EXPLORING NATURAL AND SOCIAL SCIENCES IN GEORGIA:

FEMALE FOREST LANDOWNERS AND LONGLEAF PINE CANOPY ARTHROPODS

by

NEIL ROYCE DINGLEY JR.

(Under the Direction of Elizabeth McCarty)

ABSTRACT

Natural and social science are used infrequently with one another. This research employs both to understand two different, yet related topics. Female forest landowners (FFLs) often lack information, experience, and a landowner network. The Women in Forestry Workshop study developed and assessed workshops for FFLs to build knowledge, confidence, peer-to-peer learning, and participants' social network. Participants showed an increase in confidence and felt empowered by the workshops. Social networks and peer-to-peer learning happened during and after the workshops among FFLs. The second study assessed arthropods in longleaf pine tree canopies and if they varied among ecological communities. A total of 4,004 arthropods were collected with flightless Collembola being the second most abundant organism collected. Canopy arthropod communities were similar among ecological communities except the number of hemipteran families. Increasing our knowledge of natural systems, such as canopy arthropods, informs landowners how better to manage and conserve their land.

INDEX WORDS: Landowner outreach, workshops, *Pinus palustris*, Collembola

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DEDICATION

"The care of the Earth is our most ancient and most worthy, and after all our most pleasing responsibility. To cherish what remains of it and to foster its renewal is our only hope."

— *Wendell Berry*

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TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1

THESIS INTRODUCTION AND LITERATURE REVIEW

Female Forest Landowners Project

Demographics and insight on female forest landowners

Historically, female landowners in the United States have not owned large amounts of land or were overshadowed by their male partners. Regional studies of landowners in the United States did not occur until 1911 and gender differences were not assessed until 1920, only listing females as landlords and not landowners (Effland et al., 1993). In 1945, the gender of the landowner was determined by their name as listed in census data (Effland et al., 1993). Currently, the number of females operating as primary decision-making forest landowners in the United States doubled from 11% in 2006 to 22% in 2013 (B. J. Butler et al., 2016) and grew to 24% by 2018 (B. J. Butler, Butler, et al., 2021). In Georgia alone, females comprise 31% of landowners with 10 or more acres of forest (B. J. Butler, Butler, et al., 2021). The growing trend of female landownership is expected to continue. The national average age of landowners is 65, and 32% of all landowners fall between the age of 65 and 74 (B. J. Butler, Butler, et al., 2021), implying a large portion of land will change ownership in the coming years. Females are more likely to have a transfer plan for their land, while males are more unlikely to sell or transfer their land in the next five years (Markowski-Lindsay et al., 2017). In general, females are less likely to be as engaged in land management as their male counterparts (S. M. Butler et al., 2018). Males and females comprise approximately the same amount for both absentee and residential landowner (80-81% landowners surveyed were male) in an Indiana study (Snyder et al., 2020).

Strikingly, only 11% of family-owned forestland has a written management plan, regardless of the owners' gender (B. J. Butler, Butler, et al., 2021). Moreover, in the southern states only 16% of forest landowners are a part of forest owners' association. (Khanal et al., 2020). The evidence demonstrates that females will continue to acquire more land and offers a rationale for the present study.

Female forest landowners (FFLs) have different perceptions and motivations than their male counterparts. Females differed from males in management goals, emphasizing transferring land to their children and treating their forestland like home in two southeastern United States counties (Schelhas et al., 2012). Males ranked both beauty and wildlife as a higher priority than females while managing and visiting their land more often than females (Schelhas et al., 2012). FFLs in Oregon "consistently emphasize good stewardship for their land now and strive for effective transfer of their land in the future," (Redmore & Tynon, 2011, p. 259). Inheritors of land (how FFLs usually obtain land) often value their land for timber and non-timber forest products (Majumdar et al., 2009), however, FFLs frequently perceive conventional land management (such as timber harvesting) as more destructive to the ecosystem (Miner et al., 2021). Males are more likely than females to enroll in some form of forest certification program (i.e. American Tree Farm System, Sustainable Forestry Initiative, etc.) (Tian & Pelkki, 2021). Moreover, not every perception of land management has a relationship to gender. The size of land being held, as well as the educational level of the landowner, can often predict how a landowner will manage their land and how they value it (B. J. Butler, Caputo, et al., 2021; Mook & Dwivedi, 2022). Smaller land holdings often imply the owner is more interested in non-timber products and services from their land (Zhang et al., 2009). However, many FFLs do not feel they

have the right language and knowledge to fully articulate their own goals (Lukacic et al., 2023), which is why further educational training is needed for FFLs.

Many forest landowners enjoy their forest land not simply for their timber but for a host of other reason, including beauty and privacy (B. J. Butler, Butler, et al., 2021). Conservation is one avenue that landowners can use to maintain their lands integrity. Males frequently have a greater attachment to place than females and are more interested in conservation (Mook et al., 2022). However, the gender of the landowner influenced if they would enroll their land in conservation programs, with females more likely to join (Gan et al., 2005; Kaetzel et al., 2009; Lambert et al., 2006). Both genders consider conserving land a higher land management priority, although there is conflicting consensus on attachment to land and interest in conservation between genders (Mook et al., 2022). Gender was not tied to concern or management of invasive plants (Clarke et al., 2019). Furthermore, gender does not give black-and-white differences: and each woman should still be treated as an individual and not simply lumped into one group that encompasses all women (James et al., 2021). FFLs are more likely to manage their forestland for ecosystem services such as water quality and carbon sequestration, which may not give them direct financial benefits (Tian et al., 2015). When women are purposefully involved in conservation, it has a potential to have a larger impact than when only men are involved in conservation because women often have a more holistic view of the land than their male counterparts and comprise roughly 50 percent of the population (James et al., 2021). With this information in mind, the current study sought to better understand FFLs intention with their land and confidence in activities related to those intentions.

Females frequently consider their forestland as “home” and have a strong sense of “place” in relation to their land. The term “place” refers to the geographic position of land, but also

"…reflect[s] both unique biophysical, social, and economic attributes" that come with location (Schelhas et al., 2012). Sense of place is often built by "place attachment" and "place meaning" (Kudryavtsev et al., 2012). Place attachment refers to how attached a person is to a location, while place meaning is the symbolic terms and meanings someone associates with a place. Other researchers include other units of measurement in "place dependence," "place identity,"," and "place satisfaction" (Eaton et al., 2019). In essence, a sense of place is how a person feels about themselves and their connection to a certain location. In this case, how FFLs associate with their land and space (physical, spiritual, and emotional) and how they see themselves occupying their land. An estimated 38% of forest landowners are considered absentee landowners with their residence at least one mile away from their land, which may influence their sense of place (B. J. Butler, Butler, et al., 2021). However, growing a sense of place with the land can happen directly (through time spent in the place) and indirectly (through presentations, educational workshops, etc.) (Kudryavtsev et al., 2012). If an FFL establishes a strong sense of place, it is unknown whether educational opportunities provided through Cooperative Extension and others could influence such feelings and, in turn, a management decision.

Supporting, growing, and sustaining a sense of place is critical when working with landowners. A sense of place, as well as thinking about future generations, motivates many decisions made by FFLs (Miner et al., 2022). A framework has been proposed to incorporate sense of place into land management education and implementation (Eaton et al., 2019). Local and community-based forestry specialists alongside forest landowners can create a social and business community that will support landowners, their goals, and their sense of place (Hitchner et al., 2019). Landowners who manage their land for habitat (for wildlife or themselves) are 40% female, and yet they do not often rely on forestry professionals for guidance. Most information

obtained about land management comes from a friend or peer. This lack of engagement with forestry professionals may occur because they believe their management ideals clash with those of the professionals (Davis et al., 2015). One female being interviewed in a study saw the lack of holistic knowledge of the forest and the "straight line thinking" of traditional (harvesting-focused) forestry to be disconcerting, leading her to avoid conventional forestry management consultants (Coutinho-Sledge, 2015). The gender knowledge or awareness gap can widen quickly with newer trends, or alternative forest use (Joshi et al., 2013). Nonetheless, many studies do not even look into the demographics of gender in relation to land holding and use (Frey et al., 2019; Haines et al., 2019). Research that includes FFLs frequently comes with a caveat that more research needs to be done with FFLs in mind and that more education needs to target this growing group of landowners (Fegel et al., 2018; Joshi et al., 2013; Lidestav & Ekström, 2000; Mook & Dwivedi, 2022).

Supporting Theories

Females are an underserved and underrepresented demographic in the field of forestry (Huff, 2017; Miner et al., 2022). They are often the last to hear about updated best management practices and improved land management techniques (Redmore & Tynon, 2011). The Diffusion of Innovation Theory (DOI Theory) gives an outline to individuals' process for accepting or rejecting an innovation, with a clear preference in reducing confusion around an innovation and knowing what advantages or disadvantages come with it (Rogers, 2003). Techniques from DOI Theory have the potential to assist FFLs in adopting new techniques that might be beneficial for them. FFLs are potentially less likely than male landowners to support land management innovations because of their lack of participation in land management (Bliss et al., 1997; Sullivan et al., 2005). In forestry, the "innovations" may be long-standing best management

practices unknown to FFLs. The DOI Theory places individuals on a "innovation curve" based on when they will take up a new technique. The smallest portion of the curve begins with innovators, then early adopters, then early and late majority as the largest portion of the population, and then finally the laggards as another smaller percent of the population and is the last to take up new innovations. (Rogers, 2003). Different demographic groups can be put on the innovation curve. For example, because FFLs may not have the knowledge their male counterparts have, they may be shy to jump on an innovation until everyone else around them has innovated, putting them in the "laggards" section. However, this cannot be generalized. FFLs may make up the early adopter section because they are more motivated than males to try something new or to do whatever it takes to keep their land in their family. Looking at education in this framework can give the agents of change the knowledge to see what people in the particular field of work are doing, what are the latest innovations, and whether they are a good fit for their participants (FFLs in this case) (Rogers, 2003).

Transferring knowledge between similar individuals is often easier and more rewarding (Rogers, 2003). Incorporating female instructors in FFL education is likely beneficial for FFLs learning. In an agriculture setting, females trust other females over their male counterparts (Trauger et al., 2008). Participants accept information readily from someone viewed as a "peer," even if that person happens to be an expert or professional (Kueper et al., 2013). This is seen again when looking at forest owners' association members vs. nonmembers communication desires for landowners, with members wanting in person communication knowing it will come from peers while non-members often want a form of distanced communication (Khanal et al., 2020). If the agent of change (educator of FFLs), is not homophilious (similar) to the participants, they can still employ empathy and put themselves in the participants' shoes as much

as possible. Empathy pushes the educator to understand the learners and convey information in a more comprehensible manner. Educators need to engage in the "core elements of empathy, reciprocal respect, thorough explanation, and an openness to two-way learning" to help diffuse knowledge on to learners (Gootee et al., 2010, p. 150). Just being there in person to relay information proves extremely beneficial, since face-to-face time with people is considered the most trusted source of information (Jacobi et al., 2011).

There are different strategies to narrow the gaps between those that have knowledge and experience and those that do not (Rogers, 2003). Redundant messaging ensures everyone has the same baseline knowledge by repeating what some would assume is common knowledge. Tailoring messages is important for those that may have the least exposure to a certain skill- or knowledge-type, for example including definitions for basic forestry terms, like stand thinning, to tailor a presentation for an audience that may not be familiar with those concepts. Lastly, allowing time for those that may not be as knowledgeable to mingle with those with more experience and knowledge. FFLs interacting with veteran landowners, DNR agents, or forest consultants can quickly narrow knowledge gaps (Rogers, 2003).

Adult Learning

The initial broad theory of adult learning by Eduard C. Lindeman in the seminal work "The Meaning of Adult Education" presented that educating adults and learning as adults is very different than educating youths and learning as a youth (Lindeman, 1926). Adult Learning Theory, or andragogy, was refined and pushed as a central theory to unify all adult learners (Knowles, 1978). Now, three main foundational theories of adult learning are seen as 1) andragogy, 2) self-directed learning, and 3) transformative learning (Merriam, 2017). When educating FFLs, these theories can supply techniques to utilize in educational workshops to

ensure that the FFLs are learning what they want and it is being done in a way that FFLs retain the most information while giving them a sense of ownership in the process.

Andragogy is the adult version of pedagogy; it comes with six different assumptions (Table 1.1). Two important andragogy assumptions that support FFL education are: "Adults are mostly driven by internal motivation…" and "Adults need to know the reason for learning something" (Knowles, 1978; Merriam, 2017, p. 23). FFL participants will likely be motivated, as demonstrated by the effort to attend the FFL educational workshops, but educators need to regularly explain the reason behind the topics presented. For example, explaining the rationale behind a presentation on ecosystem services will give greater motivation to FFLs to learn about the topic. Self-directed learning theory puts the power and control in the learner's hands, which requires the individuals to be motivated to learn (Caffarella, 1993; Loeng, 2020). Program settings, like workshops, rarely use self-directed learning because it does not involve educators and is often done individually. Lastly, transformative learning theory is jump-started by an event occurring in the learner's life that makes them rethink beliefs and motivates them to expand their knowledge (Merriam, 2017; Mezirow, 1978). FFLs usually obtain land through inheritance (Crim et al., 2003), signifying that a death has occurred within the family, which could motive them to learn through transformative learning theory. Suddenly owning a large tract of land, however one acquires it, can be the sole catalyst as well.

The three adult learning theories help guide how workshop and outreach event approaches serve FFL participants. Adult learning involves a holistic approach not only with the mind, but the body and spirit as well. Educational programs need to recognize that "learning is a communal activity, it is lifelong and predominantly informal" (Merriam, 2017, p. 32; Merriam & Kim, 2007). Workshops have the flexibility to offer participants holistic learning by having peer-to-

peer engagement, discussion sessions, outdoor activities, resources for next steps, and can build on each other while being responsive to participant-identified needs (Brooks-Harris & Stock-Ward, 1999; Ma et al., 2012) By creating communal learning among both participants and professionals, workshops give FFLs a foundation to their informal learning.

Outreach Workshops

Workshops and outreach programs can relay essential land management information and also offer participants financial benefits through enhancing land management decisions and extending landowner social networks (Hughes et al., 2005). Many existing organizations want to empower FFLs. Organizations with resources and outreach programs are widely available online, such as Land and Ladies, Women and Forests, and Women Owning Woodlands. Outreach and informal education can grow FFL confidence to navigate the unique aspects of land management. FFLs often do not feel confident to ask land management questions as their male counterparts (Huff, 2017). Creating a space and teaching method that is inviting to the targeted group (FFLs) must be thought about carefully (Cooper & Brownell, 2016).

