

- i. *Leptoglossus* m/r/r – resolve budget allocation (Strong, Lindgren). Done. See item 3a (iii) below.
- j. Pesticides trials budget details (Bennett). Done. See item 3a (v) below.
- k. Fact sheet draft to Woods; fact sheet final deliverables into proposal (Bennett). Done. Woods, Diane Douglas, and FGC contractor have created fact sheet formatting template from draft fact sheet. Deliverables added to proposal (see item 3b (ii) below).
- l. Draft budget request (All). On-going. See item 3c below. Carry forward.
- m. Overhead discussions updates (Woods). On-going. Carry forward.
- n. PM TAC page on FGC website; create listserver (Woods, Diane Douglas, Keith Thomas). Ongoing. Carry forward.
- o. Resolve Sharepoint access issues (Bennett). Done. All members should now have access.

3. 2009/10 BUSINESS PLANNING (Strong)

- a. **Research proposals (Strong).** Proposals that had undergone revisions to text and/or budgets subsequent to 28 Jan meeting were presented and discussed.
 - i) *Dioryctria* reproductive biology (UoAlberta). See attached. Proposal well focussed; management objectives now very clear. Voucher specimens issue addressed. Field assistant budget line item clarified. Addressing potential need for new molecular work is on-going and not critical to current proposal. **Bennett & Strong will ensure that management objectives statement is incorporated into proposals template.**
 - ii) *Leptoglossus* IR & visible light (SFU). See attached. Proposal well focussed; timelines and objectives now very clear. **Bennett & Strong will ensure that timelines statement is incorporated into proposals template.**
 - iii) *Leptoglossus* mark/release/recapture (MoFR, UNBC, UBC-O). See attached. Budget issues clarified.
 - iv) *Contarinia* pheromone synthesis pathway (SFU). No changes.
 - v) Pesticides trials (CropHealth). See attached. Budget updated. Discussion centred on potential pesticide choices. No “all-inclusive” systemic currently available. Of 5 potentials listed in proposal, spinetoram and spirotetramat seem promising, others are unlikely to be effective against internal cono- or spermatophagous species. Pesticides trials remain the most immediately important work for PM TAC. **Strong will organize meeting with Mario Lanthier, Yvonne Herbison, Bennett, Corrigan, and Crowder prior to field season to discuss trials including pesticide choices and treatments.**
 - vi) Lab funding proposal (MoFR). No issues noted. \$15k added to budget to allow for hiring of technical assistance as needed.
- b. **Operational proposals (Bennett).**
 - i) Pest management Interior operations (MoFR). No issues noted with this proposal.
 - ii) Field guide development (MoFR). See attached. Current fiscal year deliverables more clearly specified.
- c. **Budget request draft (Bennett).** See attached budget table. Full funding amount is significantly less than 2008/09 request. “Option 1” (preferred) will be for full funding, “option 2” will be \$15k less (delete from lab funding proposal), “option 3” will be \$25k less (delete from lab funding proposal as per option 2 with cuts to other projects to be determined by PM TAC discussion if necessary after announcement of award amounts by FGC). **Bennett will draft and circulate budget request document; final draft of request to be delivered to Woods by 3 March.**

4. ADJOURN. Date for next meeting not set. Meeting adjourned at about 11:05 AM PST.

Draft budget table development - PM TAC 2009/10 fiscal year

Current proposals & budgets		24/ii/09		24/ii/09 rounded	
			Subtot		Subtot
1	Research lab materials/supplies	28 000		28 000	
2	<i>Dioryctria</i> reproductive biology (UoA)	39 267		39 300	
3	<i>Leptoglossus</i> m/r/r (UNBC & UBC-O)	51 787.68		51 800	
4	Host detection - IR & visible light (SFU)	33 394		33 400	
5	<i>Contarinia</i> pher. development (SFU)	11 000		11 000	
6	Pesticide trials (Crop Health A&R)	43 050		43 100	
SUBTOTAL - Research			206 498.68		206 600
7	Interior pest management program	25 000		25 000	
8	Field Guide development	8 000		8 000	
SUBTOTAL - Other projects			33 000		33 000
TOTAL (proposals)			239 498.68		239 600
10	Strong & Bennett salary costs (approx)	170 000		170 000	
TOTAL budget (incl. salary costs)			409 498.68		409 600

- *Dioryctria* & *Leptoglossus* m/r/r studies include 8% overhead
- Host detection & pheromone development studies include 10% overhead
- Pesticides trials \$\$ = 3 tree species (1 species = 14 350); includes cone assessments, seed extraction, and germination test costs; no \$\$ for product costs.

Reproductive biology of *Dioryctria abietivorella* – Proposal – February 23, 2009

Proposed research: April 2009 – March 2010

Field work will be completed by September 2009 and laboratory work will be completed by March 2010. Our main objectives for this season will be to assess seasonal flight phenology, mating status throughout the flight period, female calling behaviour, adult longevity and egg production. All work, unless otherwise stated, will be conducted in the Douglas-fir breeding orchards located at the Kalamalka Research Centre (KRC). All insects for laboratory and field experiments will be reared from Douglas-fir cones collected at KRC. Voucher specimens of male and female *D. abietivorella*, harvested from light trap catches at several times through the season as well as sample individuals from each experiment, will be lodged at the Strickland Entomological Museum

Mating Behaviour

It is important to know when moths are reproductively active, during the adult lifespan, season and day, in order to develop pest management tactics that target reproductive behaviours such as pheromone-based monitoring, mating disruption or attract and kill technologies.

1. Light trap monitoring

Objectives:

- To determine the flight phenology and reproductive status of female *D. abietivorella* moths in seed orchards throughout the flight season.
- **Management objective:** Knowledge of reproductive biology is essential to successful pheromone control or behavioural management of *Dioryctria*. With good information on the timing of female flights, we can better target pheromone introductions to the orchard. We will also have an indication of flight duration, suggesting whether moths originate within or outside the orchard of interest. Moths originating outside the orchard of interest may have mated before arriving, thus potentially scuttling mating disruption efforts. Understanding mating status will also help us evaluate the likelihood of mating outside the orchard of interest, and the motivation for multiple matings, both of which can reduce the chance of success for pheromone-based control. In general, when designing a pheromone based control method, the more knowledge we have of the reproductive behaviour of the target insect, the greater the likelihood of success.

Progress to date:

Female seasonal flight activity and mating status were monitored using an improved protocol modified from 2007. In June 2008, two black light traps were placed in Douglas-fir blocks at KRC, Vernon Seed Orchard (VSOC) and PRT. The traps, separated by at least 500 m, were hung on a line strung between two trees and positioned in the upper-mid canopy. Traps were run five days a week and monitored twice during that period. Females were captured from June 20th to September 19th, 2008. The collected females were dissected to assess mating status (presence and number of spermatophores) and to confirm species identification.

