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SageSTEP, "SageSTEP News, Winter 2014, No. 23" (2014). *Newsletters*. 13.  
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# Sagebrush Steppe SageSTEP Treatment Evaluation Project

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- Aroga Moth, p. 5

Issue 23, Winter 2014

## Ecological Responses of Arid Wyoming Big Sagebrush Communities to Fuel Treatments

By Scott E. Shaff & David A. Pyke

Land managers across the Intermountain West are applying various fuel treatments to Wyoming sagebrush ecosystems in hopes of reducing fire potential. One concern is that cheatgrass (*Bromus tectorum* L) may invade treated areas if the ecosystem lacks resistance to invasion or resilience to recover from disturbances. The SageSTEP project is designed to help land managers understand how plant communities respond to fuel treatments. We evaluated plant community responses for three years after sagebrush thinning treatments, which included prescribed fire, mowing, and aerial application of the herbicide tebuthiuron (Spike 20P®). None of the sites were seeded. Additionally, Imazapic, a pre-emergent herbicide (Plateau®), was applied to reduce cheatgrass.

The Imazapic results are covered in the accompanying article.

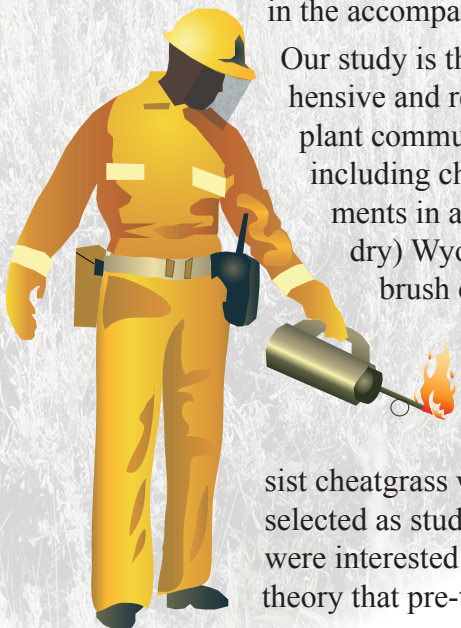
Our study is the first comprehensive and replicated study of plant community responses, including cheatgrass, to treatments in arid (warm and dry) Wyoming big sagebrush ecosystems. Areas with sufficient perennial herbaceous cover to potentially resist cheatgrass were specifically selected as study locations. We were interested in testing the theory that pre-treatment perennial

## Cheatgrass Control with Imazapic: What Influences Success and What Are the Side Effects?

M. Lee Davis

Cheatgrass (*Bromus tectorum*) is of particular concern in Western rangelands where soil disturbances create ideal conditions for cheatgrass invasions that may result in the displacement of native vegetation and altered fire regimes. Fuels reduction treatments often are employed by land managers to reduce potential wildfire severity, but they may also create conditions for cheatgrass invasion.

Interest in the use of imazapic, (a pre-emergent herbicide that targets annual species), for the control of invasive annual grasses in shrub and grasslands has steadily been growing among land managers, but much uncertainty remains concerning potential side effects and long term efficacy. The SageSTEP project now has a multi-year data set from Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) sites that is beginning to shed light on these issues. Imazapic does not appear to be a cure-all for cheatgrass infestations, but is a promising tool for limiting cheatgrass expansion when fuels reduction treatments are employed. Maintaining perennial grass cover and minimizing soil disturbance are likely to increase the effectiveness of imazapic and to limit cheatgrass expansion as well. Vegetation trends related to the effects of fuels treatments are presented in a companion piece in this issue. Here



Continued, next page...

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## Ecological Responses, cont.

herbaceous cover and spatial distances among perennial plants are early warning indicators of community resilience and cheatgrass dominance. We examined impacts of fuel reduction treatments on the short-term dominance of bare soil, and specific plant species or groups. Our preliminary results show that prescribed fire and mowing reduced woody biomass by at least 85% over three years. Herbaceous fuels were only reduced by fire (72%), but only in the first year and the herbaceous fuels recovered to pre-treatment levels by year 3. Mowing increased herbaceous fuel biomass at least 36% over the three years. Tebuthiuron did not significantly impact woody or herbaceous biomass during the three years post-treatment.

