Enclosure 1

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

PROJECT STATUS: New, not previously funded.

PROJECT NUMBER: R5-2000-01

PROJECT TITLE: Improved Spread and Intensification of the Dwarf Mistletoe Impact Model, an Extension of the Forest Vegetation Simulator (FVS)

SUBJECT: Planning and Public Information, Disease Management, Modelling, dwarf mistletoe

PROJECT OBJECTIVE(S): Improve and demonstrate the capability of the non-spatial spread and intensification module of the Dwarf Mistletoe Impact Model (DMIM) of the Forest Vegetation Simulator to accurately predict the spread and intensification of dwarf mistletoe for a variety of species.

BRIEF DESCRIPTION OF PROJECT: The Dwarf Mistletoe Impact Model (Hawksworth and others 1995) used to project mistletoe spread and intensification for the Forest Vegetation Simulator (FVS) will be repaired to describe mistletoe dynamics in various stand types. Model performance in terms of spread and intensification will be assessed by comparison to the behavior of these indicators observed in long-term field studies. Relationships will be developed and validated for true fir in California; ponderosa pine in Oregon, Colorado, and Arizona; lodgepole pine in Idaho, Wyoming and Colorado; and western larch in Montana (Hawksworth and Marsden 1990). A model form (Maffei and others 1999) will be used that accounts for differential rates of spread and intensification in trees of different sizes and stands of various vertical structures. Changes by size class in percent of trees infected and DMR (Hawksworth 1977) will be used to describe spread and intensification for each observation period of each field plot. (The number and length of periods vary by field study but most include at least several 5-10 year periods.) The final report will include sections describing observed mistletoe spread and intensification in the field studies (table, graphs, and summary equations) and analyzing model behavior in terms of sensitivity and goodness-of-fit (Chen and others 1993, Smith and Rose 1995).

FHP LEAD CONTACT : Susan Frankel, Plant Pathologist, R5

PRINCIPAL INVESTIGATOR(S) and their AFFILIATION,
Brain Geils, Rocky Mountain Research Station, Flagstaff, AZ
Helen Maffei, FHP-R6, Bend, OR

COOPERATOR(S):

Ellen Goheen, FHP-R6, Central Point, OR
Mary Lou Fairweather, FHP-R3, Flagstaff, AZ
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JUSTIFICATION: The Forest Vegetation Simulator (FVS) is used throughout the USDA- Forest Service for forest planning, project-level analysis and watershed analysis (Teck and others 1997). Because dwarf mistletoe is a widespread disturbance agent, the dwarf mistletoe extension (DMIM) is automatically run when mistletoe incidence and severity data are included with the input. Unfortunately, the current DMIM does not account for increased spread from overstory to understory trees. Therefore in many situations now simulated, projections underestimate long-term mistletoe effects. This work will correct and validate model behavior using data from numerous long-term studies conducted throughout the Western Regions. A revised model developed from a greater range of data and validated against observed behavior will provide realistic and defensible projections for more situations. These projections are needed to communicate dwarf mistletoe impacts to forest managers and the general public.

URGENCY: When the initial DMIM was developed, spread and intensification were modeled with limited data and for projecting mistletoe under even-aged silvicultural systems. Present trends, however, are leading to the formulation of many, uneven-aged, multi-storied, old-growth stands. Although these stand structures were not well described by previous versions of the DMIM, data has become available to meet the critical need for projecting mistletoe impacts in stands of complex vertical structure. Furthermore, management decisions are now frequently challenged and their silvicultural basis closely scrutinized. It is therefore imperative that the DMIM be validated against observed mistletoe behavior with rigorous and demonstrative methods.

