FHP TECHNOLOGY DEVELOPMENT PROJECT PROPOSAL
Use for projects not previously funded.

PROJECT STATUS: New, not previously funded.

PROJECT NUMBER: NA-2000-04

PROJECT TITLE: Development of guidelines and a model system to facilitate placement of barrier control lines for oak wilt.

SUBJECT: Forest Disease Management, Disease Modeling, *Ceratocystis fagacearum*

PROJECT OBJECTIVE(S): The project objective is to develop an optimal working model (or models) and guidelines for oak wilt barrier placement that will be useful for locations throughout the entire Midwest, regardless of soil type.

BRIEF DESCRIPTION OF PROJECT: Several studies have attempted to model the behavior of the oak wilt pathogen in regard to disease transmission through root grafts, with a resulting variety of equations for predicting the spread of oak wilt on a particular soil type, or within a particular stand (e.g., Appel et al. 1989; Bruhn et al. 1991; Himelick and Fox 1961; Menges and Kuntz 1985). However, none of these studies has examined the operational effectiveness of vibratory plow lines placed by contractors who routinely do this kind of work, and thus fail to address critical questions regarding the practical usefulness of these models.

We propose that examining the effectiveness of such barriers made during the past five years can make significant improvements in the placement of root graft barriers. We further propose the development of a model that would explain the success or failure of these barriers. Expected improvements in barrier placement would save trees that would be needlessly sacrificed under existing models, would minimize "skips" of the disease past the established barriers, and would thus help to ensure that the placement of root graft barriers is optimal.

The questions that will be answered include:

1. What is the theoretical rate of tree-to-tree spread of the oak wilt pathogen in various soil types encountered in the active oak wilt region of the Upper Midwest?

2. How effective are the current methods for establishing root graft barriers (usually simply the vibratory plow operator's judgment), and what could be gained by using a specific model for establishing these barriers (see question 3, below)? This portion of the study would extend preliminary information developed by the St. Paul Field Office, and provide data for the development of an effective model for the placement of root graft barriers.

3. Using existing or proposed models of oak wilt spread, what is the extent and distribution of tree mortality that can be expected using different guidelines for establishing root graft barriers?

FHP LEAD CONTACT (FHP person submitting the proposal): Joseph G. O'Brien, Plant Pathologist

PRINCIPAL INVESTIGATOR(S) and their AFFILIATION (person leading the project):

Co-Principal Investigators:

Dr. Gary Johnson, Associate Professor of urban forestry, University of Minnesota
Dr. Joseph G. O'Brien, Plant Pathologist, Northeastern Area S&PF, St. Paul, MN

COOPERATOR(S) (person contributing to the project but not leading):

Graham Mahal, graduate student, University of Minnesota
Dr. Jennifer Juzwik, Research Plant Pathologist, North Central Research Station, USDA Forest Service, St. Paul MN

Dr. Tom Skalbeck, Entomologist, USDA Forest Service, North Central Research Station, USDA Forest Service, St. Paul MN
Ron McRoberts, Statistician, USDA Forest Service, North Central Research Station, USDA Forest Service, St. Paul MN
Rose Ingram, Silviculturist, USDA Forest Service, Huron Manistee National Forest
Roger Mech, Entomologist, Michigan DNR
Steve Kunde, Professional Arborist, St. Paul, MN
Steve Cook, Professional Arborist, St. Paul, MN
Minnesota Dept. of Transportation
Hennepin County Parks Commission, Hennepin County, MN

JUSTIFICATION: How will the proposed project strengthen FHP program delivery/capability? What is the potential advantage over existing technology?

Oak wilt is the most serious disease of red oak species in the eastern United States. Observations by state and federal forest health professionals in the Midwest suggest that oak wilt is a growing problem in this region, with new infection centers occurring much more frequently than in the past. Currently, the best control measure for oak wilt is using a vibratory plow or trencher to interrupt the connected root systems of trees that are grafted together, but good information regarding effectiveness is lacking.