Fuel treatments that reduced biomass and changed the structure of fuel (move fuel from live to dead or to litter) may result in an initial decline of herbaceous cover, followed by an increase in herbaceous cover, provided the plant community is resilient to the disturbance. Fire reduced perennial tall grass cover by 59% relative to the untreated control in the first year after fire, but perennial tall grass cover returned to pre-treatment levels by year 2. Cover of all remaining herbaceous groups, including cheatgrass, was not changed by fire, mowing, or tebuthiuron. Although cheatgrass did not differ significantly from controls with any woody fuel treatment, we observed an increasing trend in cover over the three years post-treatment. Additional work that examined only a subset of our data showed a significant increase in cheatgrass cover by year 4 after fire.

Previous work by Reisner et al. (2013) has demonstrated that increases in cheatgrass cover are related to increases in gaps among perennial plants, increases in bare soil, and decreases in lichen and moss cover. Fire resulted in an increase of at least 28% in gaps greater than 2 m among perennial plants over three years. This increase may have resulted from fire reducing the density of perennial short grasses between 40 and 58%. Fire also decreased lichen and moss cover between 69 and 80% and increased the percentage of bare ground between 21 and 34%. The combination of decreased lichen and moss cover, increase in bare ground, and reduction in perennial short grass cover may be an indicator of potential increase in cheatgrass cover. Future research on post-disturbance plant community

responses that focuses on identifying early indicators of cheatgrass invasion and risks associated with fuel reduction treatments may help managers decide if probabilities for positive responses will outweigh risks of negative responses. An increase in cheatgrass cover is a major fuel management concern in Wyoming big sagebrush ecosystems because it changes the fire regime by creating a continuous fuel source. Our preliminary results suggest that cheatgrass may continue to increase based on early warning indicators related to higher cheatgrass cover. It is also important to note that fuel management of arid Wyoming big sagebrush communities can immediately reduce woody plant fuels using prescribed fire or mowing, but reduction can be delayed at least three years if tebuthiuron used. Managers may want to consider the complimentary goal of creating communities of herbaceous perennials with discontinuous fuels.

SageSTEP provides a unique opportunity to study ecosystem responses across a range of ecoregions. Our design focuses on collecting data from many sites rather than focusing on site-specific differences to provide broad, science-based findings useful for predicting both short- and long-term plant community responses to management activities. These responses may develop slowly and can require over 20 years of post-treatment monitoring to determine if a community is resilient to these disturbances. Our initial results are an important first step in understanding resistance and resilience of Wyoming big sagebrush ecosystems in the Intermountain West and may help support the refinement of predictive decision support tools.

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## Cheatgrass Control, cont. from pg. 1

we focus on the results of imazapic application across alternative fuels reduction treatments. In general, cheatgrass cover was most affected by imazapic application and the number of years from treatment rather than the type of fuels reduction treatment employed at our sites.

As previously covered in the fall newsletter, initial data from the SageSTEP study indicate that imazapic has provided ongoing suppression of cheatgrass (Figure 1). After fuels reduction treatments cheatgrass cover increased each year post treatment in plots that were not treated with imazapic and by year 4 was an average of 44% greater than in year 0. By 4 years post-treatment cheatgrass cover levels in subplots treated with imazapic had recovered to pre-treatment levels, but remained 95% lower than cover levels in plots that were not treated with imazapic. While the application of imazapic did not rid the treatment plots of cheatgrass, it does appear to keep cheatgrass cover from expanding as a result of fuels treatments. Additionally, imazapic provides several years of cheatgrass suppression that may be useful in providing a window of reduced competition that could potentially increase the effectiveness of additional restoration treatments such as the seeding of native species.

