Columbia Basin Landscapes Workshop:

Linking Science and Management to Improve Restoration Success in the Shrub Steppe

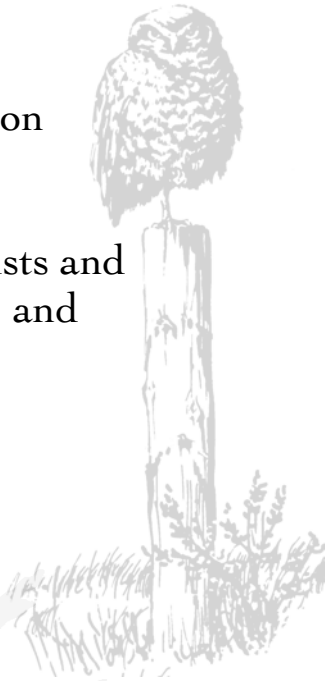
April 26 - 28, 2011

Red Lion Columbia Center, Kennewick, WA

There has not been a workshop specific to Columbia Basin Shrub-steppe, yet there is a tremendous amount of on-going research in the region.

Our intent with this workshop is twofold:

- to provide the opportunity to disseminate current information on managing/restoring Columbia Basin shrub-steppe to land managers, and
- to promote communication and collaboration among scientists and land managers from federal and state agencies, universities, and private organizations.



GRATITUDE

We would like to acknowledge the following sponsors

whose generous financial and in-kind contributions

helped make this event possible:

The United States Fish and Wildlife Service
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The South Central Washington Shrub Steppe/Rangeland Partnership

The Nature Conservancy of Washington

The Society for Ecological Restoration Northwest Chapter

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Department of Energy/Pacific Northwest National Laboratory

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Society for Ecological Restoration
Northwest Chapter

WORKSHOP AGENDA

Please note all events will be held in the Ballroom

Tuesday Afternoon, April 26

10:00AM **Registration table opens**

1:00 PM **Welcome, overview, logistics** ***Mike Gregg***
USFWS Land Management Research Demonstration Program, Region 1 Shrub Steppe, Burbank, WA

Session 1: Biocontrols

Jennifer Andreas, Moderator
WSU Extension Integrated Weed Control Program Director

1:20 PM **Insects with an attitude: biocontrol agents for noxious weeds** ***Larry Skillestad, Technician***
USDA APHIS, Plant Protection and Quarantine, Spokane, WA

1:50 PM **"Who put bugs in the break room fridge?" Integrated use of biocontrols on the Hanford Reach National Monument** ***Kevin Goldie, Wildlife Biologist***
USFWS, Mid-Columbia River National Wildlife Refuge Complex, Burbank, WA

2:20 PM **Field inoculation trials demonstrate that a seed pathogen can eliminate the cheatgrass carryover seed bank** ***Julie Beckstead***
Associate Professor of Biology, Gonzaga University, Spokane, WA

2:50 PM **Break** *Refreshments will be served*

3:20 PM **Cheat'n the cheatgrass** ***Ann Kennedy, Soil Scientist***
USDA ARS, Adjunct Professor, Washington State University, Pullman, WA

3:50 PM **Engineering and applied research challenges associated with commercialization of biopesticides** ***Christopher F. Wend, Director***
Bioscience Division, Northwest Agri Products, Pasco, WA

4:30 PM **Adjourn**

Tuesday Evening Social and Poster Session

This event made possible by The Nature Conservancy of Washington

4:40-5:30 PM **Poster Setup**

6:00-9:00 PM **Social and Poster Session**

Come meet your colleagues
and learn what's going on in the shrub-steppe
during an evening of browsing and visiting
free beverages and hors d'oeuvres
(REMEMBER your drink tickets!)

Wednesday Morning, April 27

7:00-8:15 AM Buffet Breakfast

Session II: Restoration

Janelle Downs, Moderator
Research Scientist, Pacific Northwest National Laboratory, Richland, WA

8:20 AM Application of holistic decision-making frameworks to invasive plant management: Approaches, limitations and potential ***Jeremy James, Research Scientist***
USDA Agricultural Research Service, Burns, OR

9:00 AM Crested wheatgrass-conversion and diversification with native species and source-identified local genetics ***Jerry Benson, Restoration Ecologist***
BFI Native Seeds, Moses Lake, WA

9:30 AM Interseeding native forbs and shrubs into established grass stands: Implications for CRP diversification ***Mel Asher, Plant Ecologist***
BFI Native Seeds, Moses Lake, WA

10:00 AM **Break** *Refreshments will be served*

10:30 AM Planting seedlings to regenerate critical shrub components in shrub-steppe; a viable tool for land managers ***Heidi Newsome, Wildlife Biologist***
USFWS, Mid-Columbia National Wildlife Refuge Complex, Burbank, WA

11:00 AM Management of fuel loading in the shrub-steppe: Responses six and seven years after treatments ***Steven O. Link, presenter***
Native Plant Landscaping and Restoration, LLC, West Richland, WA

11:30 AM Rangeland restoration on Wanaket Wildlife Area ***Tanya Harrison, Ass't Wildlife Biologist***
Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Pendleton, OR

12:00 AM Capitalizing on what shrub-steppe restoration pioneers have learned A shrub-steppe Restoration Manual ***Richard Tveten, Restoration Ecologist***
Washington Department of Fish and Wildlife, Olympia, WA

12:30-1:30 PM **Lunch** *Buffet Style in the Ballroom*

Wednesday Afternoon, April 27

Session III: Short and Long Term Fire Effects

Sonia Hall, Moderator
Arid Lands Ecologist, The Nature Conservancy

1:30 PM **Invertebrate response to sagebrush steppe restoration treatments: unintended consequences?**
James McIver, Senior Research Associate Professor
Eastern Oregon Agricultural Research Center, Oregon State University, Union, OR

2:10 PM **Fuel treatments, livestock grazing, and invasibility Some preliminary results from SageSTEP**
David A. Pyke
USGS Forest and Rangeland Ecosystem Science Center, Corvallis, OR

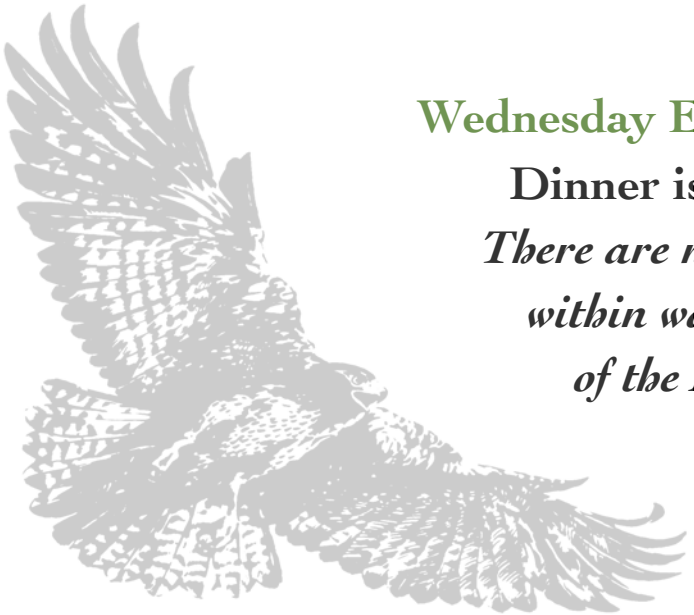
2:40 PM **Monitoring of post-fire rehabilitation treatments in sagebrush steppe: Challenges and future directions**
Troy A. Wirth, Presenter
USGS Forest and Rangeland Ecosystem Science Center, Corvallis, OR.

3:10 PM **Break** *Refreshments will be served*

3:40 PM **Long-Term effects of multiple wildfires and management on the Arid Lands Ecology Reserve**
Jon Bakker
Assistant Professor of Restoration Ecology and Management, University of Washington, Seattle, WA

4:10 PM **Low elevation shrub steppe post fire rehabilitation on the Hanford Reach National Monument, northern units: Where, when and weather**
Richard Easterly and Debra Salstrom
SEE Botanical Consulting, Bellingham, WA

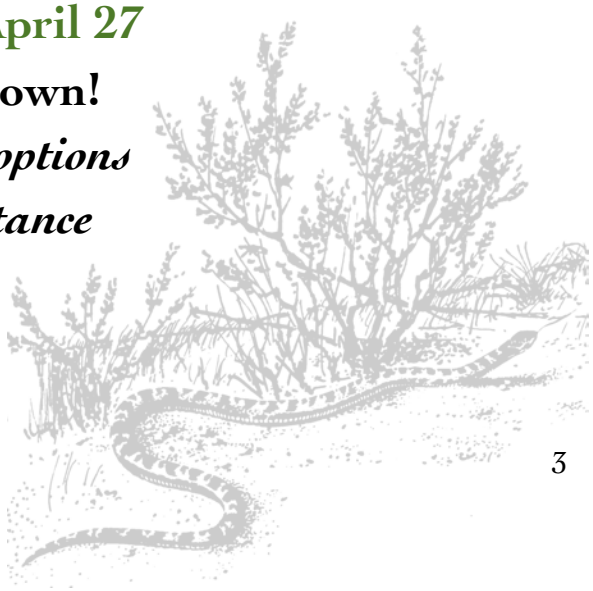
4:40 PM **Closing Remarks and Field Trip Logistics**



Wednesday Evening, April 27

Dinner is on your own!