LINK TO NATIONAL FHP TECHNOLOGY DEVELOPMENT PRIORITIES:

This project addresses two of the four National priorities for STDP. It fulfills the request to develop techniques to quantify the impact (forest structure and function) of insects and diseases as disturbance agents in forest ecosystems including their interactions with other disturbance agents. The Forest Vegetation Simulator, Dwarf Mistletoe Impact Model that this project will revise and validate, portrays the impacts of dwarf mistletoe on forest stand dynamics. Dwarf mistletoe interactions with other disturbance agents can be modelled using the revised model along with other FVS tools, such as the FVS fire model, and other pest model extensions for bark beetles or root disease.

This project also addresses the priority to develop guidelines for the integration of silvicultural procedures to reduce the adverse impacts of insect and diseases. The DMIM along with FVS is designed to compare silvicultural prescriptions. With a properly functioning model, foresters and pathologists will be able to evaluate the impacts of various silvicultural guidelines in stands infested with dwarf mistletoe and understand stand dynamics over time.

SCOPE OF APPLICATION: FVS variants have been developed for most of the forested regions of the United States. This project would benefit all areas with dwarf mistletoe, primarily the Western Regions, and would be posted on the FVS and FHTET website, available for use by all interested persons. It could be used immediately and included in FVS training courses given annually in each Region. Its utility will continue for more than 10 years.

RESEARCH BASIS: Development of the DMIM began in 1990 with a workshop sponsored by the Forest Service (Methods Application Group) and facilitated by Environmental and Social Systems Analysts (ESSA 1990). At that time a two track plan was proposed. An interim model would be quickly developed from existing data for stands managed under traditional even-aged silviculture. Work would also begin on a more comprehensive model that would require additional programing and data but be responsive to a wider range of conditions and treatments. Additional workshops were held to develop these models. The Pest Trend Impact Plot System (PTIPS) was established to provide data for model construction and validation. The interim model for even-aged stands proceeded and was released for general use as the DMIM (Hawksworth and others 1995). Modeling mistletoe spread and intensification in stands of complex vertical structure proved more difficult. A strategy for the comprehensive model was proposed using a detailed, process-oriented, spatial-statistical simulation pproach (Robinson and Sutherland 1995). Compared to the DMIM, the spatial-statistical

model required much more programming, calibration, and data input. It has not yet been released for general use.

Geils and Mathiasen (1990) demonstrated a procedure for describing mistletoe intensification in Douglas-fir of multistory, mixed conifer stands. Empirical relations were determined between the proportion of trees increasing 1, 2, or more DMR classes in 10 years and a set of predictor variables. These variables described size of the target tree (DBH) , mistletoe severities in the target tree (DMR class) and in the neighborhood (average DMR of likely inoculum sources), and the density of trees in that neighborhood (BA). Maffei and others (1999) simplified the process by segregated trees into only two strata, overstory and understory. They fixed intensification rates for understory trees by initial DMR based on observations in one ponderosa pine study. Their algorithm has been implemented as the prototype Understory Spread and Intensification Enhancement. These two similar approaches were presented to a west-wide working group (Tucson, AZ April 28-29, 1999) as a simplified, alternative strategy for modeling spread and intensification in uneven-aged stands of various species.

Within infested areas, dwarf mistletoes are persistent and eventually build to large populations which seriously reduce host growth and longevity. Because of long generation times, annual fluctuations in reproduction, slow rates of crown development, and the coarseness of the DMR system, rates of mistletoe spread and intensification should be observed and projected on a decade basis (~ 5 to 15 year periods). Consequently, long-term studies with reliable observations are required to provide the data for model construction and validation. Research and monitoring studies of sufficient number, length and variety are now available for these purposes (Hawksworth and Marsden 1990). Mistletoe spread and intensification in a population of host trees is not only determined by mistletoe reproduction but also by host longevity, ingrowth, and crown changes. Therefore, the meaningful test of simple spread and intensification enhancements is how well the revised DMIM describes observed changes in percent of trees infected and average DMR over several decades. The long-term studies allow us to assess from a management perspective, how well the DMIM mimics mistletoe behavior over an adequate time period in at least some real stands.

