



IN THIS ISSUE

- PAGE 2
Future Forests = PineRefSeq + PINEMAP
- PAGE 3
Forestry Professional Case Study: Adaptive Forester Typifies and Advances the PINEMAP Mission
- PAGE 4
Early Impacts of Rainfall Manipulation and Fertilization Treatments on the Ecophysiology of Loblolly Pine in the Georgia Tier III Installation
- PAGE 6
The PINEMAP Fellowship Program: Notes from Year One
- PAGE 8
Determining the Impact of Hurricane Risk on Optimal Forest Management in Southern Pine Plantations



PINEMAP is working to integrate key research, education, and outreach networks to create and disseminate the knowledge that enables landowners to:

- *harness planted pine forest productivity to mitigate atmospheric CO₂;*
- *more efficiently use nitrogen and other fertilizer inputs; and*
- *adapt forest management approaches to increase resilience in the face of climate variability and climate change.*

Visit the PINEMAP web site:
<http://www.pinemap.org>

Like PINEMAP on Facebook:



Mapping the future of southern pine management in a changing world.

Project Director's Message

Timothy A. Martin
School of Forest Resources and Conservation, University of Florida

Greetings from PINEMAP!

Welcome to the second issue of the *PINEMAP Press*, a quarterly newsletter from the Pine Integrated Network: Education, Mitigation, and Adaptation Project. The purpose of this newsletter is to inform and educate on important research results and programs coming out of the PINEMAP project. The articles in this issue exemplify the full range of activity in our interdisciplinary project, from leaf physiological measurements to hurricane risk modeling, and from undergraduate student outreach to on-the-ground forest management. The PINEMAP project integrates these diverse projects to create and disseminate the knowledge that will enable landowners to: harness planted pine forest productivity to mitigate atmospheric CO₂; more efficiently use nitrogen and other fertilizer inputs; and adapt forest management approaches to increase resilience in the face of climate variability and climate change.

Please visit our web site (<http://www.pinemap.org>) and/or become a fan of our Facebook page (www.facebook.com/pinemap) for more information about PINEMAP and for ongoing project updates.

~Tim Martin



This photo shows snow collected in the throughfall exclusion structures at the PINEMAP Tier III (Throughfall Exclusion x Fertilization) site in McCurtain County, Oklahoma.

Photo by Casey Meek.

Future Forests = PineRefSeq + PINEMAP

Tom Byram, Department of Ecosystem Science and Management, Texas A&M University and Texas A&M Forest Service
 Ross Whetten, Department of Forestry and Environmental Resources, North Carolina State University
 Nick Wheeler, College of Forestry, Oregon State University
 David Neale, Department of Plant Sciences, University of California at Davis

$P = G + E + GXE$ describes the interactive effects of genetics and environment on the observed phenotype and is one of the most powerful ideas in all of modern biology. Two USDA NIFA-funded projects are now working to elucidate the components of this model in unprecedented detail. The Pine Reference Sequences project (PineRefSeq) is attempting to develop the first genome sequence for loblolly pine (G) while PINEMAP investigates how the environment (E) interacts with individual trees and stands (GXE) to form the forest of the future (P).

The two projects are linked through shared goals and personnel: PINEMAP Principal Investigators Tom Byram and Ross Whetten serve on the PineRefSeq Science Advisory Committee, and Carol Loopstra serves as a Principal Investigator on both projects. PineRefSeq, now in its second year, has \$15 million in funding over five years and also plans to sequence sugar pine and Douglas-fir. PINEMAP has \$20 million in funding over a similar five year period and is addressing carbon cycles, resource efficiency, and response to climate to achieve sustainability of southern pine plantations.

The goal of the PineRefSeq project is to provide a genome sequence for an individual loblolly pine, which will enable future experiments to discover the molecular diversity underlying genes, promoter regions, and transcription factors. The ultimate aim is to provide an annotated list of genes describing their function, regulation, and the place they occupy in biochemical pathways critical to growth, fitness, and adaptability. PINEMAP approaches the problem through the other components of the equation by examining how the environment influences phenotypes. Genetic variation is the critical point at which the two projects overlap, and the source of considerable project synergism.