Dioryctria abietivorella, *pseudotsugella*, *reniculelloides*, *okanaganella* and *auranticella* were captured. Because of the difficulties in identification to species, taxonomic groups (Neunzig 2003) will be used in analyses. Multiple mating occurs in females of all species collected.

Data will be analyzed using repeated-measures ANOVA to see if there is an effect of season on species composition and mating status. In *D. abietivorella* the number of matings differs by trap month (see Appendix Fig. 1). We are in the process of finding a reliable way to measure spermatophore size to determine if male reproductive investment changes throughout season. In 2009, the light trapping experiment will be expanded to incorporate the beginning of the flight period in April and May and flight activity in other host blocks (pine and spruce). These data will indicate the importance of host association on moth capture and mating status throughout the season.

Male *D. abietivorella* adult flight was also monitored weekly between May 4th to September 30th, 2008 using pheromone traps located in KRC, VSOC and PRT Douglas-fir blocks. Trap capture of male moths was compared with female moths captured in light traps (see Appendix Fig. 2). Females stopped appearing in the light traps after August 17th while males were still present after this time. It should be noted that 96 of the 97 *D. abietivorella* females caught had mated at least once. Females may not disperse before mating and may not encounter the light traps. This technique may not attract virgin females and would therefore not be useful for tracking flight phenology of the entire population. It is interesting to note that males are present and flying in late summer and early fall when no females were captured in the light traps. Because only mated females were captured, it is hard to know if females have died off or are not mated and not captured in traps.

Methods:

- a. Female seasonal flight activity and mating status will be monitored using the successful 2008 light trapping protocol. Trapping will be initiated in late April and continue throughout the season until October. Two black light traps will be placed in Douglas-fir blocks at KRC, Vernon Seed Orchard (VSOC) and PRT. Additionally, *Dioryctria spp.* flight in pine and spruce blocks at KRC will be monitored. Traps will run five days a week and will be monitored twice during that period. The collected females will be dissected to assess mating status (presence and number of spermatophores) and to confirm species identification. Spermatophores present in the cervix bursae will be measured. As well, wings will be digitally measured to determine if female mating success is correlated with body size.
- b. Male adult flight will also be monitored weekly using pheromone traps placed in KRC, VSOC and PRT. Trap capture of male moths in pheromone-baited traps will be compared with female moths captured in light traps to determine if trap capture in pheromone traps is indicative of female flight activity and mating status.

2. Calling behaviour

Objectives:

- To determine when, within day and season, female moths release pheromone to attract males.
- To determine if female calling behaviour varies with female age.
- To determine if female attractiveness varies with female age.

- **Management Objective:** This information will assist in evaluating the potential for pheromone control techniques, as well as help optimize insecticide control efforts. The most efficient mating-disruption techniques use "puffers" to disseminate pheromone. Knowing exactly when the females are calling will enable us to perfectly time pheromone release to maximize disruption of the female calling, while minimizing the amount of expensive pheromone used. Furthermore, we will be able to modify pheromone release through the season if we know that aging females call differently or become less attractive with age. This information can also be used to maximize the efficacy of pesticide applications by spraying when the insects are most active, and therefore most susceptible. In general, when designing a pheromone based control method or optimizing an insecticide method, the more knowledge we have of the reproductive behaviour of the target insect, the greater the likelihood of success.

Progress to Date:

Originally this experiment was to be conducted at various times throughout the season to assess the effect of season on calling behaviour. However, we were only able to rear adult moths by August 2008 due to the unseasonably cold weather conditions. Therefore, this experiment was conducted only during the late season and addressed the periodicity of female calling behaviour over a 24-hour interval and how this behaviour is modified by female age. We conducted five trials in total with the first occurring in mid-August. Three trials were conducted in the field and two in the laboratories at KRC. Females were from one of three ages groups: young (0-1 day old), middle (5-7 days) and old (10-12 days). In the field trials, insects were placed individually in a mesh-capped 207 ml plastic cup and provided with sugar water. The cup was suspended from a Douglas-fir branch at a height of approximately 1.5 m. Female behaviour was monitored every 30 minutes over a 24-hour period. Because of the lateness in the season and resulting cool outdoor temperatures further trials were conducted indoors. The same protocol was used for trials inside the research station with minor modifications. During the first indoor trial, we did not provide a host volatile source but did so for the second trial. The presence of foliage seemed to stimulate oviposition behaviour rather than calling behaviour. These data will be analyzed for the effect of age on the timing of calling and oviposition initiation and duration.

The 24-hour calling trials should be repeated in 2009 so that the seasonality of calling behaviour can be accurately measured. In fall 2008, some of the remaining field-collected cones had mature larvae that had not exited. These cones were placed in large plastic containers and set outside until December 7th, 2008, then placed in a -2 C cooler to overwinter. The adults resulting from these overwintering larvae will be used to conduct calling trials in early May.

Methods:

- a. Experiment 1 will test the hypothesis that female calling behaviour varies throughout the day and with age of the females. Based on our initial studies in 2008, it is expected that middle and older females will release pheromone earlier in the scotophase. The protocol will be similar to that used in 2008. Virgin female moths in each age group (young, middle and old) will be individually placed in clear, perforated cups and observed under field conditions for calling behaviour. Females will be monitored every

30 minutes for 24 h to determine when females release pheromone. Three independent observation periods will be conducted with new females at three different times in the flight season (early-May; mid-July; and early-September). During each observation period, 10 females will be observed in each age treatment.

- b. Experiment 2 will compare the attractiveness of virgin females of different age groups to male moths in a trapping study conducted during peak moth flight. Traps will be baited with virgin females in each of three age groups: young, middle and old. Two traps of each age group will be located in each of three Douglas-fir blocks at KRC for two nights and male moths attracted to the delta traps will be enumerated every 30 minutes beginning 1 hour prior to the onset of scotophase and ending 1 hour past the end of scotophase. This will verify that calling behaviour is correlated with pheromone release. A synthetic pheromone-baited trap will be positioned in the same blocks as a positive control.
- c. Experiment 3 will test the hypothesis that female calling behaviour is influenced by the presence of host material. This experiment will be conducted in the laboratory. Females will be exposed to one of the following treatments: 1) no host material; 2) Douglas-fir foliage (branch and needles); or 3) Douglas-fir cones. This experiment will be conducted under mid-summer conditions that reflect peak moth flight field conditions. Females will be monitored at 30-minute intervals starting 1 hour prior to the onset of scotophase lasting until 1 hour past the end of scotophase.

