Component II: Protection of Agricultural and Horticultural Crops

2a. Rangeland/Pasture and Arid Land Crops (U.S. Value 2007: $103 billion)

***Problem Statement*:** Our Nation's grass and shrub lands, including range, pastures, hay and turf lands, provide forages, open spaces and ecological services that contribute significantly to our agricultural, environmental, economic, and social well-being. Forage-livestock systems are the foundation of an animal industry that contributes more than $90 billion in farm sales annually to the United States economy. The estimated value of production from the 61 million acres of land providing grass and alfalfa hay is $13.5 billion. Rangeland, pasture, and forages together comprise about 55 percent of the total land surface of the United States, about a billion acres. Privately owned lands comprise about 45 percent of this total, or about 640 million acres. Rangeland, pasture and arid lands do not produce optimum yields and quality due to the following gaps in the biology, ecology and integrated management approaches for invasive and noxious weeds and destructive insects:

- Growth and Development of Perennial Weeds
- Delayed Response to New Invasions That Can Result in a Long Term Pest Problem
- Restoration of Invaded Sites
- Biological Control of Perennial Weeds
- Outbreaks of Grasshoppers and Mormon Crickets

***Research Needs*:**

1. **Growth and Development of Perennial Weeds**

   Importance: Leafy spurge and Canada thistle are noxious perennial weeds in many temperate regions of North America. In four northern Plains states, leafy spurge causes an estimated $130 billion in damage by reducing cattle carrying capacity on rangeland and is displacing an endangered plant species. White top or hoary cress is another widely distributed threat to rangelands, croplands and riparian habitats and has been declared a noxious weed in 14 United States and three Canadian provinces. Hawkweeds, recent invaders in the western United States that adapts to pastures, hayfields and a wide variety of other habitats, are expanding their range at about 16 percent per year. Canada thistle is widely distributed and is invasive in many ecosystems.

   Research Gaps: For most weed species the key biological characteristics governing reproduction, dispersal, and establishment need to be described and the

mechanisms, pathways, and factors that control their expression need to be defined and clarified. Long-term genomics research is needed to understand weedy characteristics and the growth and development of noxious and invasive weeds.

Actions: ARS will:

Control, Fundamental Biology

- Define and clarify biological factors, mechanisms, and pathways that regulate reproduction and dormancy in vegetative propagules of perennial weeds needed to enhance biologically-based weed management.
- Define and clarify biological factors, mechanisms, and pathways that regulate seed development, dormancy and germination in weeds needed to manipulate the production and destruction of weed seeds.

2. Delayed Response to New Invasions and Pest Outbreaks

Importance: Canada thistle, leafy spurge, and other established invasive weeds continue to impact the productivity of rangelands and the stability of associated natural areas. Newly introduced invasive weeds, if not rapidly controlled, will exacerbate the problems associated with established invasive weeds. Organic ranchers and farmers identified better weed and pest management as a top research need. Dependable, fast-acting, environmentally safe natural herbicide formulations for weed management are needed for a comprehensive, biologically based IPM program designed to control pests in rangeland and associated natural areas.

Research Gaps: A number of microbially produced phytotoxins have been identified and characterized, several of which have modes of action that are different from currently available synthetic herbicides. In addition, several microbial products with surfactant qualities have been isolated and described. In a number of cases, the potential for use of these natural compounds either alone or in combination for the control of weeds in agricultural systems has not been fully evaluated.

Actions: ARS will:

Control, Natural Herbicides and Formulations

- Identify genes involved in the regulation of microbially produced phytotoxins and develop methods to utilize that knowledge to enhance phytotoxin production to levels that meet commercial production needs.
- Develop formulations of natural herbicide and natural surfactant combinations and assess their efficacy on the major weeds of agricultural production systems and natural areas.

3. Restoration of Sites Degraded By Perennial Weed Infestation

Importance: Invasive species alter soil biological, chemical, and physical features and thereby native plant communities of rangelands. To return grazing lands to or maintain them at an economically viable level of productivity requires knowledge of the effects of weed infestations on biotic properties of soils supporting these rangeland plant communities. The after-effects of weed control measures can include shifts in soil and rhizosphere microbial communities. If populations of species of fungi and bacteria that cause seedling diseases are stimulated by such control measures, reestablishment of native or other desirable forbs and grasses may be impaired. Strategies to improve restoration may require practices that mitigate deleterious plant pathogen inoculum levels.

Research Gaps: How the presence of invasive species alters soil biology and affects key orbs and grasses in rangeland plant communities has not been investigated in short and mixed grass rangelands. Additionally, the shifts in soil microbial community structure as a consequence of infestations of invasive weeds has not included identification of predominant fungal and bacterial species within such microbial communities and their effects on native and other desirable species. For example, insect herbivory occurring as a consequence of the release and establishment of insects for biological control can alter root physiology and rhizosphere microbial ecology, especially when root herbivory is involved. Identification and characterization of species that are favored by insect herbivory (or long-term residence) of invasive weeds would lead to more effective restoration programs for rangelands.

Actions: ARS will:

Control, Fundamental Biology

- Identify species in soil microbial communities that predominate as a result of weed invasion or after successful biological control and investigate their effects on native and other desirable species.

Control, Ecological Interactions

- Investigate the structure of soil and rhizosphere microbial communities associated with long-term infestations.
- Identify and test the effects of soilborne fungi and bacteria associated with insect root herbivory of perennial rangeland weeds.

