

Biological control of spotted knapweed in the southeastern US

Date: June 1, 2012
Award Number: 10-CA-11420004-217
Report Period: May 17, 2010 through May 16, 2012
Project Period: May 17, 2010 through May 16, 2012
Recipient: University of Arkansas
Recipient Contact Person: Mike Sisco
Principal Investigator/Project Director: T. J. Kring

Progress Achieve in Accomplishing Project Goals& Objectives (*Objectives correspond to those in the approved grant application*).

Objective 1: To expand the existing biological control program of spotted knapweed by increasing redistribution of a seed head weevil (*Larinus minutus*) and by initiating a release program for the root weevil *Cyphocleonus achates*.

The proposed work in this project hinged on our ability to successfully establish and redistribute this knapweed natural enemy throughout the target areas in Arkansas. Additional collections of over nearly 25,000 (~17,000 in 2010 and 7,300 in 2011) *L. minutus* were made from diffuse and spotted knapweed infestations along the Front Range of the Rocky Mountains between Colorado Springs and Boulder, CO. In 2010 we were provided additional assistance from personnel with the Colorado Department of Agriculture who were making collections in the same areas. These large collections, were combined with earlier, smaller collections and releases made earlier as part of another project. These efforts allowed us to make significant releases of *Larinus minutus* (minimum releases of 300/location) at 40 unique locations in Arkansas. The numbers released per site were adjusted in proportion to the size of the knapweed populations at each location, and we believe these adjustments allowed us to be very successful in establishing this species in Arkansas. As of this writing, we have confirmed establishment of *L. minutus* at 38 of the 40 release sites. Knapweed populations were destroyed (by construction/road work) at the 2 release sites where establishments failed. We have documented this establishment in the literature (Minteer, C. R., T. J. Kring, J. Shen and R. N. Wiedenmann. 2011. *Larinus minutus* (Coleoptera: Curculionidae), a biological control agent of spotted knapweed (*Centaurea stoebe* spp. *micranthos*) established in northern Arkansas. *Florida Entomol.* 94(2): 350-351.).

We initiated an effort to collect and redistribute adults of the knapweed root weevil, *Cyphocleonus achates*, from Colorado to Arkansas in 2010 with a release of ~2,500 adult *C. achates*. Additional collections of ~1,300 adults in 2011 allowed us to colonize this species in nine distinct locations in west-central Arkansas. These collections in Colorado were made in cooperation with Colorado Department of Agriculture and Texas A&M University, largely from the Bolder CO area. These are the first releases of this species in Arkansas or any southern state. Adults were observed on the knapweed plants at all of these release sites the year after release, and at 4 of the 5 2010 release sites more than 2 years after release. Biological control practitioners wait until a “3-

year, 3-generation” rule is satisfied, so we will wait until the summer of 2013 to formally document the establishment of the species.

The presence of adults of both *Larinus minutus* and *Cyphocleonus achates* at virtually all of the release locations signifies a high quality of the collected and released material. This longevity and retention of adults at release sites over multiple years was a characteristic of successful establishments of these species in the Canada, the Pacific Northwest and Colorado, thus fueling our optimism about the establishment of species and the ultimate reduction of spotted knapweed throughout Northwestern Arkansas.

Objective 2: To examine the relationship of controlled burns and other vegetation management tactics on knapweed invasion/spread along roads, forest edges and other forest systems.

Releases of both biological control agents were made in northwestern Arkansas in large infestations of spotted knapweed in managed areas completely surrounded by state or federal forests. One of these is a large glade (~80 acres) being managed as a restoration area in McIlroy State Game Management Area. This area (“Glade”) area was scheduled to use a combination of mowing, herbicides and controlled burns to manage invasive species and undesirable woody plants. The second area is a former cattle ranch (“Ranch”) that was previously overgrazed and is being managed as a game preserve, maintaining large open areas (>1,200 acres). Management techniques in this area include mowing, herbicide use and aggressive removal (cultivation) of undesirable species and replanting of desirable vegetation and subsequent fertilization.

Because the current project was initiated after spotted knapweed flowering began at these two locations in 2010, no assessments of the impact of subsequent management treatments could be made in the 2010-2011 season. However, both locations provided some opportunity to examine the interactions of these management tactics with each other. Evaluations of each biological control agent (alone, and acting together) is conducted using permanent plots established at multiple locations across the state. These plots were established in areas where neither species was released, where one or the other was released, and where both species were released. As the agents become fully established, we expect that their impact on knapweed populations will be visible through an increase in plant damage, a reduction in the size of knapweed results, and ultimately a reduction in new knapweed seedlings (resulting in reduced contributions to the 8-year seed bank). The seed head weevil (*L. minutus*) is established at both location, and the knapweed root weevil (*C. achates*) was recovered in both locations this year (2012).