Supporting the growing group of FFLs involves outreach. Forest owners' goals for land management will differ, and they will oftentimes find traditional outreach material uninteresting if it does not speak to their goals (Kuipers et al., 2013), something supported by adult learning theory. The individuality of the forest landowner must be considered when engaging with them through outreach (Kuipers et al., 2013; Redmore & Tynon, 2011). Traditional methods of conducting workshops consist of having participants listen to numerous presentations with short question sessions at the end. Traditional presentations can work well if there is ample time for discussion and questions that engage the individual. Currently, engaging in only formal presentation-only methods are considered less successful and can often be intimidating to

participants. To avoid this, peer-to-peer learning was implemented in Massachusetts forestry workshops with success. It allowed the participants to maneuver to relevant topics and retain shared information longer (Ma et al., 2012). Peer-to-peer education allows inexperienced landowners to learn from the veterans, while experienced landowners can acquire new ideas and enthusiasm from the new landowners. In West Virginia, 51 percent of females surveyed said they would be interested in a peer-to-peer network (Fegel et al., 2018). One main reason for landowners to join owners' associations is for the networking it provides (Khanal et al., 2020). Professionals and experts engaging in workshops as peers, create a more comfortable setting for participants to discuss and even dream, without the fear of being scorned by professionals (Kueper et al., 2013). Peer-learning for FFLs brought inspiration, confidence, and self-efficacy in a Finland landowner study (Hamunen et al., 2020). Moreover, active learning is viewed as more effective, resulting in more information retained (Caprariis et al., 2001; Gopalan et al., 2018; Prince, 2004). In forestry, "marteloscopes," or permanent forest plots for training forestry professionals, are being used as an active way to train (Soucy et al., 2016). In addition, built in discussion time is crucial to creating an environment that is motivating to learn, assists participants to retain more information, and fosters peer-to-peer communication (Alozie & Mitchell, 2014; Gray & Madson, 2007; Roehling et al., 2010). Active learning and holistic learning are companions and the built-in activity time gives participants an opportunity to engage in holistic learning (Dewing, 2010). When done well, active learning can engage the mind, body, and spirit (Dewing, 2010). For example, it not only allows the participants to physically feel the soil beneath them, but to understand some of the processes and nutrients in the soil that help with tree growth, discuss that with peers, and strengthen a community of landowners (FFLs in this case). They can then recognize the inter-connectedness of all that is happening between

themselves the landowner, the environment, and the trees. Many landowners feel an environmental, social, and spiritual desire to take care of their land, making holistic learning ideal to approach the landowners spectrum of feelings towards caring for their land (Andrejczyk, Butler, Dickinson, et al., 2016). Outreach workshops allow for connections to be made between potential peers, they can set a baseline of educational awareness for landowners, and give an opportunity to relay past and future beneficial scientific findings to landowners (Jamison & Muth, 2022). It also allows for educators and researchers to listen to the participants to know what they need and want to learn more about (Anderson, 2008). Although there has a been a great amount of literature regarding workshops, there has been fewer involving females, even less with FFLs. When put together (FFLs and workshops), there has been only a small number of limited studies. This lack of knowledge prompted the current study in Georgia to fill in those gaps.

Outreach Evaluations

Training programs and workshops have been used for decades to train employees, create streamlined productions, and ensure that the knowledge of all employees or organization participants was set on the same educational foundation (Council, 2005; O'Leary et al., 2004; Schultz et al., 2011). The development of these workshops led to evaluating mainly the products (i.e., how much knowledge was gained, did production gain efficiency, etc.). The Kirkpatrick Model was developed 50 years ago as an evaluation tool (Kirkpatrick & Kirkpatrick, 2006). It focused on program results, assessing if the program was effective and worthwhile. Since then, the product, rather than the process, of teaching has been the focus of workshops. However, it remains important to evaluate both the product and the process.

One model for evaluating different angles of workshops would be the CIPP model (Stufflebeam, 2000). CIPP stands for context, input, process, and product evaluation. Using the CIPP model allows flexibility for the evaluator in how and what they are evaluating. Evaluators can use one portion of CIPP or all when evaluating. Context evaluations "… describe the context for the intended service … identify intended beneficiaries and assess their needs … identify problems or barriers to meeting the needs … identify area assets and funding opportunities that could be used to address the targeted needs … [and] assess the clarity and appropriateness of program, instructional, or other service goals (Stufflebeam, 2000, p. 287). Context evaluations are essentially a proposal or a grant that seeks to show the background information for the research or service, who it will be for, obstacles that may occur progress, where sources of funding can be obtained for this project and assess the service or research as it goes along. Context evaluations allows others to see the research or service not only in present environment but also within the historical environment. Input evaluations build off a context evaluation by deciding whether a suggested service has the potential to be successful. Once events (i.e. workshops) have been created and implemented they should be evaluated. Process and product of the CIPP model fit here. Process evaluation makes sure the process and execution of the program or system is working well. Are the participants engaged and enjoying themselves? The product evaluation is ensuring goals for the participants are being met and are the participants the ones that should be the beneficiaries of this service. One evaluation can potentially investigate both the process and the product simultaneously. CIPP product evaluation cannot be made by one standardized instrument, but an evaluation that is fitted for the product being evaluated.

Evaluating workshop objectives can range from qualitative interviews and anecdotes to quantitative survey approaches (Burns, n.d.; Smidt et al., 2009). Selecting the most appropriate

evaluation method for the research questions being asked is critical to obtain useful data. Evaluation methods can range drastically, however there are some basic methods that are both valid and reliable when it comes to data collection. Qualitative data collection can give depth otherwise lost to researchers. This data can be commonly collected through noting concerns, comments, or questions participants may have at workshops, as well as more formal interviews and focus groups facilitated by a guide of questions. Quantitative data can be reliably collected using well-constructed questionnaires where demographic data can be compared to scaled responses to questions for a deeper understanding of participants and their knowledge, attitude, or behaviors. Quantitative data can then be analyzed precisely when the researcher knows what questions they are trying to answer.

Qualitative Evaluations

Qualitative data, such as focus groups and interviews, can be used to evaluate education methods involving human dimensions. This form of data gives richness and deep insight into research questions that may have multiple answers. One way to evaluate qualitative data is through reflexive thematic analysis (Braun & Clarke, 2006). Thematic analysis allows the researcher to put qualitative data into themes, without creating rigid rules, allowing for flexibility with different data types. Themes are created by the researcher when reviewing answers given to different questions. Reflexive thematic analysis forces the researcher to explain the thought processes behind their analysis and lays out transparent analysis and results (Braun & Clarke, 2019). The depth of thematic analysis gives a unique perspective on the data otherwise lost in quantitative analysis. In the context of this study, collecting both quantitative and qualitative data was important because they both fill a void where the other cannot, in terms of the depth and quality of each data for its specific purpose.

Quantitative Evaluations

Time and convenience are limiting factors to evaluating a workshop. Participants can develop what is referred to as "survey fatigue," where non-response or less-genuine responses may be recorded because of long surveys or multiple ways of evaluation being put on participants (Porter et al., 2004). The evaluations need to be concise, with qualitative data being gathered at different stages throughout the event. Frequently, a problem called response-shift bias can occur when surveys are handed out before a workshop and then again after a workshop to gauge a change in knowledge, or confidence (Howard, 1980). Response-shift bias is where a participant over- or under-estimates their initial confidence and knowledge and then shifts their response accordingly after the workshop or event, making it appear they gained or lost confidence, when that may not be the case (Howard, 1980). The retrospective post-then-pre survey design was first proposed in 1979 to help mitigate response-shift bias (Geldhof et al., 2018; Howard, Ralph, et al., 1979; Howard, Schmeck, et al., 1979; Howard & Dailey, 1979). A retrospective post-then-pre survey allows for an efficient means of collecting data, allowing more workshop time to be dedicated to the holistic learning because the retrospective approach gathers data only at the end of the educational event. Retrospective surveys are an efficient way to gauge the impact of extension work and public outreach on humans, who are notoriously difficult to measure (Raidl et al., 2004).

Survey evaluations provide valuable quantitative and limited qualitative data regarding workshops. However, other evaluation methods should be used in conjunction with surveying methods to delve into the depth of qualitative data and to see how workshops may affect individuals. Focus groups are an easy, low-cost, and high output method of collecting qualitative data. This method has been used for many different academic fields, including business

marketing and health (Wilkinson, 1998). Outreach professionals have started incorporating focus groups to obtain in-depth data that may not surface with conventional quantitative data collection methods (Giri & Darnhofer, 2010; Kilgore et al., 2007; Moskell et al., 2011). In focus groups the researcher facilitates and moderates the discussion, while gleaning info from the voluntary participants. They function to shepherd the discussion, rather than being the center of the discussion (Nyumba et al., 2018). The researcher must moderate a group with ease because a focus group straying from the core questions can give irrelevant or chaotic data. Effective focus group management is essential to keeping the focus group on task (Wilkinson, 1998).

The Theory of Planned Behavior (TPB) is a way to evaluate participants' intentions throughout a certain time period and predict their future behavior (Ajzen, 1991). TPB can estimate how a participant will behave in certain scenarios and what obstacles may change the participants' behavior by looking at the participants' attitudes, societal norms, and their perceived behavioral control for whatever behavioral intention that is being assessed. As an example, TPB was used to observe how landowners would react to an invasive insect being found on their forest land. Their intentions beforehand can help predict their future reaction to an invasive species. In this scenario, TPB demonstrated that subjective norms (societal norms) were the biggest obstacle or catalyst to landowners' reactions (Holt et al., 2021). To help change certain negative behaviors, the subjective norms in place around that intention or behavior should be addressed. Giving discussion time to converse engages participants and perhaps changes norms that hinder more active land management. One can then determine people's attitudes towards subjects by surveying their confidence. Perceived behavioral control is usually tied to their confidence in a skill, their resources, and time to perform a task (Ajzen, 2020). Using the TPB framework, a

survey can be created to investigate one or more components to then help predict future behavior of landowners.

Social Research in Forestry

In 2003, gaps in forestry-related social research remained: "…the full power of social research has yet to be brought to bear on forest issues in the South … social research has a fundamental role to play in our efforts to maintain the integrity and enhance the benefits of the southern forests" (Schelhas et al., 2003, p. 8). As previously noted, many studies have been conducted throughout the United States and in the Southeast to assess the social aspect of forestry and natural resources. Social research is necessary to create effective forest management because it informs effective communication to underserved landowners, helps better understand obstacles landowners may have, and explain negative social norms that are impacting the management of forests. However, social research is challenging to execute well. Not all social research and subsequent assessment tools are equal as they are often formatted for specific situations with certain factors remaining stable (Ajzen, 1991). For example, from a validity and reliability standpoint, assessment tools that gauge how well teachers in Georgia learn a new teaching technique should not be used for teachers in another state, nor should it be used for participants learning something other than that specific teaching technique. Reassessing validity and reliability each time before an instrument is used is considered a best practice. Forestry research does not incorporate social science enough, often because of the lack of subject matter expertise (Jacobson & Duff, 2008; Sample et al., 2015). Applying social science tools would greatly enhance many research areas because it would include the human aspect of a project (Jacobson & Duff, 2008). Including the human aspect while studying a forest health problem

would allow researchers to know how humans are connected to this problem, whether they are helping or hindering it, and whether that changes the approach to the problem.

Although a gap exists, social research on minority landowner perceptions, motivations, and how they can be supported is growing within forestry (Goyke & Dwivedi, 2021; Hitchner et al., 2019; Majumdar et al., 2009; Miner et al., 2021). Differences in stakeholders and in demographics, such as attitudes or perceptions towards certain management techniques, are the most heavily studied areas of social science in forestry (B. J. Butler, Butler, et al., 2021; Cruz et al., 2021; Tumpach et al., 2018). Areas of current study include not only differences in demographics but differences in the worldview of landowners and how they approach the environment around them (Cruz et al., 2021).

Outreach projects have used social science to go beyond the traditional engagement and use techniques to engage with their audience such as indirectly through sites like Wikipedia (Radtke & Munsell, 2010). People often do not want to be "studied" nor want to engage with strangers, which has led researchers to get creative. The language educators use to describe land is important when it relates to promoting management ideas to landowners. Land, and the associated language that comes with it, is a means for self-actualization. Using language that dismisses what is a part of them can quickly turn FFLs away from important educational moments. For example, the words or terms, such as "family forest owner" are seen with a negative connotation by land owners, and the term "forest" carries more negative baggage than the alternative term "woods" or "woodlands" (Andrejczyk, Butler, Tyrrell, et al., 2016). These language preferences likely come from a complex web of social environment and attitudes towards organizations or business that may use that language. Incorporating these language preferences into outreach products can help scientists better relay important scientific discoveries

to stakeholders (Andrejczyk, Butler, Tyrrell, et al., 2016). Workshops that have friendly and inviting language to the target demographic (FFLs, in this case), allow for the participants to not be intimidated or harbor subconsciously cautious feelings about a workshop. Evaluating FFLs confidence with land management before and after workshops, their intention with their land, and how connected they are to their land, allows the researcher to better understand knowledge and skill gaps and effective ways to address such gaps among FFLs. The following research questions guided data collection: (1) Are the workshops changing FFL confidence in land management? Land management constructs are: pine silviculture, wildlife and conservation management, fire management, forest health, and land management finances. (2) What are FFLs' intentions after attending workshops i.e., FFLs will engage the most in which land management activities? (3) Does confidence or participants' intentions with their land vary with demographics? (4) Are workshops providing a platform to start FFL social networks? Lastly, (5) are workshops creating a space for peer-to-peer learning?

Social research continues to give us valuable information to know how to help different demographics and which groups of the population need the most help. Humans are not distinct from the landscape nor nature but are a portion of it. Conveying scientific research to the groups that need the new information is extremely important. For example, researching canopy arthropods in longleaf pine trees in Southwest Georgia could be needed or desired information for FFLs that have vast swaths of longleaf. It may help FFLs who have goals to improve biodiversity or help pollinators. Having a scientific component coupled with a social science component allows for data to be triangulated and disseminated appropriately.

Canopy Arthropod Project

Tree canopy research

The tree canopy represents a world rarely visited by humans except for adventurous children wanting to see how high they can climb. Some researchers have kept that childish spirit and continue to explore tree canopies. However, tree canopy research started on the ground. Many different canopy ecosystem traits are noted from ground observations or by collecting materials that have fallen from the treetops (Schueller et al., 2019). Studies of forest species in vertical gradients, height profiles, and three dimensions were not widely published until 1961 with a paper discussing bird diversity in the forest (MacArthur & MacArthur, 1961). Research and accessibility have been slowly spreading to different tree canopies, starting with the biodiversity hotspots of tropical canopies. Approaches to accessing the canopy differ with the ecosystem type. Methodologies include climbing the trees, lifting traps attached to branches, balloon rafts, permanent or long-term crane use, and canopy walkways in trees (Basset et al., 2003; Nakamura et al., 2017). Old growth canopies are even more challenging to access without potentially damaging plant species underneath the larger trees (Schowalter, 2017). Reaching a tree canopy could involve moving people or equipment 30 feet or 100 feet off the ground. Recommended collaboration among research departments to combine new technology, such as LIDAR equipped drones, could expand canopy studies further (Müller et al., 2014, 2018).

The vast difference in tree height makes the term “canopy” different to define. The canopy was defined in 2015 as “the aerial part where all the foliage, buds, fine branches, associated flora and fauna, the suspended oil and interstices (air) of a forest are combined.” (Valencia-Cuevas & Tovar-Sánchez, 2015). Frequently, vertical ecosystem research is not in the tree canopies but at a pre-determined height for consistency, which may or may not be in the

canopy (Behan-Pelletier & Winchester, 1998; Ulyshen et al., 2010). Moreover, canopy research commonly involves research on one specific species and often uses varying collection methods unique to the objective of the research project (Müller et al., 2014, 2018). Any collection method will have a bias for collecting certain insect taxa (Dilling et al., 2007; Hill & Cermak, 1997; Skvarla et al., 2021). Collecting methods include but are not limited to flight intercept traps, sticky traps, funnel traps, and branch clippings. Arboreal pitfall traps, collectors that are placed in crevices or holes made in branches and tied down, were used to study ants that may climb into the canopy (Kaspari, 2000). Manually handpicking from canopies has been done to investigate any lesser-mobile arthropods (Volf et al., 2019). In denser plantation stands, sweep netting from bucket trucks in lower canopies works to collect a large and diverse quantity of arthropods (Hartley et al., 2010). A comprehensive sampling method is canopy fogging with an insecticide and then collecting the insects that fall onto a collection tarp. However, even fogging cannot capture the insects that may be living in the plant tissue of the tree (Dial et al., 2006). The fogging method can potentially affect other ecosystems away from the canopy and must be careful done (Adis et al., 1999; Schowalter & Chao, 2021). Goals of canopy studies may include documenting the life cycle of an insect, pest management effectiveness (and indirect impacts of management use), or how an arthropod species interacts with the tree (Aikens & Buddle, 2012; Costa & Crossley, 1991; Leroy et al., 2022).

