Current Knowledge and Attitudes: Russian Olive Biology, Ecology and Management

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ABSTRACT

The primary goals of a two-day Russian olive symposium held in February 2014 were to disseminate current knowledge and identify data gaps regarding Russian olive biology and ecology, distributions, integrated management, and to ascertain the feasibility and acceptance of a proposed program for classical biological control of Russian olive. The symposium was hosted by the Northern Rockies Invasive Plant Council in conjunction with NRIPC's 3rd Invasive Species in Natural Areas Conference, held February 10-15, 2014, in Spokane, WA. Funding to support the Russian olive symposium was received through a USDA NIFA AFRI Foundational Program grant awarded in response to the 'Controlling Weedy and Invasive Plants' (A1131) program priority area. Talks delivered by invited research subject experts were interspersed with facilitated large group and smaller breakout group discussions. Key invited management and stakeholder representatives also discussed first-hand experiences with Russian olive as a conflict (invasive and beneficial) species in the western U.S., and provided details about the implementation and efficacy of current Russian olive IPM options. The symposium was ultimately initiated to help establish an atmosphere of dialogue and trust among researchers, policy makers, stakeholders and resource managers. This highly focused forum allowed participants to gain a common and updated understanding of many important aspects of the biology, ecology and management of Russian olive. This in turn contributed to productive dialogue, identifying, and hopefully mitigating conflicts of interests about the potential biological control of Russian olive.

Nomenclature: Russian olive, *Elaeagnus angustifolia* L. ELGAN

Key words: Russian olive, invasive species, wildlife habitat, weed biological control

INTRODUCTION

The scale, ecological value and vulnerability of landscapes affected, potential for unacceptable collateral damage to native flora and fauna, and attendant regulatory intricacies increase the operational challenges of herbicide-based management of riparian invasive species (e.g., Sheley et al. 1995; SERA 2011a, -2011b, -2014; Federal Insecticide, Fungicide, and Rodenticide Act [FIFRA]; Clean Water Act [CWA] and Endangered Species Act [ESA]). Under such circumstances, classical biological control can present an attractive alternative to current conventional options for sustainable management of widely distributed riparian invasive species. However, the spread and establishment of biological control agents do not stop at political or habitat boundaries and because their release is effectively irreversible, conflicting interests over the proposed use of biological control may and often do arise (Dudley and Bean 2012). Conflicting interests are further intensified when the plant species targeted for biological control is perceived to play an important beneficial economic or ecological role. Under these circumstances, the planned release of a classical biocontrol agent poses an unacceptable threat to a valued resource (Stanley and Fowler 2004; De Wit et al. 2001; Turner 1985).

Implementation of classical biocontrol of the invasive tree Russian olive, *Elaeagnus angustifolia* L. (Rosales: Elaeagnaceae) (ITIS 2015), currently faces a number of conflicting interests (Bean et al. 2008). Russian olive is thought to have been initially introduced to the U.S. in the 1800s as an ornamental (Hansen 1901). Until recently, Russian olive was recommended or supplied through state and federal agencies for windbreak/shelterbelt use and as wildlife habitat (Christensen 1963; Olson and Knopf 1986; Zouhar 2005). In upland, arid locales within the Northern Great Plains, such as eastern Montana, the Dakotas, and parts of Wyoming, few if any native trees grow and survive as well as Russian olive (Rundel et al. 2014; Stannard et al. 2002). The fruits of Russian olive, known as drupes, are utilized as food, shelter and perches by birds; 92 avian species have been associated with Russian olive in the Columbia Basin alone (Denny 2006). Hunters, outfitters and guides are strong proponents of Russian olive due to its reputation as an important source of both habitat and food for game species (Zouhar 2005). Farmers and ranchers value Russian olive because it provides shelter in summer and winter, protecting livestock from the hot summer sun and cold winter winds. For residents of this area, Russian olive is highly desired because it plays an important beneficial role, and is therefore rarely considered an invasive noxious weed (Sing and Delaney 2015, this volume).

Russian olive has escaped cultivation in disparate regions of its adopted North American range. In fact, nearby intentional planting of Russian olive was the most critical among a suite of eleven environmental variables predicting the occurrence and abundance of native and invasive riparian woody species (McShane et al. 2015). Widespread successful invasion, establishment and increasing dominance in western and southwestern riparian plant communities has led to Russian olive's current status as a state designated noxious weed (CO, NM, UT, WY), invasive species (CA, NE, WI), or regulated species (MT) (USDA, NRCS 2015a). Even east of the Mississippi River where an exotic congener, autumn olive (*Elaeagnus umbellata*), can be locally much more prevalent and invasive (http://www.eddmaps.org/), Russian olive is considered a noxious weed in the state of Connecticut. By 2002, Russian olive was found to be the fourth most frequently encountered and fifth most abundant western U.S. riparian plant species (Friedman et al. 2005). However, with plenty of currently unoccupied but suitable habitat for future range expansion, it could feasibly ascend in future rankings (Friedman et al. 2005; Reynolds and Cooper 2010; Jarnevich et al. 2011).

Russian olive can outcompete (but see Lesica and Miles 2004) and replace ecologically (Pendleton et al. 2011) and culturally (Pretty Paint-Small 2013; Zelitch 1970) important native trees and shrubs. Russian olive biological, ecological or life history traits conferring some degree of competitive advantage over native trees such as cottonwood include: seedling recruitment that is not limited to large flooding events; superior drought tolerance; seedlings that are comparatively less shade intolerant; and mature trees that are injured or felled much less frequently by beavers (Shafroth et al. 1995; Lesica and Miles 1999, -2001, -2004; Katz and Shafroth 2003; Reynolds and Cooper 2010). As a nitrogen-fixing species, Russian olive also potentially functions as a so-called 'transformer' invasive species (D'Antonio et al. 2004) due to its ability to alter both terrestrial and benthic nutrient and community dynamics in invaded riparian areas (Reynolds and Cooper 2010; Follstad Shah et al. 2010; Mineau et al. 2011, -2012).

Russian olive is not a consistently beneficial habitat component, and is more likely to be perceived or confirmed as a nuisance species where it becomes invasive and dominant, primarily in lowland, water proximate settings (Stannard et al. 2002; but see Espeland et al. 2014). In riparian areas, thickets formed from Russian olive trees armed with dense, spreading and thorny branches provide protected nesting sites to some species but may limit, even exclude access of larger stock and game animals to drinking water (Ghekiere 2008; Montana Audubon 2010).

Negative impacts of Russian olive are not always obvious, and are often indirect. Stoleson and Finch (2001) found that southwest willow flycatcher nests in Russian olive trees were more likely to be parasitized by the brown-headed cowbird (*Molothrus ater*) than nests placed in native tree species. Friesen and Johnson (2013) trapped more of the West Nile Virus (WNV) vectoring mosquito *Culex tarsalis* in Russian olive and caragana shelterbelts (n=183) than marsh (n=7) or grass (n=0) habitats in the Medicine Lake National Wildlife Refuge. Stoleson and Finch (2001) found that the mourning dove *Zenaida macroura* preferred to nest in Russian olive, utilizing it at a disproportionately higher rate than according to its relative availability; in their study, Friesen and Johnson (2013) identified mourning dove as the avian (and wildlife) species most frequently used as a host by blood-fed engorged *C. tarsalis*. Consequences of removing invasive species once native fauna have become acclimated or even dependent on the resources they provide must also be considered (Hultine et al. 2010). Smith et al. (2009) detected a drop in black-chinned hummingbird (*Archilochus alexandri*) nest survival following a fuels reduction program, which entailed removal of Russian olive and *Tamarix* spp. via single or combined mechanical, fire and herbicide treatments. Researchers concluded that nest placement in native cottonwoods post-treatment resulted in increased nest placement height, which was correlated with increased predation risk (Smith et al. 2009).

Riparian infestations of Russian olive are responsible for significant economic and resource losses (Wilson and Bernards 2009). Incursion of Russian olive trees, their roots and drupes into recreational areas, grazing lands, irrigation channels and in other waterways presents a chronic maintenance challenge to private and public land management (Lesica and Miles 2001; Olson and Knopf 1986). Russian olive fruits can spread along waterways (Lesica and Miles 2004) where seeds remain viable for an extended period (Pearce and Smith 2009). Consumption of the fruits by birds, wildlife and livestock does not necessarily compromise the viability of the seeds, which can lead to spread away from immediate riparian habitats (Edwards 2011; Katz et al. 2001). European starling, an abundant invasive species with a continental distribution, feeds extensively on Russian olive drupes (Edwards 2011) and may compete with native cavity nesting avian species for rare nesting sites (Johnson and Glahn 2005) in areas dominated by Russian olive because it does not typically form cavities.

Comparisons are often, and in some ways, erroneously drawn between a planned program for classical biological control of Russian olive and the troubled *Tamarix* spp. biocontrol program. In 1994 the tamarisk leaf beetles (*Diorhabda* spp.) gained formal approval from USDA APHIS PPQ for release as a classical biological control agent of *Tamarix* spp. in the western U.S. The southwestern willow flycatcher, *Empidonax traillii extimus* (Passeriformes) (http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=B094), one of four willow flycatcher subspecies (Federal Register 2013), was formally listed as an endangered species by the USDI Fish and Wildlife Service in 1995 (Federal Register 1995). The southwest willow flycatcher nests in *Tamarix* spp. in riparian areas throughout the southwestern U.S. where this weedy shrub/tree has replaced native willows and cottonwoods (Friedman et al. 2005). Both unassisted spread and deliberate and illegal southern redistributions of the biological control agent brought it into direct contact with this endangered avian subspecies (Bateman et al. 2010). Rapid defoliation or mortality of *Tamarix* spp. before adequate alternative nesting site trees become available for use by southwest willow flycatcher is a serious concern (Dudley and Bean 2012; Hultine et al. 2010). Acclimation of the southwest willow flycatcher to *Tamarix* spp. nesting sites may also have elevated the importance of this weedy species as a habitat component (van Riper III et al. 2008).

