International Broom Initiative Report 2005-06

US Department of Agriculture-Agricultural Research Service (ARS) & Cooperators

Overview:

At the request of multiple customers and funded through a Congressional appropriation mandate, the USDA-ARS Exotic and Invasive Weed Research Unit, Albany, CA, initiated a cooperative project on the biology and biological control of French and Scotch brooms in the Pacific West Area of the United States. This work is being conducted domestically in the states of Washington, Oregon and California and internationally with assistance from the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO) and the USDA-ARS European Biological Control (EBCL) Laboratories both located in Montpellier, France. As CSIRO was well underway in conducting foreign exploration and host-specificity testing of potential biological control agents of French broom invading Australia, a contract was established with Dr. Andrew Sheppard to continue this work and include key non-target plant species important for the Western United States. Additionally, studies were initiated in the United States to assess potential release sites for new French Broom agents and to characterize current levels of attack of previously released agents on Scotch broom in cooperation with the US Military and The Nature Conservancy. Parallel assessments were also begun with the goal of assessing the impact of new potential biological control agents on European native and American introduced populations of brooms to characterize any potential host-plant response differences that may have evolved through separation of this invasive plant species from its long-term natural enemies found in Europe. Potential genetic and/or physiological host plant differences may alter expected biological control impact and thus be critical in any benefit/ risk assessment conducted on the introduction of such agents into the US. This work was being conducted by a PhD candidate (Ms. Angelica Herrera) under the supervision of Drs. Nick Mill at UC Berkeley, and Ray Carruthers of USDA-ARS. Dr. Walker Jones is also participating in this effort through support from EBCL. Extensive reports (approx. 50 pp) are available on all aspects of this project upon request. This version has been summarized in brief format for wider distribution.

Biological Control of French Broom:

Under a Cooperative Agreement between USDA-ARS and CSIRO, research has been underway since mid 2004 as part of the International Broom Initiative on classical biological control program against *Genista monspessulana* French broom (Cal-IPC A 1 Invasive Weed List). Earlier Phases 1 and 2 (CSIRO 2002, 2003) achieved the following; a) completed a literature review and quantitative surveys of natural enemies across 80% of the native range of French broom, including other brooms and gorse where possible, b) developed a flexible priority list of potential biological control agents for this weed based on degree of specificity and predicted efficacy, c) developed a draft host specificity test plant list for submission to TAG in which the key test plants group are the native US lupines, d) completed biological studies and standard host specificity tests for the agent on the top of this list, the multi-voltine psyllid, *Artinnis hakani* (Loginova) (Hemiptera; Homoptera) against 80% of the plant species on the draft TAG test list, and e) undertook supplementary risk analysis (following Isaacson 1998) for US lupines of the broom bruchid beetle, *Bruchidius villosus* (Förster), already released into the United States. Parallel US based efforts have focused on the establishment and assessment of potential release sites for new broom agents and participating in overseas assessment activities of new agents as tested in France. Ms. Herrera is currently spending several months in Montpellier France where she is working in with CSIRO and EBCL staff to complete the European broom assessments.

European Native-Range Studies (CSIRO):

The objectives of Phase 3 were:

1) Complete quantitative surveys of French broom throughout its native range.
2) Complete host specificity testing of the French boom psyllid, *Arytinnis hakani*.
3) Initiate host specificity testing of the French broom apionid seed weevil, *Lepidapion* nr. *argentatum* (Gerstäcker).
4) Field estimate parameters in the population dynamics of French broom and key natural enemies in the native range and use this to develop a coupled population management model for French broom.
5) Define and publish a strategy for which agents will be released based the population ecology of French broom in its native and exotic range.

Brief Results by objective:

Objective 1:

In 2004-2005 different surveys were made through Spain, Portugal and Morocco during the flowering period of *G. monspessulana*. Surveys in Spain and Portugal were follow-up trips to sites located on previous visits to collect complementary data and also to collect insect material for host testing work. Although many insects have been found attacking the target French broom, biological control efforts have been focused to ones exhibiting the most potential for efficacy and host-specificity.

Two arthropods consistently stand out as being potentially specific enough and widespread enough to be clear candidates as potential biological control agents for French broom. These remain the French broom psyllid, *Artytinnis hakani* and the pod apionid weevil *Lepidapion* nr *argentatum.* The remainder of this project will focus on these candidates.

Objective 2:

The official test plant list developed by CDFA and USDA-ARS has been evolving through 2005 into a application to USDA-APHIS TAG (Akers et al., 2005). This has necessitated the inclusion of further test plant species into the testing schedule which have nearly all now been supplied by Pat Ackers at CDFA to CSIRO. This list includes 43 species of plants, 25 of which are native to the United States while others include crop plants and other key plants including other related invasive species. A combination of laboratory and field feeding and ovipositional tests were used to assess the psyllid.