In the United States, canopy arthropod communities have been assessed in different forest types, including in cut and uncut hardwoods in North Carolina, tropical forests in Puerto Rico, and coniferous trees in Western Oregon and eastern North America (L. Butler, 1995; Dilling et al., 2007, 2009; Lowman & Schowalter, 2012; Mallis & Rieske, 2011; Schowalter, 1995; Schowalter et al., 1981, 2005; Schowalter & Zhang, 2005). Canopy arthropod research

studies gives a baseline to answer questions such as how chemicals are affecting forest canopies, how old growth and young growth canopies may differ, and how urbanization may affect arthropod communities. The changing climate has prompted latitudinal research on canopy arthropods to predict future changes in canopy structure. In Australia, the arthropods found were consistent for each latitudinal point, meaning that latitude, along with the environment could predict what arthropods were present. Broad changes have been studied in temperate forests and how it may influence arthropods in the future (Andrew & Hughes, 2005; Sallé et al., 2021).

Ground arthropods have been used to predict soil health and act as bioindicators (Madzaric et al., 2018; Straalen & M, 1997; Suheriyanto et al., 2019). However, canopy arthropods could become valuable bioindicators for the forest, designating healthy forests compared to other forests or past data (Maleque et al., 2006; Valencia-Cuevas & Tovar-Sánchez, 2015; Vitanović et al., 2018). Canopy arthropods can also be a marker for habitat diversity. They have a bottom-up influence on habitat diversity on arthropod community structure (Halaj et al., 2000), meaning that the diversity of higher tropic-level species in the canopies (birds, mammals, etc.) rely on the arthropod diversity.

Canopy research in southeastern forests

The Southeast has fueled many timber, canopy, and tree related research because this region is the largest contributor to timber in the United states (Assogba & Zhang, 2022; B. Butler & Wear, 2013), Due to the introduction of the invasive pest, the hemlock wooly adelgid, different insecticide treatments were evaluated on how they effected canopy arthropods. Separately, arboreal spiders were recorded to see the future effect the decline of hemlocks may have on them (Dilling et al., 2007, 2009; Mallis & Rieske, 2011). Canopy arthropod sampling using fogging and branch clipping (with collapsible bag) was compared in mixed hardwoods near Otto, NC.

Canopy arthropod richness and abundance was both higher with fogging. The fogging yielded more species such as winged parasitoids, which a branch clipping would easily miss. However, they both gave roughly the same percent of carnivorous and herbivorous insects. (Blanton, 1989). Hymenoptera was the dominating canopy arthropod one year and Hemiptera the next when insecticide knock-down was used for two years to sample arthropods in plantation slash and eucalyptus stands. (Messick et al., 2018).

In the Southeastern United States, pine ecosystem studies are abundant, yet mature pine canopy studies are lacking. The longleaf pine ecosystem is especially important, as it has dwindled from its estimated original 37 million hectares to now under 1 million hectares, making it home to many threatened species (Jose et al., 2006). In Alabama, longleaf pines were fitted with climbing traps to collect arthropods moving along the trunk to determine if canopy arthropod abundance and biomass were related to stand age. The most diverse orders collected were Coleoptera, Araneae, and Hymenoptera (Hanula et al 2000). Arthropods living on pine bark from ground-level to the lower canopy were collected using fogging. Arthropod abundance was twice as high in longleaf pine trunks compared to loblolly pine trunks. The arthropod community was comprised predominantly of hymenopterans (mainly ants), coleopterans and blattodeans (Horn & Hanula, 2002).

Vertical distribution of Arthropods

Studying vertical distribution of arthropods has become increasingly popular (Aikens & Buddle, 2012; Preisser et al., 1998; Stork et al., 2001; Ulyshen et al., 2010; Urban-Mead et al., 2021). Two distinct heights are often used in vertical distribution studies, while others may employ what is considered overstory and understory canopy planes, and others use easily accessible heights. The vertical distribution research suggests that arthropod structure changes

consistently with sampling height (Wardhaugh, 2014). Beetle abundance and species diversity differ based on location in the canopy. Trap heights must be taken into account when studying beetle populations. (Miller et al., 2020). Past vertical distribution studies at the Jones Center at Ichauway in southwestern Georgia have centered on the southern pine beetle (*Dendroctonus frontalis*) a pest insect species, and canopy disturbance (Aubrey et al., 2012; Coulson et al., 1999; Pecot et al., 2007; Sheehan & Klepzig, 2021; Six & Klepzig, 2021).

Arthropod Community Structure

The types of tree species that make up the canopy and openness of the canopy cover helps determine the canopy and ground arthropod community structure (Perry et al., 2018). When gaps are made within the canopy or trees begin to shade out existing canopy gaps, arthropod communities change rapidly following the ground vegetation shift (Perry et al., 2018). Canopy arthropod species assemblages can vary depending on if a tree is growing in isolation or growing within a forested patch (Ozanne et al., 2000). Additionally, the major type of canopy cover and the subsequent ground level vegetation can help predict what type of arthropod community occurs in the ecosystem or micro-ecosystem (Landsman & Thiel, 2021; Lanta et al., 2018). For instance, in a fire-disturbed longleaf open canopy, native wiregrass, or slim leaf pawpaw, among other native plants are common. The individual plant species and the plant communities can then be used to predict what arthropods will be found (Schaffers et al., 2008). Community structure will change slightly as seasons change, along with small changes between night and day-time structure (Schowalter, 2017). Canopy diversity promotes arthropod diversity and hybridization of closely related trees species increases canopy arthropod species richness (Maldonado-López et al., 2018; Vaca-Sánchez et al., 2021). Ground to canopy community structure was researched closely in orchard settings, showing that the more diverse the ground

cover, the more diverse and balanced the arthropod community structure was (Castro et al., 2021). A balanced arthropod community is where there is no excess of a particular type of arthropod, causing the arthropod to potentially become a pest species. Moreover, with a growing urban population, studying the effects of urbanization on arthropod structure is becoming increasingly popular and important (Christie et al., 2010).

Knowledge of canopy arthropods is continually growing. Many canopy arthropods are transient species that are going from one place to another, often called tourists (Thunes et al., 2003). Flightless arthropods, including mites and collembola, also occur in tree canopies. Flightless arthropods were the most abundant species in some studies (Behan-Pelletier & Walter, 2000; Coleman & Hendrix, 2000; Ozanne, 1996; Schowalter, 2017; Valencia-Cuevas & Tovar-Sánchez, 2015). These flightless insects potentially spend their entire lifecycle in the canopy, never touching the ground. More research would increase understanding of how flightless insects reach the canopy and if or when they come down.

The Jones Center at Ichauway in Southwest Georgia is a research facility with a pre-agricultural longleaf pine ecosystem. The plant community structure is unique, including many rare and endemic plants, a consistent fire disturbance regime, and varying ecological communities within the larger longleaf pine ecosystem. The longleaf pine ecosystem is difficult to classify as an old growth forest, since there are consistent disturbances (Schowalter, 2017). However, plant diversity, as well as a naturally maintained ecosystem through fire, allows for a high diversity of arthropods. Although no larger canopy arthropod studies have been completed, a thorough literature review (Sheehan & Klepzig, 2021) documents arthropod studies in this system. There are an estimated 4000-5000 different arthropod species found in the xeric longleaf pine community typical of the Southeastern United States (Folkerts et al., 1993). Both the

abundance and diversity in this ecosystem is extremely high. Pitfall traps in burned and unburned longleaf pine ecosystem obtained more than “163,000 arthropods from 31 orders, 265 families and 932 genera” (Hanula & Wade, 2003). Nonnative species, such as exotic fire ants were most prevalent in frequently burned areas, while overall ant abundance increased with fire disturbance (Atchison et al., 2018). Some wingless insects may migrate to the canopy to avoid fires in these fire-maintained systems (Dell et al., 2017).

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Table 1.1 Six Assumptions of Andragogy adapted from Knowles, 1978

Assumptions
1. As a person matures his or her self-concept moves from that of a dependent personality toward one of a self-directing human being. 2. An adult accumulates a growing reservoir of experience, which is a rich resource for learning. 3. The readiness of an adult to learn is closely related to developmental tasks of his or her social role. 4. There is a change in time perspective as people mature – from future application of knowledge to immediacy of application. Thus, an adult is more problem centered than subject centered in learning. 5. Adults are mostly driven by internal motivation, rather than external motivators. 6. Adults need to know the reason for learning something

CHAPTER 2

GROWING CONFIDENCE: WOMEN FOREST LANDOWNER WORKSHOPS IN GEORGIA

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Abstract

The number of female forest landowners (FFLs) has been growing throughout the United States. This growth demands educational outreach for a demographic that is often behind their male counterparts in experience and education. The purpose of this exploratory study was to design and host educational workshops geared towards FFLs and to answer the following questions using quantitative and qualitative methods: (1) Are the workshops changing FFL's confidence in land management? (2) What are FFLs' intentions after attending workshops? (3) Does confidence or participants' intentions with their land vary with demographics? (4) Are workshops providing a platform to start FFL social networks? Lastly, (5) are workshops creating a space for peer-to-peer learning? A total of 41 questionnaires were collected with 28 being participants surveyed for the first time. Confidence increased after attending workshops, and participants had exceedingly high intentions to engage in most land management activities. Qualitative data from focus groups and interviews indicated that participants built a network and grew by peer-to-peer learning. Empowering FFLs seems to be one of the first steps to increase their engagement with other FFLs, their own land, and with forestry professionals.

Key Words: Empower, Land Management, Intentions, FFL, Social Networks, Adult Education Theory

Introduction

The Greek philosopher, Heraclitus, said “Change is the only constant in life,” and to this day, the statement prevails. Change is a welcome trend in forest landownership in the United States because female landownership is increasing (Butler et al., 2021). Females were first listed as landowners in 1945, after only being listed as landlords, rather than landowners, since 1911 (Effland et al., 1993). Even so, females were not well represented in the male dominated landowner group, making up a miniscule portion of landowners. Since then, landownership demographics have changed drastically (Butler et al., 2021). In 2018, female forest landowners (FFLs) constituted 24% of forest landowners in the United States, more than double from 2006 (Butler et al., 2021). However, FFLs are likely at a disadvantage because FFLs have less formal land management training, active management experience, and a less developed social network of other forest landowners on which to rely compared to male landowners (Miner et al., 2021). These obstacles can result in FFLs lacking confidence in their decision making abilities, which may lead to less, or even no, active land management (Lukacic et al., 2023).

Natural sciences research seldom includes social sciences research (Jacobson & Duff, 2008; Sample et al., 2015; Schelhas et al., 2003), however, these disciplines may overlap with great benefit, especially in forestry. Studying the FFL demographic demonstrates a combination of natural and social science research by gauging what education FFLs need and what future natural resource outreach may help them. There can be conflicting evidence for certain landowner trends based on gender (Berget et al., 2023; Mook et al., 2022). Some demographic trends cannot be consistently generalized, but there are some meaningful trends that can be helpful in developing women landowner outreach. However, it's important for educators to realize that each landowner is an individual and making generalizations can be problematic

(Cruz et al., 2021; Munton, 2019). FFLs have a similar level of concern as males regarding conservation (Mook et al., 2022). However, FFLs are more inclined than males to make land management choices that promote ecosystem services, even if those actions do not provide a financial benefit (Tian et al., 2015). FFLs commonly view traditional forest management as destructive to the environment (Miner et al., 2021). FFLs often acquire land through inheritance, and people who inherit forest land are more likely to value their land for the timber. Males often have a greater attachment to their land and are more likely to enroll their land in certificate programs (Majumdar et al., 2009; Mook et al., 2022; Tian & Pelkki, 2021). Noting differences between female and male landowners is part of gauging the education needs for each group.

FFLs can be divided into more specific demographic categories, such as age, landholding size, duration of landownership, marital status, educational background, and ethnicity. Each demographic difference could relate to a different educational approach (Vanderford et al., 2014). Forestry educators can assist, support, and encourage FFLs, especially given the changing demographic of female landownership (Harriman et al., 2020). It is easier for educators to reach a larger group of FFLs, and as FFL ownership increases, the FFL community has a higher potential to support themselves. FFLs will be making more land-related decisions over time. Private landowners need to make educated decisions that do not harm their own livelihood, or the land they manage, to create sustainable forests and a healthy forest economy (Daniels et al., 2010).

One outreach avenue is to hold workshops specifically geared towards FFLs (Kueper et al., 2013). Outreach events not only provide knowledge transfer to FFLs, but also help develop confidence and a larger FFL peer-learning network (Hamunen et al., 2020). Participants are more likely to trust and receive information from someone they perceive as similar to themselves

(Rogers, 2003). Moreover, participants are more open to information coming from someone they view as trustworthy (Malka et al., 2009). Workshops can attract both veteran and new landowners and incorporate many female forestry experts. Educating and encouraging a peer network of FFLs ensures pertinent information and informed decision-making will disseminate quickly among this demographic group (Rogers, 2003). Outreach workshops provide a platform for educators, outreach specialists, and researchers to gather information to understand FFLs education and outreach needs ultimately enhancing outreach for FFLs in the future (Anderson, 2008). However, information is lacking on evaluations with FFL educational workshops. How FFLs respond to different evaluation methods, the evaluation needs of FFLs, and what type of evaluation benefits both FFLs and researchers together has not been explored in a workshop environment.

Clearly identifying the target audience is a critical step in crafting a workshop. For the purpose of this manuscript, the audience is adult females who own or want to own land. Well-developed workshops provide a comfortable atmosphere that feels safe for the target audience to ask questions, engage, and learn (Chakanika et al., 2019; Knowles, 1980; Sargeant et al., 2006). Originally, educating adults was seen as the same as education for children, or pedagogy (Knowles, 1978; Lindeman, 1926). Using pedagogy was a disservice to the adult students. In the past, adult education operated under the assumption the adult students lacked experience, which resulted in frequently belittling education settings for adult students (Forrest & Peterson, 2006). With further research, adult learning theory, or andragogy, became widespread. Adult engagement increases when the reason that learning topics are being covered is clear (Knowles, 1978). Fortunately, audiences of FFL targeted workshops usually understand why they are learning each topic. Nonetheless, it is still valuable to reinforce the importance behind the

knowledge provided to the FFL participants. Moreover, recognizing the experience participants bring with them and their desire to apply most of what they learn (Knowles, 1978, 1980; Loeng, 2018), allows for educators to tailor more specific outreach events. Transformative learning theory compliments andragogy and FFL workshops (Merriam, 2017; Mezirow, 1978). This theory assumes the learner has gone through some distinct transformation that motivates them to learn. Many FFLs have inherited, will inherit, or will buy larger land tracts. The acts of buying or inheriting (with the assumption that someone close has passed away) large acreages possibly represent transformative events and can motivate FFLs to learn. Transformative learning theory, along with FFLs' concerns and needs, encourage workshop attendance, while andragogy compels educators to teach in a way that is meaningful to the participants.

Andragogy is used to its full potential in outreach workshops where adults are frequently engaged and ready to learn. However, techniques borrowed from other social research help to educate and evaluate FFLs. Diffusion of innovation is how innovations are diffused and adapted throughout society or sub-populations such as farmers or forest landowners. However, it also gives detailed suggestions on how to bridge gaps between the knowledgeable and the inexperienced landowner (Rogers, 2003). Connecting FFLs with different experience and educational levels is critical for diffusion of innovation and education to occur. Participants arrive with varying background knowledge, experience, and future goals. Workshops help unify the participants and grow a stronger social network (Hughes et al., 2005). In person workshops provide time for face-to-face interactions, helping FFLs see each other as trusted information sources (Jacobi et al., 2011). However, consistently evaluating and improving every workshop is essential for meeting the target audience's needs.