Trade-offs between reproduction and longevity

It is important to know the potential adult lifespan of moths so that pest management activities targeting mating and reproduction can be appropriately timed. It is important to assess longevity of mated and virgin moths as reproductive activity often results in a trade-off with adult longevity in moths and can result in a shortened adult lifespan. Knowledge of adult longevity will also allow us to pick appropriate age intervals for experimentation on calling and oviposition behaviours (below).

1. Adult Longevity

Objectives:

- To determine the lifespan of virgin and mated male and female *D. abietivorella* moths in the laboratory.
- To determine if lifespan is modified by mating status.
- **Management objectives:** This information will help guide insecticide control programs, determine extent of generation overlap, and help in making decisions about future damage potential based on current *D. abietivorella* densities. For example, if overwintered adults of *D. abietivorella* live only a short period, then perhaps a single well-timed spray against adults will result in season-long control. Further, we might base a mating-disruption effort on the longevity of mated females, and then find that virgins live many weeks longer than mated females, leading to failure of the mating disruption effort. In general, when designing a pheromone based control method, the

more knowledge we have of the reproductive behaviour of the target insect, the greater the likelihood of success.

Progress to Date:

Experiments measuring the lifespan of mated male and female adult *D. abietivorella* as in 2008 did not appear to result in successful matings as none of the eggs laid were fertile. Mating status of females will be confirmed by dissection. The average adult lifespan of virgin moths was determined to be 10.1 (± 0.40 SE) days and this does not appear to differ between the sexes nor between moths held individually or with another moth in the same cup. This lifespan is shorter than was initially found in 2007, but this difference may be due to dissimilar rearing conditions (diet versus cone-fed). Additionally, lifespan of females used in the August and September 2008 calling experiments was > 11 days. Because of these different findings and only being able to assess virgin moths in 2008, this experiment will be repeated in 2009.

In 2008, the lifespan of same sex pairs in the same container was measured to quantify the general effect that a second moth may have on another in the same rearing container. There was not a significant reduction in lifespan as a result of pairing and therefore it can be assumed that any changes we might observe in the longevity of mated pairs in 2009 are due to mating.

Methods:

Newly-eclosed male and female moths from a laboratory colony will be weighed and placed in individual containers with access to sugar water and distilled water. The experimental set-up will be modified from 2008 to ensure that the adults are exposed to enough host material to induce mating. Host material will be placed inside each individual container and changed every 3 days. The moths will be checked daily for mortality and any eggs laid by individual females will be counted. Female moths will be dissected after they die and the number of eggs in the ovaries will be counted and added to any eggs laid throughout their lifespan. These data will indicate if there is a tradeoff between longevity and reproduction. The area of one forewing of each moth used in each experiment will be digitally measured and wing-size will be used in addition to moth weight as a covariate in analyses to account for the effect of size on female fecundity. The following experiments will be conducted:

- a. Experiment 4 will test the hypothesis that there is a trade-off between reproduction and longevity in *D. abietivorella* and we would expect that virgin females would live longer than mated females. Virgin males and females (30 individuals per treatment) will be maintained either individually or with the opposite sex in individual containers and placed in a growth chamber. Lifespan and the females' potential lifetime fecundity (eggs laid + eggs in ovaries) will be determined. The mating status of females paired with males will be confirmed through dissection.

Appendix

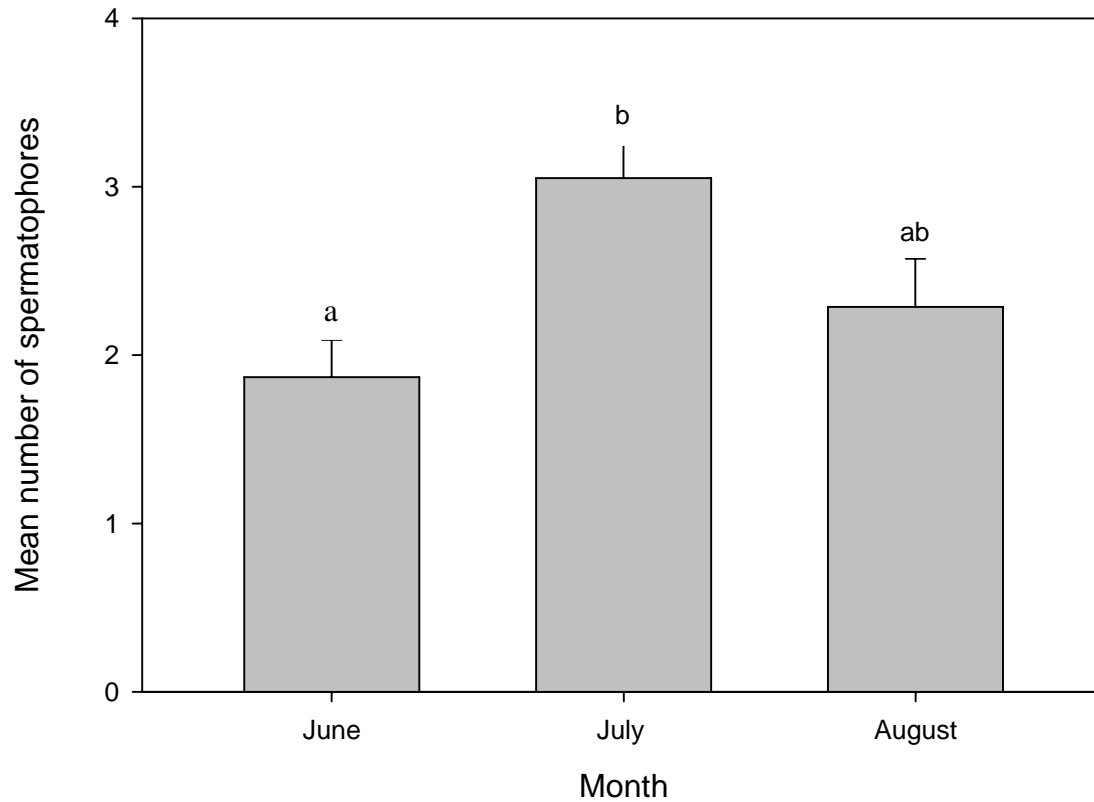


Fig. 1. Mean number of spermatophores present in female *Dioryctria abietivorella*. Data is compiled from UV trap catches at 3 sites conducted between June 20th to September 19th, 2008 ($n=97$; mated: $n=96$). Trapping was conducted in Douglas-fir blocks at the Kalamalka Research Centre, Vernon Seed Orchard and PRT in the Okanagan Valley, British Columbia. Means were compared using Tukey's Honestly-Significant-Difference (Systat 12).