While imazapic is useful in suppressing cheatgrass following disturbance, we are also interested in potential side effects on native vegetation. Imazapic

application did suppress native annual forbs for several years post-treatment, although the effects were short term (Figure 2). Importantly, less common native annual forb cover like *Plantago patagonica* (wooly plantain) and *Gayophytum racemosum* (blackfoot groundsmoke) recovered to pre-treatment levels by year 3 and did not differ between imazapic and non-imazapic plots (Figure 2). This indicates that imazapic application did not have an ongoing negative effect on total native forb cover or on the cover of rare forbs in our plots.

There is concern that imazapic may negatively affect the cover of Sandberg bluegrass, which is an important native perennial shallow-rooted grass. Our data showed a short term suppression of Sandberg bluegrass that followed a similar pattern as native forb cover. By year 3 post-treatment Sandberg bluegrass recovered to pre-treatment levels in plots treated with imazapic (year 0 = 10%, year 3 = 11%). Perennial native grasses as a whole (including Sandberg bluegrass) also showed a slight initial depression in plots treated with imazapic, but by 4 years post-treatment perennial tall grass cover was comparable in imazapic and non-imazapic treated plots (13%, s.e.=0.83 vs 11%, s.e.=1.06).

Although cheatgrass was suppressed in plots treated with Imazapic, the return of cheatgrass in both treated and untreated plots was exceptionally variable. Pre-treatment perennial grass cover appears to exert a

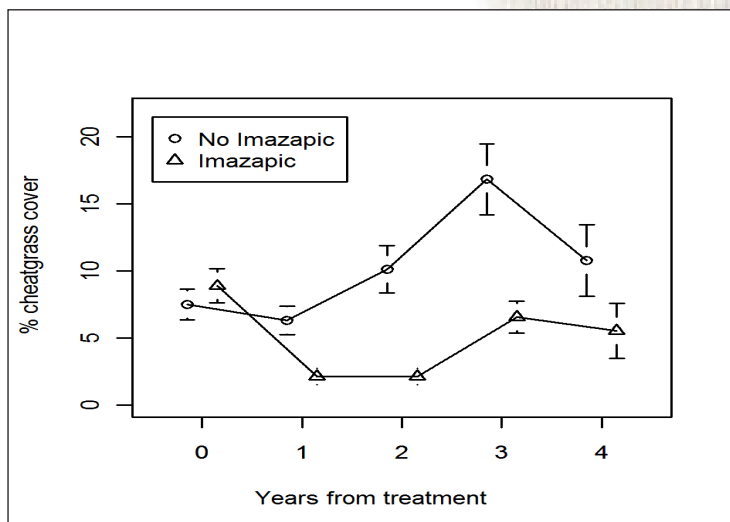


Figure 1. Cheatgrass cover pre-treatment (Year 0) and post treatment (Years 1-4) in plots within fuels reduction plots treated and not treated with imazapic.

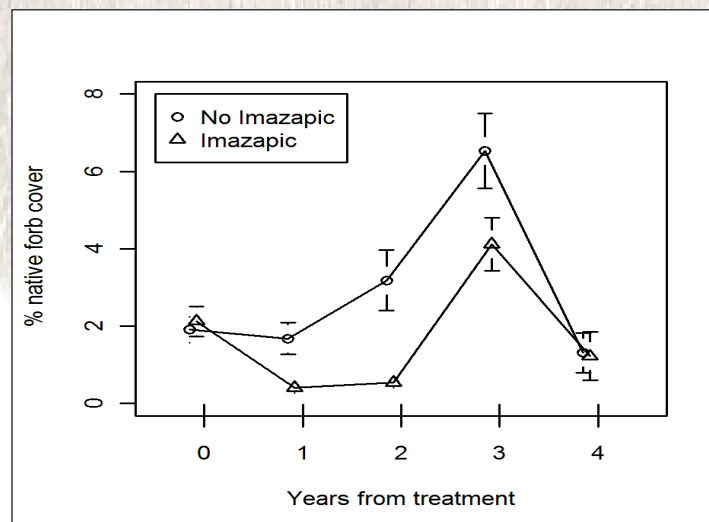


Figure 2. Native forb cover pre-treatment (Year 0) and post treatment (Years 1-4) in plots within fuels reduction plots treated and not treated with imazapic.