Studies on *A. hakani* host specificity now show that *A. hakani* will oviposit on some test plants in the Genisteae (the tribe containing *G. monspessulana*). This includes some other genera/species in the same subtribe Genistinae as *G. monspessulana* and some species of *Lupinus* in the subtribe Lupininae. In some cases nymphal development to adult does occur on some of the species in each of the genera at risk. The field test shows that oviposition on non-targets is “not” just a cage effect.

Some species of *Lupinus* in the lab can support *A. hakani* development through to adult even when not selected in oviposition tests. This indicates that *A. hakani* does pose a potential risk to some native species in the US. However in each case, the levels of oviposition, development or survival were several times lower than on *G. monspessulana*.

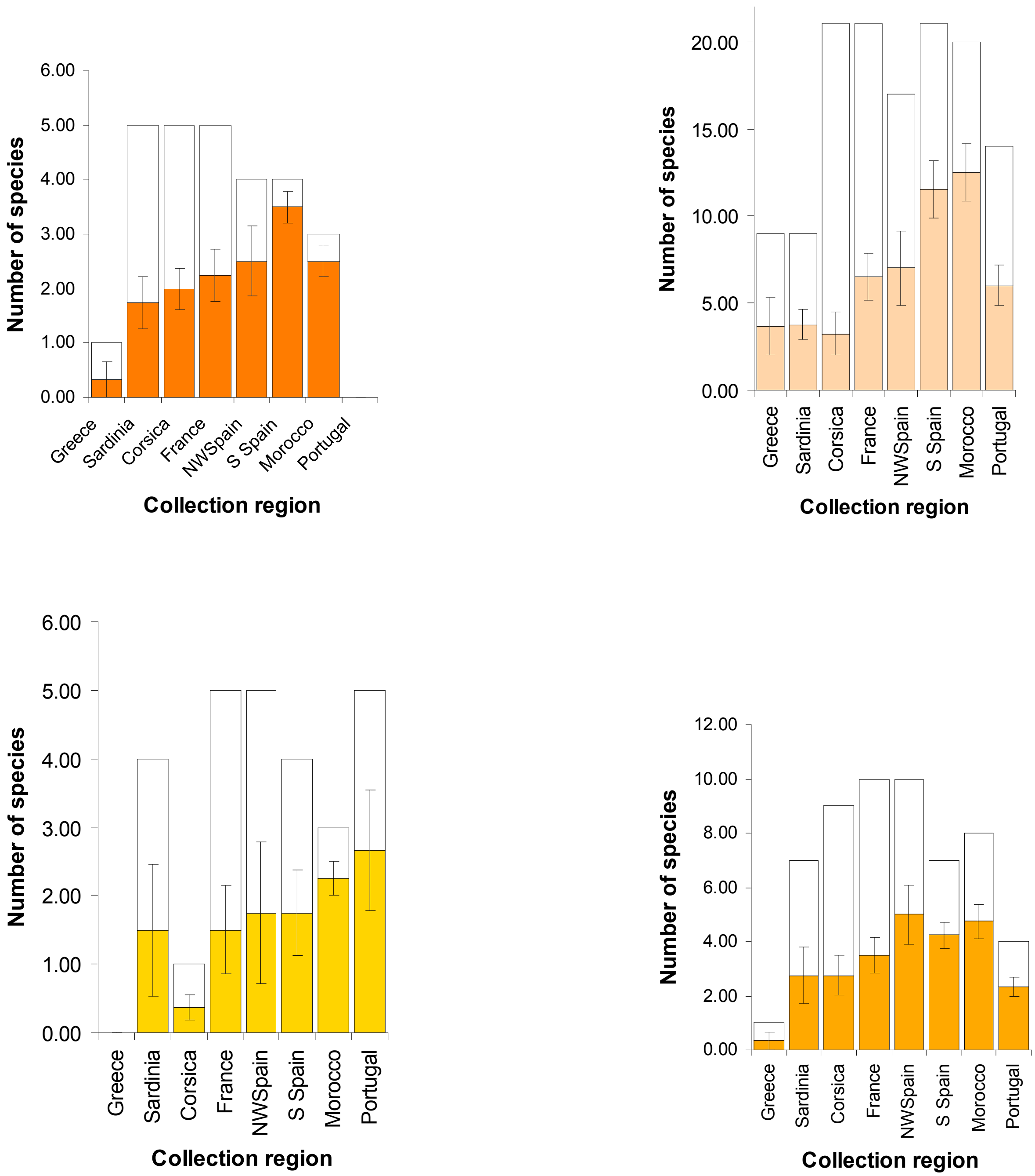


Figure 1. Mean number of species sampled on French broom per site (filled section ±SE) and total number (bar ht) for each region sampled for species a) specific to *Genista*, b) specific to the Genisteae, c) species specific to the Fabaceae and d) generalist flower visitors etc.

