

Report and Recommendations for Future Forest Health Protection Cooperation with the Brazilian Agricultural Corporation in the Control of Sirex noctilio: *Integration of the Biological Control and Remote Sensing Components*



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By

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Introduction

Since 1992, the US Forest Service has cooperated with the Brazilian Agricultural Corporation (EMBRAPA) in the control of the European Woodwasp, *Sirex noctilio* (Sirex) initially by funding a workshop and later by the establishment of a project: "The Development of an Integrated Pest Management Program for the Woodwasp *Sirex noctilio*, a Serious Pest of Exotic Pines in Brazil, 1997-2000". The background and justification for this cooperation with EMBRAPA is explained in the original project plan. Under this plan most assistance has been focused on rapidly establishing a biological control program. This biological control program is now established and operational.

To facilitate the continued success and monitoring the effectiveness of the biological control program, it will be necessary to accurately map host type, delimit the outbreak area, and determine intensity of tree mortality via remote sensing and aerial survey techniques. This information will be used to support the introduction of biological control agents and direct silvicultural prescriptions for treatment.

In response to this increased emphasis on remote sensing, the Forest Health Protection International Activity Team (IAT) provided funding for Jim Ellenwood, Forest Health Technology Enterprise Team Remote Sensing Program Manager, and Andrew Knapp, Aerial Survey Specialist, to travel to Curitiba, Brazil during July 1999. The objectives of this trip, as outlined by the IAT, were as follows:

- Determine the potential benefits of assistance in the remote sensing component of the Sirex Project.
- Evaluate current remote sensing technologies available to EMBRAPA.

- Determine specifically what Brazil is requesting: technical assistance (aerial survey, CIR digital imagery, satellite imagery) technology development, training, funding, etc.
- Determine the status of the existing Participating Agreement, and which, if any objectives will not be attained by the expiration date.
- Identify remote sensing accomplishments made under the current and past Participating Agreements.

Since the original agreement and project plan were developed, a number of important biological, economic, and administrative developments have occurred:

- During 1998, a pest risk assessment, with Sirex as one of the targeted pests, was conducted by the USFS and APHIS. Sirex was found to be high in all applicable risk criteria: probability of establishment, entry potential, colonization potential, and spread potential (see attached draft pest risk assessment).
- The area of Sirex infestation has rapidly expanded within Brazil since 1997. Sirex has now been found in Uruguay and threatens Chile and Argentina. The total outbreak area is unknown due to lack of a substantial mapping program. Some of this expansion is into unmanaged forests as well as commercial forests. As the outbreak enters smaller, unmanaged forests, control becomes more difficult. Additionally, many of these smaller “mom and pop” forestry operations supply dunnage material for local ports which offer the opportunity to spread Sirex.
- US forest product companies (Boise Cascade, Westvaco, Champion) are rapidly expanding into Brazil for the purpose of exporting wood products to the US. Boise Cascade is currently building a 90 million dollar sawmill within the Sirex outbreak area (see attached Idaho Statesman article).
- Control of existing exotic pests and exclusion of new pests are now very high priority in all US Government natural resource agencies. The Forest Health Protection International Activity Team identified protecting US Forests from exotic pests as its number one goal in its 1998-1999 Plan of Work. USFS International Programs requested a briefing paper on the Sirex Project for the Chiefs recent trip to Brazil and has requested information on the Sirex project for posting on their website.
- Due to declining economic conditions, Brazil recently devalued its currency by 50% (as compared to the US dollar). This resulted in significant country-

wide cutbacks in all government agencies, particularly natural resource agencies such as EMBRAPA.

Background of Remote Sensing Component

While funding in the original project plan was primarily focused on rapidly initiating an operational biological control program, a significant amount of remote sensing research was conducted before and during the project. The Federal University of Parana, EMBRAPA, and private forest products companies primarily provided funding. Eastman Kodak Company supplied some equipment. Andrew Knapp and Brazilian cooperators conducted the majority of this work (see attached Activities and Publications).

Current remote sensing technologies available to EMBRAPA

Based upon investigation, EMBRAPA possesses a good remote sensing capability through the possession of remote sensing software and computer hardware. Hardware consists of a Pentium-based PC, a SUN Sparc5 workstation, a 36x48 backlit digitizer, a 36" inkjet plotter, and an Ethernet LAN. Remote sensing software includes a commercial remote sensing package (PCI) and a Brazilian agency-developed training package called SPRING.