The proposed technology development project would take into account the limitations inherent in establishing oak wilt barriers in operational control efforts, and would provide valuable guidelines and models for agencies, communities and landowners seeking to control oak wilt through the use of root graph disruption techniques. Currently, oak wilt control with vibratory plow lines is achieved by guesswork on the part of the contractor, or by using models developed for very specific sites or soil types. There is a strong need for a relatively simple model that would allow quick and efficient placement of control lines, taking into account those factors necessary to achieve an acceptable level of control, without sacrificing trees needlessly.

URGENCY: Briefly explain. Does the project address a crisis situation? Would delay result in irreversible loss? If this project is not done now, what will be lost?

Oak wilt is a disease that appears to be increasing in importance in the Midwest, perhaps meeting the definition of a "crisis," as new infection centers are arising with increasing frequency. Without the models and guidelines that will be products of this project, we expect that many oak trees will be needlessly sacrificed, as a result of overly conservative placement of control lines, as well as control line failures ("skips") caused by placement too close to the infected trees.

In addition, there are currently too few contractors to provide the needed control measures (using vibratory plows) and those currently engaged in using this equipment have few guidelines (other than their personal experience) to ensure that they are placing the control lines properly. We anticipate that in the future, more contractors will be offering vibratory plowing for oak wilt control, and will benefit from the existence of guidelines for control line placement.

LINK TO NATIONAL FHP TECHNOLOGY DEVELOPMENT PRIORITIES: Does the project address a national steering or technical committee priority? Briefly explain.

This project directly and specifically addresses the second of the national priorities listed in the call letter, regarding development of guidelines that integrate silvicultural procedures…to reduce the adverse impacts of insects and diseases. There is some controversy over the status of *Ceratocystis fagacearum* as a native or non-native organism, which also affects the applicability of this proposal to national priority #4, regarding non-native pests.

Although still subject to debate, the preponderance of evidence suggests that *C. fagacearum* is a native pathogen, but it behaves (epidemiologically and symptomatically) much like an exotic pest on red oak species. In addition, the fungus has either greatly extended its range over the past 50 years, or has become much more important as urban expansion has encroached upon relatively undisturbed oak forests in the eastern United States.

SCOPE OF APPLICATION: How widely are the results of the project likely to be applied - geographic area, range of pests, length of time.

The results from this project are expected to be applicable, for an extended, indefinite period, to much of the eastern United States, but will be most useful in the Lake States region, and in the tier of states just south, including Michigan, Wisconsin, Minnesota, Iowa, Illinois, Indiana, Ohio, and Missouri.

RESEARCH BASIS: Briefly explain the strength of the research basis for this proposed technology development project? Provide any publication citations.

Several studies have attempted to model the behavior of the oak wilt pathogen in regard to transmission of disease through root grafts, resulting in a variety of equations for predicting the spread of oak wilt within a stand (Appel et al. 1989; Bruhn et al. 1991; Himelick and Fox 1961; Menges and Loucks, 1984; Menges and Kuntz 1985).

Over one million feet of root graft barrier, as the vibratory plow lines are called, have been established since 1992 in the Minneapolis/St. Paul area alone. Most of these lines have been established by contractors who own the proper equipment, or by communities that have pooled resources to purchase a vibratory plow. In all cases, the intuition and accumulated experience of the plow operators has determined the placement of these barrier lines. This is partly because the models developed for barrier placement originated in other states and on different soil types, and partly because of the widespread view that the models are overly conservative in the recommendations for barrier placement. Excessively conservative line placement may sacrifice trees that have a low probability of becoming infected in the year after barrier placement, and which would have been protected by the placement of a line proximal to the nearest infected tree. Placing barrier lines too far from the infection center may actually promote “skips” or failures of the line to contain the disease within the treated area. This is because root grafts can become reestablished across the barrier over time. If the spread of disease to the barrier (through sacrificed trees inside the barrier line) is sufficiently slow, root grafts may become reestablished before the fungus actually reaches the barrier line.

Complicating any assessment of the effectiveness of barrier line placement is the common practice of establishing two barrier lines: the closest to the existing infection center is termed the “secondary” line and attempts to protect the maximum number of trees, and the outer line is termed the “primary” line because it is expected to be the ultimate zone of protection for uninfected trees. Preliminary studies undertaken by the USDA Forest Service have indicated that secondary lines installed using current intuitive practices are up to 85% effective, and primary lines are up to 93% effective (unpublished data).

