Update

Forest Health Technology
Enterprise Team Update

USDA Forest Service, State and Private Forestry, Forest Health Protection, Forest Health Technology Enterprise Team Fall/Winter 2000

Remote Sensing: FHTET in Brazil

The USFS and Brazil's Agriculture Research Agency (EMBRAPA) use satellite technology to control the spread of Sirex *woodwasps, Brazil's number one forest plantation pest.*

Factoids:

- *Sirex is Brazil's top pine plantation pest*
- *It poses significant environmental and economic risks to the U.S.*
- *It can attack all pine species*
- *It can spread up to 180 kilometers per year*
- *Contact--**Dennis Haugen** (FHP-NA) (651)649-5248 dhaugen@fs.fed.us*

There is no ironclad guarantee that any prescribed treatment or procedure will work against an outbreak. However, one thing is certain: For any treatment to be effective, it has to run its course. Along that course, progress must be monitored and milestones must be met.

The signing of the Work Plan For Cooperative Work on Developing an Integrated Pest Management Program (IPM) for *Sirex* Woodwasp *(Sirex noctilio)* between Brazil and the U.S. marks such a milestone. In 1992, USFS helped establish a biological control program to rear and deploy a parasitic nematode *(Deladenus siricidicola)* against *Sirex*, which, according to the Work Plan, has become the number one pest in Brazil's pine plantations, and which could have significant negative environmental and economic impacts if introduced to U.S. forests. Since then, the two countries have cooperated on studies and actions to locate and contain *Sirex* in exotic pine plantations in Southern Brazil. The new work plan will at once help sustain the cooperation, continue the work, and reduce the risk of *Sirex* introduction into U.S. forests.

Sirex can attack all pines, but prefers loblolly *(Pinus taeda)* and slash *(P. elliotti)* pines, which are the main plantation pines in Brazil, and which are native to North America. Furthermore, these pine species account for much of the wild forests and plantation timber in the Southern U.S. *Sirex* kills its pine hosts, and can travel up to 180 kilometers per year, naturally.

What's being done

Brazil and the U.S. have launched a high-tech / low-tech battle against *Sirex*. It's an on-going and "cyclical" operation, so it has no real beginning or end, but the theory behind the process is not complex:

- Locate the pine forests
- Survey for groups of dead trees
- Inspect individual trees for mortality, signs of infestation, and the presence of the woodwasp and / or its larvae.
- If *Sirex* is found, assess both the level of infestation within trees, plus the geographic limits within which the woodwasp is contained.
- Implement a campaign to introduce the biological control agent.
- Monitor the IPM program.

Continued, page 2

What's in the Update. . .

FHTET in Brazil, from page1

Locating the pine forests

Most *Sirex* infestations in Brazil are confined to exotic pine plantations. However, whereas large plantations are generally obvious, mapped and accessible by road, small plantations are not. Hence, the most efficient way to locate pine stands is through satellite imagery.

Thirteen Landsat 7 images have been delivered for this project. The digital data contained on the images is being analyzed with the use of a GIS-based software called SPRING, which was developed for Brazil's National Institute for Space Research (INPE) by a partnership among Brazil's Agricultural Research Agency (EMBRAPA), IBM-Brazil, and the Computer Graphics Technology Group of Brazil (TECGRAF-PUC Rio). INPE will provide technical support for SPRING applications and classifying imagery for host-type mapping. Jim Ellenwood (FHTET, Fort Collins) and Andy Knapp (Forest Health Protection, Northern Region) assisted EMBRAPA with aerial surveys and acquired color infrared images, and provided technical advice and guidance on using satellite imagery for classifying pine plantations. The classifications will then be used to create maps to locate plantations on the ground.

Landsat7 Satellite Image--NASA

This is one of 13 images collected in Southern Brazil. It is too small for detail, but gives you an idea of how discerning an eye you need to identify pine plantations.

Detection and Monitoring

Once pine stands are located, ground and aerial mortality surveys can be conducted to detect woodwasp infestations. If *Sirex* is not detected, or detected at very low levels (<5% mortality), trap trees are randomly deployed to detect the presence of the woodwasps, and sections of some trees are removed and inspected for *Sirex* larvae.

If *Sirex* is found, assessing the level and extent of the damage is a matter of broadening the search area until a boundary is detected, beyond which *Sirex* is no longer detected.

Factoids:

- *Thirteen Landsat 7 satellite images have been utilized, so far*
- *FHTET helps classify plantations and analyze infrared images*
- *The parasitic nematode,* (D. siricidicola) *attacks Sirex*
- *Containment is accomplished through sanitation and salvage*
- *Contact--***Jim Ellenwood** *(FHTET-Fort Collins) (970) 295-5842, jellenwood@fs.fed.us*

Control efforts: Contain and attack

Containment is accomplished through sanitation and salvage, i.e., the removal of trees that have been killed or infected by the woodwasp.

The most effective way to attack *Sirex* is to introduce a biological agent, the parasitic nematode *(D. siricidicola)* into the infested pine stand. The parasite attacks the *Sirex* larvae and pupae in the tree, and infects and sterilizes — but does not kill — the females. *Sirex* females mature, take flight and lay eggs. However, the eggs do not hatch, and can contain up to 200 nematodes, which will penetrate the trees and seek out other *Sirex* larvae.

Dennis Haugen (Forest Health Protection, Northeastern Area) is providing technical expertise to Brazil on the rearing, release and evaluation of the nematode and other *Sirex* parasites.

More about Sirex, pages 1, 3 thru 5

Sirex: Prevention and Treatment

It's all about preventing this pest from spreading beyond Brazil and entering the U.S.

Sirex woodwasps are present in more than 250,000 hectares (>20%) of pine plantations in southern Brazil, and without effective prevention and treatment, it can travel up to 180 kilometers per year, naturally. It won't confine itself to the plantations of Brazil; human intervention is a must.

Prevention: The highest rate of mortality from *Sirex* infestation occurs in overstocked stands. Hence, thinning is the most effective preventive measure against *Sirex*. Taller trees that dominate the canopy are likely to be more vigorous than others and show more resistance to *Sirex*. Hence, in the event thinning is necessary, taller trees would be given preference (left standing) over shorter, damaged, forked or deformed trees.

Treatment: The preferred methods for control vary depending upon the severity of the infestation and tree mortality.

- Undetected: Continue to monitor
- Light (<5% tree mortality): Inoculate trap trees
- Moderate (<10% tree mortality): Inoculate infested trees
- Heavy (10% - 50% tree mortality): Salvage killed trees, thin overstock, sanitize dead and dying trees
- Very Heavy (>50% tree mortality): Regeneration or clear cutting.

