TITLE: Assessment of Butternut Health on Public and Private Lands in the Eastern United States

LOCATIONS: New England, New York, Georgia, Tennessee, and North Carolina

DURATION: THREE YEARS FUNDING SOURCE: BASE (EM)

FUNDING REQUEST: YEAR 2 OF 2 FUNDING

PROJECT LEADERS:

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OVERALL OBJECTIVE: Assess the health of butternut in the eastern United States

SPECIFIC PROJECT OBJECTIVES BY PI:

1. Assess butternut canker disease incidence and severity (VT& TN PI's).
2. Assess and monitor mortality of butternut due to butternut canker disease (VT).
3. Locate and monitor healthy butternut trees for potential genetic studies (VT & TN).
4. Develop and test a GIS-based predictive model for selected National Forests to determine habitat characteristics of butternut (TN).
5. Conduct analyses to determine if disease severity is associated with specific site/environmental conditions (VT & TN).

JUSTIFICATION: The butternut canker fungus (*Sirococcus clavigignenti-juglandacearum* Nair, Kostichka, and Kuntz) (SCJ) is believed to be an exotic pathogen that has had a serious biological, ecological, and economic impact on butternut (*Juglans cinerea*) throughout its range in eastern North America during the past 30+ years. Forest inventory data for North Carolina and Virginia indicate that butternut canker disease is the most likely cause of the 77% decrease in number of butternut trees inventoried between 1966 and 1986. A limited Wisconsin survey revealed that 91% of the live butternut trees were diseased and 27% of the total population was dead in 1993. The USFS has established butternut management and harvesting guidelines, and recently, the federal government placed butternut on their "sensitive species list" due to the impact of this exotic pathogen.

In the Northeast (NE), limited information is available on the health status of butternut. However, in Vermont (1993-96), a total of 1317 living butternut trees were evaluated on 18 permanent plots, and 94% of the trees examined were cankered, with incidence ranging from 68 to 100% among sites. Initial severity ratings also varied among sites, but initial mortality levels were quite low except for those sites with high severity ratings where mortality approached 25%. Only 6% of the trees appeared healthy and of these less than one-third have been designated as candidates for grafting and future genetic work. This selection process has been in cooperation with Dr. Mike Ostry (USDA FS, St. Paul, MN).

DESCRIPTION:

a. Background: The incidence, severity, and rate of mortality of butternut due to infection by SCJ have not been adequately assessed. Butternut is not significantly represented in the national forest health-monitoring (FHM) network of plots, but where the species occurred in 1991, there appears to have been significant mortality by year 2000 (Butternut FHM plot data, C. Barnett, USDA FS). Therefore, our proposed butternut assessment will provide a significant amount of new information on the health status of this "sensitive species" and will significantly complement FHM detection and monitoring efforts on both public and private lands throughout the Eastern region. This study also will provide a more accurate assessment of butternut health on different sites including riparian zones, which is quite limited in FHM and FIA datasets. Following our previous inventory and assessment of butternut, we intend to expand our study to include the rest of New England, New York, Georgia, Tennessee and North Carolina, which will significantly add more trees and sites to our existing database and thereby provide for a more accurate assessment of butternut health in the region.

b. Methods: Our previous assessment methods can be used to assess and monitor changes in butternut health throughout its range. All inventoried trees (standing living and dead, and dead and down) will be numbered and GPS locations recorded to provide a GIS database designed for long-term evaluation and monitoring efforts. Individual tree data will include basic forestry measurements such as DBH, crown class, crown diameter, etc. as well as a health assessment. This health assessment will evaluate crown condition (dieback, density, and transparency per FHM guidelines), epicormic branching, root health (cankering and root rot), stem health (number of cankers, heart rot, etc). All data will be compiled and analyzed to assess variations in incidence, severity, and mortality of butternut on different sites or as influenced by environmental conditions.

GIS data sets will include information on soils, moisture relationships, site geology, land use/cover, various topographic layers, etc. These layers will be used to determine habitat conditions for butternut. Butternut locations and habitat conditions will then be used to calculate the Mahalanobios distance statistic as an index of butternut habitat suitability. This habitat suitability model will be tested using a bootstrapping technique that predicts distance values for butternut locations. A multivariate regression model will be used to determine the relationship between health conditions and habitat characteristics.

