United States
Department of
Agriculture

Forest Service

**Pacific
Northwest
Region**

Umatilla NF

Wallowa-Whitman
NF

Report No.
BMPMSC-**01-04**

December 2000

Project Manager
Nick Greear

Douglas-fir Tussock Moth Project

Final Report

2000

Douglas-fir Tussock Moth Project

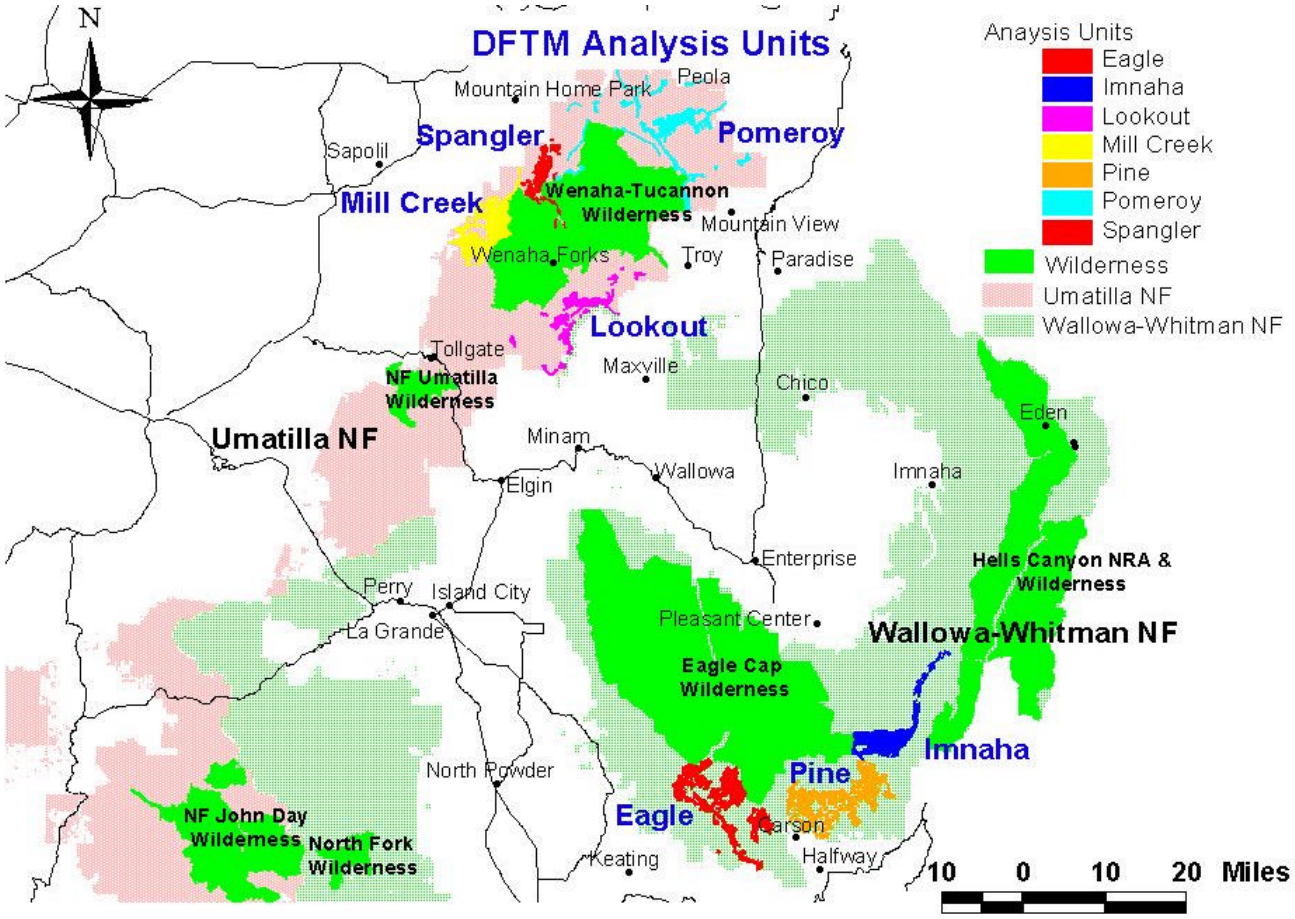
Final Report

For

Umatilla National Forest

and

Wallowa-Whitman National Forest



Douglas-fir Tussock Moth Project Area

Table of Contents

Executive Summary....1
I. Project Area....3
II. Accomplishments....3
III. Entomology (Paul Joseph, Roger Sandquist)....4
A. Verification Of Treatable Populations....4
B. Insure Proper Timing of Insecticide Application....5
C. Estimate Population Densities....6
D. Protection Of Foliage....8
IV. Virus and Parasite Monitoring (Don Scott)....13
A. Introduction....13
B. Objectives....14
C. Methods and Procedures....14
D. Results and Discussion....16
E. Conclusions and Recommendations....29
V. Riparian Shade Monitoring (Tom DeMeo, Kathryn Boula, Mark Fedora)....30
A. Introduction....30
B. Purpose....30
C. Methodology....30
D. Data Analysis....33
E. Results....33
F. Discussion....33
G. Acknowledgments....34
VI. Operations (Art Anderson)....34
A. 038 Carrier....34
B. Virus Handling....35
VII. Contracting (Carl Culham)....35
A. General....35
B. Events Chronology....36

C. Final Contract Quantities....36
VIII. Finance (Dana Reid)....36
A. Organization....37
B. Personnel & Hiring....37
C. Per Diem & Travel....38
D. Payroll....38
E. Claims....39
F. Accidents, Injury, Illness....39
G. Procurement....39
H. Costs....39
I. Total Project Costs and Cost per Acre....40
IX. Safety (Steve Snider)....41
A. Summary Of Field Crew Activities....42
X. Information (Judy Wing)....42
XI. Project Critique....43
A. Group Critique....43
B. Additional Recommendations from Team:....44
1. Command....45
2. Aviation Operations....48
3. Finance Section....48
References....49

Appendices:

A: Analysis Unit Maps
B: Organization Charts
C: Operational Accomplishments
D: Project Costs Summaries
E: Project Entomology Plan
F: Degree Day Summary

Executive Summary

The Project was initiated as a result of a tussock moth outbreak. Based on the 1997, 1998, and 1999 results of the "early warning system", an outbreak of Douglas-fir tussock moth was predicted. The outbreak was validated by the occurrence of about 21,000 acres of defoliation in 1999. An Environmental Analysis was conducted, an Environmental Impact Statement published and a Record of Decision signed (http://www.fs.fed.us/r6/nr/fid/eisweb/dftm_eis.htm) empowering action to be taken, if necessary.

The history of damage by this insect required the agency to be prepared to suppress its populations if significant resources were threatened. The tussock moth typically defoliates trees in patches, sometimes over large areas, which can result in significant tree mortality. In the early 1970s approximately 700,000 acres were defoliated in Oregon, Washington, and Idaho. There was approximately 17,270 acres of total mortality in patches, and 75 % tree mortality over 62,070 acres, and 10 % tree mortality over 275,660 acres (USDA Forest Service, 1974).

The Regional goal for the National Forests affected by the DFTM: To maintain existing desired vegetative conditions in Areas of Concern that are at risk from Douglas-fir tussock moth defoliation within the next two to five years. These areas include but are not limited to aquatic and terrestrial species habitat, areas for human use and enjoyment, and administrative areas.

There is a need for management intervention into the natural cycle of the DFTM: The need exists to protect specific Areas of Concern where tussock moth defoliation would change or jeopardize vegetative conditions in Threatened and Endangered (T & E) species habitat, health, and safety areas, and areas where the Forest Service has made substantial investments (such as a seed orchard). Preserving this vegetation would maintain desired habitats for fish and wildlife, preserve campgrounds, and maintain important scenic viewsheds. Additionally, there is a concern for public health. The hairs on the larvae can cause welts, rashes, and other allergic reactions in some people.

Objectives for areas of the Umatilla (Walla Walla and Pomeroy Ranger Districts) and Wallowa-Whitman (Pine Ranger District and Hells Canyon NRA) National Forests:

- Protect riparian habitat where defoliation would cause unacceptable degradation of occupied habitat, especially critical spawning or rearing habitat for salmon, steelhead, and bull trout (loss of shade, increased sedimentation, etc
- Protect designated old growth and late/old structure ("OG/LOS") stands where defoliation would substantially degrade habitat values.
- Protect residential and administrative sites where defoliation and the presence of large numbers of larvae would adversely affect people living or working there. This would include work centers, special use permit summer home sites, resorts, or established camps.
- Protect high use recreation sites where defoliation and the presence of large numbers of larvae would adversely affect many forest visitors. This would include campgrounds, picnic areas, and interpretive sites.
- Protect municipal watersheds where an existing formal agreement is in place and where 100% defoliation would have unacceptable impacts on water quantity or quality.

- Protect designated foreground scenic Areas of Concern where defoliation would have a substantial adverse impact on scenery.
- Protect seed orchards and plantations of genetically superior trees where defoliation would result in a considerable loss of investment and a reduction of seed needed for future seedling demand.
- Protect areas where investments have already been made to protect Douglas-fir or other firs from bark beetles.
-

The proposed action was to spray TM Bio-Control on areas where outbreak or sub-outbreak populations of DFTM populations have been verified.

In mid-January, 2000 we began to make plans to initiate an insect suppression project if a final decision was made to proceed. An organization was established using the Incident Command System as a model. On February 14-15 the primary team had been assembled and we held our first meeting in La Grande Oregon. Further planning meetings were held March 13-17, April 17-21, and then on May 3-5. The project fieldwork started May 8 with local employees.

Up to 113 personnel worked approximately 53,000 hours and drove about 96,000 miles. About 200 hours flight time were logged. We treated almost 40,000 acres with TM Bio-Control, had four minor personal injuries, three vehicle accidents of which two were minor, and only one aviation SAFECOM filed.

Direct Project field costs, including the spray contract, were approximately $2,659,000 ($67 per acre). Total costs including preparation of the EIS and (future) monitoring are estimated to be $3,242,000. The EIS is valid for three more years within the Region.

Initial entomological analysis indicates how well the following objectives were achieved:

1. Identification of treatable populations of tussock moth was met.
2. The timing of application of the virus was met with a high degree of confidence.
3. The estimation of population densities (pre and post spray) was accomplished.
4. Initial estimates indicate that treatment objectives for foliage protection were met. Success in interrupting the population cycle of the insect can only be determined in one to two years.

This Final Report provides summary information applicable to future project managers, especially the Project Critique (Section X). All known relevant electronic files are made a part of this report on a CD-ROM. Hard copies of all maps, entomology field forms, lab results, and administrative paperwork are considered a part of this Final Report and are to be retained at the Forestry and Sciences Laboratory in La Grande Oregon at the discretion of the Regional Forest Insect and Disease Group.

The successful completion of this project is the result of everyone who worked on it, but especially the seasonal employees from the Pomeroy and Halfway areas and the primary contractor, Heli-Jet of Eugene, Oregon.

I. Project Area

The project area included seven analysis units that stretched across the Blue Mountains of Northeast Oregon and Southeast Washington. The Walla-Walla and Pomeroy Ranger Districts were involved on the Umatilla NF and the Pine District and southern portion of the Hells Canyon National Recreation Area were involved on the Wallowa-Whitman National Forest.

An Environmental Impact Statement was prepared by the Region that addressed the Douglas-fir Tussock Moth (DFTM) infestation in both Oregon and Washington. It identified 1,890,570 acres of DFTM host type acres on both forests.

After intensive sampling for the locations of treatable populations, two of the analysis units were dropped from treatment (Lookout and Pomeroy) which left 291 spray blocks in the remaining five analysis units as displayed in Table 1. Maps of the analysis units that display spray block locations are found in Appendix A.

II. Accomplishments

Field crews verified sub-outbreak populations of DFTM in five of the seven analysis units. Pomeroy and Lookout Analysis units were removed from project when field surveys showed low to moderate DFTM populations. Eventually 39,602 acres were sprayed on the Umatilla and Wallowa Whitman National Forests as shown in Table 1 below.

Table 1: Project Area Acres

Analysis Unit	Gross Acres	Non-Treatment Acres	Potential Treatment Acres	Number Spray Blocks	Total Acres Sprayed
Eagle	22,641	12,255	10,386	84	10,378
Imnaha	13,147	5,299	7,848	24	7,845
Pine	21,060	6,121	14,939	123	15,204
Lookout	8,682	8,682	0	0	0
Mill Creek	13,729	10,530	3,199	19	2,263
Pomeroy	13,886	13,886	0	0	0
Spangler	6,163	2,336	3,827	41	3,912
TOTALS	99,308	59,109	40,199	291	39,602

III. Entomology (Paul Joseph, Roger Sandquist)

The objectives of the Project Entomological activities were four fold. This report will describe those objectives and explain how well each was accomplished. The four objectives are:

1. Verify that Douglas-fir tussock moth (DFTM) populations were at high sub-outbreak (10 larvae/1000 sq. inches foliage, mid-crown) or higher in areas proposed to be treated.

2. Ensure the proper timing of insecticide application.

3. Estimate the pre-treatment and post-treatment DFTM population densities.

4. Measure defoliation rates and monitor the short-term protection of critical areas of concern where severe defoliation could change vegetation conditions and impair or imperil critical resource needs such as habitat for threatened and endangered species.

A. Verification Of Treatable Populations

This objective proved to be the most difficult and time consuming to accomplish. Past suppression projects generally treated later in the outbreak cycle when visible defoliation and high populations were apparent. Approximately 21,000 acres were defoliated in 1999. Including the area defoliated (1999) and the areas identified from the fall (1999) cocoon density sampling as having a high probability of treatable populations ($\geq$10 larvae/1000 sq. inches foliage, mid-crown), seven analysis units (AU) were identified. These AUs contained areas of concern that were analyzed for treatment in the Final Environmental Impact Statement (FEIS). The seven analysis units consisted of approximately 102,368 acres. Four of the analysis units (Mill, Spangler, Pomeroy, and Lookout) totaling 45,520 acres were located on the Umatilla National Forest, south of Pomeroy Washington. The remaining three analysis units (Pine, Eagle, and Imnaha) totaling 56,848 acres were located on the Wallowa-Whitman National Forest near Halfway, Oregon. An additional 25,000 acres (plus or minus) with treatable populations, not identified as areas of concern in the FEIS for treatment, were used for untreated controls. Assuming the acres defoliated in 1999 supported a treatable population, it still left the entomology crews approximately 100,000 acres to qualify for treatment.

The seven analysis units were then divided into spray blocks, which had similar topographic characteristics and were operationally feasible to treat with helicopters. A total of 662 spray blocks were established within the seven analysis units with an average size of 155 acres. The small size of the spray blocks was the result of small, sometimes isolated areas of concern. This situation was more prevalent in the Halfway area than it was in the Pomeroy area.

The procedure outlined by Mason et al. (1993) was followed to assess cocoon densities over each analysis unit in a one-time procedure to qualify or modify the boundaries of each analysis unit (see project entomology plan, appendix E-1).

A minimum of fifty, 50-tree plots was established in each analysis unit. Additional plots were established in areas, within the analysis unit, that appeared to have low numbers of cocoons present. Analysis unit boundaries were then modified to omit those areas supporting a predicted population below treatment criteria. Additional plots were established in the modified analysis unit to obtain a minimum of 50 plots.

