Production Forestry - Timber Management and Wood Utilization

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V(A). Planned Program (Summary)

1. Name of the Planned Program

Production Forestry - Timber Management and Wood Utilization

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
123	Management and Sustainability of Forest Resources			80%	
511	New and Improved Non-Food Products and Processes			20%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

Year: 2008	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	6.0	0.0
Actual	0.0	0.0	8.3	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c 0	1890 Extension 0	Hatch 471919	Evans-Allen 0
1862 Matching 0	1890 Matching 0	1862 Matching 868025	1890 Matching 0
1862 All Other 0	1890 All Other 0	1862 All Other 740213	1890 All Other 0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Conduct research, report results, assist with technology transfer

This program includes research to develop optimum procedures for hardwood timber management and harvest, to increase the efficiency of wood utilization while developing new uses for hardwoods, and, increasingly in the future, to devise new processes to efficiently utilize wood and timber resources in the production of renewable bio-energy and bio-products. Timber management research includes specifically the development of models to predict yields, systems to protect forest resources from insect pests, disease, and invasive species; harvest management protocols for optimum regeneration and re-growth; methods to use harvest and processing wastes to efficiently produce bio-energy; programs that respond to research needs and concerns of corporate and private owners and provide economic comparisons among alternative management and harvest methods.

Wood utilization research likewise is focused on hardwoods with a goal of maximizing hardwood timber to lumber throughput, reducing the impact of brown rot fungi; development of non-destructive methods to determine lumber strength and stiffness, expanding uses for Appalachian hardwoods; and devising sawmill systems for moderate sized to small operations. Additional research will develop systems for use at harvest to optimize bucking; develop new uses for low quality hardwoods, use ground penetrating radar to develop non-destructive scanning methods to identify subsurface defects in hardwood logs and incorporate cellulose nanocrystals into biopolymer composites to determine the effect on mechanical properties.

An optimal tree-stem bucking system was developed for central Appalachian hardwood species using 3D modeling techniques to generate log bucking decisions and increase the value of the tree stem. The 3D optimal bucking system for Appalachian hardwood species could increase values from 26-43% per tree stem. The bucking comparison will provide results to analyze how to optimize log bucking.

Stranding variables were adjusted to produce an acceptable strand for OSB production while reducing the fines content, hence improving the yield from logs used to make OSB. Through this research "Increased Use of Low-quality Wood in the Upland Hardwood Region of North America" we have determined that a geometrically desirable strand could be produced from oak species for OSB production. Panels containing various percentages of oak were produced and tested for mechanical properties. Results indicate that oak may be used for OSB production in moderation.

Approximately 100 tons of pulpwood was produced from traditional supply chains in cooperation with five wood products companies in West Virginia to investigate the feasibility of an improved merchandizing program. Currently, over 400 sawlogs have been merchandized from the pulpwood procured from industry cooperators, and resulting lumber yields have been documented. Results from this research showed what characteristics need to be addressed when maximizing returns from pulpwood inventories. The research on improved pulpwood merchandizing has found definite trends in economic feasibility related to the species and characteristics of pulpwood that is merchandized and has shown improved yields during the production of value-added products from merchandized pulp.

Ground Penetrating Radar (GPR) has shown the ability to detect embedded defects in wooden logs and provide information that can be used to develop automated algorithms for orienting the cutting blade for optimal sawing, thus minimizing defects in finished products and increasing their market value tremendously. Significant increase in productivity can be achieved by regulating and coordinating the sawing process through the active control of saw blade's orientation and or the log orientation based on prior knowledge of the interior defects. These yield improvements are in addition to the reduction in waste from conversion of presently discarded logs into lumber.