There are numerous options within walking distance of the Red Lion.



Thursday April 28

Field Tours (limited to first 80 registrants)

6:30-7:30 AM **Breakfast and checkout**

Breakfast for field tour participants only

Please check out prior to departing on the tour

There will be a place to store your bags during the tour

7:45 AM **Buses depart** from the Red Lion Hotel

Participants **must choose** one of the two tours described below:

Field Tour Route #1 – Shrub-Steppe Restoration

This field trip will focus on shrub-steppe restoration on Hanford Reach National Monument/Saddle Mountain National Wildlife Refuge. Stops during the morning will highlight restoration work on the Arid Lands Ecological Reserve and the Weather Station fire on Saddle Mountain. Heidi Newsome and Richard Easterly will lead the discussions. There will also be an opportunity to discuss research on Black Fingers of Death, a new potential biological agent for cheatgrass, with Julie Beckstead. We will venture to the top of Saddle Mountain for lunch and then after lunch, the tour will follow the Columbia River along the eastside of the Monument to the Ringold fish hatchery. ***Lunch and beverages will be provided.***

Field Tour Route #2 – SageSTEP

This field trip includes a stop at the SageSTEP Joint Fire Science research plots on Saddle Mountain National Wildlife Refuge. Dave Pyke and James McIver will follow up their workshop presentations with continued discussion of the SageSTEP project. In addition, Ann Kennedy will discuss a potential cheatgrass biocontrol agent, which was a recent addition to the SageSTEP research program. We will venture to the top of Saddle Mountain for lunch and then after lunch, the tour will follow the Columbia River along the eastside of the Monument to the Ringold fish hatchery. ***Lunch and beverages will be provided.***

5:00 PM **Buses return** at approximately 5pm. *This is a target time; exact return time cannot be predicted. Please be flexible.*

Presentation Abstracts

Session I: Biocontrols

Insects with an attitude: biocontrols agents for noxious weeds

Larry Skillestad, Technician
USDA APHIS PPQ, 222 N Havana Street, Spokane, WA 99202

Undesirable, invasive noxious weeds have become a scourge of both public and private lands and waterways in our country. The economic impact of these invaders is astronomical, considering the loss of forage and habitat which sustain wildlife and domestic species along with the time, equipment, and chemical herbicides used to combat these weeds. Various methods are used to suppress these nonnative weeds from chemical herbicides, to burning, to cultivation. Classical biological control in which selected host-specific, plant attacking insects, mites, nematodes, and pathogens are introduced from the invasive plants' native lands provide an additional tool for land managers. The presentation provides an introduction to the concepts of biological control of invasive, nonnative noxious weeds. It will describe techniques to determine if any of these agents are currently present at a site. The presentation will also provide participants with available options to access sources of biological control agents.

"Who put bugs in the breakroom fridge?" Integrated use of biocontrols on the Hanford Reach National Monument

Kevin Goldie, Wildlife Biologist - US Fish & Wildlife Service, Mid-Columbia River National Wildlife Refuge Complex, 64 Maple St, Burbank, WA 99323

The Hanford Reach National Monument (Monument) was established in June 2000 in part to protect one of the last large contiguous blocks of shrub-steppe remaining in the Columbia Basin. Invasive plants are one of the biggest threats to the Monument, causing general habitat degradation, decreased diversity, and greatly decreased fire return intervals. An Integrated Weed Management Plan (IMP) was completed in 2003 as a guiding document to address this threat. The IMP emphasizes the importance of full integration of treatments, not only within individual infestations but also between local infestations across the landscape. To actually make this plan functional in application, under real-world constraints, the use of biological control agents (biocontrols) is essential. Numerous recent catastrophic wildfires have only served to emphasize this integration requirement. On the Monument biocontrols have been deployed both in conjunction and in sequence with more traditional response treatments, including chemical, mechanical, and cultural controls. To date the US Fish & Wildlife Service has released 21 separate biocontrols on the Monument for 7 different invasive plant species. As with most things in invasive plant control they have had varying degrees of success so far; most have not yet had time to fully establish.

Field Inoculation Trials demonstrate that a seed pathogen can eliminate the cheatgrass carryover seed bank

Julie Beckstead - Gonzaga University, Susan Meyer - USDA Forest Service, Phil Allen – Brigham Young University

A major obstacle to seeding success with native species as part of post-burn rehabilitation in arid shrubland ecosystems is competition from exotic annual brome grasses such as cheatgrass (Bromus tectorum). One problem with current control methods of Bromus is that they do little or nothing to eliminate ungerminated Bromus seeds that carry over in the seed bank. In this study, we investigated the potential for the naturally occurring seed pathogen Pyrenophora semeniperda (Ascomycota; imperfect state Drechslera campanulata) as a biocontrol tool to eliminate the Bromus residual seed bank. In field experiments, we determined the effectiveness of this pathogen as a biocontrol organism, alone and in combination with other control measures. We also evaluated risks to non-target organisms, including seeded species. Our results showed that application of laboratory-produced bulk inoculum of P. semeniperda reduced the proportion of viable seeds and increased the proportion of killed seeds in the potential carryover seed bank. At the highest loads, kill proportion averaged 89%, which represented a mean increase of 35% over background disease levels, which averaged 54%. The kill proportion reached 100% in some treatment combinations. When uninoculated native grass seeds were planted into field-collected seed-zone samples from field inoculation experiments, native species were able to emerge to high percentages in samples from inoculated as well as control plots (86-97% emergence in inoculated samples, 96-98% in control samples). Inoculum augmentation increased mean infection and mortality, but this effect was small (2.4 - 2.6%). This study indicates that using the naturally occurring seed pathogen P. semeniperda as a biological control holds considerable promise in the arsenal of tools that land managers need in order to combat annual bromes.

Cheat'n the Cheatgrass

Ann C. Kennedy, Tami L. Stubbs, Jeremy C. Hansen, and Renee Schultheis
USDA-ARS and Washington State University, Pullman WA

Bacteria can exert a subtle, yet profound, effect on plant growth. We isolated various bacteria from the roots of grasses in the Palouse area of eastern Washington state. Select bacteria inhibit seed germination as well as root growth; is competitive in soil; and produces metabolites that inhibit target-plant growth. These bacteria are predominantly saprophytic organisms that live on or in plant roots, surviving on organic compounds released by plant root cells. We have found a number of bacteria that specifically inhibit various grass weeds, but do not suppress growth of native plant species. These naturally-occurring soil bacteria inhibit plant growth by the production of plant-suppressive compounds. These bacteria are excellent biological control agents because they are aggressive colonizers of the roots and residue, but they do not exist in high numbers in the soil.

In the arid and semi-arid regions of the western United States, perhaps the single most important invasive species is the Eurasian winter-annual grass Bromus tectorum L, known as downy brome on croplands and cheatgrass on rangelands. We showed that naturally occurring bacteria screened for selective cheatgrass suppression inhibited cheatgrass while not reducing desirable plant

growth. In rangeland field studies, these bacteria suppressed cheatgrass and allowed for increased growth of other rangeland plant species, setting the stage for effective restoration. The bacteria can function as a direct delivery system for the natural plant-suppressive compounds they produce. Application of these bacteria during seed bed preparation or after fire followed by suppression of cheatgrass root growth may allow other plant species to out-compete weeds, thus leading to the establishment of more desirable range species.