Assessing workshops formatively and summatively can provide rich qualitative and quantitative FFL data for educators. Program evaluations have morphed throughout the years. Previously, evaluations often focused on the product of the workshop and whether participants learned or gained specific skills (Kirkpatrick, 1977; Smidt et al., 2009). However, evaluations should focus on both the outcomes and the processes (teaching and delivery methods) of the workshops which contributed to those outcomes (Stufflebeam, 2000). One way this is accomplished is through the Context, Input, Process and Product Evaluation (CIPP) Model (Stufflebeam, 2000). Context evaluation looks at why something should be done, while input evaluation assesses how something should be done. The process and product evaluations assess the process of the implementing the solution gained from the input and the product of the process (Stufflebeam, 2000). The CIPP model creates a holistic avenue to evaluate a project from the inception to the product. Frequently, evaluators will use all four aspects of the CIPP model or focus only on specific parts of the model. For example, process and product evaluation are the most commonly used in workshop evaluations and workshop product outcomes (increase in knowledge, confidence, etc.) (Stufflebeam, 2000). The first two portions, context and input, are often used in the planning stages of a project for grant funding, planning, and ensuring the problems and intended audiences are defined through needs assessment methods. The process evaluation guarantees the application of the project (i.e., educational workshops), goes well. A designated evaluator on the education team is crucial to ensuring assessments are implemented consistently among workshops (Stufflebeam, 2000). Product evaluations assess the outcome of the education event (i.e., what did FFLs gain), making sure the goals for the event and the targeted audience were addressed (Stufflebeam, 2000). Both process and product evaluations are essential for workshop assessments. Additionally, evaluations should be straightforward, inviting

to preform, and have ample time to complete with social exchange theory in mind (Dillman et al., 2014; Homans, 1958). Social exchange theory denotes that participants will be more willing to help the researcher when they receive something from completing the evaluation, even if the reward is simply feeling good about helping a graduate student with their research (Cropanzano & Mitchell, 2005; Homans, 1958).

Questionnaires are a commonly used tool for evaluating extension workshops (Robelia & Murphy, 2012). Questionnaires which are based on theory can add validity to data collection procedures. The Theory of Planned Behavior (Ajzen, 1991) predicts behavior by considering a person's intentions and has been used in the past with family forest landowners (Holt et al., 2021; Karppinen & Berghäll, 2015). A person's intentions are determined by their attitude towards a certain behavior, the subjective norms around the behavior, and the person's own perceived behavioral control (Ajzen, 1991). Asking participants how likely they are to do something, combined with participants' confidence levels for land management activities provides data to predict future participant behavior. Furthermore, evaluating connection to the land is a tactic to gauge how likely someone will engage in activities on their land (Leahy & Lyons, 2021). Combining connection to land, intentions, and confidence can give a clearer picture on where landowners are motivated. Constructs can also be used in questionnaires. Constructs are groups of three or more statements on confidence levels for a combination of similar topics that create a balanced perspective on landowner motivation. For example, three questions regarding different parts of pine silviculture provides a researcher with a better idea about a participant's confidence on that subject than one single statement on silviculture. The predicted behavior, along with demographic data, can assist outreach teams in supporting FFLs.

The overall objective of this study was to understand FFLs education needs and provide workshops that will build their knowledge and confidence while providing a platform for developing social networks. Our goal was to answer the following research questions: (1) Are the workshops changing FFLs' confidence in land management? (2) What are FFLs' land management intentions after attending workshops? (3) Does confidence or participants' intentions with their land vary with demographics? (4) Are workshops providing a platform to start FFL social networks? Lastly, (5) are workshops creating a space for peer-to-peer learning?

Methods

Female Forest Landowner Workshops

The University of Georgia's Warnell School of Forestry and Natural Resources hosted a Women in Forestry Workshop Series. Workshops were held three times in the Fall 2022 and four times in Spring 2023. A team of outreach faculty tailored workshops to fit FFL needs using research-based FFL information (Miner et al., 2021; Mook et al., 2022; Mook & Dwivedi, 2022) and their experience. Workshops were held in different regions of Georgia to be accessible to FFLs throughout Georgia. Locations included: Athens in north-central, Alapaha in south-central, Guyton in eastern, and Dry Branch in central Georgia. The workshops targeted women owning, were obtaining, or were interested in obtaining forested land. Workshops included free registration, lunch, refreshments, and coffee. Most workshops started at 8:00 am and continued until 3:00 – 4:30 pm, depending on participant enthusiasm and the length of presentations. However, the start time was delayed to 9:00 the later workshops based on participant feedback. The workshops provided ample time for socialization to promote peer-to-peer learning and building new social networks among landowners, as well as the presenters. Socialization was encouraged by scheduling longer refreshment breaks, extended lunches, and having a flexible

approach to the workshop schedule (i.e., if participants where having a productive discussion, organizers allowed the conversation to continue) (Horsfall & Cleary, 2008; McIntyre et al., 2008; Watson et al., 2019).

Experienced FFLs and forestry professionals from the University of Georgia, government agencies, and forestry education outlets spoke at the workshops. Speakers were chosen based on their experience in owning land, expertise in a certain subject, and/or teaching experience with a preference for female speakers. The Georgia Forestry Commission, Georgia Department of Natural Resources, United States Department of Agriculture Natural Resources Conservation Services, University of Georgia Extension, Gaskins Forest Education Center, and Land and Ladies were workshop partners.

Presenters were encouraged to engage the audience with minimal PowerPoint slides and focus on discussion, hands-on activities, and extended time for questions which was in line with adult learning theory. Although some experienced landowners were present, forestry terms were explained regularly to ensure that no one was left behind. In many workshops, a panel of 2-3 experienced FFLs fielded questions and discussed their experiences as landowners. Workshop planning was iterative, and adjustments were made based on participant feedback and knowledge gaps from earlier workshops following formative evaluations. The presentation topics in the Spring 2023 workshops were developed based on FFLs-expressed interest from Fall 2022 workshops. Each Women in Forestry Workshop was distinctive with few overlapping presentations. The participants were encouraged to attend as many workshops as possible since each one conveyed new information. FFLs that attended were sent follow-up emails after each workshop to provide information on upcoming workshops, answers to questions from discussion times, links to requested resources, and outreach publications. FFLs were encouraged to attend

multiple workshops, as different information was presented at each workshop. Additionally, these emails ensured that all the participants had access to each other's email addresses to promote connectivity among participants. A website maintained by the Warnell School of Forestry and Natural Resources outreach team devoted to women in forestry was updated regularly with announcements, upcoming workshops, and resources from previous workshops.

Workshop assessments

Workshop participants were assessed by three methods: 1) a 4-section written survey to gather quantitative data, 2) a focus group or interview held after the workshop, and 3) conversations with participants during the meeting to obtain qualitative data. The last method involved writing down what questions were asked by participants and conversation topics among participants. These methods were piloted in the first workshop and then were officially used to collect data in subsequent workshops (IRB ID # PROJECT00006326). This multi-faceted approach collects quantitative, qualitative, and anecdotal data to achieve a robust view of participants' experiences. Section 1 of the written survey was a retrospective post-then-pre survey on FFL confidence. The section contained 18 statements using a five-point Likert scale ranging from "I have no confidence in my knowledge of the subject" to "I have high confidence in my knowledge of the subject" to survey confidence before then after the workshop. These statements ranged from estate planning and timber stand establishment to tree identification and diagnosing forest health problems (Table 2.1). There were five main constructs among 16 of the statements: pine silviculture, wildlife and conservation management, fire management, forest health, and land management finances, with two additional statements related to non-timber forest products and conservation (Table 2.1). Section 2 of the written survey gauged participants' intent to engage in land management activities using a 5-point Likert scale ranging from very

unlikely to very likely (statement details in results section). Constructs were not used in section 2 of the survey. Section 3 evaluated how connected FFLs felt to their land (if they owned land). Section 4 collected participant demographic and other pertinent information including: age, acres owned, educational level, marital status, length of time holding land, whether they were their land's sole owner, how they obtained the land, how experienced of a landowner they were (self-rated), what type of environment they grew up in, and if they would recommend the workshop to others. These demographics were chosen because it gave researchers a good idea of who was showing up to the events, what type of landowner they were, and more of their background. The survey was formatted to reduce survey fatigue by minimizing questions, using simple wording, and taking less than 10 minutes to complete following Dillman's recommendations (Dillman et al., 2014).

Focus groups were conducted one to two weeks after each workshop with volunteer participants. These focus groups were conducted over Zoom with audio-only recording and involved a relaxed conversation with a M.S. graduate student guiding the discussion. The discussion approach allowed the conversation to flow while covering topics, including comfort-level of the workshops, presentation quality, and whether networking or peer-to-peer learning occurred. Focus groups were held with one or multiple participants, depending on participant time and availability. To collect additional qualitative data, conversations were noted that seemed unique or prevalent throughout the workshops, and common participant questions were revisited during the interview or focus group.

Using the CIPP model, each workshop built on feedback from previous workshops as changes were implemented based in insight from participants. Focus group and interview qualitative data were put into common emerging themes. Distinct or common questions and

comments made by participants were noted and added to qualitative data themes. Focus groups and interviews followed the same flow of questions with slight alterations after the first interview to ensure applicable questions were being answered (Graneheim & Lundman, 2004). Focus group and interview questions, along with observations during the workshops, provided qualitative data to determine if FFLs were building a social network and engaging in peer-to-peer learning. The purpose of the interviews and focus groups was to see what how participants were motivated at the workshops to be active in land management. Themes which emerged from the raw data were examined by the lead researchers' graduate committee to ensure consistency in interpretation.

Subjectivity Statement

All interviews and focus groups were conducted by the lead author, who subsequently analyzed the transcriptions. He grew up in Georgia, obtaining a Bachelor of Science in biology with a minor in chemistry. He has worked as an environmental educator, environmental compliance specialist, plant health care specialist, and on various restoration projects. He believes that there is a constant and consistent need to recognize disparities between genders and consider those inequalities when approaching research about conservation, land management, forestry, and natural resources. He is convinced that land management should be approached in a holistic manner and that forestry and natural resources can be an avenue for conservation and working landscapes.

Statistical Analysis

Responses to the scaled items on the questionnaire were recorded in Excel, and each anonymous participant received an ID number. Survey data were analyzed in IBM SPSS software version 28.0 (*IBM SPSS Statistics*, 2021) and Microsoft Excel version 2201 (*Excel*,

Microsoft, 2023). Confidence levels for survey constructs were assessed using Cronbach's alpha values to determine the reliability of each construct. Confidence before and confidence after were treated as separate constructs for statistical purposes. Any constructs that fell below a Cronbach's alpha value of 0.7 was not used as a construct and statements on confidence level were analyzed individually. Before and after workshop changes in confidence level were tested using a paired two-tailed T-test ($P > 0.05$). Due to small sample sizes, demographic data and intentions were viewed descriptively, using frequencies, mean (and associated standard deviation), median, minimum, and maximum.

Results

Questionnaire Quantitative Results

Survey data were collected from six of the seven Women in Forestry Workshops with 41 individual surveys collected including participants who attended multiple workshops and took the survey multiple times. Only 28 instruments were collected from first-time participants. Repeat participants were not included when analyzing intention or demographics to avoid recounting demographic data or make certain intentions higher or lower. These first-time participant data were used in demographic analyses. Repeat participants were used when measuring confidence since each workshop was different and confidence utilized a retrospective post-then-pre test.

The demographic make-up of the workshops was relatively consistent. Demographics given below are based only on the first-time respondents that answered the demographic questions. Some participants declined to answer demographic questions. The average reported age was 53.4 years old (23 out of 28 first-time respondents) with an age range of 25–81 years old. Participants were mostly Caucasian at 84.6%, with 11.5% African American, and 3.8%

multiple ethnicities. Acres owned ranged from 0 – 7000, with an mean and median of 628 acres and 123 acres, respectively. Participants self-rated their level of experience as a forest landowner at an average of 2.54 on a 5-point scale, indicating on average, they saw themselves as mid-level experienced. Sixty percent of participants were sole landowners, while 40% co-owned their land. Marital status was almost split evenly with 55.6% participants married and 44.4% not married. Only 7.4% of participants did not own land yet, while 48.1% and 33.3% purchased and inherited land, respectively. Moreover, another 11.1% both purchased and inherited land. The majority (57.7%) grew up in a rural environment, while 30.8% grew up in a suburban environment, and only 11.5% grew up in an urban environment. Interestingly, 40.7% of participants obtained a master's degree, while 7.4% and 3.7% had a high school diploma and a trade school degree, respectively. Another 33.3%, and 14.8% of participants had a bachelor's and doctoral degrees, respectively. Demographic results provide information on who attended the workshops and helped workshop facilitators plan for what to expect in the future.

Before the workshops, participants' lowest confidence was in using land for non-timber forest products, while highest confidence was in game species identification. After the workshops, participants' highest confidence was in managing land for ecosystem and species conservation, and lowest confidence was in intermediate stand treatments. Before and after changes in confidence were all significant at the alpha 0.05 level ($P < 0.05$). The largest change in confidence was selecting the appropriate management techniques to enhance wildlife habitat for a species, and the lowest change in confidence was game species identification (Table 2.2). Although all before and after changes in confidence were significant at the 0.05 level, FFLs average confidence change among all the statements was 1.1 points on a 1 – 5 Likert scale, demonstrating that confidence rose significantly in all areas (Table 2.2).

Reliabilities within constructs were all acceptable. Eight of the before and after confidence constructs had Cronbach's alpha scores above 0.7 and were retained as reliable constructs (Table 2.1). Two before and after constructs' (before and after for administration/financial planning) Cronbach's alpha scores were below 0.7, implying unreliable constructs. Participants' before to after workshop confidence increased significantly for all the eight retained constructs (Table 2.3).

Participants lowest intention was to produce non-timber forest products. Buying new land was the next lowest intention. Participants' highest intention was furthering their land management knowledge, followed in a tie by attending other workshops for forest landowners and implement management practices that maintain forest health. Aside from the two lowest intentions, all intention averages were above 4.0 (out of 5), indicating that they were motivated to take next steps (Table 2.4). Overall, participants' sense of place for their land, assessed by the two questions related to connection and identity to land, was high at 4.85 (SD = 0.37) and 4.58 (SD = 0.64), respectively. The high intentions, coupled with a strong sense of place, is evidence for participants' likelihood to engage in intentional land management activities following participation in the workshop(s). Because the number of participants was low for a powerful statistical analysis, the changes in confidence and intention among demographics were not tested. However, the demographic data still gives valuable information on potential participants in future workshops in Georgia.

Qualitative Results

The participants from the Women in Forestry Workshops provided rich qualitative data that produced an overarching concept based on motivation with five themes: Participants were motivated at the workshops to be active in land management by their: **1.** goals, **2.** increase in

confidence, **3.** Concerns, **4.** peer-to-peer networking, and **5.** thoughts about the workshops. Each of these five themes contained at least two sub-themes (Table 2.5).

Goals

FFLs had different goals for attending workshops and being engaged in land management. Under this goal-oriented theme, participants expressed an interest in making sure they improve their present and future finances, continue their legacy of their land for future generations, and continue learning. As one newer landowner shared, "I guess timber production. It is a goal, but it is not the ultimate goal." Another veteran landowner voiced a similar goal driven by the lack of clarity when they were younger:

> We have two children, and I want to make it as easy as possible for them. When I inherited the land, it was like a shot in the dark. I inherited this, and I lived on this land all my life, but the cultural way in southern Georgia, the parents did not discuss finances with their children.
> [*Improving present and future finances*]

Goals for continuing legacy is an emerging subtheme for prospective landowners. These participants saw owning land as something both good for the present and to sustainability generate a secondary source of income. Many participants wanted future land management to be easier for their children financially. Prospective landowners wanted to create a land legacy their children could understand and desire to work toward continuing. A participant expressed fear that her son would sell family land for a low price without realizing the financial benefits of landownership. Stopping future loss of family landownership fell under this legacy subtheme. One participant described younger people as not interested in the land and likely to take the quick money from selling the land. With this, they wanted to make sure their son sees the benefit of that legacy.

