PROJECT NUMBER:
R1-2000-03

PROJECT TITLE:
Improved risk rating, detection, and impact assessment of balsam woolly adelgid and hemlock woolly adelgid.

PROJECT STATUS:
Continuing (funds are being requested for the next fiscal year).

EXPECTED PROJECT DURATION:
3 years.

ERIGINAL EXPECTED COMPLETION DATE PF THE PROJECT:
FY 2003.

EXPECTED COMPLETION DATE OF THE PROJECT:
FY 2003.

SUBJECT:
Improving detection technology, quantifying the impact on stand structure, remote sensing, *Adelges piceae*, *Adelges tsugae*.

STATUS OF SUBJECT SPECIES:
Adelges piceae (balsam woolly adelgid) is a non-native species.
Adelges tsugae (hemlock woolly adelgid) is a non-native species.

PROJECT OBJECTIVES:
The overall objective of the proposed project is to develop the use of remotely sensed data to improve the detection and monitoring of balsam woolly adelgid and hemolck woolly adelgid infestations. Risk rating of stands and impact assessments will also be conducted for balsam woolly adelgid in stands of subalpine fir. The four specific objectives of the project are to:

- Develop the use of hyperspectral and multispectral remote sensing data for detection and delineation of subalpine fir decline and the presence of balsam woolly adelgid in affected stands.
- Develop GIS-based technologies for the combination of remote sensing and other data types for risk rating stands of subalpine fir for infestation by balsam woolly adelgid.
- Determine the impact of balsam woolly adelgid on stand structure and regeneration of subalpine fir.
- Develop the use of hyperspectral and multispectral data for detection and delineation of hemlock woolly adelgid infestations affecting eastern and Carolina hemlock in the eastern United States.

BRIEF DESCRIPTION OF THE PROJECT:
Balsam woolly adelgid (BWA), *Adelges piceae*, is an introduced forest pest of true firs. It is widely established in North America, but is only recently expanding its range into the interior west. Currently, visible and color near-infrared aerial detection surveys are among the primary techniques used to detect and delineate insect infestations within forests. However, BWA damage is often not visible using this technology, even when infestations are in advanced stages. In addition, another introduced adelgid, the hemlock woolly adelgid (HWA), *Adelges tsugae,* is currently causing significant mortality to native hemlocks in the eastern United States. The proposed project will develop methodologies that will allow forest managers to take advantage of two important developments in remote sensing: a) the decreasing cost and greater availability of multispectral data from Landsat 7 and NASA/Earth Observing System (EOS) sensors and b) the ability to obtain low-cost high-resolution imagery in selected narrow bands with digital cameras and digital video systems. Both of these advances in remote sensing technology will be used in developing schemes for early detection and monitoring of BWA and HWA infestations as well as the impact of BWA on stand structure. The monitoring system we seek to develop has two important stages. First, multispectral data sets will be combined with existing information in a GIS to generate risk maps for large areas. Then, the areas identified as high-risk can be targeted for more detail monitoring with narrow-band remote sensing areal surveys. The methodology for these surveys will be developed using ground and aircraft measurements over controlled plots with various stress factors, and refined and tested under typical conditions for aerial surveys. This technology may allow forest managers to discriminate between various agents that can be involved in fir decline (such as BWA, root rots and western balsam bark beetle), as well as distinguishing between those agents and other plant stresses such as moisture stress. Following the determination and delineation of BWA infestations, ground measurements will be used to examine the impact of BWA on fir regeneration within the infested stands.

CHANGES TO ORIGINAL PROJECT SCOPE OR OBJECTIVES:
There have been no major changes to the scope or objectives of the project. Two minor change have occurred:

- First: the majority of the first year has been spent examining subalpine firs in two areas. We had originally planned on examining trees from more infestations/areas during the first year. However, due to questions that were raised, we made several additions to the original scope of the proposal (see below) and concentrated our efforts into just the two areas during this past summer. Additional sites have been identified and data collection will be expanded to include these areas during the next field season.
- Second: while we had identified multi-spectral data as a potential source of information, we had not identified the source of the data we would use. We have acquired SPOT data (20m pixel resolution) from two years and will be examining this data for use in change detection involving infested stands.