Sequencing the loblolly pine (*Pinus taeda*) genome is far from trivial. At seven times the size of the human genome, it is one of the largest sequencing projects to ever be attempted (Figure 1). To further complicate matters, the pine genome is literally awash in repetitive DNA: gene families regulated in tissue specific ways, nonfunctional pseudogenes, highly repetitive structural sequences, and possibly millions of relics of genetic reorganization in the form of transposons and retrotransposons. Despite these difficulties, the project has already had considerable success and recently released a draft sequence to the research community (see http://www.nifa.usda.gov/newsroom/news/2013news/01111_loblolly_genome.html).

Meanwhile, PINEMAP is collecting measurements on phenotypes, environments, and genotypes with the goal of predicting the performance of future forests. PINEMAP researchers are already using the PineRefSeq sequence to verify and design platforms to acquire the most meaningful genotypes of the trees they are studying. Initially, this takes the form of: 1) verifying genetic variation seen in existing databases from other projects, 2) designing platforms that will efficiently assay this variation, and 3) ensuring that all relevant parts of the genome are represented. The eventual goal is to identify functional differences, either in the structure of alternative forms (alleles) of important genes or in their regulation. The extensive database of interacting phenotypes and genotypes generated by the PINEMAP project will inform and validate the annotation process, or the assignment of function to the gene sequence developed by the PineRefSeq project. This will be an iterative process, as PineRefSeq generates new sequences and proposes new putative functions and as PINEMAP measures additional traits in novel environments. The outcome of this synergistic effort will be a better understood, more resilient, and more productive future forest.

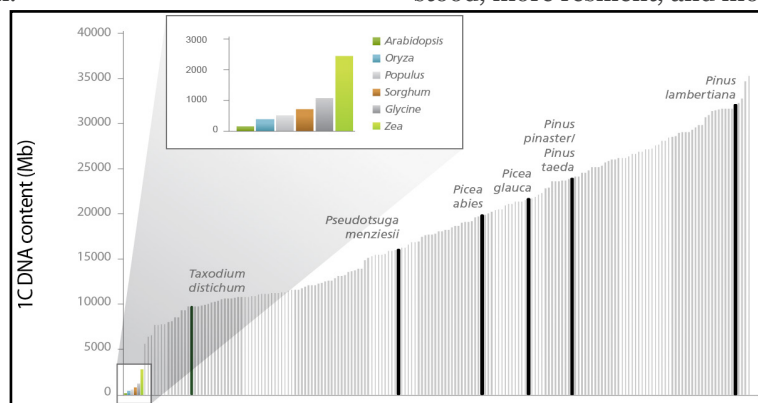


Figure 1. Relative genome size of several conifers compared to several species previously sequenced. Image credit: modified from Daniel Peterson, Mississippi State University.

Forestry Professional Case Study: Adaptive Forester Typifies and Advances the PINEMAP Mission

Mark Megalos

Department of Forestry and Environmental Resources, North Carolina State University

When colleagues from the University of Florida and the Southeastern Climate Consortium asked for a case study from a forestry professional who is successfully adapting to changes in the field, we went to a reliable source, Mr. Jim. Jim is the consummate professional—a traditional forestry consultant with a history of deploying tactics that work. He is willing to tackle any and all challenges that cross his land management path—mineral extraction, water intake pipes, restoration, right-of-way condemnation, invasive species control, and endangered species protection—the whole gamut.

Jim works and lives in the Sandhills region of North Carolina, a vulnerable ecosystem renowned for its fire frequency, droughty soils, and keystone species—longleaf and loblolly pines. Recently, Jim has focused his efforts on restoring and profitably managing longleaf and ever-present loblolly on a landscape where residential, commercial, and military entities compete for acreage and other amenities. His land management tool chest is varied and involves all the financial and management resources at hand: planning, harvesting, thinning, herbicides, leasing, pinestraw, farm receipts, and prescribed fire. But as much as Jim is a doer, he is a consummate observer of people, plant response, and, increasingly, weather and phenology (i.e., the timing of the onset of bud break, leaf out, seed maturity, leaf fall, and dormancy).

The decision to favor pines is purposeful. Fast growth, market demand, and resilience to harsh weather are primary benefits. For longleaf pine, the ability to withstand hurricane force winds while furnishing an annual profit return from

pinestraw harvest is an added bonus. After experiencing a tornado in January 1995, a hurricane in September 1996, and an early season ice storm in December of 2002, Jim has learned to be ready for any and every contingency. Planting the right species on the right soil and location is a key aspect of his risk management portfolio.