4. Biological Control

Importance: Biological control is by consensus the primary tactic for managing exotic invasive perennial weeds on rangelands that are typically of low monetary

value but that provide significant ecological services. However, past and potential ecological risks associated with releases of too many agents and/or agents of low impact or effectiveness has made the release of fewer agents with documented higher impacts preferred. Most priority perennial rangeland weeds do not have insects among their most promising biological control agents, necessitating an increased emphasis on plant pathogens as biological control agents.

Research Gaps: Criteria for selecting sites to release biological control agents are not well established. Also lacking is an understanding of how microbes and microclimatic factors impact establishing insects used in weed biological control. Procedures for pre-release testing of the potential of new biological control agents, especially combinations of insects and pathogens, have not been developed. Studies in the native range of the target invasive weed species can aid the determination of the potential effectiveness of candidate agents by their effects on weed density.

Actions: ARS will:

Control, Biological

- Identify and test possible plant pathogens that may be synergistic in combination with insects that are priority candidates for biological control of perennial rangeland weeds.

- Determine the diversity of plant pathogens occurring in both the native and invaded ranges of target rangeland weeds.

5. Outbreaks of Grasshoppers and Mormon Crickets

Importance: Grasshopper and Mormon cricket outbreaks have plagued farmers and ranchers for centuries, competing with livestock, wildlife, and humans for food supplies. Grasshoppers cause the loss of an estimated $1.25 billion per year in forage in western U.S. rangelands and are often the dominant rangeland herbivore in terms of biomass and vegetation consumed. Grasshopper and Mormon cricket outbreaks on rangeland or Conservation Reserve Program (CRP) land can also pose a severe threat to adjacent cropland. Pesticides have historically been the primary tools used to combat outbreaks, with over 13 million acres of Federal land sprayed in the last major grasshopper outbreak. Increased public concern over non-target effects of pesticides, combined with high costs of spraying large areas, has made it imperative to develop new cost effective and environmentally sustainable management tactics. Of additional importance, grasshoppers may contribute to grassland health in ways that are of interest to Federal, state, and private land managers, as well as conservation organizations.

Research Gaps: Little is known about the mechanisms and factors that underlie grasshopper and Mormon cricket population dynamics and dispersal. Extensive

outbreaks are cyclical, but knowledge of how they are influenced by drought, food availability, predation, disease, climate change, and contemporary rangeland and agricultural practices is lacking. Further research on rangeland management approaches, including livestock grazing and fire, is needed. This research needs to be conducted in multiple ecosystems, as grasshoppers respond differently to grazing, fire, and weather in different ecosystems. To provide much-needed alternatives to pesticide control, research on cultural practices and development and enhancement of control with microbials will be critical. Finally, almost nothing is known about the influence of grasshoppers and Mormon crickets on grazing system sustainability, exotic plant invasions, and grassland restoration.

Actions: ARS will:

Control, Fundamental Biology

- Define biotic and climatic factors that influence the likelihood of outbreaks and migration to enhance predictions of when outbreaks and migration will occur.
- Analyze spatial orientation and dispersal in migrating grasshoppers and Mormon crickets.
- Determine the effects of rangeland management techniques such as livestock grazing, fire, and chemical control.
- Clarify how grasshoppers and Mormon crickets influence grazing system sustainability, grassland health, and the relationships between exotic and native grassland plants.
- Identify new, commercially acceptable microbial control agents and/or increase efficacy of existing agents to suppress outbreaks, especially as replacements for pesticides in environmentally sensitive areas.
- Define and clarify biological factors, mechanisms, and pathways that regulate locomotion, reproduction, and immunity to pathogens to enhance biologically-based grasshopper and Mormon cricket management.

***Anticipated Products*:**

- Increased applied and fundamental knowledge of seed dormancy, propagules for weed management, and other aspects of the weed vegetative reproductive biology in agroecosystems.
- Information on specific genes and gene-products involved in plant growth and development.
- Genomic resources for investigating biological characteristics of leafy spurge and Canada thistle.
- Knowledge of mechanisms by which microbial phytotoxin production can be modified to significantly increase yields.
- Knowledge of, and techniques for, the on-site production of natural herbicides.

- Recommendations for the selection and use of natural herbicides for the rapid control of invasive weeds in agricultural and natural areas.
- Characterization of soil and rhizosphere microbial community structure associated with perennial weed infestations of rangelands.
- Restoration practices that account for the accumulation of higher inoculum levels of plant pathogens and deleterious rhizosphere bacteria.
- Biological control agents for perennial weeds of rangelands including white top, leafy spurge and hawkweeds.
- Protocols for testing soilborne plant pathogenic synergists of insects released for the biological control of one or more target weed species.
- Increased applied and fundamental knowledge on the biology and ecology of crickets and grasshoppers.

Potential Benefits (Outcomes):

- Scientifically-based, cost-effective, environmentally-safe strategies for weed and insect management in rangeland agroecosystems.
- Preservation of rangeland and associated natural lands resulting from the rapid control of invasive plants.
- Reductions in crop losses to weed competition.
- Ecologically sound and economically beneficial methods of weed control that are compatible with organic and conventional production systems.
- New strategies and approaches for restoration of rangelands degraded by invasive species.

USDA ARS Resources:

- Invasive Insect Biocontrol and Behavioral Laboratory, Beltsville, Maryland
- Natural Products Utilization Laboratory, Oxford, Mississippi
- Northern Plains Agricultural Research Laboratory, Sidney, Montana
- Overseas Biological Control Laboratory, Montpelier, France
- Plant Science Research Unit, Fargo, North Dakota
- Sustainable Agricultural Systems Laboratory, Beltsville, Maryland