METHODS: This project will be conducted in six stages by numerous participants over two years.

Stage 1. Assemble data into a common format. Information from many different series of long-term, fixed area plots will be compiled into a common, documented database (Access, based on the FSVEG structure). Data will be provided by Region 1 (Taylor) for western larch, by Region 2 and RMRS (Geils) for lodgepole pine and ponderosa pine, from Region 3 (Fairweather) and RMRS (Geils) for ponderosa pine, from Region 4 (Hoffman) for lodgepole pine, from Region 5 (Frankel) for true fir, and from Region 6

(Goheen) for ponderosa pine. Database construction and population will be accomplished by FHTET (Adams) by January 31, 2000.

Stage 2. Prepare data summaries. Tables and graphs will be constructed for each plot describing host and mistletoe dynamics by species, size class, and observation period. Descriptors will include trees per acre, basal area per acre, percent infected, DMR, and other selected indicators. Although these tables will be directly computed from the observed data, the tables will be formatted to resemble output from the FVS/DMIM. Graphs will illustrate time trends of observed behavior and projections using the DMIM. Summaries will be prepared by Geils (February) and reviewed by the cooperators. These summaries will be used to determine how data are pooled and allocated for further analysis and subsequent validation.

Stage 3. Characterize mistletoe spread and intensification. Statistical analysis will be conducted by Geils (March) to describe the change in DMR class distribution by decade for various initial conditions (DMR, tree size, and other significant factors). The strategy agreed to at the Tucson work meeting will be used (general approaches described by Geils and Mathiasen 1990 and by Maffei and others 1999). We will attempt to use a common regression model across studies so that species differences are reflected in model coefficients and can be compared. Where differences between species or regions are not epidemiologically important, data will be pooled. Analysis results including confidence estimates and residual analysis will be presented to the cooperators for review and comment before proceeding to the next stage.

Stage 4. Revise model code. A revision of the DMIM will be constructed in a manner similar to the Understory Spread and Intensification Enhancement but using the relationships derived in the previous stage. Work will be conducted by FHTET (Adams) and include testing for proper interface to FVS and required debugging.

Stage 5. Validate revised DMIM. Comparisons of model output (changes in percent infected and average DMR by size class) will be prepared by Geils (April). In addition to the graphs similar to those prepared in the first stage, model performance will be evaluated with statistical techniques such as described by Smith and Rose (1995) and Frankel and others (1998). Cooperators will provide input as to the magnitude of difference between observation and prediction which is acceptable from a management perspective. Comparisons will be made for the model to reserved data (for statistical purposes) and for the model and each study (for evaluation purposes). If the revised DMIM is acceptable to the cooperators, it will replace the former version.

Stage 6. Report results and make recommendations. Three reports will be prepared to document this project. FHTET (Adams) will write an amended users guide for the revised model; upon satisfactory review by the cooperators, it will be released in 2000 as an FHTET publication. Geils will lead drafting a General Technical Report with all

the cooperators as co-authors; the GTR will contain detailed descriptions of source data, analysis, and validation results (to be published in 2001). Frankel, Geils, and Maffei will also prepare a journal article (suggested outlet Western Journal of Applied Forestry) that briefly describes the problem, approach, results, and significance to forest management.

MEASURE OF SUCCESS: The project will be a success when two accomplishments are realized:

1) the Dwarf Mistletoe Impact Model currently used in FVS has been replaced with a revised model that better represents dwarf mistletoe spread and intensification for several tree species;

2) model predictions have been compared to field data from long-term studies in several Regions of the United States to demonstrate the model is making reasonable and defensible projections of dwarf mistletoe impact in forest stands.

COOPERATORS: See list of cooperators above.

Brian Geils, USDA-Forest Service, Rocky Mountain Research Station will statistically model the data and provide coefficients for use with Maffei's understory spread and intensification equations. He is the primary investigator and will dedicate 3 months full-time in Fort Collins and a similar time in Flagstaff distributed over the course of the project.