This cooperative study will expand assessment of butternut to include trees on both public and private lands throughout the eastern range of this species in the US. Our State cooperators will assist in locating butternut trees for intensive survey on both public and private lands. Federal cooperators will assist with locations on Federal lands and will participate in data assessment.

c. Products: The above project objectives are designed to establish and maintain a GPS/GIS database that will enable us to monitor and reassess the health status of butternut over time. New information from this study will help to better understand the threat this exotic pathogen poses to butternut and will support development of new butternut management guidelines for this "sensitive species." The location of disease-resistant trees will be noted and the information sent to our cooperators and Drs. Ostry (northern states) or Schlarbaum (southern states) for inclusion in breeding programs and future restoration efforts. Also, this study will provide valuable information on severity of butternut canker disease for different sites and will form a basis to assess site conditions relative to potential impact on butternut health.

Results of this research will be published in a regular and timely manner as research abstracts, proceedings papers, and/or in peer-reviewed manuscripts as well as presented to the Forest Health Monitoring Workshop as a poster. Presentations at the Northeastern Forest Pathology Workshop, and Northeastern Division of the American Phytopathological Society and selected forest health and ecological meetings in the South are planned. In addition, these butternut data will be offered for inclusion in a Forest Health Monitoring program database.

d. Schedule of Activities (VT):

Year 1: Work with state cooperators to establish potential sampling locations. Train field personnel and establish data management system. Begin site visits and field sampling (initial) /data entry/management/assessment/quality assurance. Progress report/FHM workshop poster (2008)

Year 2: Continue field sampling (extensive). Data entry/management/assessment/quality assurance Final report/FHM workshop poster/publications/other technology transfer activities including development of a discussion session for all cooperators and other interested personnel.

Schedule of Activities (TN):

Year 1: Compile butternut locations and generate predictive models based on known locations. Train field personnel for field assessment, establish data management system and begin field assessment based on predictive models. Data entry/management/assessment/quality assurance. Graft putative resistant butternuts. Progress report/FHM workshop poster.

Year 2: Continue field assessment. Data entry/management/assessment/quality assurance. Test whether tree health is influenced by habitat conditions. Determine potential butternut restoration sites. Graft putative resistant butternuts. Final report/FHM workshop poster/publications/other technology transfer activities.

e. Attachments: Progress Report/Previous Accomplishments/List of Cooperators/Request for Additional Funds : See Attached

COSTS: (Vermont PI)

	Item	Requested FHM EM Funding	Other Source Funding	Source
YEAR (1 of 2) APPROVED (In Progress)				
Administration	Salaries	42,200	In-kind	Cooperators/Plant Technologies
	Travel	7,000	In-kind	Cooperators
Procurement	Operating	5,200		
Total Direct Costs (yr 1 of 2)		54,400		
Cost Share by Applicant (20%)			13,660	
YEAR (2 of 2) REQUESTED				
Administration	Salaries	45,522	In-kind	Cooperators/Plant Technologies
	Travel	9,000	In-kind	Cooperators
Procurement	Operating	4,200		
Total Direct Costs (yr 2 of 2)		$57,722		
Cost Share by Applicant (50%)			$57,722	
**Request for Additional Funding		8,000		** See Reason for request (Attached)
Additional Cost Share by Applicant			8,000	
		$65,722	$65,722	

Costs: (Tennessee PI)

	Item	Requested FHM EM Funding	Other Source Funding	Source
Year (1 of 2) APPROVED (In Progress)				
Administration	Salaries	17,500	In-kind	UT
	Fringe	5,950*		
	Travel	10,000	In-kind	UT
Procurement	Operating	7,000		
	Indirect	7,079**		
Totals (yr 1 of 2)		47,519	+ 20%	Coop Match UT
Year (2 of 2) REQUESTED				
Administration	Salaries	17,500	In-kind	UT
	Fringe	5,950*		
	Travel	5,000	In-kind	UT
Procurement	Operating	5,000		
	Indirect	5,854**		
Totals (yr 2 of 2)		39,304	+ 50%	Coop Match UT

* Overhead = Fringe

**Indirect costs @ 17.5% (May be negotiated with UT as match)

Project end date: April 30, 2009

Attachments:

Progress Report (2007)