Biological control is the most effective campaign against *Sirex*, and the most effective weapon in that campaign is the nematode, *D. siricidicola*.

The nematode has a two-stage life cycle: One free and one parasitic. In the free form, the nematode burrows into the tree in search of food, the only source being the same fungus, *Amylostereum areolatum,* on which the *Sirex* larvae feed.

This fungus is symbiotic to, and the principal nutrient for, *Sirex* larvae. When the nematode encounters a *Sirex* larva, it quickly develops into an infectious adult parasite and penetrates it. The nematode

Continued, page 5

More about Sirex, pages 1, 2, 4 and 5

Factoids:

- *Sirex occupies 250,000 ha. of pine plantations in Brazil*
- *Highest mortality from Sirex occurs in overstocked stands*
- *Parasitism levels from nematode* (D. siricidicola) *can reach 99%*
- *Biological control is most effective campaign against Sirex*
- *Contacts--**Jim Ellenwood** (FHTET-Fort Collins) (970) 295-5842, jellenwood@fs.fed.us* ***Dennis Haugen*** *(FHP-NA) (651) 649-5248 dhaugen@fs.fed.us*

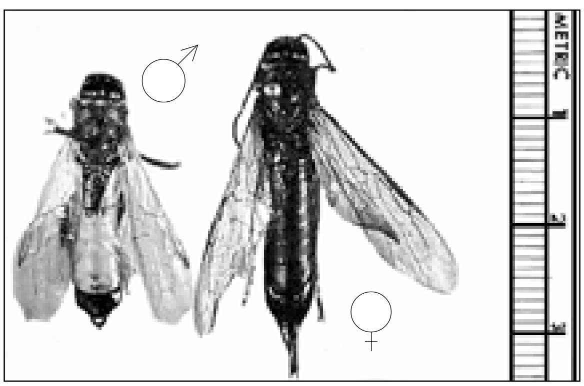
Conferences

- Forest Inventory and GIS: Real Challenges, Practical Solutions. **January 9-10**. Portland, Oregon. Sponsored by A1 Inventory Working Group, Society of American Foresters, and Western Forestry and Conservation Association. **http://www.westernforestry.org/GIS.htm**
- The FHP Remote Sensing Workshop will be held in Salt Lake City from **February 12 - 16**. Contact Jim Ellenwood (FHTET, Fort Collins) **jellenwood@fs.fed.us**
- Branching Out: Spatial Technology Goes Mainstream. **February 19 - 22**. Vancouver Trade and Convention Centre, Vancouver, British Columbia. **http://www.gis2001.com**
- Eradication of Island Invasives: Practical Actions and Results Achieved. Auckland, New Zealand. **February 19 - 23**. **http://www.issg.org/index.html#Conference**
- 2001 GITA Annual Conference XXIV. **March 4 - 7**. San Diego Convention Center, San Diego, California. **http://www.gita.org/events/01xxiv_open2.html**
- The Forest Service GeoSpatial Conference to be held in cooperation with the Univ. of Utah in Salt Lake City for **April 16 - 20. http://fsweb.gsc.wo.fs.fed.us/fsgeospatial01/index.html**
- North American Insect Work Conference. **May 14-18**. Edmonton, Alberta, Canada. **http://nofc.cfs.nrcan.gc.ca/nafiwc**

Sirex Biology

Sirex is Brazil's top pine plantation pest. FHP and FHTET are working hard to find, control and contain it, there.

The *Sirex* woodwasp (*Sirex noctilio*) is an insidious world traveler, unwitting benefactor of international trade, and a blight on local forest plantation business and economies wherever it takes up residence. It is endemic to Europe, Asia, and North Africa, and reaches its greatest density in the Mediterranean. Since the turn of the century it has stowed away in packing material, lumber, and logs, and colonized New Zealand, Australia, Brazil, Argentina, Uruguay and South Africa. It can



Jim Ellenwood

Sirex noctilio.

spread naturally up to 180 kilometers per year.

Sirex has become the principal pest of concern in all forests where it has been introduced. In Brazil, tree mortality rates as high as 60% have occurred in some exotic pine plantations. In pine plantations in Australia, *Sirex* has caused up to 80% tree mortality in just three years.

Within its native range, *Sirex* is a secondary invader of weakened and stressed pines, but it is known to attack firs and spruces, as well. (Very rarely, it attacks larch and Douglas-fir.) Particularly vulnerable to *Sirex* attacks are Monterey pine *(Pinus radiata)*, a native of California and the principal plantation pine in New Zealand and Australia, loblolly (*P. taeda)*, and slash pine *(P. elliotii)*, natives to the Southeastern U.S. and the principal plantation pines in Brazil.

Generally, the woodwasp completes one generation per year in temperate climates (e.g., Australia, Southern Brazil), but can stretch that to two years in cooler climates (e.g., New Zealand, Tasmania). Adults emerge throughout the summer, with peak emergence in early fall. Males outnumber females between 1.5:1 and 32:1.

Females are attracted to stressed trees. Generally, their initial flights are less than four kilometers. Once suitable trees are found, the females drill their ovipositors into the outer sapwood, secrete both a toxic mucus and a symbiotic fungus (*Amylostereum areolatum*), and lay up to three eggs per site. Depending upon its size, a female can lay between 20 and 500 eggs.

The toxin and fungus deliver a one-two punch that kills the trees and creates suitable environments for the larvae. The fungus softens the wood, causing it to rot. Some larvae penetrate to the center of a tree. As they burrow and mature, the larvae feed on the nutrient rich fungus *(A. arealatum)*. The larvae mature in ten to eleven months and pupate in the inner bark. Adults emerge two to three weeks after that.

More about Sirex, pages 1 thru 3, 5

Factoids:

- *Sirex attacks Monterey pine* (Pinus radiata) *loblolly (*P. taeda)*, and slash pine* (P. elliotii)*, all native to the U.S.*
- *Egg-laying females are attracted to stressed trees.*
- *Female secretes fungus and mucous that kills the tree and creates a suitable environment for the larvae.*
- *Contact--**Dennis Haugen** (FHP-NA) (651)649-5248 dhaugen@fs.fed.us*

Enterprise Team Update

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Assessing *Sirex* Risks

Sirex is Brazil's top pine plantation pest. FHP and FHTET are working hard to find, control and contain it, there.

Forest Health Protection's and FHTET's involvement in Brazil's battle to control *Sirex's* spread in that country is as much a pre-emptive strike against a would-be attacker of U.S. forests as it is a gesture of good will. It's far less costly and efficient to control it where it is and deny it access to U.S. forests, than to fight a limited ground war against it after it has landed.