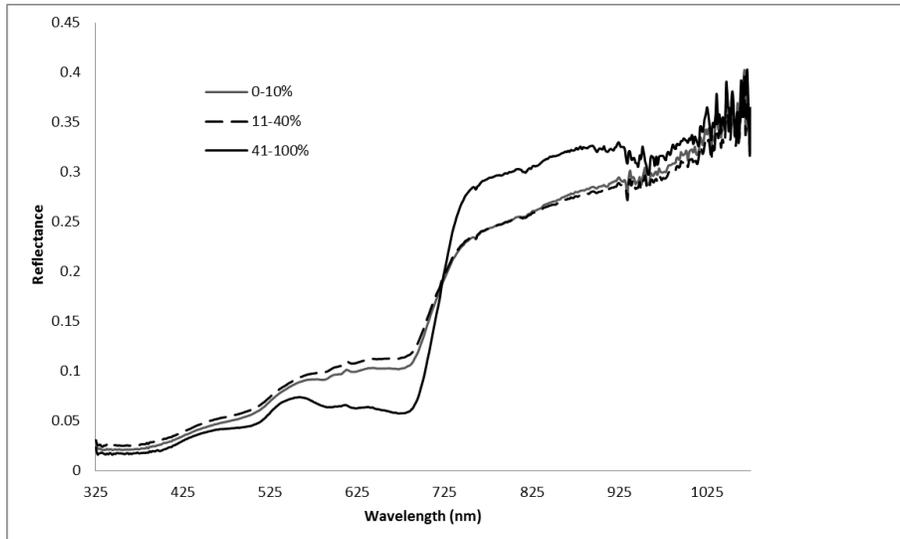
Mowing, cultivation and herbicide treatments were applied as scheduled at both locations. The ongoing area-wide drought has prevented application of the planned controlled burns at the Glade location (no burns were proposed at the Ranch location). Given the extensive amount of fallen woody debris from ice storms and the continued drought, the landowner will likely cancel plans for a controlled burn, although the

cooperating agency has retained remove controlled burnings in their restoration protocol. As a result, treatment zones intended to be burned were subjected to a spring mowing in May, 2011 and March 2012 instead. These mowings were timed to be just prior to knapweed flower production, as recommended. These mowed areas were split into herbicide-treated (spot applications) and non-treated as originally proposed. While it is premature to evaluate the interaction of these treatments with the action of the newly colonized biological control agents, the relative success (and failure) of the standard treatments has been documented in 2011 and are still under evaluation in 2012. The protocol was a holistic one, not just focusing on knapweed. Mowing efforts significantly reduced sycamore and juniper stands in treatment areas, and in 2011 knapweed populations were significantly reduced due to the subsequent drought (mowed plants did not re-sprout as is typical). However, knapweed seedling densities were extremely high in mowed areas in the spring of 2012, as knapweed was released from grass competitors (due to drought) and woody herbaceous species (due to mowing). The landowner at the Ranch location as agreed to apply no treatments to the 2 release locations on his property (each ~1A) to allow a controlled evaluation of knapweed response to the both biological control agents. The ranch landowners cultural management practices have focused on mowing (in a minor way) and a complete replacement of vegetation (broad spectrum herbicides, cultivation, replanting of desired vegetation and fertilization). Mowing efforts resulted in a significant reduction in knapweed in the spring of 2011, but resurgence in the spring 2012 was evident, as was experienced at the Glade location. However, the vegetation replacement program has largely eliminated knapweed and most other undesirable species, but at a great cost. This landowner is not bound by external agency prescribed restoration protocols (as at the Glade site), and has not been limited by financial concerns. Therefore, the Ranch site serves as an excellent one to evaluate the released agents in a controlled, largely undisturbed area that he set aside for our use. However, the remaining non-release areas do not represent typical (or economically feasible) alternatives to knapweed management.

Objective 3: To develop and refine remote sensing techniques to aid in GIS-based vegetation analysis which provide data on knapweed spread and control as biological control agents impact knapweed populations.