Project Title: ASSESSMENT OF BUTERNUT HEALTH ON PUBLIC AND PRIVATE LANDS IN THE EASTERN UNITED STATES

Date: September 27, 2007

Award Number: 06-CA-11244225-307

Project Period: May 1, 2006 – April 30, 2009

Reporting Period: May 1, 2006 – September 27, 2007

Recipient Contact Person: Dale R. Bergdahl

Principal Investigator: Dale R. Bergdahl
Plant Technologies

Co-Investigator: Scott E. Schlarbaum
University of Tennessee

Progress Achieved in Accomplishing Project Goals and Objectives:

Plant Technologies

Progress Report (2007)

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Introduction

The butternut canker fungus (*Sirococcus clavigignenti-juglandacearum* Nair, Kostichka, and Kuntz) is believed to be an exotic pathogen that has had a serious biological, ecological, and economic impact on butternut (*Juglans cinerea*) throughout its range in eastern North America during the past 30+ years. Forest inventory data for North Carolina and Virginia indicate that butternut canker disease is the most likely cause of the 77% decrease in number of butternut trees inventoried between 1966 and 1986. A limited Wisconsin survey revealed that 91% of the live butternut trees were diseased and 27% of the total population was dead

in 1993. The USFS has established butternut management and harvesting guidelines, and recently, the federal government placed butternut on their "sensitive species list" due to the impact of this exotic pathogen. Canada has listed butternut as an endangered species.

In the Northeast (NE), limited information is available on the health status of butternut. However, in Vermont (1993-96), a total of 1317 living butternut trees were evaluated on 18 permanent plots, and 94% of the trees examined were cankered, with incidence ranging from 68 to 100% among sites. Initial severity ratings also varied among sites, but initial mortality levels were quite low except for those sites with high severity ratings where mortality approached 25%. Only 6% of the trees appeared healthy and of these less than one-third have been designated as candidates for grafting and future genetics work.

The incidence, severity, and rate of mortality of butternut due to infection by SCJ have not been adequately assessed. Butternut is not significantly represented in the national forest health-monitoring (FHM) network of plots, but where the species occurred in 1991, there appears to have been significant mortality by year 2000 (Butternut FHM plot data, C. Barnett, USDA FS). Therefore, this butternut assessment is designed to provide a significant amount of new information on the health status of this "sensitive species" and will significantly complement FHM detection and monitoring efforts on both public and private lands throughout the Eastern region. This study also provides a more accurate assessment of butternut health on different sites including riparian zones, which is quite limited in FHM and FIA datasets. This study is intended to expand our previous assessment work to include the rest of New England, New York, Georgia, Tennessee and North Carolina, which will significantly add more trees and sites to our existing database and thereby provide for a more accurate assessment of butternut health in the region. Also, this study is identifying potential candidate trees for future genetics work and possible restoration efforts.

Progress to Date:

The initial startup of this project was delayed due to Federal funding issues until late August 2006 (start date: May 1, 2006). However, progress has been achieved in preparation for and the activities associated with actual field data collection and data management systems. In addition, my previous Forest Service Cooperator (C. Ash) resigned her position in fall 2006. This resignation left me without her cooperative efforts (see Coop Agreement for details). As a result, I carried out the coop activities of identifying potential site locations for assessment this year, which resulted in some delay in field data collection as it required more office time on my part. However, field data collection is now on track as we have completed assessments in most of Maine and all of northern New Hampshire (See results below). Recently, late summer 2007, M. Miller-Weeks was assigned duties associated with this coop agreement.

Since butternut is a relatively rare species, especially in certain areas, the identification of potential sites for assessment is very important to the overall success of this project. For the most part, our state cooperators (ME, NH, RI, MA, CT& NY) have been helpful in identifying potential butternut sites for assessment. However, both MA and RI recently indicated that they know of **NO** butternut locations in forested areas and only report a few yard trees in community settings. Therefore, I have been contacting consulting foresters, arborists, USFS ecologists & wildlife biologists, Northern Nut Growers Association members, Native American groups, USDA Soil Conservation Service personnel, state park personnel, TNC, eco–reserves, private individuals, and other land management agencies, etc., in an effort to locate suitable sites to assess.

