Journal of Extension

Volume 57 | Number 3 Article 23

6-1-2019

Economic Impact of a Large-Scale, Collaborative Forest Health Project: A Model for Making a Difference

John D. Kushla
Mississippi State University

Stephen G. Dicke
Mississippi State University

James E. Henderson
Mississippi State University

Jason Gordon
Mississippi State University

Andrew J. Londo
Ohio State University

See next page for additional authors

Economic Impact of a Large-Scale, Collaborative Forest Health Project: A Model for Making a Difference

Authors

John D. Kushla, Stephen G. Dicke, James E. Henderson, Jason Gordon, Andrew J. Londo, and James Meeker

Journal of Extension
www.joe.org

June 2019
Volume 57
Number 3
Article # 3FEA3
Feature

Economic Impact of a Large-Scale, Collaborative Forest Health Project: A Model for Making a Difference

Abstract

The U.S. Department of Agriculture Forest Service, Mississippi State University (MSU) Extension, and the Mississippi Forestry Commission partnered on the Southern Pine Beetle Prevention Project, a collaboration on forest health. MSU Extension provided educational outreach to a wide audience of forest landowners and screened applications for the project's tree-thinning cost-share program. From 2006 to 2016, the collaboration spent $4.5 million on educational outreach and cost sharing. Using IMPLAN, we estimated the project's economic contribution to the state at $60.2 million, a value representing a benefit–cost ratio of 13:1. Collaboration is an effective means for agencies to leverage resources, and impact analysis is a useful tool for evaluating Extension program effectiveness.

Keywords: collaboration, economic impact analysis, IMPLAN, forest health, southern pine beetle

John D. Kushla
Professor and Extension Forestry Specialist
North Mississippi Research and Extension Center
Mississippi State University
Verona, Mississippi
John.Kushla@msstate.edu

Stephen G. Dicke
Switzer Distinguished Professor and Extension Forestry Specialist (Retired)
Central Mississippi Research and Extension Center
Mississippi State University
Raymond, Mississippi
Stephendickems@gmail.com

James E. Henderson
Professor and Head
Coastal Research and Extension Center
Mississippi State University
Biloxi, Mississippi
J.Henderson@msstate.edu

Jason Gordon
Associate Extension Professor of Urban and Community Forestry
Department of Forestry
Mississippi State University
Starkville, Mississippi
jason.gordon@uga.edu

Andrew J. Londo
Professor and Assistant Director of Agriculture and Natural Resources
Ohio State University
Columbus, Ohio
Londo.2@osu.edu

James Meeker
Entomologist, U.S. Department of Agriculture Forest Service
Forest Health Protection, Alexandria Field Office
Pineville, Louisiana
JRMeeker@fs.fed.us

Introduction

Extension educators have a history of collaborating on large-scale projects. For example, Ehmke and Mount (2007) reported on a consortium of natural resources organizations focused on educating small-scale landowners in the Intermountain West. The Small Acreage Conservation Education and Outreach Project brought together natural resources educators from various organizations to address management needs on small properties

(Ehmke & Mount, 2007). Diaz, Jayaratne, Bardon, and Hazel (2014) developed a framework for modeling successful large-scale coalitions. They found that successful collaborators were able to address input from many stakeholder groups and build trust among partners (Diaz et al., 2014). Successful coalitions develop solutions that satisfy the various organizational objectives and stakeholder needs.

Such a coalition carried out the Southern Pine Beetle Prevention Project in Mississippi. Southern pine comprises 43% of the commercial forest in Mississippi, most of which is privately owned by individuals or families (Oswalt, 2015). The most devastating insect to this forest resource is the southern pine beetle (SPB) (*Dendroctonus frontalis* Zimmermann). The risk and consequences of SPB are too great to be addressed by one organization alone—partnerships are needed to address the complex biological and social issues created by the hazard. Thus, collaborations are key to outreach education and SPB prevention in Mississippi. The Mississippi SPB Prevention Project has served as a model for Cooperative Extension and agency collaboration in the South.

