RMRS Invasive Species Program Taxonomic Group Focus Areas

I. Plants

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Exotic plants dramatically impact natural communities and disrupt ecosystem services (Mack and others 2000). Although the bulk of current impacts are caused by relatively few exotic species, many additional exotics that are currently established at low levels are increasing in density and distribution and present substantial imminent threats. Additionally, new exotic plants will likely continue to be deliberately and accidentally introduced, which represents a potential pool of new invasive species. Managers have responded to the threat of invasive species in wildlands with a significant increase in the use of current management tools. However, many of the tools now being applied to wildland exotic plant management, such as herbicides and classical biocontrol, originated in intensive agricultural systems and are proving to be more challenging to apply over large areas in complex ecosystems (Pearson and Ortega 2009). Finally, exotic plant invasions are commonly exacerbated by disturbances such as wildfires, timber harvest, road building, burning, and grazing by livestock and native herbivores. The combined effects of multiple and interacting disturbances on populations of exotic plant species, especially in the face of projected climate change, are uncertain but potentially severe (Sieg and others 2010). Our National Grasslands are particularly threatened by invasive plants. Large areas of native grasslands are juxtaposed to intensive agricultural systems that serve as an almost continuous source of new invasive plants. Further, plant species widely sown as forage for livestock or roadside stabilization are invading native grasslands and adversely impacting wildlife habitat and overall biodiversity. Thus, extensive research is needed in all aspects of exotic plant invasions in the Intermountain West.

(1) Prevention. Given the continuing introduction of new invasive plants and expansion of current species, it is important to identify which new species present significant threats and which communities are most susceptible to invader impacts. This requires assessing both the causes of invasion, such as the attributes that determine invader establishment and success, and the conditions that determine community susceptibility. RMRS scientists are conducting research to identify attributes of successful plant invaders (Sieg and others 2003; Sutherland 2004; Pearson and others in press; Ortega and others in press), evaluating biotic and abiotic factors that affect invasion into native communities by notorious invaders such as cheatgrass *(Bromus tectorum)* (Chambers and others 2007; Gundale and others 2008) and spotted knapweed (*Centaurea stoebe*; Ortega and Pearson 2005; Ortega and others in press; Pearson and others ongoing). One study is systematically sampling invaders across grasslands over a 40,000 km^2 areas in the native range of Turkey and the invaded range of Montana to examine the causes of invasion for over 20 species and quantitatively rank all invaders in the native range according to distribution and impact (Pearson and others ongoing). Station scientists and collaborators are also examining how disturbances such as wildfires (Smith and others 2009b; Dodge and others 2008; Kuenzi and others 2008; Zouhar and others 2008; Fornwalt and others 2010) and management activities such as timber harvest (Wienk and others 2004; Sabo and others 2009; Wacker and Butler ongoing), salvage logging (Fornwalt ongoing), fuels treatments (Zouhar and others 2008; Owen and others 2009; Fornwalt ongoing), prescribed fire, and roads (Fowler and others 2008, Birdsall and others 2011) affect exotic plant invasions. Work is also underway to evaluate how community response to disturbance (resiliency) relates to community invasibility (Pearson and others ongoing). Recent studies are also revealing how biotic resistance from higher trophic levels may help prevent invasions (Pearson and others 2011 and ongoing). An important area for future research is developing strategies for locating and monitoring intact systems in order to target them for protection from invasion.

(2) Early Detection and Rapid Response. To reduce the spread and impact of invaders, it is necessary to understand how invaders disperse, determine where they are likely to establish and spread, develop monitoring protocols to detect new invasions, and create tools to rapidly control new populations. A priority in this regard is identifying non-invaded or little-invaded areas that can be protected from invasions. Thereafter, early detection provides the only real opportunity to locally eradicate new populations of invasives; however, because these new populations tend to grow exponentially, the window of opportunity is brief. RMRS staff are developing bioclimatic models to prioritize areas for preventing the spread of invaders (Warwell ongoing) and strategies for monitoring exotic species presence in Forest Inventory plots (Rudis and others 2006), on Forest Soil Disturbance monitoring plots (Page-Dumroese and others 2009a and 2009b), and on rangelands (Anderson and others 2004). Station scientists are examining the role of roads, trails, and canyons as dispersal corridors for new invaders (Butler ongoing; Fowler ongoing); assessing the role of native species in dispersing spotted knapweed seeds (Sutherland ongoing); and developing management tools, including herbicide application protocols for eradication of cheatgrass (Sutherland ongoing) and sickleweed (*Falcaria vulgaris*; Butler ongoing) and community-based action programs to control yellow starthistle (*Centaurea solstitialis*; Pendleton and Pendleton ongoing; Meyer ongoing). Although important research is currently underway on Early Detection and Rapid Response, we need more work in this area. In particular, there is a need for research that establishes the economical value of preventing invasions from expanding compared to managing and mitigating them once widely established. Currently, not enough research and management effort is put into addressing new invasions before native populations and communities are impacted. There is also a need for more spatial modeling research to prioritize areas for protection and additional work to develop methods for monitoring and eradicating new invasions. Finally, there is a need to develop remote sensing techniques such as aerial surveys to advance detection strategies.