But these aren't the only reasons for favoring pines; their ability to withstand fire is legendary. Fire can be a powerful tool in managing pests and invasives, but if not used properly, the results can be disastrous. In determining when to engage in prescribed fires and other activities like harvesting, Jim and his crew rely on the latest technology, a RAWS weather station about 2 miles away from their site. Access to real time weather data, such as wind, temperature, and relative humidity, has allowed his crew to make timely adjustments, like shifting to nighttime ignition, spot firing, or other tactics. Jim's devotion, advocacy, and expertise with fire have not gone unnoticed. In 2011, he received the North Carolina Prescribed Burner award from the North Carolina Prescribed Fire Council, a group he has been a part of since its inception in the early 2000s.

Jim encourages PINEMAP researchers to present their latest findings at local and regional Extension events, and he provides expert review of factsheets and presentations, even welcoming graduate students to help conduct burns. Our experiences with Jim exemplify the types of outcomes we are trying to achieve in PINEMAP: direct, two-way interactions with forest managers resulting in more resilient forest management for a changing world.



Forester Jim hosts a field day at a client's forest.
Photo by Chris Brown, NC Forestry Association.

Early Impacts of Rainfall Manipulation and Fertilization Treatments on the Ecophysiology of Loblolly Pine in the Georgia Tier III Installation

Joe Clark, Stan Bartkowiak, and Lisa Samuelson
School of Forestry and Wildlife Sciences, Auburn University

A central goal of the PINEMAP project is to quantify climate, soils, and management impacts on carbon sequestration in planted pine ecosystems and provide data on these impacts to build and verify models that simulate pine forest dynamics under varying climate. To help achieve this goal, we are studying the interactive effects of a 30% reduction in rainfall and nutrient availability on the ecophysiology of loblolly pine. This field experiment is part of the PINEMAP Tier III “Throughfall Exclusion x Fertilization” network, in which nutrients and water are manipulated at four sites situated at the edges of the native loblolly pine range (Figure 1).

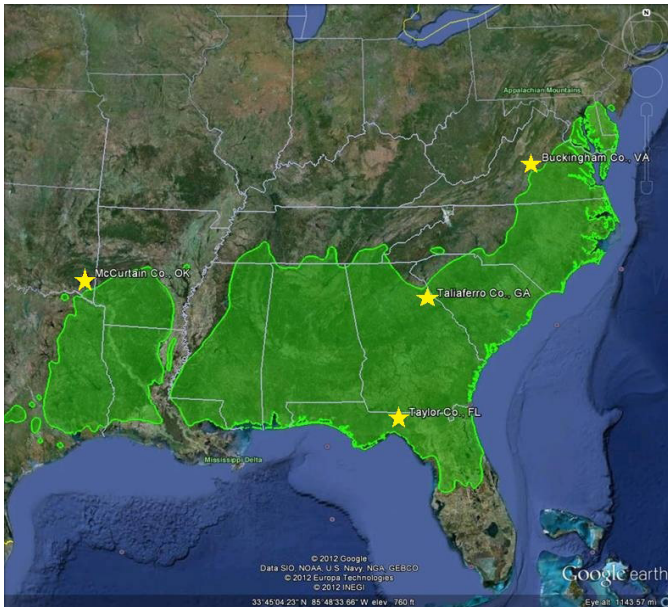


Figure 1. Location of Tier III “Throughfall Exclusion x Fertilization” research sites.

The Georgia Tier III site is located in the Piedmont physiographic region in Taliaferro County. At this site, seedlings were planted in 2006 and treatments consisting of two levels of rainfall (ambient or 30% reduction in ambient rainfall) and two levels of fertilization (none or 224 kg N ha⁻¹, 28 kg P ha⁻¹ and 56 kg K ha⁻¹) were initiated in spring 2012. The 30% reduction in ambient rainfall was achieved using exclusion troughs covering 30% of the land area in a plot (Figure 2). From July through November 2012, we examined leaf physiological characteristics such as net photosynthesis, stomatal conductance, and leaf water potential. In addition, sap flow measurements began in October 2012 and will be used to estimate stand level water use and canopy level stomatal conductance. Leaf area index (LAI) and intercepted radiation (IPAR) have been monitored since May 2012.