Literature cited:

Appel, D.N.; Maggis, R.C.; Nelson, E.L.; Jeger, M.J. 1989. Measurement of expanding oak wilt centers in live oak. Phytopathology 79: 1318-1322.

Bruhn, J.N.; Pickens, J.B.; Stanfield, D.B. 1991. Probit analysis of oak wilt transmission through root grafts in red oak stands. Forest Science 37(1): 28-44.

Himelick, E.B.; Fox, H.W. 1961. Experimental studies on control of oak wilt disease. Ill. Agric. Exp. Sta. Bull. 680:48

Menges, E.S., Loucks, O.L. 1984. Modeling a disease-caused patch disturbance: oak wilt in the Midwestern United States. Ecology 65(2): 487-498.

Menges, E.S.; Kuntz, J.E. 1985. Predictive equations for local spread of oak wilt in southern Wisconsin. Forest Science 31(1): 43-51

METHODS: Briefly describe how the project is designed; including hypothesis to be tested/question to be answered, statistical approach to be used, and quality control/quality assurance procedures.

Rate of spread of the oak wilt pathogen in various soil types will be measured by observing the development of disease in naturally infected stands where control efforts are not currently being employed. Each tree within the study area will be located on an accurate map using GPS and laser rangefinder devices, and several characteristics of each tree will simultaneously be recorded. Stand characteristics such as composition (tree and shrub species), soil type and depth, topography, water availability, and other variables will also be recorded. Development of symptoms of all trees within each stand will be recorded. To supplement the development of the model, some unpublished historical data on local spread of oak wilt may also be used. The data will be used to evaluate the effectiveness of several different potential models that predict the spread of oak wilt (mentioned previously) and to develop one or more specific models for conditions in the Midwest. Models that have been previously developed elsewhere involve either linear regression or probit analysis of the variables involved,

which include some measure of the diameters of infected and healthy trees, and the distances that separate these trees. Both of these approaches will be tested with the data obtained, and the best-fitting models will be elaborated.

Existing root graft barriers, established within the past five years, will be examined to determine their effectiveness in containing the spread of the oak wilt pathogen. All trees adjacent to, and inside and outside of the secondary and primary lines will be inspected for oak wilt symptoms, which will be recorded. Measurements will include DBH, DBH of the nearest wilted or dead tree, and distance from the primary and secondary lines. Other models and guidelines currently in use will be applied to the site and the number of trees affected, both inside and outside the actual line placement, will be recorded. This information will be used to evaluate and validate any potential models that are developed, and to compare results with existing models, which are assumed (as a working hypothesis) to be very conservative in their suggestions for barrier line placement.

MEASURE OF SUCCESS: How does the Region/Area intend to judge whether the project is a success? What outcomes are expected to result from the project and/or the implementation of the technological products/methods?

The region would consider this project a success if guidelines are developed that would allow efficient and proper placement of vibratory control lines for oak wilt management. The outcome of this project will be better management of oak wilt and more confidence on the part of the contractors involved in control efforts. Ultimately, the project should save thousands of valuable trees that would be sacrificed using existing techniques for oak wilt control.

COOPERATORS: List names, affiliations. For non-FHP cooperators, describe the project role and time commitment of each.

Dr. Gary Johnson, Associate Professor of urban forestry, University of Minnesota (10%). Major graduate student advisor to Graham Mahal, and project coordinator.
Dr. Joseph G. O'Brien, Plant Pathologist, Northeastern Area S&PF, St. Paul, MN (10%). Technical assistance regarding oak wilt biology and epidemiology, project co-coordinator, and committee advisor to Graham Mahal.

Graham Mahal, graduate student, University of Minnesota (50%). Primary technical responsibility for project completion.