Engineering and Applied Research Challenges Associated with Commercialization of Biopesticides

Christopher F. Wend, Director, Bioscience Division, Northwest Agri Products, Pasco, WA

Many years of fundamental research are often necessary to identify a possible candidate for biocontrol. This is just the first step on a long trip toward a commercial product. The ideal biocontrol candidate coming out of a fundamental research program would have some intellectual property associated with it, have a clear mode of action, be very specific in its target, perform well compared to conventional tools, and attenuate in the environment once it has completed its mission. This is not a complete list and the absence of some items does not necessarily stop the initial investigation of the idea. Early evaluation includes market need, comparison and compatibility with conventional practices, and cost modeling to estimate whether a process can be scaled. Once a decision is made to investigate an organism for possible technology deployment, it must be brought into the lab and investigated for compatibility with engineered processes. Challenges from growth medium optimization and bioprocess conditions to final formulations are all part of the applied research necessary to scale up a bioprocess to commercial levels. This process is guided by experimental design methods such as response surface methodology and parameter estimation for process models. If it looks like a technology is possible, then a business decision is made to move into a registration phase. This decision also includes cost for toxicology and tools and trials to examine environmental fate and transport. If all goes well, registration is successful along with the appropriate field trials and a product can be launched. Examples with cheat grass suppression technology development may be discussed along with other biotechnologies.

Session II: Restoration

Application of holistic decision-making frameworks to invasive plant management: Approaches, limitations and potential

Jeremy James, Research Scientist, USDA Agricultural Research Service, Burns, OR

Invasive plants pose a multi-dimensional, catastrophic threat to aridland systems in the West. Harsh and fluctuating environmental conditions make invasions difficult to predict and manage and inhibit reestablishment of native species in degraded areas. Even as traditional invasive plant management strategies are aggressively employed, researchers and managers have yet to curtail the most serious invasions. A number of holistic decision-making frameworks have been proposed for guiding restoration programs. While the potential utility of these tools is high, successful application of these approaches have been limited. This presentation discusses the general concepts and development of holistic decision-making frameworks, outlines several key limitations that inhibit the full potential of these decision tools and then discusses several lines of work where managers and researchers could jointly to improve applications of these tools.

Crested wheatgrass-conversion and diversification with native species and source-identified local genetics

Jerry Benson, Restoration Ecologist, BFI Native Seeds, Moses Lake, WA

Crested Wheatgrass – a non-native Euro/Asian species, has extensively been planted for soil stabilization and livestock forage on millions of acres of degraded rangelands and CRP acres of the Western US and Canada. Much work has been done over the last 50 years by USDA - ARS to breed super strains of Crested Wheatgrass which functionally create monocultures of the species allowing for very limited diversity of the plant community. The species is hardy and establishes readily though it has limited wildlife habitat value. During the last 20 plus years, significant interest has developed around the subject of diversification of Crested Wheatgrass stands with local genetics of native species. This process is intended to improve wildlife habitat values and create long term, self-sustaining plant communities which provide diverse soil and wildlife values. At BFI, we have endeavored extensively to develop strategies and processes that facilitate the site conversion of the established Crested Wheatgrass in a manageable time frame and using local native species. We utilize an array of tools to achieve this end, including agronomic production of native seed to be used on the sites. Also, we utilize mowing, spraying, harrowing, sweep chiseling and drill seeding. All of these processes are very time sensitive while functioning together to facilitate the project's success.

Interseeding Native Forbs and Shrubs into Established Grass Stands: Implications for CRP diversification

Mel Asher, Plant Ecologist, BFI Native Seeds, Moses Lake, WA

Two small-scale field trials were initiated in 2008 and 2009 to test the effectiveness of interseeding a diverse mix of native forbs and shrubs into established grasslands planted with typical CRP grass mixes. The first trial compared the effectiveness of three interseeding techniques in one and three year-old grass stands. Interseeding techniques included 1) broadcasting, 2) broadcasting followed by culti-packing, 3) broadcasting followed by harrowing, and 4) drill seeding. In the one year-old grass stand, high variability led to only one significant conclusion: drill seeding was more effective in seeding large seeded species ($p < 0.5$). There was no significant difference ($p > 0.5$) amongst seeding methods in seedling emergence for any individual species, small-seeded species, or total species. In the three year-old grass stand, there was no difference in seeding methods ($p > 0.5$) on individual species, small or large-seeded species, or all species combined. Seedling emergence was five times greater in the one year-old grass stand, as compared to the three year-old grass stand. Few seedlings survived past the first growing season in the three year-old grass stand.

The second trial tested the efficacy of grass-selective herbicides in reducing competition from established perennial grasses and cheatgrass when interseeding native forbs and shrubs into a typical CRP grass stand. Two rates were tested in an approximately 5 year-old grass stand. The seed mix was drill seeded in winter of 2010, and herbicides were applied in spring 2010. Both rates of herbicide arrested bunchgrass growth for the rest of the growing season, and controlled cheatgrass, which resulted in nearly 3 times the number of forb seedlings in the treated plots, as compared to control plots ($p < 0.5$). The second year data, to be collected in spring 2011, will be critical in determining establishment success.

Planting seedlings to regenerate critical shrub components in shrub-steppe; a viable tool for land managers

Heidi Newsome, Wildlife Biologist, USFWS, Mid-Columbia National Wildlife Refuge Complex, Burbank, WA

The Hanford Reach National Monument was established in June 2000, in part to preserve one of the last large expanses of shrub-steppe desert once common in the Columbia River Basin. However, preservation of the area has not eliminated the threats to this ecosystem. Repeated wildfires and the pervasive presence of non-native plants have combined to impact the quality and functionality of the land as wildlife habitat. Efforts to assess the impacts from wildfires and to stabilize and rehabilitate burned areas have been conducted. Treatments to revegetate portions of the burned areas have included aerially seeding sagebrush and planting bareroot and container-grown (tubling) native shrub seedlings. Seeded sagebrush was evaluated for emergence and establishment. Planted shrubs were evaluated for survival based on stock type and treatment. Planting success was also reviewed in relation to treatment and environmental variables. Statistically no sagebrush was established from aerial seeding, but was established from ground broadcast seeding. Planted bareroot sagebrush without added mycorrhizae generally had the greatest survival, followed by tublings. Bareroot sagebrush with added mycorrhizae generally had the lowest survival. Amount and timing of seasonal precipitation also impacted sagebrush survival. Planting tube-grown or bare-root seedlings appears to be a viable method for restoring critical shrub components to shrub-steppe habitats.

Management of fuel loading in the shrub-steppe: Responses six and seven years after treatments

Steven O. Link, Native Plant Landscaping and Restoration, LLC, West Richland, WA 4604 E. Robin Ct., West Richland, WA 99353 and Randy Hill, USFWS, PO Drawer F, Othello, WA 99344

Our objective was to determine if our strategy to reduce *Bromus tectorum* cover and thus fire risk is sustainable after implementation. Our primary task was to test the hypothesis that the bunchgrass, *Elymus wawawaiensis*, established in 2003 will show an increasing degree of *B. tectorum* control over three years. Here we discuss results for the first two years. Six years after plots that were burned, treated with Plateau herbicide at a rate of 4 or 8 oz/acre, and then drill-seed with *E. wawawaiensis* had significantly ($p = 0.0016$) less *B. tectorum* cover (14.4 ± 4.17%) than plots that were only burned (37.9 ± 3.65 %). In 2009, the effect remained with significantly ($p = 0.0003$) less *B. tectorum* cover (19.1 ± 3.95%) in treated plots than in plots that were only burned (47.0 ± 3.42%). We tested the hypothesis that native species cover and richness and cover of aliens in Plateau only plots will not be different from controls 6 and 7 years after treatment application. Cover of native species in Plateau only plots was not significantly different from that in control plots in 2008 ($p = 0.155$) or 2009 ($p = 0.167$). Cover of alien species in Plateau only plots was not significantly different from that in control plots in 2008 ($p = 0.061$) or 2009 (0.074). Native species richness in Plateau only plots was not significantly different from that in control plots in 2008 ($p = 0.142$) or 2009 ($p = 0.106$). The number of *E. wawawaiensis* plants in twelve monitored plots increased from 694 in 2004 to 946 in 2008 and 1022 in 2009. We found a strong reduction in *B. tectorum* cover with increasing density of *E. wawawaiensis*.

Rangeland Restoration on Wanaket Wildlife Area

Jenny Barnett, Wildlife Biologist, USFWS, Cheney, WA and Tanya Harrison, Assistant Wildlife Biologist, Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Pendleton, OR

Three different rangeland restoration methods are being attempted at Wanaket Wildlife Area, located along the south shore of the Columbia River in Umatilla County, Oregon. Wanaket is managed by the Confederated Tribes of the Umatilla Indian Reservation. Operations and maintenance of Wanaket is funded by Bonneville Power Administration, through the regional fish and wildlife mitigation program. Much of the wildlife area consists of shrub-steppe/grasslands dominated by cheatgrass and weedy forbs. The OWEB and WUWU projects were blanket sprayed in spring and seeded with native species in winter 2009/10 and winter 2010/11, respectively. The WUWU project was sprayed for 3 consecutive years, while the OWEB project was sprayed only once. The Interplug project is located in an area of cheatgrass dominated swales intermixed with Sandberg's bluegrass-dominated patches surrounding rocky outcrops. Broadcast spraying of the area would negatively impact the few remaining native plant communities. Instead 1,800 native grass and forb plugs were planted in circles previously sprayed with glyphosate to reduce cheatgrass competition. Monitoring plots were established on all project sites in 2009 to track changes in plant community composition over time. Monitoring transects were also established to estimate survival of plugs in the Interplug project. Currently, percent of exotic grasses and forbs have been reduced on the OWEB and WUWU sites. One year plug survival results on the Interplug project is successful enough to warrant an expansion of the project, and an Interplug II project will commence in spring 2011.