## Cheatgrass Control, cont.

strong influence on the reestablishment of cheatgrass in both treated and untreated plots (Figure 3). High levels of pre-treatment perennial grass cover were associated with lower post-treatment cover of cheatgrass, although when pre-treatment perennial grass cover is less than 25%, post-treatment cheatgrass cover appears to be limited by other factors. Once perennial grass cover has been accounted for, the most important factor for explaining the reestablishment of cheatgrass was pre-treatment cheatgrass cover. Plots with high levels of pre-treatment cheatgrass cover and

lower levels of perennial grass cover were more likely to have high post-treatment cheatgrass cover, but the average maximum post-treatment cheatgrass cover was reduced by roughly half by imazapic application. Analyses also revealed that 30-year average maximum temperature and precipitation were important factors influencing variability in post-treatment cheatgrass cover. These trends are somewhat difficult to interpret due to the low number of sites, but wetter, cooler sites tended to show better post-treatment resistance to cheatgrass compared to warmer, dryer sites.

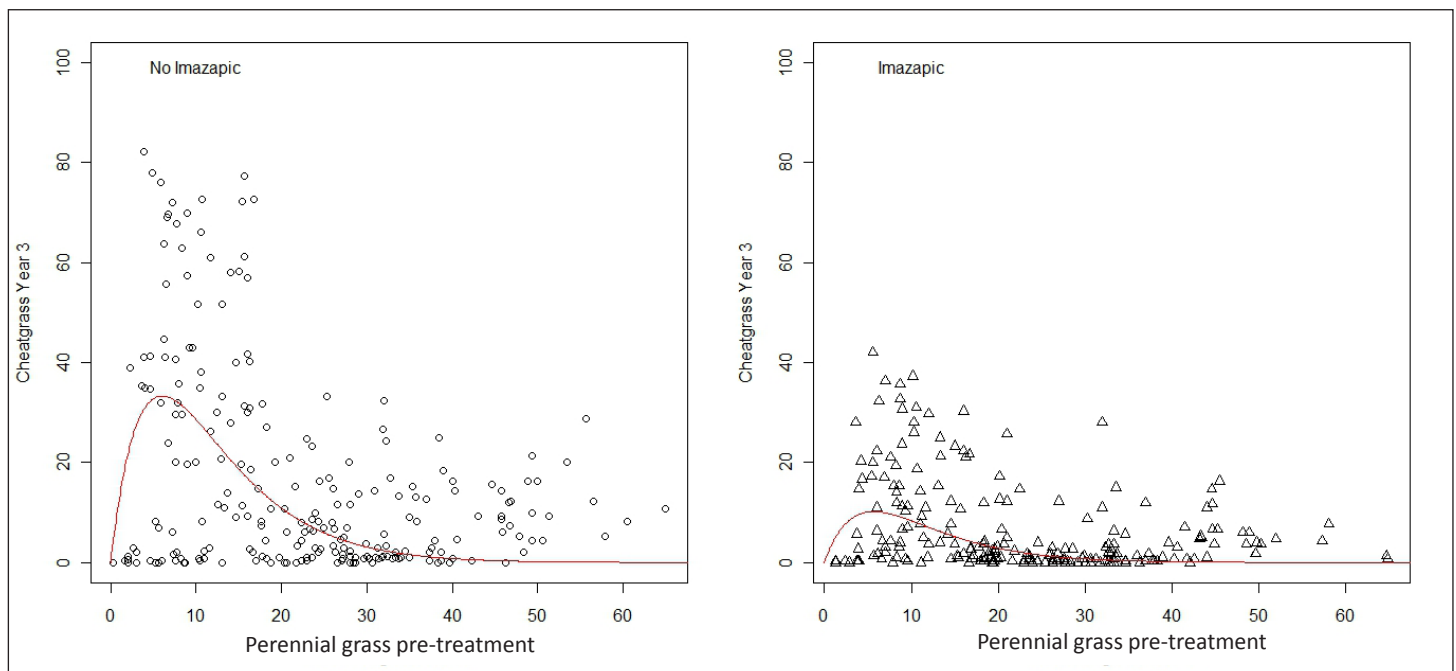


Figure 3. The effect of pre-treatment (Year 0) native perennial grass cover and imazapic application on cheatgrass cover three years after treatment initiation. In general, higher levels of perennial grass cover are associated with suppressed cheatgrass cover. Imazapic application suppressed cheatgrass cover and was especially important in limiting the return of cheatgrass at lower perennial grass cover levels.