The last subtheme under the "goals" theme was the desire to continue learning. One participant said:

> I just dove head in… we've gotten this property and I've gotten so invested in, like, what kind of birds are out there, like, what kind of wildlife stuff? What kind of insects? And then I went off and I applied to go back to school again…
>
> [*Continue learning*]

An additional participant mentioned wanting to keep their forest healthy and "to learn what we're doing." Lastly, another participant wanted to learn about available resources and where to learn about new land management activities.

Confidence Increase

Participant's focus group answers also indicated their increase in confidence. Participants' self-perceived confidence grew in basic knowledge and in knowing how to ask the right questions. One participant said: "I'm feeling a little bit more confident because this at least gave me the knowledge and the education of things to look more into." Another participant agreed in saying:

> [The workshops] allowed me to ask better questions. When I meet with somebody, like a forester or a wildlife management person, you're not just starting at square one - asking like… how does our forest look?
>
> [*Basic knowledge & how to ask the right questions*]

Moreover, inspiration from others and the workshop itself helped boost confidence. A participant described an experienced landowner as her new superhero. While another lady said:

> I came home with [a] renewed sense of purpose … just seeing these women who are already in the thick of it and who are already taking charge, it gave me a sense of you know, you can totally learn this.
>
> [*Inspirational*]

This increase in confidence was observed in every workshop and motivated these FFLs to engage with each other and with their land.

Concerns

Worries were one of the driving forces behind FFLs attending these workshops, which was highlighted during participant discussions. FFLs worried about invasive plants and animals, not being physically close to their land, and their own safety on the land. One landowner's main concern was hogs and the destruction they were having on the land, while another's was invasive plants and not knowing if plants present on their land were invasive. "Last [workshop] we attended was a feral hog workshop - we have hogs. That has taken up 50% of our time pre-worrying. About destruction and the water. And the fact that they can contaminate the water …" FFLs not physical living on their property bring another host of worries with them. An absentee landowner participant voiced her concern in saying "…my biggest concern would be feeling like an absentee landowner and really having to trust the people that I hire to do the best work for me and deciding [what to do]." Landowners who do not physically live on their forest property can feel like they are not part of the local community and may feel unsafe as an "outsider." One African American participant expressed safety concerns around potentially owning rural land as a minority and engaging in land management activities away from their known community.

Peer-to-peer Networking

Attending a workshop alone can be intimidating, but it can also produce rewarding connections between participants that allow for peer-to peer networking. Throughout the workshops, participants were able to form connections. One participant expressed joy of meeting someone new after the workshop started late, “Yeah, initially when I got there, I was like, I could have slept another 30 minutes, but then I met [her] and it was so fun.” Others were happy that they could interact with different representatives of government agencies. One participant remarked:

> [The workshops] made it feel very accessible and easy, and not as overwhelming, which I think a lot of times when women are in male dominated spaces, it's easy to feel intimidated because you just assume that, like these men know something that I don't know.
>
> [*Peer-to-peer learning*]

Additionally, networking allowed FFLs to share contact information, and some participants started a shared online folder to store land and forest management material. Workshops also created a space for peer-to-peer learning. Participants were able to have conversations over lunch, connect after the workshops, and learn from their peers. Some participants were extremely motivated to make multiple connections while others were thankful for the opportunity to make one or two connections.

Thoughts About the Workshop

The last theme emerging from the interviews and focus groups was the participants’ 5. thoughts about the workshops. Many participants were grateful for a female-oriented space where they easily felt heard: “I’m impressed that y’all are doing this. I think that women have been left out – it’s a man world.” While another participant mentioned wanting her partner to

attend workshops to be on the same page as her when it comes the importance of good land management. Another participant was thankful the workshops did not come across as patronizing to women:

> Sometimes people like they almost like try too hard and it comes across as weird or even like "oh hey ladies" and it comes across as kind of condescending. None of that was going on.
>
> [*Comfort-level*]

The comfort-level provided by the open format of the workshops produced more productive discussions and learning. As one participant succinctly put it: "I can ask all the dumb questions and not feel stupid" and other participant conveyed the feeling by saying, "You definitely created that space where people felt seen and heard. I feel like my overall word is empowered..." Participants also voiced their enjoyment of the topics, including finances, landowner grants, ecological management, pond management, and communication styles. Overall, participants were pleased with the workshops' environment and educational content, with the majority wishing that there were more in the future or had been able to attend other past workshops.

Aside from the focus groups and interviews, participants did mention important factors in their decision to attend workshops. One participant said she felt behind other family members that had inherited the land with her. Another participant was concerned that anyone under 30 years old just wanted to move to the city. In one discussion session participants expressed they were glad their husbands were not present because the female-focused environment gave them a place to have a voice. Participants asked relatively straightforward and simple forestry and natural resources questions. Yet those questions demonstrated the need for constantly and

consistently bridging the gap between the experienced and unexperienced, as well as producing an environment where participants felt comfortable asking those questions.

Discussion

The participants came with different land management circumstances, displaying the unique challenges to tailoring outreach workshops to FFLs. Participants owned conservation easements, large timber producing establishments, new and smaller tree farms, or did not yet own land. Presentations needed to be general yet also specific enough to educate both inexperienced and experienced landowners. This study highlights the importance of empowering and building FFLs' confidence. Average confidence grew across all constructs and survey items even though participants had diverse land management backgrounds. Confidence gains do not indicate participants are ready to immediately engage in the different land management techniques, but their increased confidence will help FFLs take the next steps. Confidence can encourage plausibility of behavior change (Ajzen, 1991). Increase in confidence in a management activity will increase the probability of them engaging in the activity. The qualitative data from the focus groups and interviews validated the conclusion that workshops facilitated confidence changes. The participants expressed increased confidence, felt more motivated, and wanted to learn more after attending these workshops.

Discussing land management activities and having professionals and experts as resources for participants may have given the participants higher motivation to engage in different land management activities. FFLs left workshops with high intentions for land management, signifying that FFLs felt motivated to engage in land management activities. Participants may not have had high intentions to buy land because most already owned land. Low intentions to engage with non-timber forest products could be the lack of information on non-timber forest

products and revenue in Georgia or low exposure to other landowners engaged with non-timber forest products.

FFL social networking grew as participants connected with each other within and outside of the workshops. Their networking was mentioned throughout the qualitative data collection, as well as repeat participants connecting again throughout multiple workshops. Peer-to-peer learning organically occurred at the workshop. Participants asked each other questions and shared contact information. Longer refreshment breaks, a diverse selection of refreshments, and an extended lunch break proved to be useful time to network and learn from each other, which has been previously observed (McIntyre et al., 2008; Watson et al., 2019).

Conversationally, participants indicated that they felt stigma when engaging with the field of land management. Participants felt stigma from others such as consultants and foresters already assuming they know nothing. However, some stigma was self-directed, for example thinking of themselves living in a "man's world" (participant 1) or simply as "just the wife" (participant 2). Creating a comfortable atmosphere to empower participants is extremely important for further engagement and to increase FFL desire to actively participate in land management education activities. This environment also encourages participants to share their thoughts and be a part of feeling heard when engaging in forestry. In the future, workshops could be based around the social empowerment theory (Zimmerman, 2000), to ensure that FFLs have a better sense of control, critical awareness, policy influence, and networking with other organizations, among other things (Zimmerman, 2000).

The participants' questions during the workshops gave evidence for consistently providing definitions of foundational terms to ensure the participants understood clearly what was being presented. Future workshops can be tailored to meet FFLs where they are. Continuing

to listen to participant concerns will cause education topics to emerge that educators may not have considered otherwise. For example, during the last workshop, a presenter discussed conversation styles, how to deal with conflict, and relationships with forestry professionals. Participants noted they felt the talk was extremely meaningful and enjoyable yet was not a typical forestry presentation topic. Transformative learning theory (Mezirow, 1978) continues to support workshops where participants are working to understand new concepts, alter their view on land management activities, and potentially change their goals based on realistic variables. The theory also supports treating and educating participants in a holistic way, since the participants are continually looking at their goals through many different lenses (sociolinguistic, moral-ethical, religious, health, etc.) (Mezirow, 2006). Furthermore, adult learning theory (Knowles, 1978) assists outreach workshops. The participants and workshops followed the assumptions of adult education: (1) they were aware of themselves and their needs, (2) they brought experience and knowledge to the workshops, (3) they wanted to learn from their recognized need to know how to better manage their land (or future land), and the workshops were centered around the participants anticipated problems and needs (Forrest & Peterson, 2006).

Overall, the Women in Forestry workshops provided participants with an opportunity to build confidence, feel more empowered, and connect and learn from fellow FFLs in Georgia. Covering a broad array of topics allowed participants to learn something new every time. Incorporating experienced FFLs, different government agencies, and subject experts expanded FFL knowledge and their professional network. Although the topics and presenters were paramount, the connections made and the empowerment of participants brought added value to Women in Forestry workshops. Creating a space for participants to explore what they need was

critical in ensuring participants learned, built confidence, and were going to engage with their new knowledge.

Recommendations for Future Research

Continuing to support FFLs is critical to ensure our forests are being maintained in a healthy manner. Continuing to provide workshops exclusive to FFLs gives their social network (and subsequent peer-to-peer learning) a support system. However, the frequency of the workshops can be relatively low. Just having an event gathering FFLs together again can help the social network from decaying over time. Workshop speakers should be experts or professionals in the field of forestry, yet more importantly, speakers should have the skill to empower participants. FFLs commonly do not grow up in the world of forestry and lack confidence in land management activities. Empowering and invigorating FFLs to learn is one of the most formidable tasks educational outreach accomplishes. Inviting experienced FFLs to share their experiences gives participants more confidence and motivation to learn, engage and socialize. This research supports previous recommendations of making refreshment breaks and lunch breaks long to encourage more social interaction. Flexibility in presentations and discussion should be promoted as every group of FFLs may have different concerns and goals that are motivating them to learn. A group discussion time at the end of the workshop without speakers present proved resourceful because it allowed participants to comfortably share concerns, ask lingering questions, receive more resources, and help educators to plan for future workshops. A larger number of participants could allow further demographic research questions to be asked. In the future, the workshops could expand to other states and state differences could be analyzed. Future research questions could include: what regions in the state (or outside of the state) have the most participation? Does speaker gender affect the engagement level from participants? Does

absentee landownership affect their management of the land and participation in workshops? What is the biggest motivator for landowners to attend the workshop? And, what type of hands-on activities prove to be the most beneficial?

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Table 2.1. Confidence statements for each construct in the workshop participant survey with Cronbach alpha values for before and after.

Construct	Before Cronbach Alpha	After Cronbach Alpha
Wildlife management construct	**0.844**	**0.751**
Managing your land with the intention to conserve the ecosystem or a certain species		
Selecting the appropriate management technique to enhance wildlife habitat for a species		
Evaluating habitat potential		
Prescribed fire construct	**0.910**	**0.926**
Identifying goals and objectives of prescribed fire		
Basics of fire weather and conducting a burn		
Developing a burn plan		
Pine silviculture construct	**0.954**	**0.944**
Site selection		
Stand establishment		
Intermediate stand treatments		
When to harvest		
Forest Health construct	**0.835**	**0.786**
Identifying characteristics of a healthy forest		
Tree identification		
Correctly diagnosing forest health problems		
Confidence statements not within a construct[A]		
Buying new land	-	-
Using your land for non-timber forest products (Nuts, berries, mushrooms, oils, seeds, medicinal plants, etc.)		
Estate planning		
Writing a land management plan		
Game species identification		

[A]Confidence statements did not make a construct, no reliability test was used, and no Cronbach's alpha was produced.

Table 2.2 Confidence statements with before and after averages, standard deviations (S.D.), differences in average, and p-value for a paired t-test.

	Before		After		Difference in average	T-value	P-value
Land Management Statements	**Mean**	**S.D.**	**Mean**	**S.D.**			
Buying new land	3.03	1.23	3.45	1.06	0.43	2.98	.002
Using your land for non-timber forest products (Nuts, berries, mushrooms, oils, seeds, medicinal plants, etc.)	2.30	1.32	3.05	1.26	0.75	4.39	<.001
Estate planning	3.29	1.31	3.82	1.04	0.53	3.22	.001
Writing a land management plan	2.68	1.29	3.65	0.92	0.97	5.16	<.001
Managing your land with the intention to conserve the ecosystem or a certain species	3.05	1.20	4.01	0.90	0.96	5.45	<.001
Selecting the appropriate management technique to enhance wildlife habitat for a species	2.76	1.16	3.85	0.99	1.09	6.73	<.001
Game species identification	3.32	1.37	3.63	1.18	0.31	2.47	.009
Evaluating habitat potential	2.66	1.22	3.29	1.23	0.63	4.31	<.001
Identifying goals and objectives of prescribed fire	3.07	1.31	3.98	1.13	0.91	4.90	<.001
Basics of fire weather and conducting a burn	2.73	1.18	3.54	1.21	0.81	5.13	<.001
Developing a burn plan	2.54	1.16	3.38	1.17	0.84	5.07	<.001
Timber stand site selection	2.49	1.25	3.11	1.30	0.62	3.93	<.001
Timber stand establishment	2.56	1.34	3.10	1.36	0.54	3.83	<.001
Intermediate stand treatments	2.51	1.27	3.02	1.28	0.51	3.65	<.001
When to harvest	2.70	1.44	3.50	1.26	0.80	4.37	<.001
Identifying characteristics of a healthy forest	3.03	1.33	3.89	1.09	0.86	4.80	<.001
Tree identification	3.07	1.29	3.49	1.10	0.42	2.66	.006
Correctly diagnosing forest health problems	2.32	1.06	3.20	1.15	0.88	4.91	<.001

Table 2.3 Women in Forestry Workshop participants' average confidence before and after for each construct and their associated difference, standard deviation (S.D.), and paired t-test p-value.

Construct		**Mean**	**S.D.**	**Difference**	S.D.	P-value
Prescribed fire	Before	8.34	3.37	-2.55	2.97	<.001
	After	10.89	3.27	-	-	-
Pine Silviculture	Before	10.32	5.05	-2.44	3.52	<.001
	After	12.76	4.87	-	-	-
Forest Health	Before	8.33	3.21	-2.17	2.88	<.001
	After	10.50	2.80	-	-	-
Wildlife	Before	8.46	3.12	-2.70	2.79	<.001
	After	11.16	2.57	-	-	-

Table 2.4 Women in Forestry Workshop attendees' average land management intentions and standard deviation. Results were from 28 non-repeat participants measured on a Likert scale from 1 to 5.

Intention	Mean	Std. Deviation
Buy new land.	2.78	1.48
Actively manage forestland.	4.41	0.89
Utilize management practices that increase timber production.	4.32	0.95
Produce non-timber forest products (nuts, berries, mushrooms, oils, seeds, medicinal plants, etc.) for sale.	3.19	1.47
Use prescribed fire as a management tool.	4.41	1.05
Hire a consulting forester.	4.57	0.74
Connect with other female forest landowners.	4.68	0.72
Further my land management knowledge.	4.79	0.5
Create an estate plan.	4.68	0.86
Implement management practices that maintain forest health.	4.71	0.54
Attend other workshops for forest landowners.	4.71	0.66
Create a written management plan for my forest land.	4.43	0.79
Work with another governmental agency to help me manage my land.	4.54	0.69
Enroll in a conservation program for my land (Conservation easement, tax break for conservation, conservation assistance program, etc.).	4.5	0.77

Table 2.5. Themes and subthemes developed from focus groups and interviews with participants from Women in Forestry Workshops in Georgia.