Capitalizing on what shrub steppe restoration pioneers have learned - A Shrub Steppe Restoration Manual

Richard Tveten, Restoration Ecologist, Washington Department of Fish and Wildlife, Olympia, WA

In collaboration with the Bonneville Power Administration and the Bureau of Land Management, WDFW is creating a shrub steppe restoration manual. The need for such a manual was identified by the people who pioneered shrub steppe restoration techniques and are concerned that their hard-earned knowledge could be lost as they retire. The purpose of the manual is to capture their collective

knowledge and provide helpful tools for determining a site's potential, executing restoration projects, controlling weeds, documenting results and sharing information.

Session III: Short and Long-term Fire Effects

Butterfly response to sagebrush steppe restoration treatments: unintended consequences?

James McIver , Senior Research Associate Professor, Eastern Oregon Agricultural Research Center, Oregon State University, Union, OR and Euell Mack

The Sagebrush Steppe Treatment Evaluation Project (SageSTEP) is a multi-site, multi-disciplinary experiment designed to evaluate ecological response to restoration treatments commonly applied in sagebrush steppe lands that have been encroached by woodlands or invaded by cheatgrass. SageSTEP evaluates a wide variety of ecological variables within several ecosystem components, including vegetation, soils, and both vertebrate and invertebrate fauna. This presentation characterizes sagebrush steppe butterfly communities and evaluates their response to restoration treatments at eighteen sagebrush steppe sites across the Great Basin and surrounding areas. Each of the 18 sites has a control plot, as well as plots that have been prescribe-burned, or treated by cutting, mowing, or herbicides. All active treatments are designed to create conditions that favor colonization or growth of native perennial bunchgrasses. Treatments were implemented at all sites between 2006 and 2009. Following treatment, 314 butterfly surveys were conducted each year between May and July within each plot using a line-transect method. A total of 3,898 individual butterflies were observed, comprising 48 species. Woodland plots generally had about 50% greater species richness than sagebrush steppe plots. At most sites, butterfly response to treatment was subtle, with species composition shifting as expected, toward species preferring more open habitat. Not surprisingly, species with larvae that feed on trees declined significantly after tree removal at those sites where they were common. Additionally, there was a trend toward declining species richness and abundance at some plots treated with tebuthiron, suggesting that some restoration treatments may have unintended consequences. Continued monitoring for at least 10 years after treatment will be necessary to fully evaluate long-term response of butterfly communities to sagebrush steppe restoration treatments.

Fuel Treatments, Livestock Grazing, and Invasibility - Some Preliminary Results from SageSTEP

Authors: David A.Pyke[1], Michael D. Reisner[2], Paul S. Doescher[2], Eugene W. Schupp[3], Jeanne Chambers[4], James Grace[5], Scott Shaff[1], Jeff Burnham[3], and Andrew Lindgren

1 U.S. Geological Survey, Forest & Rangeland Ecosystem Science Center, Corvallis OR
2 Oregon State University, Department of Forest Ecosystems and Society, Corvallis OR
3 Utah State University, Wildland Resources Department, Logan UT
4 USDA Forest Service, Rocky Mountain Research Station, Reno NV
5 U.S. Geological Survey, National Wetlands Science Center, Lafayette LA

Fire is a natural driver of succession within sagebrush steppe ecosystems pushing a mixed shrub and grass plant community to a grass-dominated system with spatially separated bunchgrasses. Over time, sagebrush tends to increase and become more prominent again until the next fire. The invasion of cheatgrass into these ecosystems has led to a potential loss of resilience of these vegetation communities with succession becoming disrupted and the ecosystem becoming prone to the dominance of cheatgrass, to a loss of shrubs, and to the formation of an alternative stable succession that revolves around frequent fires and continuous fuel provided by the dry litter of cheatgrass. In the SageSTEP project, we are attempting to understand the resilience of sagebrush steppe ecosystems in light of the invasion and presence of cheatgrass. We have preliminary evidence that as heat stress, water stress and livestock grazing increase, perennial grasses may shift from being spatially separated from shrubs (competitive relationship) to becoming more associated with shrubs (facilitative relationship) and may create larger openings among perennial plants. These openings create invasion sites and sites of cheatgrass dominance. Fires, whether prescribed or wild, lead to some mortality of perennial grasses and that this mortality would likely be greater for grasses located near or under shrubs than for those located away from shrubs. Since sagebrush is killed by fire and some perennial grasses will likely die as well, gaps among the remaining perennial plants increase and lead to the potential for cheatgrass to become more prominent. Our initial results indicate that simple measures of gap distance among perennial plants may provide an excellent early warning tool for the resilience of the native plant communities and may aid in understanding those locations where cheatgrass might be expected to increase after fires.

Monitoring of post-fire rehabilitation treatments in sagebrush steppe: Challenges and future directions

Troy A. Wirth and David A. Pyke, USGS Forest and Rangeland Ecosystem Science Center, Corvallis, OR
3200 SW Jefferson Way Corvallis, OR 97331

In 2008, the US Fish and Wildlife Service implemented a series of seeding treatments to mitigate potential negative consequences of the Milepost 17 and Wautoma fires on the Fitzner-Eberhardt Arid Land Ecology Reserve (ALE). The majority of the area was treated with aerial or drill seedings combined with the herbicides Plateau® and Journey®, and six different seed mixes. Weather in the area was very dry in the spring of 2009, and wet in the spring of 2010 relative to the 30-year average. Preliminary results indicate that in 2009, very little germination of any seedlings were found at any of the aerial seeding treatments. In contrast, a small but significant level of emerging seedlings were found at the drill seeding treatments compared to no-drill plots in 2009 (0.87 grass seedlings/m^2).

In 2010, a much wetter year, there were many emerging grass and forb seedlings across both the aerial and drill seeding areas. In the aerial seeding treatments, preliminary analyses indicate that the density of emerging seedlings was not statistically different than the non-seeded treatments (3.05 and 5.08 plants/m^2 in the seeded and non-seeded treatments, respectively). In the drill seedings, there were generally significantly higher densities of seeded grasses in the drilled compared to the non-drilled plots (4.20 and 0.13 plants/m^2 in the drilled and non-drilled plots, respectively). Residual effects of herbicide applied in early 2008 appeared to be differentially affecting the change in cheatgrass from 2009 to 2010. Preliminary results suggest that within aerial seeding treatments, there was a greater reduction in cheatgrass densities from 2009 to 2010 when either Plateau® or Journey® herbicide was applied relative to unsprayed areas. Within drill seedings, declines in cheatgrass were greatest with Plateau® at 4 oz/acre application rate, but were not statistically different.

Post-fire rehabilitation projects require a great deal of effort to monitor effectiveness and current funding procedures only allow monitoring during the initial stage of recovery for a plant community following fire. In order to address the issue of long-term recovery, we are currently pursuing two projects that will attempt to synthesize results of post-fire treatments applied throughout the west. By assessing a large number of treatments, we may be able to formulate general rules that land managers can follow based on the general conditions of the burned areas such as elevation, average precipitation, soil type, and condition of pre-fire vegetation.

Long-Term Effects of Multiple Wildfires and Management on the Arid Lands Ecology Reserve

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The Arid Lands Ecology Reserve (ALE) was established to protect one of the largest extant sagebrush steppe ecosystems in the Pacific Northwest. Unfortunately, it has been stressed by several factors in recent decades, including the occurrence of more and larger fires and invasion by *Bromus tectorum* (cheatgrass) and other alien plant species. Management responses to these factors include herbicide application, seeding of native species, and out-planting of Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) seedlings. Several series of permanent vegetation plots have been established in and around ALE on sites spanning a range of abiotic conditions. Remeasurements of these plots numerous times over the last 20 years provide insights into the consequences of these stresses and activities; several of these insights are summarized here. First, low-elevation plant communities changed significantly following repeated fires, whereas high-elevation communities were more resilient. The functional traits of dominant species, particularly their ability to re-establish after fire, are critical for understanding these different responses. Changes in community composition can be conceptualized in a state-and-transition model and visualized through multivariate control charts. Second, species accumulation curves differ over time and space. Analyses of plant diversity can be sensitive to the scale of analysis. Third, biotic soil crusts (mosses and lichens) are affected by fire history, abiotic conditions, and biotic conditions. The vegetation is a poor predictor of soil crust composition. Permanent plots can provide insight into long-term responses to planned activities (e.g., management actions) and unplanned events (e.g., wildfires). When properly designed, measured, and analyzed, permanent plots can provide invaluable linkages between science and management.