Various newspapers and magazines in the NE (including Canada) have published articles on our butternut research following the New York Times article last November. Also, I have been interviewed for several radio and TV offerings by stations in the area. These articles and interviews resulted in many inquiries about our butternut work and have provided some additional sites for assessment. These additional contacts, while time consuming, have been successful in locating butternut sites for this study. Site visits are in progress and they will continue throughout this fall and will begin again in spring 2008 (pending continued funding).

Our field data collection and data management systems are established. All sites are being mapped and GPS location data taken. Potential candidate trees for future genetics/grafting/restoration work are being identified and mapped (see note below table).

In May 2006, the Canadian Forest Service contacted me about coordinating a similar study in eastern Canada using our survey techniques. I have instructed them in our survey methods. They will be responsible for their survey efforts but will be willing to share their field data and GPS/GIS information with us. This additional information will provide us with a more complete understanding of the health of the butternut resource throughout North America.

In July 2007, I conducted a 2 day field training session on butternut health assessment for Paul Berrang (USFS, Regional Forest Geneticist), and Green Mountain National Forest personnel. They are interested is initiating a butternut restoration project for the forest. Also, I have been asked to conduct a similar training session (possibly next spring) for State of Vermont Forest Protection personnel as they wish to work cooperatively with efforts on the GMNF.

The following is a list of invited presentations at various meetings in the NE:

Butternut workshop and seminar, Ottawa, Ontario, Canada. May 2006
Butternut symposium, Niagara Falls, Ontario, Canada. October 2006
Butternut meeting w/Murray Carpenter, NY Times reporter, November 2006
Butternut field trip, NED APS meeting, Burlington, VT, November 2006
Butternut field meeting w/local TV Station, December, 2006
Butternut symposium, NESAF/NEFPC meeting, Fairlee, VT, March 2007
Butternut discussion, NEFPW, Matamoras, PA, May 2007
Butternut lecture, GMNF, Rochester, VT, July 2007
Butternut lecture, CT Ag. Exp. Stn. New Haven, CT, upcoming (Oct, 2007)

The following table is a listing of our butternut tree assessments to date: This is just a brief overview as all field data are not in a computerized data base at this time.

State	# Trees	# Dead	% Dead	# Candidate trees*
ME	**308**	**90**	**28%**	**25***
NH	**271**	**74**	**27%**	**41***
Totals	**579**	**164**	**28%**	**66***

***Candidate trees:**

Most trees assessed as potential candidate trees in the field were found in areas nearer the coast of Maine and New Hampshire. They appear to be butternut or at the very least butternut like. They were all located in areas where butternut canker was present. On one of the sites in NH, the land owner (about 80 yrs old) thought that her parents had planted some Japanese walnuts on the farmstead many years ago. Some trees in that area were quite large and appeared healthy but others were severely diseased. In other areas where trees were severely cankered, we would occasionally find healthy appearing trees or trees that may have had a couple of cankers or healed cankers. These trees have been exposed to intense inoculum pressure but appear to have stood the test of time. I consider these trees to be good candidates. However, in my opinion, only DNA analysis will eventually answer the true identity of these healthy appearing “candidate” trees.

Nut Production:

In all areas surveyed, there was **NO** nut production this year. However, there was evidence of nut production in the past as nut shells were present around the healthiest appearing trees in an area. All nut shells appeared to be butternut-like. It appears that trees that have significant crown (major limb) dieback have lost

their ability to reproduce. Therefore, once this crown mortality happens their only means of regeneration will be via stump sprouts. We did observe some stump sprouting but many of those sprouts were already infected and many were dead.

Data Analysis:

A more through data analysis will be completed at the end of this field season (2007). These data will be summarized and presented in a poster format at the upcoming FHM meeting in 2008.

Problems Encountered:

The main problem encountered to date is associated with finding butternut sites to assess. Our state cooperators have been helpful but we need to be able to access more information about potential locations. Therefore, we need to obtain locations from a variety of land management personnel as outlined above. This takes time but has been a good option for finding additional butternut sites. Also, this past year (November- August) this project was without the Forest Service cooperator and as a result this project required more of my time for office activities. Hopefully, M. Miller-Weeks can now provide some additional assistance in the location of potential study sites.