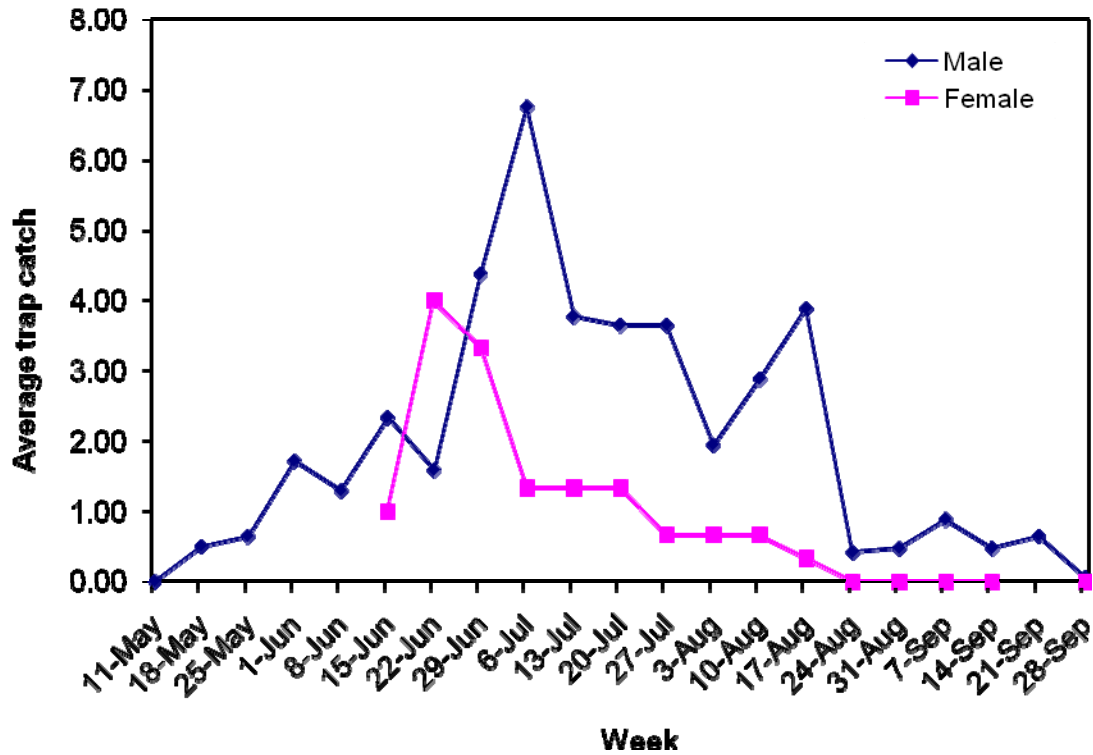


Fig. 2. 2008 seasonal flight of male and female *Dioryctria abietivorella* in British Columbia. Males were caught using pheromone-baited diamond traps and females were caught using UV light traps. Data is compiled trap catches at 3 sites conducted between May 4th to October 4th, 2008. Trapping was conducted in Douglas-fir blocks at the Kalamalka Research Centre, Vernon Seed Orchard and PRT in the Okanagan Valley, British Columbia.

Salaries:

Graduate student salary (UA 2 nd year Master's-level graduate stipend)	18,300
Field assistant salary: \$13.00 per hour x 35 h per week for 16 weeks + 11% l	8,081
Total salaries	26,381

Notes

Caroline's salary, total \$22,434:	
From this project, \$22,434 x 0.67	15,031
From TAship, 22,434 x .33	7,403
Total	22,434
Remaining in "Stipend", this budget	3,269

Materials and supplies:*Small equipment :*

Black light traps (2) at \$157.25 each	315
Black lights (6) at \$10.50 each	63
Misc. lab supplies	300

Insect rearing supplies :

Misc. supplies	300
Total materials and supplies	978

Travel:

Conference travel : to include airfare, accommodation, and registration.

Covered by remaining budget from Stipend.

Vehicle rental for summer field work :

Vehicle rental: \$995 per month x 5 months, less \$2000 share with UNBC	2,975
Gas: 1,500 litres x \$1.35 per litre	2,025
Accommodation for grad student (\$800 x 5 months)	4,000
Total travel:	9,000

Subtotal**36,358**

University Overhead: 8%

2,909

TOTAL REQUESTED**39,267**

Research Proposal

Characterization and Development of Cone-derived Infrared Radiation and Wavelengths of Visible Light for Attraction of Western Conifer Seed Bugs

Submitted by Gerhard Gries
Simon Fraser University, Department of Biological Sciences
February 19, 2009

Background

We (1, 2; Zahradnik, unpubl.) have shown that: (1) Western Conifer Seed Bugs (WCSBs) use infrared radiation (IR) as a foraging cue to locate cones; (2) visual and very-near IR spectra (300 – 1000 nm) from cones and needles differ; (3) in electro-retinograms, WCSBs respond to specific wavelengths of visible light, indicating that they are multichroic; (4) receptor sites for all wavelengths tested are present in dorsal, equatorial, and ventral regions of female and male eyes; (5) for key wavelengths of light (390, 433, 474, 505, 527, 572, 592, 621 nm), the retinal response (mV) increases with increasing light intensity; (6) for all key wavelengths, the males' light- or dark-adapted eyes respond more strongly than the females' eyes; (7) in 2-choice laboratory bioassays, adult WCSBs are more strongly attracted to green than red light, and to green than no-light; (8) in field experiments, more WCSBs are captured in green traps than in yellow, white or black traps; and (9) small green traps are more effective than large green traps in capturing WCSBs.

Predictions

Based on results described above, discussions with colleagues (Drs. Bennett, Lindgren, and Strong) and their students, and exploratory experiments conducted in 2008, we predict that: (1) specific wavelengths of visible light reflected from cones constitute foraging cues for WCSBs; (2) IR, visible-light wavelength(s) and specific cone (trap) size are synergistic cues for attracting WCSBs; (3) preference by WCSBs for specific conifer clones may be based, in part, on contrasting IR signatures; and (4) optimal trap size must not greatly exceed natural cone size.

Research Objectives

1. To determine whether preference by WCSBs for specific conifer clones is based, in part, on contrasting IR signatures;
2. To determine behavioral responses of WCSBs to key wavelengths of visible lights;
3. To investigate interactions between IR radiation and specific wavelengths of visible light for attraction of WCSBs; and

4. To determine optimal trap size or type for WCSBs.

Objective 1: To investigate IR “signatures” of different spruce clones (collaborative project with Drs. Staffan Lindgren, Ward Strong, and their student Tamara Richardson)

In spruce orchard 341 in the Kalamalka seed orchard (BC Ministry of Forests and Range, Vernon, British Columbia, BC), 3 clones with strong, medium or least attractiveness to WCSBs will be selected. In early season, 3 cone clusters (of at least 3 cones each) per tree will be flagged and labeled, thermographic and photographic images taken (see below), and one cone removed for terpene analysis (not part of this project). Utilizing these labeled cone clusters, the procedures will be repeated in mid and late season.