Low Elevation Shrub-Steppe Post Fire Rehabilitation on the Hanford Reach National Monument, Northern Units: Where, When and Weather

Richard Easterly and Debra Salstrom, SEE Botanical Consulting, Bellingham, WA

We'll assess variability in the initial success of vegetation rehabilitation efforts (drill- and aerial seeding and herbicide application) after three wildfires in the northern part of the Hanford Reach National Monument, Pasco Basin, WA. All three fires (Weather Station and McLane in 2005, and Overlook in 2007) occurred on Ringold substrate (Pliocene) overlain by Pleistocene cataclysmic flood deposits that have more recently been sorted by wind. Substrates are sand-dominated, and include stabilized dunes and dune-trains. We will discuss differences in treatment success in relation to site resiliency, prefire vegetation, and treatment precipitation patterns.

Some drill seeding on Weather Station and, to a lesser extent McLane, was effective in getting bunchgrasses established. Seeding treatments at Overlook have not yet been proved effective, although results are still unfolding there. All of the area burned in the Weather Station and McLane fires was treated with Roundup, so we were unable to assess its effect. On the area burned in the Overlook fire, areas were treated with the herbicides Journey, Plateau and Roundup, and some sites left untreated. Along with suppressing cheatgrass after the first year, Journey (and to a lesser extent Plateau) treatments apparently caused mortality of non-target species, particularly Sandberg bluegrass and spring ephemeral species. After three growing seasons, the density of Russian thistle (which dominated some areas) and other summer annuals was higher on sites treated with Journey (and to a lesser extent Plateau) than on sites that were treated with Roundup or untreated with herbicides. No differences were detected between the Roundup and untreated sites after three growing seasons.

Presenters

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Ann Kennedy is a Soil Scientist with the USDA-ARS Land Management and Water Conservation Research Unit in Pullman WA and an Adjunct Professor at Washington State University. She works in the area of in soil microbiology and soil microbial ecology. Her research includes soil microbial community dynamics in native and cropping systems, residue management, biological weed control, rhizosphere ecology and soil quality. Dr. Kennedy received her PhD in Soil Science from North Carolina State University and her MS in Agronomy from the University of Missouri. Dr. Kennedy is a Fellow in the Soil Science Society of America and the American Society of Agronomy. Dr. Kennedy investigates the role of soil microorganisms in sustainable agriculture. Her research includes soil microbial community dynamics in native and cropping systems, residue management, biological weed control, rhizosphere ecology and soil quality. She uses naturally occurring weed-suppressive bacteria to control grass weeds.

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Dr. Wend is the Director of the Bioscience Division at Northwest Agri Products in Pasco, WA and is responsible for the commercialization of biotechnology for use in agriculture and land management. He is a registered Professional Engineer (Montana) and has a background that includes chemical, environmental and bioprocess engineering, biofilms, and microbiology. Dr. Wend is also an Adjunct Professor in the Department of Civil and Environmental Engineering at Washington State University Tri-Cities where he teaches graduate level environmental engineering courses and serves on graduate committees.

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Dave Pyke obtained all his college degrees from Washington State University. He received a BS in Range Management with a Wildlife habitat option in 1976, an MS in Forest and Range Management in 1977, and a Ph.D. in Botany 1984. In 1977, he began research on the population biology of cheatgrass and native plants within the Intermountain West and has continued to focus on these species and their ecosystems. He became a faculty member in the Range Science Department at Utah State University where he studied native and invasive grasses of the Great Basin and taught courses on vegetation analysis and population biology. In 1992, he began his federal research career with the Bureau of Land Management in Corvallis Oregon. Although the agency has changed from the BLM to the USGS, he has remained in Corvallis refining his research on rangeland assessments, fire ecology, native plant restoration and invasive plant management in semi-arid ecosystems of the Intermountain West. He has published over 75 basic and applied science papers relating to these topics. Currently, he is an editor for the journals Restoration Ecology and Oecologia. He is also the Project Leader for the USGS Coordinated Intermountain Restoration Project.

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Heidi Newsome has been a Wildlife Biologist for the National Wildlife Refuge System for the past 14 years. She is currently a Wildlife Biologist with the U.S. Fish and Wildlife Service at the Mid-Columbia River National Wildlife Refuge Complex. Heidi has a Bachelor's degree in psychology/biology from Santa Clara University (1990) and a Master's Degree in Wildlife Science from Oregon State University (1997). She has worked in the Mid-Columbia Region since 1999. Her focus over the past several years has been shrub-steppe ecology and management, with emphasis on post-wildfire re-habilitation. Her duties at the Refuge Complex include native habitat restoration, invasive plant management, and wildlife surveys.

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Major research emphasis is inter-disciplinary effects assessment of management practices in forest and rangeland ecosystems, including prescribed burning, mechanical treatments, and livestock grazing. Specifically, I have taken technical and administrative leads in several projects designed as management experiments, in which realistic treatments are applied at operational scales, and in which variables important to managers are measured over meaningful lengths of time. These projects have all been designed to offer managers integrated information, the kind of information that can be used to assess tradeoffs in the choice of alternative management practices. Trained as an entomologist, I evaluate effects of these land management practices on invertebrates, including ants, spiders, butterflies, and pollinators. I am involved in studies on ant foraging ecology, ant social organization, and the ecology of insects with defensive adaptations.

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Jeremy James is a Research Scientist with the USDA-ARS in Burns, OR. He completed his PhD in 2004 at the University of California, Davis and joined ARS in 2005. His research focuses on examining plant and soil mechanisms that influence restoration outcomes in aridland systems. Current projects included examining seedling demography following post fire restoration, examining how soil abiotic and biotic processes influence seedling establishment, determining how functional traits of restoration species can be used to predict field performance.

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Jon is an Assistant Professor in the School of Forest Resources at the University of Washington. He works closely with land managers to improve the restoration and management of terrestrial ecosystems, particularly prairies, shrublands, and forests. He earned his Ph.D. from Northern Arizona University (2005), M.Sc. from the University of Regina (1996), and B.A. from Dordt College (1994).

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Jerry was born in northwest Washington on a small dairy farm and was putting up his own hay crop by the time he was 13. He graduated from Central Washington University in1970 with a degree in botany, and graduate work in plant physiology. Through the years, he has developed two careers, one being crop farming, which includes vegetables, seed crops, forage and grain. The second career has been as a habitat analyst and restoration ecologist with the Washington Department of Fish and Wildlife from 1971 to 2001. Jerry now acts as an Agricultural Management Consultant helping state, federal and native tribes, wildlife land managers in prescribing agricultural practices and restoration procedures for management of wildlife lands. Jerry's native seeds production and restoration business provides clients with source-identified native grass and forb seed for use in restoring native vegetation. This is combined with providing on-site installation of restoration practices.

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Julie Beckstead is an Associate Professor of Biology at Gonzaga University in Spokane Washington where she teaches community ecology and conservation biology. She received her Ph.D. in Plant Biology from the University of Illinois at Urbana-Champaign. Professor Beckstead's current research focuses on the natural enemies of cheatgrass, Bromus tectorum, specifically a seed pathogen that kills cheatgrass seeds.

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Kevin Goldie is a wildlife biologist with the US Fish & Wildlife Service, Mid-Columbia River National Wildlife Refuge Complex, where he's worked for the last seven years. Before that he spent five years as a seasonal-temporary ricochet, working from the rainforests on the Olympic Peninsula, to the sequoias of the Sierras, to the farm and riverlands of Missouri, to the basalt plateaus of the Great Basin. Kevin earned duel Bachelor's degrees from Washington State University (Pullman) in 2000: one in Wildlife Management, the other in Wildlife Resource Science. His focus and duties for the last five years have been split predominantly between burned area rehabilitation, invasive species control, and survey and monitor work.

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Larry has worked for USDA as a Plant Protection and QuarantineTechnician since the summer of 1976. He has worked extensively with biological control agents of weeds in Washington since USDA became actively involved in this program in the 1980s. The successful development and establishment of many insectary sites in the state has provided USDA the opportunity to share these agents with cooperators throughout many western states and as far away as Minnesota and New York.