The remote sensing staff consists of a fulltime remote sensing specialist and several support technicians. Extensive skills are limited, however a cooperative arrangement with the local University provides some support. The fulltime remote sensing specialist does not speak English. In a translated conversation, the preference was to utilize the SPRING software for image processing. Upon further investigation, it is believed that this software is better suited for smaller remote sensing projects rather than a large project. The commercial based software package (PCI) is more than capable of performing a large-scale remote sensing project.

One small remote sensing project was demonstrated during the visit. This project involved the classification of a small tree species and demonstrated their capability of performing remote sensing projects.

EMBRAPA frequently enters into contracts with other government agencies, non-governmental agencies (NGOs) and private in-country consultants to accomplish projects. One private company recently purchased a CIR digital camera and other companies and one NGO has expressed interest in purchasing additional camera systems. Unfortunately, this technology has not been used for forestry applications and sufficient expertise does not exist within EMBRAPA or outside companies or agencies to complete processing, analysis and interpretation of CIR digital images of forested areas or Sirex damage.

Accomplishments

Following is the remote sensing objective from study plan “The Development of an Integrated Pest Management Program for the Woodwasp *Sirex noctilio*, a Serious Pest of Exotic Pines in Brazil, 1997-2000:

“Evaluation of the technical and economic efficiency of aerial sketchmapping and infrared imagery to monitor Sirex noctillio spread and damage, and identify susceptible type”

Unlike the biological control component of the project, only funding for travel and per diem was provided for accomplishment of this objective. Project funding was provided by EMBRAPA, the Federal University of Parana, FUPEF (a foundation for forest research) and private wood product companies. Following is a brief summary of the remote sensing accomplishments made under the current and past Participating Agreements.

Aerial sketchmapping:

During 1996 and 1997, concurrent with color infrared (CIR) digital camera flights over small plantations near Lages, Santa Catarina, Andrew Knapp and Dr. Attilio Disperati evaluated the pest signature of *Sirex* for the applicability of aerial sketchmapping. While the pest signature was not at its peak and weather conditions were less than favorable, it was obvious that aerial sketchmapping could be used to identify areas infested with *Sirex*. Results of these studies were presented at two remote sensing workshops and an international workshop on *Sirex*.

In 1997, a survey to determine the availability, cost, and condition of aircraft suitable for aerial sketchmap surveys in areas currently experiencing *Sirex* activity was undertaken by Andrew Knapp. It was determined that aircraft availability for aerial sketchmap surveys would not be a problem since many large private forest products companies have light high-wing aircraft.

Dr. Disperati and William Ciesla conducted a more in-depth study of aerial sketchmapping in 1998 (www.fatorgis.com.br/artigos/florest/vespa/vespa.htm). Results of this study indicated that aerial sketchmapping offers a rapid, cost effective approach for rapid classification of *Sirex noctillio* damage.

Considerable support exists for the initiation of an aerial survey program targeted to delimit and quantify the Sirex outbreak from EMBRAPA. Two formal requests (1993 and 1998) have been submitted to the US Forest Service requesting assistance in developing an aerial survey program. Considerable support also exists from private companies. Private companies have funded all of the flights conducted to date.

Additionally, Andrew Knapp conducted two three-day remote sensing seminars at the Federal University of Parana focusing on remote sensing of forest insects and diseases in 1994 and 1996.

Color Infrared Digital Imagery

During 1996 and 1997, Andrew Knapp and Dr. Attilio Disperati conducted CIR digital camera flights over areas infested by Sirex near Lages, Santa Catarina. Images were compared to natural color aerial photographs and aerial observations. Areas were ground checked and results indicated that the CIR imagery can significantly enhance identification of dead and dying trees at all outbreak levels. This information has been published in professional papers in Brazil and the United States (see attached Activities and Publications).

35mm Oblique Natural Color Aerial Photography

Oblique 35mm natural color aerial photography was acquired over areas infested by Sirex near Ponte Alta do Norte, Santa Catarina in 1997 by Andrew Knapp. These photos were used to help quantify Sirex damage in conjunction with CIR digital camera imagery and ground surveys. Currently infested (fading) trees could be counted and stand boundaries easily identified. This information was published and presented at a remote sensing conference in Curitiba in October 1998.