A cocoon density of 3.75 cocoons per 50-tree sample was required to identify a treatable population with at least 10 larvae per 1000 square inches of foliage, mid-crown. Areas, generally spray blocks, where estimated populations fell between treatable and non-treatable were not dropped at this time. Subsequent larvae samples (sequential sampling in the lower crown, Mason 1979) within those questionable spray blocks were the final determining factor to treat or not to treat.

A total of 88 spray blocks (11,794 acres, gross) were dropped from Oregon analysis units and a total of 294 spray blocks (36,213 acres, gross) were dropped from Washington analysis units. The project dropped 382 spray blocks (48,007 gross acres) from treatment consideration. The decision to drop these blocks was based on predicted population densities obtained from cocoon density samples or sequential larval samples. (See Appendix E, Project Entomology Plan).

The "operational use" of the fall cocoon density sample to predict subsequent treatable larval populations did not work well on this project. Later larval samples of spray blocks that were dropped from treatment status as a result of low numbers of cocoons being found actually supported, in some cases, treatable populations ($\geq$ 10 larvae/1000sq. in. foliage, mid crown). Those spray blocks dropped because of low cocoon densities, but which were near or adjacent to blocks meeting the treatment criteria, were sampled using the sequential larval sampling procedures of Mason, 1979. As a result of this additional sampling, some spray blocks in the Mill Creek and Spangler analysis units were again considered for treatment. Treating these additional areas required the setting of spray block priorities since the availability of the carrier, 038, was limited. It was decided to reduce the volume of 038 per acre to ¾ of a gallon to increase the number of total acres that could be treated with the 038 that was on hand. This decision enabled the project to treat the majority of the additional blocks.

The objective of identifying treatable populations was, for the most part, met. Too much reliance was placed on the cocoon sampling to initially disqualify spray blocks for treatment. There were no spray blocks treated that did not qualify but several spray blocks that did meet treatment criteria were not treated as a result of predictions of populations derived from the cocoon sampling.

B. Insure Proper Timing of Insecticide Application

Degree days were monitored using existing RAWS stations located within and near the analysis units to estimate the time of DFTM egg hatch (Wickman 1985). This did not work well using the RAWS stations. Perhaps the use of a biophenometer within the spray block would provide the correct information. See Appendix E for data.

Egg masses were tagged at each development plot in each accessible spray block. The egg masses were monitored for egg hatch and every second or third day from the time of first egg hatch for complete egg hatch and larval dispersal from the egg mass. Where feasible, spray blocks not easily accessible were randomly sampled for egg hatch, dispersal, and larvae development. Those spray blocks not accessible were released for treatment based on near-by accessible spray blocks with similar aspect and elevation. Once larval dispersal was complete within the spray block, established larval development plots within the spray block were sampled.

First egg hatch occurred in Oregon on May 25th on Pine analysis unit at 3800 ft. elevation and in Washington June 1st on Spangler analysis unit at 3600 ft. elevation.

The larval development plots were sampled every two or three days until 60% of the larvae had reached the second instar (L2) or larger. The spray block was then released for treatment. If the spray block was not treated within 72 hours of its release, the spray block was re-sampled and the 72-hour time limit started again. Thanks to the Air Operations group and the willingness of the contractor to treat small isolated spray blocks when they were released, this situation did not occur often.

The last spray block was released in Oregon in the Pine analysis unit on July 12th and in Washington in the Spangler analysis unit on July 15th.

This objective was met very well and with a high degree of confidence.

C. Estimate Population Densities

A minimum of 50 five-tree evaluation plots was to be established in each analysis unit as well as each control area. Population densities were determined from those plots immediately after the larvae had reached 60% L2 or larger. This was just prior to the spray block being released for treatment. If treatment did not occur within 72 hours of block release, the evaluation plots were re-sampled. In these cases, the pretreatment densities were determined from the last evaluation sample taken prior to treatment. Because of limited and difficult access to the Mill Creek analysis unit only 25 evaluation plots were established in the 19 spray blocks. Fifteen plots were established in a control area for the Mill Creek and Spangler analysis units.

The established evaluation plots were again sampled twenty-eight (28) and thirty-five (35) days after treatment or in the case of the control areas, when treatment would have occurred. This sample was from different branches on the same trees the pre-spray density sample was taken. The 35-day post-spray density, although taken, is not listed because pupation had started to occur on some sites making estimates of larval density unreliable. The pre-treatment and 28 day post-treatment larval densities for each of the treatment analysis units and each of the control, no-treatment areas are listed in Table 2. The densities are portrayed in numbers per 1000 square inches of foliage, mid crown.

Table 2. Corrected Mortality derived from pre and post-treatment larval density estimates on treated analysis areas and untreated control areas.

		MEAN LARVAL DENSITY ± SE, 1000 in^2 MID-CROWN			
ANALYSIS AREA	NUMBER OF PLOTS	PRETREATMENT	28 DAY POST	CORRECTED MORTALITY	CONTROL AREA
Pine	171	47.90 ±3.57	3.97 ±0,65	54.4%	Duck
Eagle	50	83.13 ±13.60	8.09 ±1.97	33.8%	Gold
Imnaha	48	46.69 ±6.33	2.60 ±0.43	69.3%	Duck
Duck control	50	34.87 ±6.28	6.32 ±1.16	n.a.	
Gold control	50	99.86 ±11.90	14.68 ±1.47	n.a.	
Mill Creek	23	21.65 ±5.58	8.56 ±3.08		n.a.
Spangler	54	67.90 ±7.44	7.15 ±0.89	60.8%	Pomeroy
Pomeroy control	15	58.00 ±8.90	15.55 ±3.90	n.a.	

The means are reported plus or minus the standard error. Corrected mortality was calculated by Abbott's formula (Abbott 1925).

The Duck control area is located on the northeast end of Pine analysis unit and on the southern end of the Imnaha analysis unit. This control area is approximately 6,000 acres and was used to estimate natural mortality in the Pine and Imnaha analysis units.

The Gold control area is located between the western two-thirds of Eagle analysis unit and the eastern one-third of Eagle analysis unit. This control area is approximately 3,000 acres and was used to estimate natural mortality in the Eagle analysis unit.

The Pomeroy control area is located west of the southern one-half of the Spangler analysis unit. This control area is approximately 400 acres and was used to estimate natural mortality in the Spangler analysis unit. The Pomeroy control area established for both the Spangler and Mill Creek analysis areas turned out to be only representative of the Spangler area, so there was no control area for Mill Creek.

This objective of estimating population densities was partially accomplished. The 28-day post spray density sample portion of this objective was met with a high degree of confidence. The 35 day post

spray density sample portion of this objective was also met but as the larvae had started to pupate in the plots sampled last, the resulting 35 day data can not be portrayed with any degree of confidence.

D. Protection Of Foliage

Tree defoliation estimates were made at the time of the pre-spray larval density sample (plus or minus a few days) and again at the 35-day post-spray larval density sample (plus or minus a few days). Wickman's (1979) 'Annotated Table of Tree Defoliation Classes by Percent of Crown Defoliated' was used to estimate and classify the amount of defoliation on a sample host tree. An additional defoliation class of '0' was added to Wickman's procedure to capture a no-defoliation class (see Project Entomology plan. Appendix E-1). The same trees will be sampled again in late August 2001.

Individual tree defoliation ratings were measured on a set of defoliation sample monitoring plots located within each analysis area to measure treatment effect. Table 3 summarizes the number of defoliation monitoring plots and sample trees within each unit.

Table 3. Defoliation plot sample sizes used in estimating treatment effects on defoliation.

Analysis Area	Number of Sample Plots	Number of Sample Trees
Pine	24	480
Eagle	24	480
Imnaha	24	480
Duck control	24	480
Gold control	24	480
Mill Creek	22	215
Spangler	48	672
Pomeroy control	14	252

The proportion of trees classified in each of the five defoliation classes was computed for each defoliation plot, and the mean and sampling error were calculated for each analysis area. The proportions in each tree defoliation class are listed in Table 4 and were plotted graphically. The graphs are below.

Table 4. Proportion of trees (SE) in each Defoliation Class in each Analysis Area

	Defoliation class				
Analysis Area	0	>0 – 10%	>10 –25%	>25 – 50%	>50%
Pine	.51 (.096)	.281 (.069)	.169 (.054)	.040 (.0024)	0
Eagle	.458 (.094)	.113 (.038)	.373 .086)	.050 (.018)	.006 (.006)
Imnaha	.129 (.056)	.623 (.054)	.233 (.047)	.013 (.005)	.002 (.002)
Duck control	.113 (.062)	.283 (.059)	.49 (.065)	.113 (031)	.002 (.002)
Gold control	.008 (.007)	.146 (.067)	.186 (.073)	.565 (.085)	.094 (.031)
Mill Creek	.875 (.054)	.105 (.041)	.02 (.019)	0	0
Spangler	.475 (.055)	.465 (.05)	.051 (.013)	.003 (.002)	.005 (.004)
Pomeroy control	.598 (.078)	.345 (.059)	.05 (.031)	.007 (.007)	0

Figures 1 and 2 display that Eagle, Pine, and Imnaha analysis areas had less defoliation than their Duck and Gold control areas. There were greater proportions of trees in higher classes of defoliation in these control areas. In Eagle, Pine and Imnaha the proportions of trees having defoliation estimated to be greater than 25% was only 0.056, 0.04, and 0.015 compared to 0.115 and 0.659 in the Duck and Gold control areas, respectively. This defoliation information coincides with the corrected mortality shown in Table 2 and shows a treatment effect.

Figure 3 displays that the treated Spangler analysis area had defoliation estimates similar to the Pomeroy untreated check. From this information alone, we cannot infer that there was an effect from the virus treatment. We surmise that for this particular environment, the population levels recorded were just at the threshold of causing visible defoliation. Our defoliation estimation techniques may not have been sensitive enough to detect differences. The larval density information shown in Table 2 however, does show a treatment effect by a corrected larval mortality of 60.8% due to the virus application. Defoliation estimates in 2001 will show us whether treatment in 2000 resulted in less defoliation in the Spangler treatment area than in the Pomeroy untreated check area.

Figure 4 displays that very little defoliation was found in the Mill Creek analysis area. This is not surprising given the low density of larval population that was treated (21.65 ±5.58 larvae per 1,000 in^2 of midcrown branch area). This population was just at the threshold (>20 first and second instar larvae per 1,000 in^2 of midcrown branch area) for an outbreak population where defoliation would be visible (Brookes, et at. 1978).

In all treated areas the corrected larval mortality figures and the defoliation intensities suggest that initial treatment objectives were met. The overall treatment objective of interrupting the population cycle and its damage can only be assessed one or two years in the future. The defoliation estimated from this first

year of the project was categorized as light in the FEIS (USDA 2000). Light defoliation was assumed to result in no tree mortality attributable to DFTM. This assumption will be checked by subsequent defoliation sampling and sampling to determine if additional beetle mortality occurred as a result of DFTM defoliation. Thus, our conclusions are preliminary at best.

Figure 1: Proportion of trees defoliated by Douglas-fir tussock moth at different tree defoliation classes on treated analysis units (Imnaha and Pine) and untreated analysis units (Duck Control), 35 days after treating with TM Bio-Control.

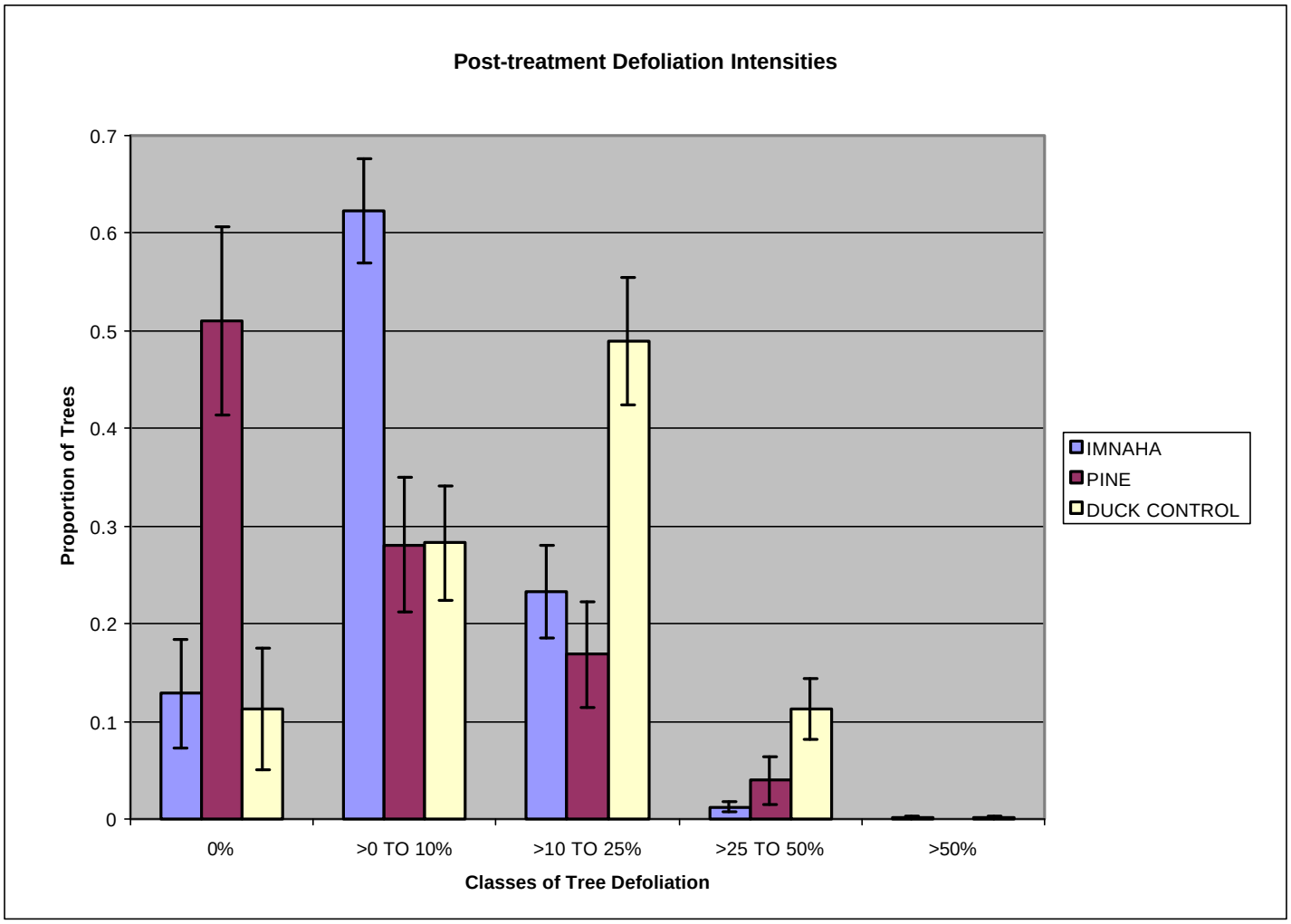


Figure 2: Proportion of trees defoliated by Douglas-fir tussock moth at different tree defoliation classes on treated analysis units (Eagle) and untreated analysis units (Gold Control), 35 days after treating with TM Bio-Control.