Theme	***Subtheme***
Goals	Improving present and future finances
	Legacy
	Continue learning
Increase in confidence	Basic knowledge & how to ask the right questions
	Inspirational
Concerns	Wildlife/Plants – more of the good less of the bad
	Being away from the land (Absentee landowner)
	Safety
Networking	Making friends/connections
	Peer-to-peer learning
	Government agency
Thoughts regarding the workshops	Female Centered
	Comfort-level
	Topics

CHAPTER 3

A PRELIMINARY STUDY OF LONGLEAF PINE CANOPY ARTHROPODS IN SOUTHWEST GEORGIA

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Abstract

The destruction, development, and overall decrease of longleaf pine (*Pinus palustris* Mill.) ecosystems over the last 200 years has resulted in more research regarding its conservation, biology, and ecology. The ecosystem holds a dizzying array of arthropod diversity, yet the arthropods community of the canopy layer are largely unknown. Longleaf pine ecosystems at the Jones Center at Ichauway in southwestern Georgia occur in three main different ecological community types: flatwoods, fluvial terrace, and uplands. Canopy arthropods in these three ecological communities were surveyed using flight intercept traps placed in the mid-canopy of longleaf pine trees to determine which taxa inhabit longleaf canopies and assess canopy arthropod abundance and richness in different ecological communities. Arthropods were collected for one week each month from May–August 2022. Specimens were identified to order-level, and coleopterans, collembolans, and hemipterans were identified to family-level. A total of 4,004 arthropods were collected over the course of the summer. Diptera, Collembola, and Lepidoptera were the most abundant orders collected in the longleaf canopies. Overall abundance, order-level abundance, family-level abundance, and order-level richness were similar among ecological communities. However, hemipteran family-level richness differed significantly) among the ecological communities. This project is the first step in understanding the longleaf canopy arthropod community and creates a platform for further studies.

Keywords: Collembola, SLAM trap, Coleoptera, flight intercept, richness,

Introduction

Longleaf pine (*Pinus palustris* Mill.) (Pinales: Pinaceae) ecosystems once covered a vast swath of land stretching from Texas to Virginia, however, the present-day coverage of longleaf pine woodlands accounts for less than 5% of the original range (Outcalt, 2000). European colonizers, rapidly exploiting the longleaf timber source with commercialized timber sawmills, caused the original longleaf pine habitat loss (Jose et al., 2006). After that, agriculture dominated former longleaf pine habitats, real estate development and roads fragmented the landscape, and feral hogs followed as a major threat to longleaf pine regeneration (Frost, 2006). Faster growing pines, such as loblolly (*Pinus taeda* L.) or slash (*Pinus elliottii* Engelm.) were commonly planted in reforested lands in southeastern landscapes, and the needed fire disturbances were suppressed, effectively limiting largescale longleaf pine regeneration. However, longleaf pine ecosystems, with the help of conservation efforts, have been increasing.

Longleaf pine ecosystems harbor some of the greatest biodiversity in the southeastern United States (Drew et al., 1998; Sheehan & Klepzig, 2021; Walker & Peet, 1983). They provide habitat to keystone species (e.g., gopher tortoise, *Gopherus polyphemus* Daudin), endangered species (red-cockaded woodpecker, *Leuconotopicus borealis* Vieillot, and hairy rattleweed, *Baptisia arachnifera* Duncan), and many insect-pollinated plants (Pitts-Singer et al., 2002; Walker, 1993). Longleaf pine ecosystems are naturally disturbed with consistent, low-intensity wild and prescribed fires (Dell et al., 2017). The frequent burn regime creates a pasture-like diverse understory and maintains an open, longleaf pine-dominated canopy. Frequent burns also create a distinct gap between ground vegetation and canopy vegetation (Outcalt, 2006). Tree canopies can be considered ecosystem islands in some respects, given the distance between the

canopy and other vegetation (Adams et al., 2017; Southwood & Kennedy, 1983). For small species, such as arthropods, to access the habitat islands in the sky, they must either fly, catch a ride on a larger flying species, or traverse the tree trunk. The renewed interest in longleaf pine, as well as growing interest in canopy systems, has drawn attention to all aspects of longleaf pine ecosystems, including canopy arthropod diversity.

Sheehan and Klepzig (2021) illuminated the research conducted thus far on arthropods in longleaf pine ecosystems. Early estimates approximated 4000–5000 arthropod species in longleaf pine ecosystems (Folkerts et al., 1993), however additional studies suggest that 4000–5000 species may be a vast underestimation of arthropod richness (Hanula & Wade, 2003; Lubertazzi & Tschinkel, 2003; Sheehan & Klepzig, 2021). For example, more than 50,000 arthropod individuals from 22 orders and 470 genera were collected climbing longleaf pine tree trunks (Hanula et al., 2000). Hemiptera and Hymenoptera (Formicidae) were most abundant, while Coleoptera were the most diverse (Hanula et al., 2000).

Arthropod response to fire regimes is a common topic in longleaf arthropod research. Ground arthropod community responses to burning vary by species (Hanula & Wade, 2003). Frosted elfin butterflies *Callophrys irus* (Godart) decrease in number with more frequent burning intervals yet depends on fire to survive (Jue et al., 2022), and exotic and invasive ant populations increase with regular burning (Atchison et al., 2018). While Sheehan and Klepzig (2021) highlighted many longleaf arthropod studies, they also identified the numerous gaps in canopy arthropod research. Our understanding of the diversity and ecological functions of arthropods in longleaf pine systems is incomplete.

Current and future ecological threats to longleaf pine [e.g., fire suppression, urban expansion, and other anthropogenic factors (Nowak & Walton, 2005)] illustrate the need for

increasing our knowledge of longleaf pine ecosystems. Establishing species diversity baseline data and tracking species diversity changes can be strong tools to assess ecosystems, as facilitating species diversity improves ecosystem functions (Isbell et al., 2011; Wallace, 2007). Arthropods are valuable indicators of ecosystem health because of their diversity in form and function (Maleque et al., 2006) and should be included in management plans (Ulyshen, 2011). Many longleaf pine ecosystems host smaller and ecologically unique communities. The Jones Center at Ichauway, a research center in southwestern Georgia, encompasses 11,000 ha of land, much of which contains natural longleaf pine ecosystems. Within the Jones Center, there are three main longleaf pine-dominated ecological communities [modified from previous descriptions in (Goebel et al., 1997)]: flatwoods, fluvial terrace, and uplands. Sites from these ecological habitats are being used for ongoing projects at the Jones Center (Klepzig et al., 2022). Although all ecological communities overlap in vegetation, they have distinct geomorphology. Flatwoods habitats contain the least drained soil with a heavier shrub and briar component. Fluvial terrace habitats are near bodies of water with excessively drained soils and have the most hardwoods present. Upland habitats contain excessively drained soils and are located farther from bodies of water, almost devoid of hardwood trees, with a more open canopy, and dominated by a wiregrass, *Aristida* sp. understory.

To date, arthropod research in southern pine canopies has focused on tree pests associated with different management treatments (Cronin et al., 2000; Kinn & Witcosky, 1978) or higher-profile species [e.g., red-cockaded woodpecker (Hanula et al., 2000)]. The longleaf pine canopy is a micro-ecosystem within the longleaf pine system where, aside from insect pests, little is known. Research noting longleaf pine canopies is often in relation to canopy gaps, disturbances, and how canopy cover can affect ground diversity (Gagnon et al., 2004; Hanula et al., 2016;

Johnson et al., 2021; Palik et al., 1997; Pecot et al., 2007; Pope et al., 2023). Some studies assessed pest insects that affect longleaf pines (Campbell et al., 2008; Hanula et al., 2002), while others have hypothesized that canopies serve as an island of refuge from fire (Dell et al., 2017). To our knowledge, arthropod diversity has not been studied in longleaf pine canopies. A previous study only used the bole of the trees for observations and not the extending branches (Horn & Hanula, 2002). An important first step in longleaf pine canopy arthropod research is to determine which groups of arthropods are common and consistent residents of longleaf canopies.

Access to the canopy proves to be the most limiting factor for many canopy arthropod studies. Numerous, yet usually intensive, methods can be used to access tree canopies for sampling. These methods include climbing, bucket trucks, cranes, balloon rafts, or collecting from the ground by hoisting collection devices into the canopy (Schowalter & Chao, 2021; Skvarla et al., 2021). Once canopy access has been established, studies regularly utilize different types of canopy sampling methods, with each method having strengths and weaknesses for the types of insects they collect (Schowalter & Chao, 2021; Skvarla et al., 2021). Canopy sampling methods include flight intercept traps of varying types, vane traps, arboreal pitfall traps, insecticide fogging, canopy sweep-netting from bucket trucks, sticky traps, and baited traps (Kaspari, 2000; Schowalter & Chao, 2021). Collecting height can also influence arthropod presence. Many arthropod communities can be affected by collection height in the canopy, including spiders (Aikens & Buddle, 2012), beetles (Dodds, 2014; Maguire et al., 2014; Miller et al., 2020; Sheehan et al., 2019; Ulyshen & Sheehan, 2019), bees (Ulyshen et al., 2010), and flies (Maguire et al., 2014). Most canopy-centric studies have occurred in the tropics to study their characteristic wide range of biodiversity. However, numerous studies have documented the rich arthropod communities found in tree canopies in North America. More than 400 insect species

have been documented in association with eastern hemlocks in studies focusing on canopies (Dilling et al., 2007, 2009; Kung et al., 2015; Mallis & Rieske, 2011). Invasive fire ants decrease native ant diversity in oak canopies (Kaspari, 2000). Additionally, multiple canopy arthropod studies have investigated different environmental and management scenarios with varying tree species (Schowalter, 1995, 2017; Schowalter et al., 1981, 2005; Schowalter & Zhang, 2005).

Flight intercept traps were used to document canopy arthropods in different longleaf pine ecological communities at the Jones Center at Ichauway. Flight-intercept traps are light enough to hoist into tree canopies and can collect both transient and residential species. Objectives included 1) documenting arthropod taxa in the longleaf pine canopy, 2) assessing overall, order-level, and family-level abundance among ecological communities and 3) assessing order-level and family-level richness among ecological communities.

Methods

Canopy sampling

The study was conducted at the Jones Center at Ichauway, in Baker County, Georgia, USA. Three sites were selected in each of three ecological communities: flatwoods, fluvial terrace, and uplands. The ecological communities are the study treatments, while site is the experimental unit. A single longleaf pine tree at each site was selected for trap placement for a total of nine traps at three sites in three ecological communities. Tree selection was based on size and branch access. Study trees had sturdy branches to support a flight intercept trap located in the middle portion of the canopy, approximately halfway into the live canopy of the tree. The mid-canopy placement was at a height of 7–13 meters from the bottom of trap to the ground, depending on the tree height and structure.

A rope was placed over a branch in each tree to hoist a flight intercept trap up without hitting lower branches. These ropes were then anchored with a ground stake. The traps were an adaptation of a conventional Malaise trap, referred to as the “standard SLAM trap (the Sea, Land, and Air Malaise Trap)” (Bioquip Products, Inc., Rancho Dominguez, CA, USA). Flight intercept traps have two poles that create two, free-standing, mesh walls crossing perpendicular to each other. The trap works like a Malaise trap and collects arthropods that hit the mesh and fly (or climb) upward into a top collection bottle filled with ethanol.

Trapping occurred one week a month from May through August 2022. The traps were assembled, collecting bottles filled with 75% ethanol, and a site and date label was placed in the collecting bottles. A smaller rope was attached to the bottom of each trap to pull traps down after sampling because the traps did not weigh enough to come down on their own. Once the trap was at the desired mid-canopy height, the top rope was secured to the base of the tree to keep it at that elevation while the smaller bottom rope was attached to the ground stake (with no tension) to ensure the trap could be pulled down. After a week, the traps were slowly pulled down and the main rope was secured again to the ground stake for future use. The traps were disassembled and removed from the sites after sampling. This process was repeated from May through August.

In the laboratory, specimens from each sample were sorted to order, and specimens from the orders Coleoptera, Collembola, and Hemiptera were determined to family-level using Borror and Delong (Triplehorn et al., 2005) and the Beetles of the World Lucid Key (Lawrence et al., 2010). These orders were chosen for family-level determinations because they are not predominantly comprised of transient species (Dilling et al., 2007; Moran & Southwood, 1982) and, if caught in the traps, are likely residents of the tree canopies. Transient species are non-predatory arthropods that have no ”lasting association” to the canopy tree species other than

temporary attraction for shelter or nourishment, but do not necessarily need the canopy habitat (Dilling et al., 2007; Moran & Southwood, 1982). A non-transient canopy species would be one that relies on the canopy for food and habitat with affinity for the canopy tree species. Individuals of Diptera and Lepidoptera were not identified to family-level, as many dipterans collected in longleaf pine canopies are likely transient (Dilling et al., 2009) and lepidopteran specimens were damaged when collected in ethanol (Evangelista et al., 2021; Maguire et al., 2014; Skvarla et al., 2021).

Statistical analyses

Data from the May–August collections were composited for statistical analyses. Abundance is synonymous with trap catch for this study. Abundance and richness were calculated at different taxonomic levels for the following response variables: overall, order-level, and family-level abundance, and order-level and family-level richness. Specifically, overall abundance is the total number of arthropods collected in traps at each site. Order-level and family-level abundances are the abundance within each arthropod order and family, respectively, collected at each site. Data were analyzed for orders that constituted 5% or more of overall abundance and families that made up more than 5% of the total abundance in their respective order. Order-level richness is the total number of orders collected at each site. Family-level richness is the number of families within Coleoptera, Collembola, and Hemiptera collected at each site, and family-level richness within each order was analyzed separately.

Analyses of variance (ANOVA) was used to determine if each response variable differed among ecological communities ($P \leq 0.05$). All data except for two families met the homogeneity of variance and normality of residuals assumptions of ANOVA and thus, were not transformed. Assumptions were tested using the Bartlett test and Shapiro-Wilk test, respectively. Mordellidae

data were transformed using a square-root transformation. The assumptions for ANOVA were not met after transforming Cicadellidae data, so a non-parametric Kruskal–Wallis rank sum test was performed ($P \leq 0.05$). All data were analyzed using R and the "tidyverse" and "ggplot2" packages (*RStudio*, 2023; Wickham, 2011; Wickham et al., 2019).

Results & Discussion

Arthropod Taxa Documented in the Longleaf Pine Canopy

From May–August 2022, 4004 arthropods were collected from longleaf pine canopies. Diptera was the most abundant order, making up 34.3% of the arthropods collected among all sites (Figure 3.1). Collembola and Lepidoptera comprised 21.8% and 17.4% of the collected arthropods, respectively. The orders Hemiptera, Hymenoptera, and Coleoptera made up 6.2%, 5.5%, and 5.2% of collected arthropods, respectively. Non-hexapods (e.g., Araneae, Pseudoscorpiones, Acari, etc.) were grouped together under subphylum Chelicerata and accounted for 4.4% of arthropods. All other hexapod orders each made up less than 2% of the collected arthropods and were not included in order-level analyses. The three least-abundant orders were Neuroptera, Blattodea, and Orthoptera, with only a few individuals collected in each order.