It is therefore remains unclear whether the field host specificity expressed by this insect, were it to be released in the USA, would actually include all or any of these US native test plant species that were found to generate positive results in the testing.

Figure 2. Five nymphal stages of *A. hakani* on mm graph paper.

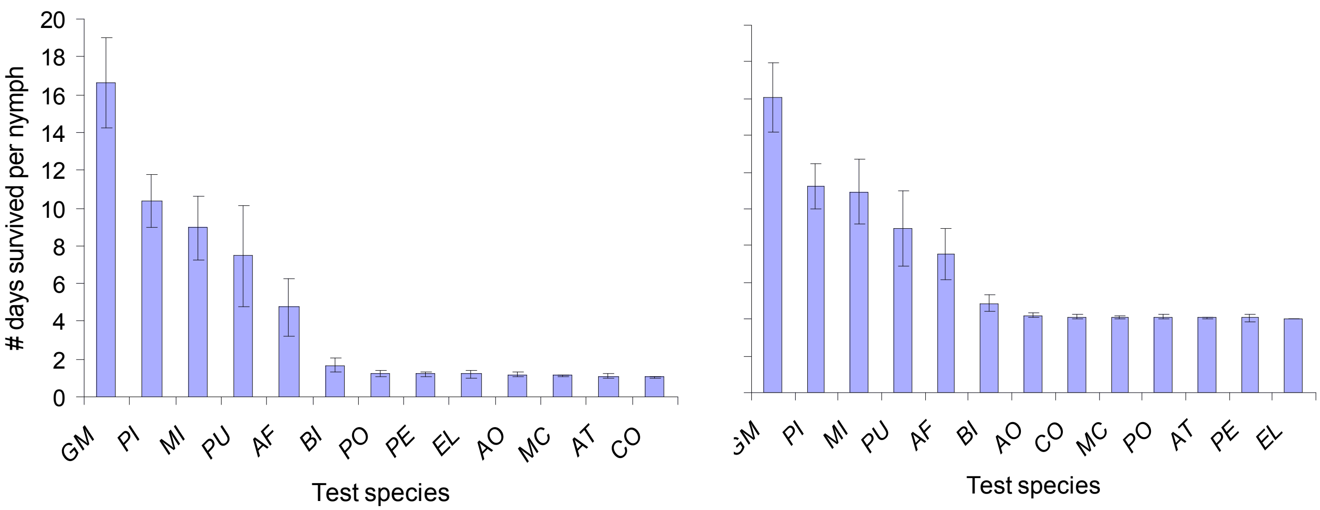


Figure 3. Mean relative survival in days (a) and development completion in larval instars (b) for *A. hakani* on 12 test plants and the target by the end of the test (GM = *G. monspessulana*, PI = *L. pilosus*, MI = *L. microcarpus*, PU = *L. pusillus*, AF = *L. affinus*, BI = *L. bicolour*, PO = *L. polyphyllus*, PE = *L. perennis*, EL = *L. elegans*, AO = *L. arboreus*, MC = *L. micranthus*, AT = *L. angustifolius*, CO = *L. cocinnus*. Means significantly different at the 5% level are labelled by different lower case letters.

Table 1. Cumulative number of *A. hakani* eggs and nymphs found on test plants and control plants in the field experiment after 4 weeks in central and satellite (4 m away) plots following establishment in the central plot and control plant removal. Control plant satellite plots were 8 m from the central plot. In the central plot the plant was the replicate, beyond this the plot was the replicate.

Test Plant Species	**Plot**	**reps**	**reps with eggs**	**Eggs per attacked plant**	**Nymphs per attacked plant**
Lupinus arboreus	Center	2	2	29 ± 0.5	28 ± 1.0
	Satellite	4	3	2.5 ± 1.8	2.5 ± 1.8
Lupinus perennis	Center	2	0	0	0
	Satellite	4	0	0	0
Lupinus pilosus	Center	2	2	205 ± 71	116 ± 6
	Satellite	4	4	17 ± 8	15 ± 6
Genista monspessulana (control)	Satellite	4	4	921 ± 93	791 ± 50

In the central plot the plant was the replicate, beyond this the plot was the replicate.

Objective 3:

Progress on host specificity testing of the apionid *Lepidapion* nr *argentatum* has been hampered by a failure to obtain reliable and consistent results on control plants in the three choice tests that have been carried out. Conditions will be adjusted and further attempts will be made this year to obtain reliable testing results.