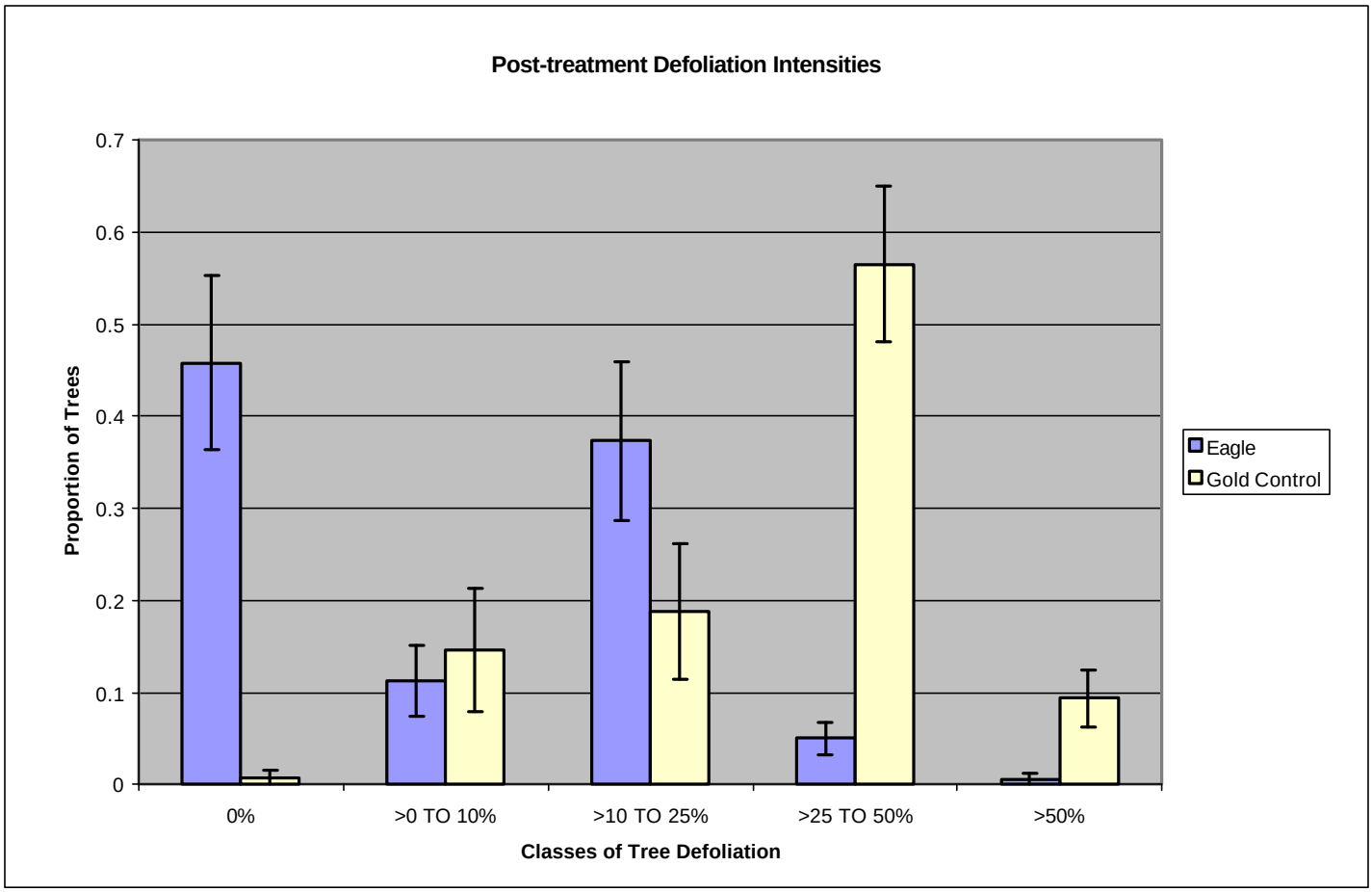


Figure 3: Proportion of trees defoliated by Douglas-fir tussock moth at different tree defoliation classes on treated analysis units (Spangler) and untreated analysis units (Duck Control), 35 days after treating with TM Bio-Control.

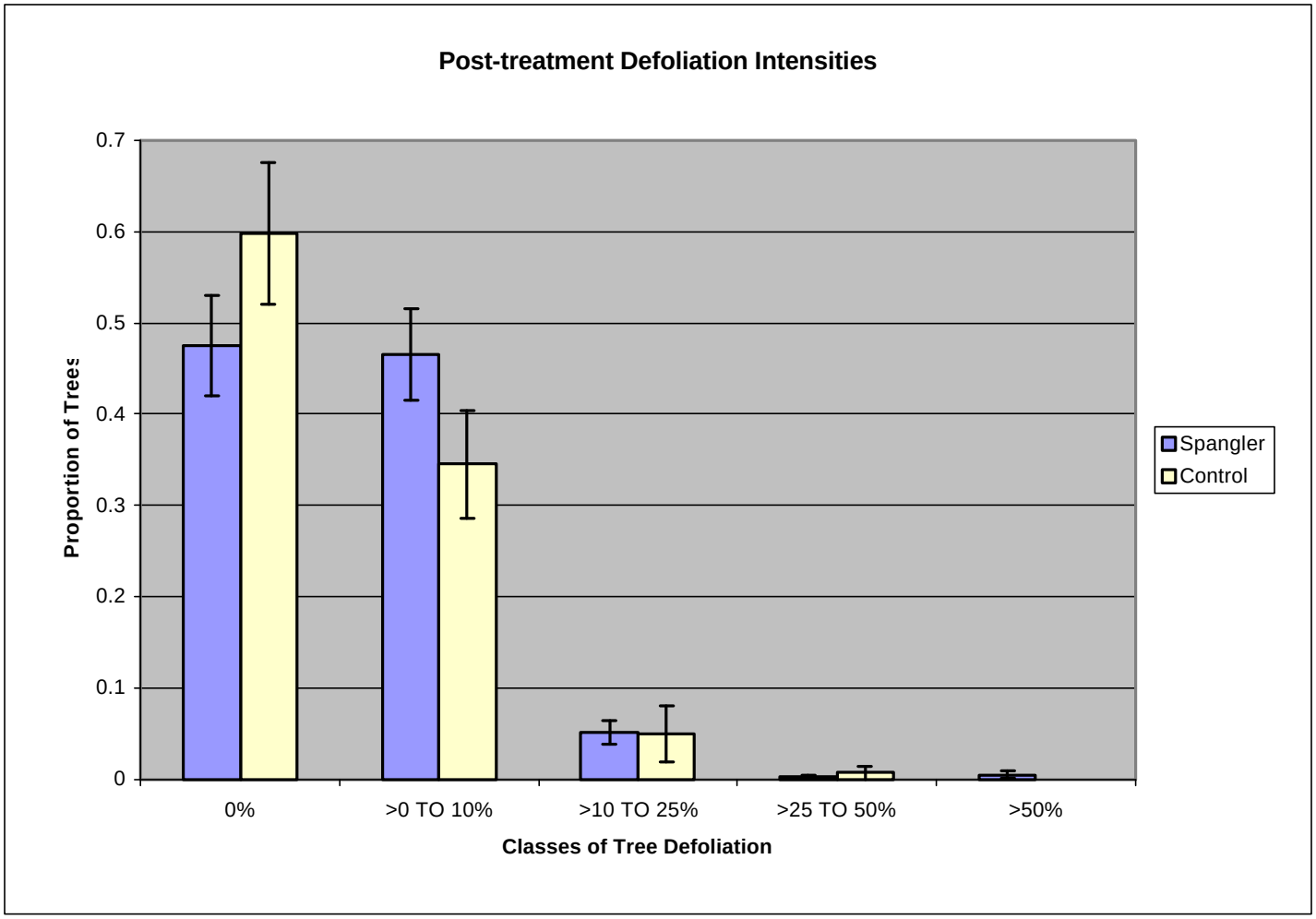
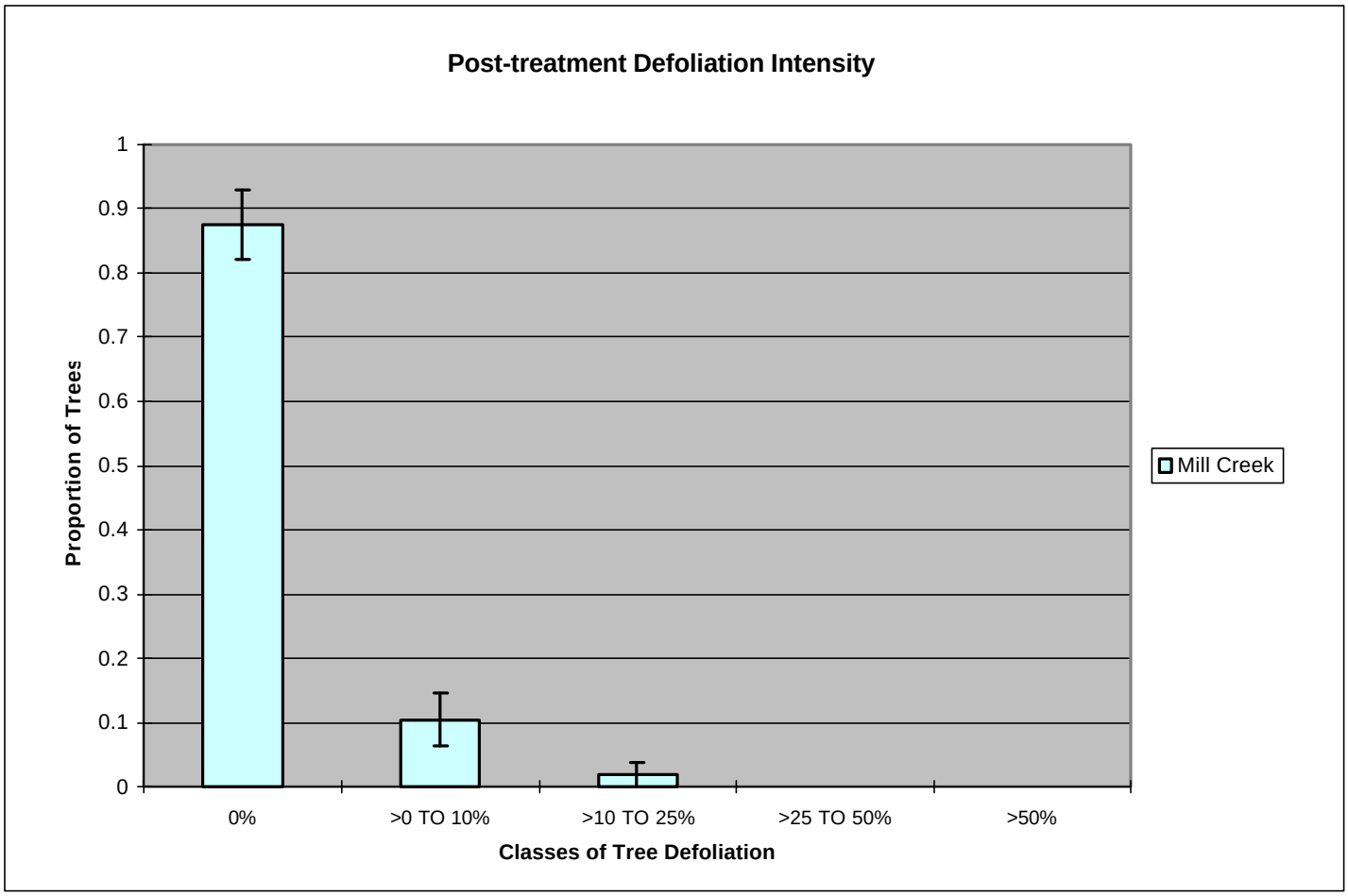


Figure 4: Proportion of trees defoliated by Douglas-fir tussock moth at different tree defoliation classes on the Mill Creek treated analysis unit 35 days after treating with TM Bio-Control.



[1] See references

IV. Virus and Parasite Monitoring (Don Scott)

A. Introduction

Under natural field conditions, populations of Douglas-fir tussock moth (*Orgyia pseudotsugata*) encounter a number of factors averse to continuing population expansion during outbreaks. These factors, working in conjunction with one another, are often responsible for terminating the outbreak. The occurrence of nucleopolyhedrovirus (NPV) is one such factor that is common to many tussock moth populations and has been recognized as playing an important role in the natural collapse of tussock moth outbreaks along with parasitism, predation,

starvation, and other factors (Brookes and others, 1978). The virus causes the Nucleopolyhedrosis (NP) disease in tussock moth larvae. It also causes mortality in the pupae when final instar larvae ingest the virus and pupate before virus replication is completed. Infection can only occur by ingestion of the virus occlusion bodies (OB) during the larval feeding stage.

Nucleopolyhedrovirus is not usually detectable in the population in the beginning or "release" phase of outbreaks, except with very intensive larval sampling. The virus typically shows up first as virus contamination of egg masses at the beginning of the year in which the disease outbreak develops (Thompson 1978). Later that same season, the virus is easily found in the larvae. The larval stages are largely responsible for active spread of the disease in tussock moth populations by the relatively simple contagion process (Thompson 1978).

B. Objectives

The primary objective of this monitoring is to determine whether the use of the virus product TM BioControl-1 induced a virus epizootic in treated Douglas-fir tussock moth populations, or enhanced and hastened a natural epizootic to help reduce tussock moth numbers in areas that were treated. In addition, this monitoring was designed to determine rates on natural virus and other mortality factors in the treated and untreated tussock moth populations.

C. Methods and Procedures

To quantify and segregate some of these natural larvae mortality factors caused by the applied treatment of TM BioControl-1 we reared field-collected larvae from treated and control blocks at different sampling intervals and determined virus and parasitism rates. Larvae were collected from plots established at the Halfway and Pomeroy Units for Development and Evaluation Sampling, and were sent to the Forestry and Range Sciences Laboratory at La Grande, Oregon (hereafter, "lab") where workers reared the larvae on artificial diet until death or pupation and adult emergence.

The unusually large number of spray blocks (291) on the Halfway and Pomeroy Units from which larvae were collected for rearing from only those units that were easily accessible resulted in monitoring a large number of larvae over the period of June 27 to the end of September 2000 when the residual larvae had completed pupation, and the monitor-rearing work was terminated.

Over the course of the Douglas-fir Tussock Moth Suppression Project we received a total of 8,535 larvae for rearing from the Halfway Unit and 2,237 larvae for rearing from the Pomeroy Unit. Development, Pre-Treatment, and Post-Treatment samples are represented by 6,722 larvae collected from treated blocks from the Halfway Unit and 1,912 larvae collected from treated blocks from the Pomeroy Unit (Table 5). Natural mortality monitoring on the Halfway Untreated Control Blocks are represented by 1,813 larvae and the Pomeroy Unit Control Blocks by 325 larvae (Table 5).

Table 5. Number of Douglas-fir tussock moth larvae received by analysis unit and sampling interval.

Project Analysis Units	No. Larvae Received by Sampling Interval					
	Development		Pre-Treatment		Post-Treatment	
	Treated	Untreated	Treated	Untreated	Treated	Untreated
Halfway (South) Units						
Eagle *(treated)*	142		474		563	
Imnaha *(treated)*	105		536		430	
Pine *(treated)*	793		1931		1748	
Duck *(control)*		20		440		306
Gold *(control)*		46		524		477
Pomeroy (North) Units						
Spangler *(treated)*	282		646		492	
Mill Creek *(treated)*	111		132		249	
SM-NT *(control)*		60		154		111

In addition to determining the induced NP prevalence rate in the population that is due to the TM BioControl-1 “virus” treatment, we recorded, collected, and identified any parasitoids that emerged from tussock moth larvae, and microscopically diagnosed all larvae that died to determine natural infection rates of nucleopolyhedrovirus in the population and infection rates from other microorganisms that might possibly be causes of larval death.