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Mel Asher is a plant ecologist with BFI Native Seeds in Moses Lake, Washington. Mel moved to the Pacific Northwest in 2003, after completing her BS is Environmental Biology at Michigan State University, and her MS is Range and Wildlife Management at Texas A & M University-Kingsville. She worked as a botanist and ecologist with the BLM and WDFW before joining BFI in 2010. Mel's current work focuses on revegetation and restoration of native habitats following contruction of roads, powerlines, and wind towers.

Richard Easterly and Debra Salstrom seebotanical@comcast.net
Richard Easterly and Debra Salstrom (SEE Botanical Consulting) are an ecologist/botanist team whose primary focus has been Central Washington. Since 1995 they have created land-based vegetation maps of more than 900,000 acres of shrub steppe, as well as having conducted extensive rare plant inventories. They strive to incorporate knowledge from multiple disciplines with the goal of understanding landscape dynamics at both fine and coarse scales. They have interpreted vegetation patterns by correlating them with geomorphology, disturbance history, and wildlife ecology, among other factors. They continue analyzing landscape changes within their area by monitoring post-fire rehabilitation efforts on the northern units of the HRNM and updating and interpreting YTC vegetation maps following large wildfires. Among other projects, they have produced historical and current ecological studies in the South Puget Sound prairies.

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Richard Tveten has worked as an ecologist for 16 years. He has B.S. in Terrestrial Ecology and M.S. in Fire Ecology from Western Washington University. He started his professional career as a botanist on Fort Lewis where he also studied the effectiveness of fire as a prairie conservation and restoration tool. He has also worked as a wetlands biologist, fish toxicologist, erosion control and storm water specialist, and native plant seed collector. He currently works for the Washington State Department of Fish and Wildlife as a Restoration Ecologist working on logging road abandonment, shrub steppe restoration, estuary restoration, HCP development and other issues related to the management and improvement of WDFW lands.

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Dr. Steven Link obtained a PhD in Botany from Arizona State University in 1983. He has worked at the Pacific Northwest National Laboratory, Washington State University, and now is the Restoration Ecologist/Botanist for the Department of Science and Engineering of the Confederated Tribes of the Umatilla Indian Reservation.

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Troy Wirth received both a B.S. in Biology and an M.S. in Rangeland Resources from Oregon State University. His Master's research examined establishment of forb species important to sage grouse after wildfire in southeastern Oregon. Since then, he has worked in both the Great Basin and Mojave Deserts primarily focused on restoration and monitoring of arid ecosystems. Since 2004, he has worked as an ecologist for the USGS monitoring post-fire rehabilitation seedings in Oregon, Washington, and Idaho.

Poster Abstracts

Leafy Spurge Management in Shrub Steppe Rangeland

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Leafy spurge is expanding on rangelands around the west, reducing grass production for cattle producers and increasing their reliance on costly herbicides for control. In Lincoln County, Washington insects have been released on several sites over the past several years with limited success. Also, herbicide applications have met with limited success because of: rough terrain, restrictions on aerial application of certain herbicides and restrictions on application next to streams. No single tool can stop the spread of leafy spurge, but an integrated approach using several options, including targeted grazing with goats that can reach remote, rough or streamside landscapes, is needed. In 2007 Craig Madsen along with Tom Platt received a Western SARE Farmer and Rancher grant to demonstrate how goats can be used as a tool to manage noxious weeds such as leafy spurge and the opportunity for goats as an enterprise for diversifying existing livestock operations or as new agriculture businesses. In 2007 two transects were installed to monitor changes in density of the leafy spurge. Photo points were also taking at the four points along each transect and of the overall transect. The area was grazed by 260 head of goats (mainly does with kids) in mid May and in mid October for three years (2007-2009). In July 2007 the Lincoln County Noxious Weed Coordinator released the *Aphthona* species flea beetle. The density of leafy spurge declined in five out of the eight plots. The production of leafy spurge declined in all of the plots. The results in this study are similar to other studies that have been done with sheep and goats. The main purpose of the grant was to increase the awareness of goats as a tool for weed management. This was done through tours and presentations. In order to get adoption of goat/sheep as a tool for vegetation management a shift in how we look at certain weeds needs to occur. For example, leafy spurge to goats and sheep is high quality forage. By using the leafy spurge as forage it can be converted into a product that can be sold versus a weed that needs to be sprayed. The challenge is to shift from eradication to long-term management. This is especially true in areas with large infestations (100 plus acres). A clear plan and proper grazing management is critical to success.

Analyzing habitat connectivity for Washington arid landscape

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Animals move across landscapes to find food and other resources, migrate between seasonal habitats, find mates, and shift to new habitats in response to environmental changes. The ability to successfully move between habitats is essential for the long-term survival of many wildlife species, from large, migratory species such as mule deer to smaller animals like white-tailed jackrabbits and Greater Sage Grouse. Over half of the shrub steppe and grassland habitats in eastern Washington have been converted to agriculture. An analysis is necessary to identify which lands provide connectivity for wildlife movement between remaining large areas of habitat, or which areas could be restored to provide it.

The Washington Wildlife Habitat Connectivity Working Group (WHCWG) is a voluntary public-private partnership between state and federal agencies, universities, tribes, and non-governmental organizations working to provide scientific analysis and tools to identify opportunities and priorities to conserve and restore habitat connectivity.

In 2010 the WHCWG released a statewide connectivity analysis assessing the current condition of wildlife habitat connectivity for Washington State and neighboring habitats in British Columbia, Idaho, and Oregon. The analysis includes a report and a set of maps derived from two modeling approaches to habitat connectivity: focal species and landscape integrity. Our analysis provided valuable insights into current patterns of wildlife habitat connectivity in our state. Both our landscape integrity and focal species analysis revealed previously undocumented landscape patterns in the Columbia Plateau ecoregion that may contribute to habitat connectivity for shrubbsteppe species.

Due to high patterns of landscape fragmentation in the Columbia Plateau ecoregion and associated arid lands, a finer scale ecoregional analysis is underway in coordination with the Arid Lands Initiative. This analysis will provide finer scale data that is more applicable to localized planning, assess the needs of species associated with more patchily distributed habitats and species with limited ranges and smaller movement scales, and allow analysis of threats specific to maintaining connectivity on this landscape such as energy development.

The Western Governor's Association (WGA) recognized the need to proactively provide wildlife and habitat information to inform the planning needs for renewable energy. The Department of Energy has provided funding to the WGA that is being used for a pilot project that will provide this information. Our Working Group is partnering with the WGA and will be providing information from our analysis to their Arid Lands Pilot Project between Idaho, Oregon, and Washington.

Can vineyard farmscaping attract high quality beneficial insects? The next frontier for IPM and habitat conservation

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With increasing human development, native flora and fauna of the shrub steppe landscape are disappearing. As these plants disappear, so does the habitat necessary to sustain insects beneficial to vineyard integrated pest management (IPM). Farmscaping vineyards to include native plants may mitigate the loss of shrub steppe flora and the beneficial insects that call them home. Vineyards are excellent candidates due to the grapevines' small ecological footprint that includes room to establish ground covers. Grape growers minimize water use to control vegetative growth and maximize berry yield. These conditions are very suitable for incorporation of native plants in eastern Washington vineyards. Biological control plays an increasingly major role in grape IPM. As pesticide options decline, growers rely more on the pest control provided by insect predators and parasitoids. No one has published studies investigating the attractiveness of native flowering plants to beneficial insects in south central Washington. Standards are lacking for designing and managing vineyard farmscapes to proactively stabilize and sustain biological control systems to realize their full potential.

In this study we aim to develop a farmscape model for Washington vineyards that increases sustainability of IPM in grapes, without compromising profitability. In addition to IPM benefits, this farmscaping will beautify vineyards and aid the conservation of threatened pollinators like native bees and butterflies, as well as acting as a conduit for wildlife conservation awareness. Key plant considerations to maximize biological control benefits include compatibility and robustness with current viticulture practices. The composition, patch size, location and efficacy in attracting target insects must be considered. Other factors include the impact of pesticide and weed management inputs and proximity to native shrub steppe habitats (source-sink dynamics).

'Ecological Makeovers' will be implemented at four vineyards to compare habitat-restored versus conventional sites. Based on baseline data gathered from 43 species of endemic plants a farmscape plan employing beneficial insect-attracting native flowering plants will be created. The plan will integrate plants already in the farmscape with additional plants shown to attract beneficial insects. Habitat-restored vineyards will be compared to conventional vineyards by monitoring pest, natural enemy, native bee and butterfly populations in each vineyard type over a number of years. Flower bloom phenologies will be recorded for each species to make it possible to plan for continuous bloom throughout the growing season. A major component of these studies will be to produce website tools that can be used for future farmscape designs for viticulture and potentially a model for similar crop systems.