The following people are cooperators on the project, providing *ad hoc* assistance with the project as needed, with a time commitment of 5% or less.
Dr. Jennifer Juzwik, Research Plant Pathologist, North Central Research Station, USDA Forest Service, St. Paul MN
Dr. Tom Skalbeck, Entomologist, USDA Forest Service, North Central Research Station, USDA Forest Service, St. Paul MN
Ron McRoberts, Statistician, USDA Forest Service, North Central Research Station, USDA Forest Service, St. Paul MN
Rose Ingram, Silviculturist, USDA Forest Service, Huron Manistee National Forest
Roger Mech, Entomologist, Michigan DNR
Steve Kunde, Professional Arborist, St. Paul, MN
Steve Cook, Professional Arborist, St. Paul, MN

PRODUCTS: What will be produced and when?

The products of this project will be a Master's thesis (Graham Mahal) that addresses the project goals, and associated publications and on line documents that will provide guidelines for the establishment of root graft disruption lines for controlling oak wilt. Preliminary guidelines should be available in FY 2001, with final publication by FY 2002. Such guidelines are in great demand but, except for those resulting from the model developed by Dr. Johann Bruhn, are lacking. Unfortunately, Dr. Bruhn's guidelines are specific to two soil types found in the upper peninsula of Michigan, and are probably not useful in determining barrier placement in other areas.

PUBLICATION: How will the project results be reported?

Reports will take the form of a Master's Thesis, and will include publication of results in scientific journals. In addition, the information derived from this study will be presented at both regional and national meetings of plant pathologists and forest health professionals. These will include the annual meeting of the American Phytopathology Society, and the North Central

Forest Pest Workshop. In addition, any guidelines or software derived from this project will be available on the Internet on an appropriate Forest Service site.

TECHNOLOGY TRANSFER: How will the technological product(s) or method(s) produced be transferred to users, adapted to other uses in the future, and/or sustained by continuing technology transfer and support activities? What management level commitments for support are/will be established for sustaining the products after conclusion of this project? The organizations and/or management decision-makers should also be listed as cooperators who are already aware of this proposal.

Because the guidelines expected from this project are in great demand, they will be made available in multiple formats, including publications, brochures, and web pages that will be readily accessible to anyone who is interested in the information. Raw data derived from the study will also be made available upon request, for future modeling efforts. No additional requests for Forest Service inputs (either materiel or financial) are anticipated to support this project after its completion.

PROJECT DURATION: Including FY 2000, how many years will it take to complete this project?
Completion expected in fiscal year 2002. FHP funding requested for FY 2000 only.

LONG TERM BUDGET: Show estimated FHP funding need by fiscal year through the projected completion of the project. Show separately the funding to be requested/provided from other sources. Contributed funds and in-kind contributions are important aspects of proposals that are carefully scrutinized by evaluators and funding decision-maker.

	Requested FHP STDP Funding	**Other Sources amount**	**Organization Name**
FY 2000	$27,000	$32,500	LCMR*
FY 2001	--------	$27,500	LCMR*
Total Budget	$27,000	$60,000	

(Funding through STDP is requested for one year only.)

FY 1999 BUDGET REQUEST: Do not include costs covered by other FHP funding which will occur regardless of this project. Show estimated FHP funding need for FY 2000. Show separately the funding to be requested/provided from other sources for FY 2000.

ITEMIZE as follows:

	Item	**Requested FHP STDP Funding**	**Other Sources amount**	**Organization Name**
Admin items:	Salary	$8,000	$23,700	LCMR*
	Overhead			
	Travel	$2,000	$800	LCMR*
Procurements:	Contracting			
	Equipment	$14,000	$7,000	LCMR*
	Supplies	$3,000	$1,000	LCMR*
	Other			
TOTAL FY 2000 Budget		$27,000	$32,500	

* LCMR = Legislative Committee on Minnesota Resources grant

STDP PRODUCTION FUNCTION

PROJECT NUMBER: NA-2000-xx

PROJECT COST: $87,000

Year	1	2
FHP Costs	$27,000	-------
Other Costs	$32,500	$27,500
Total	59,500	$27,500

Total project costs: $87,000

PROJECT OBJECTIVE (BRIEF DESCRIPTION OF THE PROJECT AND EXPECTED OUTCOME):

Several studies have attempted to model the behavior of the oak wilt pathogen in regard to disease transmission through root grafts, with a resulting variety of equations for predicting the spread of oak wilt on a particular soil type, or within a particular stand. However, none of these studies has examined the operational effectiveness of vibratory plow lines placed by contractors who routinely do this kind of work, and thus fail to address critical questions regarding the practical usefulness of these models.