The larval sampling procedure, including collection of larvae for virus and parasite monitoring, are described in the Project Entomology Plan, Appendix E.

Entomology personnel from the Halfway and Pomeroy Units either shipped larval collections to the lab by FedEx overnight, or drove the larval collections over to the lab, several times a week so that larvae would not have to be re-fed at the Project sites. Larvae received at the lab were transferred to individual, clean, sterile, plastic Petri dishes in which a small piece of artificial insect diet had been placed. The larvae were reared at about room temperature (71°F; 50-60% RH) until death or pupation and adult emergence. Larvae were checked daily for mortality and were re-fed with fresh diet every 2nd or 3rd day. The rearing procedure we followed was essentially that described by Thompson and Peterson (1978).

During each daily check all dead larvae were screened for obvious signs of virus infection (e.g., we used flaccid cadaver with a disintegrating integument that easily ruptures when disturbed to indicate frank virus infections). Results were recorded on paper forms for later entry of these data into spreadsheets. Those cadavers that could not be easily diagnosed by initial screening were checked with a compound light microscope by phase contrast microscopy to determine cause of death.

Tussock moth larvae that were parasitized were segregated from other larvae and held at rearing conditions until the parasite adults emerged from their puparia or from the tussock moth larval cadaver. All parasites were saved for later identification to species, where possible.

All data were entered into Quattro Pro™ spreadsheet programs on a personal computer for subsequent statistical analysis. We used the computer program, StatMost™,Ver. 3.5 (DataMost® Corporation, Salt Lake City, Utah) for all statistical analysis. In addition, we used a Microsoft® Visual Basic™ computer program written by Tommy Gregg, Air Quality, Forest Insects and Diseases Staff, Pacific Northwest Region to calculate corrected control mortality using Abbott's Formula (Abbott 1925).

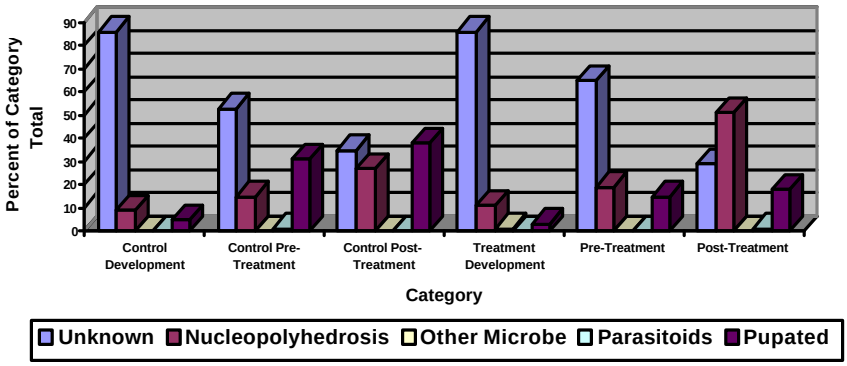
D. Results and Discussion

Larval Mortality Factors

Tussock moth mortality in field-collected larvae reared in the laboratory resulted from several identified agents: several parasitic hymenopterans (*Hyposoter masoni*, *Hyposoter fugitivus pacificus*, *Meteorus tersus*, *Phobocampe* sp., *Phobocampe pallipes*, *Apanteles* sp., and *Tetrastichus* sp.); a dipteran (*Carcelia yalensis*); a bacterium (*Bacillus cereus*); several fungi (*Entomophthora* sp., *Beauveria* sp., *Candida* sp.); and from nucleopolyhedrovirus. These mortality agents were all naturally occurring in the tussock moth population. In addition, we had noted over the course of rearing in some of the larvae collected prior to treatment, and in some larvae collected after treating, the presence of occlusion bodies (OB) in squash slide preparations subjected to microscopy that appeared abnormally large mixed in with polyhedra of other sizes, and not distinctly associated with nuclei of specific tissues known to be affected by nucleopolyhedrovirus. These larvae manifested symptoms characteristic of cytoplasmicpolyhedrovirus (CPV): often appearing retarded in growth, and the cuticle of the skin did not easily rupture as with NP infections (Poinar and Thomas 1978). We suspected these OB's to possibly be from naturally occurring cytoplasmicpolyhedrovirus, although we did not confirm their association with midgut epithelial tissue or conduct other confirmational testing due to lack of time and appropriate reagents, stains, and histological equipment (cf. Martignoni and others 1969; Sikorowski and others 1971).

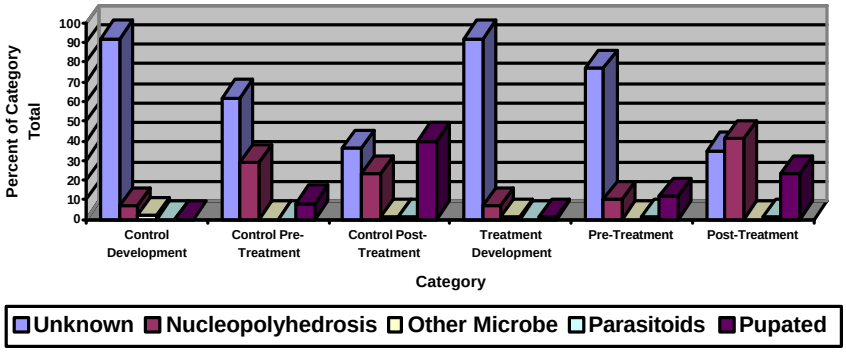
An unusually large proportion of unknown larval mortality occurred in the field-collected tussock moth larvae in all collections over the course of rearing larvae from both Halfway (fig. 5) and Pomeroy (fig. 6) Units. While we suspect some of this mortality resulted from injuries to larvae during field collection or handling in the lab, the overriding cause of this mortality is still somewhat mysterious, but may have resulted from combinations of heat exhaustion (prolonged exposure to abnormally high daily temperatures in the field), desiccation, and stress to the larvae due to increased rearing lab temperatures that occurred during air conditioning system failures. On at least two occasions mechanical or electrical systems within the primary air conditioning system failed and shut down all laboratory cooling during several days of some of the hottest days of the summer (with temperatures greater than 95 ^{o}F); thus exposing larvae to constant 24-hour ambient indoor temperatures that may have exceeded 86 ^{o}F over the course of several days. The system was repaired as quickly as possible, and alternative cooling systems were brought in and utilized, but we believe that larvae never fully recovered from the effects of constant high temperature, and irreversible physiological damage to larvae may have resulted in their subsequent death, days and weeks later. Many of the dead larvae had a dried and shriveled, triangular appearance much like those described and illustrated by Dahlsten and others (1977), which were eventually presumed to have died from heat exhaustion when the mortality of those tussock moth larvae was found to correspond closely with four days of abnormally high temperatures from a heat wave.

Figure 5. 2000 Douglas-fir Tussock Moth Suppression Project Cause-Specific Mortality Monitoring on South End Analysis Units - Halfway Ranger District



Also like the heat-killed larvae described by Dahlsten and others (1977), while we could find some evidence of NP pathology in numbers of our dead larvae, typical disease symptoms had not advanced to the stage in which larvae would have been killed by the disease; thus these larvae could not be recorded as having virus. It is interesting to note that Pacific Northwest Research Station Scientists concurrently conducting bark beetle pheromone research using Lindgren Funnel Traps within the Halfway Project area, found similar appearing dead tussock moth larvae in their funnel trap collections of bark beetles when the traps were hung beneath trees undergoing tussock moth defoliation (personal communication with Dr. Jane L. Hayes, Forestry and Range Sciences Laboratory, La Grande, OR, August 26, 2000). These larvae have been microscopically diagnosed for cause of death. Out of 50 larvae examined, 37 (or 74%) were found to have free occlusion bodies and/or nuclei "packed" with occlusion bodies. In most cases, although these larvae contained occlusion bodies, they were not present in enough abundance to produce frank cases of nucleopolyhedrosis. It was apparent that most of these larvae had been infected by the virus from TM BioControl-1 treatments, or by natural virus, but had actually succumbed to heat exhaustion during the unusually warm temperatures in the field, during the heat wave period. There were several days during the past summer in which temperatures reached 100 ^{o}F or more, and these temperatures undoubtedly contributed to some level of larval mortality from heat exhaustion.

Figure 6. 2000 Douglas-fir Tussock Moth Suppression Project Cause-Specific Mortality Monitoring on North End Analysis Units - Pomeroy and Walla Walla Ranger District



During recent visits to areas of tussock moth defoliation on the Pine Ranger District and Walla Walla Ranger District, we also observed numerous dead larvae around defoliated host trees that we concluded were killed by heat exhaustion over the summer (see fig. 7).

Cause-specific Larval Mortality From Nucleopolyhedrosis (NP)

The proportions of unknown larval mortality declined with each larval collection period: Development, Pre-Treatment, and Post-Treatment. Conversely, the proportion of NP cases increased over time for both Halfway and Pomeroy Units (figs. 5 and 6, respectively), with the exception of the Pomeroy Units untreated control which followed a different pattern. Both the Development and Pre-Treatment larval collections showed low levels of Nucleopolyhedrovirus (typically less than 25% of the total dead larvae in the collection), with infection rates observed in the Pre-Treatment collection roughly doubling those of the earlier Development collection on Halfway Unit, and showing a less consistent pattern on the Pomeroy Units (figs. 5 and 6, respectively). This is an indication that natural virus had begun to show up in the population prior to any treatment with TM BioControl-1, and was beginning to spread through parts of the outbreak where larval densities were highest. At high population density horizontal

Figure 7. Douglas-fir tussock moth larvae killed by heat exhaustion, Jubilee Analysis Unit, Walla Walla Ranger District, Umatilla National Forest (August 30, 2000).

transmission dramatically increases the disease in tussock moth populations (Martignoni 1999). Occurrence and rapid spread of the virus is especially noticeable in areas where defoliation is highest the previous year. The natural virus levels at Halfway appeared to be slightly higher than those in the Pomeroy larval collections at nearly all larval collection periods on treated blocks, but not necessarily in the untreated control blocks. This may partially be due to the fact that population levels were higher at Halfway than they were at Pomeroy (see Table 2), but natural virus loads in the population may have been more variable between the areas. For example, the untreated control area on the Pomeroy unit (fig. 6) seemed to have a higher natural virus infection rate than any other analysis units from either project location. In addition the high natural virus infection rate on the Pomeroy control explains why so little defoliation occurred on the analysis unit when it was compared with the Spangler analysis unit (fig. 3, see precious section).

The presence of natural virus in the tussock moth populations from Halfway was not entirely unexpected. Tussock moth egg masses collected from the Pine Ranger District at Halfway, Oregon in fall of 1999, and bioassayed for presence of NPV by the Canadian Forest Service under contract with the U. S. Forest Service were found to have a low level of nucleopolyhedrovirus. The estimated percent of NPV in the tussock moth population based on egg mass virus contamination assays was found to be less than 1% for the Halfway population (personal communication with Dr. Imre S. Otvos, Canadian Forest Service, April 27, 2000). However, we did not have prior knowledge about the level of "pre-Project" egg mass virus from the Pomeroy Unit (Mill Creek and Spangler Analysis Units) because egg masses were not collected for assay from that portion of the project, as they were from Halfway. Had we collected and bioassayed egg masses for natural virus in 1999 from the Pomeroy unmits, it is very likely we would have detected virus there, as well.

The relevance of egg mass virus has great bearing on the dynamics of a tussock moth population, and the change in status of the population over time. It is known, for example, that field occurrence of NPV-contaminated eggs in some cases can be an indication of population collapse. Thompson (1978) indicates that NPV-contaminated eggs can be detected at the beginning of the year in which a virus epizootic develops.

The Post-Treatment collections made between 7-10 days after treating both the Halfway and Pomeroy Units with TM BioControl-1 indicated a significant rise in the rates of NP infection in tussock moth larvae. The number of cases of nucleopolyhedrosis in the Halfway Post-Treatment larval collections increased from 565 to 1410; an increase by a factor of 2.5 times (fig. 5). The analysis of the Pomeroy larval mortality data indicates an increase from 77 to 260 in the number of cases of nucleopolyhedrosis from the Pre-Treatment collection to the Post- Treatment collection, respectively (fig. 6); an increase by a factor of about 3.4 times. It is significant to note that a dramatic increase in virus- caused mortality occurred after treatment on both the Halfway and Pomeroy Units; however, the difference in rates of increase between the two units cannot be explained on the basis of our data set. There appears to be factors involved that we do not have adequate information on to be able to offer an explanation for the differences between units in rate of virus increase.

Observations from a field visit with Wallowa-Whitman NF, Pine RD, and PNW Research personnel to the Halfway treated blocks on August 31, 2000 seemed to confirm the high virus infection rates we were observing in the rearing lab. We observed virus-killed larvae smeared on, or hanging from host foliage of nearly every tree we looked at. In fact, we saw very few live larvae during our visit to the TM

BioControl-1 treated blocks. The applied treatments of TM BioControl-1 to the spray blocks most decidedly caused a nucleopolyhedrosis epizootic in this tussock moth population, and certainly hastened the mortality of larvae over large areas.

The amount of virus present in larvae from the Halfway Unit Untreated Control Blocks is relatively consistent with the amount of virus found in Pre-Treatment collected larvae from treated blocks (fig. 5). On a percentage basis, the level of virus in Control Block larvae collected from the Pomeroy Unit dataset (fig. 6) appears to be higher than the Pre-Treatment larvae collected from Treated Blocks. In spite of this difference the Post-Treatment data clearly shows that the treatment initiated an epizootic on the treated Pomeroy blocks.

When we examined the Post-Treatment virus infection rates averaged separately for the treated analysis units and for the untreated control analysis units for both the Halfway portion of the project and the Pomeroy portion of the project, we found essentially the same average rate of infection at 7-10 days after treating (table 6.). Average virus infection rate was 50.7% on the Halfway analysis units, and 49.5% on the Pomeroy analysis units (Table 6). Interestingly enough, this rate of infection coincides perfectly with the LD_{50} of the TM BioControl-1 lots that were applied. In other words, the grams of TM BioControl-1 that were applied to spray blocks (i.e., the dosage) was the quantity required to produce mortality in 50% of the test population based on a laboratory bioassay of the production lots of TM BioControl-1. Hence, it appears that our dosage rate was correct in targeting a 40-50% induced initial virus infection rate in the treated "field" populations of tussock moth. The objective of treatment with an LD_{50} dose of TM BioControl-1 was to initiate an epizootic by infecting 40-50% of the population soon after treatment, then rely on the contagion process to spread the virus to the rest of the population in one or more subsequent "waves" of virus mortality spaced roughly 14 days apart. We assume this occurred, but were unable to monitor the subsequent infection levels in the residual population due to limited resources and budget to support this additional work. Some supplemental follow-up sampling did occur on portions of analysis units that were dropped from treatment due to apparent low populations of larvae. The natural virus infection rates in these populations varied from about 9% to about 19% of the larvae collected at about 35 days post-treatment. This is probably enough virus to carry over to next year, where it will increase in the population and cause higher rates of larval mortality next year, hastening the collapse of the outbreak. When cause-specific mortality from virus is adjusted for control mortality by Abbott's formula (Abbott 1925) we found the overall mortality on the Halfway larval collections to average only 31.2%, but cause-specific mortality from the Pomeroy larval collections averaged 77.0%. The fact that the Post-Treatment Control NP rate actually averaged less than the Pre-Treatment rate may be partially responsible for this result, though we cannot explain why this occurred.