Objective 4:

Previous work on gorse and broom have shown the benefit of population models for optimizing a management strategy for target weeds that will (a) assist agent selection through type of damage, (b) help explain why the target has become such a successful invader and (c) provide a framework for testing integrated management strategies in the invaded range. Through field data collection and population parameter estimation on the population dynamics of French broom and its natural enemies, a population management model has been developed for French broom along similar lines (see CSIRO, 2000).

So far the only data available to the project to parameterize the population model has been from the native range and some data from Australia. It was envisaged at the start of this Phase in the cooperative agreement that data would become available from the exotic range in California through the collaboration with the PhD student Angelica Herrera on the project. This aspect of the project should now develop further with her recent arrival for a 7 month stay in France, as she has initiated detailed plant sampling across many different sites in Northern California in an attempt to characterize French broom in 15 different locations in the US and Europe (see section on US Invasive-Range).

<u>Objective 5:</u>
Publication of a biological control strategy will be made in a leading biological control journal once the risk assessment of the current agent under study is sufficiently complete which is not the case at the present time.

US Invasive-Range Studies (ARS):

French broom, *Genista monspessulana* (L.) L. Johnson (Fabaceae), is a leguminous, perennial shrub native to the Mediterranean, but commonly found in coastal areas and mountain slopes in California and Oregon. It has invaded disturbed and undisturbed areas such as grasslands, river-banks, forests, and roadsides. To date, *G. monspessulana* occupies approximately 40, 000 hectares of wildlands and commercial forests. An interesting observation regarding invasive plants is that some species are more vigorous and abundant in their introduced range compared to their native range. This section of the project examines differences between native (French) and introduced (California) populations of French broom.

Objectives:
1) To assess and contrast basic plant ecology, including age structures and population densities (between French and America populations of French broom for objectives 1-4).
2) Differentiation of expression of plant chemical defences against herbivores.
3) Assessment of plant resistance to psyllid herbivory.
4) Determination of psyllid performance, as measured by observed population growth rates, development times, and adult size in field grown plants.

Brief Results by objective:
To date, research has begun only on objectives 1 and 2, until psyllids are available for use in California quarantine facilities and/or the open field environment:

<u>1. French broom plant ecology studies:</u>
<u>*Hypothesis:*</u> *French broom plants are more vigorous, grow taller, and live longer in introduced (California) than in native (France) habitats?*

French broom populations: population density, age structure, plant reproduction, seedbank density, and flower density and survival. These data were collected from 15 broom populations from the introduced range, with an additional 15 sites to be sampled in the native range. The study was conducted in California during 2005, and will be continued in France during 2006 at the beginning of summer when pods are matured and have not started to dehisce. The following sites have already been assessed in California. At these locations, French broom population density, age structure, and plant reproduction was assessed in mature stands where adjacent plants with overlapping branches were located. Sampling areas were randomly chosen within the patch and all plants growing within 1 m^2 grid-area at the soil surface were collected. If there are less than 30 reproductively active plants in the first grid, the sampling area was increased sequentially along a transect. The height, stem diameter, and age were determined for each plant collected, as well as total seed production. The seed bank was assessed using 30 sampling locations where soil cores were taken in the surface litter (estimate depth), and at soil depths of 0-2.5 inches, and 2.5-5 inches. The number of seeds/m^2 was estimated for each site sampled and seed viability was assessed using the tetrazolium test.

Table 2. French Broom Ecology Study Sites in California

Site #	County	Location	Public or Private Land	Region
1	Shasta	McCloud Bridge	Federal: Whiskeytown-Shasta-Trinity Recreational Area	Sierra Foothills
2	Butte	253 Bald Rock Road	Private	Sierra Foothills
3	El Dorado	Kuarry Trail	State: Auburn State Recreation Area	Sierra Foothills
4	El Dorado	Stagecoach Trail	State: Auburn State Recreation Area	Sierra Foothills
5	Mendocino	Road 24: Fire Road	State: Jackson State Forest	Coastal - inland
6	Mendocino	Fire Road	State: Jackson State Forest	Coastal
7	Sonoma	3350 Skaggs Springs Road	Private	Coastal - inland
8	Sonoma	Vista Point	Private: Redwood Company	Coastal - inland
9	Sonoma	Tin Barn Road	Private: Redwood Company	Coastal
10	Marin	By San Pedro Road gate	State: China Camp State Park	Coastal
11	Alameda	Hwy 24 - Hillside	City of Oakland Park	Coastal
12	Alameda	Graham Trail	East Bay Parks: Redwood Regional Park	Coastal
13	Monterey	Riley Ranch Road	State: Point Lobos State Reserve	Coastal
14	Monterey	Olmsted Road	County: Jacks Peak County Park	Coastal
15	Monterey	Maher Road	Private ranch	Coastal - inland

Flower density and survival was assessed on 15 randomly selected plants at each site. Plants were selected to represent the variety of different ages (estimated by main stem thickness and divided into 3 groups = young, mid, and fully matured plants) present at the site. At peak flowering, 5 branch terminals from each plant were randomly selected at different height levels from top to bottom. The number of flowers and buds from the top 30 cm portion of each branch was counted. At seed maturation, the number of pods and seeds were compared to flowers/pods actually set. These data are now available for use in a French broom population dynamics and management model to compare with CSIRO collected data from Europe.