Sirex is not picky about how it travels. The larvae are found at all depths in wood, and could be present in all untreated lumber from infested trees. Hence, *Sirex* can "ship out" first class in high grade cut or finished timber, economy class in medium grade un-sawn logs, or steerage class in low grade packing material used for other cargo.

Its arrival in the U.S. could spell disaster for pine forests and plantations. Here's an assessment (Dennis Haugen—FHP, Northeast Area) of what could happen in the U.S. should *Sirex* not be controlled and contained in Brazil:

1) Probability of pest establishment
   a) Entry potential: High
      i) *Sirex* life cycle is one year or longer, so larvae and pupae could easily survive the transit inside the wood.
   b) Colonization and spread potential: High
      i) If introduced, a high probability of colonization among pines would be expected within a five-mile radius of its ports of entry.
      ii) *Sirex* can spread at the rate of 180 kilometers/year, will attack any stressed or weak pines, regardless of species, in its path, and can survive in any US climate.

2) Consequences of pest establishment
   a) Economic damage: High
      i) Conservative projections place potential losses between $24- and $130-million. (*Sirex* killed up to 1.75 million trees in 1990 in Australia; damage was estimated at between $1- and $4-billion.)
      ii) The impacts of *Sirex* infestation will be worse in the Southeastern U.S. than in the Western US.
      iii) Minimum costs to contain *Sirex* in the U.S. through biological (nematode) control once it arrives are around $3.50/acre in plantations, and somewhat less in natural stands. (In a worst case scenario, *Sirex* could spread across 750-million acres of natural forests in the eleven Western States in just 25 years.)

3) Environmental damage potential: High
   a) The effect of *Sirex* on native pine forests would be significant.
      i) Changes in stand composition could occur through selective mortality.
   b) Overall tree mortality could increase through an increase in other destructive pest populations — bark beetles, root rot, etc.
   c) *Sirex* is very aggressive and could reduce populations of native woodwasps.

More about Sirex, pages 1 thru 4

Factoids:

- *Sirex larvae live one year; pupae would survive transit in woood to U.S.*
- *Economic loss to U.S. could reach $130 million if Sirex invaded.*
- *Environmental damage potential is high; overall tree mortality would increase.*
- *Contacts--**Jim Ellenwood** (FHTET-Fort Collins) (970) 295-5842, jellenwood@fs.fed.us **Dennis Haugen** (FHP-NA) (651)649-5248 dhaugen@fs.fed.us*

Sirex Prevention & Treatment, from page 3

doubles in size within its larval host and moves to the reproductive organs when the *Sirex* larva pupates. The worms sterilize, but do not kill the *Sirex* pupae. Adult female woodwasps emerge, take flight, and lay eggs. The eggs do not hatch, but each egg can contain up to 200 nematodes.

Parasitism levels vary, but have reached as high as 99% within stands in which *Sirex* infestations levels were less than 5% at the time the nematode was introduced.

TM Biocontrol-1 Sees Use against Douglas-fir Tussock Moth in the Pacific Northwest

Results show promise that this virus-based insecticide can help control the spread of DFTM.

It has been a long haul, but 26 years after The EPA issued the first experimental use permit for the TM Biocontrol-1, the insecticide has finally seen real-world action against Douglas-fir tussock moth (DFTM; *Orygia pseudotsugata*).

Factoids:

- *Relative to other biological insecticides, TM Biocontrol-1 has fewer potential effects on non-target moths and butterflies.*
- *TM Biocontrol-1 is a natural virus that attacks DFTM.*
- *Heavy damage is expected in Oregon by 2002.*
- *Caterpillars do all the damage.*
- *Contacts--**Iral Ragenovich** (FHP - R6) (503) 808-2915, iragenovich@fs.fed.us **Dick Reardon** (FHTET - Morgantown) (304) 285-1566, rreardon@fs.fed.us*

What's more, preliminary information suggests that the insecticide works.

Between June 15 and July 18, 2000, TM Biocontrol-1 was used against a DFTM outbreak in the Umatilla and Wallowa-Whitman National Forests in Washington and Eastern Oregon. Initial analyses of larval mortality, defoliation, and virus presence suggest that the insecticide interrupted the population cycle and prevented any damage that otherwise would have occurred next year. (Further evaluations will be conducted next year.)

DISCUSSION

The biological control agent

The USDA Forest Service has been driving the development, production and EPA registration of TM-Biocontrol-1 since the 1960s. FHTET was instrumental in completing bioassays and developing technologies to improve its performance and application, and in re-registering the insecticide in 2000.

Its active ingredient is a natural virus (nucleo polyhedrosis virus — NPV) that is often the primary cause of the collapse of DFTM outbreaks under natural conditions. The virus is specific only to the DFTM and two other species of tussock moths in the West. Hence, relative to other biological insecticides, it has fewer potential effects on non-target moths and butterflies.

Purpose and need

DFTM populations have been rising east of the Cascades in Oregon and Washington for several years and are expected to cause heavy damage before cycling to a stop in 2002 (see *DFTM Outbreak*, page 8). An Environmental Impact Statement (EIS) was prepared to identify an appropriate course of action to take against the outbreak. According to

Continued, page 7

More about DFTM and TM Biocontrol-1, pages7 thru 10

Biology of the Douglas-fir Tussock Moth

The Douglas-fir Tussock Moth (DFTM; *Orygia pseudotsugata* McDunnough) is a native of fir forests from British Columbia to Southern California, Arizona, and New Mexico, though historically the most extensive outbreaks have been in the Pacific Northwest. DFTM caterpillars (larvae) are a major defoliator of fir forests in western North America. In fact, the caterpillar does all the damage. Douglas-fir and true firs are the moth's preferred food source; however, they will feed on other species when all available fir needles have been eaten. Large populations of larvae can completely strip trees of all their needles in a few weeks.

Caterpillars emerge in the spring from eggs and eat the conifer's needles, beginning with the current year's (new) growth and progressing to the older needles as the larvae mature.

Continued, page 8

TM Biocontrol-1, from page 6

the Record of Decision (ROD—May, 2000), TM Biocontrol-1 was selected as the preferred biological agent to use against the DFTM, and that its use was necessary

> . . . to maintain the vegetative conditions of specific Areas of Concern where the tussock moth defoliation would change or jeopardize vegetative conditions for resources, such as: aquatic and terrestrial threatened and endangered species habitat; watersheds; areas for human use and enjoyment; and areas where the Forest Service has made substantial investment.