The U.S. Department of Agriculture (USDA) Forest Service initiated a proactive SPB prevention program across the South in 2003 (Nowak, Asaro, Klepzig, & Billings, 2008). Most commercial forestland in Mississippi is privately owned (Oswalt, 2015), and the Forest Service considered Mississippi State University (MSU) Extension to be an ideal mechanism for reaching the state's private forest landowners. The USDA Forest Service joined with MSU Extension in 2006 to provide educational programming to this target audience. Subsequently, the USDA Forest Service offered an economic incentive for SPB prevention through a monetary payment for thinning pine stands. The Mississippi Forestry Commission (MFC), which had an administrative infrastructure for cost-share programs involving forest landowners, joined the project in 2008 as we implemented the pine-thinning cost-share program. Meanwhile, MSU Extension made site visits to screen for landowner participation in the cost-share program. The Mississippi SPB Prevention Project functioned as a collaboration of the USDA Forest Service, MSU Extension, and the MFC from 2008 to 2016.

In this article, we describe Extension's role in the SPB Prevention Project and report on the economic impact of the collaborative effort. To determine the economic impact, we used the IMPLAN model, now maintained by the University of Minnesota (Minnesota IMPLAN Group, 2009). The IMPLAN model was originally developed by the USDA Forest Service in cooperation with the Federal Emergency Management Agency and the University of Minnesota for estimating the economic impacts of forest management plans (Alward, Davis, Depotakis, & Lofting, 1985). Information on Extension's role in the SPB Prevention Project and economic contributions of the project can provide insights that will enable other Extension professionals across the nation to implement successful collaborative programs and evaluate the economic impacts of Extension efforts.

Background

The Pine Resource in Mississippi

The commercial pine timber in Mississippi is on about 8.4 million ac across the state (Oswalt, 2015). Overall, commercial pine stands (pulpwood and sawtimber combined) have a total estimated volume over 752 million tn, with a market value of $11.12 billion (Henderson, 2016). Table 1 shows breakdowns of these values by region and product. Just over 80% of the commercial forest in Mississippi is owned by nonindustrial, private forest owners (Oswalt, 2015). Furthermore, forestry and forest products are leading contributors within the agricultural sectors of Mississippi's economy with regard to employment, compensation, output, and value-added processing (Henderson, Barnes, Falconer, Williams, & Sites, 2016). The goal of the SPB Prevention Project was to help protect this valuable forest resource.

Table 1.
Mississippi's Pine Resource

Region	Acres	Pulpwood volume (million tn)	Sawtimber volume (million tn)	Pulpwood value ($ million)	Sawtimber value ($ million)
Southwest	2,653,214	206.36	148.90	1,650.88	3,573.60
Southeast[a]	2,946,246	158.63	109.16	1,269.04	2,619,84
Central	2,105,981	65.23	55.58	521.84	1,333.92
North	631,858	3.12	4.88	24.96	117.12
Delta	77,638	0.14	0.25	1.12	6.00
Total	8,414,937	433.48	318.77	3,467.84	7,650.48

Note. Area and volume estimates are from regional inventory reports by the Mississippi Institute for Forest Inventory (2009, 2010, 2014, 2015, 2016). Market values are based on statewide average prices (Henderson, 2016).
[a]Longleaf pine is resistant to southern pine beetle and comprises approximately 10% of the pine resource in southeastern Mississippi. Area and volume estimates were reduced accordingly.

SPB Biology

The SPB is the most damaging insect pest to southern pines (Coulson & Klepzig, 2011). Loblolly, shortleaf, and pitch pines are highly susceptible to SPB attack, meaning that many Mississippi forest landowners are susceptible to the associated effects (Oswalt, 2015). Longleaf and slash pines are more resistant, most likely attributable to their higher sap production (Hodges, Elam, Watson, & Nebeker, 1979). As one of several native pine bark beetles, the SPB bores galleries beneath the bark of pines. Adult beetles and larvae feed in galleries on the phloem tissue (the tissue conducting carbohydrates in the tree, just beneath the bark), effectively girdling and eventually killing affected trees.

