FHP TECHNOLOGY DEVELOPMENT PROJECT PROPOSAL

PROJECT STATUS: New

PROJECT NUMBER: R10-2000-01

PROJECT TITLE: Developing new image analysis technology to manage cedar decline.

SUBJECT: image analysis, resource classification, forest decline, cedar decline

PROJECT OBJECTIVES:
The objectives of this project are to:

1. Develop repeatable techniques through image analysis to spatially locate and quantify dead and dying yellow-cedar (cedar decline);
2. Apply the newly developed technique to create a resolute GIS delineation of the cedar decline resource on a pilot project study area, and collect ground truthing data to verify results;
3. Develop a GIS/image analysis classification method useful in forest planning, linked to previously developed information on snag age condition and size.

BRIEF DESCRIPTION OF PROJECT:
There is increasing interest in quantifying cedar decline information as dead yellow-cedar is becoming more important as a timber sale resource. Test sales of dead yellow-cedar have been profitable even using helicopter-yarding methods. The wood's numerous desirable characteristics are retained in the decay resistant heartwood long after death. There is a need to determine the amount of resource available beyond the current (simple location through aerial sketch mapping) information. Addressing this need is twofold; first we need to develop a mechanism to more precisely locate the existing decline resource (beyond current sketch-map capabilities); second the resource needs to be attributed with stand-condition, density / volume information. Several ways of obtaining this information will be explored, using image analysis at several scales and GIS analysis. The test results will be checked using the existing GIS cedar decline sketchmapped layer, existing inventory or plot data, and ground truth plots. The developed techniques will be feasibility rated based on scale and potential scope of application. The benefit of this project is to shift timber harvesting from old-growth spruce-hemlock stands to underutilized dead yellow-cedar stands. Other benefits not quantified include preservation of wildlife habitat, less impact on anadromous streams, and fewer conservation assessments. This project will strengthen research/S&PF information delivery.

FHP LEAD CONTACT:
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PRINCIPAL INVESTIGATORS:
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COOPERATORS:
R10 NFS (Regional Office and Tongass National Forest)
Everett Hinkley – EAM Remote sensing specialist, Juneau, Alaska
Ron Skilling – EAM Geometronics/ Land surveying Group Leader,
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Jim Russell – Silviculturist, Chatham Area, Sitka, Alaska
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FHTET
Ross Pywell – FHTET GIS and spatial analysis Program Manager,
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PNW Research (Juneau Forestry Sciences Laboratory)
Frances Biles – GIS specialist,
John Coauette - Statistician

JUSTIFICATION:
Decline of yellow-cedar has been aerially sketch-mapped on more than 500,000 acres in southeast Alaska. Recognition of the extent of this decline, the consistently high value of yellow-cedar wood, and changing market conditions in Alaska have spurred interest in capturing the economic potential of this resource (Hennon and Shaw 1997). A trial salvage logging on Wrangell Island in 1996 (joint S&PF/NFS/private industry project) demonstrated economic potential, even when logging was conducted by helicopter. This form of salvage is cost effective and leaves an aesthetic residual forest.

Although we have a general idea where the cedar decline occurs through aerially sketchmapping, this information is incomplete and of limited use to land managers. The existing data for this layer was collected during aerial surveys using sketchmapping techniques over a period of about 12 years with several different observers. Currently the layer is merely presence or absence of cedar decline. Land managers have expressed the need for quantifying amount of effect within a decline polygon (i.e. density/volume/stand classification), however, any classification done during our aerial survey is only qualitative and will vary between aerial observers. With existing remotely sensed data, image/GIS analysis tools and ground truthing data, the means are available to develop the technology needed to produce a repeatable, consistent, classified layer.

The responsibility for collecting insect, disease and decline information lies with FHP. While sketchmapping techniques are adequate for periodic outbreaks and easily delineated events, we need to develop alternative tracking and classification methods for cases like cedar decline. This decline persists on the landscape and while current information has been useful, we lack the technology needed to quantify and classify this disturbance process. With refined spatial and classification information, FHP and

research will not only provide managers with additional information they are requesting, but will have better information to progress farther in exploring causal agents in this mysterious decline.