Coding and database management will be done by FHTET contractors.

FHP pathologists from Regions 1,2,3,4,5,6, will provide data, suggestions and review model outputs from their areas for reasonableness.

Judy Adams will assist with overall project management and Susan Frankel will ensure that the project is proceeding on schedule and all cooperators are informed of progress.

PRODUCTS AND PUBLICATION: A revised Dwarf Mistletoe Model Extension will be provided to FHTET and the FVS Forest Management Service Center for distribution with FVS variants over the world wide web. An amendment to the Dwarf Mistletoe Model Users Guide will be provided to document model changes and their rationale. The changes would be included in the basic FVS training provided annually in each Western Region. The model validation results will be published as a scientific paper in the Western Journal of Applied Forestry.

TECHNOLOGY TRANSFER: The revised model will be bundled with the FVS variants and distributed to FVS users over the internet. Changes and rationale will be

documented in an amendment to the User's guide and could be downloaded from the FHTET pest models web site. The changes will be included in the pest models section of the Regional FVS training taught by FHP pathologists.

PROJECT DURATION: Two years.
Completion expected at end of fiscal year 2001.

LONG TERM BUDGET:

Budget, Year 1.

	Item	**Requested FHP STDP Funding**	**Other Sources amount**	**Organization Name**
Admin items:	Salary	$36,000	$	_____
	Overhead	$4,500		
	Travel	$4,500		
Procurements:		Contracting		
	Equipment			
	Supplies			
	Other			
TOTAL Year 1 Budget		$45,000		

Budget, Year 2.

	Item	**Requested FHP STDP Funding**	**Other Sources amount**	**Organization Name**
Admin items:	Salary		$	_____
	Overhead	$4,500		
	Travel	$4,500		
Procurements:		Contracting		
	Equipment			
	Supplies			
	Other	$36,000		
TOTAL Year 2		$45,000		

FY 1999 BUDGET REQUEST:

	Item	**Requested FHP STDP Funding**	**Other Sources amount**	**Organization Name**
Admin items:	Salary	$36,000	$	_____
	Overhead	$4,500		
	Travel	$4,500		

Procurements:		Contracting
	Equipment	
	Supplies	
	Other	
TOTAL FY 2000 Budget		$45,000

LITERATURE, CITATIONS, ATTACHMENTS, etc:

Chen, C.; Marsden, M., Taylor, J.E. 1993. Sensitivity analysis of the interim dwarf mistletoe impact modeling system for the user. Report MAG-93-10. Fort Collins, CO. U.S. Department of Agriculture, Forest Service, Forest Pest Management, Methods Application Group. 13 p.

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Smith, E.P.; Rose, K.A. 1995. Model goodness-of-fit analysis using regression and related techniques. Ecolo. Model. 77:49-64.

ENCLOSURE 2 - STDP PRODUCTION FUNCTION

PROJECT NUMBER: R5-2000-01
Improved Spread and Intensification of the Dwarf Mistletoe Impact Model, an Extension of the Forest Vegetation Simulator (FVS)

PROJECT COST:

Year	0 (initial year of project)	1	Total
STDP request	$45,000	$45,000	$90,000

PROJECT OBJECTIVE: The objective of this project is to revise and validate the dwarf mistletoe model embedded in the FVS model. With the revised and validated model, silviculturists and other forest land managers can evaluate alternative management scenarios for areas infested with mistletoe. This will result in better management of dwarf mistletoe on forested lands and high-value recreation areas. Without the model repair, forest land managers will not have an analysis tool and dwarf mistletoe will not be as well managed therefore forest growth will be diminished.