# Research Highlight

**A look at what the Great Basin science community is studying:**

## Attack of the Moth: Monitoring the sagebrush defoliating *Aroga* Moth and Aiding its Enemies

**By Lael Gilbert and Virginia Bolshakova**

It could be a Hitchcock movie, if tiny, fuzz-covered moths inspired more terror. The native *Aroga* moth (*Aroga websteri*) is a hugely effective killer of big sagebrush in the Great Basin, leaving behind landscape-wide vistas of dust-colored stems of sagebrush dead and dying. Effects of these outbreaks are serious. Sagebrush ecosystems are already in decline, and intense, widespread herbivory such as an *Aroga* moth infestation can lead to changes in plant communities, population levels of other animals, and rates of nutrient cycling, kicking a system that is already down. Historically it was believed these tiny moths with narrow, fringed wings made a large-scale appearance only occasionally – about every decade. But a recent spiraling schedule of outbreaks seems to have escaped from some controlling set of factors – factors that scientists like Dr. Virginia Bolshakova, (Biology, USU) with the support of Dr. Ted Evans (Biology, USU) have set out to understand.

As a foundation, Virginia researched the ecological cues that might cause or prevent outbreaks of *Aroga* moth. She monitored the moth, got to know its natural enemies, and determined how environmental factors like temperature and precipitation can impact moth populations. She developed a degree-day model to describe the insect's development over time. Virginia wanted to give managers a tool to describe the timing of the insect's development and to help determine the likelihood of an outbreak, and she found it in weather.

The amount of heat in the spring plays a key role in determining the timing of insect outbreaks on Great Basin rangelands. Since the metabolism of ectotherms like the *Aroga* moth is dependent on temperature, Virginia reasoned that there was likely a range of conditions, that when reached would allow the insect to flourish during outbreak years.

When Virginia looked into the historical data for outbreaks and compared them to weather data, she



*Aroga websteri* outbreaks in big sagebrush can lead to changes in plant communities, population levels in other animals, and rates of nutrient cycling, kicking a system that is already down.

found a pattern associated to the insect's degree-day development (accounting for how many warm days occurred, and how warm they actually were). Outbreak years had consistently moderate temperatures ... and a pulse of rain in June (300% above June average rainfall in northern Utah in 2009, Hipps and Wang 2009). The temperatures gave the moth enough warm days to develop to a critical period without being too warm or too cold. The pulse of rain coincided with that critical period in larval development and seemed to push the population over the edge. Those two factors seemed to be enough to bring about a burst in the moth population.

The next step, of course, would be to better understand how to possibly control the critters. The ideal way to do that would be to let the ecosystem keep them in check. As part of a food chain, the *Aroga* Moth has natural enemies – tiny parasitoids (parasitic wasps that use the moth as a host for their larvae, whom ultimately kill and consume it, sometimes from the inside out, and sometimes from the outside in, depending on the wasp). The question for Virginia was why in some areas major parasitoid species occurred