USDA APHIS PPQ effectively revoked prior approval for field releases of *Diorhabda* spp. in 2010 when it explicitly prohibited the interstate movement of these agents (APHIS 2010). The source of conflict in this case was obvious: biological control of an invasive tree species was eclipsed by a perceived need to protect the same invasive tree species from harm, due to the role it may currently play as a key component of an endangered species' critical habitat (Dudley and Bean 2012). Conversely, the desire of Northern Great Plains residents to preserve established Russian olive shelterbelts represents an aesthetic preference and a labor and money saving decision. The importance of aesthetic value should not, however, be under-estimated as it has been a significant source of stakeholder resistance to ongoing biological control of riparian *Tamarix* spp. (Hultine et al. 2014) and planned biological control of Russian olive. The rights of landowners to express their horticultural preferences vs. societal economic and ecological burdens imposed by invasive Russian olive presents a conflict of interest significantly different, but no less challenging, than that confounding *Tamarix* spp. biological control.

DeLoach (1981) discusses a similar conflict of interest over the hypothetical biological control of mesquite in the southwestern U.S., noting that although "total damage to the livestock industry probably exceeds direct beneficial values by 7 to 15 times," and that shade tree benefits to homeowners restricts biocontrol efforts to "organisms that attack only flowers, seed or young plants and thus limit the further spread of the weed." A similar tactic has been used in South Africa to curtail the unchecked spread of invasive *Acacia* spp. while avoiding harm to existing trees or stands deemed beneficial (Moran et al. 2003).

Conflicts of interest in weed biological control programs can be mitigated or avoided by bringing stakeholders together very early in the process of biocontrol agent development for a given target weed (Hayes et al. 2008). At that stage, dialogue can verify majority agreement on two key points: 1) that it is acceptable to release a biocontrol agent capable of spreading and interacting with a broad range of ecological receptors, wherever the target weed occurs throughout North America; and 2) that a monitoring plan needs to be in place that can effectively detect potential indirect or non-target environmental harm caused by the agent. Nontarget impacts need to be detected or identified as early as possible to determine a) whether the situation can be mitigated (e.g., with restoration following *Tamarix* defoliation by *Diorhabda*; Dudley and Bean 2012), and b) if the potential agent should be removed from further consideration as a viable management option against the target weed.

The primary goals of a two-day Russian olive symposium held in February 2014 were to disseminate current knowledge and identify data gaps regarding Russian olive biology and ecology, distributions, integrated management, and to ascertain the feasibility and acceptance of a proposed program for classical biological control of Russian olive. The symposium was hosted by the Northern Rockies Invasive Plant Council in conjunction with NRIPC's 3rd Invasive Species in Natural Areas Conference, held February 10-15, 2014, in Spokane, WA. Funding to support the Russian olive symposium was received through a USDA NIFA AFRI Foundational Program grant awarded in response to the 'Controlling Weedy and Invasive Plants' (A1131) program priority area. Talks delivered by invited research subject experts were interspersed with facilitated large group and smaller breakout group discussions. Key invited management and stakeholder representatives also discussed first-hand experiences with Russian olive as a conflict (invasive and beneficial) species in the western U.S., and provided details about the implementation and efficacy of current Russian olive IPM options. The symposium was ultimately initiated to help establish an atmosphere of dialogue and trust among researchers, policy makers, stakeholders and resource managers. This highly focused forum allowed participants to gain a common and updated understanding of many important aspects of the biology, ecology and management of Russian olive. This in turn contributed to productive dialogue, identifying, and hopefully mitigating conflicts of interests about the potential biological control of Russian olive.

CONFLICTING PERCEPTIONS OF RUSSIAN OLIVE

Keith Douglass Warner delivered the symposium keynote opening address: "Reframing the social values questions that underlie invasive plant conflicts: issues to consider for Russian olive." Warner illustrated how invasive species control is simultaneously an economic, ecological, and ethical act influenced by social values (Warner et al. 2008). Social values shape human perceptions of invasive species and control efforts taken against them. Participatory public engagement or 'buy-in' from the public on invasive species control is therefore of critical importance to avoiding or reducing conflicts of interest, through collaborative partnerships that engage the public, or at the very least, by actively seeking public input on control projects (Warner 2016 – this volume; Warner 2013).

Kevin Delaney (co-authors Erin Espeland, Andrew Norton, Sharlene Sing, Kenny Keever, John Baker, Massimo Cristofaro, Roman Jashenko, John Gaskin and Urs Schaffner), summarizing pros and cons in "Russian olive – a suitable target for classical biological control in North America?" affirmed the over-arching purpose of the symposium. Delaney proposed that by addressing and discussing potential conflicts of interest relatively early in the development of a Russian olive biological control initiative, delays or termination of a well-developed, heavily invested in biological control program could be avoided (Delaney et al. 2013). Specific points he asked participants to contemplate and discuss over the course of the symposium included: 1) negative and positive economic, environmental or social impacts caused by Russian olive in North America; 2) goals of Russian olive management; and 3) feasibility of classical biological control to achieve Russian olive management goals. He proposed that focusing on fruit-reducing agents might be a way to reach common ground among key stakeholders regarding Russian olive as a suitable target for biological control.

Sharlene Sing (co-author Kevin Delaney) presented results of an internet based survey to assess stakeholder attitudes toward Russian olive and Russian olive control, including classical biological control (Sing and Delaney 2016 – this volume). The objectives of the survey were: 1) to categorize stakeholders by geographic location, profession and professional affiliation; 2) to categorize stakeholder perceptions of Russian olive as a problematic and/or beneficial organism; 3) to assess the ecological, economic and geographic scale of perceived benefits and/or detriments associated with Russian olive; and 4) to have stakeholders identify potential benefits and/or risks that might arise from the implementation of a classical biological control program for Russian olive. An unanticipated outcome of the survey was its utility in identifying contentious issues and conflicts of interest; this information was then used to efficiently focus discussion where it was most needed, throughout the Russian olive symposium.

Janet Ellis identified steps taken by a stakeholder driven collective to reduce the spread and intensity of Russian olive infestations in Montana in spite of highly polarized opinions about its risks and benefits. The stakeholder group (Montana Native Plant Society; Montana Audubon) targeted making changes in state policy that would restrict the use and distribution of Russian olive. A petition (Montana Native Plant Society 2008) submitted to the Montana Department of Agriculture succeeded in having Russian olive placed on the Montana statewide noxious weed list as Priority 3 regulated plant (but not as a Montana listed noxious weed species). This designation represents a meaningful compromise between widely conflicting interests. According to the Montana Department of Agriculture's noxious weeds website (http://agr.mt.gov/agr/Programs/Weeds/PDF/2013WeedList.pdf), the risks posed by Russian olive are acknowledged without requiring action to be taken against existing trees: Priority 3 regulated plant species such as Russian olive "have the potential to have significant negative impacts. The plant may not be intentionally spread or sold other than as a contaminant in agricultural products."

RUSSIAN OLIVE BIOLOGY

Sarah Reichard used Russian olive as a case study of invasive plant life history traits that contribute to the successful spread and establishment of introduced woody species (Reichard and Hamilton 1997). For Russian olive, these included a comparatively brief juvenile period (3-5 years); ability to fix nitrogen; efficient seed dispersal from the parent plant; and phytochemical or mechanical (thorns) protection from predation/parasitism. Biogeographical traits correlated with invasiveness in weedy species were confirmed in Russian olive's wide latitudinal native (western to central Asia) and adopted (northern Canada to southern Texas) range, although its status as an invasive species in regions/continents other than North America was not significant. Russian olive's success in North America was primarily attributed to traits promoting reproduction and enhancing resistance to stress.

Gabrielle Katz (co-authors Jonathan Friedman and Patrick Shafroth) reviewed geographic and genetic influences on Russian olive phenology throughout its North American distribution. Thresholds in chilling requirements for Russian olive winter seed dormancy (Katz and Shafroth 2003) and spring bud burst were found to vary across the latitudinal gradient where this species occurs in the western U.S. Inadequate chilling results in reduced spring bud burst for trees at the southern-most extent of Russian olive's North American distribution limits. Katz's preliminary results suggest that natural selection may be acting on southern U.S. Russian olive populations, resulting in locally evolved reductions in chilling requirement. Further, under climate warming, these results suggest that the southern distribution of Russian olive may not necessarily contract if chilling requirement is an ongoing adaptation linking bud burst with appropriate local conditions; an expansion of the northern distribution remains probable.