Benefits of Continued Cooperation to the US:

- The remote sensing component of the Sirex Project will augment the effectiveness and efficiency of the current biological control program by providing the capability to delineate host extent superimposed with existing outbreaks and bio-control release areas. Containment and control of Sirex in Brazil will result in a substantially reduced risk of Sirex introduction into the US. A conservative estimate of economic damage to US commercial forests (principally *Pinus taeda* and *Pinus elliottii*) if Sirex establishment occurs, is approximately 24 to 130 million dollars. (USDA Forest Service Pest Risk Assessment, 1992). Additionally, environmental damage would be significant with radical changes to stand composition in native forests. A

significant reduction in the genetic base of *Pinus radiata* could occur throughout native stands if *Sirex* becomes established. While susceptibility is not known, pine forests of the western US could be affected (see attached draft pest risk assessment).

- Building Forest Health Protection specialists' expertise in the detection and evaluation of exotic pests will enhance the expanding role of Forest Health Protection in the exotic pest arena. Identification of infested areas via aerial surveys and remote sensing will provide valuable training and information should *Sirex* become established in the US.

Specific Areas of Requested Assistance

Satellite Imagery

While the larger landowners maintain land cover records for their lands, many of the smaller landowners have poor records of the existing extent of the *Sirex* host species. There is no national mapping effort to map the southern pine plantations. In order to monitor the extent and effectiveness of the bio-control efforts, there is a need to map the extent of the southern pine plantations. Assistance is requested to provide:

- Financial support to procure 14 Landsat satellite images (Path/Row 220/77-78, 221/76-78, 222/76-78, 223/76-78, 224/76-78) that cover the Brazilian State of Parana. Procurement of satellite imagery through the Brazilian government is more costly than procurement through the US government (\$4500 per image versus \$600 per image – images with all 7 bands). Imagery from the newer and improved Landsat 7 has recently become available. Imagery obtained through the EROS Data Center can be purchased for \$600. Six of the 14 images are currently available for purchase.
- Technical advice and review for conducting image analysis of the acquired Landsat imagery. Classification using a hybrid approach will be utilized to delineate southern pine plantations in 5 classes of various age and density classes. The purpose of this classification is to identify the host as well as provide an avenue for assessing potential risk for *Sirex* spread. Advice on the classification procedures, setting up training sites, and conducting accuracy assessments for the first image would set the stage for subsequent imagery to be processed. Procedures developed for the state of Parana would eventually be applied to the other Brazilian states with pine plantations.

Aerial Sketchmap Surveys

Assistance is requested in helping initiate an aerial survey-training program based on the “train the trainers” concept suitable for application throughout areas of Sirex infestation. This will include:

- Aerial sketchmap (classroom, field, and flight) training for mapping of Sirex activity.
- Preparation of an aerial survey handbook and training materials.
- Creation of an aerial survey training CD focused on Sirex and modeled on the “virtual aerial survey” CD and workbook produced by the British Columbia Ministry of Forestry.

The objective will be to have a core group of trained EMBRAPA and private forest product company personnel trained to safely, efficiently, and economically conduct aerial surveys for Sirex and a portable training package suitable for use throughout areas of Sirex activity.

CIR Digital Imagery

CIR digital imagery can be used for determining mortality levels, mapping small areas of Sirex activity and as training site data for satellite imagery. This technology is currently available in Brazil. Specific areas of requested assistance are:

- Image analysis and interpretation for Sirex and mosaicking of CIR digital images.
- Creation of a training CD demonstrating image analysis and interpretation of CIR digital imagery of Sirex at various outbreak levels.

The objective will be to have in-country expertise in with CIR digital imagery processing, analysis and interpretation of Sirex damage.

Small Format Aerial Photography

Due to the well defined and small size of forest plantations, small format aerial photography can be utilized to formulate a multistage sampling system incorporating aerial sketchmap surveys, small format aerial photography, CIR digital imagery and ground data acquisition surveys. Areas of requested assistance are:

- Develop a multistage sampling system utilizing small and medium format oblique aerial photography, CIR digital imagery, aerial sketchmapping and ground surveys to support a decision matrix for Sirex management.
- Training in small format aerial photography techniques and development of a training manual for use with Sirex.

The objective will be to have in-country expertise and a portable training package for small format aerial photography and multi-stage sampling techniques for use with Sirex.

Recommendations

A new Participating Agreement should be drafted and finalized before the expiration of the current Agreement in August of 2000. This will allow for continued cooperation and scientific exchange.