University of Tennessee

Progress Report (2007)

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INTRODUCTION

The butternut canker fungus (*Sirococcus clavigignenti-juglandacearum* Nair, Kostichka, and Kuntz) is believed to be an exotic pathogen that has had a serious biological, ecological, and economic impact on butternut (*Juglans cinerea*) throughout its range in eastern North America during the past 30+ years. Forest inventory data for North Carolina and Virginia indicate that butternut canker disease is the most likely cause of the 77% decrease in number of butternut trees inventoried between 1966 and 1986. A limited Wisconsin survey revealed that 91% of the live butternut trees were diseased and 27% of the total population was dead in 1993. The USFS has established butternut management and harvesting guidelines, and recently, the federal government placed butternut on their "sensitive species list" due to the impact of this exotic pathogen.

Species restoration will rely on finding butternut trees with putative resistance to incorporate into breeding programs. Forest Inventory and Analysis data indicate that butternut makes up less than 0.5 percent of the trees in the South, however independent surveys have found patchy areas with large numbers of butternut trees. A proven approach to locate surviving butternut trees within the national forests is by using multivariate statistical techniques and geographic information system (GIS) technology. The University of Tennessee's Tree Improvement Program has developed successful habitat models for the Great Smoky Mountains National Park, Mammoth Cave National Park, and the St. Francis National Forest. In addition, the GIS approach can also be used to determine if certain environmental influences may provide more favorable conditions for the fungus (as has been documented for dogwood anthracnose), causing the disease to be more severe in particular areas. However, no known studies have examined the environmental influences on the severity of butternut canker disease. Such knowledge would be crucial for restoration efforts.

METHODS

Habitat Modeling

We compiled a database of butternut locations (n = 134) from Great Smoky Mountains National Park in Tennessee and North Carolina. Habitat conditions for those butternut locations were characterized using 10 different habitat layers (e.g., slope, aspect, distance to streams). The resolution of the data layers was 90 m, and the extent included Great Smoky Mountains National Park and the Cherokee, Pisgah, Nantahala, and Chattahoochee National Forests.

We calculated a multivariate statistic, Mahalanobis distance, to generate a habitat model. Mahalanobis distance, or D^2, is a measure of dissimilarity. We used this statistic as an index of habitat

suitability by comparing habitat conditions with those of the 134 butternut locations. The D^2 statistic was calculated for each pixel in the study area by combining information from each of the chosen variables based on the following equation:

$$D^2 = (\underline{x} - \underline{\hat{u}}), \hat{\Sigma}^{-1}(\underline{x} - \underline{\hat{u}}),$$

where $\underline{x}$ is a vector of habitat characteristics for each cell in the GIS grid, $\underline{\hat{u}}$ is the mean vector of habitat characteristics of the 134 butternut locations, and $\hat{\sum}^{-1}$ is the inverse of the variance-covariance matrix, also from the 134 butternut locations. The Mahalanobis distance statistic represents the standard squared distance between a set of sample variates, $\underline{x}$, and "ideal" habitat represented by $\underline{\hat{u}}$. Smaller values indicate conditions similar to those of the original sampling locations, whereas larger values represent increasingly dissimilar conditions.

Field Sampling

We arbitrarily chose Mahalanobis distance values <10 to identify important habitats within the 4 National Forests. One thousand points were randomly generated within those important habitats to develop search plots for butternut. Each search plot consisted of the 90-m pixel corresponding to the random point plus all surrounding 90-m pixels, creating a search radius of 135 m.

Field crews were instructed to visit each plot center and then to make several passes throughout the plot to ensure the entire area was covered. All trees that fell in plots were recorded. Additionally, we instructed field crews to record incidental locations of butternut (butternut trees that did not fall in plots) to maximize our sample size.

If butternut was present, we collected coordinates of the tree with a GPS receiver and collected information on tree height, diameter at breast height (DBH), and height at first life branch. Additionally, we collected information on tree health, including crown condition (dieback, density, and transparency per FHM guidelines), and cankers (per butternut canker classification system).

PRELIMINARY RESULTS

To date, field searches have only occurred in the north sections of the Cherokee and Pisgah National Forests, but field crews will begin searching the southern sections, as well as the Nantahala and Chattahoochee National Forests this fall. Currently, we have collected 120 new butternut locations (111 living). Fifty-one of those trees were collected in the Cherokee National forest and the remaining 69 were collected in the Pisgah National Forest. The average disease severity (based on the butternut classification system) was 2.14 with 10 being the most severe. The mean tree height, DBH, height to first live branch, crown diameter, and the crown condition measurements are summarized in Table 1.