Table 6. 7-10 Day Post-Treatment Proportion of Larvae Infected with Nucleopolyhedrovirus by Sampling Period on Halfway and Pomeroy Analysis Units, 2000 Douglas Fir Tussock Moth Suppression Project.

Analysis Unit	Sample Size	Development (%)	Pre-Treatment (%)	Post-Treatment (%)
Eagle (treated)	1179	13	13	49
Imnaha (treated)	1071	6	12	50
Pine (treated)	4472	12	23	53
Average Rate		**10.3**	**16.0**	**50.7**
Duck (untreated)	766	15	23	36
Gold (untreated)	1047	7	8	20
Average Rate		**11.0**	**15.5**	**28.0**
Spangler (treated)	1420	7	10	46
Mill Creek (treated)	492	5	10	53
Average Rate		**6.0**	**10.0**	**49.5**
SMNT (untreated)	325	7	29	23

NP Infection Rates on Individual Analysis Units

Individual analysis units showed similar patterns of NP infection rates over time on both the Halfway analysis units (figs. 8 thru 10) and the Pomeroy analysis units (figs. 11 thru 12). In all cases, the natural virus infection rates were low, usually less than 20%, in Pre-Treatment (and Development) collections, but dramatically increased after treatment. Similarly, the untreated control units for the Halfway analysis units (i.e., Duck, fig. 13; and Gold, fig. 14) showed a trend of increased natural virus rates over time but did not reach levels as high as on the treated analysis units at 7-10 days after treating. The SMNT untreated control analysis unit for Mill Creek and Spangler Analysis Units on the Pomeroy project (fig. 15) had a somewhat different pattern of virus infection rates over time. On this control area the natural infection rates increased dramatically from the Development to the Pre-Treatment sampling period, but then declined slightly at the 7-10 day Post-Treatment collection period. However, the standard errors for these two evaluation samples (i.e., Pre-Treatment, 3.53% and Post-Treatment, 3.9%) overlap, so the sample means fall within the statistical variation or standard errors about those means.

Figure 8. Distribution of Mortality Rates by Sampling Period, Eagle Analysis Unit

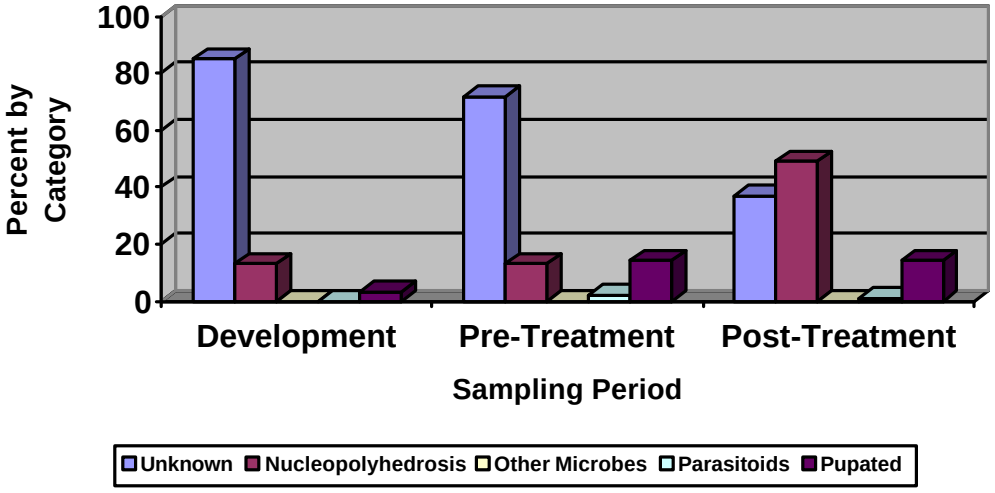


Figure 9. Distribution of Mortality Rates by Sampling Period, Imnaha Analysis Unit

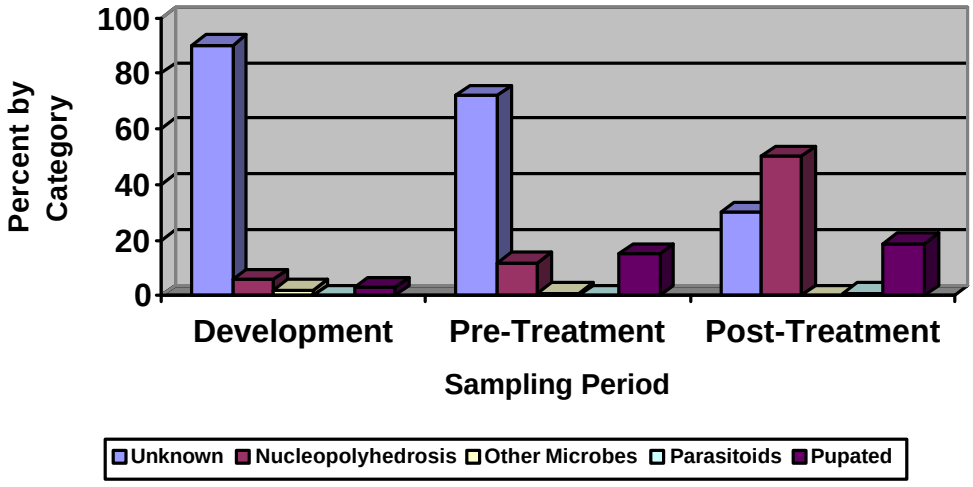


Figure 10. Distribution of Mortality Rates by Sampling Period, Pine Analysis Unit

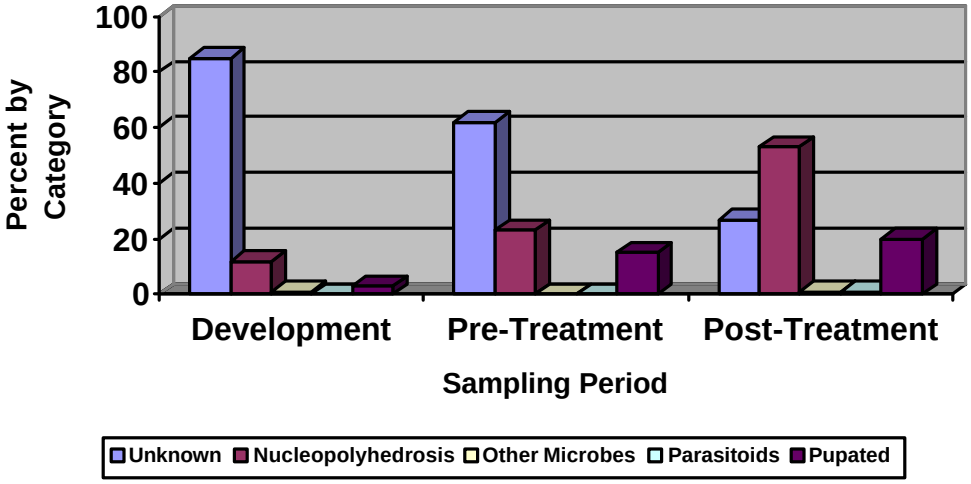


Figure 11. Distribution of Mortality Rates by Sampling Period, Mill Creek Analysis Unit

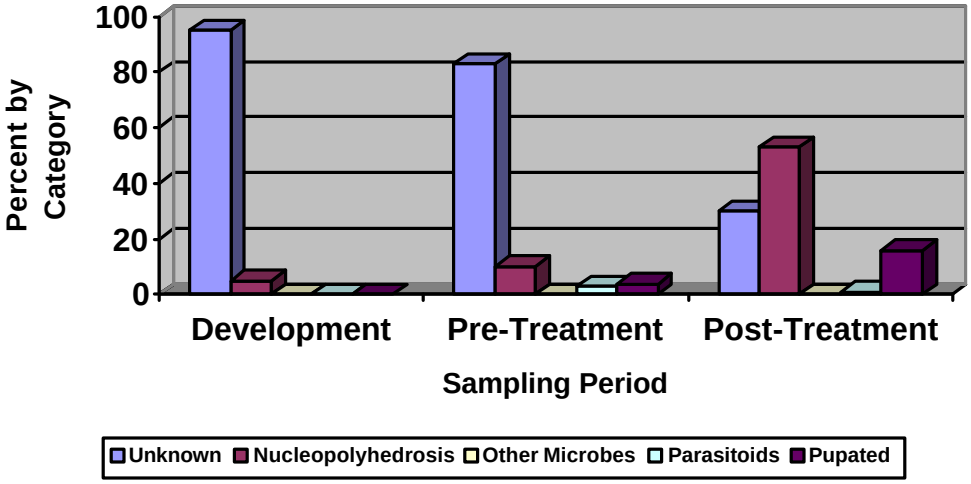


Figure 12. Distribution of Mortality Rates by Sampling Period, Spangler Analysis Unit

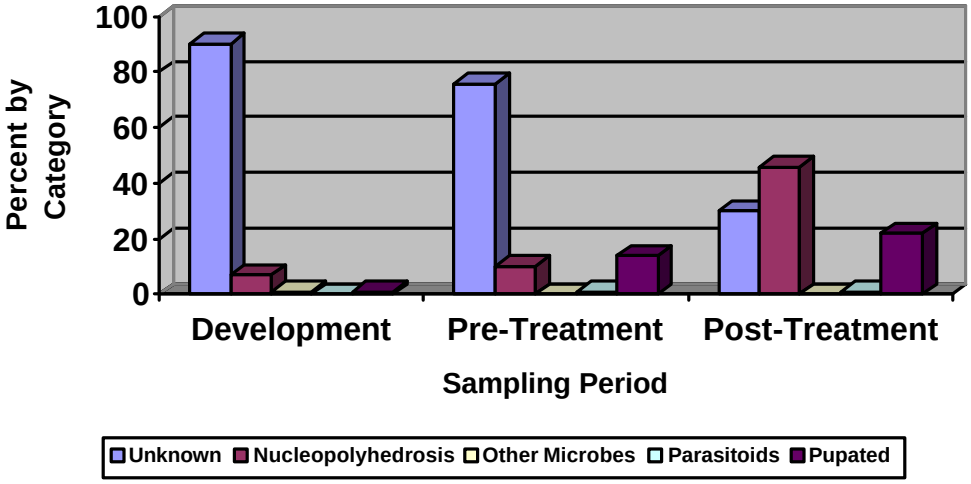


Figure 13. Distribution of Mortality Rates by Sampling Period, Duck Control Analysis Unit

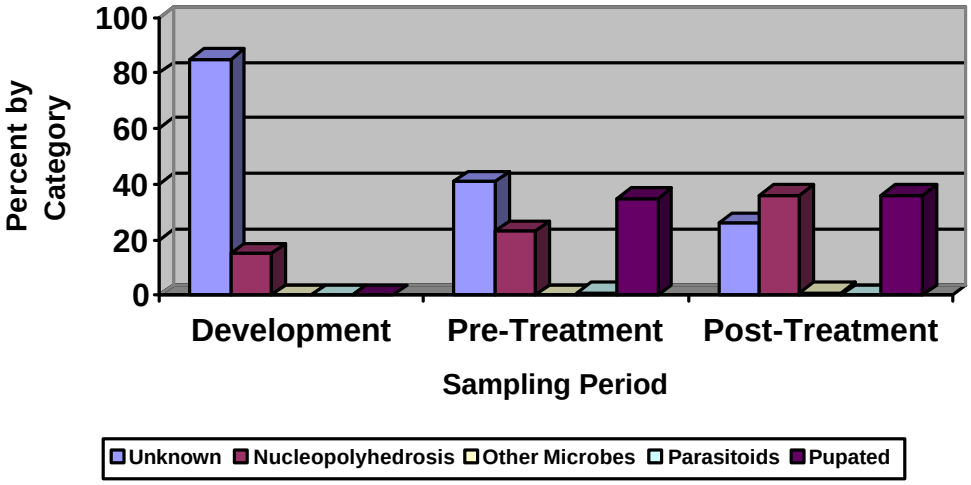


Figure 14. Distribution of Mortality Rates by Sampling Period, Gold Control Analysis Unit

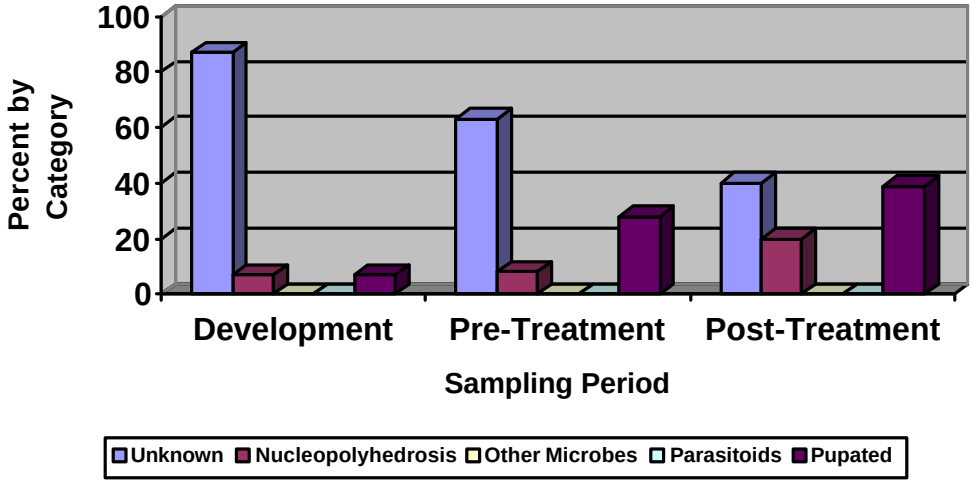
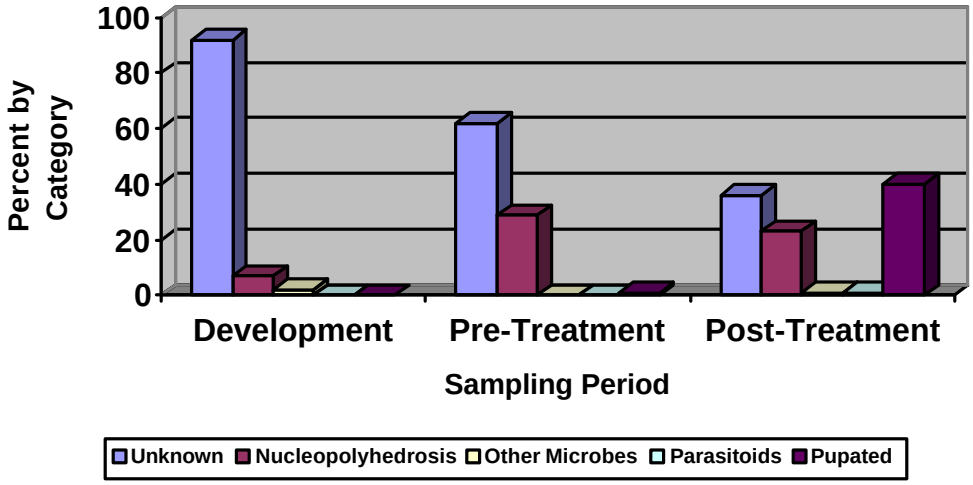


Figure 15. Distribution of Mortality Rates by Sampling Period, SMNT Control Analysis Unit



Parasitism Rates on Analysis Units

Primary parasitism occurs at all stages of tussock moth except the adult stage (Torgersen and Dahlsten 1978). There are a number of guilds of parasitoids that attack the tussock moth as early-instar larvae (e.g., up to about 4th instar), while other guilds attack in late instars or during the pupal stage.