An advantage of flight intercept traps is that they can catch strong flying insects and canopy transient species, thus, resulting in high numbers of dipterans and lepidopterans collected (Ritter et al., 2019), which was observed in longleaf pine canopies. In hemlock trees, dipterans made up the majority of the arthropod abundance collected with canopy malaise traps (Dilling et al., 2009). Lepidopterans in the canopy of southern pine species have not been studied to our knowledge. However, there are many pine ecosystem lepidopterans (Asaro et al., 2003; Berisford et al., 2016; Jue et al., 2022; Rudolph & Ely, 2000) and certain forest ecosystem moths are seen

as potential bioindicators (Summerville et al., 2004). The high abundance of collembolans, a wingless hexapod, was unanticipated. Once again, no southern pine canopy study has delved into collembolan abundance. Canopy collembolans occur in pine canopies in Norway as the second most abundant taxon behind Acari (Thunes et al., 2003), are present in other conifers, such as Japanese cedar (Yoshida & Hijii, 2005), and occur to varying degrees in other deciduous forest canopies (Greenslade et al., 2016; Palacios-Vargas et al., 1998; Shaw, 2015). Changes in Douglas fir canopy structure changed the abundance of collembolans (Halaj et al., 2000) and there may be an association between bark beetles and collembolans (Hofstetter et al., 2015; Stone, 1990). Nonetheless, how did collembolans first arrive in longleaf canopies and into the traps? Do they grow up with the tree, travel up the trunk, or ride on another species to get to the top? Getting caught in the flight intercept traps infers collembolans are moving extensively through the canopy. Although wingless, collembolans can move through passive wind dispersal (Farrow & Greenslade, 1992; Joimel et al., 2018). Collembolans may have migrated into traps from short distance wind dispersal from branches, directly moving from branches located near a trap, or by traveling along the rope that attached the traps to branches.

Abundance

Average overall abundance collected in the flatwoods, fluvial terrace, and uplands ecological communities, was 385, 467, and 483 respectively (Figure 3.2). Overall abundance did not vary among the ecological communities (Table 3.1). Coleoptera, Collembola, Diptera, Hemiptera, Hymenoptera, and Lepidoptera had similar order-level abundance among ecological communities (Figure 3.3, Table 3.1).

Twenty-four, four and 15 Coleoptera, Collembola and Hemiptera families, respectively, were collected in longleaf canopies, (Table 3.2). Only four families comprised more than 10% of

the total abundance of their respective order and seem to be common canopy inhabitants: Ptinidae (Coleoptera), Entomobryidae (Collembola), Cicadellidae (Hemiptera), and Cixiidae (Hemiptera). Ptinids comprised 24.9% and 1.3% of the coleopterans and the collected arthropods, respectively. The collembolan community was dominated by the Entomobryidae, which comprised 97.3% of the collembolan abundance and 20.7% of collected arthropods. Cicadellidae and Cixiidae comprised 68.2% and 12.2% of the hemipteran abundance, respectively, and 4.0% and 0.7% of the collected arthropods, respectively. Family-level abundance for the coleopteran, hemipteran, and collembolan families did not vary among ecological communities (Table 3.1). The ecological communities, while unique in their own way, are within one larger ecosystem and are relatively close together. Habitat classification differences among the ecological communities did not seem to extend to canopy arthropod abundances.

Richness

A total of 10, 12, and 12 orders were collected from the flatwoods, fluvial terrace, and upland ecological communities, respectively. Order-level richness did not vary among ecological communities (Figure 3.4, Table 3.1). Only five and six individuals were collected from the orders Blattodea and Orthoptera, respectively, and none were collected from the flatwoods. The low abundance for these groups could be due to lack of hiding places for larger arthropods, where foraging birds, such as the red-cockaded woodpecker, look for meals (Hanula et al., 2000). Not collecting these orders in the flatwoods does not clearly indicate that they do not occur in canopy habitats, given their low numbers in the fluvial terrace and upland sites and the SLAM traps may be a weak trap to collect these orders.

Coleoptera and Collembola family-level richness, the number of families present at each site, was similar among ecological communities (Table 3.1, Figure 3.5). Coleopteran richness was high with 9–12 coleopteran families at each ecological community, and 24 overall (Table 3.2). In longleaf, most coleopteran studies focus on scolytine beetles (Campbell et al., 2008; Hanula et al., 2002; Schowalter, 2012) or trap the beetles from near ground-level (Sullivan et al., 2003). This is the first documentation of coleopteran longleaf pine canopy diversity to our knowledge.

Hemiptera family-level richness significantly differed between fluvial terrace and uplands ecological communities (Figure 3.5, Table 3.1). Fluvial terrace had an average of 3.3 hemipteran families compared to 7.3 in uplands. The fluvial terrace is along the Ichawaynochaway Creek and has more shrubs and hardwoods and a relatively denser canopy than uplands. Closed canopy systems can increase arthropod activity in the canopy (Folkerts et al., 1993), which may be related to the higher hemipteran family-level richness in fluvial terrace ecological communities. However, canopy cover can also result in lower species richness on the forest floor (Swart et al., 2018). Although variations in canopy density was not measured, canopy cover could be a driving factor in the difference in hemipteran richness between fluvial terrace and uplands.

Conclusion

Longleaf pine ecosystems are hubs of biodiversity. Conserving longleaf habitats is critical and increasing our knowledge about this system is key to conservation. Arthropods are an extremely biodiverse group in longleaf pine ecosystems and an excellent group to begin exploring longleaf canopy biodiversity. There is little canopy arthropod diversity variation at the family level among these ecological communities thus, differences in habitat do not seem to

translate to the canopy, with the exception of hemipteran family-level richness. Collembolans are permanent and abundant residences of longleaf pine canopies, and 24 coleopteran families were documented in longleaf canopies. This project is the first step in understanding longleaf pine canopy arthropods and their subsequent ecology.

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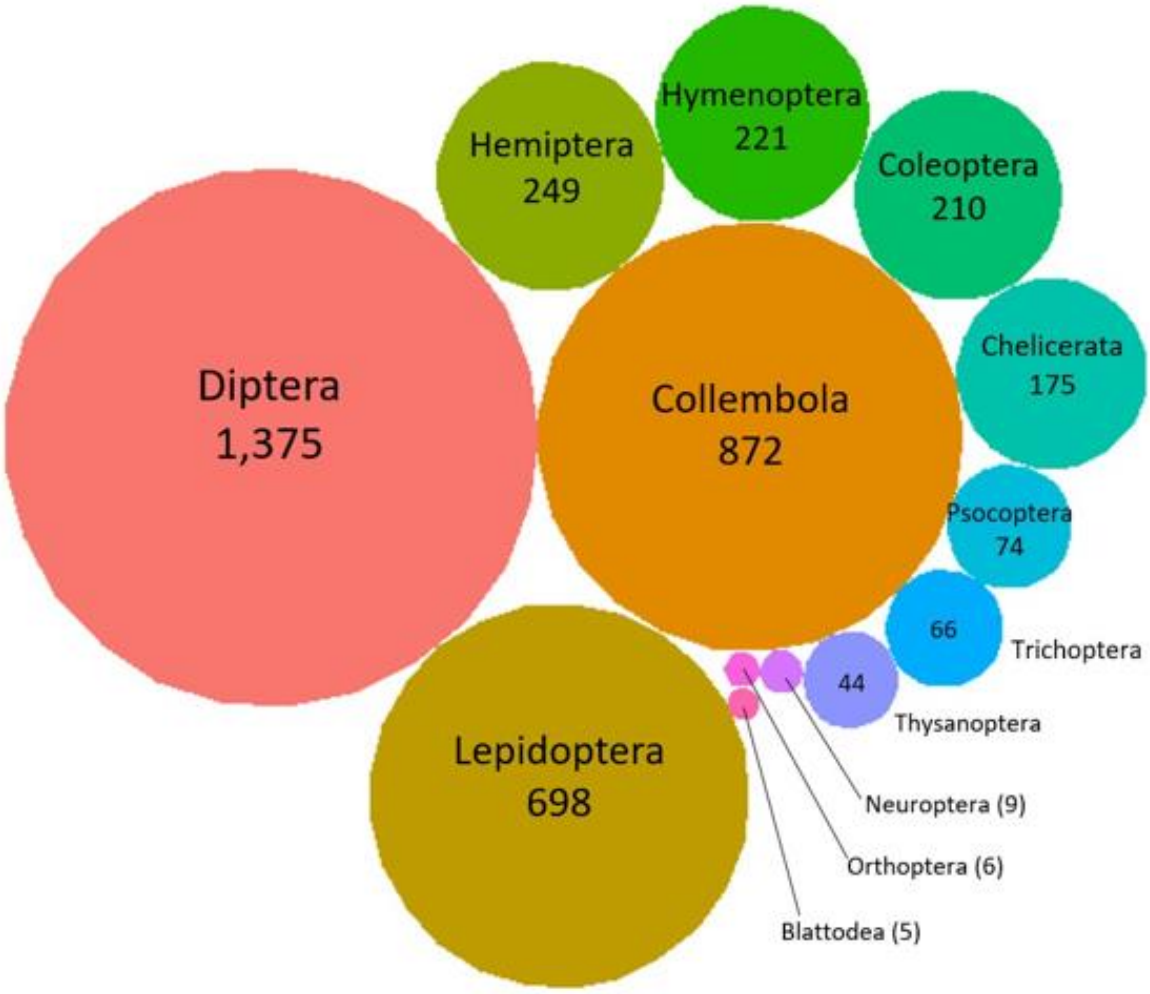

Figure 3.1: Arthropod orders and abundance collected among all sites in longleaf pine canopies at the Jones Center at Ichauway in Southwest Georgia, May — August 2022. Each bubble is labeled with the arthropod order and the number of specimens collected. The size of each bubble is representative of the abundance arthropods collected from each order among all sites combined.

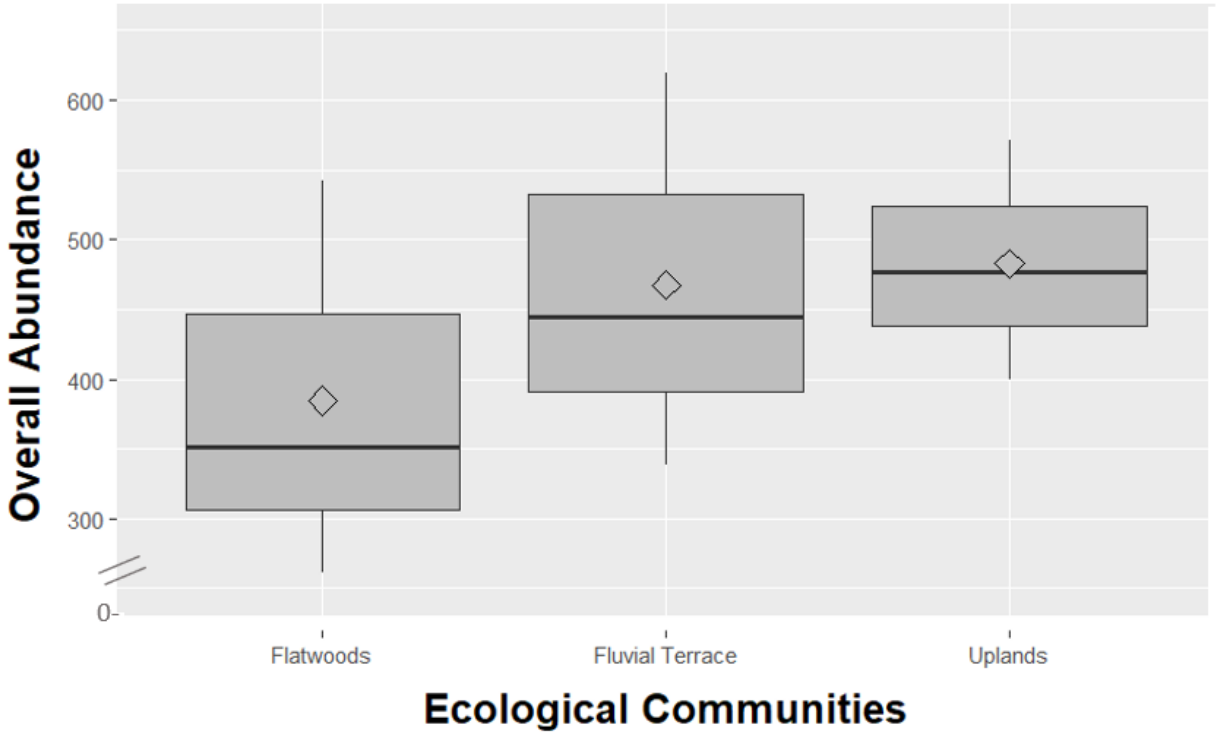

Figure 3.2. Overall abundance[1] in longleaf pine canopies among ecological communities at the Jones Center at Ichauway in Southwest Georgia. Boxes contain the 25th to the 75th percentiles of the data. End points of the whiskers are the highest values that do not extend past 1.5 multiplied by the inter-quartile range. The solid line and diamond in each box indicate the median and arithmetic mean, respectively. Data were analyzed with an ANOVA ($P < 0.05$).

[1]Overall abundance is the total number of arthropods collected at each site.

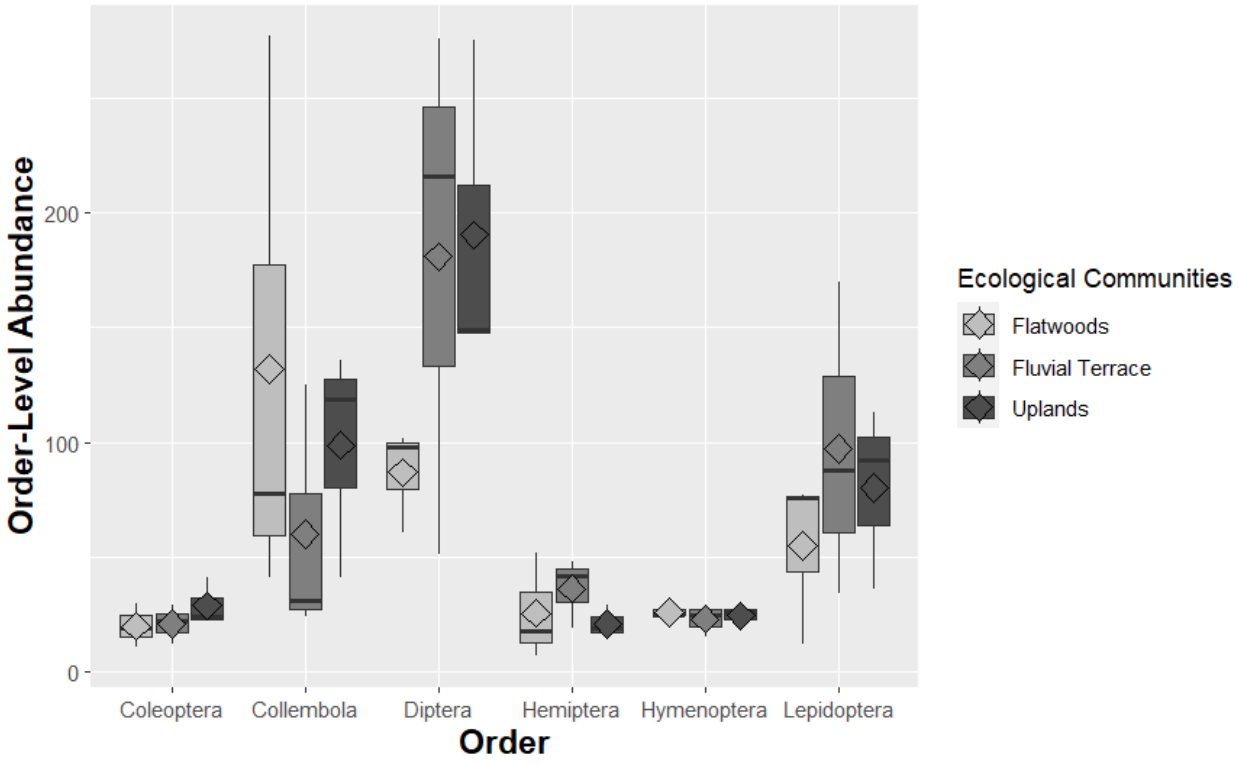

Figure 3.3: Order-level abundance[1] in longleaf pine canopies among ecological communities at the Jones Center at Ichauway in Southwest Georgia. Each order displayed comprised greater than 5% of the arthropod community abundance. Comparisons of ecological communities are being made within each order and not among orders. Boxes contain the 25th to the 75th percentiles of the data. End points of the whiskers are the highest values that do not extend past 1.5 multiplied by the inter-quartile range. The solid line and diamond in each box indicate the median and arithmetic mean, respectively. Data were analyzed with an ANOVA ($P < 0.05$).