Some trees were found to have canker-free boles. These trees will be candidates for grafting into a breeding orchard at the East Tennessee Research and Education Center, Plant Sciences Farm Unit and for seed collection to establish resistance tests under heavily infected trees and for silvicultural tests to define critical parameters for butternut reintroduction. A seed crop was observed on certain trees, and collections will be made in September and October. The resulting seed will be planted at the Georgia State Nursery and grown for one year, with out-plantings established in 2009.

Table 1. Measurements collected from the 120 butternut trees located in the north sections of the Cherokee and Pisgah National Forests, 2007.

Measurement	$\bar{x}$	***SD***
DBH	30.78	13.05
Tree height	16.68	6.20
Height to first live branch	5.25	3.74
Crown diameter	9.65	3.59
Percent crown dieback	19.18	22.52
Percent crown density	70.78	18.41
Percent foliage transparency	2.24	19.72
Crown position	2.24	0.46
Crown light exposure	2.90	1.05
No. of major cankers (>5 in) on main stem	4.90	2.87
Butternut rating	2.16	1.04

Previous Accomplishments

Vermont PI: Previous Accomplishments (2005): FHM butternut pilot study

The butternut canker fungus (*Sirococcus clavigignenti-juglandacearum* Nair, Kostichka, and Kuntz) (SCJ) is believed to be an exotic pathogen that is having a serious impact on butternut (*Juglans cinerea*) health throughout Vermont. The following is a brief summary of progress to-date on our current project (2002-04) titled: Assessment of the rate of progression of butternut canker disease. The initial phase of this project was designed to reassess incidence, severity, and mortality of all 1300+ butternut trees located on 18 permanent plots originally established in 1993-96. The latter phase (2003-05) was expanded to add plots to include all counties throughout Vermont. In 1993-96 we found that butternut trees generally grow on both upland and riparian sites in small groups rather than as scattered, individual trees. These trees had an average DBH of about 15 inches. We also found a high degree of cankering (90+%) and tree mortality that averaged about 12% (range 0-26%). Also, regeneration (seedlings, saplings) for all practical purposes, was lacking which is probably due to extensive crown dieback and therefore reduced seed production. Results from our reassessment of permanent plots indicated that while incidence had not substantially changed, severity had significantly increased. In general, crown ratios and crown densities have decreased, and crown transparency has stayed the same; however, crown dieback has substantially increased since the early assessment. Also, *Armillaria* and other root rots as well as evidence of heart rots and other forms of stem decay, had substantially increased since the initial inventory. Mortality levels are now at 40+% and we believe that this high rate of mortality (an increase of 30+% in 8+ years) is highly significant and an indication of how rapidly we are losing this tree species.

During the latter phase of this project, we expanded the survey and assessment to include trees growing on both upland and riparian sites throughout Vermont. This has resulted in the assessment of 944 additional trees to-date from 13 of 14 counties in Vermont. Only Grand Isle County is missing as this area is mostly agricultural and butternut trees are rare; however, when found they are usually diseased and in various stages of decline. In 2003-04, tree mortality rates (standing dead trees only) ranged from 15.7% (Lamoille Co.) to 67.1 % (Caladonia Co) with a statewide average of 45.9%. In addition, dead and down trees were also noted in all counties but not tallied as part of this assessment. Both stem cankering and percentage of stem girdling appeared higher for riparian sites, but mortality levels were higher for upland sites. This higher mortality level for upland sites may be explained by the higher incidence of *Armillaria* and other root rots on these sites.

The above abstract only highlights some of our progress to-date on this butternut assessment project. A more detailed final report is in preparation and will include a Master's Thesis that focused on the reassessment portion of this project. Upon completion of the final report, a poster will be prepared for presentation at the annual FHM meeting this coming year.

The following NEDAPS abstract was published in Phytopathology following presentation at the annual meeting of the Northeastern Division of the American Phytopathological Society (October 2005).

Impact of *Sirococcus clavigignenti-juglandacearum* on health of butternut. T. Schmalz and D.R. BERGDAHL. University of Vermont, Burlington, VT 05405.