Sampling and project area

The DFTM Early Warning System (see *FHTET Update*, spring 1999) predicted that the 2000 outbreak would be more widespread than earlier outbreaks. Ground surveys were necessary to pinpoint areas most likely to suffer heavy damage.

Factoids:

- *The findings indicated potentially high tussock moth out-breaks on about 80,000 acres*
- *Larvae cease feeding within several days after ingesting the virus, and then die several weeks later.*
- *Only National Forest lands were involved in the project.*
- *Contacts--**Iral Ragenovich** (FHP - R6) (503) 808-2915, ragenovich@fs.fed.us*
  ***Dick Reardon** (FHTET - Morgantown) (304) 285-1566, rreardon@fs.fed.us*

DFTM cocoons were surveyed in the fall of 1999 to predict where large populations would occur in 2000. Population levels were estimated, and this information was overlaid onto GIS maps. The findings indicated potentially high tussock moth outbreaks on about 80,000 acres on the Umatilla and Wallowa-Whitman National Forests.

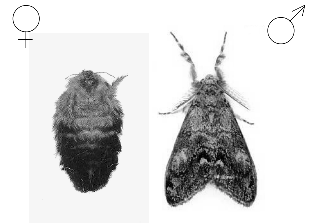
There were five analysis units established within the survey area, and for logistics and treatment purposes, those units were divided into smaller spray blocks.

Application and monitoring

Units were identified for treatment based on preliminary population sampling; treatment would occur only after additional spring sampling confirmed the presence of treatable populations of DFTM larvae. Blocks were released for treatment when (1) unit populations had, on average, ten or more larvae per 1,000 in^2 of foliage and (2) 60% of the insects reached at least the second instar.

Spraying had to occur within three days after the blocks were released for spraying. If this deadline was missed, sampling had to be done again before spraying could be done. Spray condition parameters included wind speed between 1 and 8 mph, and relative humidity more than 50%. Most spraying occurred between 5 and 7 am, as weather permitted.

Only National Forest lands were involved in the project. Helicopters sprayed TM-Biocontrol-1 over 39,392 acres in five units. (Not all of potential outbreak areas were recommended for treatment; in many places, DFTM can act as a positive natural disturbance agent by reducing overstocking and creating stand openings.) Notices were posted at recreation sites and along roads, and the public was contacted daily within treatment areas. Dick Reardon (FHTET-Morgantown) helped mix the insecticide with a specially developed carrier.



Female DFTM are flightless and have threadlike antennae, while males have feathery antennae

http://www.forestry.ubc.ca/fetch21/FRST308/lab5/orgyia_pseudotsugata/tussock.html

Results sampling

Larvae cease feeding within several days after ingesting the virus, and die several weeks later.

Defoliation levels were assessed both before treatment and 35 days after treatment; population samples were taken just prior to treatment, and 28 and 35 days after treatment. Two live larvae were collected before treatment on one to three plots per spray block, and then two live larvae were collected from each plot at seven to ten days after treatment. The larvae were sent by express delivery to a lab in La Grande, OR, and reared until they died; cause of death was then determined. Mortality due to virus should increase after spraying.

Details of the 2000 project (as well as maps of the project areas) can be viewed on a Pacific Northwest Region website at http://www.fs.fed.us/r6/nr/fid/dftmweb/project.htm.

More about DFTM and TM-Biocontrol-1, pages 6, 8 thru 10

DFTM Biology, from page 6

Trees are killed from the top down, retarding their growth and making them susceptible to disease and secondary infestations by insects such as bark beetles.

Populations are cyclical, with outbreaks occurring every seven to 13 years. Outbreaks typically occur in mature and over-mature, multi-story stands with high density of host trees, tend to last two to four years, and end very suddenly. Since females do not fly, outbreaks generally arise in place, with little or no spread into un-infested or previously treated areas.

At low population levels, parasites and birds kill a large proportion of the eggs, larvae, and pupae. At outbreak population levels, extensive larval mortality is caused by a combination of competition for food and the naturally occurring nuclear polyhedrosis virus (NPV). At outbreak population levels, damage can be minimized by applying insecticides, including TM-Biocontrol-1, the polyhedrosis virus, and *Bacillus thuringiensis kursaki* (B.t.k.), a bacterium-based insecticide. TM-Biocontrol is specific to DFTM and two other western tussock moths, while B.t.k. will affect caterpillars of other moths and some butterflies.

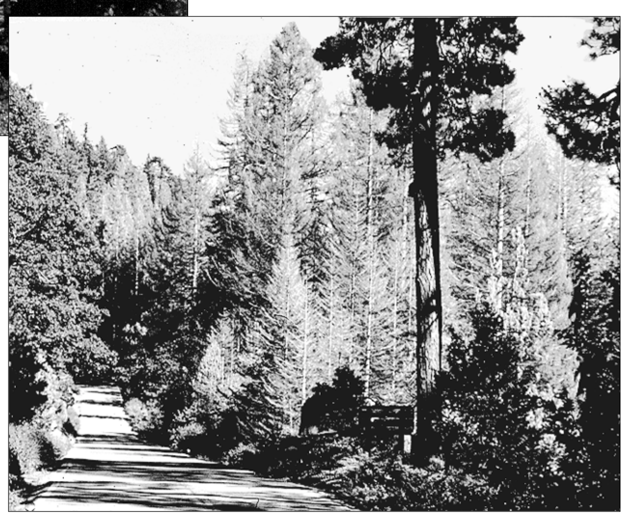
Effects of DFTM outbreaks are not undesirable in all circumstances. Hence, not all outbreaks require a response. DFTM acts primarily in mature and over-mature stands, and outbreaks can help reduce stand densities, create food sources for other organisms, and create openings for regeneration of young trees.

Factoids:

- Populations are cyclical; outbreaks occur every 7 - 13 years.
- Heavy defoliation and damage are likely in summer, 2000.
- Contacts--**Iral Ragenovich** (FHP - R6) (503) 808-2915, iragenovich@fs.fed.us **Dick Reardon** (FHTET - Morgantown) (304) 285-1566,rreardon@fs.fed.us **John Wenz** (R5 - Stanislaus N.F.), (209) 532-3771 ext.323, jwenz@fs.fed.us

DFTM Outbreak History

Douglas-fir tussock moth (DFTM) populations have been rising east of the Cascades in Oregon and Washington for several years. According to data from the early warning trapping system (see *FHTET Update*, spring 1999), this trend appears to be more widespread than outbreaks in the 1980s and 1990s. During the summer of 1999, DFTM caused light to medium defoliation on approximately 21,000 acres of forest in the Blue Mountains of northeastern Oregon. Heavier defoliation, and more extensive damage were predicted for the summer of 2000. The current outbreak is expected to take place between 2000-2002, but could last through 2004. The naturally occurring virus and localized starvation probably will cause DFTM populations to collapse — but not before defoliation causes significant damage in many areas.