Peter Lesica (co-author Scott Miles) discussed biological and ecological influences underlying Russian olive's replacement of native riparian cottonwood forests in the western U.S. Canopy cover, growth rate, age structure and damage associated with beaver activity for Russian olive, plains cottonwood (*Populus deltoides*) and green ash (*Fraxinus pennsylvanica*) were compared at 34 sites on the Marias and Yellowstone Rivers in eastern Montana. Results of this study indicate that Russian olive attains reproductive maturity at approximately ten years of age in Montana, with less than one new plant recruited per mature tree annually (Lesica and Miles 2001). Even though Russian olive was found to grow at nearly three times the rate of the native late-successional green ash at sites where both occurred, long maturation time and low recruitment rate characterize Russian olive invasion as slow compared to other exotic invaders. Beavers were found to play pivotal role in the dominance of Russian olive on the Yellowstone and Marias Rivers. On most river channels sampled, the majority of cottonwood trees occurring within 50 m, and 21% beyond 50 m, of the river channel were damaged by beavers; Russian olive suffered little damage regardless of location. Lesica and Scott concluded that cottonwood establishment and dominance are not precluded on unregulated rivers where flooding events reinitiate primary succession beyond the zone of beaver activity (Lesica and Miles 2001). However, because cottonwood establishment will often be restricted to lower terrace sites along regulated rivers, beavers will prevent cottonwood from developing a mature canopy close to the river and this will likely have little effect on the continued invasion of Russian olive (Lesica and Miles 2004).

GEOGRAPHIC SCALE OF THE RUSSIAN OLIVE INVASION

Linda Vance (co-author Claudine Tobalske) described how precise and accurate mapping of invasive species such as Russian olive is a necessary precursor to estimating habitat loss, recognizing spatial patterns in distribution and abundance, and identifying areas where targeted management efforts might be most effective (e.g., Vance 2005; Vance and Stagliano 2007; Vance et al. 2006) . Coarse scale, pixel-based spectral imagery classifications will likely suffice for applications where currency and repeatability are important. For other purposes, particularly at smaller spatial scales, classifications made using object-based high resolution imagery were recommended. Vance experimented with two broad approaches to mapping the extent and distribution of Russian olive in Montana's Yellowstone River Basin. Pros and cons and results obtained were compared using commonly available and easily manipulated Landsat 30m imagery vs. 1m National Agricultural Imagery Program (NAIP) aerial photography. Accuracy of Russian olive classification ranged from 80-96% across nine Montana rivers, including the Bighorn, Clark's Fork of the Yellowstone, Marias, Milk, Missouri, Powder, Tongue and Yellowstone. NAIP detected 6521 total Russian olive hectares in 2009, most of which were largely confined to eastern Montana. Plans are underway to redo mapping and analysis to compare past and present Russian olive distributions using current NAIP data. The proposed project will evaluate potential land use/attribute and spatial predictive factors. Methods will also be developed for distinguishing Russian olive from a closely related native congener, silverberry (Elaeagnus commutata), which is widely distributed in western Montana.

Jason Pither and **Liana Collette** found an increasing awareness and growing concern among Canadian invasive species managers regarding the potential threat Russian olive poses to riparian ecosystems within Canada. However, a lack of information about past, present, and forecasted future distributions, and known and potential impacts on native flora and fauna make accurately assessing the scope of the threat posed by Russian olive difficult. Findings concerning (i) historical shelterbelt plantings, (ii) niche model predictions of potential future distributions, and (iii) insect assemblages associated with Russian olive trees in the south Okanagan region of British Columbia are reported in Collette and Pither 2015. Maps depicting the extensive geographic scope of the Government of Canada's discontinued Prairie Shelterbelt Program (1901-2013), which resulted in the planting of 1,086,654 Russian olive seedlings, showed that Russian olive's current distribution and abundance is likely correlated with proximity to sites according to the number of Prairie Shelterbelt Program seedlings planted there in the past. So-called "remote surveys" exploiting Google Earth and Google Street View images were proposed, in addition to shelterbelt planting data, as a way to increase the number of available Russian olive occurrence records to meet record number requirements for ecological niche modeling. Remote surveys increased Russian olive occurrence records in southern British Columbia 5117%, from 29 (=shelterbelt planting data alone) to 1484 records (shelterbelt planting data supplemented with occurrence records generated via remote survey). Potential distribution of Russian olive across North America (focusing on Canada), derived from continent-wide planting/occurrence records and niche modeling predicted that a significant invasion would likely occur, based on habitat suitability, north along the Fraser and Thompson Rivers. Contrary to results reported from earlier U.S. studies, the richness, diversity and composition of insect assemblages associated with Russian olive were no different than assemblages associated with two commonly co-occurring native shrubs, Saskatoon (*Amelanchier alnifolia* Nutt.) and Woods' rose (*Rosa woodsii* Lindl.) (Collette 2014).

ENVIRONMENTAL IMPACTS OF RUSSIAN OLIVE

Graham Tuttle (co-authors Gabrielle Katz and Andrew Norton) described the effects of Russian olive and removal efforts on soil N, available light and plant community structure along the Arikaree and Republican Rivers in eastern Colorado. Russian olive plots consistently had twice the soil available N (ppm) and half the available light (relative PAR intensity) of reference plots. Reductions in resource availability under the influence of Russian olive resulted in lower native perennial grasses cover and greater annual grass and exotic forb cover than reported from comparable reference plots. Environmental variables contributing to the strength of the Russian olive effects were identified through non-metric multidimensional scaling (NMDS) with ordination and mixed-model ANOVAs. Position within the riparian system (channel bed vs. historic flood plain vs. perennial wetland), and the presence of gallery cottonwood forests influenced the magnitude of Russian olive's effect on available N, light and plant community composition. Russian olive presence was correlated with higher soil available N in channel bed plots than in historic flood plain plots. Both soil available N and available light were higher in open areas than under cottonwood forest. Elevated soil available N and available light translated into greater impacts on plant community structure in channel bed and open plots. Overall, impact of Russian olive on ecosystem processes was found to be highly context dependent, with greater effects on both biotic and abiotic responses on sites that had higher resource water and light availability (Tuttle et al. 2012).

Susan Lenard (co-authors Paul Hendricks and Linda Vance) investigated impacts of Russian olive replacement of riverine stands of plains cottonwood on bats in southeastern Montana. Electronic bat detectors used to measure the relative activity of bats in stands dominated by plains cottonwood or Russian olive along the Yellowstone and Powder Rivers in southeastern Montana. Bat species detected in 18 stands (12 cottonwood, 6 Russian olive) included the silver-haired bat (*Lasionycteris noctivagans*), big brown bat (*Eptesicus fuscus*), western small-footed myotis (*Myotis ciliolabrum*), western long-eared myotis (*Myotis evotis*), little brown myotis (*Myotis lucifugus*), and Townsend's big-eared bat (*Corynorhinus townsendii*) (the latter two are Montana species of concern - http://mtnhp.org/SpeciesOfConcern/?AorP=a). Although bats were detected in all stands, their activity was greatest in stands dominated by cottonwood, positively correlated with percent canopy cover of cottonwood, and negatively correlated with percent canopy cover of Russian olive. Russian olive is shorter (14 vs. 25-30 m), forms a denser canopy, has thorny (vs. thornless) branches, has much harder wood and thinner bark than the plains cottonwood. Stand attributes beneficial both to bat flight and roosting, and to cavity nesting for native bird species such as northern flicker, downy woodpecker, hairy woodpecker, red-headed woodpecker, white-breasted nuthatch, black-capped chickadee and red-breasted nuthatch, were most prevalent in cottonwood stands (Hendricks et al. 2012). Degradation of bat habitat may amplify threats posed by white-nose syndrome (WNS). WNS has already been confirmed in the big brown bat and little brown myotis, while the causative fungus of WNS, *Pseudogymnoascus destructans*, has been detected on the silver-haired bat but with no diagnostic sign of WNS documented thus far (https://www.whitenosesyndrome.org/about/bats-affected-wns).

Colden Baxter (co-authors Madeline Mineau and Kaleb Heinrich) contextualized riparian invasions of exotic terrestrial species such as Russian olive by focusing on the coupled vulnerability of land and water. Nitrogen subsidies leaching into streams, a consequence of Russian olive's ability to fix dinitrogen (N_2), can alter stream nutrient dynamics. Stream reaches in Idaho and Wyoming invaded by Russian olive had higher organic nitrogen concentrations and exhibited reduced nitrogen limitation of aquatic primary producers, compared to reference reaches (Mineau et al. 2011). Decomposing leaves and drupes falling from streamside Russian olives, an abundant allochthonous energy source, can alter stream organic matter budgets. A pre- and post-invasion comparison determined that Russian olive invasion was associated with a nearly 25-fold increase in recalcitrant stream litter input. Russian olive inputs were additionally associated with a 4-fold increase in streambed stored organic matter, but with no attendant changes in gross primary production or community respiration, estimated stream ecosystem efficiency declined by 14% (Mineau et al. 2012).

Inputs from Russian olive may also alter the composition of food resources for both native and nonnative benthic fauna, and thereby influence their abundance and productivity. No significant change was detected in the total secondary production of invertebrates in response to the altered food base (e.g., Russian olive litter subsidized stream and streambed), although there were changes in some individual taxa. The results of dietary and stable isotope analysis indicate that dominant, native macroinvertebrates selected Russian olive litter at a rate below what would be expected based on proportionate availability as a food source (Mineau 2010; Mineau et al. 2008).