URGENCY:
Information is needed as soon as possible as controversy and debate about timber management on the Tongass National Forest has reached national levels. Local community industries are struggling to convert to new niches with the recent closing of the two existing pulp mills in southeast Alaska. The Forest Service is seeking methods of meeting this demand in ways that are sensitive to wildlife resources and that leave an aesthetic residual forest. Refined and classified yellow-cedar decline resource information is urgently needed as land managers turn to the dead cedar resource for emerging specialty markets and as an alternative to the traditional use of old-growth timber. Also, critical research into the possible causes of cedar decline as they relate to biotic and a biotic landscape influences could be analyzed with the spatial information developed from this project.

LINK TO NATIONAL FHP TECHNOLOGOY DEVELOPMENT & NATIONAL PRIORITIES:
This proposal will develop a technique to quantify and classify the impacts of a forest disturbance agent, cedar decline, and will provide a useful planning tool to forest managers. A number of technical committee's have priorities that will be met with this proposal, although the priorities of the Survey, Evaluation and Monitoring will most frequently be addressed. Techniques will be developed to detect and quantify the effects of a forest decline relating to forest resource availability. The developed techniques will be valuable in monitoring the location, trends and history of this and other forest declines. The remote sensing options developed with this work will develop a GIS package of data readily available for analysis.

This proposal addresses one of the action items of the Forest Protection Technology Strategic Goals (Healthy Forests for America's Future, a Strategic Plan, 1993): develop technology to evaluate the impacts of vegetation management practices and pests on forest health and resource values. This project also addresses a priority of the Western Disease Steering Committee: Develop technologies and methods that increase our understanding of ecosystem function of dwarf mistletoe, heart rots, and cedar decline in boreal ecosystems in order to efficiently manage these diseases at predictable, desirable levels in managed forests. It also satisfies the priority to devise technologies/applications that aid landscape level forest health assessment. This proposal will promote clear understanding the scope, condition and location of this forest decline, which is a valuable first step in treating and understanding the problem.

This project supports sustainable forest ecosystem management and all of the four key areas (watershed health and restoration, forest roads, and recreation are the other three key areas) of Chief Dombeck's Natural Resource Agenda for the 21st Century. The first priority of sustainable forest ecosystem management is to maintain and restore the health

of our ecosystems and watersheds. Second, the National Forests should be a model for demonstrating how active forest management can meet economic needs and maintain and restore watershed health. Third, the National Forests should be a model for demonstrating how active forest management can meet economic needs and maintain and restore watershed health. Fourth, we need to help provide stability within the ecological limits of the land so that companies will make needed investments and provide jobs. Fifth, find new ways to use an in-place, highly skilled workforce to accomplish much needed forest management and restoration. Helicopter logging of yellow-cedar decline areas instead of harvesting the spruce-hemlock forest by more soil disruptive processes satisfies these five goals. The logging of yellow cedar decline stands is gentle on the landscape and does not fragment it in the way other management practices might. The remarks of Chief Dombeck at a Society of American Foresters' breakfast on September 21, 1998 included the point: Values such as large and unfragmented landscapes, wilderness and roadless areas, clean water, protection of rare species, old growth forest, naturalness -- these are the reasons most Americans cherish their public lands.

SCOPE OF APPLICATION: Specific use of results will be made by managers on all three administrative areas of the Tongass National Forest and by those that represent State and Native lands. Sampling and analysis methods will be available nationally in any situation where the use and evaluation of dead trees and declining forests is dependent on the spatial quantification and classification of the resource.

RESEARCH BASIS:
The same 5-class snag system, which now has accurate estimates of time-since-death for each class, has been used in epidemiological studies of yellow-cedar, marking guidelines for salvage sales, and in projects on volume recovery. Wood strength tests (e.g., McDonald et al. 1997), wood durability, and heartwood chemistry are also currently under investigation in relation to snag class. Pilot Vegetation mapping efforts using TM imagery was attempted in the mid 1990's meeting marginal success, although detection technologies for cedar decline were not developed. Prior vegetation image analysis efforts have only been partially successful on the Tongass but mapping cedar decline is more promising given the spectral signature of dead wood and dying trees. The greatest challenge will be developing a classification method that is meaningful to managers. Aerial detection survey is the only remote sensing technique that has been developed and used for detection of cedar decline to date.

METHODS:
This study will investigate the use of multi-stage sampling to characterize 4 different concentration classes of decline.