The Post-Treatment larval collection was scheduled to occur at 7-10 days after treatment. Since most tussock moth larvae would be at 4th instar or earlier at this sampling period, we expected to miss the

guilds of parasitoids that attack tussock moth during the late-larval and pupal stages unless an additional later collection was made. Hence, to estimate total parasitism rates more accurately, we arranged to have the Suppression Project Entomology Section also make late larval collections, roughly between the 28-day and the 35-day Post-Treatment Density (Evaluation) sample. We then reared these larvae and obtained additional information about virus and parasitism rates in these later development stages.

The parasitoid guilds observed in rearing of the field-collected larvae were similar between the two project locations (Pomeroy and Halfway). We reared 6-8 different insect parasitoids from each location. In fact, the only parasitoid found on the Pomeroy units that was not found on the Halfway units was *Hyposoter fugitives pacificus* (compare figs. 16 and 17). Conversely, two parasitoids, *Phobocampe* sp. (undetermined) and *Tetrastichus* sp., were found at the Halfway units, but not at Pomeroy (compare figs. 16 and 17). In total, parasitoids appeared to be a relatively minor mortality factor on the project. Their numbers, though, are expected to increase to a greater extent next year since increases in natural enemies tend to lag behind the increasing host insect population.

There is no doubt that the affected stage of the tussock moth is important in translating mortality factors into population reduction or population collapse. For example, the 1973 and 1974 population dynamics studies by Mason (1981) found that during the 1970's tussock moth outbreak in the Blue Mountains, virus disease and insect parasites apparently had a minimal effect on early larvae, although both increased their effectiveness later in the season (in older larvae). This study found over 20% of the late larvae were infected with virus, and 47% of the pupae were killed by parasites. The author concluded that these mortality rates late in the season undoubtedly affected the survival of tussock moth that generation, as well as contributed to the overall population collapse. The results of rearing our late-instar larval collections resulted in an average natural virus infection rate of 48.8% and a parasitism rate of 30.0%. So, while our late-larvae NP infection rate is higher than that found by Mason (1981), our parasitism rate of late-instar larvae was slightly lower. We did not monitor pupal parasitism rates during this project.

The late-instar NP infection rate we observed is interesting because it demonstrates further that natural virus was clearly spreading and increasing in the tussock moth populations on the Wallowa-Whitman and Umatilla National Forests. This mortality factor in conjunction with the parasitism, and other natural mortality agents, including starvation, will bear watching next year as they will be major factors in the collapse of these populations.

Each parasitoid is an important mortality factor during differing developmental stages of the insect. The stages in which each parasitoid attacks are summarized in Torgersen (1977; 1981).

Figure 16. 2000 Douglas-Fir Tussock Moth Suppression Project Parasitoid Results: South End Analysis Units – Halfway Ranger District

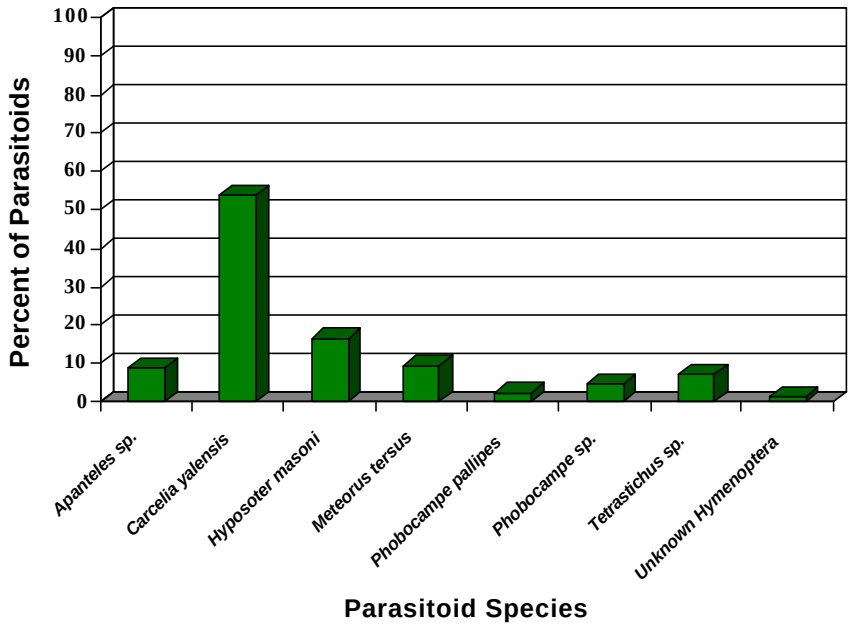
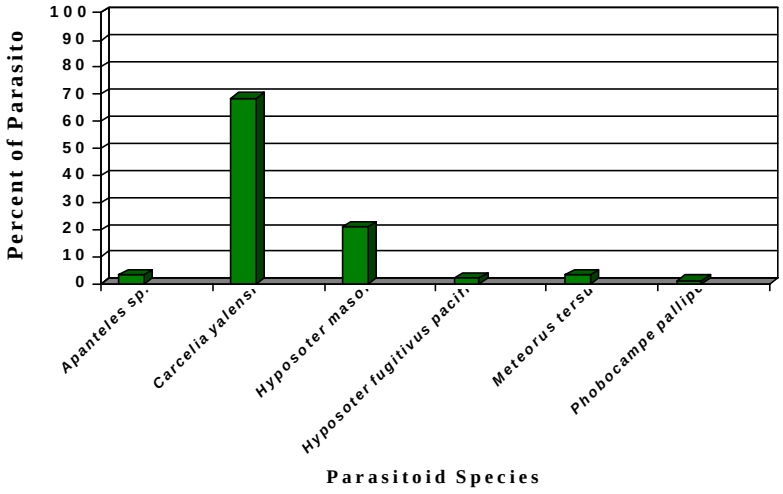


Figure 17. 2000 Douglas-Fir Tussock Moth Suppression Project Parasitoid Results: North End Analysis Units – Pomeroy and Walla Walla Ranger Districts



Our monitoring of parasite populations did not demonstrate any untoward or deleterious effects of the virus on this natural enemy complex. The treatments with TM BioControl-1 occurred during adult parasite oviposition activity for many of these species, and surely presented a physio-pathological challenge to these insects. They were not only exposed to the applied spray, but many of their progeny developed within infected host larva tissues where they consumed occlusion bodies of the virus. Since this virus is naturally occurring, and has evolved with the tussock moth and various other tussock moth natural enemies, we had no reasons to suspect any incompatibilities, and our observations from rearing of the parasites substantiated that. We did not evaluate all the possible guilds of natural enemies, but to the extent that we reared out adult parasites and observed their behavior, we believe, as others have shown before, that there are no deleterious effects of the virus on natural enemy guilds or complexes.

E. Conclusions and Recommendations

The TM BioControl-1 treatments dramatically increased the larval mortality rates over natural virus mortality rates throughout treatment areas. Treatment applications clearly induced an NP epizootic and enhanced the spread of natural virus in the population. Although natural virus was present prior to treating, there is nothing in our results to suggest that this level of virus alone would have spread as rapidly in the population this year without the inoculative treatments with TM BioControl-1. In that regard, a widespread epizootic from natural virus would probably not have occurred until next year—the anticipated year of collapse of this tussock moth outbreak cycle. Hence, we were successful in causing the epizootic to occur a year earlier than it would have under natural conditions, and we have clearly demonstrated that TM BioControl-1 is efficacious when applied under difficult operational conditions.

Use of the Early Warning Detection pheromone trapping system to predict an increasing population of tussock moth of potentially outbreak proportions (see other chapters in this Project Report) appears to have worked well in providing the Forest Service with the appropriate lead time to accomplish NEPA requirements to allow the treatment of the population a year earlier in the outbreak cycle, than has typically been done in the past. While treatment options for tussock moth are somewhat limited, TM BioControl-1 is an excellent choice due to its effectiveness, safety, narrow target specificity, and environmental compatibility.

This project has demonstrated that operational use of TM BioControl-1 did effectively induced an NP epizootic that we believe will prove to be a decisive factor in the termination of this tussock moth outbreak either this year or next. While foliage protection was one of the primary objectives for treatment of these tussock moth populations, it won't be until next year, when defoliation plot trees are re-sampled for defoliation, top-kill, and mortality, that the success of that objective can be fully measured and evaluated.

Additional monitoring of the populations in 2001 will also be important to substantiate the continuing decline and collapse of populations that resulted from virus treatments, as well as to follow the course of natural mortality in helping to bring about the termination of the current tussock moth outbreak. Parasitoid rates, as well as NP prevalence rates in the residual population will need to be assessed in 2001. The diversity of parasitoids in this population of tussock moth is a healthy indicator of only some of the guilds of organisms that are important factors influencing tussock moth population abundance. It is beyond the scope of this monitoring to evaluate all the key mortality factors that are involved in the termination of tussock moth outbreaks. Others have provided excellent research results towards that body of knowledge in the past (e.g., Mason 1981). Through this monitoring effort, we provided a documentation and verification of induced, as well as natural virus infection rates, and parasitism rates, and demonstrated the induction of a virus disease epizootic in the treated tussock moth population perhaps a year earlier than would have occurred naturally. We believe the strategy to suppress populations of tussock moth and protect foliage to the benefit of "resources of concern," has been accomplished, but the real measure of success will be next year when it is determined the extent to which trees on treated areas have retained foliage, produce new foliage, have been top-killed, or are killed by defoliation or bark beetles that are attracted to sufficiently weakened host trees, relative to untreated areas. It is essential that all of this follow-up monitoring be conducted in 2001 to bring proper

closure to the 2000 Douglas-fir Tussock Moth Suppression Project in the Blue Mountains. This follow-up work will be conducted pending availability of funding.

2 See references

V. Riparian Shade Monitoring (Tom DeMeo, Kathryn Boula, Mark Fedora)

A. Introduction

In late May 2000, the Pacific Northwest Regional Forester signed a record of decision (ROD) authorizing spraying of TM Biocontrol and Bt on selected National Forests in eastern Oregon and Washington. During 2000 only TM Biocontrol was used. This pesticide is species specific, killing only the Douglas-fir tussock moth and one other closely-related tussock moth species. The objective of this spraying was to limit defoliation caused by anticipated outbreaks of the Douglas-fir tussock moth. TM Biocontrol Spraying began in June and was completed by July 13, 2000.

B. Purpose

The purpose of this document is to outline implementation of a portion of the monitoring plan in the final environmental impact statement (FEIS) (Appendix I). Monitoring in the FEIS takes two forms: 1) monitoring the application and conduct of the project itself; and 2) monitoring the effectiveness of the treatment in achieving the objectives of the project. This document partially addresses (2) in that the monitoring described here assesses the effectiveness of the treatment in limiting defoliation.

The specific objective of the monitoring described herein is to indirectly monitor defoliation along streams of value to bull trout. In the FEIS, loss of foliage in riparian zones is thought to have an adverse effect on fish. Less foliage means more sunlight reaching these streams; this could possibly raise stream temperatures to levels adversely affecting fish spawning and survival (FEIS, pp IV-15 to IV-26).

C. Methodology

Six National Forests are affected by this ROD: the Colville, Umatilla, Wallowa-Whitman, Malheur, Ochoco, and Fremont National Forests. We initially limited our scope to the Wallowa Whitman and Umatilla, because 1) our logistical limitations of time and personnel precluded monitoring over many areas; and 2) at the time we began our effort, only the Wallowa Whitman was likely to be sprayed. In order to make meaningful comparisons, three treatments were selected for monitoring: 1) bull trout streams affected by tussock moth and sprayed; 2) bull trout streams affected by tussock moth and not sprayed; and 3) bull trout streams not affected by tussock moth, and hence not sprayed.

In developing this monitoring plan, we considered the six planning areas slated for spraying: Pine, Eagle, Imnaha, Mill Creek, Pomeroy, and Spangler. The first three are on the Wallowa-Whitman NF; the latter three on the Umatilla. The Eagle, Lookout, Mill Creek, Pomeroy, and Spangler areas were dropped from monitoring consideration because they either did not have or had too few bull trout

streams scheduled for spraying, or because they were likely to be dropped from the spray list. This left only the Pine and Imnaha areas for consideration, both on the Wallowa-Whitman. We selected the Pine area because of the number of bull trout streams to be sprayed (37, versus 4 for the Imnaha).

Care was taken to sample, wherever possible, the same stream order and vegetation series in each case. We required easy access to streams, since the daily timeframe for sampling was narrow. Three streams in each of the three treatments were sampled, for a total of nine streams sampled. Streams were randomly selected from the group of streams meeting stream order, treatment, vegetation series, and access criteria. Each stream was sampled in late June 2000, before significant defoliation occurred, and before any of the sampled areas were sprayed. We sampled again in late August 2000, well after all spraying had been completed, to examine whether spraying of riparian areas had any effect on shade.

This report includes the results of the June and August samplings. A final sampling is planned for August 2001, to examine the possible effects of foliage regrowth over the next year.

Streams were sampled using a transect following the stream. Transects began at a randomly selected point along the stream, but starting points were constrained to locations with easy road access. Solar radiation reaching the stream was sampled at 10-m intervals along the transect, for a total of 100 sample points per stream (or 1000 m of stream length). This means a total of 900 points.

An blueprint paper technique (Emmingham and Waring 1973) was used to measure the solar radiation at each point sampled. Blueprint paper is sensitive to sunlight, and can be used to index the amount of sunlight received over an elapsed time. Small (2.5 cm X 2.5 cm) booklets of this paper were stapled together and placed in petri dishes, with one dish per sample point. Each booklet was comprised of 15 sheets. Because our objective was to measure the energy reaching streams, sample dishes were placed on rocks or logs in streams wherever possible. Where this is impractical the dishes were left on the streambank.

The blueprint paper technique does not measure solar radiation directly. The papers measure radiation indirectly by changing color when they are exposed to sunlight; e.g., 2-3 exposed sheets indicate low light levels; 10 would indicate very high levels.

The blueprint papers are not examined or “read” in the field. They are collected and kept under dark conditions. In the office the color of the papers is fixed by exposure to ammonia vapor. Once fixed the papers can be stored indefinitely and re-examined at any time.

Blueprint paper exposure to sunlight is first correlated with an electronic instrument measuring solar radiation (in this case, a pyranometer). Blueprint paper used in our field sampling was calibrated with electronically measured light levels at the University of Oregon Solar Radiation Monitoring Lab on June 13, 2000. Petri dishes with booklets of blueprint paper were made up beforehand, and exposed at

intervals from 5 minutes up to 5 hr 20 min. Instrumentation at the lab recorded the w/m^2 for each interval; this was downloaded to a computer and made available on a spreadsheet. By comparing the number of sheets exposed with the amount of radiation received, a log linear relationship was derived:

$$\log x = (y + 4.1197)/2.4928$$

Where x = solar radiation received in w/m^2

y= no. of sheets of blueprint paper exposed

and 4.1197 and 2.4928 are constants.

We obtained an r^2 for this relationship of 0.97, similar to Emmingham and Waring's (1973) value of 0.99. (For this and all analyses, we used SAS (SAS Institute 1986).)

Using this equation, we could predict the amount of light received for any number of blueprint sheets found exposed in the field.