Unlike most co-occurring native fish species, invasive carp (*Cyprinus carpio*) are armed with large "pharyngeal" teeth that can be used to crush and derive energy from Russian olive drupes (Taylor 2013). Carp densities have increased significantly following Russian olive establishment while the abundance of native fish has declined over the same period. Increasing water turbidity through feeding-related disturbance and fecal contributions to streambed sediment, carp have significant negative impacts on native fish species that thrive best in cool, clear water. Carp eggs, fry and juveniles function as a prey subsidy for nonnative predators such as bass and perch, which may also enhance within and between trophic level pressures on already challenged native fish species.

Richard Fischer discussed investigations of bird community response to vegetation cover and composition in riparian habitats dominated by Russian olive. Concerns about potential degradation of wildlife habitat were weighed against benefits such as habitat structure, food and cover provided by Russian olive in a subset of seven out of more than 50 Habitat Management Units (HMUs) along the Snake and Columbia Rivers. These HMUs are managed by the U.S. Army Corps of Engineers (USACE) to mitigate the loss of wildlife habitat to inundation, the result of dam construction on the lower Snake River. Southeastern Washington breeding and winter riparian bird community response to spatial variation in vegetation cover, including variations in the proportion of Russian olive cover, were assessed.

Summer and winter bird surveys and remotely sensed (IKONOS/Worldview) vegetation assessments generated data for 181 breeding bird points and 172 winter riparian bird points (Fischer et al. 2012). Analyses included 51 avian species, of which 5 were deemed riparian-dependent breeding species. Total woody vegetation cover on the 353 points included in the analyses ranged from 0-100%, with a median value of 35%; Russian olive composition ranged from 0-100%, with a median value of 89%. Total woody cover influenced avian density, richness and summer composition, which peaked between 50-70%, regardless of Russian olive proportion contributing to total woody cover.

HMU stewardship by USACE needs to strike an informed balance between effective management of invasive riparian plants such as Russian olive, and reducing unintended or undesirable wildlife or wildlife habitat impacts resulting from weed management activities. Spatial removal guidelines for woody riparian species in particular were found to be lacking. A study was therefore recently initiated to investigate and identify the most cost- and ecologically- effective spatial configurations for Russian olive removal, for the purposes of ecosystem restoration, on USACE-managed lands. Flora and fauna were monitored pre- and post-removal on randomly selected plots superimposed on irrigation circles within study HMUs. An equal number of plots were set aside as controls as the number receiving a range of spatial removal treatments. Treatments included the following spatial removal configurations: 'clump cutting' to reduce Russian olive to 40% cover; removal of Russian olive from two of four quadrants in the irrigation circle, again reducing Russian olive cover to 40%; removal of Russian olive from one of the two semicircles bisecting the irrigation circle plot, to achieve a Russian olive cover of 40%; and no Russian olive removal (control). Control plots were randomly selected but conformed to three cover classes of Russian olive (all n=9): 20-40%, 41-60% and >60%.

MANAGEMENT OF RUSSIAN OLIVE: REMOVAL PROJECTs

Lars Baker (co-authors Michael Wille and James Leary) presented results of a study evaluating the usefulness of herbicide ballistics technology (HBT) (Leary et al. 2014), which uses paintball guns to deliver metered doses of herbicide to individual trees, for control of salt cedar and Russian olive. One hundred plants of each species were selected for treatment along Five Mile Creek, a tributary to Boysen Reservoir, located 20 miles north of Riverton, WY. Efficacy of HBT herbicide applications was compared to percent kill attained through standard foliar, cut stump and basal bark applied treatments. 2 ml paint balls were loaded with 25% triclopyr in basal oil (~ 10% a.i.) or 25% imazapyr in basal oil (~ 5% a.i.) and fired using compressed air at the target plants, releasing the treatment on impact. Treatment doses used, as paintball number equivalents of volume of herbicide/oil solution, were as follows: 6 paintballs (=12 ml of herbicide/oil solution), 12 (=24 ml), 18 (=36 ml) and 24 (=49 ml). Herbicide-loaded paintballs were applied to one side of treated plants, aimed to hit the trunk at 0.3-0.5 m above ground. Treated plants were evaluated at 12 and 24 months after treatment.

Triclopyr efficacy against salt cedar was found to be good overall, except for foliar applications (foliar: 0%; basal bark: 100%; cut stump: 100%; HBT: 81-98%). Efficacy of HBT applications of triclopyr on Russian olive was generally poor: 44-75% kill was attained with paintball-applied trunk treatments, improving to 60-80% kill when treatment was applied to the foliage. Imazapyr treatments produced less consistent results on both salt cedar (foliar: 94%; basal bark and cut stump: 25% and 60%; HBT: 30-50%) and Russian olive, and also resulted in non-target injury to nearby plants. Efficacy of HBT applications of imazapyr on Russian olive (paintballs/kill) ranged from 13-38% using 6-24 paintballs. Based on these results, the authors thought it would be worthwhile to develop a dose response curve for HBT application of triclopyr/basal oil on salt cedar that could be used to fine tune the application method and rates to get results comparable with currently labeled basal bark and cut stump applications, while using a significantly reduced amount of active ingredient. The estimated reduction in the amount of herbicide/oil mix used per treated salt cedar tree would be 24-49 ml using HBT vs. 355 ml for basal bark treatment might offset the increased cost of HBT ($3.27-$7.44 vs. $1.17). HBT applications of herbicide on salt cedar control would be particularly useful against trees that are sparse, have a scattered distribution, or occur in remote or difficult to access locations. Efficacy of HBT applications on Russian olive was generally low and inconsistent with both herbicides, using the application rates stated above, possibly because several hits were required to breach the bark.

Jim Ghekiere (co-author Warren Kellogg) presented results of an ongoing, innovative demonstration project initiated in 2008 by the Marias Watershed group to evaluate costs, logistics, and operational issues associated with a full-scale Russian olive removal project on the Marias River. The overarching goal of the project was to compare available technologies and approaches for Russian olive removal from a riparian area. The project demonstrated and evaluated Russian olive removal treatments for success and cost effectiveness, to be used as a model to inform future removal projects along the remaining untreated stretches of the Marias River, and on other affected rivers/streams throughout Montana. Control methods demonstrated in the project included: basal bark herbicide treatment, cut-stump herbicide treatments following cutting with a gyro-track mulcher, cut-stump herbicide treatments with "hot-saw" cut trees, cut-stump herbicide treatments with chain saw cut trees, foliar application of herbicide to seedlings, and foliar applications of herbicide to mature trees. Cut-stump and basal bark treatments used a 1:3 mix of triclopyr and basal bark oil.

Poor control was obtained with treatments that involved cutting or mulching trees to ground level. Extensive damage to stumps, nearly complete removal of bark and destruction of the cambium layer under the bark resulted when the mulcher was used. Loss of the bark and cambium layer, critical respectively for herbicide uptake and translocation, resulted in the emergence of thick, bushy regrowth from stumps the following year. Conversely, herbicide uptake and translocation was highly successful in trees cut cleanly to a height of 18-24 in then treated with herbicide. Treatment efficacy was 90-95% in the first year on all trees that had been cut cleanly, leaving the bark intact, whether cutting was by hot-saw, chain saws, or pruners. Results varied with the age or size of treated trees: basal bark treatments on mature trees with trunks over 3" in diameter that had not been cut yielded poor results, while foliar treatments were generally successful on young trees and seedlings.

Landowner cooperators have agreed to participate in the removal project along 49 miles of the Marias River, and 10 miles of Pondera Creek. Stakeholder assessment of the project was accomplished through weed tours and float trips before (2007) and after treatments were initiated (2009, 2013). To date, removal has been completed on 29 miles of the Marias River and 10 miles of Pondera Creek; Russian olive has also been inventoried on the next 19 miles of the Marias River. Prospects for the continuation of this project are positive due to the combined commitment and ongoing support of local federal agency (USDI Bureau of Land Management) and private land owners and managers.

Erin Espeland (co-authors Mark Peterson, Jennifer Muscha, Robert Kilian and Joe Scianna) discussed known and potential ecosystem effects of Russian olive control, in this case, removal followed by re-vegetation. Alterations in canopy architecture and secondary weed invasions following re-vegetation were identified as potential influences that may mediate changes in the abundance and diversity of arthropods, birds and mammals, soil processes, and forage quality and quantity following the control of Russian olive via removal and re-vegetation treatments. Vegetation, soils, and insect data were recorded from four 1.2 acre plots before Russian olive was removed in April 2011, to compare trajectories in these communities to trajectories in nearby reference plots where Russian olive was not removed. Removal using a tree shear followed by immediate application of a 1:3 mix of triclopyr to basal bark oil was effective. A significant flooding event in May 2011 likely facilitated re-sprouting from roots in 3.9% of the 2500 total cut and herbicide treated trees. The same flooding event may have led to the 2-fold increase in densities of Russian olive seedlings on removal plots compared to reference plots, in fall of 2011. Because high densities of tamarisk seedlings were similarly detected in removal plots, a foliar treatment of 1 oz triclopyr: 3 tsp aminopyralid mixed with >1 oz of surfactant was applied to all weedy trees in removal plots in 2012 and 2013.

