the most consistently significant among mean peak values. From spatial interpolation, peak intensity was generally highest at the northeast portion of East Texas, with a decreasing trend towards the southwest portion of the region. Patterns of species differentiation within the population and individual responses to environmental stressors is implied, with increased sample quantity and geographic coverage recommended for more accurate representation.

Willis, J., M. Varner, J. Cannon, J. Puhlick, D. Bragg, and C. Schalk

Impact of pine species identity on woodland ecosystem services (ORAL)

The southeastern United States has engaged in woodland restoration on public land over the past three decades. One of the major objectives of this effort has been to replace loblolly pine (*Pinus taeda*) and slash pine (*P. elliottii*) with longleaf pine (*P. palustris*) or shortleaf pine (*P. echinata*) on sites where low-intensity fire frequently occurred. While increasing the prevalence of longleaf pine and shortleaf pine is consistent with historical accounts of species composition prior to European settlement, the influence of pine species identity on woodland functionality has not been rigorously examined across a range of ecosystem services. The importance of pine species identity on ecosystem function has significant silvicultural implications, as, in some cases, restoring species composition and structure may be required to achieve functional restoration. However, in other situations, the desired functionality might be achieved by simply restoring forest structure. Our presentation will evaluate the impact of pine species identity on understory flammability, water availability, wildlife habitat, carbon sequestration potential, productivity, forest health, wood quality, and disturbance resistance and resilience.

Wolfe, B., and A. Eisley

Leaf turgor loss point among bottomland hardwood forest trees (ORAL)

Droughts disturb forest dynamics, and they are projected to increase in frequency and intensity with global climate change. Independently, hydrological modification affects water availability in bottomland hardwood forests (BLH) that occupy floodplains throughout the southeastern United States. Together, these impacts have the potential to disrupt BLH and cause forest dieback. Forecasting these effects requires knowledge of tree species drought tolerance and its underlying drivers. Leaf turgor loss point (TLP) is associated with drought tolerance and tree species distributions at local to global scales, likely because low TLP enables physiological function during periods of water deficit. We measured TLP among 20 tree species in a BLH in central Louisiana. We found that BLH species had similar TLP to upland forest species. Contrary to global trends, TLP was weakly positively correlated with drought tolerance scores among BLH species. Within BLH species, TLP declined from early to late growing season and from wetter to drier habitats, but these shifts were small compared to those in other ecosystems. These results suggest that BLH species have physiological tolerance to drought conditions that are more severe than they generally experience. Some BLH species may use drought avoidance strategies rather than physiological tolerance, which would allow them to have both high TLP and a high drought tolerance score. The observed variation in TLP among species and its plasticity within species

suggest that TLP is a promising trait for characterizing drought responses among BLH species.

*** Young, J., B. Bullock, C. Montes, and J. Rheney**

Characterizing spatial dependencies of competing vegetation in thinned loblolly pine stands (ORAL)

Spatial structures influence the development of forest stands. Individual crop trees which have similar traits to their neighbors are likely to be spatially dependent. In intensively managed plantations the presence of competing vegetation has been shown to limit crop tree productivity, suggesting that occurrence of undesired vegetation is also spatially dependent since it is competing for the same site resources. Silvicultural treatments applied throughout rotation systematically alter the spatial structure of forests to favor crop tree production, but any resultant competing vegetation growth is also influenced by changes in resource distribution. However, the spatial dependence of competing vegetation in intensively managed plantations has yet to be explored. A long-term regional study from the southeast US which monitored the growth of intensively managed loblolly pine, as well as competing vegetation, is used here to characterize the spatial dependence of competing vegetation following operational, mid-rotation silvicultural treatments. Preliminary analysis indicates that spatial dependence may vary based on treatment, thinning intensity, and type (herbaceous or woody) of competing vegetation present. We plan to further assess spatial autocorrelation among competing vegetation through explicit calculation of spatial indices. Characterizing the spatial dependence of competing vegetation following mid-rotation silvicultural treatment provides insight to how management decisions can impact the distribution of competing vegetation in intensive pine plantations.

*** Zhang, T., J. Yang, R. Will, and C. Zou**

Interaction between climate change and increased tree canopy cover will reduce water yield (POSTER)

Increasing stand density and stocking can increase sequestration of atmospheric carbon in forest ecosystems. However, increasing tree canopy cover may enhance ecosystem water use, especially for water-limited regions along the western edge of the southeastern forest. In this modeling study, we compared the impact of increased tree cover on evapotranspiration (ET) and water yield in a sub-humid woodland watershed (31% tree cover, mean annual precipitation (MAP) 913 mm) and a humid forest watershed (55% tree cover, MAP 1358 mm) under the current climate and a prevailing climate change scenario (2 °C increase in temperature and 10% decrease in MAP) using the Soil & Water Assessment Tool (SWAT). If tree cover was increased to 81% for the sub-humid woodland watershed and to 85% for the humid forest watershed, runoff would decrease by about 37% and 11% under current climate conditions, but 50% and 32% decreases would occur under the climate change scenario, respectively. ET increased in all watersheds under both scenarios but increased less under climate change scenarios, mainly due to reduced precipitation. Our study suggests that while both increased woody cover and climate change had significant impacts on water resources, the combined effects were not additive. Increasing tree cover by allowing woodlands to convert to forest or replacing woodlands with plantations will reduce water yield. The impacts of forest cover change on regional water yield must be carefully considered.