Operationally, petri dishes with blueprint papers were placed along streams at dusk, and retrieved the following day at dusk. We thus were collecting data on the full amount of radiation received during the entire day. We sampled June 21-23, 2000, and August 22-23, 2000 along the following streams:

High tussock moth levels, subsequently sprayed (HIGHSPR):

Meadow Creek

East Pine Creek

Trail Creek

High tussock moth levels, not sprayed (HIGHNO):

Gold Creek

Long Creek

Little Eagle Creek

Relatively low tussock moth levels, not sprayed (LOW):

Little Elk Creek

East Pine Okanogan Creek

Holbrooke Creek

On each day sampled, three dishes per transect were also placed on a nearby site in full sunlight to index the amount of sun available that day. Since results are expressed as the percentage of full sun available, no bias is involved due to sampling on different days or with different light conditions.

D. Data Analysis

A mean sunlight exposure can be developed for each stream, and responses compared through analysis of variance with class variables of treatment and stream. Because values are expressed as percentages of full light available, all data were arcsin-transformed before analysis (Zar 1984). For tables and presentation, values were converted back to actual percents.

E. Results

Processing blueprint paper in ammonia vapor proved to be immensely time-consuming. In some cases blueprint papers could not be processed because dishes were turned over in the field, became wet, or were not picked up. On average, this loss represented 9 percent of the sample data per transect.

For the June (before spraying) sampling, both treatment ($F=9.79$, $p<0.001$) and stream ($F=14.64$, $p<0.0001$) differed significantly (Table 1) in light levels. No significant difference ($p<0.05$) in light levels was found between streams with relatively low levels of tussock moth larvae and those with high levels of larvae slated for spraying. Those with high levels of moth and not scheduled for spraying had significantly lower ($p<0.05$) light levels (Table 2).

Light levels differed among streams, but the pattern was not striking (Table 3).

Late August (after spraying) results are similar (Table 4), with no meaningful changes from the June results.

F. Discussion

The range of values for both June (80 to 90 percent of full light) and August (78 to 90 percent of full light) is striking in two respects. First, the range over these nine streams across the Pine District is narrow—only 10-12 percent of full light. Second, there was remarkably little change between the June and August samplings.

Results thus far therefore suggest the streams we sampled were similar in the shade they experienced, regardless of the level of insect activity in June 2000. Moreover, the slight (if any) change in light levels between June and August 2000 suggests there was little or no insect defoliation along the streams.

Although our sampling scheduled for August 2001 could of course yield different results, results of the two samplings in 2000 strongly suggest: 1) Little defoliation from tussock moth along streams; and 2)

No demonstrable effect of spraying in affecting light levels reaching streams. Results suggest little effect of tussock moth on light levels affecting streams thus far. Monitoring will continue next year to assess possible increases in defoliation as the tussock moth population builds.

G. Acknowledgments

We gratefully recognize the advice of Bill Emmingham, Oregon State University; Xiquan Chen, Michigan Technological University; and Julie Concannon, US Fish and Wildlife Service, Portland, Oregon, in developing the methods.

Frank Vignola and staff at the University of Oregon Solar Radiation Monitoring Lab gave us a day of their time to perform the calibration. Staff at the Pine Ranger District, including the fire crew, provided critical assistance in placing and retrieving dishes in the field. Similarly, the Youth Conservation Corps crew assembled these dishes, a monumental task. Finally, Paul Joseph, Linda Collier, and Ken Snell of the tussock moth project team provided logistical and administrative support for the work.

[3] See references

VI. Operations (Art Anderson)

The aerial application contractor for this project was Heli-Jet Inc. of Eugene Oregon. The first application was made on 6/15/00 and the last application was on 7/18/00. During that time, 39,602 acres were treated. The application took 113 hours of helicopter time with an additional 39 hours of helicopter time for application monitoring and reconnaissance. A breakdown of acres treated per day and aircraft usage is shown in the Operations Appendix C.

A. 038 Carrier

The carrier used for this Project was 038A and purchased from Omnova Solutions Inc. of Greensboro North Carolina. Dick Reardon, a Forest Service employee, served as the government representative for production of 038 and provided valuable information and assistance to the Project. His primary concern with the carrier being shipped from the East coast was the settling of solids.

The first load of carrier arrived on June 11 and sampling indicated no settlement. After the product was metered into holding tanks, it was determined that the product came within 0.1 tenth of 1% of the tare weight and the metered gallons at 9.7 lbs per gallon weight.

There was a slight difference between the 038 and the 038-A carrier. The 038 seemed to separate out more after sitting over night, and there also seemed to be a bit of difference on the spray cards as reflected by a halo effect.

The 038A carrier worked well and we recommend using that carrier in the future.

B. Virus Handling

The TM Bio-Control virus came shipped in various sized packages based on the lethal dose (LD_{50}) bio-assay report. Five lots had a range of these per/acre doses in order to be able to come within 10% of the helicopter load calculation. This caused some time in load configurations and preparing the virus for the next day's operation. However the Project came within 5% of the acres treated and the amount of virus used based on a one-acre dose per each gallon of 038 carrier.

The mixing of virus and carrier was done one load at a time due to the limited 48-hour viability of the mixture. The virus was first mixed in a five gallon bucket with two-three gallons of carrier with a paint paddle and then was mixed through in-line agitation into 300 gallon tanks located at the helispots.

After the day's operation was completed the tanks and the Helicopter spray systems were rinsed/cleaned with water free from chlorine and with a ph of between 5.8 and 7.2.

VII. Contracting (Carl Culham)

A. General

Items contracted for the Project included: Aerial application of TM Bio-Control, administrative flights in support of both the aerial application and moth surveys, and the carrier 038. The virus was government furnished.

Based on the variable conditions associated with this Project (uncertain spray block sizes, location, and release sequence) a requirements contract with firm-fixed pricing was utilized. The contract was solicited as a Request for Proposals; technical capability was considered more significant than price when the proposals were evaluated. The estimated value of the work required the solicitation to have a formal source selection plan approved at the Washington Office level. Subsequent award was also approved by Contracting in the Forest Service Washington Office due to the value.

Considerations in drafting the solicitation/contract package included the following:

- The type of contract and method of solicitation.
- Issues specific to the statement of work for the aerial application and administrative flights.
- Aircraft safety requirements,capabilities and configurations, and pilot qualifications.

- Timing for award so that contract resources could be available at the earliest spray opportunity (on or about June 1).

B. Events Chronology

November 16, 1999 - Request for Contract Action Submitted to Contracting
November 16, 1999 to January 18, 2000 – Solicitation/contract package, Source Selection Plan, And Aviation Safety Plan Drafted
December 2, 1999 - Service Contract Act Wage Rates Requested
January 18, 2000 – Source Selection Plan submitted through RO to WO for Approval
February 2, 2000 – Source Selection Plan Approved by WO

February 25, 2000 – Aviation Safety Plan Approved
February 28, 2000 – Request for Proposals Issued
March 28, 2000 – Proposals Received
March 29, 2000 – May 1, 2000 – Proposals evaluated and negotiations
May 1, 2000 – Award Recommendation submitted through RO to WO
May 23, 2000 – Award Approved by WO
May 31, 2000 – EIS/ROD process completed
June 2, 2000 – Contract Award and Pre-Work Meeting
June 15, 2000 – First Aerial Application Flight

July 15, 2000 – Last Aerial Application Flight

C. Final Contract Quantities

Aerial Application of Virus Formulation	Estimated	107,000 Acres	@ $28.38 Per Acre.
	Actual	39,602 Acres	@ $28.38 Per Acre.
Administrative Flights	Estimated	55 Hours	@ $650.00 Per Hour
	Actual	55 Hours	@ $650.00 Per Hour
	(Mod #3)	1.7 Hours	@ $1,800.00 Per Hour

Total Final Contract Value: $1,131,232.34

VIII. Finance (Dana Reid)

The Wallowa-Whitman National Forest was the host unit of the Project. Therefore, all business and financial matters were handled through the Wallowa-Whitman. The Command and General Staff made the following financial decisions prior to implementing the project:

- All employees will adhere to the rest and recuperation Guidelines of 1 day off in 14 and 2 days off in 21. The IC set this example and enforced it with all employees.
- Employees will be guaranteed 8 hours per day, except during days off.
- Employees will be on a variable week tour, Monday through Friday.
- No Compensatory Time will be allowed.
- Sick Leave will be charged if off work due to illness.
- Section Chiefs can approve up to 12 hours per day, IC must approve all additional overtime.

A. Organization

The Finance Chief was located at the Incident Command Post in Halfway. Two part-time Personnel Time Recorders were to be located at each incident headquarters (Halfway and Pomeroy) for the majority of the project, but would extend to full-time during the spray operations. The local business administration folks at Pomeroy were available; therefore, they worked part-time throughout the entire project. One handled the personnel and payroll, and the other was responsible for purchasing, travel, and cost tracking. This worked exceptionally well. There were no outreach response forms received for Halfway, therefore, several Wallowa-Whitman employees were utilized and rotated in to work during the part-time period. Two full-time employees split the spray operations period.

B. Personnel & Hiring

The project managers were recruited by Nick Greear, Project Manager, in January. He and three staff members were also part of (fire) Incident Management Teams and were dispatched to fires during the project, which caused some difficulties.

An outreach was sent out to all personnel offices in the region as well as through the special emphasis program network to fill additional miscellaneous overhead and entomology crewmember positions. Position titles listed in the outreach were those from the Incident Command System without a description of the duties. This caused confusion, as many positions did not follow the traditional ICS job descriptions. We received enough outreach response forms to fill a portion of the positions, which were filled as details. We were short mostly helicopter managers and finance personnel. Responses were received from Forest Service, Bureau of Land Management and National Park Service employees. An interagency agreement was written to allow the BLM and NPS employees to participate. Additional outreaching was done until the majority of the positions were filled.

Simultaneously, a vacancy announcement was flown to advertise for temporary entomology crewmembers and radio operators. Advertising for the positions was done thru area newspapers as well as flyers hung at local businesses. Due to the early start of the project, it was difficult to locate enough people available. Therefore, hiring was an ongoing process through approximately the third full week of the project.

All detailers received a request for personnel action and a letter with a project overview and expectations. The letter would have been more beneficial with more clarification and detailed information about hours, days off, overtime, etc. Each detailer completed an "Information Sheet" with personal, payroll, and travel information that was utilized in the finance section.

Numbers of employees working on the project varied throughout the duration of the project. Some employees supported both Halfway and Pomeroy and others were assigned specifically to one location. The Command & General Staff was split between both locations. The following is Table 11 of total personnel working on the project of which the "Shared" column represents the number of employees that supported both Halfway and Pomeroy.

Table 11: TOTAL PERSONNEL WORKING ON THE PROJECT

	Shared	Halfway	Pomeroy	Total
Overhead	15	10	13	38
Entomology Crews (Detailers, Temporaries, Locals)	0	39	35	74
Air Operations	0	13	7	20
Miscellaneous Support	33	2	8	43
TOTAL PERSONNEL ON PROJECT	48	64	63	175
Most Personnel at One Time (PP 12)	99 On site, 113 Recording Time			

C. Per Diem & Travel

Detailers assigned to the project were in per diem status and standard per diem rules were in effect. For the most part, temporaries worked from their official duty station and were not in per diem status. However, if they were relocated for short periods, they received per diem. The Finance Section completed travel vouchers for all employees. Copies of the vouchers were sent to employee's home units.

D. Payroll

Payroll was a challenge due to Lotus Notes, which requires all personnel to have their own profile to process time. The Finance Section processed time for all personnel on the project, with the exception of local employees and those employees that had a Lotus Notes profile set up on the project. This decision was made because of the long hours employees would be working as well as the number of computers available. This required the timekeepers to access the detailer's home unit server and lotus notes profile to enter their time, which would then be processed through the employees home unit. This process prevented employees from showing up on the missing T&A reports for their forest.

Time for the temporaries was processed through the Wallowa-Whitman NF. No user profiles were set up through the Wallowa-Whitman for the Halfway employees and through the Umatilla NF for the Pomeroy employees.

Problems and confusion did occur regarding overtime and days off. Because the project was being managed under the Incident Command System, detailers made assumptions that the project was run as a typical "fire" in terms of payroll, therefore, they were expecting a guarantee, 7 days a week.

E. Claims

No claims were filed as a result of the project.

F. Accidents, Injury, Illness

Three vehicle accidents occurred during the incident; one involving a third-party. There was no fault to the government employee. Minimal minor injuries were reported and processed through the finance section.

G. Procurement

Procurement for the project was separated into two categories: 1) Aerial Application Contracting, and 2) Operations Purchasing. The Operations Chief acted as the Contracting Officer's Representative and was delegated authority to handle the Aerial Application Contract. Resource orders were used for operations purchasing to order equipment and supplies for the project. Orders were processed through the Logistics Section. The local district offices assisted with these purchases as well as the use of government credit cards.

H. Costs

Tracking costs for the project was a challenge. During the planning phase, employees charging time to the project had a responsibility for turning in number of hours worked and dollars spent on per diem and purchases for tracking purposes. Once the project started, costs were gathered at both locations and entered into a spreadsheet for the entire project. The difficulties came with the magnitude of employees charging to the project but were not actually detailed to the project.

The Job Code Summary Statement reports (Project Manager Statements) were not reliable for tracking daily charging. The reports for each month were not available until the following month and charges made to the reimbursable codes would not show up for potentially several months.

Project Costs were tracked separately for Halfway and Pomeroy. Costs for personnel are actual costs for work at each site. Personnel that supported both Halfway and Pomeroy are split based on the acreage sprayed (Halfway – 33,236 acres, 84% and Pomeroy – 6,156 acres, 16%). Most Command & General Staff personnel supported both locations, therefore are shared costs as well. Costs for government vehicles, supplies and equipment, and aircraft were split by the percentage of acres sprayed.

See the "Wallowa-Whitman and Umatilla National Forests 2000 Douglas-fir Tussock Moth Project Summary Cost Report" for a breakdown of project costs and cost per acre, additional costs obligated outside of the project, and projected costs thru 2001.

The cost per acre is high due to the initial project direction, which was for application of a large number of acres, approximately 85,000 acres. The acreage for application decreased significantly resulting in a high cost per acre. In addition, the project total costs are higher than projected as some of the obligated costs that were incurred from sources outside of the project, i.e. DNA analysis of the virus, were charged to the project job code and are therefore, included in the project costs. These were not initially projected as part of the project costs.

I. Total Project Costs and Cost per Acre

Table 12:

	(Shared Costs)	HALFWAY	POMEROY	TOTAL
Salary	$17,548	$615,243.36	$394,633.92	$1,009,877.28
Per Diem		85,588.82	64,877.60	150,466.42
Government Vehicles	$117,563.32	99,928.82	17,634.50	117,563.32
Supply/Equipment	231,077.94	196,416.25	34,661.69	231,077.94
Aircraft (Contract)	1,131,232.34	961,547.49	169,684.85	1,131,232.34
Aircraft (Call When Needed)	19,043.00	16,186.55	2,856.45	19,043.00
TOTALS (+5%)		$1,974,911.29	$684,349.01	$2,659,260.30
Acres Sprayed		33,362	6,175	39,537
COST PER ACRE		$59.20	$110.83	$67.26

Shared costs include costs that could not be assigned to one specific area and thus are distributed between Halfway and Pomeroy by the 84/16% acreage split.

*Salary & Per Diem are split by actual costs, which include some shared personnel costs. The $17,548 is for Environmental Monitoring, which was not captured in the Salary costs.