Continued assistance to the Sirex project in funding and in technical support via FHP technical specialists is recommended. The funding (\$25,000) and technical expertise provided by USDA FHP Northeast Area was critical to the success of the biological control component of the Project. Continued funding at this level is recommended. This will provide continued assistance in the biological control area and provide sufficient funding for the accomplishments of the goals and objectives of the remote sensing component ensuring overall project success.

Because Sirex is a worldwide problem, it is recommended that other funding sources (International Programs, Foreign Agriculture Service, etc.) be explored in addition to FHP funding. This will provide funding for an on-going program and allow for complete outbreak delimitation, intensive monitoring and continued assistance in biological control.

EMBRAPA officials and Sirex project leaders emphasized a number of points during our discussions:

- A strong desire for continued cooperation and participation with the USFS for the control of Sirex via a new Participating Agreement. USFS assistance was critical in the successful development of the current biological control program.
- The need for increased emphasis in the remote sensing component of the project.
- The biological control and remote sensing components of the project must be integrated.
- Continued participation of the existing technical specialists: Dr. Dennis Haugen (biological control), Andrew Knapp (aerial survey and CIR digital imagery) and Jim Ellenwood (satellite imagery).

- The project size should be kept small and manageable and be financially accountable.

During our discussions with EMBRAPA a framework for an overall work plan was developed. This was based on past project plans and study plans and is an integration of the biological control and remote sensing component. It assumes some level of USFS FHP support.

Proposed International Forestry Project Work Plan

Project Title: Integrated Pest Management Program Utilizing Biological Control and Remote Sensing for the Woodwasp *Sirex noctilio* in Pine Plantations of Southern Brazil.

This study plan addresses USDA Forest Service Forest Health Protection support and cooperation with EMBRAPA in the control of *Sirex noctilio* (Sirex).

Through this project Brazil will implement a more efficient and effective Integrated Pest Management Program. This technology will be available to other South American countries with Sirex infestations. A successful control program in Brazil will result in greatly lower risk of Sirex introduction into the United States.

Principal Authors/Cooperators:

Carlos Alberto Mazza, EMBRAPA Remote Sensing Coordinator
 Susete Penteadó, EMBRAPA Biological Control Specialist
 Edson Tadeu Iede, EMBRAPA Biological Control Specialist
 Erich Schaitza, EMBRAPA Technology Transfer Specialist
 Andrew Knapp, USFS Remote Sensing Specialist
 Dennis Haugen, USFS Entomologist
 Jim Ellenwood, USFS FHP-FHTET Remote Sensing Program Manager

Period of Execution: January 2000 – January 2003

Justification: This plan would be considered a second phase of the original plan, "Development of an Integrated Pest Management Program for the Woodwasp *Sirex noctilio* (Hymenoptera: Siricidae) a Serious Pest of Exotic Pines in Brazil, 1997-2000") and is based on the justifications outlined in the original study plan. This plan expands the monitoring and remote sensing component of the previous study plan. Results of the initial study plan, discussions with EMBRAPA Sirex Project leaders, and a recent remote sensing evaluation indicate:

- Host type mapping utilizing Landsat imagery is feasible.

- Aerial sketchmapping can be utilized for mapping Sirex damage.
- CIR digital imagery can be utilized for accurately determining infestation levels and as satellite imagery training sites.
- A multistage sampling system can be implemented to support a decision matrix for Sirex management.
- Evaluation and monitoring of the efficiency and effectiveness of biological control methods is necessary.

Objectives:

- Identify areas susceptible to attack by *Sirex noctillio* in the State of Parana, Brazil via satellite imagery.
- Accurately delimit the current extent of the Sirex outbreak via aerial sketchmapping and ground surveys.
- Develop a decision matrix to support management actions to control Sirex (see Figure 1).

Techniques:

A. Host-type Mapping

- Process Landsat TM digital images of the State of Parana to map the occurrence of Pinus species and identify potential areas of attack by Sirex.
- Utilize Kodak DCS-420 CIR Digital Camera System imagery as training site data for satellite image classification.
- Establish ground sample plots for training and accuracy assessment of Landsat imagery.