Each of the four removal plots was divided into five sub-plots which were assigned the following re-vegetation treatments in spring 2012: 1) herbs, a mix of 4 native grasses: slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*), prairie cordgrass (*Spartina pectinate*) and switchgrass (*Panicum virgatum*), and 9 native forbs: western yarrow (*Achillea millefolium*), dotted blazing star (*Liatris punctate*), prairie clover (*Dalea* spp.), prairie coneflower (*Ratibida* spp.), Maximillian's sunflower (*Helianthus maximiliani*), Canadian milkvetch (*Astragalus canadensis*), prairie thermopsis (*Thermopsis rhombifolia*), echinacea (*Echinacea* spp.), and Lewis flax (*Linum lewisii*), 2) herbs + 4 native shrub species: golden currant (*Ribes aureum*), chokecherry (*Prunus virginiana*), buffaloberry (*Shepherdia* spp.) and Woods' rose (*Rosa woodsii*), 3) herbs + 4 native tree species: narrow leaf cottonwood (*Populus angustifolia*), plains cottonwood (*Populus deltoids*), boxelder (*Acer negundo*) and ash (*Fraxinus* spp.), 4) herbs + shrubs + trees, or 2) control, with Russian olive removed but no re-vegetation. No significant difference in understory cover between control and re-vegetated subplots was detected by the second year of the study, in spring 2013. Establishment of seeded herbaceous species on re-vegetated subplots in the initial year of the study was very low due to drought conditions, overall slowing re-vegetation with this functional class. Shrub and tree survivorship ranged from 50.5-92.4% and 25.0-84.6%, respectively, and was not enhanced by the use of weed fabric.

Soil analyses indicated no response of nematodes, fungi, or ciliates to Russian olive removal. However, because soil bacteria communities showed opposite trajectories in removal and reference plots, future investigations on how Russian olive removal impacts soil functions such as decomposition and nutrient availability will focus on bacterial communities. Additional reference plots will be added to the study because the original reference plots experienced a different flooding history than the removal plots in spring 2011. Investigation of potential ecosystem effects of foliar applied herbicides will be expanded because this type of treatment leaves no slash piles but standing Russian olive snags retain beneficial tree architecture. Analysis of insect community data from sweep and pitfall samples, and game camera data will be used to determine if animal utilization of removal areas differs from Russian olive-dominated areas.

Scott Bockness (co-authors Amy Ganguli, Jack Alexander and Gary Horton, Jr.) reported results of innovative conservation approaches, including prevention and control, biomass utilization/bioenergy generation, to the management of Russian olive and salt cedar infestations affecting the Missouri River watershed (Rindos et al. 2014). The project incorporated short- and long-term vegetation monitoring to evaluate ecological changes, riparian system health and function, and natural resource enhancement following the treatment of invasive plants. A consultant partner, Synergy Resource Solutions Inc., completed baseline monitoring on treatment and control sites to evaluate pre- and post-treatment conditions of the target weeds and the wider vegetation community, and to demonstrate the long-term efficacy of treatment methods and the influence of initial site conditions on results attained. Cut-stump and basal bark treatments were successful but areas treated with mulch removal (mechanical mastication) alone and no application of herbicide experienced high regrowth, which required unplanned follow-up applications of herbicide (Bockness et al. 2013). On all study sites, follow up treatments of non-target weedy species were essential to facilitating the establishment, re-establishment or increases in desirable plant species. On one site, Russian olive cover of 80.7% in 2012 declined to 0% in just one year following removal and herbicidal treatment. On the same site, tall wheatgrass production increased more than three-fold following Russian olive treatment. Post-treatment production of tall wheatgrass increased from 1,437 lb/acre in 2012 to 3,050 lb/acre in 2013, and to an estimated 5,400 lb/acre in 2014 (Sterling et al. 2014).

Woody biomass of native tree species, acquired as a byproduct of forest management activities, has been a common fuel source for heat and power generation over the past two decades in the western United States. Russian olive and saltcedar biomass harvested following cut-stump and herbicide treatments were tested to determine their potential utilization as the raw materials or 'feedstock' for biofuel energy applications. Extensive independent testing confirmed that biomass resulting from herbicide-treated trees did not contain high levels of toxic residues; that it could be safely used as a bioenergy source; and that it had heat/energy values comparable to other currently used biofuel sources. Russian olive BTUs (8,055) were lower but comparable, with an average calorific value of 90.2% of traditional forestry species, to a range of tree species commonly used as a source of biofuel (Douglas fir - 9,050 BTUs); ash produced from Russian olive was low at 1%, compared to 1.1% for Douglas fir. Results of ash fusion tests indicate that the ash fusion temperature of Russian olive at 2700°F is high enough that when burned, would be unlikely to cause fouling or the formation of "clinkers" in typical biomass fueled systems. However, costs associated with harvesting and transporting saltcedar and Russian olive biomass to the limited number of regional biofuels facilities currently available suggests that until local/area users are developed, this will not a cost-effective source of biofuel.

Detailed descriptions of all aspects of this project and results are disseminated through a dedicated website available online at www.weedcenter.org/mrwc/cig

RUSSIAN OLIVE REMOVAL PROJECTS: COMMUNITY RESPONSE

Lindsey Woodward recounted high and low points in Hot Springs County Weed and Pest Control District's battle against Russian olive and tamarisk invasions, which has been ongoing since 2003. County efforts to remove Russian olive and tamarisk from tributary drainages of the Bighorn River contributed to a larger management project extending throughout the Bighorn Basin, culminating in the removal of both invasive tree species from the river corridor (USDA NRCS 2015b). Project partners included Big Horn Basin Weed and Pest Districts and Weed Management Associations, ditch companies, USDI Bureau of Land Management, Wyoming state lands, USDA Natural Resources Conservation Service, Wyoming Wildlife and Natural Resources Trust, Wyoming Game and Fish Department, along with numerous private landowners. In 2011, target weed populations were mostly cleared from tributary drainages and the reintroduction of natives was well underway. The next phase of the project, large scale removal projects on the Bighorn River, began in 2012 with funding from a number of partners in place. Up to that point, response from the residents of Hot Springs County Weed and Pest Control District had been almost entirely positive, and those who opposed the removal of Russian olive and tamarisk were able to opt out of control programs. However, opposition to the project began to mount as large scale, highly visible work progressed on the Bighorn River. Opposition to the project became increasingly pronounced and aggressive, but fairly creative in nature, with highly motivated opponents reaching out to like-minded residents through novel vehicles such as classified ads and a Facebook page. The most common source of dissatisfaction with the project arose from the widely-held perception that Russian olive and saltcedar removal was depleting wildlife habitat. Rehabilitation of affected areas is an important component of responsible invasive plant management, especially in ecologically sensitive habitats. However, full recovery of functional and aesthetic values following treatment and restoration occurs at a range of highly site-specific spatial and temporal scales. Residents initially opposed to the removal program were more likely to reconsider and give weed control agencies a chance to help with habitat recovery once the full details of the program, especially rehabilitation efforts, were communicated. The range of effects that rehabilitation of Russian olive and tamarisk infested areas will have on wildlife within the Big Horn Basin, similar to the restoration of vegetation on along the river corridor, will likely take some time to be fully realized.

Josh Shorb discussed progress made by the Shoshone River and Clarks Fork River Coordinated Resource Management (CRM) program, which was created in 2010 to focus on the control of Russian olive and salt cedar (Parsons 2010). Initial financial support to fund the project's original treatment goal, to remove 5,000 consolidated acres of Russian olive and saltcedar, came through a $300,000 Wyoming Wildlife and Natural Resource Trust Fund grant which was matched to total $824,719.65, including funding from USDA NRCS, Park County Weed and Pest District, and significant landowner cash ($148,494.15) and in-kind ($82,691.83) contributions. The project's goal, to eradicate as much Russian olive and salt cedar as possible, would return invaded riparian areas to fully functioning, native species dominated ecosystems. Shoshone River expanses targeted for treatment as part of the CRM project began at the Buffalo Bill reservoir and continued to the Park/Big Horn county line, and included all major tributaries. Affected areas along the Clark's Fork to be treated as part of the project began at the Clark's Fork Canyon and extended to the Wyoming/Montana state line, and included all major tributaries. From its inception, this project faced many challenges as residents' opinions about removing Russian olive and salt cedar varied wildly. Landowners supportive of the project began treatments as soon as funding was available. Landowners opposed to the project declined to participate in any aspect of Russian olive and saltcedar control. Despite the availability of funding, as of January 2014, which was five years after the first coordinated removal efforts began in 2009, only 1,445.6 consolidated acres of Russian olive and 32 acres of saltcedar had been removed. The most significant challenge to the successful execution of this project proved to be the wide divergence of opinion or values assigned to Russian olive and saltcedar. Some residents viewed the trees as noxious weeds, while many others perceived them to be essential components of critical wildlife habitat. Vociferous and emotional public opposition to this project was therefore undoubtedly motivated by the high stakes believed to be at risk.