## Attack, cont.

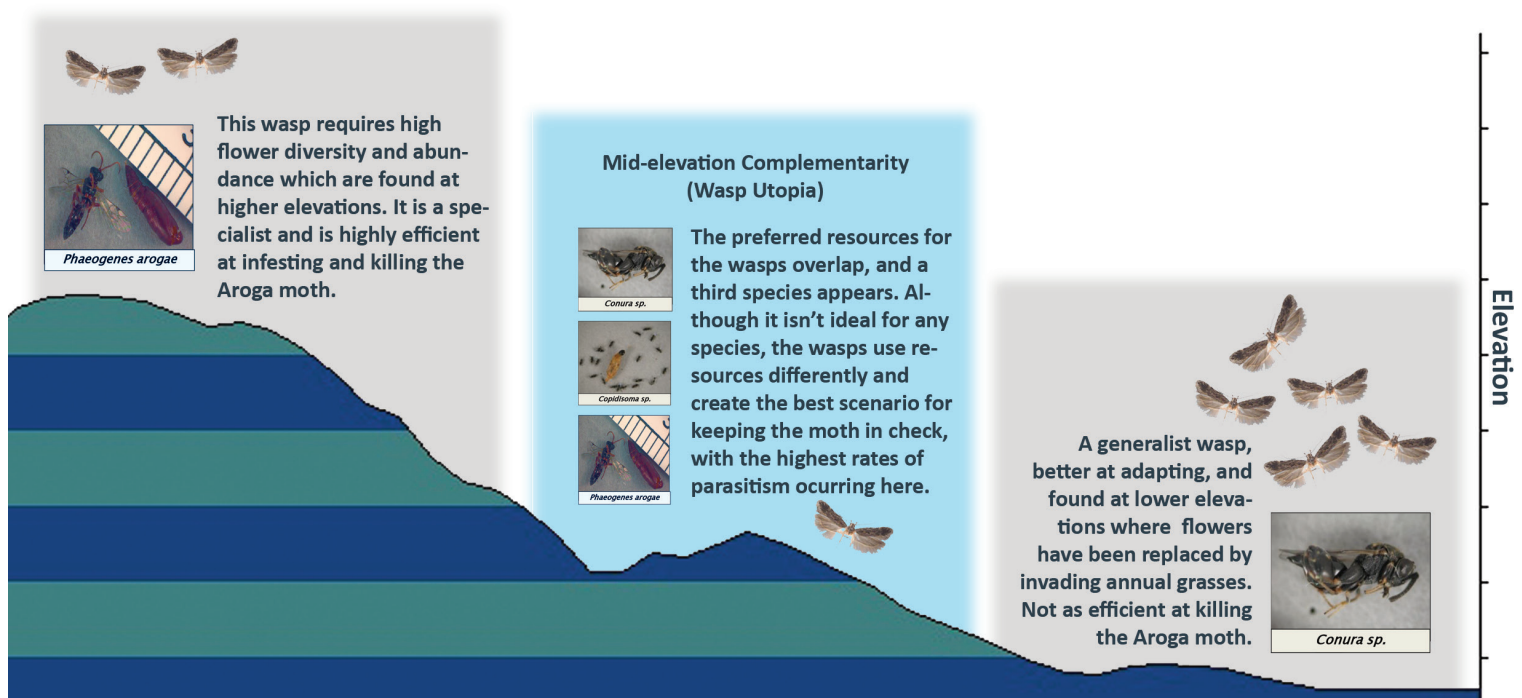
in up to 80 percent of the moths, keeping the moth population low, but in other areas there were very few of the wasps, or none at all. What sort of invitation did the parasitoids need to show up to the party, and what kind of resources would keep them there?

Three factors stood out. The first was elevation. Virginia had 38 one-acre study plots cast over a wide range of montane sites. Overall parasitism increased as altitude increased, but it was unclear why. Then there was the question of how the parasitoid located its meal. When sagebrush is attacked, the plant sends out chemical distress signals, an SOS to which some parasitoids are attracted, indicating that lunch is likely available. A third factor dealt with foods parasitoids need to thrive – protein and sugar. The protein comes from consuming the *Aroga* moth (or if you aren't picky, a beetle or other insect will work just as well). Understory forbs and/or flowering shrubs provide the sugar. Virginia looked at several types of wasp (all parasitoids and enemies of the *Aroga* moth) who interacted with these factors in different ways. She manipulated the environment ... adding flowers, mimicking the chemical distress signal, and in one experiment spraying sugar water over sites ... to see what resources would best suit the wasps. She then collected thousands of the *Aroga* moth from these manipulated sites and reared them in the lab, watching

for which wasp might pop out of the pupal cases and in what quantity. "It was like Christmas," she said. She found that all wasps are not alike.