Initial studies indicate that the 30% rainfall exclusion treatment has a significant effect on leaf physiology. Across all measurement months, rainfall exclusion reduced net photosynthesis by 12% on average and stomatal conductance by 27% (Figure 3). Predawn leaf water potential was reduced by rain exclusion, but midday leaf water potential was not affected. Preliminary sap flow data indicates a 20% reduction in total daily transpiration in response to the rain exclusion treatment, from 1.5 to 1.2 mm day⁻¹ over a 7-day period in October, which was due to a reduction in midday maximum sap flux density. As of yet, fertilization has not had a significant effect on these variables.



Figure 2. Throughfall exclusion structures at the Tier III site in Taliaferro County, Georgia. Photos by Madison Akers.

Continued on page 5.

Early Impacts of Rainfall Manipulation and Fertilization Treatments

continued from page 4

In comparison, fertilization has affected LAI, with changes detected as early as June 2012 (Figure 3). Peak LAI increased from 1.7 with no fertilization to 2.1 with fertilization. At peak LAI, IPAR increased from 70% to 80%. Thus far, rainfall exclusion has not had a significant effect on LAI or IPAR and interactions between the rainfall exclusion and fertilization treatments have not yet been detected.

These results indicate early responses to changes in the availability of water and nutrients. To date, net photosynthesis, stomatal conductance, and predawn water potential have been

sensitive to water availability, and leaf area production has been responsive to nutrient availability. A key question to be answered is whether, over time, interactions will develop between water and nutrient availability. For example, increased leaf area production in response to fertilization may also increase tree susceptibility to drought events. Results from this study will contribute to the PINEMAP Decision Support System which will provide landowners and managers the tools necessary to make decisions about managing planted pine for increased carbon sequestration, enhanced fertilizer efficiency, and resilience to altered disturbance regimes.