Cellulose nanocrystals were produced from Avicel, recycled pulp, hardwood dissolving pulp and pine dissolving pulp using three "Green" technologies, sono-chemical-assisted and microwave assisted hydrolysis. Four solvent systems, deionized water, maleic acid, oxalic acid, and endoglucanase enzymes were evaluated. In deionized water, Avicel produced cellulose nanocrystals with average diameter of 21, plus or minus 5 nm (minimum 15 nm and maximum 32 nm). Cellulose nanocrystals from recycled pulp were not distinctively spherical and had an average diameter of 23, plus or minus 4 nm (minimum 14 nm and maximum 32 nm. Only one treatment of maleic acid produced cellulose nanocrystals and only from Avicel. These were cylindrical in shape and were of greater dimensions, length of 65, plus or minus 19 nm and width 15 nm. Cellulose nanocrystals from microwave-assisted hydrolysis of hardwood dissolving pulp and Pine dissolving pulp are currently undergoing characterization. Current commercial nanofillers such as nanoclay are all produced from non-renewable finite resources. A potential alternate nanofiller is cellulose nanocrystals from wood residues. It has the potential of creating a high value product from wood residues.

A regional sawmill support program was developed to help sawmills define their profitability in terms of their standard log grades and to help them benchmark their productivity against their competitors. The regional log and lumber yield initiative has conducted 12 visits in 2007 to 3 hardwood sawmills. Log and lumber characteristics were collected on >750 logs representing 7 hardwood species during these visits. A total of 30 visits have been made through the course of this study and over 2000 logs have been followed through the production process.

Preliminary research demonstrated that veneer clippings can be successfully transformed into composite materials using traditional consolidation and gluing technologies. Furthermore, it was confirmed that mechanical properties of the composites can be engineered by statistical methods. Different matrix materials were used as binders in order to select the best viable combinations. Among them we find the polyurethane foams (PU) as a potential component of the new clipping-based products. In the reported period various PU-veneer prototypes were produced and their mechanical properties analyzed.The successful completion of the project will lead to well defined technological steps for manufacturing novel composite materials both for interior and exterior applications. The obtained results could provide motivation to initiate pilot-manufacture of the proposed products. Additionally, the scheduled analytical works may provide useful information to the composite industry in future development processes. Furthermore, the raw material source for the wood based composite industry will be extended without

increasing logging.

Understanding the underlying factors influencing forest management decisions of a diverse group of private forest landowners could form the basis for developing, modifying and targeting policy instruments to motivate non-industrial landowners in forest management.The main objective of this research is to conduct a comprehensive survey of private landowners in West Virginia to provide information on the different aspects of their behavior related to the management, production and utilization of forest resources and implications on the hardwood resources of the State.

Two sets of surveys have been conducted to date. The first was conducted in 2005 and examined four categories of decisions related to forest management: timber harvest, silvicultural activities (i.e., tree planting, herbicide application, fertilization, thinning, grapevine control, and timber stand improvement), property management activities (i.e., road construction, road maintenance, surveying/boundary maintenance, and access control), and wildlife habitat management and recreation improvement activities. Four models were developed to examine factors affecting each category of forest management activity. The results showed that landowner, ownership, and management characteristics of private landowners are associated with their forest management decisions. Specifically, age, education, profession, income, ownership size, period of forestland acquisition, distance of the forestland to the place of residence, whether the forestland was purchased or acquired through inheritance or as a gift, primary objective of forestland ownership, and presence of a written forest management plan were found to be significant determinants for at least one of the categories of forest management activities. The models explained 25%, 27%, 31%, and 24% of the variation in timber harvesting, silvicultural activities, property management activities, and wildlife habitat management and recreation improvement activities, respectively. The second survey conducted in Fall of 2008 examined landowners participation in West Virginia's Managed Timberland Tax Program. Data entry and analysis is currently on-going.

Atmospheric deposition is thought to impact forest productivity through, among other things, depletion of soil calcium, and deterioration of water quality through increased nitrate leaching to streams. A greater understanding of nutrient release dynamics from organic matter such as leaf litter in the forest floor under conditions of atmospheric deposition and liming with calcium will help determine actual impacts and effectiveness of remediation methods.