ADDITIONS TO ORIGINAL PROJECT SCOPE OR OBJECTIVES:
There have been several additions to the scope of the project. These include

- The hand-held spectro-radiometer requires direct sunlight for its use in data collection. Because of this, foliage and limbs are removed from trees in the interior of a stand and moved into direct sunlight for data acquisition. We have had to address concerns regarding the validity of our ground-based measurements acquired in this manner. We designed a test of the data which involved taking spectral measurements for a set period of time prior to and directly following the clipping of limbs and foliage. The test was conducted on three tree species and demonstrates that the clipping has no effect on spectral response over the time period tested (15 minutes).
- Similarly, our data collection design requires that we remove and pile foliage to simulate the overlap of foliage that occurs in a natural canopy. Again, we designed a test in which the foliage was piled for several replicate measurements and we have thus far found no measurable differences.
- Along with the measures of balsam woolly adelgid infestations mentioned in the original proposal, we have initiated data collection on the impact of the insect on understory (regeneration) subalpine fir. If regeneration of subalpine fir is being directly impacted by the insect, it will have a cascading effect through time on the species ability to be maintained within the infected stands.
- There has been some confusion regarding the life cycle of balsam woolly adelgid in the intermountain west. Therefore, we are initiating studies next year to examine the life history of the insect at various elevations along a gradient to answer such basic questions as:
  - How many generations per year does the insect have at various elevations?
  - Can we find/identify any natural enemies that are attacking the insect?
- Because of the economic importance of grand fir to the intermountain west, we have initiated data collection on grand fir that we have identified that are infested with balsam woolly adelgid.

FHP LEAD CONTACT:

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FHP LEAD INVOLVEMENT:
During the first year of the project, the role of the FHP lead has primarily been to review and make recommendations on the progress and procedures of the project during its initiation phase.

PRINCIPAL INVESTIGATORS:

Stephen Cook, Department of Forest Resources, University of Idaho, Moscow, ID
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Karen Humes, Department of Geography, University of Idaho, Moscow, ID
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PRINCIPAL INVESTIGATORS INVOLVEMENT:
The two principal investigators have been responsible for conducting the majority of work on the project during this first year.

Dr. Cook has been involved with every stage of the project to date. He has designed and supervised the collection of ground data, has been involved with the collection and assessment of the remotely sensed data, has been involved with the statistical analysis of the data that has been collected to date and has taken the primary role in reporting on the project. Dr. Cook has committed approximately 20% of his time to this project during the past fiscal year.

Dr. Humes has been involved with all aspects of the project that involve the collection and analysis of the remotely sensed data. She has been instrumental in the design, interpretation and analysis of the data that has been conducted to date and was instrumental in recommending and obtaining additional sources of remotely sensed data that are being examined for use in this project. Dr. Humes also serves as the thesis advisor for the graduate student who is currently conducting much of the data collection (Ryan Hruska). She has committed approximately 20% of her time to this project during the past fiscal year.

COOPERATORS:
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COOPERATOR INVOLVEMENT:
With the exception of Jim Ellenwood, the cooperators have not been involved with the project during the past year. Jim's primary role has been to review and critique some of the methodology that is being used in the conduct of the project. Additional cooperator involvement this fiscal year will be in identifying additional infestations of balsam woolly adelgid for investigation (Ladd Livingston and Iral Ragenovich) and will be consulted for the interpretation and analysis of the remotely sensed data (Jim Ellenwood, Dennis Murphy and Paul Gessler). Fred Hain will be involved during the third year of the project when work is conducted in the eastern United States that involves the hemlock woolly adelgid.

PRODUCTS AND DUE DATES:
At the end of the first year, the University of Idaho is to provide:

1. Field test and provide improved data for the detection of balsam woolly adelgid infestations using narrow band filters and available hyperspectral data (i.e. NASA AVIRIS data).
2. Ground and foliar-based spectral characterization of trees impacted by balsam woolly adelgid and other agents.
3. Identification of narrow bands containing the most information about the balsam woolly adelgid infestation.

At the end of the second year, the University of Idaho is to provide:

1. Continued ground and foliar-based spectral characterization of trees, concentrating on varying degrees of balsam woolly adelgid infestation.
2. Develop and validate a GIS-based risk assessment methodology for balsam woolly adelgid using a combination of remotely sensed and other data types.

At the end of the third year, the University of Idaho is to provide:

1. Improved validation of the system for balsam woolly adelgid.
2. Extension of the system for hemlock woolly adelgid in the eastern United States.

At the conclusion of the project, the University of Idaho is to provide:

1. Spectral characterization of fir foliage impacted by several potential agents involved in subalpine fir decline, but concentrating on balsam woolly adelgid.
2. Spectral characterization of hemlock foliage infested with hemlock woolly adelgid.
3. Impact assessment of balsam woolly adelgid on subalpine fir.
4. A preliminary hazard risk rating scheme for balsam woolly adelgid infestation of subalpine fir stands in the interior west.

ACCOMPLISHMENTS TO DATE:
This is the first year of a three year project. Therefore, no final products have been completed. Work is ongoing on two publications and a M. S. thesis (by Ryan Hruska in the Environmental Sciences program at the University of Idaho). The major accomplishments from the first year of the project are:

- Acquisition of a NASA AVIRIS flight to provide hyperstral data of balsam woolly adelgid infestations in the St. Joe National Forest. The flight occurred in July, 2000.
- Collection of stand composition data from over 100 plots in the area covered by the AVIRIS data. The stands are dominated by two tree species, hemlock and subalpine fir. The stand data will be used to determine the feasibility of using this data type for distinguishing between stands based upon species composition and tree density. The data set also contains information on the level of infestation of the subalpine fir component by balsam woolly adelgid. The infestation data will be incorporated into the analysis of adelgid impacts of spectral signatures and will be tested for the detection infestations using hyperspectral data.