In addition, pine bark beetles, including SPB, often introduce blue stain fungi (*Ophiostoma minus* [Hedgc.] Syd. & P. Syd) into the water-conducting tissue of the tree, which is known as xylem or sapwood (Paine, Raffa, & Harrington, 1997). As blue stain fungi colonize the sapwood, water conduction within the tree is disrupted. Moreover, the spread of blue stain fungi through the sapwood substantially lowers product values (Sinclair, Ifju, & Heikkenen, 1977).

High SPB populations can develop quickly, with six to eight generations produced per year in the South (Thatcher & Pickard, 1964). During outbreak conditions, SPB can attack healthy pines. Economic losses from SPB outbreaks have averaged $43 million annually across the South (Pye, Holmes, Prestemon, & Wear, 2011).

Thinning to Prevent SPB Attack

The focus of MSU Extension forestry education is on mitigation of risk to forest landowners. Thinning is the most commonly accepted silvicultural treatment for preventing or mitigating damage of SPB in southern pine stands (Belanger, Hedden, & Lorio, 1993). Thinning involves conducting a partial harvest to reduce the number of trees per acre, usually by removing the least desirable trees and saving the best for final harvest. Thinning of loblolly pine (below 100 ft^2 of basal area per acre) improves tree vigor, and the increased distance between potential host trees reduces likelihood of SPB attack (Brown, Nebeker, & Honea, 1987).

The effectiveness of thinning to prevent SPB-caused timber losses was demonstrated following the 2012 SPB outbreaks on the Bienville and Homochitto National Forests in Mississippi. Nowak, Meeker, Coyle, Steiner, and Brownie (2015) found that 99.7% of the 910 SPB infestations occurred in stands that had not been thinned within the preceding 6 years.

SPB Prevention Project in Mississippi

Landowners participating in the SPB Prevention Project needed a written forest management plan as used in the Mississippi Forest Stewardship Program. Thus, the primary role for MSU Extension was to facilitate landowners' having such plans by providing education on SPB biology, prevention of SPB attacks through thinning, and management planning. These education efforts preceded landowner participation in the project's cost-share program administered by the MFC. The objective of the cost-share program was to motivate landowners to thin their pine stands for risk reduction. The thinning effort was modeled on one used by the Texas Forest Service (Billings, Smith, & Murphrey, 2006). As previously noted, MSU Extension also screened properties for acceptance into the cost-share program. This screening process had the additional benefit of providing opportunity for one-on-one education with landowners through the site visits. The target action item for the cost-share program was first thinning of pine stands with moderate to high SPB hazard ratings (Belanger et al., 1993). After Extension provided education, screening, and a management plan for thinning, the MFC processed the USDA Forest Service cost-share reimbursements and distributed them to participating landowners.

Table 2 summarizes accomplishments of the SPB Prevention Project from 2006 through 2016 (federal fiscal year basis). During this period, MSU Extension Forestry received $2.02 million for educational outreach. MSU Extension Forestry used tax roll mailing lists to promote short courses and workshops about forest health to a wide audience (Londo, Kushla, & Smallidge, 2008). Overall, educational outreach funds supported 291 programs provided to over 12,600 participants and directly funded five positions (3.5 full-time equivalent) through 2011 (these positions were funded by MSU Extension after 2011).