A research trial investigating effects of atmospheric deposition and forest management effects on sustainable forest productivity showed that high levels of atmospheric nitrogen deposition decreased nitrogen retention in foliar litter and probably contributes to nitrogen leaching in forests. This study, done in collaboration with the USDA Forest Service, also has implications for phosphorus nutrition in forest trees.

Additionally, this work gave rise to a new approach to determine whether foliar litter can act as a nitrogen-retention mechanism in forests. Results of this study have practical implications in mitigating the effects of atmospheric deposition on forest productivity. A new study begun in August 2007, is analyzing tree biomass changes under nitrogen deposition.Root samples will be collected to determine effects of nitrogen deposition on tree root biomass. This work builds on previous work and will culminate in the development of nutrient budgets for young forests impacted by deposition and treated with lime. An extension of this project was an analysis of stream water chemistry in another forest impacted by atmospheric deposition - in Adirondack Mountains of NY to determine spatial and temporal variation in water-dissolved elements.

In another effort, the pilot study started in fall, 2004 to determine the fate of nitrogen released from leaves decomposing with small woody pieces as a carbon source, has ended.Samples were analyzed with and research results shared in a major forest soils conference, as well, as submitted as a research note to a scientific journal. Through this study, I was able to provide preliminary evidence for the fate of N mineralized from leaf litter. The importance of this finding is in increased understanding of nitrogen cycling in forests.

Maximizing profits during the conversion of hardwood logs into hardwood lumber is a primary concern for sawmill owners. Recently there has been an increase in the competition for hardwood logs in order to meet increasing demands for timber products. It is also critical to use timber resources efficiently because of the trends of increased log costs and limited availability.An optimal sawing system is needed to provide the most efficient method of maximizing the grade and yield of hardwood lumber from saw logs, which is a start to solving these problems. Once information about the shape of a log, and number and position of internal and external defects is obtained by scanning, a suitable sawing strategy is needed to combine the information and determine the optimal sawing pattern.The first cut determines the remaining cuts which must be either parallel or perpendicular to the first cut in the grade sawing method. The key to the sawyer is the ability to combine scanning information and an optimal sawing algorithm to maximize the lumber value and yield. During the production of lumber, the best *open face algorithm* developed can help the sawmill operators to correctly select the first opening face, which is critical to receiving the highest yield lumber from a log. At the same time, the *heuristics log grade sawing algorithm* can determine the greatest lumber value from a given log. An algorithm to determine the best opening face on a hardwood log, using log shape and surface defect data has been developed, which is suitable to grade sawing method. Log grading is obtained by a computer algorithm which is based on grading rules developed by the US Forest Service. A second algorithm based on NHLA grading rules, is nearly complete to grade the sawn lumber.

Additionally, we have developed a software system to implement the algorithms in a 3-D visual simulation environment. When a sawyer selects a log from the database, a 3-D visual log will be generated and displayed in the screen. By clicking the "live sawing" button, the log can be sawn from the best open face. So far, only the live sawing has been simulated. The user can change the sawing factor, such as lumber sizing and kerf width to reproduce lumber at the same log. The generated sawing patterns will be displayed in the 3-D environment. Users can view the lumber either from the small end or the large end of the log by rotating it. The detailed information about all the lumber including lumber dimension, surface measure area, volume, value, and grade is displayed in the designated area of the screen. A hardwood grade sawing algorithm is being developed considering that most sawmills use grade sawing method to produce lumber to date. The program is expected to be

uploaded to a website and accessible to the general public for ease of use and convenience. The system can be used as a decision-making system for hardwood lumber production and training tool for novice sawyers.

A survey of methods employed by university wood science and technology (or related) programs to improve public awareness and understanding of their programs has been developed and is expected to be administered in January. The survey is being conducted in collaboration with the Society of Wood Science and Technology as a project of the Society's Committee on Education.In addition, proposals have been submitted to obtain supplementary funding from external sources to support this line of research. Participation in a National Research Needs Workshop and the 51st Annual Convention of the Society of Wood Science and Technology as the Society's President was part of a larger effort to advance the profession through better articulation of research and educational needs in wood utilization and in advancing better international cooperation within the profession.It is expected that this project will identify positive messages concerning the wood products industry and forest management and test the effectiveness of those messages in improving public perceptions about the industry and its related professions. Promotion of wood science and technology on an international level through the vehicle of the Society of Wood Science and Technology resulted in the Society's first annual convention held outside North America and led to the initial accreditation by SWST of a program outside the United States.