(3) Control and Management. Once strong invaders become widespread, few tools can effectively suppress them over large regions. Moreover, because the ecosystems are so complex, the tools can sometimes result in unintended consequences such as when non-target species are affected or the target weed is replaced by another weed (Pearson and Ortega 2009). Thus, research is required to identify the circumstances where management intervention is appropriate, improve the effectiveness of current management tools, develop new tools, and refine the applications of weed management tools to maximize their effectiveness and minimize their side effects. RMRS scientists and collaborators help managers apply ecological concepts to the management of grass invasions (D'Antonio and others 2009) and are conducting experiments to better understand resistance to and persistence of invasions (McGlone and others in press). Station scientists are examining how plant community composition changes in response to invasion by saltcedar (*Tamarix* spp.; Johnson and others 2009), and leafy spurge (*Euphorbia esula*; Butler and Cogan 2004) and spotted knapweed (Ortega and Pearson 2005), as well as studying effects of invaders on system processes (Nosshi and others 2007; Butler ongoing; Chew ongoing) and animals (Ortega and others 2006; Pearson 2009, 2010; Finch ongoing) to determine required mitigation. Scientists are working to advance weed biocontrol by advocating for comprehensive support of biocontrol that includes more complete and formal evaluations of introduction outcomes (Maron and others 2010). They are working on biocontrol of cheatgrass using native fungal pathogens (Meyer and others 2008a, 2008b; Beckstead and others 2010; Pendleton ongoing), developing new biological control agents for other terrestrial and aquatic plants (Magana ongoing; Markin ongoing), evaluating the efficacy and safety of biological control agents for leafy spurge (Butler and others 2006; Wacker and Butler 2006), spotted knapweed (Pearson and others 2000; Pearson and Callaway 2003, 2005, 2006, 2008; Ortega and others 2004, 2006; Sturdevant and others 2006; Pearson and Fletcher 2008; Ortega and others in press; Pearson and others ongoing), and yellow starthistle (*Centaurea solstitialis*) (Birdsall and Markin 2010). They are also evaluating the efficacy of herbicides (Butler 1994; Crone and others 2009; Ortega and Pearson 2010, 2011) and cattle grazing for weed control (Medina ongoing), and conducting economic assessments to prioritize areas and resources for managing invasions (Jones ongoing). RMRS scientists are conducting numerous studies to determine the effects of management activities, including fire, Burned Area

Recovery treatments, fuels treatments, and timber harvest (Zouhar and others 2008; Butler ongoing; Landres ongoing; Pendleton and Pendleton ongoing; Smith and others ongoing) on invasions.

(4) Rehabilitation and Restoration. The primary challenge in rehabilitating or restoring a site lies in identifying and reestablishing altered structural and functional components of the impacted community. Little is known about how the severity of ecosystem alterations impacts long-term sustainability, especially with regards to climate change. Even less is known regarding the restoration (requiring extensive management inputs)–rehabilitation (requiring intensive inputs) thresholds, or how they may change with time. Research is required to prioritize systems for restoration or rehabilitation, identify the residual effects of invaders following successful suppression, quantify the extent to which natural successional processes may restore systems, develop guidelines and approaches for reintroducing and reestablishing native species, and prevent re-infestation of the original invader(s) and secondary invasions. RMRS scientists are conducting research to quantify the effectiveness of various control measures at restoring native plant and animal communities and natural processes (Finch and others 2006; Smith and others 2006a, b, 2009a; Bateman and others 2008, 2009; Butler and Wacker 2010; Ortega and Pearson 2010, 2011; Finch and others in review; Chung ongoing; Collins-Merritt ongoing; Ortega and others ongoing) and to understand and prevent reinvasion and secondary invasion following weed control (Ortega and Pearson 2010, 2011; Pearson and others ongoing; Shaw ongoing). RMRS scientists are developing native seed mixes for seeding following exotic plant control and other management activities (Callaway and others ongoing), assessing the effectiveness of seeding in curtailing exotic species invasions following wildfires (Fornwalt 2009; Stella and others 2010; Peppin and others 2010), developing sources for native seed mixes (Butler ongoing; Shaw ongoing), and developing native seed propagation protocols (Meyer ongoing). Work is also being done to identify and propagate weed resistant genotypes of native species for use in restoration (Sutherland and others ongoing). Molecular markers are being used to determine historical population structure of plant species and inform target conditions for restoration (McArthur ongoing). Scientists are exploring how soil microorganisms affect shrub establishment in the presence of cheatgrass (Pendleton and others 2007), as well as the effect of herbicides used to treat cheatgrass on shrubs and associated mycorrhizae (Owens and others 2011). Research is also underway to understand human perspective on exotic plant management and restoration work (Raish ongoing). RMRS scientists have made a good start in the area of restoration research, but much more work is needed in developing restoration techniques, such as reseeding, and in understanding the factors inhibiting restoration, such as soil transformations and secondary invasions (Pearson and Ortega 2009; Pearson and others ongoing).

RMRS scientists have developed several important websites (see also Table 2) to help communicate research results to customers related to these overall products (RMRS Invasive Species Working Group http://www.rmrs.nau.edu/invasive_species//), the ecology of biological invasions and their management (Pearson and Ortega, http://www.fs.fed.us/rm/wildlife/invasives/), and leafy spurge management (Butler, http://www.team.ars.usda.gov/). RMRS is also providing information on interactions between fire and exotic plants through literature reviews of more than 100 invasive plant species in the Fire Effects Information System (http://www.fs.fed.us/database/feis/plants/weed/weedpage.html) and is informing managers on a national scale through a “Rainbow Series” literature review on fire and exotic plants (http://www.fs.fed.us/fmi/products/Zouhar_et_al_2007.html, and Zouhar and others 2008). Quantitative analysis of knowledge gaps, such as that regarding fire and exotic plants (http://www.fs.fed.us/fmi/products/Zouhar_et_al_2007_pdfs/Chap12.pdf), can provide guidance for future research in the Intermountain West and nationally.

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