B. Mapping Existing Damage

- Determine optimum techniques for aerial sketchmap surveys of Sirex attacked areas.
- Evaluate and utilize hard copy Landsat imagery for use as aerial sketchmap survey base maps for Sirex mapping.
- Use Kodak DCS-420 CIR Digital Camera System imagery for detecting advanced mortality levels (>10%).
- Acquire small and medium format oblique aerial photography of Sirex damage.
- Develop and evaluate trap tree deployment protocol.

C. Monitoring and Evaluation

- Compile a GIS database of *Sirex* attacked areas and control activities.
- Review rate of spread and extent of damage change over 3-5 year period.
- Evaluate nematode effectiveness in control of *Sirex*.

- Monitor natural enemies in controlling the spread of *Sirex*.
- Monitor economic efficiency of biological control and remote sensing components.
- Develop a multistage sampling system utilizing small and medium format oblique aerial photography, CIR digital imagery, aerial sketchmapping and ground surveys to support a decision matrix for *Sirex* management.

D. Technology Transfer

- Implement a technology transfer plan for aerial surveys and biological control targeted to local forest farmers, extension services, and pest management agencies.
- Create an internet website for information dissemination and exchange on *Sirex*.

E. Principal USFS FHP Areas of Assistance in the Remote Sensing Component

- Host type mapping via LandSat imagery utilizing CIR digital imagery for training site data.
- Aerial sketchmap training and program development.
- GIS data base development.

F. Suggested USFS FHP Technical Consultants and Skills

- Dr. Dennis Haugen: extensive past experience in *Sirex* biological control in Australia and Brazil.
- Andrew Knapp: aerial sketchmapping experience, previous CIR digital imagery acquisition and analysis experience in Brazil. Ability to speak Portuguese.
- James Ellenwood: experience in all phases of satellite image analysis and project management. Experience in cover type mapping and forest inventory.

G. Initial Budget 1999 -2000 (budget for 2001 – 2003 is dependent on outside funding sources).

| <u>Item</u> | <u>EMBRAPA</u> | <u>USFS</u> |
|------------------------------------|-----------------|---------------------|
| Satellite Images | | \$8,400 |
| Software and support | \$5,000 | |
| Satellite training site evaluation | \$14,500 | |
| Per Diem (EMBRAPA) | \$3,000 | |
| Travel Costs/ Per diem (US)* | | \$17,000 |
| Material | \$1,000 | |
| Aircraft Costs | \$9,600 | |
| Equipment | \$3,000 | |
| Salaries | \$58,000 | \$9,600 (Home unit) |
| Total | \$94,100 | \$35,000 |

*Dennis Haugen: 14 days
 *Andrew Knapp: 21 days
 *Jim Ellenwood 14 days

| <u>Sirex Project Personnel (Brazil)</u> | <u>Time Allotted to Remote Sensing Component of Project</u> |
|---|---|
| Carlos Mazza | 60% |
| Susete Penteado | 20% |
| Edson Tadeu | 20% |
| Erich Shaitza | 20% |
| Sergio Guimaraes | 50% |
| Ivan Jorge da Silva | 20% |

Figures and Attachments:

Figure 1. Tree mortality caused by *Sirex noctilio*, Santa Catarina State, Brazil.

Figure 2. Demonstration of *Sirex noctilio* Management Utilizing Biological Control and Remote Sensing.

Figure 3. Location of Sirex outbreak in Brazil.

Attachment 1. Activities and Publications.