2. French broom biochemical studies:

Hypothesis: *There a significant difference in the expression of total quinolizidine alkaloids and tannins produced as a chemical defence against herbivores in native (France) verses introduced (California) populations of French broom?*

Quinolizidine alkaloids (QAs) are characteristic of legume plants in the tribe Genisteae and provide a qualitative chemical defence against insect herbivores such as psyllids. Plant material were collected from 10 populations (sites) in the introduced range (California) during 2005 and samples from 10 more sites will be collected in France during 2006.

Sampling was (US) or will be (Europe) conducted at the following phonological stages: budding, peak flowering, immature seeds, matured seeds, and non-reproductive stages where seeds and flowers are no longer present. At each site, ten mature, reproductively active plants were randomly chosen from each population. Within each plant, 15 branches were (will be) randomly chosen and leaves from the terminal 10-12 cm collected, placed in open paper bags, and air-dried in the laboratory at room temperature. Dried samples were stored in paper bags in freezer (-20 to

-30ºC) until chemical extraction. Because it is not possible to conduct this study simultaneously in California and France, samples were collected in California during 2005 and will be collected in France during 2006. Results of these studies are yet to be finalized, as sampling of all French broom plants in Europe has not yet been completed.

Biochemical Study Sites

Site #	County	Locations	Public or Private Land	Region
1	Shasta	Pine Point Campground	Federal: Whiskeytown-Shasta-Trinity Recreational Area	Sierra Foothills
2	Butte	253 Bald Rock Road	Private	Sierra Foothills
3	El Dorado	Hwy 49 – by Park Headquarters	Auburn State Recreation Area	Sierra Foothills
4	Madera	Beasore Road – Bass Lake	Private	Sierra Foothills
5	Mendocino	Road 24: Fire Road.	State: Jackson State Forest	Coastal - inland
6	Sonoma	621 Skaggs Springs Road	State park: Lake Sonoma	Coastal - inland
7	Alameda	Graham Trail	East Bay Parks: Redwood Regional Park	Coastal
8	Monterey	Riley Ranch Road	State: Point Lobos State Reserve	Coastal
9	San Luis Obispo	Perfumo Canyon Road	Private: Close to Perfumo Canyon Open Space County Park	Coastal
10	Santa Barbara	San Marcos Pass, by Hwy154	Federal: Los Padres Nat. Forest	Coastal

Ms. Herrera is currently in Montpellier, France where she is working in cooperation with ARS scientists at the European Biological Control Laboratory and with Andy Sheppard at CSIRO. Dr. Carruthers plans to travel to Montpellier this June to further assess this joint research and to ensure long-term project stability in Montpellier, as Dr. Sheppard is now preparing to return to Australia this spring. It is our hope that USDA-ARS scientists at the EBCL will participate more directly in this project under the direction of the new Laboratory Director, Dr. Walker Jones.

Biological Control of Scotch Broom (ARS):

Scotch broom (*Cytisus scoparius)* is considered a noxious pest in the Pacific Northwest, from the San Francisco Bay Area north to Canada and in other areas of the US including as far east as Colorado (Coombs et al. 2004). In particular, USDA-ARS has been requested to address infestations of Scotch broom in areas where The Nature Conservancy has been working with the US Military on Fort Lewis, located near Tacoma, Washington. At Fort Lewis, this invasive plant has spread onto prairies and forested lands, and limits the available area for combat training on the base, as well as displacing native vegetation from these areas. Traditional control treatments, such as mowing and/or herbicides, are currently used in attempts to manage this invasive plant along with the introduction of classical biological control natural enemies. Such managed areas are referred to in this document as "treated" while similar areas where no management has been conducted are generally referred to as "untreated". In future years, further divisions between management methods will be assessed and more detailed assessments made as it related to biological control effectiveness and overall Scotch broom control.