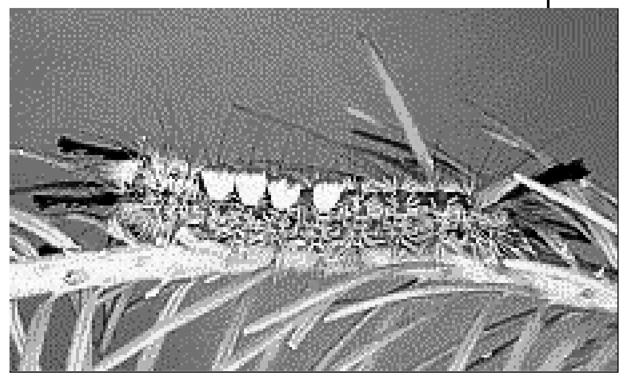


Two images of the same section of road and forest. The image to the left was taken in September, 1998. The image at the bottom was taken one year later. The lighter trees have been damaged by DFTM.

More about DFTM and TM Bio control-1, pages 6, 7, 9, 10

Late In

Chronology of TM Biocontrol –1 Development & Registration History



Late Instar DFTM
http://www.forestry.ubc.ca/fetch21/FRST308/lab5/orgyia_pseudotsugata/tussock.html

1916. The ***first recorded outbreak*** of the Douglas-fir tussock moth (DFTM) at Chase, British Columbia. Several major outbreaks have occurred since then with detailed documentation starting in mid-1940s.

1947. The ***nucleopolyhedro virus*** (NPV) of the Douglas-fir tussock moth was first ***identified*** from larval collections near Troy, OR, Colville, WA, and Orofino, ID.

1964. A new insect pathology project was established at the US Forest Service Pacific Northwest Research Station to develop a ***control method using the nucleopolyhedrosis virus*** (NPV) of the Douglas-fir tussock moth.

1965. Simulated field trial resulted in ***population suppression of DFTM*** with a dose rate of 50×10^9 polyhedral inclusion bodies (PIBs) per acre. Eggs collected near Goose Lake in northern California established the inbred strain of DFTM for standardized NPV production.

1966. Initiation of the Forest Service Joint Research & Development effort to identify the specific virus, toxicity, small-scale propagation, formulation of spray mixtures, and conduct field-tests. The first of three successful ***contracts awarded to private industry to propagate DFTM larvae and the NPV.***

1972. The Environmental Protection Agency ***(EPA) banned DDT***, which was the only effective insecticide used for the control of DFTM. A second contract was awarded to private industry to propagate the NPV.

1974. ***EPA issued the first Experimental Use Permit.*** This same year, money was appropriated for the Expanded Douglas-fir Tussock Moth Research and Development Program in the 'Forest and Rangeland Renewable Resources Planning Act'. The third and last successful contract was awarded to private industry for NPV propagation. All three contractors produced a total of approximately 10,000 acre doses of the NPV. This year was also the last time the Forest Service was granted emergency authorization to use DDT.

1976. The ***NPV for the Douglas-fir tussock moth was registered*** as a microbial control agent and labeled as TM BIOCONTROL-1 in the United States. This was the first virus registered for a forest pest.

1978. A fourth Forest Service ***contract*** was awarded for ***production of 50,000-acre doses of the NPV.*** This contract was terminated for lack of performance (no virus produced) in 1979.

1980. The Forest Service Pacific NW Region (R-6), established the ***first*** and only ***large scale TM Biocontrol-1 Baculovirus Production Facility*** in Corvallis, OR, under the management of Dr. Donald Scott. The original goal was to produce 50,000-acre doses of the NPV.

1986. Health Canada, Pest Management Regulatory Agency, approved the registration of TM Biocontrol-1 for use against DFTM in Canada.

1993. The Region 6 ***TM Biocontrol-1 Baculovirus Production Facility was closed in June.*** From 1980 until closure in 1993, the facility had produced the equivalent of approximately 400,000-acre dose of the virus. The virus was placed in monitored storage at the Forest Sciences Laboratory at Corvallis, OR.

1998. ***FHTET re-registered the virus*** under the trade name TM-Biocontrol. The updated label complied with the revised Federal Insecticide, Fungicide, and Rodenticide Act (as amended in 1988). The Enterprise Team also initiated a contract with the Canadian Forestry Service to bioassay the NPV product in storage.

2000. ***The Pacific NW Region (R-6)*** developed a field project and selectively ***applied the virus to 39,392 acres*** in "Areas of Concern" in National Forests of Washington and Oregon. EPA approved an amended label in August with the trade name TM Biocontrol-1. The revision basically updated the environmental hazard statement and improved the information content on the label.

Contact: John Stein (FHTET - Morgantown) (304) 285-1584, jstein@fs.fed.us

More about DFTM and TM Biocontrol-1, pages 6 thru 9

The Web Corner

Douglas-fir Tussock Moth in The Pacific Northwest

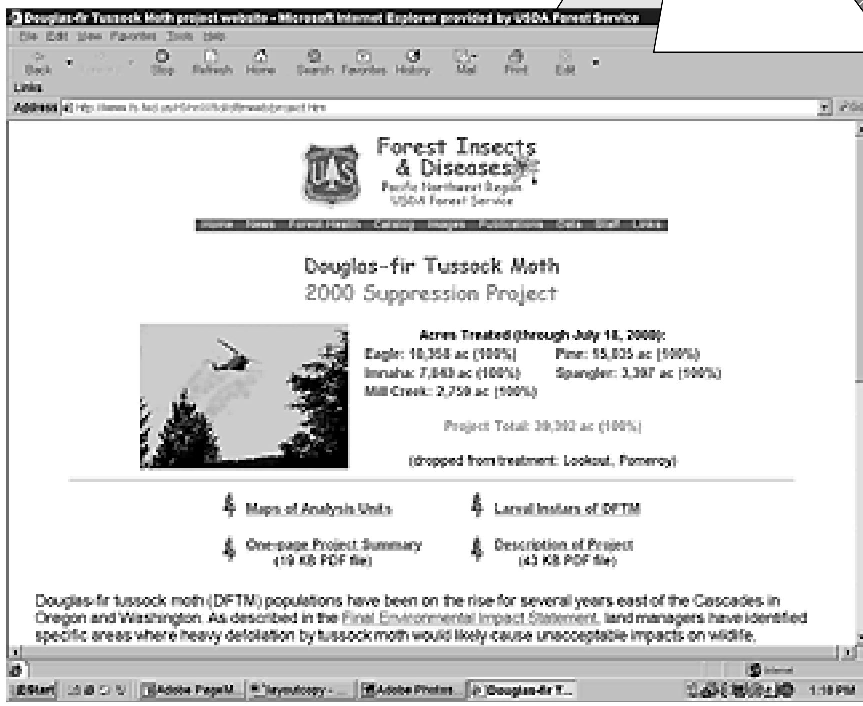
http://www.fs.fed.us/r6/nr/fid/dftmweb/

This website has four sections including: Suppression Project 2000 (shown at right); *Environmental Impact Statement/Record of Decision; and Tussock Moth Biology and Management.*

You'll find the site easy to navigate and packed with useful information about DFTM.