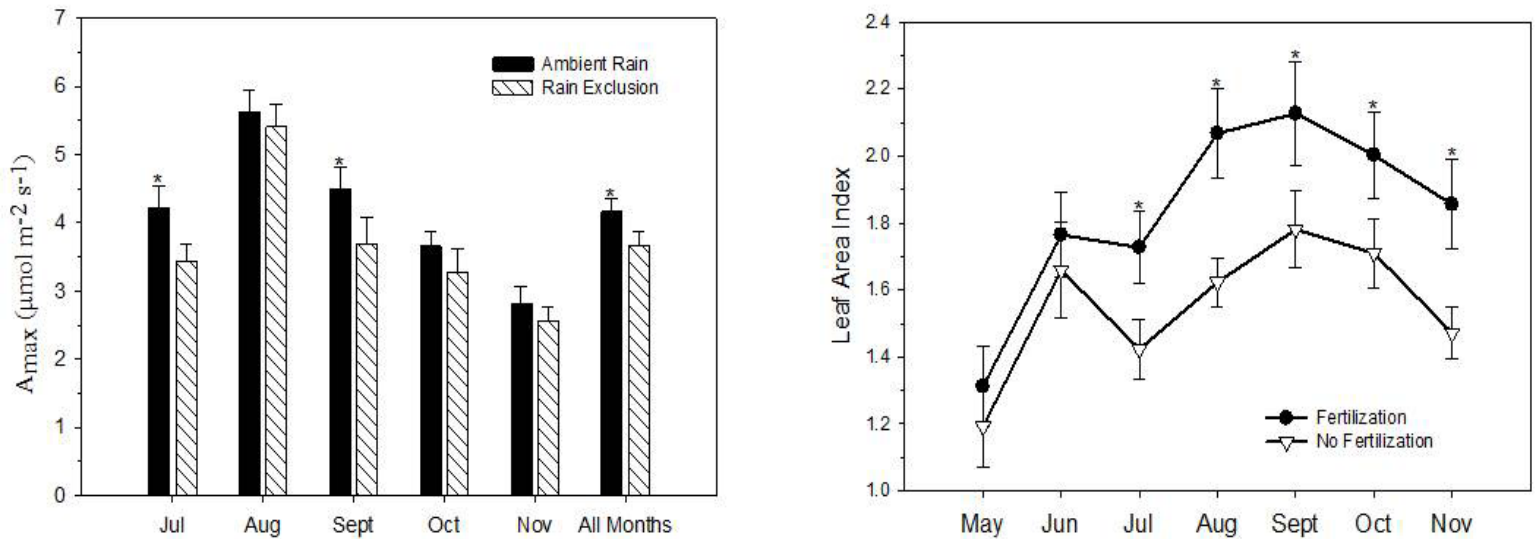


Figure 3. Influence of the rainfall exclusion treatment on leaf light-saturated net photosynthesis (A_{max}) and influence of fertilization on leaf area index (LAI) of loblolly pine at the Georgia Tier III research installation. Asterisks indicate a significant difference between treatments.

For additional information on this research, contact Lisa Samuelson (samuelj@auburn.edu).

The PINEMAP Fellowship Program: Notes from Year One

John B. Kidd and John R. Seiler

Department of Forestry and Environmental Resources, Virginia Tech

The PINEMAP Fellowship Program was developed to meet student education and training goals within PINEMAP's Education Aim. The fellowship program is both innovative and integrative, combining a summer undergraduate research experience with a fall distance course. Undergraduate students from across the United States apply to become fellows and are paired with a graduate student, post-doctoral research associate, or staff researcher mentor from a PINEMAP institution. The mentor supervises the undergraduate throughout a 12 week paid summer fellowship, and fellows experience the range of activities involved in the rigorous scientific research of PINEMAP. Upon completing the summer fellowship, fellows return to their home universities for fall courses and participate in the distance course, *Effective Communication Skills*. Five of six undergraduate fellows successfully completed the first, trial year of the program in December 2012, and the program will support 12 fellows in 2013 and 18 in 2014.

During summer 2012, all six fellows successfully completed their summer internship; the sixth did not continue with the distance course. Regardless of individual placements, fellows were hired as temporary wage employees of Virginia Tech. Fellows received up to \$7,000 for 12 weeks of full time work at the mentor's university.

Fellows in the 2012 program worked at Virginia Tech, North Carolina State University, and the University of Florida. Graduate students who participated as mentors were members of three of PINEMAP's Aim groups (Silviculture and Ecophysiology, Economics and Policy, and Education). Fellows were encouraged to conduct a small, related research project under the guidance of mentors when feasible and were required to keep a weekly journal reflecting on various aspects of their summer fellowship.

"I found [the fellowship] to be a wonderful summer and it gave me a fantastic foundation to build...what will ideally be a long career in science."

~Will Kennerley, 2012 PINEMAP fellow

During the fall semester, fellows were required to participate in the *Effective Communication Skills* class co-taught by Virginia Tech faculty. Fellows signed up for 3 credit hours of letter-graded, independent study at their home university. Course instruction included students identifying standards of learning (SOL) for their state and considering how presentations based on summer research could meet specific SOL. For example, in one presentation, the fellow utilized a terrarium and a CO₂ gas analyzer to show the process of photosynthesis decreasing atmospheric CO₂ and respiration increasing atmospheric CO₂ (Figure 1). *Continued on page 7.*



Figure 1. Will Kennerley (far right), a 2012 PINEMAP fellow, demonstrates how forests can impact atmospheric CO₂ levels to a high school biology class in Southwest Virginia. Will used a small scale terrarium "forest" and CO₂ gas analyzer to track changing CO₂ levels.

Photo by April Addington, Twin Springs High School, Nickelsville, VA.

The PINEMAP Fellowship Program: Notes from Year One

continued from page 6

Fellows outlined their presentations and developed and practiced them several times in front of peers and course instructors over a four-week period. During this time, fellows also coordinated with teachers to deliver highly polished presentations in local public secondary school classrooms (Figure 2). Approximately 1,000 public school students heard presentations on forests and climate change (Table 1).

Table 1. Individuals reached through the 2012 PINEMAP fellowship program.

Outreach metric	Number
Fellowships completed	5
Presentations delivered	≥ 50
Schools visited	14
Teachers visited	≥ 22
Students reached	~ 1,000

Later in the semester, students used skills gained during their summer research experience to write a scientific abstract, create a scientific poster, and develop a PowerPoint presentation. Each student was graded based on class participation, submitted assignments, and evaluations of at least 10 public school presentations. Final grades were provided to the sponsoring faculty member at the student's home institution.