Thermographs and photographs will be taken with (i) an AGEMA Thermovision 550 camera (FLIR Systems Ltd., Burlington, Ontario L7L 5K2, Canada) sensitive in the 3 – 5 μm IR range, (ii) a Fluke TI-20 thermal imager (Fluke Corp. Everett, WA USA 98206) sensitive in the 8 – 20 μm IR range, and (iii) a Nikon Coolpix 995 (Nikon Canada, 5-13511 Crestwood Place, Richmond, B.C., V6V 2E9 Canada). The recording distances will be kept at 2 m and 10 m and the emissivity (the ratio of the radiation emitted by a surface to the radiation emitted by a black body at the same temperature) at 0.75. At least on one date, area and spot-apparent temperatures recorded thermographically will be compared to concurrent direct temperature measurements with a thermocouple (Omega HH 506 RA multilogger with type K 0.032 thermocouples; Stanford, CT 06907-0047) inserted under a scale of an *in situ* cone or into a nearby needle.

Objective 2: To determine behavioral responses of WCSBs to key wavelengths of visible lights

Attraction of male and female WCSBs to candidate key wavelengths of visible light (see background) will be tested in a chamber modified from a previous design (1, 2). The chamber will consist of a glass aquarium (50.5 \times 26.7 \times 33 cm high) nested inside a larger aquarium (61 \times 33 \times 41 cm high) with ice water between them, and a glass top covering the inner aquarium. A PVC tube (7cm inner diam) will be sealed between the two aquaria in each of the two end sections to exclude water, allowing light stimuli to enter the inner aquarium. All treatment light stimuli will be generated by the OneLight instrument, whereas control light stimuli (e.g., white light) of identical intensity will be generated by a light emitting diode (LED) (Figure 1). Single insects will be released from an etched open Petri dish (10 cm diam) resting on a pedestal (9 \times 9 \times 10 cm) within the inner aquarium. They will be exposed to light stimuli entering the chamber through the PVC tubes. Insects climbing onto and walking 10 cm toward the distal end of an etched glass rod (0.8 \times 45 cm) inserted through the Petri dish will be considered responders.

Objective 3: To investigate interactions between IR radiation and specific wavelengths of visible light for attraction of WCSBs

A. Laboratory experiments. The same bioassay setup and protocol as deployed under Objective 2 will be implemented. Yet, test stimuli will differ. The experiments will test whether attractiveness of IR radiation to WCSBs (1, 2) can be enhanced through addition of specific wavelengths of visible light. In experiments 1-3, the control stimulus will be

IR radiation and the treatment stimulus will be IR radiation coupled with specific wavelengths of visible light. Experiments 4-6 will be identical except that visible-light wavelengths (instead of IR radiation) will serve as the control stimulus. Experiments 4-6 may require 2 (prohibitively expensive) OneLight instruments. Thus, they will be conducted only if LEDs *in lieu* of the OneLight instrument can be employed for emission of visible-light wavelengths. In experiments 1-3 (and possibly in experiment 4-6), strong and weak IR radiation will be generated from Pyrex glass flasks (1000 ml) containing heated (42°C) or ice-cooled (4°C) water (see reference 1). Front-surface optical mirrors (13 × 13 cm; SEA-UV protected, aluminium broadband, SiO₂-coated; Praezisions Glas & Optik GmbH, D-58640 Iserlohn, Germany) will reflect IR radiation (but not conductive or convective heat) into the inner aquarium. To ensure that bioassay insects can perceive IR radiation stimuli while they are residing in the Petri dish or walking on the glass rod, a horizontal laser will be used to position properly both IR sources and mirrors.

B. Field trapping experiments. Taking results obtained under objectives 1-3 into account, PVC pipes will be painted with a different color, or color combination, and fitted with a retaining mechanism (adhesive, contact insecticide, electrocuting device). Their spectrometric profiles in the ultraviolet through near-IR range under natural sun or halogen light will be measured with both an HR4000 high-resolution spectrometer (responsive: 200-1100 nm, >50% sensitivity: 300-750 nm; Ocean Optics, 830 Douglas Ave. Dunedin, FL 34698) and an NIR256-2.5 extended-range near-infrared spectrometer (responsive: 900-2550 nm, >50% sensitivity: 1500-2550 nm; Ocean Optics). Pipes with a spectrometric profile resembling most closely that of a natural cone, or most strongly reflecting the key wavelength(s) of visible light most attractive to foraging WCSBs, will be deemed candidate “traps” and field tested.

To investigate in the field a potential interaction between IR radiation and visual-light wavelengths, candidate pipe traps (see above) will be tested in paired trap experiments at Sechelt Seed Orchards. Ten cone-bearing white pine trees will be selected with at least 10 m between trees. An experimental pipe will be placed to the east and west side of each selected tree. Pipes will be made with a permanent cap at the bottom and a removable lid, and suspended from an L-shaped pole by thin wire ~ 2 m above ground. One randomly assigned pipe per tree will be filled with ice water (weak IR radiation), the other left empty to absorb solar radiation and heat up (strong IR radiation).

Objective 4: To determine optimal trap size or type

A small and a large version of a pipe trap with optimal IR and other spectrometric characteristics (see Objective 3) will be tested in paired trap experiments (design as above). Each consecutive experiment will retest the better trap from the preceding experiment *versus* either a larger version of it (if the large trap was more effective before) or a smaller version of it (if the small trap was more effective before). Experiments will continue until the optimal trap size has been determined.

Milestones

By fall 2009, we anticipate to have completed:

- Objective 1: To investigate IR “signatures” of different spruce clones
- Objective 2: To determine behavioral responses of WCSBs to key wavelengths of visible lights
- Objective 3 (Laboratory experiments): To investigate interactions between IR radiation and specific wavelengths of visible light for attraction of WCSBs

By fall 2009, we anticipate to have started on:

- Objective 3 (Field experiments): To investigate interactions between IR radiation and specific wavelengths of visible light for attraction of WCSBs

By fall 2010, we anticipate to have completed:

- Objective 3 (Field experiments): To investigate interactions between IR radiation and specific wavelengths of visible light for attraction of WCSBs
- Objective 4: To determine optimal trap size or type

Budget

Salary: \$25,158

(a) PhD student Tracy Zahradnik: \$11,000 (summer and fall term 2009 @ \$5,500 each);

(b) Research Associate Dr. Stephen Takács: \$5,000; (c) Undergraduate Research Assistant: \$9,158 (18 weeks @ \$480 per week (= \$8,640) plus 6% benefit (\$518).