Steve Brill hosted a screening of a video that he appears in, "River of Time, Wyoming's Evolving North Platte River" (McMillen 2012). The narrator begins by contextualizing invasive tree management programs in neighboring southeast Wyoming counties, reviewing facts while compelling images aptly convey the origin, history and importance of the North Platte River. Goshen, Platte, Converse, Natrona and Carbon counties, the five Wyoming counties that the North Platte River flows through, consolidated efforts in 2007 to control riparian infestations of Russian olive and saltcedar by forming the Upper North Platte River Weed Management Area (Duncan 2012). Upper North Platte River WMA partners include private landowners, USDI Bureau of Land Management (BLM), Bureau of Reclamation (BOR) and National Park Service's Northern Great Plains Exotic Plant Management Team (NGP-EPMT), Wyoming

Game and Fish, USDA Natural Resource Conservation Service (NRCS), affected Wyoming Conservation Districts and County Weed and Pest Districts, Wyoming Department of Agriculture and others. Alterations in the functioning and services provided by natural and managed ecosystems affected by Russian olive and saltcedar invasions along the Upper North Platte River WMA are identified, and short- and long-term ramifications of these alterations are explored. Since its inception in 2007, WMA partners have treated more than 4,400 acres of saltcedar, and 2,800 of Russian olive; pros and cons of these efforts and the techniques used are discussed. Residual woody biomass generated through removal projects remains an ongoing and pressing issue. The video was produced and directed by Becky McMillen, Insight Creative Independent Productions of Scottsbluff, NE, and is available for viewing free of charge online at: http://www.icindie.com/riveroftime.html

MANAGEMENT OF RUSSIAN OLIVE: BIOLOGICAL CONTROL

Dan Bean (co-author Tom Dudley) discussed first-hand lessons learned from the ongoing *Tamarix* biocontrol program and their relevance to the nascent Russian olive biocontrol program (Bean et al. 2008). Lessons learned from the *Tamarix* spp. biocontrol program included: 1) although biocontrol programs and the Endangered Species Act may share the same long term goals, conflict will be inevitable in the short term; 2) biocontrol is safe because host range testing (of candidate biocontrol agents) is so accurate and conservative; 3) the trajectory of biocontrol programs are predictable, not 'haywire' ('haywire' according Dr. Robin Silver, a retired emergency-room physician in Phoenix, professional wildlife photographer, and co-founder of the Center for Biological Diversity in a press release issued September 30, 2013 "Lawsuit Filed to Save Endangered Southwestern Songbird From Habitat Destruction Caused by Invasive Beetles" http://www.biologicaldiversity.org/news/press_releases/2013/southwestern-willow-flycatcher-09-30-2013.html); and 4) although the time scale of biological control is difficult, given institutional attention span, stakeholder enthusiasm does not wane.

Regarding the goals of biological control: goals and pathways to achieve them need to be clear and well-articulated. The goals of classical biological control of weeds are ultimately dictated by the trenchant, chronic and sustained nature of target weed infestations; eradication is not a realistic, or in certain cases, even desirable aspiration. Suppression of well-established, widely distributed target species below economically and ecologically damaging thresholds to achieve non-dominant representation within mixed vegetation assemblages, is particularly important when native species become acclimated to their presence and use. Reductions in the proportionate contribution of *Tamarix* and Russian olive to total composition of woody riparian species, and not eradication, will therefore continue to be the goal of biological control of these two target species, especially within southwest willow flycatcher nesting habitat.

Regarding the safety and trajectory of biological control: biocontrol requires a higher level of stakeholder and public education than conventional weed control. Classical biological control involves the consideration of many more interacting and complex factors (e.g., agent population dynamics and dispersal) than chemical or mechanical control. An under-informed public may be more susceptible to unsubstantiated, sensationalist negative publicity. Of the more than 300 special insects assessed during the foreign exploration phase of the *Tamarix* biocontrol program, only four, including the *Diorhabda* complex, were judged to be safe enough to undergo extensive host specificity testing.

Regarding the time scale of biological control: the nature, scale and duration of biological control projects make collaboration essential. The first stage of biological control programs, objectively confirming the appropriateness of targeting the species for biological control, then identifying and assessing the safety and efficacy of candidate agents, involves an investment of time and funding that necessitate collaboration. The second stage of biological control programs, documenting the candidate agent's biological responses and ecological interactions under novel (North American vs. native range) field conditions is another herculean task requiring extensive collaboration. The third stage of biological control programs, implementation, moves beyond the focused study of the agent and characterizing the range of its interactions with the target weed and other ecological receptors. Implementation at the most basic level involves figuring out how to best use this new 'tool' (i.e. the biocontrol agent) to control the target weed. Developing optimal protocols for 'applying' and evaluating the control efficacy of the agent released to address diverse management needs also requires a significant collaborative effort. Long term commitment by end users and participating land management entities is critical for the success of inherently long term projects such biological control. Long term commitment to funding, collecting, analyzing and publicizing relevant and high quality ecological monitoring data is particularly important for identifying and responding to unanticipated impacts and interactions. As an example, unanticipated rapid increases in the density and spread of *Diorhabda* resulting from initial U.S. field releases significantly impacted *Tamarix* within the nesting range of the southwest willow flycatcher well before the estimated 10-20 year lag between releases of the first beetles and when restored bird habitat was thought to be required (Dudley and Bean 2012). Field data have also refuted a number of predictions about *Tamarix*, *Diorhabda* and how their ongoing interactions impact the southwest willow flycatcher.

Notable controversies that arose during the development of the *Tamarix* biocontrol program involved contradictory assessments of 1) the value of *Tamarix* as a wildlife habitat component, particularly for the endangered southwestern willow flycatcher; 2) the potential for biological control of *Tamarix* to result in water savings; and 3) the long term outlook for riparian restoration in the presence of *Tamarix* biocontrol. Value of basic and applied research, site monitoring, stakeholder consortia, public education and the engagement of policy makers in the tamarisk biocontrol program were discussed with a view toward the future and potential success of Russian olive biological control.

Urs Schaffner (CAB International in Délémont, Switzerland) delivered the symposium keynote closing address, discussing the potential for classical biological control when the target is a 'conflict species', as has become the case with Russian olive. Russian olive originates from central Asia, with a native range extending into western and eastern Asia. Russian olive is a characteristic species of the *tugai*, an imperiled riparian forest ecosystem unique to the continental, winter-cold deserts of Central Asia. *Tugai* forests consisting of fast growing deciduous tree species such as poplar (*Populus euphratica*, *P. pruinosa*), Russian olive and willow (*Salix* spp.) historically occupying the flood plains and deltas of the Amu Darya, Syr Darya, Zaravshar and Vaksh Rivers have nearly disappeared due to Soviet-era afforestation, intensified agriculture and alteration of hydrological regimes (Tupitsa 2007). Russian olive has been exploited for many purposes in the native range: orchards are planted with cultivars developed to express fruit characteristics that enhance their attractiveness for human consumption; trees are also planted to function as windbreaks, shelterbelts, and as shade trees; and woody biomass is used as a source of fuel. The perception that Russian olive in North America also confers significant ecological and anthropogenic benefits continues to be strongly and widely held throughout the western and southwestern United States.

Although the general goal of biological control is constant, to reduce the density and spread of the target organism below ecological or economic thresholds, the goal or goals of weed management programs are often un- or under-defined. Similarly, biological control intended for use as a stand-alone treatment is subject to far fewer practical restrictions in implementation but may be too slow-acting or unable to achieve adequate control than if it was used as a component of integrated weed management; this aspect of the weed management program should be defined *a priori* implementation or treatment. In all cases, the underlying purpose of biological control should be habitat management, specifically to use biological control to retain or cause a defined habitat benefit. The capabilities of the agent should also therefore be matched to the desired habitat benefit.

To date, extensive native range surveys have identified more than 60 invertebrates associated with Russian olive (Schaffner et al. 2014). However, conflicting interests over the proposed release of biological control agents against Russian olive have restricted initial investigations to candidate agents to those that would reduce seed production and thereby the spread of Russian olive through seeds, without killing established trees. Two invertebrate species have been selected for in-depth study: the mite *Aceria angustifoliae*, which attacks leaves, inflorescences and young fruits of Russian olive, and the moth *Ananarsia eleagnella*, which mines the shoot tips and the fruits of Russian olive trees. The selection of these two candidate agents assumes that Russian olive invasion of North American riparian habitats has occurred through seed dispersal, so invasion processes can be slowed or stopped by reducing propagule pressure.

The symposium concluded with the development of a strategic approach to coordinating data collection on knowledge gaps revealed through the previous two days of presentations and discussions. The goal of the data collection would be to provide scientific evidence to answer lingering questions about the drivers of Russian olive invasion in riparian ecosystems, environmental impacts of Russian olive invasion, socio-economic implications of Russian olive invasions, and management options for Russian olive invasions.

REFERENCES

APHIS - Animal and Plant Health Inspection Service (2010) Memo to PPQ State Plant Health Directors from Alan Dowdy, Director of Invertebrate and Biological Control Programs announcing moratorium for biological control of salt cedar using tamarisk leaf beetle. U.S. Department of Agriculture, Plant Protection and Quarantine, Emergency and Domestic Programs, Riverdale, MD. https://www.usbr.gov/uc/albuq/rm/CBPvegMgmt/saltcedar/pdfs/2010/BeetleMemoUSDA.pdf. Accessed May 8, 2015

Bateman HL, Dudley TL, Bean DW, Ostoja SM, Hultine KR, Kuehn MJ (2010) A river system to watch: documenting the effects of saltcedar (*Tamarix* spp.) biocontrol in the Virgin River Valley. Ecological Restoration 28:405–410.

Bean D, Norton A, Jashenko R, Cristofaro M, Schaffner U (2008) Status of Russian olive biological control in North America. Ecological Restoration 26:105–107.

Bockness S, Ganguli A, Alexander J, Horton, Jr. G (2013) Monitoring the long-term treatment efficacy of saltcedar (*Tamarix spp.)* and Russian olive (*Eleagnus angustifolia* L.). http://www.weedcenter.org/cig/docs/Saltcedar%20and%20Russian%20Olive%20CIG%202014%20Poster%20Feb%207%202014.pdf. Accessed May 8, 2015

Borell AE (1951) Russian-olive for Wildlife and Good Land Use. Washington, D.C.: U.S. Department of Agriculture Leaflet No. 292. 8 p.