Butternut canker, caused by *Sirococcus clavigignenti-juglandacearum* (SCJ), results in extensive decline and mortality of butternut (*Juglans cinerea*) throughout its range in North America. On permanent plots in northern Vermont, SCJ infection and butternut mortality rates were 92% and 12%, respectively (1993-1996). Reduced crown vigor and secondary pathogens, especially *Armillaria* sp., were associated with SCJ infection. In 2001-02, SCJ infections increased to 96% and tree mortality to 41%. When examined in 2002, trees that exhibited main stem or root cankering in 1996 were more likely to be dead and have *Armillaria* root rot and increased epicormic branching compared to uninfected trees, especially in understocked stands. Suppressed trees were most likely to die, and dominant trees had highest rates of *Armillaria* root rot, other root rots, and heart/trunk rots. Logistic regression models found mortality was significantly associated with canker presence, root rots, crown class, and stocking level ($P < 0.05$). Butternut canker plays a significant role in increased mortality, occurrence of secondary pathogens, and reduced overall health of trees.

Our final project report in the form of a poster was submitted after the project end date (extended to: 9/30/05).

Tennessee PI: Previous accomplishments and related studies at the University of Tennessee

The University of Tennessee's Tree Improvement Program (UT-TIP) has dedicated a substantial amount of effort working with cooperators to restore butternut to the forests in an efficient manner. Study areas include: genetics, ecology, pathology, and dendroecology. Researchers have taken a landscape approach to successfully delineate butternut habitat in the Great Smoky Mountains National Park (van Manen *et al.* 2002) and identify potential butternut restoration sites in Mammoth Cave National Park (Thompson *et al*., In press). The UT-TIP is also in the process of refining and developing GIS-based models to define ideal habitat conditions in various National Forests and multiple National Parks. Since 1993, surveys for surviving butternuts have been conducted on state, federal and private lands in Tennessee, North Carolina, Georgia, and other southern states. These surveys have produced a large data base that can be used for modeling and other studies. In addition to the spatial modeling approach, researchers have worked to develop a butternut canker classification system, which consists of a scoring procedure, to assess the severity of butternut canker disease. Also, researchers are using FHM guidelines for determining crown condition, so that impacts that may or may not be related to butternut canker disease can be assessed.

A paper on the use of GIS-predictive models for locating butternuts on the St. Francis National Forest will be submitted before the end of 2007. Manuscripts on several National Parks are currently being prepared for submission to refereed journals. Butternut plants in gaps and small openings on North Carolina National Forests and the Cherokee National Forest are being evaluated for growth and survival to determine light/site requirements. Resistant tests under diseased trees also continue to be evaluated for survival and number of cankers per stem. These results will be discussed at the forthcoming U. S. – Canadian Butternut Workshop in October.

Thompson, L. M., F. T. van Manen, S. E. Schlarbaum, and M. DePoy. 2005. A Spatial Modeling Approach to Identify Potential Butternut Restoration Sites in Mammoth Cave National Park. Restoration Ecology 00:00-00. (*In* press).

van Manen, F. T., J. D. Clark, S. E. Schlarbaum, K. Johnson, and G. Taylor. 2002. A model to predict the occurrence of surviving butternut trees in the southern Blue Ridge Mountains. Pages 491–497 *in* J. M. Scott, P. J. Heglund, and M. L. Morrison, editors. Symposium on predicting species occurrences: issues of scale and accuracy. Island Press, Covelo, California.

FOREST HEALTH COOPERATORS – 7 STATE AREA-NEW ENGLAND AND SOUTHERN REGION

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Request for additional funding Year 2 of 2 (D. R. Bergdahl)

Justification: I am requesting an additional $8,000 to the previous budget submitted for year 2 of 2. This increase is primarily do the additional time I needed to spend locating potential butternut sites for assessment. This phase of the project was primarily the responsibility of the Forest Service Cooperator (C. Ash) but upon her departure last November this work was left to be done. It is my understanding that M. Miller-Weeks (S&PF) has recently (August) been assigned to this project and will help fill that void in the future. However, because of this delay, I have had to spend time in the office doing the location work rather time in the field doing assessments which means that I will need to spend additional time to catch up on my planned and budgeted activities. All funds will be used for field assessment activities excluding travel expenses. An additional amount of $8000 will be cost-shared by the PI.