"I think that this course was a great help for my graduate school plans; this whole internship was really. I was able to work closely with multiple grad students and I feel that I have a much better understanding of what graduate school really entails."

~Paul Decker, 2012 PINEMAP fellow

Based on what we learned in 2012, we will be making some adjustments to the program. We will increase the level of communication required from all participants. Hourly pay for the summer will be reduced but extended into fall as an incentive for continued participation in outreach to public school students; the maximum wage available remains unchanged. Finally, course material for the class will begin mid-summer so that fellows can present to secondary schools earlier in the fall semester, easing the burden on students during the fall and allowing more time for discussion and reflection on assignments and experiences. Additionally, we will conduct evaluation research to identify: 1) outcomes that individuals achieve as participants in the fellowship program and 2) how well the fellowship program is meeting its goals.

For additional information on this program, contact John Kidd, PINEMAP Intern Program Coordinator, at jbkidd@vt.edu or access the fellowship program webpages at <http://www.pinemap.org/education/undergraduate>.



Figure 2. Paul Decker (far right), a 2012 PINEMAP fellow, teaches students about measuring trees and calculating the amount of carbon stored in trees.

Photo by Angela Borealo, Shawsville Middle School, Shawsville, VA

Determining the Impact of Hurricane Risk on Optimal Forest Management in Southern Pine Plantations

Andres Susaeta, Douglas Carter, Sun Joseph Chang, and Damian Adams
School of Forest Resources and Conservation, University of Florida

Catastrophic natural events have a significant influence on forest management decisions, and climate change has the potential to increase risks related to hurricanes and other extreme weather events. In the southern U.S., hurricanes pose a major economic threat; from 1949-2006, total economic property losses due to hurricanes amounted to \$127 billion, representing 85% of the nation's total losses due to hurricanes.

The traditional Reed model (1984) is a tool used to assess the effect of the risk of catastrophic event on optimal timber harvesting and profitability of a forest stand. One of the limitations of the traditional Reed model is that the probability of risk of catastrophic events and salvageable portion of the forest stand are assumed to be constant for all harvest

time periods. Age, as well as biological and ecological conditions of the forest stand, may influence the probability of a natural hazard and the possibility of salvageable operations. These parameters are highly variable and uncertain, thereby increasing the risk of management decisions related to rotation age.

To address these limitations, we developed a generalized version of the Reed model that accounts for not only risk of natural hazards but also allows all other factors to vary between different timber crops (Figure 1). Consequently, the optimal harvest age may also vary from timber crop to timber crop. We applied the generalized Reed model to a representative even-aged slash pine plantation. *Continued on page 9.*

$\frac{\partial V_k(T_k)}{\partial T_k} + e^{(r_k + \lambda_k)T_k} \phi_k$ <p>MRV</p> <p>Net marginal revenue of the stand (MRV) resulting from waiting an extra year to harvest</p> <p>$V_k(T_k)$ = stumpage value of T_k years old stand of timber crop k</p> <p>ϕ_k = marginal return due to salvage operations for timber crop k</p> <p>r_k = discount rate for timber crop k</p> <p>λ_k = probability of risk of fire for timber crop k</p>	=	$(r_k + \lambda_k)V_k(T_k) + (r_k + \lambda_k)LEV_{k+1}$ <p>MCW</p> <p>Marginal cost of waiting (MCW) one extra year to harvest</p> <p>r_k = discount rate for timber crop k</p> <p>λ_k = probability of risk of fire for timber crop k</p> <p>$V_k(T_k)$ = stumpage value of T_k years old stand timber crop k</p> <p>LEV_{k+1} = the future land expectation value for timber crop $k + 1$ year</p>
<p>If the $MRV \leq MCW$, the landowner should harvest the forest stand.</p> <p>If the $MRV > MCW$, the landowner should wait for another time period.</p>		

Figure 1. The generalized Reed model equation and key relationships. The left side of the equation represents the net marginal revenue of the stand (MRV) by waiting one extra year to harvest. It includes earnings due to the growth in stumpage value and the marginal return due to salvage. The right side of the equation represents the marginal cost of waiting (MCW) one extra year to harvest, including the cost of holding the stand value-interest earned on the stumpage value and the cost of holding the land-interest earned on the future land value.