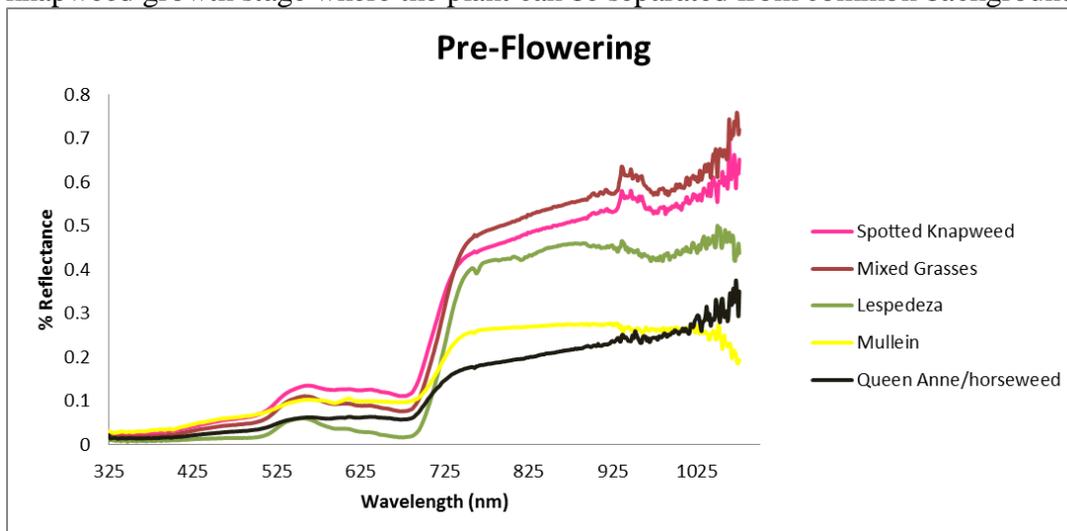
Spectral characteristics of spotted knapweed populations were measured using a FieldSpec HH UV/VNIR handheld spectroradiometer (Analytical Spectral Devices Inc.). Measurements were taken in 2010 at two sites early in the growing season (pre-flowering). Measurements during flowering and post senescence were collected in the summer of 2011. Three different spotted knapweed population sizes (<10%, 10-40%, and 40-100% spotted knapweed cover) were measured to determine differences in spectral curves among varying population sizes. Measurements of surrounding, non-spotted knapweed, vegetation were also recorded to determine the separability of the spectral curves. The spectral curves for spotted knapweed (pre-flowering) and the other vegetation measured exhibited typical spectral curves for vegetation.

Analysis to determine differences among the spectral curves will not be completed until all spectral curves are collected; however, the spectral curves seen for pre-flowering spotted knapweed appear to differ in the % reflectance from the other vegetation sampled. The graph below depicts the reflectance data for pre-flowering knapweed at the three classes of weed ground cover.



Spotted knapweed reflectance curves in bud at three cover classes (<10%, 11-40%, and 41-100% spotted knapweed).

Measurements of surrounding (non-spotted knapweed) vegetation were also recorded to determine if the spectral curves could be separated. Surrounding plants were identified (38 species) and the reflectance of each and common combinations of plants were recorded. An example of these reflectance curves appears below (one knapweed stage, selected plant species). By analyzing areas of the curve in each stage where knapweed has a distinct reflectance (for example, between 725 and 900 nm below), we were able to identify wavelength regions for each knapweed growth stage where the plant can be separated from common background species.



Therefore, we found that it is feasible to separate spotted knapweed spectral curves from other vegetation sampled by using the spectral bands available on the new WorldView-2 satellite (see table below) (Minteer et al., *in review*). Images from this satellite may be purchased for specific location (80km² minimum area) at a specific time (e.g., during knapweed flowering), and will be the focus of future proposals. However, the objective of the current project has been met, in that we have determined that remote sensing of spotted knapweed is entirely feasible using the newest technology available.

Spotted knapweed cover	<u>Phenological Time</u>		
	Bud	Flower	Senescence
<10%	Blue, NIR II	NIR II	Green
11-40%	Green, Yellow, Red, NIR I, NIR II	Blue	Red-edge
41-100%	NIR I, NIR II, Red	NIR I	Red-edge, NIR I, NIR II

Difficulties Encountered *(As applicable, should include information on specific reasons why goals and objectives were not met, and analysis and explanations of cost overruns and high unit costs)*

Goal/Objective 1:

The objective has been fully satisfied.

Goal/Objective 2:

Problem: The controlled burn treatment could not be applied as scheduled. The landowner and cooperating agency could not agree on removal of the controlled burnings from their restoration protocol, but no burns were possible in 2011 or 2012.

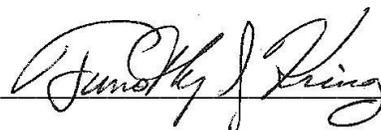
Resolution/Corrective Action Plan and Schedule: Because restoration protocol preceded and supersedes our project, we had adjusted our objectives to fit their plan. The burn treatment was initially included in our project simply because a burn protocol was already in place. In reality, controlled burns are not typically applied for knapweed management in Arkansas. Therefore, while we were unable to collect data on burned treatment plots, we do not consider it as a setback to this project or specific objective.

Goal/Objective 3:

The objective has been fully satisfied.

Activity Anticipated Next Reporting Period

None under this agreement, which terminated May 16, 2012

Signature:  _____

Date: June 1, 2012