Field travel: \$2,500

Materials and laboratory supplies: \$2,700

Administrative overhead (10%): \$3,036

Grand total: \$33,394

References

- (1) Takács S, Bottomley H, Andreller I, Zahradnik T, Schwarz J, Bennett R, Strong W, and Gries G. Infrared radiation from hot cones on cool conifers attracts seed-feeding insects. *Proceedings of the Royal Society B*. doi:10.1098/rspb.2008.0742.
- (2) Takács S, Bottomley H, Andreller I, Hardin K, Strong W, Bennett R and Gries G. *Leptoglossus occidentalis*: Communication signals & foraging cues. Presentation at the 31-October-2007 Meeting of the Pest Management Technical Advisory Committee

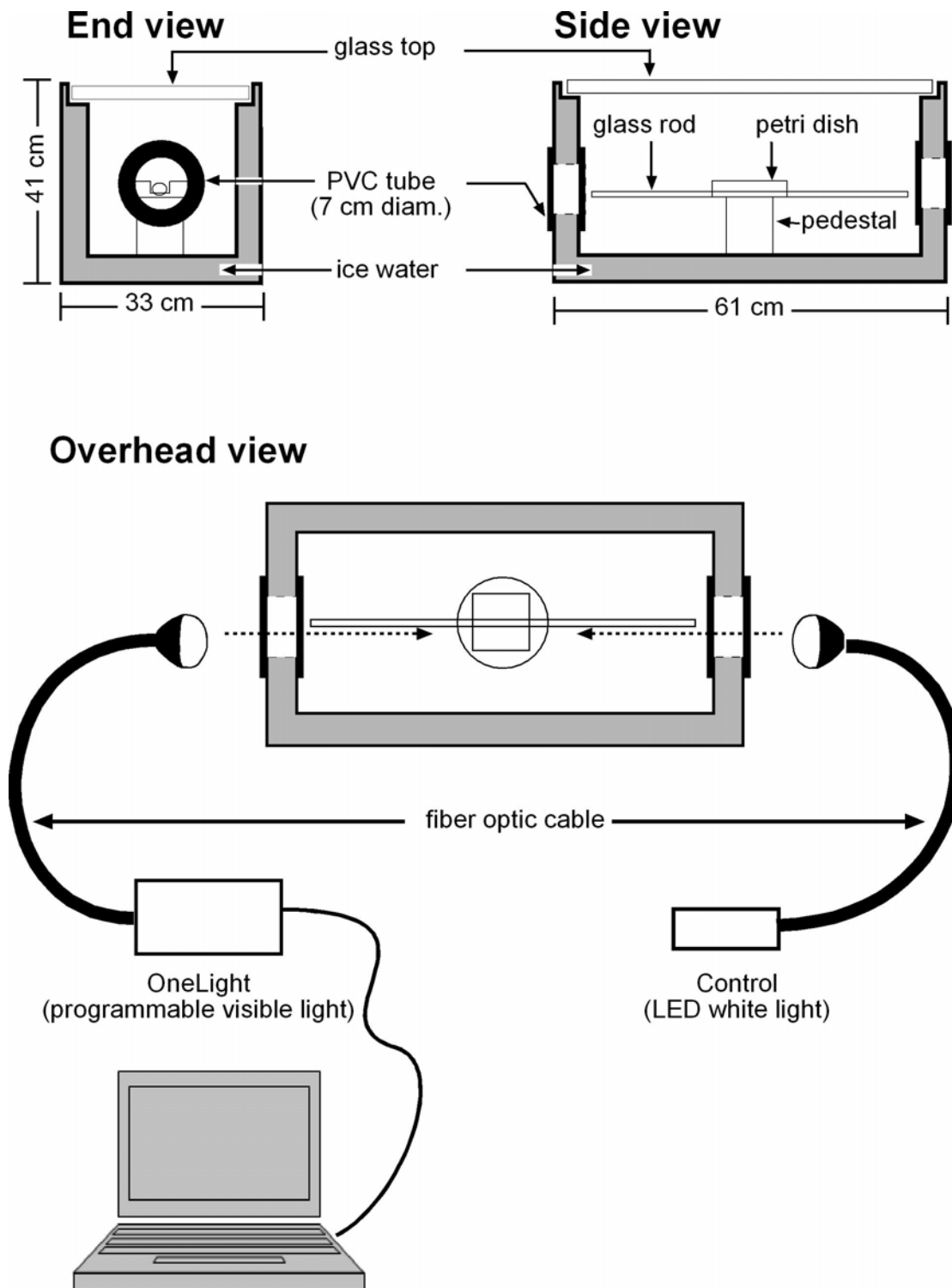


Figure 1: Bioassay set-up.

LEPTO MRR PROJECT

BUDGET, 2009-10

	BUDGET	BCM _o FR	UNBC	UBC-O	MITACS FUND-MATCHING	
					2009	2010
Salaries						
Graduate student stipend \$18,300 + 12% benefits	\$20,496.00		\$20,496.00			
Summer assistant \$12.50/hr x 40 hrs x 16 weeks + 12% benefit	\$8,960.00			\$8,960.00		\$8,960.00
Peak season casual help: \$10/hr x 4 people x 3 weeks	\$4,800.00			\$4,800.00		\$4,800.00
Total Salaries	\$34,256.00		\$20,496.00	\$13,760.00		\$13,760.00 NCE program
Travel						
Supervisor' visits, 2 x \$500	\$1,000.00		\$1,000.00			
Lodging for field season, 4 months x \$800	\$3,200.00		\$3,200.00			
Vehicle rental, shared with UA: \$500/month x 4 months	\$2,000.00		\$2,000.00			
Vehicle fuel: \$150 per month	\$600.00		\$600.00			
Total travel	\$6,800.00		\$6,800.00			
Materials and supplies						
Marking equipment	\$500.00			\$500.00		
Insect handling containers and supplies	\$500.00			\$500.00		
Misc	\$500.00			\$500.00		
Orchard lift: \$7/hr x 384 hrs	\$2,688.00	\$2,688.00				
Terpene Analysis 324 samples x \$15	\$4,360.00	\$4,360.00				
Total M&S	\$8,548.00	\$7,048.00		\$1,500.00		\$1,500.00 NCE program
Subtotal	\$49,604.00	\$7,048.00	\$27,296.00	\$15,260.00		
Overhead, 8%	\$2,183.68		\$2,183.68			
TOTAL BUDGET, 2009-10	\$51,787.68	\$7,048.00	\$29,479.68	\$15,260.00		\$15,260.00

E-mail to

Date

WARD STRONG
B.C. Ministry of Forests
Vernon, B.C.