Examining the effects of invasive annual grass control methods on Mima mounds across two geological substrates at Turnbull National Wildlife Refuge, Wa

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Invasive annual grasses such as *Bromus tectorum* (cheat grass) have a detrimental effect on the ecology of rangelands and prairies. They can form monocultures which reduce native species abundance and reduce the availability of quality forage. Mima mounds in Eastern Washington provide habitat for native species communities and are in many cases heavily invaded with annual grasses. These mounds are comprised of fine particle size, nutrient rich top soil and are underlain by basalt bedrock or alluvium. The area between mounds, especially on the basalt substrate has shallow soil and does not support plant life throughout the summer. The mounds therefore are a vital source of forage during the hot dry months. The goal of this study is to examine the effect of several control methods on the abundance of invasive annual grasses. I looked at the effect of every possible combination of Plateau herbicide, soil amendment with carbon in the form of sucrose, and native seed addition across both substrates. Abundance was measured as percent cover and number of stems per plot. There was one $1m^2$ plot per mound and stem counts were recorded for a $400cm^2$ corner of each plot. A baseline vegetation survey was conducted during the summer of 2009, treatments were applied in the late summer and fall of 2009 and then the plots were re-surveyed. I tested the change in abundance among all treatments using ANOVA. Herbicide significantly decreased both percent cover and stem counts across both substrates ($p<0.001$) and had a significantly greater effect on the mounds underlain by alluviaun as compared to those underlain by basalt ($p=0.01$).

Restoring shrub-steppe habitat in Washington: Moving beyond anecdotes

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Efforts to restore shrub-steppe habitats in Washington have been undertaken by state and federal agencies, as well as private landowners, for several decades. However, progress in successfully re-establishing native vegetation that approaches the diversity,

abundance, composition, and structure of native shrub-steppe assemblages has been slow. Numerous obstacles have impeded these efforts, and there are few resources available that synthesize local and regional restoration experience and lessons learned. Instead, most managers have had to develop and refine restoration practices based on their own successes and failures, together with inferences drawn from methodologies used in other regions. To provide practitioners with more comprehensive information on successful restoration methods, we are working with managers from WDFW, BLM, USFWS, the tribes, and other agencies and organizations to document past restoration efforts, particularly in former CRP fields, and to compile this information in a standardized format. In approaching this synthesis, it has become evident that for most restoration projects, little information exists beyond qualitative, anecdotal descriptions to characterize the current status of vegetation composition. This lack of detail makes it difficult to effectively evaluate the success of restoration actions. Therefore, we have developed simple, standardized, quantitative vegetation assessment protocols, which we will use to gather comparable data from restored sites. From this, we plan to synthesize information from a variety of shrub-steppe restoration projects in Washington, as well as encourage other managers to more rigorously document restoration methods and results.

Cheatgrass, burning and Conservation Reserve Program grasses: A 2011 revisitation

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In the Columbia Plateau of Washington State, perennial grasses are the vegetative cover crop used most often for erosion control in fields enrolled in the USDA Conservation Reserve Program (CRP). Prescribed burning is used to control cheatgrass. Canopy cover of seeded species and cheatgrass was compared in 2008, the second season post-burn, for six burned and six unburned fields. In the second season after a prescribed burn, there was no significant difference in mean percent cheatgrass canopy cover between burned and unburned fields. Mean percent canopy cover of big bluegrass (*Poa secunda* J. Presl) was greater in unburned than burned fields. However, there was no difference in mean percent canopy cover of Snake River wheatgrass (*Elymus wawawaiensis* J. Carlson & Barkworth*)* in burned and unburned fields. The different responses may reflect the presence of new plant growth that was damaged by fire or buds that are protected from fire by soil or plant litter. In spring 2011, the fifth season post-burn, the same fields will be revisited and population data collected and analyzed.

Biotic and abiotic characteristics interact with fire history to influence biological soil crust cover and composition in the Columbia Basin

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Biological soil crusts (BSCs) in semiarid shrub-steppe are composed of organisms, particularly mosses and lichens, that live at the soil surface and provide services such as fixing nitrogen, absorbing water, and preventing erosion. BSC growth is affected by abiotic conditions, biotic factors, and disturbance. Abiotic conditions (topography, soil characteristics) affect available moisture and nutrients both at a landscape and microhabitat scale. Biotic factors (vegetation cover, litter) reduce growing space through shading and shoot density. Disturbances (fire) remove or damage BSC or change the microhabitat through the removal of vegetation. These factors also interact, making it difficult to understand their relative importance. However, this information could guide decisions to preserve BSC diversity and ecological services. We examined the factors that affect the cover and composition of BSC communities in Columbia Basin sagebrush-steppe. Much of this habitat has been converted to agriculture and pasture, and remaining areas have been invaded by the non-native cheatgrass (*Bromus tectorum*) and have experienced increased fire frequency. We sampled the BSC and vegetation communities across a range of elevations and disturbance histories and recorded environmental and soil characteristics. We used structural equation modeling to understand how explanatory variables interacted and related both directly and indirectly to moss and lichen cover. We related abiotic conditions, biotic factors, and disturbance to BSC composition. We quantified the relationship between BSC composition and vegetation composition. Fire history affected lichen cover directly and indirectly through its effects on vegetation and litter. Moss cover was not affected by vegetation but by microsite characteristics and fire. A total of 45 species or morphological groups were recorded. Small crustose lichens and mosses were associated with more disturbed sites, and foliose and fruticose species with moister microsites. High cover of cheatgrass was strongly negatively related to BSC, and sandier soils at low elevations were associated with higher cheatgrass cover. Plots showed much higher variation in BSC than vegetation composition, and vegetation was a poor predictor of BSC composition, especially in low elevations. Implications for stewardship include preventing dominance by densely growing invasive plant species, and reducing the frequency and spread of fires. The strength of direct and indirect effects can guide prioritization of restoration or protection to the most affected regions, for example, protecting sandier soils from cheatgrass invasion may promote higher crust cover in those areas. Fire and abiotic conditions had a strong effect on vegetation and interacted to affect BSC cover and composition.

Using multivariate control charts to communicate long-term changes in sagebrush-steppe vegetation communities.

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The Arid Lands Ecology Reserve (ALE) of the Hanford Reach National Monument formerly contained one of the last major expanses of Wyoming big sagebrush-dominated habitat in the mid-Columbia Basin. However, increasing wildfire frequency and extent, in response to growing numbers of anthropogenic ignitions and changes in fuel structure caused by cheatgrass invasion have caused successive and noticeable reductions in sagebrush cover. Despite this, changes to the structure of vegetation communities as a whole are more complex to visualise. Significant investments have been made in restoration treatments such as herbicide application, native seeding, and out-planting of sagebrush. To fully evaluate the effects of repeated disturbances and to prioritize and evaluate restoration activities, managers need to understand how entire vegetation communities change over time. Visualizing these changes for individual species is not always effective or efficient. Multivariate control charts (MCCs) provide a simple method for visualizing changes in the entire community. MCCs quantify the change from one measurement to the next based on changes in species abundance. We use an array of vegetation monitoring plots dating back almost 20 years to demonstrate how MCCs can effectively show changes in community composition. Plots are located on and off ALE, and span a wide range of environmental conditions, fire frequencies, and restoration actions. We used MCCs to depict change in vegetation composition, demonstrate how vegetation communities differ in response to fire, and assess the degree to which vegetation changed from its initial composition. Plots that experienced more frequent fires showed the greatest change, although those that had not burnt within the last 20 years still underwent noticeable changes. Communities dominated by resprouting species, such as three-tip sagebrush or perennial bunchgrasses, and those at higher elevations showed the least change in composition. Our results suggest observed patterns of resilience to repeated burning can be explained by plant functional traits, elevational differences in environmental conditions and previous fire history. MCCs are a promising way for managers to track the impacts of disturbances and restoration, particularly when combined with individual monitoring of species of particular concern, such as cheatgrass and big sagebrush. Whilst MCCs can be used to analyse trends with regards to initial vegetation composition, this may not represent the target of restoration. MCCs could potentially be used to analyse change with regards to desired, final states though more work is required to define methodologies for deciding upon such detailed restoration objectives.

The effects of fire disturbance on stage structure of riparian woody species in the shrub steppe seven years after fire.