The site has many links that will take you to sites within the US and Canada. There are photo galleries, charts and tables available. Information on some sites is in PDF *format, and accessible only with an* Adobe Acrobat Reader, *which is available as freeware from* Adobe (http://www.adobe.com).

Also, there are links to other forest-pest and health sites.



Other websites to visit

- **http://willow.ncfes.umn.edu/pubs/fth_pub_pages/fidlpage.htm** USDA-FS. Forest Insect and Disease Leaflets. Alphabetic and numeric listings of online FID Leaflets, fact sheets and 'how-tos', with links to related forestry websites.
- **http://www.fs.fed.us/na/morgantown/fhp/palerts/palerts.htm** USDA-FS. Common pest alerts in the U.S.- Master List of common pests, and related links.
- **http://www.fs.fed.us/foresthealth/i_d_news/i_d.html** USDA-FS State and Private Forestry. Forest Insect and Disease News Bulletins.
- **http://ipmwww.ncsu.edu/opmppiap** USDA- Office of Pest Management Policy and Pesticide Impact Assessment Program. Home Page. OPMP provides coordination to pest management programs across several USDFA agencies, and oversees the PIAP. This site contains a pesticide database, and list of publications.
- **http://www.aphis.usda.gov/nbci/nbci.html** USDA-APHIS (Animal and Plant Health Inspection Service). National Biological Control Institute was established by APHIS in 1990 "as part of the Department's commitment to implement biological control, sustainable systems, and integrated pest management …to promote, facilitate, and provide leadership for biological control." This site provides numerous links to biological control web sites.
- **http://www.scisoc.org/ppigb/** Hosted by the American Phytopathological Society. The website for the Plant Pathology Internet Guidebook. It is a subject oriented Internet resource guide for plant pathology, applied entomology, and all related fields.

Exploring a new Technology In Digital Sketchmapping

Good-bye paper, hello touchscreens

Aerial sketchmapping is nearly as awkward today as it was 80 years ago when the first recorded aerial survey was conducted on budworm damage in Quebec and Ontario, Canada.

As much an art as it is a science, the process involves one or two sketchmappers sitting in a small, often cramped airplane, peering out windows at the forest below, and recording their observations on several, usually taped-together USGS topographical maps.

For all that, it is the most accurate and efficient means of monitoring and recording forest change over large areas.

But improvements are underway. The Remote Sensing Applications Center (RSAC — Salt Lake City, UT) and the Forest Health Technology Enterprise Team (FHTET — Fort Collins, CO) are beta-testing a new digital technology, which, if early field trials (beta tests) are any indication, will at once:

- Elevate both the art and science of sketchmapping
- Improve its accuracy, and
- Simplify the entire process.

A Global Positioning Satellite (GPS) receiver is crucial to digital sketchmapping. The receiver, plus special software, allow two things to happen, simultaneously. First, they display on a computer monitor in the cockpit the USGS topo map (usually 1:100,000 for contiguous states; 1:125,000 for Alaska) that corresponds to the area over which the plane is flying. Second, they plot and track the plane's progress across the displayed map. Hence, the sketchmapper is always aware of the plane's position, relative to what s/he observes below. The computer monitor is touch-sensitive. The sketchmapper records her/his observations directly onto the digital map by sketching polygons on the monitor. The data is automatically stored in digital form.

Advantages of this digital system include:

- Ease of use
- Quicker analysis of forest damage
- Higher quality data
- Lower potential for errors

Factoids:

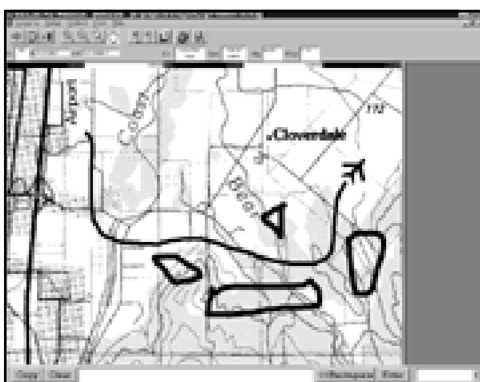
- *The technology is now in beta-testing*
- *The response from field trials and demos has been positive and enthusiastic.*
- *Contact--**Ross Pywell** (FHTET - Fort Collins) (970) 295-5848, rpywell@fs.fed.us*

User Response and System Refinement

By and large, the response from field trials and demos has been positive and enthusiastic. But it is the intent of beta-testing to find problems — and indeed, there are

Continued, page 12

More about Digital Sketchmapping, pages 12 thru 14



Simulation

Beth Schulz (FHP-Region 10) uses a touch-screen to do real-time digital sketchmapping in Alaska.

Sketchmapping continued, from page 11

problems with the technology. Improvements must be made in the following four areas before the technology can be deployed:

- Improve user/software interface
- Reduce the amount of equipment, cabling, and overall weight of the system
- Improve reliability of the hardware and software
- Enable two sketchmappers to work on the same map on separate monitors, simultaneously

Problems: To begin with, the system was designed to utilize existing Forest Service computer and GPS equipment, meaning IBM ThinkPads, Windows 95, and Trimble GPS units (see *System Configuration*, below). This configuration proved unsuitable for the vibration-prone, confined space of a light aircraft. The vibrations would cause some computer lids/screens to close, causing the computer to shut down, and connectors to shake loose. (Altitude and vibration might shorten the useful life of disk drives, too.) By its nature, the system is memory-intensive; large files are being updated and manipulated continuously. The longer the system remains up during a survey, the slower it gets. Ultimately, it can slow to the point where the maps on the screen do not refresh fast enough to keep up with the plane's flight progress. Sometimes, a system would lock up altogether. Finally, as now configured, only one sketchmapper can use the system at a time.