Tuesday November 18, 2008

Sir;

DRAFT FOR DISCUSSION

Please accept this letter as a proposal to conduct field efficacy trials with the "Cone and Seed Pest Group" of B.C. Ministry of Forests during the 2009 season.

Please examine this proposal and call our office with questions or comments.

1) *The project protocol is slightly revised as per our recent communications.*

- *Objective*
Field test the efficacy and phytotoxicity of various insecticides for control of target insect pests on target outdoor-grown conifer trees in seed cone orchards.
- *Treatments*
 - Water control
 - Grower standard (commercial formulation of dimethoate)
 - 4 insecticides to be determined (1 rate per product, either 1 or 2 applications)
 - Total of 10 treatments
- *Experimental set-up:*
 - Field-grown conifer trees, various sizes, at Kalamalka Research Centre, Vernon
 - 1 host, 10 treatments, 10 replicates (one tree per replicate), total 100 trees
 - One non-treated buffer tree around each sprayed plant
 - Complete block design
- *Application of treatments*
 - For each test product, one or two applications, timing to be determined in spring
 - Treatments applied with a hand-operated back-pack sprayer at 30 psi.
 - Application for thorough plant coverage, volume target 1000 liters / hectare.
- *Assessment: cone collection in early summer*
 - Late June to early July, 10 cones per tree X 100 trees.
 - Cones kept refrigerated for prompt shipping to contractor in Gibsons.
 - Evaluation of pest infestation by dissection of cones.
- *Assessment: cone collection in late summer to early fall*
 - When cones are mature, 10 cones per tree X 100 trees.
 - Cones sent to the Kalamalka Research Station.
 - Evaluation of seed quality from standard procedures.
- *Assessment: phytotoxicity rating of plant damage*
 - Rating of phytotoxicity damage on a 1-unit scale from 0 (none) to 10 (dead).
 - One rating for each experimental tree at 0, 2, 7 and 21 days after treatment.
- *Reporting*
 - Final report, with description of methods and application, by November 31.
 - Statistical analysis of results to determine per cent control versus untreated.
- *Project location*
 - Kalamalka Research Centre, Vernon

- *Estimated cost*
- \$9100 + gst.

Yours truly,

Mario Lanthier
Certificate of Training for Nursery Inspections, Agriculture and Agri-Food Canada
Certificate of Training in Good Laboratory Practices, Pacific Rim Consulting

*Member of the B.C. Landscape Nursery Association -
Landscape Alberta Nursery Trades Ass. - Western Canada Turfgrass Association -
American Phytopathological Society - International Society of Arboriculture*

Nov 18 comments:

- 1) This is a draft document. Your earlier discussion indicated the trial protocol is still under development. I hope our proposal will help make decisions to finalize the protocol. We can then make adjustments to the proposal.
- 2) The proposal is for 1 host tree only. We consider it non-practical to conduct such a large project on 3 hosts plants at once. We would gladly consider 3 separate trials, for 3 separate hosts, all with the same protocol (but possibly different target insect pests).
- 3) For your information, the proposed quote is for 14 days of work. Day rate is standard for this type of work and includes 2 persons working together (to ensure accurate application of product and accurate data collection). Set-up of treatment trees is likely one full day of work (running). Application is two days of work total. Rating for phytotoxicity is 4 days of work total (one day per rating). Cone collection is likely one day each time (2 days total).

December 1 comments:

- We will commit staff to ensure smooth management of the trial, or 2 or 3 trials, as is determined in the future. There are 3 persons in this company with a "pesticide applicator certificate" and practical experience with spraying, and 2 of those have practical experience with trial set-up and maintenance.
- As you mention for cone collection and delivery (our responsibility) but not cone evaluations or seed extraction (other contractors), and then statistical analysis of results (our responsibility).
- Noted for GST exemption from the province.

Refinements in response to Jan 28 PMTAC meeting:

A. Three further budget items:

1. Cone half-cuts: Julie Brooks contract. 100 samples x .5 hrs/sample x \$50/hr = \$2500
2. Seed extraction: Kal S.O. 100 samples x \$25/sample = \$2500
3. Germinations: 10 tests (combined reps from each treatment) x \$25/test = \$250

So increase budget for each trial by \$5250.

TOTAL BUDGET PER TRIAL: \$9100 + 5250 = \$14,350

B. Add water-sensitive spray cards to buffer trees to monitor drift: one-time test at first spray event; hang 4 cards at the far side of buffer trees in 4 directions around 5 spray trees. Ward will look after this; it will not add to the CropHealth budget. (cards will cost about \$150 including shipping)

C. Cone selection: divide cone-bearing portion of tree into 10 cells, collect one cone from each cell. While this sounded like a good idea at the time, as I thought about it I realized that often (in fact usually) the selected trees bear cones on only one or two branches, or only the very top or very bottom of the tree. This is hard to predict at the time trees are selected for the trial, before buds burst. Many things influence final cone set and distribution including wind during pollination, late frosts, etc. Only occasionally will there be cones spread all over the tree. Therefore I think a rigid, stratified sample regime will be unworkable. We may be able to devise a flexible stratified system by dividing the cone-bearing portion of the tree into 10 regions, and collecting one cone from each region. This becomes quite subjective as the cone-bearing portion becomes smaller, approaching the haphazard system I have used in the past. I propose we carefully identify a haphazard system that will reduce the chance of preferentially selecting damaged (or undamaged) cones.

D. Pesticide Selection: Until we know our final budget, I will not work hard on pesticide selection. If the budget is reduced, we may choose to maintain working with three tree species, but reduce the number of pesticides tested. However, in conjunction with Yvonne Herbison (with the PMRA), I have tentatively selected the following candidates:

- **spinetoram** (Delegate, Group 5). A spinosyn, derived from actinomycetes. Broad-spectrum contact and stomach with short residual. Mammalian LD₅₀ >5,000, low environmental hazard. Current Canadian registrations for codling moth, Oriental fruit moth, leafrollers, apple maggot, plum curculio
- **methoxyfenozide** (Intrepid, Group 18.) An ecdysone agonist (moulting hormone mimic). Contact and stomach against butterfly and moth larvae only; persistent residual action. Mammalian LD₅₀ >5,000, runoff water hazard. Current Canadian registrations for codling moth, Oriental fruit moth, leafrollers.
- **Chlorantraniliprole** (Altacor, Group 28.) A muscle contraction inhibitor (Ca⁺⁺ disrupter). Broad-spectrum stomach; persistent and mobile in the environment. Mammalian LD₅₀ >5,000. Current Canadian registrations for codling moth, Oriental fruit moth, leafrollers; USA has registrations against beetles as well.
- **Tebufenozide** (Confirm, Group 18.) An ecdysone agonist (moulting hormone mimic). Contact and stomach against butterfly and moth larvae only; persistent residual action. Mammalian LD₅₀ >5,000, runoff water hazard. Current Canadian registrations for codling moth, Oriental fruit moth, leafrollers.
- **Spirotetramat** (Movento, group 23). A lipid biosynthesis inhibitor. Systemic throughout plant, active against heteropterans (sucking insects). Mammalian LD₅₀ >2,000. No current Canadian registrations.