- Collection of spectral data on the foliage of several tree species including subalpine fir, spruce and ponderosa pine. This data will allow separation of species by foliar spectral reflectance patterns.
- Collection of data to assess the impact of the ground-collection methodology on the reflectance characteristics of the measured foliage. Tree limbs are cut and removed from the trees prior to spectral characterization. Therefore, an experiment was conducted to determine what (if any) changes occur in the spectral signature of foliage as a result of this limb removal. There are no significant changes in the spectral signature of the foliage from before removal of the limbs throughout a 15-minute observation and measurement period following removal of the limbs. Therefore, the technique of removing foliage and taking the ground-based measurements within a short time after removal has affect on the reliability or accuracy of the data.
- Collection of data to assess variability in the measurement of spectral signatures using ground-based techniques. Limbs (with foliage) of subalpine fir were removed and measurements taken at various angles to determine the variability of the data collection method. The data acquired does show some variability, but there wee no significant differences in the major spectral characteristics among the three data collection techniques.
- Collection of ground data to assess the change in spectral signature of subalpine fir following infestation of the trees with balsam woolly adelgid. There are distinct differences in the spectral signatures of non-infested versus infested trees in several spectral regions that include wavelengths in approximately the 600-700nm, 800-1000nm, 1200-1350nm, 1400-1750nm and 2000-2400nm ranges. These measurements are based on trees from only two infestation locations. During the second year of the project, trees from additional sites (both infested and non-infested) will be examined.
- While grand fir is not as susceptible to attack by balsam woolly adelgid, it is a very suitable host for the insect. Grand fir is also a more economically important tree species in the interior west then is subalpine fir. We have identified six pairs of grand firs with one tree being heavily infested with balsam woolly adelgid, while the neighboring tree is not infested. Additional pairs of trees will be identified next summer. The spectral signatures of the foliage from these pairs of trees will be collected and compared to determine if there is a consistency in the change in spectral characteristics as identified for the infested subalpine firs.
- Acquisition of two scenes of SPOT, multispectral data (20m pixel resolution) from July 1998 and July 2001. This multi-temporal data is being examined to determine its potential for use in change detection analysis of the affected stands.

FIRST FISCAL YEAR FUNDED:
FY 2001.

FUNDS OBLIGATED FROM BEGINNING OF PROJECT THROUGH CURRENT FISCAL YEAR:

	Item	FHP-STDP Requested Funding	UI Funds	Received Funding	Expended Funding
Previous Year FY 2001					
Administration	Salary	$ 39,604	$ 26,271	$ 65,875	$ 69,840
	Overhead		$ 23,932	$ 23,932	$ 23,932
	Travel	$ 6,500		$ 6,500	$ 2,502
Procurements	Contracting				
	Equipment				
	Supplies	$ 3,600		$ 3,600	$ 3,633
YEAR TOTALS		$ 49,704	$ 50,203	$ 99,907	$ 99,907
Current Year FY 2002					
Administration	Salary	$ 32,371	$ 15,613	$ 47,984	
	Overhead		$ 28,792	$ 28,792	
	Travel	$ 6,000		$ 6,000	
Procurements	Contracting				
	Equipment				
	Supplies	$ 6,000		$ 6,000	
YEAR TOTALS		$ 44,371	$ 44,405	$ 88,776	

FY 2003		Requested FHP STDP Funding	Other Source Funding	Source
Administration	Salary	$ 32,371	$ 15,420	University of Idaho
	Overhead		$ 28,220	University of Idaho
	Travel	$ 4,500		
Procurements	Contracting			
	Equipment			
	Supplies	$ 6,500		
YEAR TOTALS		$ 43,371	$ 43,640	

FUNDS NOT USED FROM PREVIOUS FISCAL YEAR:

All allocated funds were used during the prior fiscal year.

EXPECTED BUDGET FOR NEXT FISCAL YEAR (FY 2003):

FY 2003		Requested FHP STDP Funding	Other Source Funding	Source
Administration	Salary	$ 32,371	$ 15,420	University of Idaho
	Overhead		$ 28,220	University of Idaho
	Travel	$ 4,500		
Procurements	Contracting			
	Equipment			
	Supplies	$ 6,500		
YEAR TOTALS		$ 43,371	$ 43,640	

DIFFERENCE BETWEEN ORIGINAL AND AMENDED REQUESTS AND JUSTIFICATION:

There are no changes in the requested funding.

STDP FUNDING NEEDED BEYOND FY 2002:

See table above for funding request for FY 2003 and matching funds from the University of Idaho.