We propose that examining the effectiveness of such barriers made during the past five years can make significant improvements in the placement of root graft barriers. We further propose the development of a model that would explain the success or failure of these barriers. Expected improvements in barrier placement would save trees that would be needlessly sacrificed under existing models, would minimize "skips" of the disease past the established barriers, and would thus help to ensure that the placement of root graft barriers is optimal.

Benefits from this project will be reduced tree mortality, with lower attendant costs for removal and replacement of trees, and re-treatment of sites.

ASSUMPTIONS:

Benefits of this project are assumed to accrue for five years.

Guidelines established by this project will decrease tree mortality (and affect removal and replacement) by 5% by efficient placement of control barriers.

Re-treatment of infection centers will be reduced by 5% because barriers are efficiently placed.

Trees cost $200 to remove after succumbing to oak wilt.

Replacement costs are $300 per tree.

20% of the dead trees will be removed, and 10% of the dead trees will be replaced.

This analysis assumes that an additional one million feet of barrier control line will be established in the area affected by this project during the next five years, and that approximately 2500 infection centers will be treated.

BACKGROUND DATA:

The following data are specific to an oak wilt suppression program in Minnesota, where good information regarding control efforts is available. We are using only the Minnesota as an example for this analysis, even though the benefits of the project should apply to the entire Midwest.

The oak wilt suppression program in the state of Minnesota celebrated the installation of one million feet of vibratory control line barrier in five years of activity (in 1996).

Total cost of the Minnesota program to that point (including administration costs) was $3.35 per foot of barrier line installed.

Current costs of vibratory barrier line installation (exclusive of administration costs) is $1.50 per foot.

Minnesota treated 2543 infection centers at a cost of $3,352,400, or $1318 per infection center.

The average oak wilt center in Minnesota contains 35.5 dead and dying trees.

A preliminary Forest Service study indicated that current barrier lines are effective, on average, 85% of the time.

CALCULATIONS

EXPENDITURE & OUTPUT VALUES (EOV) WITHOUT PROJECT:

(1 million feet of barrier line placed at $1.50 per foot) + (15% of centers requiring retreatment at $1.50 per foot) = $1, 725,000

+

(20% of dead trees removed)*(2500 centers)*(35.5 trees per center)*($200 per tree) = $3,550,000

+

(10% of dead trees replaced)*(2500 centers)*(35.5 trees per center)*(300 per tree) = $2,662,500

=

$7,937,500 total expenditures without project

EXPENDITURE & OUTPUT VALUES (EOV) WITH PROJECT:

(1 million feet of barrier line placed at $1.50 per foot) + (10% of centers requiring retreatment at $1.50 per foot) = $1,600,000

+

(20% of dead trees removed)*(2500 centers)*(35.5 trees per center)*($200 per tree)*(95%) = $3,372,5000

+

(10% of dead trees replaced)*(2500 centers)*(35.5 trees per center)*(300 per tree)*(95%) = $2,529,375

=

$7,501,875 total expenditures with project

BENEFIT (CHANGE IN EOV) ATTRIBUTABLE TO PROJECT:
B = $(with) - $(without)

B = $7,937,500 - $7,501,875 = $436,625

BENEFIT/COST RATIO:
B/C = $(with) - $(w/o)
$(STDP cost) + $(treatment cost, where applicable)

B/C = $7,937,500 - $7,501,875 / $87,000 = 5.0

BENEFIT ATTRIBUTABLE TO STDP:
Benefit attributable to STDP funds = $(STDP cost) x (B/C)

$27,000 X 5.0 = $135,000

PNV OF PROJECT:
PNV of project = $(Benefit) - $(cost)

$436,625 - $87,000 = $349,625

PNV OF STDP:
PNV of project = $(Benefit attributable to STDP) - $(STDP cost)

PNV = $135,000 - $27,000 = $108,000