The seed feeding beetle, *Apion fuscirostre*, was released as a biological control agent against Scotch broom in the United States, in the 1960s (Andres 1979). Parker (1997) first observed the beetle on Fort Lewis in 1995 on six different Scotch broom populations, but it was a new arrival into this area, as it was not found in a similar survey in 1993. Current preliminary observations indicate that the beetle is now widely distributed on the base and beginning to impact seed production to some degree. However, detailed assessments of its population and impact have not been performed to confirm this, nor evaluations conducted on its compatibility with other Scotch broom control measures. USDA-ARS is now involved in conducting assessments *of A. fuscirostre* on Fort Lewis and assessing its impact in preparation for the development of expanded IPM efforts including the addition of potential new biological control agents. Thus the long-term goal of this project is to create an effective IPM program by combining biological and more traditional methods of control such as burning, mowing and herbicide application.

In 2005 a preliminary study was conducted to assess the population status of *A. fuscirostre*. This preliminary assessment and associated information was used to prepare for a season-long study that is to be conducted in spring and summer of 2006.

The objectives of this preliminary study were:

1) To determine the population and damage levels of *A. fuscirostre* on Scotch broom stands exposed to and excluded from traditional control methods.
2) To assess Scotch broom ecology, reproduction and seed bank density tied to differing Scotch broom control methods and seed weevil, *A. fuscirostre,* densities.

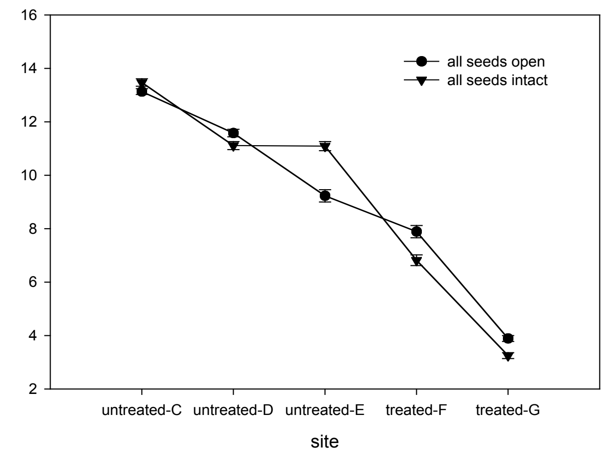
<u>1. Plant and seed weevil assessment:</u>
A. fuscirostre is a seed feeding weevil that has one generation per year. During the winter months most adults overwinter beneath Scotch broom in the litter, but it is possible to find active adults during warm winter days. Overwintering adults become active in spring, especially during the flowering stage, as females feed on flowers to stimulate egg production. Females oviposit eggs next to immature seeds found inside green pods and larvae feed on developing seeds. One larva consumes and completes development in one seed, but it can partially consume adjacent ones. The larva pupates and then emerges as an adult inside the cavity of the seed it consumed. When pods mature and dehisce, adults are thrown from pods along with seeds. Adult beetles from this new generation feed on terminal stem shoots and eventually disperse to find overwintering sites. Further, *A. fuscirostre* is parasitized by a small, black ectoparasitoid, *Pteromalus sequester*. The wasp overwinters in the adult stage and becomes reproductively active during the summer. *P. sequester* oviposits eggs directly on third instar larvae or pupae of *A. fuscirostre* housed within a pod. In late summer, all stages are conveniently located in pods.

To initiate a assessment, seven sites were sampled from August 8th to August 12th in 2005 on Fort Lewis. Scotch broom plants on five sites, designated A-E, are controlled solely by biological control using natural occurring *A. fuscirostre*, as no other active management activities were conducted at these locations by the military or cooperating TNC staff members. Scotch broom in the remaining two sites, F and G, were controlled by a combination of biological control and physical/chemical control methods such as mowing and/or herbicide application conducted in previous years. These study sites were spread throughout the base to represent the different treatment types of treatments and broom stands now in existence. Based on this preliminary sampling a more complete assessment is planned and underway for the 2006 field season.

To determine the level of weevil infestation in each stand, 20-25 plants were randomly selected and cut for processing. For each plant the height, basal stem diameter, number of annular rings and total number of seedpods were counted. Then, all the intact pods, up to 100, were collected and stored in a brown paper bag to facilitate drying and to prevent molding of pods. Each pod was later dissected under a microscope in the lab to assess the number of *mature seeds* (all full grown seeds both undamaged and damaged by weevil), *immature seeds* (those that did not make it to maturity either because of abortion by the plant itself, or by feeding from homopterous insects), *intact seeds* (mature seeds that are completely undamaged), *infested seeds* (mature seeds that show full or partial evidence of insect damage), and the number of *all seeds* (the combination of mature seeds and immature seeds).