Table 2.
Summary of Southern Pine Beetle (SPB) Prevention Project Funding in Mississippi

Year (federal fiscal funding)	Educational outreach ($)	Thinning cost sharing ($)	Actual thinning (ac)
2006	238,619	0	0
2007	304,792	0	0
2008	309,169	334,450	6,339
2009	299,108	300,875	5,890
2010	370,432	526,568	3,709
2011	360,033	675,250	9,103
2012	74,151	234,145	3,121
2013	45,150	205,867	2,746
2014[a]	21,225	198,450	2,646

Total	2,022,679	2,475,605	33,554

[a]The spending of fiscal year 2014 dollars finished in fiscal year 2016. The role of Mississippi State University Extension Forestry in the SPB Prevention Project ended September 30, 2016.

Educational outreach included evening programs at county forestry association meetings, short courses such as Managing Your Pine Plantation or Managing the Family Forest in Mississippi (Gordon, Kushla, & Londo, 2013), and workshops such as Are My Pine Trees Ready to Thin? Through these educational programs, MSU Extension distributed 144,454 copies of publications on forest health, thinning, SPB biology, and SPB prevention. MSU Extension also used the funds to purchase mensuration equipment for county forest associations to allow their members to evaluate their own pine plantations by applying what they learned in the thinning workshop. In addition to these efforts, MSU Extension conducted 496 site visits on properties of forest landowners involved in the cost-share program. Approximately 425 landowners were enrolled in the cost-share initiative of the SPB Prevention Project (A. J. Londo, personal communication, January 9, 2019).

Also shown in Table 2 are the funds spent on cost sharing for the first thinning. Cost-share funds amounted to $75 per acre on qualifying stands and capped at $12,750 per individual forest landowner. From 2008 through 2016, a total of $2,475,605 was spent to incentivize first thinning on 33,554 ac of pine timber. The cost-share funds followed the SPB hazard across the state during the project period. Cost-share funding for the project began in northern Mississippi in 2008. However, as the SPB hazard shifted southward, so too did the cost-share funding. After several years, the SPB hazard again shifted northward in Mississippi, and the cost-share funding followed. As indicated in Table 2, the educational outreach costs totaled $2,022,679. Together with the $2,475,605 spent in the cost-share program, total project funding was $4,498,284.

Economic Impact of the SPB Prevention Project in Mississippi

Impact analyses have been used for evaluating Extension programming in the forestry sector. For example, Marcouiller, Ray, Schreiner, and Lewis (1992) used the IMPLAN model to evaluate economic impacts from Extension programming in southeastern Oklahoma. Marcouiller et al. (1992) evaluated the impact of forestry programming intended to increase the wood supply and consequent economic development. More recently, McConnell (2013) used impact analysis to evaluate sawmilling and wood preservation in the Ohio forest economy.

The value of the IMPLAN model lies in how it tracks the movement of money through an economy. For impact analysis, the IMPLAN model is run with a particular sector in the economy and then without that sector in the economy. The difference in output is the impact that sector has on the economy (Henderson et al., 2016). For Extension professionals specifically, then, the value is in having the capacity to generate an estimate of the economic impacts of Extension programming.

IMPLAN is well suited to evaluation of the impacts of the Mississippi SPB Prevention Project. Blaine, Bowen-Ellzey, and Davis (2011) provided a fine explanation of how IMPLAN models the flow of money through the economy. Relevant to our circumstances, the forestry-related sectors in the Mississippi economy include logging, solid wood fabrication, wood furniture manufacturing, and pulping or paper production. In the Mississippi SPB Prevention Project, cost-share funds given to forest landowners encouraged partial harvests of pine through thinning. The direct effect of the cost-share funds came from loggers' buying supplies and equipment and hiring labor to conduct that first thinning. The direct effect also included the increased economic activity as this harvested wood was sent to mills for making pulp, paper, and other wood products. The indirect effect of the cost-share funds continued to spread through the economy as suppliers bought more goods and services to support this increased logging activity. Finally, the induced effect of the cost-share funds was reflected in additional economic activity from increased household spending (for food, clothing, recreation, shelter) through employment due to the logging activity from the first thinning.