Development of BC conifer cone and seed insect field guide (2009-10 fiscal)

BACKGROUND

Started in the 2006-07 fiscal year with Forest Genetics Council “incremental funding”, this project’s objective is to produce electronic and hardcopy versions of an illustrated field guide to British Columbia conifer cone and seed insects. Initial work focused on compiling a list of insects to include in the guide, performing an initial literature search for relevant information on identification, biology, and management of listed insects, and assembling a collection of previously unpublished images for inclusion in the guide. Two contractors have done most of the work to date: a project coordinator (organizing literature search and collection of images, drafting and initial editing of individual species fact sheets, and coordinating activities of project participants) and a professional photographer (producing images of various life stages of listed insects for which publication quality images do not exist). This proposal outlines work and budget needs for continuation of contracted work in the 2009-10 fiscal year.

ACHIEVEMENTS TO DATE (Jan 2009):

Project Coordinator

1. Completed literature search on “priority” British Columbia cone and seed insects (see Appendix).
2. Prepared initial drafts of 8 individual “fact sheets” for priority species from literature search materials and other sources (see Appendix).
3. Organized photographer field work agenda to fill “image gaps” for various life stages of cone and seed insects.

Photographer

1. Produced new images for 11 categories listed in Appendix.

FURTHER ACHIEVEMENTS EXPECTED BY 2008-09 FISCAL YEAR END:

Project Coordinator

1. Complete search for existing unpublished useable images of various life stages of BC cone and seed insects.
2. Draft text for individual “fact sheets” for remaining priority species (see Appendix) from literature search materials and other sources.
3. Edit and arrange text drafts and images into 2-4 page “fact sheet” format using latest version of Eastern Canada cone and seed insect field guide as model (*i.e.*, draft assembly of total of 11 fact sheets to be completed).
4. Organize photographer field work agenda to fill “image gaps” for various life stages of cone and seed insects.
5. Edit field guide text components written by project team members (Robb Bennett, Jim Corrigan, Ward Strong).

2009-10 WORK OUTLINE:

Project Coordinator

1. No further contractable work required in 2009-10 fiscal year.

Photographer

1. Under direction of project leader (Bennett) and project coordinator (and in collaboration with team members), through studio and field photography produce new images of life stages of remaining priority British Columbia cone and seed insects (including damage caused by them).

BUDGET

	Photographer	
Studio and field production of images – ~8 days @ \$680 / 8 hr day (\$85/hr)		6,000
Travel, materials, & supplies		2,000
	TOTAL	8,000

Appendix: List of BC cone and seed pests for consideration for inclusion in field guide
(bolded names highlight fact sheet drafts expected by 2008/09 fiscal year end)

		PRIORITY	DONE
MITES	Yellow cedar eriophyid (<i>Trisetacus chamaecyperi</i>) Spruce spider mites (<i>Oligonychus</i> sp.) Conifer rust mites (<i>Nalopella</i> spp)		
TRUE BUGS	Conifer seed bug (<i>Leptoglossus occidentalis</i>) Pine cone spittle bug (<i>Aphrophora canadensis</i>) Green spruce aphid (<i>Elatobium abietinum</i>) Various conifer aphids (<i>Cinara</i> & <i>Mindarus</i> spp.) Various adelgids (especially <i>Adelges cooleyi</i> <i>A. lariciatus</i> <i>Pineus pinifoliae</i> <i>P. similis</i>	* * *	Yes Images lariciatus Other gall images
BEETLES	<i>Ernobius punctulatus</i> Pine cone beetle (<i>Conophthorus ponderosae</i>) Douglas-fir twig beetle (<i>Pityophthorus orarius</i>) Terminal weevils (especially <i>Pissodes strobi</i>) Root collar weevils (esp <i>Hylobius warreni</i>) Other bark beetles? <i>Dendroctonus ponderosae</i> <i>Ips pini</i> <i>Pityogenes</i> sp others?	* *?	
MOTHS	Larch casebearer (<i>Coleophora laricella</i>) Cone blastobasid (<i>Holcocera</i> sp.) Cone cochylid (<i>Henricus fuscodorsana</i>) Clearwing pitch moths (<i>Synanthedon novaroensis</i> <i>S. sequoiae</i>) Pine needle sheathminer (<i>Zellaria haimbachi</i>) Douglas-fir cone moth (<i>Barbara colfaxiana</i>) Spruce budworm (<i>Choristoneura occidentalis</i>) Seedworms (<i>Cydia strobilella</i> <i>C. piperana</i>) Pine cone borer (<i>Eucosma rescissoriana</i>) Fir coneworm (<i>Dioryctria abietivorella</i>) Other coneworms (esp. <i>D. auranticella</i> , <i>D. cambiicola</i> , <i>D. pseudotsugella</i> <i>D. reniculelloides</i> <i>D. rossi</i>) Fir cone looper (<i>Eupithecia spermaphaga</i>)	* * * * * * *	Yes strobilella Images
TRUE FLIES	Cone resin midge (<i>Asynapta hopkinsi</i>) D-fir cone gall midge (<i>Contarinia oregonensis</i>) D-fir cone scale midge (<i>C. washingtonensis</i>) Spruce cone gall and axis midges (<i>Kaltenbachiola</i> spp.) Redcedar cone midge (<i>Mayetiola thujae</i>) Scale midges (<i>Resseliella</i> spp.) Spruce cone maggot (<i>Strobilomyia neanthracina</i>) Other cone maggots (<i>Strobilomyia</i> spp.) Fir seed maggot (<i>Earomyia abietinum</i>)	* * * * *	Yes Yes Yes
WASPS	Seed wasps (<i>Megastigmus albifrons</i> <i>M. atedius</i> <i>M. lasiocarpae</i> <i>M. spermotrophus</i> <i>M. tsugae</i>) Sawflies (<i>Neodiprion</i> spp)-- e.g. yellowheaded spruce sawfly	*	"spp"