The use of Landsat 5/7 TM imagery will be used initially to classify different intensities of Cedar Decline using a hybrid classification based upon training sites selected from aerial survey, photogrammetrically delineated areas, and Forest Inventory and Analysis plot data. A comparison utilizing image histograms, separability measures, and contingency matrixes will be made to affirm the appropriate delineation technique for training sites. Source photography will be from existing high altitude color-infrared (CIR) NASA

photography, digital orthoquads, and low altitude resource photography. CIR digital camera photography may be acquired to supplement existing photography in site-specific areas. The classification process will investigate the utilization of additional image transforms, such as NDVI, tassel-cap transforms, and texture bands in addition to terrain data for slope, aspect, and elevation.

From the generated classification, 2-3 pilot study sites, which exhibit a range of characteristics of cedar decline stands, will be selected for intensive sampling of stocking levels, tree diameters, forest composition and concentration of the 5 cedar snag classes.

We will Identify and establish a plot design for accuracy assessment. The number of plots will be determined by the variability within the selected 4 classes. The accuracy assessment will be utilized to determine the effectiveness of the initial cedar decline classification and to evaluate the effectiveness of using Landsat imagery. Subsequent processing may be needed to adjust the classification. Depending on the success achieved with Landsat TM imagery, we may alternatively examine classified DOD satellite imagery (A regional cooperator has the necessary security clearance).

MEASURE OF SUCCESS:
The most direct measure of success will be the statistical validity of the resulting classification when compared to plot data. The tiered approach of this project produces an opportunity for success at two levels:

1. A successful method for more accurately providing spatial presence or absence for cedar decline and,
2. A successful method for generating a valid stand level classification technique linking to prior snag class information.

This project will be successful if managers use the newly derived information to make more informed decisions about potential management options in cedar decline areas. Success could be measured by the number of resulting cedar salvage sales that are not appealed or that do not reach litigation. One of the criticisms of the STDP program has been the lack of “buy-in” from management to promote products. The yellow-cedar work to date has enjoyed a tremendous cooperation between research, management, and the public. Yellow-cedar management has been a way to expand the use of silviculture techniques in Alaska. The silviculture staffs have been very supportive of recent yellow-cedar projects. Their information needs are our technology transfer goals.

PRODUCTS:
New methods and techniques using remotely sensed data and plot data to spatially quantify cedar decline and other forest declines with a similar signature. New methods to classify decline leading to new ways to manage cedar decline.

PUBLICATION:
Publications will most likely result in a USDA Forest Service technical paper or a PNW research note. Professional journal publication is possible in a journal such as PE&RS (Photogrammetric Engineering & Remote Sensing).

TECHNOLOGY TRANSFER:
Newly generated techniques with pilot project results will be electronically distributed to all R10 offices via CD. Methods and techniques will be communicated to technical and administrative employees of the Forest Service at all levels ranging from the Regional Office to Ranger Districts while the project is being conducted and after its completion. Technology transfer will also take place through publication, formal presentations and informal discussions.

PROJECT DURATION: 2 years.
Budget

		Cooperators	
		Salaries and In kind contributions	
Contribution	STDP	PNW	R10 / NFS
FY2000	$23,920	$15,556	$28,632
FY2001	$23,920	$15,556	$28,632

Needs			
Imagery/equipment*		Provided	Provided
Training data/ Ground truthing / plot work			
Travel and perdiem**	$15,000		
Publication	$1,000		
Salaries (PP with COLA) for			
1 GS-14 3 PP @ 3443/PP D,P,W		$10,329	
1 GS-12 3 PP @ 2320/PP D,P,W			$6,960
1 GS-12 3 PP @ 2320/PP I,P			$6,960
1 GS-12 1 PP @ 2320/PP W			$2,320
1 GS-9 8 PP @ 1549/PP D,P,I,W			$12,392
1 GS-9 1 PP @ 1549/PP D		$1,549	
1 GS-7 3 PP @ 1226/PP I		$3,678	
1 GS-5 8 PP @ 990/PP P,W	$7,920		

D=Design, P=Plotwork, I=Image Processing, W=Writing & Analysis

*Imagery and equipment needs are available through the R10 regional office and the Juneau Forestry Sciences Lab. The regional office will provide the needed TM imagery, new ('96, '98) 1:60,000 IR photography, new 1:60,000 DOQs and recent resource photography. A new image processing workstation with ERDOS Imagine ($16,000 each) is available through each of the above mentioned cooperators.