[1]Order-level abundance is the total number of arthropods in each order collected at each site.

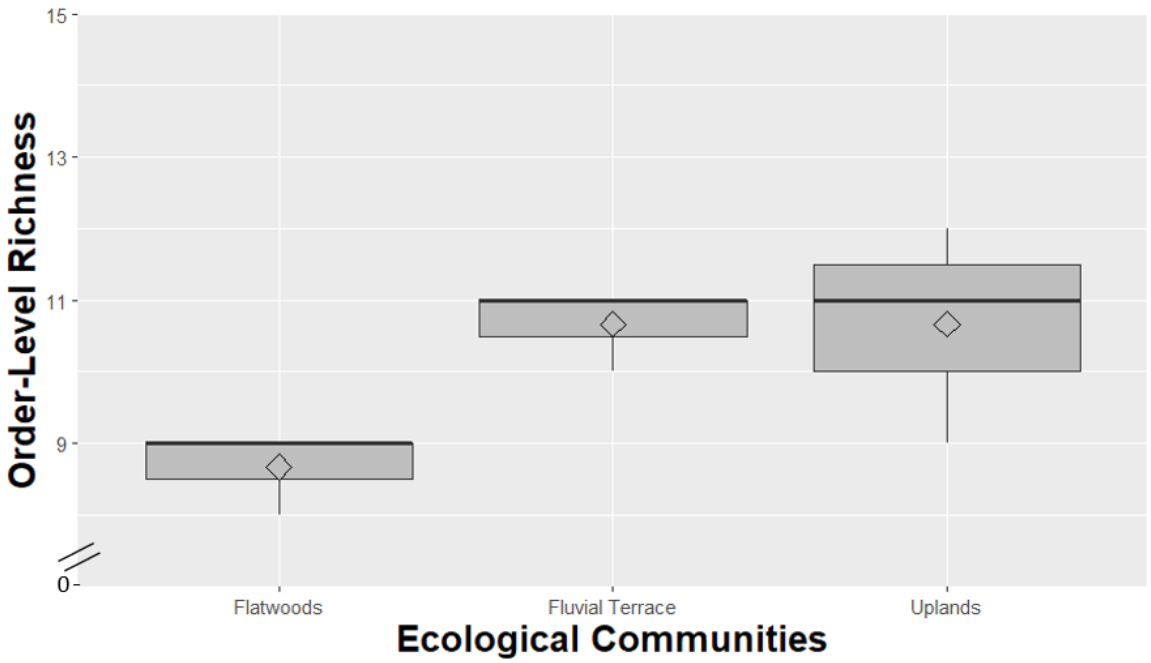

Figure 3.4. Order-level richness[1] in longleaf pine canopies among ecological communities at the Jones Center at Ichauway in Southwest Georgia. Boxes contain the 25th to the 75th percentiles of the data. End points of the whiskers are the highest values that do not extend past 1.5 multiplied by the inter-quartile range. The solid line and diamond in each box indicate the median and arithmetic mean, respectively. Data were analyzed with an ANOVA ($P < 0.05$).

[1]Order-level richness is the number of orders collected at each site.

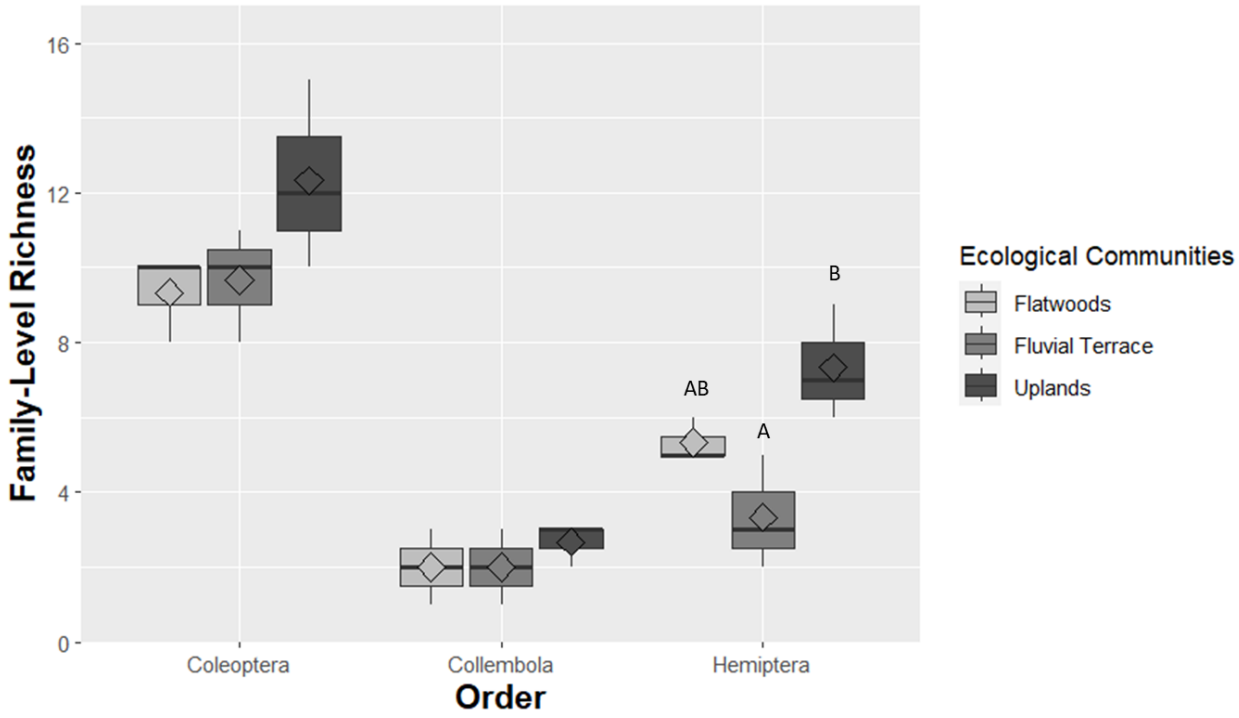

Figure 3.5: Family-level richness[1] in Collembola, Coleoptera and Hemiptera in longleaf pine canopies among ecological communities at the Jones Center at Ichauway in Southwest Georgia. Comparisons are being made within orders and not among orders. Boxes contain the 25th to the 75th percentiles of the data. End points of the whiskers are the highest values that do not extend past 1.5 multiplied by the inter-quartile range. The solid line and diamond in each box indicate the median and arithmetic mean, respectively. Data were analyzed with an ANOVA ($P < 0.05$). Different letters above a box indicate a significant difference between ecological communities.

[1]Family-level richness is the number of families collected at each site.

Table 3.1: Overall abundance, order-level abundance, family-level abundance, order-level richness, and family-level richness among ecological communities in longleaf pine canopies among ecological communities at the Jones Center at Ichauway in Southwest Georgia.

Response Variable	Numerator Degrees of Freedom	Denominator Degrees of Freedom	F-Value	P-Value[1]
Overall abundance[2]	2	6	0.521	0.619
Order-level abundance[3]				
- Diptera	2	6	1.511	0.294
- Collembola	2	6	0.535	0.611
- Lepidoptera	2	6	0.533	0.612
- Hemiptera	2	6	0.665	0.549
- Hymenoptera	2	6	0.266	0.775
- Coleoptera	2	6	0.802	0.491
Family-level abundance[4]				
Hemiptera				
- Cicadellidae	-	-	-	0.88[5]
- Cixiidae	2	6	3.2	0.113
- Flatidae	2	6	0.483	0.639
Coleoptera				
- Curculionidae	2	6	1.12	0.386
- Elateridae	2	6	0.6	0.579
- Mordellidae[6]	2	6	1.129	0.383

- Ptinidae	2	6	0.009	0.991
- Silvanidae	2	6	0.273	0.77
- Tenebrionidae	2	6	1.348	0.329
- Zopheridae	2	6	1.219	0.36
Collembola				
- Entomobryidae	2	6	0.523	0.617
Order-level richness[7]	2	6	4	0.079
Family-level richness[8]				
- Coleoptera	2	6	2.433	0.168
- Collembola	2	6	0.571	0.593
- Hemiptera	2	6	7.2	**0.025**

[1]Data were analyzed with an ANOVA ($P < 0.05$).
[2]Overall abundance is the total number of arthropods collected at each site.
[3]Order-level abundance is the total number of arthropods in each order collected at each site.
[4]Family-level abundance is to the total trap catch for each family
[5]Cicadellidae data were analyzed with a Kruskal Wallis Test.
[6]Data were square-root transformed.
[7]Order-level richness is the number of orders collected at each site.
[8]Family-level richness is the number of families collected at each site

Table 3.2: All coleopteran, collembolan, and hemipteran families collected in the longleaf pine canopies at the Jones Center at Ichauway in Southwest Georgia.

Order	**Family**	**Abundance[1]**
Collembola	Entomobryidae	827
Collembola	Katannidae	16
Collembola	Neanuridae *sensu lato* [2]	7
Coleoptera	Aderidae	1
Coleoptera	Anthicidae	5
Coleoptera	Anthribidae	1
Coleoptera	Bostrichidae	2
Coleoptera	Cerambycidae	10
Coleoptera	Chrysomelidae	6
Coleoptera	Cleridae	6
Coleoptera	Coccinellidae	3
Coleoptera	Corylophidae	2
Coleoptera	Curculionidae	19
Coleoptera	Elateridae	12
Coleoptera	Laemophlaeidae	2
Coleoptera	Latridiidae	7
Coleoptera	Mordellidae	17
Coleoptera	Mycetophagidae	9
Coleoptera	Oedemeridae	1
Coleoptera	Phalacridae	3
Coleoptera	Ptinidae	52
Coleoptera	Scirtidae	2
Coleoptera	Silvanidae	12
Coleoptera	Staphylinidae	4
Coleoptera	Tenebrionidae	13
Coleoptera	Throscidae	5
Coleoptera	Zopheridae	15
Hemiptera	Achilidae	4
Hemiptera	Aleyrodidae	1
Hemiptera	Anthocoridae	3
Hemiptera	Aphididae	5
Hemiptera	Cercopidae	1
Hemiptera	Cicadellidae	161
Hemiptera	Cixiidae	29
Hemiptera	Coccomorpha[3]	2

Hemiptera	Derbidae	6
Hemiptera	Flatidae	17
Hemiptera	Issidae	1
Hemiptera	Miridae	3
Hemiptera	Pentatomidae	1
Hemiptera	Phylloxeridae	1
Hemiptera	Reduviidae	1

[1]Total number of specimens collected in each family during 2022
[2]Includes Neauridae and Brachystomellidae
[3]Male scale specimens in the infraorder Coccomorpha

CHAPTER 4

THESIS CONCLUSION

Female Forest Landowner Workshops

The trending growth of female forest landowners (FFLs) does not seem to be slowing down, with the average age of landowners at 65 years old. State-level research should continue to provide optimal educational outreach to FFLs. Moreover, they should learn how regional landowner holding and gender differences compare to national data. Catering education towards FFLs encourages better management practices, higher confidence, a greater social network, peer-to-peer learning, and a better sense of community. The participants attending the seven different workshops hosted by Warnell School of Forestry and Natural Resources were extremely competent women. However, many lacked experience or knowledge in land management to make them confident in their abilities to learn and enact land management activities. The workshops gave them space to learn more about forest management and provided a baseline of information to build a foundation for the participants to start learning more. The research, although extremely important, is eclipsed by the importance of guaranteeing the participants' needs were met and that they were able to learn in a comfortable environment.

Participants grew in confidence over the course of the seven workshops. This is heartening news, indicating the participants, FFLs and future FFLs, have increased in knowledge of land management activities. Moreover, they now know what questions to ask to grow their knowledge further. The participants were ready to engage with different land management activities. Their intent to engage in those activities were high across the board except for buying

land and producing non-timber forest products. Furthermore, connection to their land was extremely high. The low number of total participants limited the demographics from being statistically tested to see whether they varied in confidence and intent.

The women expressed gratitude for the workshop opportunity and left feeling empowered. Furthermore, the participants used the coffee breaks, lunch, and later start times to interact with peers, ask questions of experts, and to grow their knowledge and network. The qualitative data gave a depth that could otherwise not be reached with quantitative data. These women were adept, ready to learn, and had a diverse background of experiences. The ability to hold workshops indefinitely and on semi-regular basis would be beneficial for FFLs. Creating a self-sustaining and supporting group of FFLs allows them to grow in their own knowledge and experience without relying on an entity to bring that to them.

FFLs have a wide array of goals, concerns, and experience. Educational outreach can focus on building participants' confidence, sense of place, and sense of empowerment. Outreach in the future should focus on creating a comfortable environment with a flexible schedule that can change on participants needs. Other, nontraditional, presentations should be used to empower women to learn and grow in confidence. Examples of these could be presentations on communication styles, understanding forestry jargon, water health, taxes, or holistic land management. The most important role of educational outreach is to create a space for FFLs to be in an environment where they can meet other FFLs, ask any questions they want to comfortably, and come away feeling confidence about their upcoming land management and their future learning. It is important to ensure that natural science education is understandable and usable for FFLs. Applicable research occurs regularly, yet many landowners will not receive that information until the scientific jargon has been explained in a fathomable manner. Educational

outreach blends social and natural sciences together. Although opposing at first sight, FFLs workshops and longleaf pine canopy arthropods do have many similarities.

Longleaf Pine Canopy Arthropods

The longleaf pine ecosystem only covers roughly two to five percent of the original range yet holds a diverse number of organisms. Understanding the longleaf pine ecosystem allows landowners to better manage and conserve natural resources. Landowners rarely manage their land with arthropods in mind unless they are a pest species. However, managing to promote arthropod abundance and diversity raises the survival of more recognizable species, such as the gopher tortoise and the red-cockaded woodpecker. Determining what canopy arthropods are present in the different ecological communities of the longleaf pine ecosystem fills in a large gap of previously unreported knowledge. Placing the ecosystem into smaller subsections (i.e., ecological communities) allows for easier understanding and comparison of the species' relationships among the subsections.

Aside from the difference in hemipteran family-level richness, it is unsurprising that there were no differences among ecological communities. However, the number of Collembola collected in the canopy was startling and represents a crucial portion of the canopy layer ecosystem and food web. Lingering questions persist on how Collembola arrived in the canopies and got caught in the trap. The flight-intercept trapping method used has a strength in catching strong flying insects. In the future other trapping methods could be used to catch potentially underrepresented taxa. Moreover, species can be determined to more specific taxonomic levels to parse out more nuanced differences. The research is the first step in studying longleaf pine canopy arthropods.

The canopy arthropod research, although mainly natural science, has social science implications. Findings from the canopy arthropod research were incorporated into a presentation about ecosystem services for an FFL workshop. Presenting on ecosystem services gave landowners more knowledge about the natural resources in forest ecosystems. Landowners are more likely to care and nurture their land when they know more about the natural resources. FFLs that attended workshops expressed interest in not only learning about how to manage land but also learning about the ecosystem, ecosystem services, and biology of their land.