Other benefits not quantified include improved information for Forest Plans and NEPA documents and an improved ability to communicate to the public about the impacts of dwarf mistletoe. These unquantified benefits may prevent or alter the outcome of lawsuits against the Forest Service, or allow a needed pest control program to be carried out with less protest from the public. One of the impetuses for this project was a real case, where a pathologist's recommendation to remove trees to suppress mistletoe was challenged by members of the public. To provide a demonstration of the need for the project, the pathologist attempted to model the changes overtime in the stand, with and without dwarf mistletoe. Unfortunately, due to the model's incorrect spread and intensification module, the dwarf mistletoe did not spread from the overstory to the understory. The model projection did not demonstrate biological reality and could not be used. The control project/timber sale was protested and much line officer and specialist time was taken up defending it.

ASSUMPTIONS:

Use of the model will allow better silvicultural treatment of dwarf mistletoe. Improved prescriptions for dwarf mistletoe will decrease mortality and increase growth on one thousandth of 1% of total area infested with dwarf mistletoe each year (306 acres/yr) westwide.

Average production per acre with better treatment is 40 MBF at rotation age.

Average production per acre without improved treatment for dwarf mistletoe is 30 MBF at rotation age.

Useful life of the model is 10 years.

Average rotation age is 100 years.

Dwarf mistletoe treatment cost is the same whether this STDP project is done or not.

BACKGROUND DATA:

30.6 million acres of western forests are infested with dwarf mistletoe (1).

Total annual loss of merchantable timber due to dwarf mistletoe in the United States is 418 million cu. ft. (2)

Average stumpage value of affected species is $106 MBF (3)

EXPENDITURES & OUTPUT VALUES WITHOUT PROJECT:

Area affected = 306 ac x 10 years = 3060 acres.
Acres affected X expected production w/o technology X value
3060 x 30 MBF X $106 MBF
9,730,800 DISCOUNTED TO $ 8,865,634

Year	Annual benefit	Annuity Factor	Discounted benefit
0	973,080	1.0	973,080
1-9	973,080	8.11090	7,892,554
		Total	8,865,634

EXPENDITURES & OUTPUT VALUES WITH PROJECT:

EOV WITH PROJECT = Acres affected X expected production with project X value -
= 3060 Ac X 40 MBF X $106 MBF
= $12,974,400 DISCOUNTED TO $ 11,820,846

Year	Annual benefit	Annuity Factor	Discounted benefit
0	1,297,440	1.0	1,297,440
1-9	1,297,440	8.11090	10,523,406
		Total	$ 11,820,846

BENEFIT (CHANGE IN EOV) ATTRIBUTABLE TO THE PROJECT
EOV WITH PROJECT - EOV WITHOUT PROJECT =

Total benefit: $ 11,820,846 - $ 8,865,634 = $ 2,955,212

BENEFIT/COST RATIO

B/C = (Benefit attributable to project)/(STDP cost + contributed cost)
= ($ 2,955,212)/ (90,000 + 30,000)
= 24.6

BENEFIT ATTRIBUTABLE TO STDP FUNDS = 24.6 x 90,000 = $ 2,214,000

PNV OF PROJECT

PNV of project = Benefit attributable to the project - (STDP cost + Contributed cost)

$2,955,212 - $120,000 = $2,835,212

PNV of STDP = Benefit Attributable to STDP funds - STDP funds requested

$2,955,212 - $90,000 = $2,865,212

References

1) Anon. 1998. Forest Insect and Disease Conditions in the United States 1997. Forest Health Protection, USDA Forest Service, Washington, DC. Pg. 23.

2) Hawksworth, F.; J.C. Williams-Cipriani; B.B. Eav; B.G. Geils; R.R. Johnson; M.A. Marsden; J.S. Beatty, G.D. Shubert, D.C.E. Robinson. 1995. Dwarf Mistletoe Impact Modeling System User's Guide and Reference Manual. Report MAG-95-2. Methods Application Group, USDA Forest Service, Fort Collins, CO. Pg. 3.

3) USDA- Forest Service, Region 5. 1998. Timber Cut and Sold Report. Unnumbered report. On file at Pacific Southwest Region Headquarters, 1323 Club Dr. Vallejo, CA.