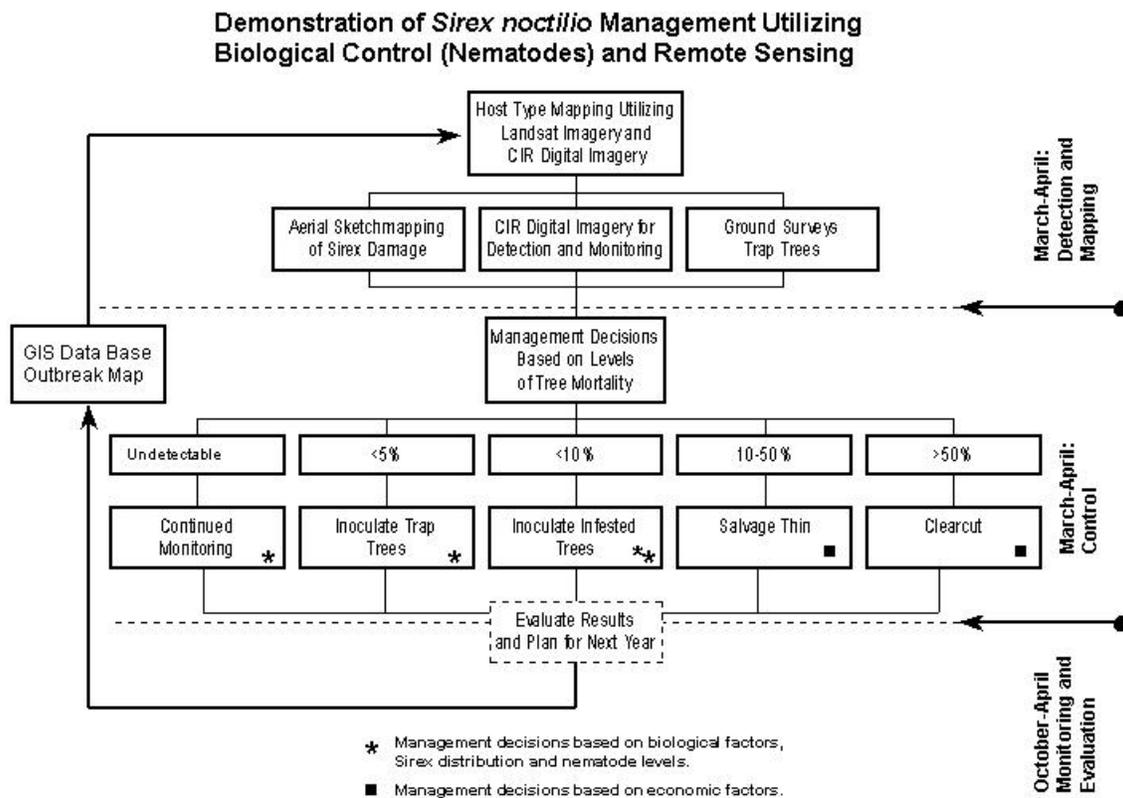
Attachment 2. Idaho Statesman article (faxed, not sent electronically).

Attachment 3. Draft Pest Risk Assessment. (faxed, not sent electronically).



Figure 1. Tree mortality caused by *Sirex noctilio*, Santa Catarina State, Brazil.

Figure 2. Demonstration of *Sirex noctilio* Management utilizing biological and remote sensing.



DH/AK/99

Figure 3. Location of *Sirex noctilio* outbreak in Brazil.



Attachment 1. Activities and Publications.

The following activities and publications completed in Brazil by Andrew Knapp and Brazilian cooperators were results of the current Participating Agreement and previous MOU with EMBRAPA.

Activities

- Technical Consultant. *Development of an Integrated Pest Management Program for the Woodwasp *Sirex noctilio* a Serious Pests of Exotic Pines in Brazil, 1997-2000* Colombo, Brazil. USFS/Embrapa.

- Instructor. Workshop for the Control of *Sirex noctilio*, November 26-28, 1998. USDA FS/EMBRAPA, Curitiba, Brazil.
- Instructor. *O Uso Do Sensoriamento Remoto Para Melhoria Das Florestas Dos Estados Unidos*, 1995. Federal University of Parana, Curitiba, Brazil.
- Instructor. *Curso Pratico Sobre Deteccao E Monitoramento De Pragas Florestais Atraves De Sensoriamento Remoto*, 1994. Federal University of Parana, Curitiba, Brazil.

Publications

- Knapp, K. A. 1999. *Integration of a Color Infrared Digital Camera System into Forest Health Protection Programs in the Western United States and Southern Brazil*. Proceedings of GIS Brasil 99: V Congresso E Feira Para Usuarios De Geoprocessamento Da America Latina. Salvador, Brazil. CD ROM.
- Knapp, K. A.; Disperati, A.; J. S. Zhou. 1998. *Evaluation and Integration of a Color Infrared Digital Camera System into Forest Health Protection Programs in the Western United States, Southern Brazil, and Anhui Province, China*. Proceedings of the Seventh US Forest Service Remote Sensing Applications Conference, Houston, TX. Pp. 257-268.
- Knapp, K. A. and J. S. Zhou. 1997. *Evaluation of a Color Infrared Digital Camera System in Southern Brazil and Anhui Province, China*. Proceedings of Resource Technology 1997: Beijing. Beijing, China.
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Attachment 2. Idaho Statesman article.

Attachment 3. Draft Pest Risk Assessment.