This equation stipulates a rule regarding harvesting: the optimal harvest age is reached when both sides of the equation are equal. Thus, if the $MRV \leq MCW$, the landowner should harvest the forest stand. If the $MRV > MCW$, the landowner should wait for another time period.

Determining the Impact of Hurricane Risk on Optimal Forest Management in Southern Pine Plantations *continued from page 8*

Increases in the current risk of hurricane-related losses would shorten the predicted optimal harvest age (Figure 2). However, a higher future risk while the current risk remains unaffected would have the opposite impact, therefore lengthening the optimal rotation age. A similar approach is applied to salvageable value, and we find that increases in current salvageable portions would lengthen the harvest age, while higher future salvageable portions would reduce the harvest age. The generalized Reed model indicates that, regardless of the timing of the natural hazard, profitability of forestlands would be negatively impacted. This suggests that increased weather variability, perhaps due to climate change or changes in local weather patterns, would have negative consequences for profitability in southern pine plantations.

The risk of hurricanes is not under human control, which means that there is a need for mitigation practices to help lessen the impacts of hurricanes. For example, coordinated efforts on the part of government could encourage landowners to enroll in a catastrophic risk insurance system to enhance the financial stability of forest management. Other strategies to reduce vulnerability to hurricanes may include changes in stand structure by balancing tree age classes and managing stand density to create wind resistant stands.

For additional information on this research, contact Andres Susaeta (asusaeta@ufl.edu).

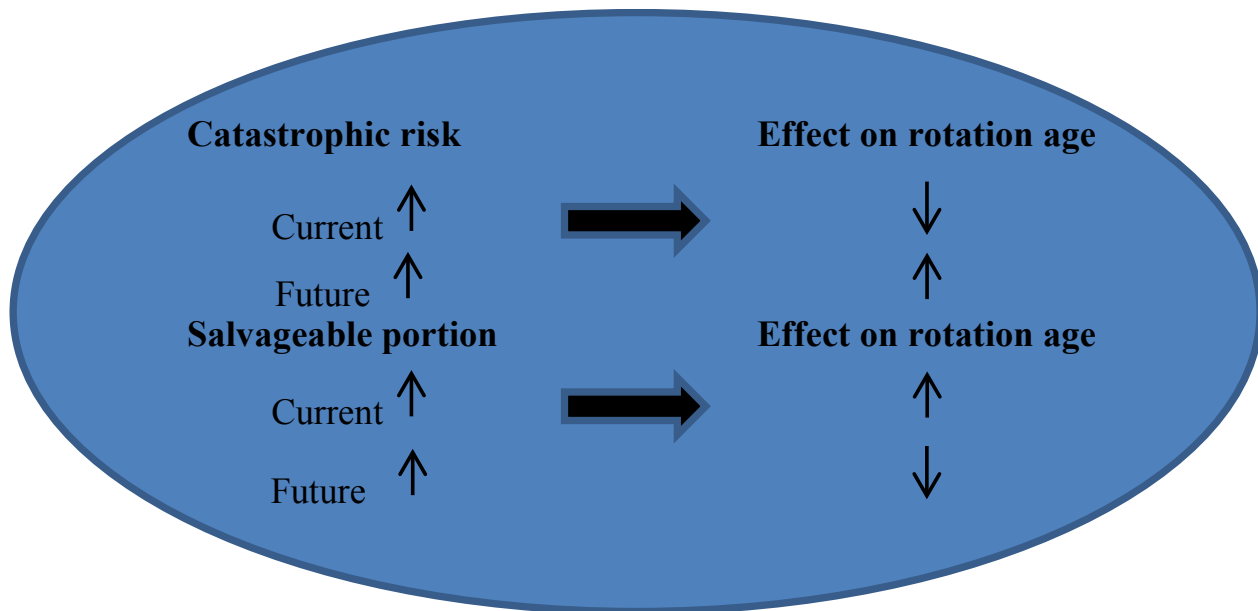


Figure 2. Effect of current and future increase in catastrophic event and salvageable portion on current rotation age.



United States
Department of
Agriculture

National Institute
of Food and
Agriculture

The Pine Integrated Network: Education, Mitigation, and Adaptation project (PINEMAP) is a Coordinated Agricultural Project funded by the USDA National Institute of Food and Agriculture, Award #2011-68002-30185.