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Riparian areas provide an ecologically diverse interface between upland and aquatic ecosystems. These areas provide food and shelter to wildlife and also improve water quality. Riparian areas are especially important in the shrub steppe where available water is limited during the dry season. Even though hydrologic, human, and fire disturbance is common in riparian areas, little is known about how fire affects this important ecosystem. This study compares the stage structure of several common riparian woody species to determine what is affecting their recovery after fire disturbance in the shrub steppe. Stage structure is a way to classify woody species based on their morphology rather than age. This is a common method for measuring vegetation since age is not always a good indicator of morphology. The objectives of this study were to enhance understanding of the effects of fire disturbance in the shrub steppe by (1) determining if stage structure of riparian woody species shifts over time as a result of fire (2) determining if other environmental factors limit recovery. Vegetation and abiotic characteristics were surveyed 3 to 4 times over a 14 year period on 5 creeks at the Yakima Training Center in Central Washington. Half the sites have not burned in recent history while the other half burned in 1996 and again in 2002 or 2003. Twenty woody riparian species were recorded during this study. Eleven species were located on both burned and unburned creeks, while 5 species were only located on burned creeks, and 4 species were only located along unburned creeks. *Salix* sp., *Rosa* sp., *Philadelphus lewisii*, and *Ribes aureum* were common across all transects. Twenty-four variables including the level of fire disturbance, hydrology, stream morphology and some common classification systems were compared with common riparian species to determine which affect the recovery of riparian woody species along these creeks. *Salix sp.* recovered quickly while species more adapted to drier conditions were slower to respond to fire disturbance. Seedling and young *Salix* sp. increased as channel width, potential bankfull discharge, and stream power increased suggesting hydrology is important for recovery. *Rosa sp.*, *Philadelphus lewisii*, and *Ribes aureum* were slower to respond to fire and appeared to be at greater densities along drier sections of the creek which often had increased slopes. This research suggests *Salix sp.* will return quickly and provide habitat and stability to riparian areas, while restoration efforts may be necessary for other species.

Mapping shrub canopy cover at the landscape scale using fine-resolution imagery

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Estimates of the relative amount of shrub canopy cover and its distribution across shrub-steppe landscapes are critical information for land managers, fire modelers, wildlife biologists, and ecologists. However, accurately mapping the spatial extent and relative quantity of shrublands across the landscape can be a difficult and time-consuming endeavor. Current methods for measuring shrub canopy cover generally rely on intensive field measurements across the area of interest. Transect or plot sampling for canopy cover can provide useful data from discrete locations, but is insufficient for developing a landscape-level understanding of shrub cover and distribution. Patterns of shrub canopy cover and distribution can be determined using fine-resolution satellite imagery or aerial photographs, but the analyses to map shrub canopy cover across large landscapes generally require detailed field data, local knowledge, and photo/image interpretation. In contrast, we use limited datasets of field –measured canopy cover with high-resolution aerial or satellite imagery and GIS technology to develop and apply models that estimate and map fine-scale shrub canopy cover. We tested automated methods for characterizing shrublands (distribution and canopy cover) for shrub-steppe regions in the Intermountain West using several types of fine-scale image data including Quickbird satellite imagery and aerial photography acquired through the National Agricultural Imagery Program. Models developed using image texture analyses and field-measured shrub canopy cover agree with field-measured values (e.g., r^2 =0.68, root mean square error of 7%) except on extremely rocky sites and in areas where shrub canopy cover exceeded 50%. This modeling approach has been applied to estimate shrub canopy cover for public lands in Idaho, the Sheldon-Hart Mountain National Wildlife Refuge Complex in Nevada and Oregon, and the Department of Energy's Hanford Site in eastern Washington. Application of this methodology provides a landscape map of patterns of low to hi shrub canopy cover that managers, modelers, and biologists can use in planning for restoration and species/community recovery.

The Wild Horse Challenge: Shrub steppe restoration and lithosols on Whiskey Dick Mountain on the Wild Horse Wind Facility, Ellensburg, WA

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Restoring shrub-steppe habitat is challenging in favorable situations, and is especially so when sites includes large areas of lithosol plant communities. Most wind farms in Washington and Oregon are located in settings with relatively deep soils that were long ago converted to agricultural crops. In contrast, Puget Sound Energy's Wild Horse Wind Facility in central Washington occurs in predominantly shallow soil rangeland with a combination of good quality shrub-steppe and high quality lithosol habitats. This presentation describes the lessons learned in planning and implementing restoration of areas disturbed during wind farm construction in this unique situation. We describe plans developed during the environmental permitting process to minimize habitat impacts and adaptations made in the field during the complex construction of this large energy facility in 2006, as well as efforts to rescue hedgehog cacti, a sensitive lithosol species, and planting of sagebrush plugs. After a brief review of preliminary restoration monitoring results compared to those at other wind farms in the Pacific Northwest, we discuss important lessons learned at Wild Horse that can be applied to other projects proposed in semi-arid, rocky terrain. These lessons include 1) improve existing roads and jeep trails whenever possible, 2) trenching for the underground electrical collection system poses a major restoration challenge, 3) keep topsoil and associated plant materials local to the area of disturbance, 4) evaluate potential effects on restoration objectives of traditional erosion and sediment control BMPs, and 5) cactus can be collected and over-wintered successfully for replanting after construction.

The Black-tailed Jackrabbit: Initial surveys of a keystone species

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Anecdotal evidence suggests that black-tailed jackrabbits (*Lepus californicus*) were historically abundant in suitable habitats of eastern Washington, and generally prefer sagebrush steppe habitats. More recent evidence suggests that populations have not been near historic levels for some time and might be declining. As populations have declined, the available shrub steppe habitats in eastern Washington have been altered and fragmented by wildfire, agriculture, urban and rural development, and other land management practices. The prevalence of exotic species, low annual precipitation, and the scale of habitat alteration limit our ability to restore these habitats in a timely manner. Lack of high quality, unfragmented shrub-steppe may be contributing to declines in this species.

Information on jackrabbit distribution and relative abundance in fragmented shrub-steppe landscapes is limited. Because these animals are nocturnal and mobile, they are extremely difficult to census, and estimates of population size and status are uncertain. Standardized surveys to determine the occurrence and abundance of this species and the status of black-tailed jackrabbits are generally lacking. Our objective is to compare two survey methods to determine presence/absence of black-tailed jackrabbits in the landscape and assess relative abundance. Spotlight driving surveys were conducted in suitable habitats on the Hanford Site during late summer when populations are at an annual peak. Track surveys along these same roadways were then conducted during winter just after snowfall. Both survey types resulted in jackrabbit detections, but results from the two survey types were not congruent. Track surveys indicated presence of rabbits in locations where rabbits were detected using spotlight surveys; however, tracks were also detected in areas where no jackrabbits were detected during spotlight surveys. These two methods provide useful information on presence/absence of jackrabbits in suitable habitats on the Hanford site, but additional survey and sampling information is needed to assess the efficiency of both methods as well as the status of jackrabbit populations with eastern Washington.

NOTES

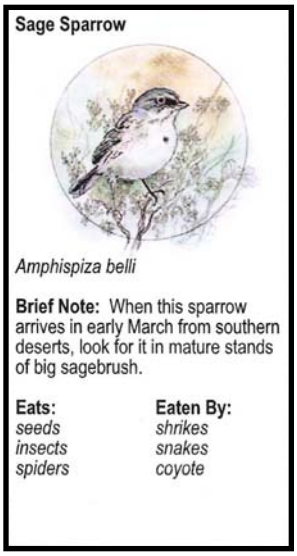
Shrub Steppe Teaching Materials

Developed in PNNL Science Alive Institute by Science Educators

Check out the poster explaining our process at the Poster Session!

The Shrub Steppe Landscape Poster, printed from the original 3'x5' oil painting that hangs at PNNL, was created as a visual aid for the classroom wall to serve as a point of reference and contextual display. The accompanying **Shrub Steppe Landscape Poster activities** are designed to help students construct their learning about plants, animals and geology of the shrub steppe. Teachers guide student discussions through the use of questioning strategies to develop key science concepts by making connections to Earth's larger systems. The activities and lessons were designed to take advantage of the opportunity to integrate reading and writing into science.

Shrub Steppe Species Cards depict flora & fauna of the unique habitat. The set of 42 cards can be used in a variety of ways to teach energy transfer in food webs. Students create games, learn to compare & contrast, and use the cards as prompts for a variety of writing styles.



Download these materials free of charge at:

http://science-ed.pnl.gov/teachers/ShrubSteppe.stm

Program Layout & Teaching Materials artwork by Jenny Rieke, PNNL Science Alive Team Artist 2005-2008