25% has been added to "Supply/Equipment" to balance with the Job Code Summary Statement dated September 2000.

The following costs are calculated in the above costs: Lab work at La Grande Lab, Mapping with Low Level Helicopter Survey, 2000 Defoliation Sampling, 2000 Environmental Monitoring, Sequential Larva Sampling, Data Entry, and DNA Analysis of Virus.

Table 13: Additional Costs Obligated

	Additional Obligations
Overruns from EIS Team	$175,000.00
Forest Monitoring for 2001	128,000.00
TOTAL ADDITIONAL COSTS OBLIGATED	$303,000.00

TOTAL PROJECT AND OBLIGATED COSTS	$2,962,260.30

Table 14: Projected Costs Thru 2001

	Projected Costs
2001 Environmental Monitoring	$13,300.00
2001 Defoliation Sampling	8,175.00
2000 Mating Disruption	90,000.00
2001 Mating Disruption	160,000.00
2001 Contract Preparation	3,020.00
Report Publication Costs	5,000.00
TOTAL ADDITIONAL OBLIGATED COSTS	$279,495.00

GRAND TOTAL	$3,241,755.30

IX. Safety (Steve Snider)

The DFTM project Incident Command Post was located at the Lions Club Building in Halfway OR and a branch Incident Command Post was located at the Pomeroy Ranger District Office in Pomeroy WA. Two safety officers (SOFR2) were assigned to this project, one at each branch of the operation. Both safety officers worked full time for the first two weeks of the project with the field going employees during orientation and required training including First Aid, CPR, and Defensive Driving. After the first two weeks, the Halfway Branch SOFR was present approximately 50% of the time, and the Pomeroy Branch SOFR was present approximately 25% of the time. Daily attendance at the morning crew briefings talking about fieldwork safety and driving safety were the emphasis areas. Job Hazard Analysis', Medical Evacuation Plans, and Aviation Safety Plans were written for this project and used during the tailgate safety sessions for reference.

When Air Operations started (6/15), daily operational and safety briefings were held at 0345 and debriefings were held at 0900. The Air Operations Chief ran these briefings.

The overall project safety record attests to the diligence of everyone with regard to safety. Starting with crew safety briefing, with follow-up crew tailgate safety meetings, and crews' attention to detail while driving and working in the field.

A. Summary Of Field Crew Activities

Table 15: Summary of Activities

Activity	Halfway	Pomeroy	Total
Hours Worked:	31,000	22,000	53,000
Miles Driven:	65,000	31,000	96,000
Aircraft Hours:	151	45	196
Injury/Illness Report	4	0	4
Vehicle. Accident	2	1	3
Aviation Safety Report	1	0	1

Two of the CA-1's required medical attention, one for a twisted knee and one for a pulled muscle in the back. The twisted knee might possibly result in additional medical attention, either surgery or physical therapy. The employee was put on light duty and has since resigned. Two of the vehicle accidents involved backing vehicles. The damage was $300 and $1000 to the vehicles. The third vehicle accident was no fault of the Forest Service employee; they were hit by another vehicle that ran a stop sign.

The SAFECOM was filed for a malfunctioning cable on a spray boom nozzle.

Overall the project safety record was very good; considering 125 people working 53,000 hours, driving 75 vehicles 96,000 miles and flying 196 hours over a period of 3 months.

X. Information (Judy Wing)

"This entire project has been a work of art, watching all the pieces come together," Tami Waldron, Baker City Record Courier, July 13, 2000. Tami was on an entomology crew and also a reporter for the Record Courier.

The above media quote sums the information efforts for this project. The project objectives of keeping employees, public, media, and legislators informed and providing a proactive approach to providing information were met.

Two months before spraying the project IC, District Rangers, and staff began talking with county commissioners and other interested publics about the entomology surveys and proposed spray project. When the entomology crews arrived in Halfway and Pomeroy, there was increased local interest in all phases of the project and a series of weekly news releases were begun.

A weekly news release/update was sent by fax every Friday. The media list included seventeen daily and weekly newspapers and radio stations in Northeast Oregon and Southwest Washington. This information was also sent to public affairs at the Forest Service Regional Office and local Forest Service offices. This weekly update provided excellent media coverage across the Blue Mountains project area.

Extensive contacts were made with the public traveling within the spray units. Signs announcing the spraying were posted at campgrounds and other strategic locations near the project. Project information bulletins were posted at a variety of downtown locations in Halfway, Richland, Pomeroy and Dayton.

Future projects should consider providing information handouts for the public to the entomology crews earlier in the project. The crews came in contact with the public regularly. When the crews began more familiar with the project, their ability and desire to share with the public increased. It would work to provide information during the regular morning briefing from the beginning of the project rather than waiting until spraying was beginning.

XI. Project Critique

A. Group Critique

The primary Team members met with Ranger District, Forest, and Regional Office personnel on July 19 to critique the project. That critique follows:

Expectations:

- The unknown amount of time needed to plan and implement the project made it difficult to commit to the entire project.
- Using ICS, but not having emergency hiring and procurement authority, was frustrating in initial planning.
- The use of consistent standards for EIS guideline interpretation on all forests was needed.

Recommendations for the Future:

- Start earlier in the year.
    - One entomology plan should be used for all projects. (Developed by September 1.)
    - Request for Contract Action needs to start by Oct. 1.
    - Cocoon Survey results need to be done by late fall (by each Forest).
- Designate a Regional Office Coordinator
    - Provide guidance and mentor Forest leaders.
    - Develop consistent reporting standards.
    - Monitor amount of virus available to meet ROD.

    - Allocate dollars to forests for administration and project management.
- Forests Should Manage Project Occurring Within Their Forest.
    - Identify early (by September 15) their project leadership from natural resources shop.
    - Determine their own organizational structure for the project.
    - Identify KSA's for each position.
    - Do their own mapping including GIS.
    - Handle their own administration (hiring, firing, etc.)
    - Handle their own Communications (radio, phone, fax, office space, etc)
- Maintain The Regional Aerial Contract
    - Aerial contract financed and administered by region.
    - Proivde a lead COR that is air operations qualified.

B. Additional Recommendations from Team:

- Air Operations:
    - Contract action needs to begin by October 1. Helicopter contract depends on early entomology verification and design.
    - Critical need for quality maps. Mapping standards should be provided. Nick has developed them in the Final Report critique.
    - Verify IHOG qualifications (Chapter 3) for air operations. John Rawlins and Art Anderson.
- Entomology:
    - Cocoon sampling needs to be done and a treatable population verified, in the field, in the fall of 2000, for all Analysis Units to be considered for treatment in 2001. This extensive field verification will provide the necessary information to make the project more efficient when spray blocks are determined and spring surveys begin.
    - Resolve issues concerning virus development, packaging amount, and handling. Don Scott and RO product manager.
    - Bring supervisors and project staff on one week before the crews start.
    - Plan for one week to train the entomology crews.
    - Provide for cross-training opportunities as project progresses.
- EIS Issues:

- Forests considering a project in 2001 or 2002 need to identify issues in the EIS that need to be amended. For example, host type maps, review of proposed projects, areas of concern in Alternative 1, and unnecessary operation guidelines in Appendix G.

- Other:
  - Supplies need to fit the site.
  - Equipment needs to be updated.
  - Improve method of hiring or contracting with Forest Service retires and non-FS personnel (ODF/DNR).
  - Hiring letters need additional details about job expectations (overtime, work schedules, length of project, R&R, and commitment).

Some members of the Project Team also provided a self-critique for their functional area; those items are listed below.

1. Command

Table 16 displays the critique of Project Managers Greear and Kleckner by function:

Table 16: IC Critique

Planning Phase:

Positive	Areas to Improve
Involvement of R.O. Pest Management (Dave Bridgwater) at all planning meetings. Had electronic copy of older Project Plans. On-site visits to each branch.	Inadequate lead-time. Started too late because of FEIS schedule. Inadequate field information from fall surveys. Had to “start fresh” with cocoon samples in the spring, which necessitated too much snow plowing and resulted in too little information for map/contract preparation. Lack of adequate and timely maps. Unnecessary operational direction in FEIS (weather parameters).

Operations Phase:

Positive	Areas to Improve
The quality of individual personnel, especially in aviation operations. incident headquarters Facilities at both Branches and the cooperation from those hosting Ranger Districts. Regional Office interest, support, and assistance. Conference calls between both Branches and the R.O. Contract Administration and on-site assistance from the Contracting Officer. Contractor professionalism and performance. High Quality FEIS and ROD. Backup I.C. Use of the Tussock Moth data base (created by Ken Snell) for record keeping and public information.	Lack of pre-designated incident management team. • Not all team members adequately understood and adhered to ICS chain of command. • People had not worked together before to understand each other, especially given the separated operation (Halfway and Pomeroy). • Mis-communication between Command & General Staff. Lack of daily C&G meetings due to part time nature of C&G. Unequal attention from three different District Rangers from too little to too much detail. Loss of key people to fires (lack of pre-designated IMT). Inability to fill resource orders (aviation). Inconsistent attendance of Pomeroy entomologist (due to health reasons). Question need for Deputy IC in Pomeroy. Not including a Planning Section Chief and/or Situation Leader in the organization. Too many tasks assigned to the Spray Operations Chief (C.O.R., Supervision of all spray operations, in charge of virus handling, report responsibilities).

	Not enough entomology ground crew supervision.

Administration Phase:

Positive	Areas to Improve
Extraordinary work by Finance Chief (Reid) and W-W personnel office (Wood) in hiring folks. High percentage use of local hires as seasonals.	Lack of AD emergency hiring authority. Needed more current cost accounting (fire assignments prevented). Inability to control costs - "fire assignment mentality". Some people abusing overtime.

Mapping:

Positive	Areas to Improve
Ability of Forest GIS shops to provide “SHAPE” files to the contractor for use with the “SATLOC” systems in the helicopters. GIS provided informational maps for management and the public. Use of the Internet for displaying maps to the public.	Lack of Situation Unit Leader early on to make mapping preparations, including GIS coordination with two Forests. Over-reliance on past map standards rather than trying new methods when anticipated map products were not available. Should establish map standards then produce them with what we have. Over-reliance on the ability of GIS to produce “all” the maps. Traditional methods using base series maps are still needed. Different “standards” of mapping information from different Forest’s in the FEIS.

	Lack of ground truthing all areas by ranger district personnel. Errors in GIS data bases.

- The most difficult part of the project was assembling a team. With the reduction in the federal workforce through downsizing and retirements, plus the impact of fire season, maintaining a leadership team throughout the Project was not possible. Future projects will likely suffer the same predicament. Two recommendations are 1) assembling a full time team to take on these types of projects, and 2) contracting the majority of the work. The latter is probably the most practical and efficient but would require writing a contract specifications in the winter.

2. Aviation Operations

- Provide more information and training on the use of TM-Biocontrol.
- Have Air Ops personnel interface more with the entomology crews.
- Use detailers when possible so that there is more long term commitment to the project.
- To overcome the uncertainties of the next day's need for certain virus dose sizes, an in-line mixing process should be developed. That way the virus is not mixed until it is pumped into the helicopter.

3. Finance Section

- If at all possible, utilize folks that are willing to commit to the entire project, rather than part-time.
- Start outreaching for detailers and advertising for temporaries as early as possible.
- Ensure outreaches explain the job duties clearly.
- Ensure detailer letter is very specific about expectations and financial matters.
- If adhering to the national safety standards (1/14 or 2/21), utilize a first-40 tour.
- Determine per diem rate prior to outreaches and inform personnel prior to receiving a commitment.
- Utilize local district personnel to complete hiring and termination paperwork, payroll processing, medical paperwork, purchasing and travel vouchers.
- Limit the number of employees that are given authority to charge to the project.
- Ensure the C&GS understands the importance of receiving cost information for cost tracking purposes.
- Provide information in the detail letter and the project announcement memo that fully explains the scope of the project including administrative and personnel issues.

References

1

Brookes, Martha H.; R. W. Stark; Robert W. Campbell, eds. 1978. The Douglas-fir tussock moth: A synthesis. Tech. Bull. 1585. Washington, DC: U. S. Department of Agriculture, Forest Service, Science and Education Agency, Douglas-fir Tussock Moth Research and Development Program. 331 p.

Mason, R. R., 1979. How to Sample Douglas-fir Tussock Moth Larvae. U.S. Dep. Agric., Agric Handb. 547.

Mason, R. R., D. W. Scott, H. G. Paul. 1993. Forecasting outbreaks of the Douglas-fir tussock moth from lower crown cocoon samples. Res. Pap. PNW-RP-460. Portland, OR: U. S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 12 p.

USDA Forest Service. 2000. Douglas-fir Tussock Moth: Final Environmental Iimpact Statement. Portland, OR: U. S. Department of Agriculture, Forest Service, Pacific Northwest Region. Indeterminate pagination.

2

Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. J. Econ. Entomol. 18: 265-267.

Dahlsten, D. L.; R. F. Luck; E. 1. Schlinger; J. M. Wenz; W. A. Copper. 1977. Parasitoids And predators of the Douglas-fir tussock moth, Orgyia pseudotsugata (Lepidoptera: Lymantriidae), in low to moderate populations in central California. Can. Ent. 109: 727-746.

Martignoni, Mauro E. 1999. History of TM BioControl-1: the first registered virus-based Product for control of a forest insect. American Entomologist 45(l): 30-37.

Mason, Richard R. 1981. Numerical analysis of the causes of population collapse in a severe outbreak of the Douglas-fir tussock moth. Ann. Entomol. Soc. Am. 74(1): 51-57.

Poinar, Jr., George 0.; Gerard M. Thomas. 1978. Diagnostic manual for the identification of insect pathogens. Plenum Press, New York. 218 p.

Sikorowski, P.; J. R. Broome; G. L. Andrews. 1971. Simple methods for detection of cytoplasmic polyhedrosis virus in Heliothis virescens. J. Invertebr. Pathol. 17: 451-542.

Thompson, Clarence G.; Linda J. Peterson. 1978. Rearing the Douglas-fir tussock moth. Agriculture Handbook No. 520. Washington, DC: U. S. Department of Agriculture, Combined Forest Pest Research and Development Program. 17 p.

Torgersen, Torolf R. 1977. Identification of parasites of the Douglas-fir tussock moth, based on adults, cocoons, and puparia. Res. Pap. PNW-215. Portland, OR: U. S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 28 p.

Torgersen, Torolf R. 1981. Parasite records for the Douglas-fir tussock moth. Gen. Tech. Rep. PNW-123. Portland, OR: U. S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 38 p.

Torgersen, Torolf R.; Donald L. Dahlsten. 1978. Natural Mortality. In Brookes, Martha H.; R. W. Stark; Robert W. Campbell, eds. The Douglas-fir tussock moth: A synthesis. Technical Bulletin 1585. Washington, DC: U. S. Department of Agriculture, Forest Service, Science and Education Agency, Douglas-fir Tussock Moth Research and Development Program. Pp. 47-53.

3

Emmingham, W.H., and R.H. Waring. 1973. Conifer growth under different light environments in the Siskiyou Mountains of Southwestern Oregon. Northwest Sci. 47(2):88-99.

SAS Institute. 1986. SAS/STAT User's Guide, Release 6.03 Edition. Cary, NC: SAS Institute Press.

Zar, J. H. 1984. Biostatistical analysis. Englewood Cliffs, NJ: Prentice-Hall, 718 pp.