Some parasitic wasps responded strongly to the sugar spray, increasing parasitism rates in the plots she had treated, but none more than *Phaeogenes*, a specialist wasp. This wasp is an *Aroga* killing machine since the *Aroga* moth is its primary source of protein. It makes sense then that *Phaeogenes* is found at higher elevations because those plots have greater diversity of and higher abundance of flowers (more sugar). It also makes sense that she saw less of this wasp at lower elevations, where much of the diversity and number of flowers had been diminished and sometimes replaced by cheatgrass (a poor source of sugar) or bare ground.

A generalist wasp (*Conura*) wasn't as attracted to the sugar spray. This wasp isn't picky about what it eats, which makes it very adaptable but only a mediocre enemy to the *Aroga* moth (when there is a lot of food on the table, you may not eat the carrot sticks). The *Conura* wasp was found in greater numbers at lower elevations – areas with fewer types of flowers and lower overall numbers of flowers. It did respond with enthusiasm, though, to the chemical SOS signal Virginia simulated using wintergreen oil. This call of distress would attract a generalist species, since it indicates an attack on the sagebrush and therefore a potential meal for the opportunistic wasp, but doesn't necessarily carry information about the type of attack.



## Attack, cont.

An interesting third scenario occurred at mid-elevation plots – a mini wasp utopia – a phenomenon Virginia labels as complementarity. At mid elevations, the preferred resources of the generalist wasp and the specialist wasp overlap, and they both show up to munch on the *Aroga* moth. A third wasp, in addition, also appears in high numbers – *Copidisoma* (which, Virginia sighs, has complicated preferences when it comes to resources and a complex life history). The intriguing thing is that although you find all three species at this level, dealing with resource situations that none of them find ideal, it is here that you find the greatest number of *Aroga* moth infested with parasitic wasps, creating the best scenario for knocking down the moth population.

Management of the *Aroga* moth during outbreaks will require a whole systems perspective, said Virginia. While no one can control the weather, it can be used to describe critical periods in *Aroga*'s life cycle and

to understand how certain conditions contribute to outbreak years. The results from Virginia's research indicate potential for parasitoids working as a diverse community of species to limit severe outbreaks of *Aroga* moth in sagebrush-steppe, if they have the resources to flourish. Promotion of a diverse community of understory flowering herbs, as part of the food web centered on the moth, will encourage parasites to come for lunch.

## References

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- Bolshakova, V.L.J. 2013. *Causes and Consequences of Local Variability in Aroga Websteri Clarke Abundance Over Space and Time*. Doctoral dissertation. Utah State University Press.
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## Announcements and Events:

- Presentation now available: [Sagebrush Steppe Treatment Evaluation Project; short-term results](#) (edited). Jim McIver. sponsored by Great Basin Fire Science Delivery
- New Fact Sheet: [Reducing Carbon Emissions from Sagebrush-Steppe](#) at [www.sagestep.org](http://www.sagestep.org)
- Southwest Fire Science Consortium: [Fostering Resilience In Southwestern Ecosystems: A Problem Solving Workshop](#). Feb 25-27, 2014, Tucson, AZ.
- Great Basin Native Plant Project Annual Meeting, March 17-18, Boise Idaho
- [Large Wildland Fires: Social, Political & Ecological Effects](#), University of Montana, Missoula, May 19-23, 2014.
- Rocky Mountain Bird Observatory. Birds and Management Decision in the Sagebrush Ecosystem. One day workshop at four locations in March and April. [laura.quattrini@rmbo.org](mailto:laura.quattrini@rmbo.org)
- Webinar series: [Invasive Plants – Issues, Challenges, and Discoveries](#) by the Grassland, Shrubland and Desert Ecosystems Science program. Jan.-May. Seven webinars about invasive plant management.

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