Celastrus orbiculatus (bittersweet) is a deciduous, dioecious round-leaved vine that establishes under closed canopy forest conditions and persists indefinitely until it is released by a disturbance that creates conditions optimal for rapid growth. It invades forested land but has also been known to persist on coasts and may possibly disrupt dune formations. C. orbiculatus can overtop and girdle native trees and shrubs along roads, in clearings and in forest gaps. Identifying and eradicating populations before they are released by an opening in the canopy is the easiest method of control.A study of control methods was conducted in Marion County, West Virginia. The study site is on a property that is approximately eighty eight acres and has an elevation of fifteen hundred feet. The slopes are generally north facing. There are two types of forest covers; cove hardwoods and yellow poplar-red maple.

Four treatments were applied to each of ten individual bittersweet stems. Treatments were randomly applied to selected vines. These treatments were: -Cut/No fence. The cut treatments were applied by cutting bittersweet stems 10cm from the ground using a lopper. -Cut/Deer Fence. Mechanical cut treatment with small fence of four feet tall and four feet in diameter around the individual vines. Each vine was cut at 10cm from the ground. -Basal Bark herbicide. Basal bark application with the lower proportion of the trunk sprayed with Garlon 4 herbicide (Triclopyr). -Cut Stump treated with herbicide. Cut stump application was applied to ten vines 10 cm above the ground with a mixture of 50 percent Round-up (Glyphosate). In addition, six transects were established to illuminate the change in C. orbiculatus abundance from edge to interior forest perpendicular to a powerline right-of-way. The transects started at the ROW forest edge and extended into the forest for fifty meters. At each 5m interval along transect, a variable width strip plot was established to quantify woody stem density of C. orbiculatus. Also at each 5m interval, a light meter was used to determine the percent of light reaching the forest floor. A line intercept sample was used to estimate shrub cover along the transect. Lengths of shrub crowns were recorded along a tape that ran along the transect. A visual estimate of crow spread was taken. Shrub heights were measured with a height pole. Light measurements were made with a light meter attached to the height pole.

Oak wilt (causative agent, *Phytophtora* species) is an aggressive disease that affects many species of oak (*Quercus* spp.). It is one of the most serious tree diseases in the eastern United States, killing thousands of oaks each year in forests, woodlots, and home landscapes.Most significant from on-going research trials was the discovery of the variety of *Phytophthora* species that were present in oak forest soil. Their role now has been better defined because of a series of pathogenicity tests conducted to test the susceptibility of various plant parts (leaves, stems, roots) to infection.Very few of the *Phytophtora* species were pathogenic. The major exception was with the species *P. cinnamomi*. This species was able to cause damage to numerous oak species, American chestnut and some understory shrubs. An extensive soil survey of sites throughout the east and Midwest demonstrated the presence of *P. cinnamomi* below 40N latitude. This finding is significant for growers of Christmas trees and woody ornamentals.

P. cinnamomi also was found associated with sites in Ohio where white oak mortality had been observed. Periods of prolonged drought may have contributed to the damaging role of *P. cinnamomi* at the Ohio sites. These studies have demonstated that temperature and other yet undefined factors may contribute significantly to the pathogenic role P. cinnamomi can play in southern climates but not in the more northern ones. Incidental to much of this research has been the discovery of several new species of *Phytophthora*. One of the most common novel species now formally described is *P. quercetorum*. The research has revealed how limited our knowledge is about forest soil microbes like *Phytophthora* species and the role they play relative to forest tree health.