Solutions: Most of the changes can be done fairly soon and at relatively low cost. **Charlie Schrader** (RSAC/RedCastle Resources, Inc.) and **Ross Pywell** (FHTET-Fort Collins) have been working with hardware and software vendors and hope to complete changes before the beginning of the 2001 field season. The team is investigating the availability and/or development of a lighter, more compact system specifically for aircraft use. The system will incorporate the touch-screen; a computer with a faster processor, larger, more durable hard drive and more memory; and a GPS receiver into a self-contained, upgradeable unit.

Generally, the norm for aerial sketch-mapping is two observers to a plane, so new software is being developed that will allow two mappers to work on the same map at the same time. This will improve communications within the aircraft; allow each observer to monitor the other in real-time; and improve the quality of the data by reducing the chances that something will be missed or mapped twice.

Summary

Feedback from digital sketchmapping field trials and demonstrations has been enthusiastic and positive. Further development and testing of a more rugged and reliable computer designed for aircraft use is needed. Once perfected, the new system will improve the quality of the data obtained from aerial surveys.

More about Digital Sketch-mapping pages 11, 13, 14

System Configuration

Development of the digital sketchmapping system was undertaken by **Ross Pywell** (FHTET-Fort Collins), **Charlie Schrader** (RedCastle Resources, Inc./RSAC), and **J.D. Mullen** and **Lowell Lewis** (Intecs International/FHTET).

The main components are a laptop computer/Windows 95; touch-screen; global positioning system (GPS) receiver; and software, including United States Geological Survey maps and Geolink®, (Michael Baker Corporation, Billings, MT). Peripherals include a power converter and distribution system, serial port adapter, and numerous connecting cables.

The touch-screens were manufactured according to performance requirements, while other components were purchased as off-the-shelf units.

A Brief History of Aerial Surveying

From, *A Guide to Conducting Aerial Sketchmapping Surveys,* FHTET 00 - 01, March 2000

In 1919, Gordon Hewitt recommended using aircraft for forest insect detection after flying over mosquito-breeding areas in parts of British Columbia. In 1920, an open-cockpit hydroplane was used to survey a spruce budworm infestation in parts of Quebec and Ontario.

One of the earliest attempts to survey forest insect damage from the air was made by J.M. Miller in 1925 over the Sierra National Forest, in California, in an open-cockpit airplane. In 1930, the Bureau of Entomology used a Forest Service airplane to survey bark beetle outbreak areas of Yellowstone National Park. In 1931, F.P. Keen, from the Portland Forest Insect Laboratory, and C.S. Cowan, Chief Fire Warden of the Washington State Fire Association, conducted the first recorded aerial survey of a forest insect outbreak in the two northwestern states when they delineated a hemlock looper outbreak in southwest Washington.

In 1947, an annual aerial survey program was instituted by the Bureau of Entomology and Plant Quarantine, USDA, cooperators from the States of Washington and Oregon, and the Weyerhaeuser Timber Company. The pioneers of the modern aerial survey, when it began in Portland, Oregon, were W.J. Buckhorn, a seasoned entomologist, and John F. Wear, a young research forester and pilot just out of graduate school after World War Two. Together, they flew aerial surveys for several years and, in 1955, wrote "Organization and Conduct of Forest Insect Aerial Surveys," the first guide to conducting aerial sketch-map surveys. Their report is still relevant today, despite the subsequent development of better maps and more powerful aircraft.

More about Digital Sketchmapping pages 11, 12, 14

Yun Wu named new FHTET Pathologist

Research scientist **Yun Wu** joined the FHTET (Morgantown) staff as a pathologist on December 31, 2000.

Currently, Yun is completing her PhD in Forestry at Michigan Technological University (MTU) and working with the Enterprise Team in Morgantown under a cooperative agreement with MTU. Her specialty is the biological control of forest diseases and weeds.

She has been in Morgantown since 1995 and previously worked with Bristol Botanics in Littleton, Colorado, and as a biological technician with Forest Health Protection at the Lakewood Service Center in Denver.

Yun earned a M.S. in Forestry, with specialties in mycorrhizae and tree relationships, at MTU, and her B.S. in Forest Pest Management at Northeast Forestry University in Harbin, China. She has worked on identifying potential biological control agents for *Cylindrocladium* root disease in forest nurseries and, most recently, on identifying and using plant pathogens as biological control agents for Mile-a-Minute (MAM) weed (*Polygonum perfoliatum* L.), an invasive plant from Asia that is spreading rapidly across the eastern U.S.

Her work on MAM has involved conducting surveys on the plant's natural control agents in its native range in northern and north-eastern China. While on this project, she helped coordinate U.S. projects on Asian Longhorned Beetle with various Chinese governmental agencies and universities.

Yun will work with Program Manager for Biopesticides and Biological Control **Richard Reardon** (FHTET-Morgantown). She will assist in developing and implementing the plant pathology component of the overall FHTET program with specific emphasis on identifying and evaluating the potential of plant pathogens as biological control agents against forest pests, including insects, diseases and weeds.

Yun's goal is to find and implement environmentally friendly methods to manage forest pests.

Who has Digital Sketchmapping?

Want to talk with someone who has seen a demo of this new technology? Want to chat with someone who has used it? Contact any of these folks . . .

Northeastern Area – 2 systems – Key contacts: **Bill Frament**, Remote Sensing Specialist, Forest Service – USDA, Durham Field Office, 271 Mast Road, PO Box 640, Durham, NH 03824. Tel: 603.868.7707, email: **wframent@fs.fed.us**, and **Rodney Whiteman**, Forester, Forest Service – USDA, Morgantown Field Office, 180 Canfield Street, Morgantown, WV 26505. Tel: 304.285.1555, email: **rwhiteman@fs.fed.us**.

Region 3 – 1 system – Key contact: **Bobbe Fitzgibbon**, Entomologist, Forest Service – USDA, Arizona Zone Office, 2500 S. Pine Knoll Drive, Flagstaff, AZ 86001. Tel: 520.556.2072, email: **bfitzgibbon@fs.fed.us**.

Region 5 – 1 system – Key contact: **Bill Woodruff**, Pathologist, Forest Service – USDA, Northeast California Shared Service Area, 2550 Riverside Drive, Susanville, CA 96130. Tel: 530.252.6680, email: **wwoodruff@fs.fed.us**.