Christiansen EM (1963) Naturalization of Russian olive (*Elaeagnus angustifolia* L.) in Utah. American Midland Naturalist 68:133–137.

Collette LKD (2014) An Ecological Assessment of Russian Olive in Western Canada: Predicted Distribution Across its Invaded Range and Insect Associations in Southern B.C. M.Sc. thesis. Kelowna, British Columbia: The University of British Columbia-Okanagan. 120 p.

Collette LKD, Pither J (2015) Russian-olive (*Elaeagnus angustifolia*) biology and ecology and its potential to invade northern North American riparian ecosystems. Invasive Plant Science and Management: 8:1–14.

D'Antonio CM, Berlow EL, Haubensak KL (2004) Invasive exotic plant species in Sierra Nevada ecosystems. Pages 175–184 *in* Proceedings of the Sierra Nevada Science Symposium. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. PSW-GTR-193.

De Wit MP, Crookes DJ, van Wilgen BW (2001) Conflicts of interest in environmental management:

Estimating the costs and benefits of a tree invasion. Biological Invasions 3: 167-178.
Delaney K, Espeland E, Norton A, Sing S, Keever K, Baker JL, Cristofaro M, Jashenko R, Gaskin J, Schaffner U (2013) Russian olive – a suitable target for classical biological control in North America? Page 352 *in* Proceedings of the XIII International Symposium on Biological Control of Weeds. Morgantown, WV: USDA Forest Service Forest Health Technology Enterprise Team. FHTET-2012-07.
DeLoach CJ (1981) Prognosis for biological control of weeds of southwestern U.S. rangelands. Pages 175–199 *in* Proceedings of the V International Symposium on Biological Control of Weeds. Canberra, Australia: CSIRO Entomology.
Denny M (2006) The Russian olive (*Elaeagnus angustifolia*) and its utilization by wild birds in the Columbia Basin of Washington and Oregon. Washington Ornithological Society News 103:1; 4–6.
Dudley TL, Bean DW (2012) Tamarisk biocontrol, endangered species risk and resolution of conflict through riparian restoration. BioControl 57:331–347.
Duncan C (2012) Wyoming counties unite to control Russian olive and saltcedar along the North Platte River. Techline Newsletter, Western Range & Wildlands Edition. Spring 2012:6–8. www.techlinenews.com. Accessed May 8, 2015
Edwards RJ (2011) Control and Dispersal of Russian olive (*Elaeagnus angustifolia*). M.S. thesis. Fort Collins, CO: Colorado State University. 117 p.
Espeland EK, Rand TA, Delaney KJ (2014) Russian olive fruit production in shelterbelt and riparian populations in Montana. Ecological Restoration 32:354-357.
Federal Register (1995) Final rule determining endangered status for the southwestern willow flycatcher. USDI-FWS, 50 CFR Part 17, RIN 1018 AB97 Federal Register, vol 60, no 38, pp 10694–10715. http://ecos.fws.gov/docs/federal_register/fr2790.pdf. Accessed May 8, 2015
Federal Register (2013) Designation of critical habitat for southwestern willow flycatcher. USDI-FWS, 50 CFR Part 17. http://www.gpo.gov/fdsys/pkg/FR-2013-01-03/pdf/2012-30634.pdf. Accessed May 8, 2015
Fischer RA, Valente JJ, Guilfoyle MP, Kaller MD, Jackson SS, Ratti JT (2012) Bird community response to vegetation cover and composition in riparian habitats dominated by Russian olive (*Elaeagnus angustifolia*). Northwest Science 86:39–52.
Follstad Shah JJ, Harner MJ, Tibbets TM (2010) *Elaeagnus angustifolia* elevates soil inorganic nitrogen pools in riparian ecosystems. Ecosystems 13:46–61.
Friedman JM, Auble GT, Shafroth PB, Scott ML, Merigliano MF, Freehling MD, Griffin ER (2005) Dominance of non-native riparian trees in western USA. Biological Invasions 7:747–751.
Friesen KM, Johnson GD (2013) Evaluation of methods for collecting blood-engorged mosquitoes from habitats within a wildlife refuge. Journal of the American Mosquito Control Association 29:102-107.
Ghekiere J (2008) A Russian olive perspective. Marias River Watershed Newsletter Summer 2008:2.
Hayes LM, Horn C, Lyver POB (2008) Avoiding tears before bedtime: how biological control researchers could undertake better dialogue with their communities. Pages 376–383 *in* Proceedings of the XII International Symposium on the Biological Control of Weeds. Wallingford, UK: CAB International.
Hansen NE (1901) Ornamentals for South Dakota. South Dakota Bulletin 72:117–123.
Hendricks P, Lenard S, Vance L (2012) Bat activity in riverine stands of native plains cottonwood and naturalized Russian olive in southeastern Montana. Intermountain Journal of Sciences 18:65.
Hubbard JP (1987) The Status of the Willow Flycatcher in New Mexico. Report to New Mexico Department of Game and Fish. Santa Fe, NM. 29 p.
Hultine KR, Belnap J, van Riper III C, Ehleringer JR, Dennison PE, Lee ME, Nagler PL, Snyder KA, Uselman SM, West JB (2010) Tamarisk biocontrol in the western United States: ecological and societal implications. Frontiers in Ecology and the Environment 8:467–474.
Hultine KR, Dudley TL, Koepke DF, Bean DW, Glenn EP, Lambert AM (2014) Patterns of herbivory-induced

mortality of a dominant non-native tree/shrub (*Tamarix* spp.) in a southwestern US watershed. Biological Invasions DOI: 10.1007/s10530-014-0829-4 (published online: 14 December 2014)

Johnson RJ, Glahn JF (2005) European starlings and their control. Internet Center for Wildlife Damage Management. http://icwdm.org/handbook/birds/EuropeanStarlings.asp. Accessed May 8, 2015

ITIS (2015) *Elaeagnus angustifolia* L. Integrated Taxonomic Information System on-line database. http://www.itis.gov. Accessed May 8, 2015

Jarnevich CS, Reynolds LV (2011) Challenges of predicting the potential distribution of a slow-spreading invader: A habitat suitability map for an invasive riparian tree. Biological Invasions 13:153–163.

Katz GL, Friedman JM, Beatty SW (2001) Effects of physical disturbance and granivory on establishment of native and alien riparian trees in Colorado, U.S.A. Diversity and Distributions 7:1–14.

Katz GL, Shafroth PB (2003) Biology, ecology, and management of *Elaeagnus angustifolia* L. (Russian olive) in Western North America. Wetlands 23:763–777.

Leary J, Mahnken BV, Cox LJ, Radford A, Yanagida J, Penniman T, Duffy DC, Gooding J (2014) Reducing nascent miconia (*Miconia calvescens*) patches with an accelerated intervention strategy utilizing herbicide ballistic technology. Invasive Plant Science and Management 7:164–175.

Lesica P, Miles S (2004) Beavers indirectly enhance the growth of Russian olive and tamarisk along eastern Montana rivers. Western North American Naturalist 64:93–100.

Lesica P, Miles S (2001) Natural history and invasion of Russian olive along eastern Montana rivers. Western North American Naturalist 61:1–10.

Lesica P, Miles S (1999) Russian olive invasion into cottonwood forests along a regulated river in north-central Montana. Canadian Journal of Botany 77:1077–1083.

McMillen B (2012) River of Time, Wyoming's Evolving North Platte River – Director's Cut for Wyoming PBS. http://www.icindie.com/riveroftime.html. Accessed May 8, 2015

McShane RR, Auerbach DA, Friedman JM, Auble GT, Shafroth PB, Merigliano MF, Scott ML, Poff NL (2015) Distribution of invasive and riparian woody plants across the western USA in relation to climate, river flow, floodplain geometry and patterns of introduction. Ecography doi: 10.1111/ecog.01285 (published online: 28 March 2015)

Mineau MM, Baxter CV, Marcarelli AM, Minshall GW (2012) An invasive riparian tree reduces stream ecosystem efficiency via a recalcitrant organic matter subsidy. Ecology 93:1501–1508.

Mineau MM, Baxter CV, Marcarelli AM (2011) A non-native riparian tree (*Elaeagnus angustifolia*) changes nutrient dynamics in streams. Ecosystems 14:353–365.

Mineau MM (2010) The effects of Russian olive (*Elaeagnus angustifolia*) invasion on stream nitrogen cycling, organic matter dynamics, and food webs. Ph.D. dissertation. Pocatello, ID: Idaho State University. 122 p.

Mineau MM, Baxter CV, Marcarelli AM, Minshall GW (2008) Riparian tree invasion reduces invertebrate diversity, biomass, and secondary production in a desert spring stream. http://scholar.google.com/citations?view_op=view_citation&hl=en&user=VI8mCeQAAAAJ&cstart=40&citation_for_view=VI8mCeQAAAAJ:3fE2CSJIrl8C. Accessed May 8, 2015

Montana Audubon (2010) Russian olive fact sheet, July 2010. http://mtaudubon.org/issues/hot/documents/Russian_Olive_FACT_Sheet_9-2009.pdf. Accessed May 8, 2015

Montana Native Plant Society (2008) Petition to place Russian olive (*Elaeagnus angustifolia*) on the Montana statewide noxious weed list as a Category 4 – watch list species. Online: http://mtaudubon.org/issues/hot/documents/Russian_olive_Petition_2008.pdf

Moran VC, Hoffmann JH, Olckers T (2003) Politics and ecology in the management of alien invasive trees: The pivotal role of biological control agents that diminish seed production. Pages 434–439 *in* Proceedings of the XI International Symposium on the Biological Control of Weeds. Canberra, Australia: CSIRO Entomology.