Outcomes of a research project to restore the American Chestnut have focused on three field-oriented topics. The first is a long-term study designed to initiate biological control of chestnut blight at an American chestnut stand near West Salem, Wisconsin. The study has been in place of 20 years and involves the release of hypoviruses (viruses that reduce the virulence of the chestnut blight fungus) by introducing them into the resident population of Cryphonectria parasitica, the fungus that causes chestnut blight. Annual evaluations of the disease have demonstrated that biological control is possible especially on trees that have been treated with strains that contain hypoviruses. Although some trees in the stand have died, others now display remission from the disease and should survive. Transition from high levels of blight to adequate levels of biological control requires significant time; in this case, more than 20 years. As biological control is achieved, seed production should be restored so that the American chestnut component of the stand can perpetuate itself.

A second topic has involved field testing of transgenic (genetically modified) strains of *Cryphonectria parasitica* to assess whether they can enhance the biological control potential of hypoviruses. The advantage the modified strains bring is their ability to transmit hypoviruses at high levels to asexual spores and also to sexual spores that result when mating occurs. The

experimentation has demonstrated that the transgenic strains can function in the forest by increasing the production of hypovirus-infected inoculum. While this condition should allow for better biological control, additional time will be required to confirm their effectiveness.

A third series of studies is designed to evaluate whether increased disease resistance that has resulted from the American Chestnut Foundation's breeding program can be combined with biological control afforded by utilizing hypoviruses. To this end, numerous chestnut species (American, Chinese, European) and a variety of Chinese X American backcrosses are growing in an orchard setting and will be used to test whether the two approaches to disease control can be combined effectively to manage chestnut blight.

Extracellular production of organic acids such as oxalic acid negatively impacts the inclusion of copper as a biocide in wood preservatives Copper tolerant fungi such as *Antrodia vaillantii* and *Aureobasidum pullulans* produce extracellular proteins in the presence and absence of copper sulfate. However, concentration of extracellular fungal proteins was very low and could not be characterized at the molecular level. Both fungi produced only one type of organic acid – oxalic acid. Production and concentration of oxalic acid varied between the two fungal species.Oxalic acid also precipitated as copper oxalate on fungal mycelia.The copper biocide is sequestered as copper sulfate and is therefore unable to diffuse through wood decay fungal cell wall and unable to inhibit/stop or kill the decay fungi.

2. Brief description of the target audience

Private and corporate commercial producers, managers, consultants, extension educators, regulators, policy makers

V(E). Planned Program (Outputs)

1. Standard output measures

Target for the number of persons (contacts) reached through direct and indirect contact methods

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	**Target**	**Target**	**Target**	**Target**
Plan	0	0	0	0
2008	0	0	0	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year	**Target**
Plan:	0
2008:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

	Extension	**Research**	**Total**
Plan	0	4	
2008	0	8	8

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

Refereed, scientific manuscripts

Year	Target	Actual
2008	4	9

Output #2

Output Measure

Scientific presentations

Year	Target	Actual
2008	6	6

Output #3

Output Measure

Producer workshops & technical assistance

Not reporting on this Output in this Annual Report

V(G). State Defined Outcomes

O No.	Outcome Name
1	Adoption of BMP management and harvesting procedures %
2	Ability to more accurately predict yields of OSB, Paralam and additional wood species from measures on standing timber - new models
3	Development and adoption of field based, computer assisted systems to aid optimal bucking - use %
4	Process for commercial production of a high quality, oak OSB panels
5	Increased use of timber harvest residue. - %

Production Forestry - Timber Management and Wood Utilization

Outcome #1

1. Outcome Measures

Not reporting on this Outcome for this Annual Report

2. Associated Institution Types

3a. Outcome Type:

3b. Quantitative Outcome

Year	Quantitative Target	Actual

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area

V(H). Planned Program (External Factors)

External factors which affected outcomes

Economy

Appropriations changes

Brief Explanation

V(I). Planned Program (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

Before-After (before and after program)

During (during program)

Evaluation Results

Key Items of Evaluation