The results of the IMPLAN analysis of the tree-thinning cost-share payments within the Mississippi economy are shown in Table 3. Over the duration of the project, the cost-share funding supported 533 jobs. Furthermore, the direct, indirect, and induced effects of the cost-share funds contributed a total of $60.2 million to the total economic activity in the state. Mississippi is a rural state with a relatively small population and has an economy in which agriculture, forestry, and forest products have a substantial role (Henderson et. al., 2016). Consequently, the tree-thinning cost-share portion of the SPB Prevention Project had a substantial impact on the state economy besides helping protect a valuable resource. Using the project funding information and economic impact estimates, shown in Tables 2 and 3, a benefit–cost ratio for the SPB Prevention Project can be calculated as 13:1 ($60.2 million/$4.5 million). This input–output type of economic analysis is a useful approach for evaluating Extension programming, especially in partnerships addressing large-scale needs.

Table 3.

Impacts of Tree-Thinning Cost-Share Funding on the Mississippi Economy

Fiscal year	**Total employment**	**Direct output (2014$)**	**Indirect output (2014$)**	**Induced output (2014$)**	**Total output (2014$)**
2008	45	5,097,642	3,372,529	1,090,188	9,560,359
2009	58	4,358,097	2,111,953	1,476,410	7,946,460
2010	48	3,452,254	808,577	1,262,633	5,523,464
2011	141	6,971,312	2,567,507	2,449,308	11,988,127
2012	53	2,401,042	823,203	2,373,039	5,597,283
2013	72	4,279,138	1,467,113	1,882,388	7,628,639
2014	116	5,275,578	1,401,352	5,332,329	12,009,259
Total	533	31,835,063	12,552,234	15,866,295	60,253,591

Implications for Extension Educators

Our results demonstrate that the SPB Prevention Project, based on principles of interagency collaboration (Diaz et al., 2014), was immensely successful during its first decade. This partnership helped protect the pine timber resource in Mississippi through greater landowner awareness and incentivized first thinning. MSU Extension conducted 291 SPB-related programs for 12,608 participants and distributed thousands of publications. MSU Extension also conducted 496 site visits to screen for landowner participation and provide written management plans for the tree-thinning cost-share program. The project received the 2012 Family Forests Education Award, presented by the National Woodland Owners Association and the National Association of University Forest Resources Programs.

The SPB Prevention Project exemplifies the effectiveness of interagency collaboration for large-scale projects. Each partner organization had strengths that complemented those of the others. The USDA Forest Service had funding to promote forest health across the southern United States by supporting SPB prevention. MSU Extension faculty and staff contributed the resources for providing educational programming and implementing the tree-thinning cost-share program through site visits and development of management plans. MFC administered the cost-share payments to participating forest landowners. All partners contributed to the overall success of the project.

Such collaborations bring together resources that go beyond those of any one partner to make impacts of large-scale programs possible. For instance, Kerna et al. (2015) applied the IMPLAN model to evaluate collaborative Supplemental Nutrition Assistance Program Education efforts in Arizona and found that, through collaboration, Extension outreach provided a means for educating the public about the availability of government food assistance (Kerna et al., 2015). In like manner, MSU Extension outreach affected a wider audience than the other SPB Prevention Project partners could have reached on their own. This is because extending knowledge to change and improve the quality of life for Mississippians is the mission for MSU Extension. It was critical to the project success to educate forest landowners about the potential hazard of SPB to their timber and to spread awareness about the tree-thinning cost-share program. Moreover, good working relationships were developed among the agency personnel involved with the project. These relationships are critical to any such endeavor. In sum, collaboration benefited all the organizations involved.