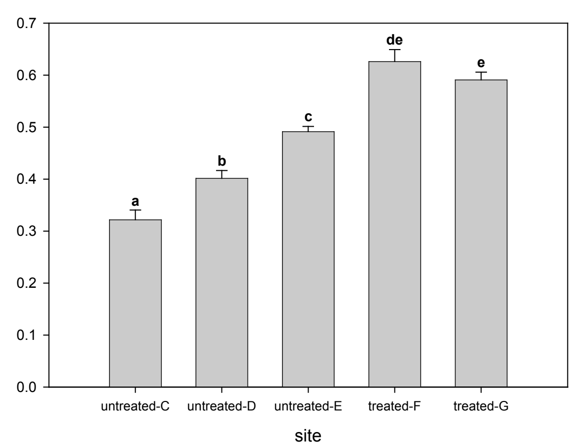
Insect activity in pods, data on the type of insect found (beetle or parasitoids), its life stage (larval, pupae, adult), and whether that individual was alive or dead, was collected. Collection site (treated vs. non-treated), pod status (intact or open), and pod length significantly determined the number of *all seeds, mature seeds,* and *immature seeds* in pods. When TNC-managed sites are viewed as a group, the means for the number of *all seeds* were lower than those from the unmanaged sites. Figure 4 shows the mean number of seeds collected per pod with clear differences shown in the overall seed production in areas where integrated management was not applied. Although not shown in Figure 4, statistically significance differences were found between TNC treated and non-treated areas.

Figure 4. Mean (± SE) number of All Seeds (mature plus dead and aborted immature seeds) for intact and open pods by site. Sites are catagorized as treated for Scotch Broom control if the site has a fire, mowing, or herbicide application, otherwise, the site is designated as untreated.



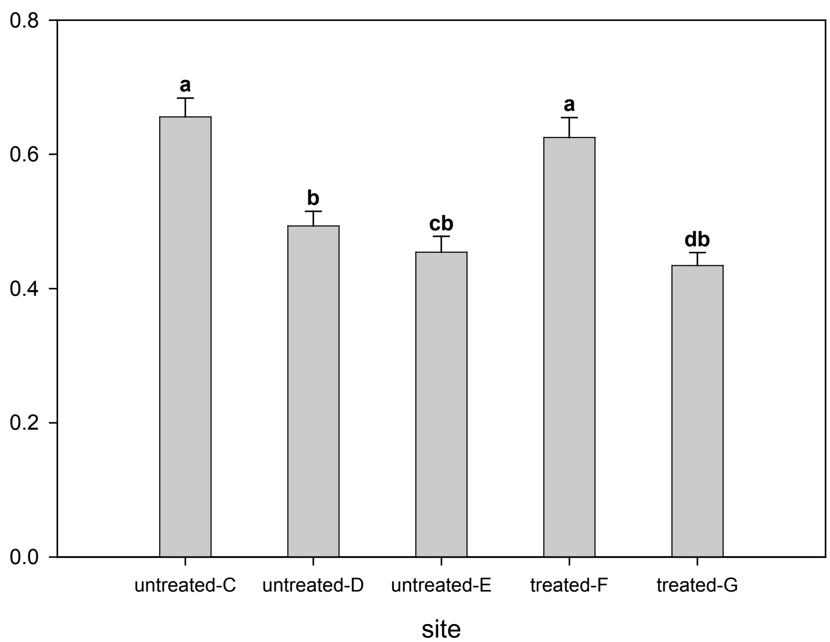
Proportion of seeds damaged was also dependent upon site and pod length. The mean proportion of seeds damaged per pod from treated sites F and G was significantly different when compared to all untreated sites (Figure 5). The difference between sites F and G, however, is not significant, but the proportion of seed damage was an average of 20% higher on treated sites when compared untreated sites. Clear separation of means by treated vs. non-treated was found showing that beetle levels were actually higher in areas where IPM treatments were used.

Figure 5 Mean (±SE) proportion of infested seeds per intact pod by site. Sites are catagorized as treated for Scotch Broom control if the site has a fire, mowing, or herbicide application, otherwise, the site is designated as untreated. For those means that share the same letter, the means are not significantly different from each other.



Because our sampling occurred late in the season, beetle adults were the predominant stage recorded. In addition, the number of parasite emergence holes and/or wasp pupal skins were counted and used to estimate the number of adult parasitoids. Also, because wasps attack the last larval stage and pupal stages of the beetle, significant damage to the seed has already occurred by the time the beetles were parasitized. We used this knowledge to estimate beetle parasitism rates by comparing the number of parasitoids over the number of infested seeds only for intact pods. Although differences were apparent and significant between sites, no relation between IPM treated and non-treated areas were apparent. It is currently unclear the overall impact of parasitism on the impact of this biological control agent as it affects Scotch broom.