**Note: travel in Alaska is expensive because of limited road systems; travel is often by jet, floatplane, or boat.

PROJECT NUMBER: R10-2000-01

PROJECT COSTS :

Year	*0*	*1*	*Total*
STDP request	23,920	23,920	47,840
PNW salaries	15,556	15,556	31,112
R10 / NFS salaries	28,632	28,632	57,264
TOTAL	68,108	68,109	136,216

PRODUCTION FUNCTION

BACKGROUND
Yellow cedar decline occurs on over 500,000 acres in Southeast Alaska. Yellow-cedar stands are monitored each year. FHP efforts are providing valuable information on potential shifting of harvest from green spruce/hemlock forest to salvage of higher value dead yellow cedar within decline areas.

Due to the extent of the land base and the inaccessibility of Alaska's forests, aerial detection is the only method of assessing the extent and intensity of insect, disease and decline occurrences. This activity is also serving as the only method of forest health monitoring in Alaska to date. At current funding, only priority areas are being flown (25-30 million acres flown annually, 5 million acres in Southeast Alaska).

Remote sensing with the use of satellite and conventional imagery would provide the least expensive method of classifying yellow-cedar stands over the whole southeast Alaska archipelago (approximately 11 million acres of forested land).

OBJECTIVE OF ACTIVITY:
FHP staff specialists conduct annual detection operations to locate insect, disease and decline occurrences and provide current maps and acreage estimates to a variety of landowners.

Forest managers require better quantification of these occurrences to shift harvesting activities from old growth stands to yellow-cedar stands with high value dead and dying trees.

A classification system would result in information that would greatly reduce the cost of selecting harvestable units.

ASSUMPTIONS:
Without this information fewer yellow cedar decline acres would be harvested and more hemlock-spruce old growth acres would be harvested.
Without FHP input, 4364 MCF of volume (Tongass National Forest, Annual Monitoring and Evaluation Report for Fiscal 1996) will be harvested at the average stumpage value

and 107 MCF (2.4% of total) will be harvested at the yellow-cedar value (actual effect experienced on Wrangell RD).
With FHP input (estimated five sales on five districts effected), a total of 3,925 MCF of volume will be harvested at the average stumpage value and 546 MCF (12.2% of total) additional volume will be harvested at the yellow cedar value.

BACKGROUND DATA:
Average stumpage value for old growth harvesting is $2964.50/MCF (Table 26, Report of the Forest Service, 1996)
Stumpage value for yellow cedar is $4,400/MCF.
Timber sale administration cost is $77/MCF (Report of the Forest Service, 1996).

Expenditures & Output Values (EOV) Without Project:
[(MCF x average price) + (MCF x yellow cedar price)]-[$/MCF administration cost x total MCF] = _____ $.

[(4364 x $2964.5) + (107 x $4,400)] - [77 x 4,471] =
$12,937,078 + $470,800 - $344,267 = $13,063,611.

Expenditures & Output Values (EOV) With Project:
[(MCF x average price) + (MCF/acre x yellow cedar price)]-[$/MCF administration cost x total MCF] = _____ $.

[(3,925 x $2964.5) + (546 x $4,400)] - [77 x 4,471] =
$11,635,663 + $2,402,400 - $ 344,267 = $13,693,796.

Benefit (Change in EOV) Attributable to PROJECT:
Benefit Attributable to Project = [with Project -without Project]

= $13,693,796 - $13,063,611 = $630,185.

Benefit/Cost:
Benefit/Cost Ratio = $630,185/$136,216 = 4.6.

BENEFIT ATTRIBUTABLE TO STDP FUNDS:
Benefits Attributed to STDP Funds = B/C* STDP Cost =

4.6 * $47,840 (discounted STDP costs) = $ 220,064.

PNV OF PROJECT:
PNV of Project = $630,185 - $136,216 = $493,969.

PNV of STDP:
PNV of STDP = $220,064 - $47,840 = $172,224.

LITERATURE, CITATIONS, ATTACHMENTS, ETC.:

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