Additionally, the application of economic impact analysis is widely applicable in Extension. As one example, Harder and Hodges (2011) used IMPLAN to quantify the important economic impact of county 4-H livestock projects in Florida. Similarly, the very positive results from the economic impact analysis for the SPB Prevention Project reflected well on the efforts of MSU Extension. Simply put, economic impact analysis can estimate the economic benefits of Extension programming in terms legislators, county boards of supervisors, and stakeholders appreciate: dollars and cents. We encourage county and state Extension personnel to consider using economic impact analysis to evaluate Extension education efforts.

The Mississippi SPB Prevention Project was clearly successful and served as evidence that Extension education is worthwhile. Extension has the capability to reach and educate large audiences. This capability is a strength Extension can bring to partnerships. Organizations can accomplish great things on a large-scale when working together. In addition, economic impact analysis is a useful tool that Extension educators can apply across a variety of disciplines. The methods we applied in the Mississippi SPB Prevention Project are examples of approaches that could be useful in many Extension realms.

Author Note

Jason Gordon is now an assistant professor of community forestry in the Warnell School of Forestry and Natural Resources at the University of Georgia.

References

Alward, G. S., Davis, H. C., Depotakis, K. A., & Lofting, E. M. (1985, May). *Regional non-survey input–output analysis with IMPLAN.* Paper presented at the Southern Regional Science Association Conference, Washington, DC.

Belanger, R. P., Hedden, R. L., & Lorio, P. L., Jr. (1993). Management strategies to reduce losses from the southern pine beetle. *Southern Journal of Applied Forestry*, *17*(3), 150–154.

Billings, R. F., Smith, L. A., & Murphrey, M. (2006). *How to prevent southern pine beetle infestations: A guide to cost sharing thinning operations in East Texas* (Publication TFS3/06/5000). College Station, TX: Texas Forest

Service.

Blaine, T. W., Bowen-Ellzey, N., & Davis, G. A. (2011). Helping clientele understand elements of the local economy through input–output modeling. *Journal of Extension*, *49*(1), Article 1FEA5. Available at: https://joe.org/joe/2011february/a5.php

Brown, M. W., Nebeker, T. E., & Honea, C. R. (1987). Thinning increases loblolly pine vigor and resistance to bark beetles. *Southern Journal of Applied Forestry*, *11*(1), 28–31.

Coulson, R. N., & Klepzig, K. (2011). *Southern pine beetle II* (General Technical Report SRS-140). Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station.

Diaz, J. M., Jayaratne, K. S. U., Bardon, R. E., & Hazel, D. (2014). A framework for integrating and managing expectations of multiple stakeholder groups in a collaborative partnership. *Journal of Extension*, *52*(3), Article 3IAW6. Available at: https://www.joe.org/joe/2014june/iw6.php

Ehmke, C., & Mount, D. (2007). Reaching the small acreage audience through collaboration: The small acreage conservation education and outreach project. *Journal of Extension*, *48*(4), Article 4IAW3. Available at: https://joe.org/joe/2007august/iw3.php

Gordon, J., Kushla, J., & Londo, A. (2013). Managing the Family Forest Landowner Short Course: A case study in Mississippi. *Journal of the NACAA*, *6*(1). Retrieved from http://www.nacaa.com/journal/index.php?jid=200

Harder, A., & Hodges, A. W. (2011). Economic impact analysis of 4-H youth livestock projects using IMPLAN. *Journal of Extension*, *49*(1), Article 1TOT3. Available at: https://joe.org/joe/2011february/tt3.php

Henderson, J. (2016). *Mississippi timber price report 3rd quarter 2016*. Retrieved from http://extension.msstate.edu/content/timber-prices-2013-present

Henderson, J., Barnes, J. N., Falconer, L. L., Williams, B., & Sites, D. (2016). *The economic contribution of agriculture and forestry production and processing in Mississippi: An input–output analysis.* Mississippi State University Extension Service Publication 2962. Retrieved from https://extension.msstate.edu/sites/default/files/publications/publications/p2962.pdf

Hodges, J. D., Elam, W. W., Watson, W. F., & Nebeker, T. E. (1979). Oleoresin characteristics and susceptibility of four southern pines to southern pine beetle (Coleoptera: Scolytidae) attacks. *The Canadian Entomologist*, *111*(8), 889–896.