Region 6 – 2 systems – Key contact: **Keith Sprengel**, Forestry Technician, Forest Service – USDA, Westside Service Center, 16400 Champion Way, Sandy, OR 97055. Tel: 503.668.1476, email: **ksprengel@fs.fed.us.**

Region 8 – 4 systems, 2 at NF in Alabama, 2 at Pineville Field Office — Key contact: **Forrest Oliveria**, Entomologist, Forest Service – USDA, Pineville Field Office, 2500 Shreveport Highway, Pineville, LA 71360. **Tel:** 318.473.7294, email: **foliveria@fs.fed.us**

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Region 10 – 2 systems. Key contacts: **Dustin Wittwer**, Biological Technician, Forest Service – USDA, Forestry Sciences Laboratory, 2770 Sherwood Lane, Suite 2A, Juneau, AK 99801. Tel: 907.586.7848, email: **dwittwer@fs.fed.us**, and **Kathy Matthews**, Forest Service – USDA, 3301 "C" Street, Suite 522, Anchorage, AK 99503-3956. Tel: 907.271.2574, email: **kmatthews03@fs.fed.us**.

Oregon Department of Forestry – 2 systems – Key contact: **Mike McWilliams** — Oregon Department of Forestry, Insect and Disease Branch, 2600 State Street, Salem, OR 97310. Tel: 503.945.7395, email: **mike.g.mcwilliams@state.or.us**

More about Digital Sketchmapping, pages 11 thru 14

Mountain Meteorology

Essential reading for anyone whose life is affected by mountain weather

C. David Whiteman's *Mountain Meteorology: Fundamentals and Applications* (Oxford University Press, ISBN 0-19-513271-8) offers an introduction to the basic principles and concepts of mountain weather, and explores their applications to natural resource management. Primarily descriptive and non-mathematical, it aims to heighten awareness and understanding of weather systems, patterns, and events in mountainous areas by emphasizing observable indicators of atmospheric processes.
The book is a comprehensive work filled with diverse examples and 274 colorful figures, diagrams, and photographs.

The mountains of North America provide most of the examples included in the text, although the principles behind the examples apply to mountainous regions around the world. *Mountain Meteorology* is divided into four parts. Part I discusses the factors that influence climate and describes the characteristic climates of mountainous areas of North America. Part II describes basic weather elements and processes. Part III focuses on mountain wind systems, which are key to understanding all types of mountain weather. Part IV applies the meteorological principles discussed in earlier chapters to selected forest and land management practices and operations.

Harold Thistle (Program Manager- Equipment & Application

Continued, page 16

Meteorology, from page 14

Technologies, FHTET-Morgantown) and **John (Jack) W. Barry** (USDA Forest Service retired) wrote a chapter, “Aerial Spraying”, for *Mountain Meteorology*, in which they discuss the role of meteorology in the aerial application of liquid pest control agents to manage plant, fungal, and animal pests in mountainous, forested areas.

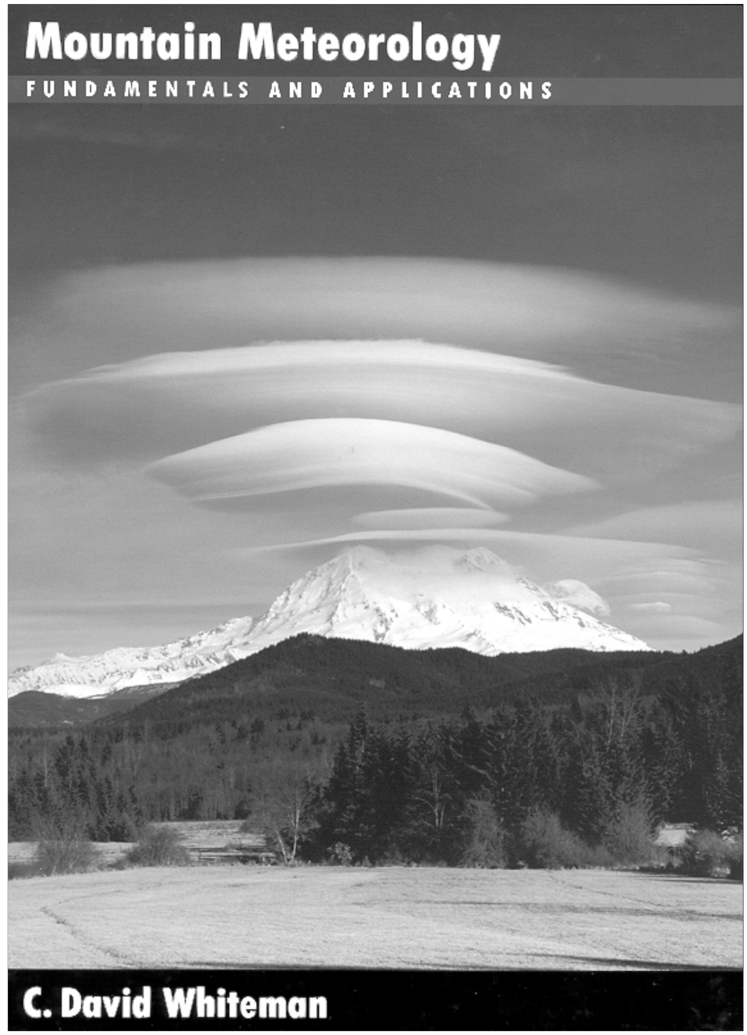
Weather is one of several factors (including phenological conditions, forest canopy characteristics, spray formulation, spray equipment, aircraft type, and pilot skills) that affect the effectiveness of a spray operation; thus, the collection of meteorological data and use of professional weather forecasters are integral to a spraying operation. Using the meteorological information presented in the book, a project manager can evaluate the information available, and integrate it into an operational plan and field operation.

Harold and Jack were also on the editorial board that provided technical resources and guidance on the technical content, and arranged for the review and publication of the manual.

Work on *Mountain Meteorology* was initiated with the support of the USDA Forest Service to address the need for a training manual for aerial spraying operations in National Forests, and was also supported by the National Weather Service and the U.S. Army. *Mountain Meteorology* is useful for those whose lives are affected by mountain weather in recreational, residential, or professional settings, and is essential for professionals, scholars, and students of meteorology.

This book is available free of charge as long as the initial order lasts. To receive a copy, write to:

Publications
USDA Forest Service
MTDC Bldg. #1
Ft. Missoula, Missoula, MT
59804



About The Author

C. David Whiteman is a Staff Scientist at the U. S. Depart-ment of Energy’s Pacific Northwest National Laboratory in Richland, Washington, where he does research in mountain meteor-ology, boundary later meteor-ology, and air pollution meteorology. He also teaches meteorology at Washington State University, is a Certified Consulting Meteorologist, and serves as an editor of the Journal of Applied Meteorology.