Olson TE, Knopf FL (1986) Naturalization of Russian-olive in the western United States. Western Journal of Applied Forestry 1:65-69.

Parsons J (2010) Neighbors team to control Russian olive. University of Wyoming Extension Publication Barnyards & Backyards Summer 2010: 5–6.

Pearce CM, Smith DG (2009) Rivers as conduits for long-distance dispersal of introduced weeds: example of Russian olive (*Elaeagnus angustifolia*) in the Northern Great Plains of North America. Pages 231–240 *in* Van Devender TR, Espinosa-Garcia FJ, Harper-Lore BL, Hubbard T, eds. Invasive Plants on the Move: Controlling Them in North America. Tucson, AZ: Arizona-Sonora Desert Museum.

Pendleton RL, Pendleton BK, Finch D (2011) Displacement of native riparian shrubs by woody exotics: effects on arthropod and pollinator community composition. Natural Resources and Environmental Issues 16:1–11.

Pretty Paint-Small V (2013) Linking Culture, Ecology and Policy: The Invasion of Russian-olive (*Elaeagnus angustifolia* L.) on the Crow Indian Reservation, South-central Montana, USA. Ph.D. dissertation. Fort Collins, CO: Colorado State University. 94 p.

Reichard SH, Hamilton CW (1997) Predicting invasions of woody plants introduced into North America. Conservation Biology, 11:193–203.

Reynolds LV, Cooper DJ (2010) Environmental tolerance of an invasive riparian tree and its potential for continued spread in the southwestern U.S. Journal of Vegetation Science 21:733–743.

Rindos E, Galli-Noble E, Bockness S, Ganguli A (2014) Final Report: Innovative Conservation Approaches to Invasive Plant Management in the Missouri River Watershed: From Invasive Species Prevention and Control, to Biomass Utilization and Bioenergy Generation. Center for Invasive Species Management, Montana State University, Bozeman, Montana. http://www.weedcenter.org/cig/docs/CIG%20Final%20Report_reduced.pdf. Accessed May 8, 2015

Rundel PW, Dickie IA, Richardson DM (2014) Tree invasion into treeless areas: mechanisms and ecosystem processes. Biological Invasions 16:663–675.

Schaffner U, Asadi G, Chetverikov P, Ghorbani R, Khamraev A, Petanović R, Rajabov T, Scott T, Vidović B, Cristofaro M (2014) Biological Control of Russian olive, *Elaeagnus angustifolia*. Annual Report 2013. CABI Ref: VM10015, Issued May 2014. 23 p.

SERA - Syracuse Environmental Research Associates (2011a) Glyphosate—Human Health and Ecological Risk Assessment: Final Draft. SERA TR-052-22-03b. Atlanta, GA: USDA Forest Service. 313 p.

SERA - Syracuse Environmental Research Associates (2011b) Picloram—Human Health and Ecological Risk Assessment: Final Draft. SERA TR-052-27-03a. Atlanta, GA: USDA Forest Service. 277 p.

SERA - Syracuse Environmental Research Associates (2014) Preparation of Environmental Documentation and Risk Assessments for the USDA Forest Service. SERA MD-2014-02b. www.fs.fed.us/foresthealth/pesticide/risk.shtml. Accessed April 3, 2015.

Shafroth PB, Auble GT, Scott ML (1995) Germination and establishment of the native plains cottonwood (*Populus deltoides* Marshall subsp. *monilifera*) and the exotic Russian-olive (*Elaeagnus angustifolia* L.). Conservation Biology 9: 1169–1175.

Sheley RL, Mullin BH, Fay, PK (1995) Managing riparian weeds. Rangelands 17:154–157.

Sing SE, Delaney KJ (2015) Stakeholder perceptions: biological control of Russian olive (*Elaeagnus angustifolia*). Pages xxx-xxx *in* Proceedings of the 3rd Invasive Species in Natural Areas Conference. Morgantown, WV: USDA Forest Service Forest Health Technology Enterprise Team, FHTET-2015-xx.

Smith DM, Finch DM, Hawksworth DL (2009) Black-chinned hummingbird nest-site selection and nest survival in response to fuel reduction in a southwestern riparian forest. The Condor 111:641–652.

Stanley MC, Fowler SV (2004) Conflicts of interest associated with the biological control of weeds. Pages 322–340 *in* Proceedings of the XI International Symposium on Biological Control of Weeds. Canberra,

Australia: CSIRO Entomology.
Stannard M, Ogle D, Holzworth L, Scianna J, Sunleaf E (2002) History, Biology, Ecology, Suppression and Revegetation of Russian-olive Sites (*Elaeagnus angustifolia* L.). USDA, NRCS Plant Materials Technical Note No. 43. 14 p.

Sterling T, Bockness S, Galli-Noble E (2014) Montana State University and Missouri River Watershed Coalition National CIG Project. Webinar presentation to Missouri River Watershed Coalition October 27, 2014, MSU-Bozeman, Montana. https://montana.adobeconnect.com/_a833421023/p7kzg0lk40x/?launcher=false&fcsContent=true&pbMode=normal. Accessed April 22, 2015

Stoleson SH, Finch DM (2001) Breeding bird use of and nesting success in exotic Russian olive in New Mexico. Wilson Bulletin 113:452–455.

Taylor A (2013) "The Russians are coming! The Russians are coming!" Idaho State University Magazine Fall 2013:14-15.

Turner CE (1985) Conflicting interests and biological control of weeds. Pages 203-225 *in* Proceedings of the VI International Symposium on Biological Control of Weeds. Ottawa, ON: Agriculture Canada.

Tukpitsa A (2009) Photogrammetric Techniques for the Functional Assessment of Tree and Forest Resources in Khorezm, Uzbekistan. Ph.D. dissertation. Bonn, Germany: Rheinischen Friedrich-Wilhelms-Universität. 148 p.

Tuttle GM, Norton AP, Katz GL (2012) Russian olive (*Elaeagnus angustifolia*) impacts on soil N, light, and plant community structure in eastern Colorado. Page 123 *in* Proceedings of the 97th Annual Meeting of the Ecological Society of America.

USDA, NRCS (2015a) *Elaeagnus angustifolia* L. Russian olive. The PLANTS Database http://plants.usda.gov/core/profile?symbol=ELAN. National Plant Data Team, Greensboro, NC 27401-4901 USA. Accessed April 6 2015

USDA, NRCS (2015b) Riparian restoration in the Big Horn Basin. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/wy/newsroom/stories/?cid=nrcs142p2_027418. Accessed April 22, 2015

van Riper III C, Paxton KL, O'Brien C, Shafroth PB, McGrath LJ (2008) Rethinking avian response to *Tamarix* on the lower Colorado River: a threshold hypothesis. Restoration Ecology 15:155–167.

Vance LK (2005) Watershed Assessment of the Cottonwood and Whitewater Watersheds. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, MT. 57 p.

Vance L, Stagliano D (2007) Watershed Assessment of Portions of the Lower Musselshell and Fork Peck Reservoir Subbasins. Report to the Bureau of Land Management, Montana State Office. Montana Natural Heritage Program, Helena, Montana. 41 p.

Vance L, Stagliano D, Kudray GM (2006) Watershed Assessment of the Middle Powder Subbasin, Montana. Report to the Bureau of Land Management, Montana State Office. Montana Natural Heritage Program, Helena, Montana. 61 p.

Warner KD (2016) Reframing the social values questions that underlie invasive plant conflicts: issues to consider for Russian olive. Pages xxx-xxx *in* Proceedings of the 3rd Invasive Species in Natural Areas Conference. Morgantown, WV: USDA Forest Service Forest Health Technology Enterprise Team. FHTET-2016-xx.

Warner KD (2013) Public engagement with biological control of invasive plants: the state of the question. Pages 340–345. *In* Proceedings of the XIII International Symposium on Biological Control of Weeds. Morgantown, WV USA: USDA Forest Service Forest Health Technology Enterprise Team. FHTET-2012-07.

Warner KD, McNeil JN, Getz C (2008) What every biocontrol researcher should know about the public. Pages 390–394 *in* Proceedings of the XII International Symposium on Biological Control of Weeds. Wallingford, U.K.: CAB International.

Wilson R, Bernards M (2009) Weeds of Nebraska: Russian Olive Biology, Identification, Distribution, Control. University of Nebraska-Lincoln Extension Publication EC167. 6 p.

Zelitch J (1970) The Lakota Sun Dance. Expedition 13:17-23.

Zouhar K (2005) *Elaeagnus angustifolia*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/plants/tree/elaang/all.html.

Sing, S.E. and K.J. Delaney. Current Knowledge and Attitudes: Russian Olive Biology, Ecology and Management, pp. 42–62. *In:* Schwarzländer, M. and J.H. Gaskin, Eds. 2014 Proceedings of the 3rd Northern Rockies Invasive Plants Council Conference February 10-13, 2014. Airway Heights, WA. USDA Forest Service, Forest Health Technology Enterprise Team, Morgantown, West Virginia. FHTET-2016-03. 189 pp.