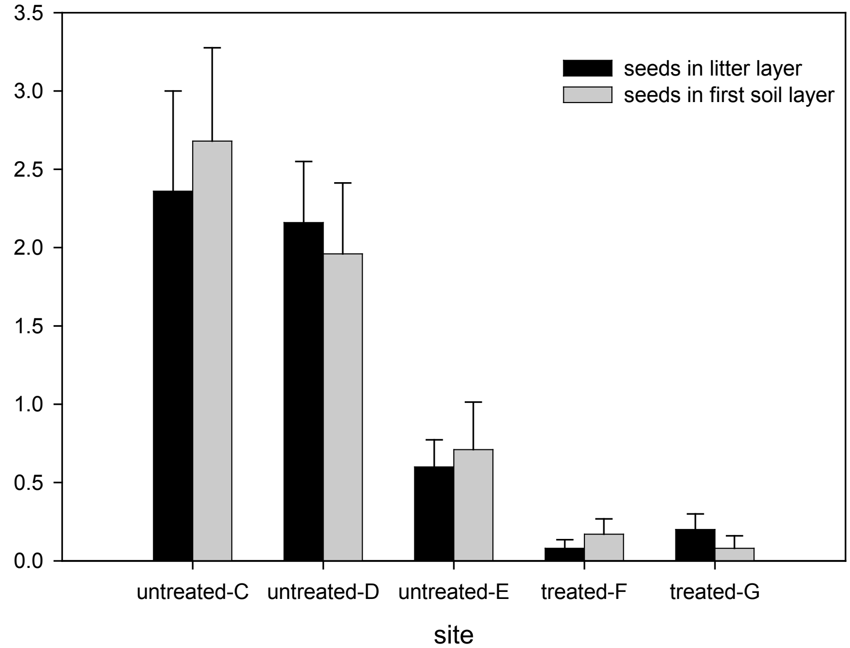
Figure 6 . Mean (±SE) parasitism rate 2 (number of parasites over infested seeds) per intact pod by site. Sites are catagorized as treated for Scotch Broom control if the site has a fire, mowing, or herbicide application, otherwise, the site is designated as untreated. For those means that share the same letter, the means are not significantly different from each other.



2. Plant growth and reproduction:

Clear differences in plant height between treated and untreated sites were observed in the field and in the number of pods/ seeds produced between treated and non-treated areas, although this difference was not always consistent and needs further assessment. Plants in treated sites were an average 136 ± 4.9 cm in height, while plants in untreated sites were an average 231 ± 8.0 cm tall. Most significantly, the number of seeds per soil sample was significantly different among sites ($H(4) = 59.54$, $p < 0.05$). TNC treated sites F and G contained significantly less seeds per sample than all untreated sites, and the difference in seed number per sample was not significant between the two treatments pattens (Figure 7). If data are pooled by treatment status, untreated sites contained an average of 3.38 ± 0.47 seeds per sample while treated sites contained an average of 0.26 ± 0.98 seeds per sample, a clear indicator of the success of the IPM activities.

Figure 7. Mean (±SE) number of seeds per soil core by site. Sites are catagorized as treated for Scotch Broom control if the site has a fire, mowing, or herbicide application, otherwise, the site is designated as untreated.



Although this study was conducted late in the season, there were enough information to develop a preliminary view of *A. fuscirostre* activity and impact on plant reproduction. The objective of this study was to determine if Scotch broom control methods and the activity of *A. fuscirostre* as a biological control agent complement each other to create a greater total reduction of plant reproduction. Results from this study indicate that although plant reproduction has to be estimated much more accurately in the future, there is a higher rate of seed damage at the pod and plant level in broom exposed to biological control and supplemented using other treatments such as mowing and/or herbicides. This suggests that the compounded effects of seed predation by the seed weevil, and physical control treatments, are significantly reducing seed bank density, and should be further studied as an effective Scotch Broom removal plan. In the spring and summer of 2006, USDA-ARS will conduct season-long studies at Fort Lewis to more accurately assess biological control potential of the seed feeding beetle and determine the negative impacts caused by the parasitic wasp. We hope that by combining the current biological control activity with new proposed biological control agents, along with locally implemented cutting and herbicide application that new more effective IPM methodologies can be developed.

Overall Project Conclusion:

Combined efforts of USDA-ARS, CSIRO, EBCL and cooperator activities are providing new information and potentially new management tools for integrated management of French and Scotch brooms. Additional work is clearly necessary on all aspects of this research effort including the acquisition and testing of new European agents for both broom species. Likewise, additional domestic assessments of invasive plant growth and development a vital both to parameterize management models and to provide pre-release baseline data for future biological control release efforts. Provided adequate resource are available, this project will be continued by all groups currently involved in this effort.