Kerna, A., Frisvold, G., Jacobs, L., Farrell, V. A., Houtkooper, L., & Misner, S. (2015). Application of IMPLAN to Extension programs: Economic impacts of the University of Arizona Cooperative Extension SNAP-Ed spending. *Journal of Extension*, *53*(6), Article 6TOT4. Available at: https://joe.org/joe/2015december/tt4.php

Londo, A. J., Kushla, J. D., & Smallidge, P. (2008). Use of county tax rolls for the creation of mailing lists for Extension programming. *Journal of Extension*, *46*(6), Article 6FEA6. Available at: http://www.joe.org/joe/2008december/a6.shtml

Marcouiller, D. W., Ray, D. E., Schreiner, D. F., & Lewis, D. K. (1992). Estimating economic impacts of programming. *Journal of Extension*, *30*(3), Article 2RIB7. Available at: https://joe.org/joe/1992fall/a6.php

McConnell, T. E. (2013). Using impact analysis to document a forest products sector's contributions to Ohio's economy. *Journal of Extension*, *51*(2), Article 6FEA6. Available at: https://joe.org/joe/2013april/rb7.php

Minnesota IMPLAN Group, Inc. (2009). *User's guide, IMPLAN Professional version 3.0*. Stillwater, MN: Author. Retrieved from http://www.implan.com

Mississippi Institute for Forest Inventory. (2009). *North Mississippi forest inventory*. Jackson, MS: Mississippi Forestry Commission.

Mississippi Institute for Forest Inventory. (2010). *Mississippi Delta forest inventory*. Jackson, MS: Mississippi Forestry Commission.

Mississippi Institute for Forest Inventory. (2014). *2012–2013 forest inventory Southwest Region, Mississippi*. Jackson, MS: Mississippi Forestry Commission.

Mississippi Institute for Forest Inventory. (2015). *2013–2014 forest inventory Southeast Region, Mississippi*. Jackson, MS: Mississippi Forestry Commission.

Mississippi Institute for Forest Inventory. (2016). *2014–2015 forest inventory Central Region, Mississippi*. Jackson, MS: Mississippi Forestry Commission.

Nowak, J., Asaro, C., Klepzig, K., & Billings, R. (2008). The southern pine beetle prevention initiative: Working for healthier forests. *Journal of Forestry*, *106*(5), 261–267.

Nowak, J. T., Meeker, J. R., Coyle, D. R., Steiner, C. A., & Brownie, C. (2015). Southern pine beetle infestations in relation to forest stand conditions, previous thinning, and prescribed burning: Evaluation of the Southern Pine Beetle Prevention Program. *Journal of Forestry*, *113*(5), 454–462.

Oswalt, S. N. (2015). *Mississippi forests, 2013* (Resource Bulletin SRS-204). Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station.

Paine, T. D., Raffa, K. F., & Harrington, T. C. (1997). Interactions among scolytid bark beetles, their associated fungi, and live host conifers. *Annual Review of Entomology*, 42, 179–206.

Pye, J. M., Homes, T. P., Prestemon, J. P., & Wear, D. N. (2011). Economic impacts of the southern pine beetle. In R. N. Coulson & K. Klepzig (Eds.), *Southern pine beetle II* (General Technical Report SRS-140) (pp. 213–222). Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station.

Sinclair, S. A., Ifju, G., & Heikkenen, H. J. (1977). Lumber yield and grade recovery from southern pine sawtimber after beetle attack. *Southern Journal of Applied Forestry*, *1*(4), 17–20.

Thatcher, R. C., & Pickard, L. S. (1964). Seasonal variations in activity of the southern pine beetle in East Texas. *Journal of Economic Entomology*, *57*(6), 840–842.