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The three-part mission of land grant universities encompassing teaching, research and extension, allows these institutions to provide tremendous service to the citizens of western states. As a faculty member and administrator at Utah State University, I work closely with citizen groups, and state and federal agencies who manage millions of acres of public lands. In Utah, we have more public land and fewer people than most states, and as such, much of our research and extension programs are focused on providing solutions to issues concerning the wise use of natural resources. We strive to find the balance between multiple uses of public lands, comparing development and extractive industries with recreational and aesthetic interests. Our goal is to enhance the value of public lands for all citizens. During the past decade, land-grant institutions have taken a leadership role in promoting the sustainable use of our natural resources by linking natural processes to systems of agriculture, rural development, water use, and energy development. Today I provide a few examples of this leadership where research and extension programs operating at Utah State University have improved the economy of our state and enhanced the aesthetic and recreational value of our public lands.

The first example epitomizes the use of natural processes to help alleviate water shortages for agriculture through the use of beaver, originally widespread throughout the mountains of Utah. Research conducted by Dr. Joe Wheaton and his colleagues at Utah State University has demonstrated that the reintroduction of beaver to watersheds in which they were extirpated, functions in much the same way as human-made dams in terms of storing and delivering water to cities and farms. As our climate warms and we move from snow to rainfall-dominated water regimes, the need for new approaches to water management has become apparent to our state water resources. Dr. Wheaton's research demonstrates that many small dams created by beavers in high mountain

meadows have the potential to delay stream flow from spring rains and recapture much of the water storage that formerly occurred in high-elevation snowfields. These beaver dam complexes work to slowly release water throughout the summer to surface water streams and ponds. The reduction of peak spring flows allows for increased late summer flows, helping grazing conditions for sheep and cattle and providing better habitat for fish and wildlife.

In addition to helping with our water resources issues, the addition of beaver to watersheds has improved groundwater supplies. These subsurface flows are especially important in delivering cooler water to streams in late summer where fish and other aquatic life have access to a broader range of thermal conditions. The re-introduction of beaver to stream systems in eastern Oregon and Washington has enhanced runs of endangered salmon in the Columbia River. The implementation of these research findings have resulted in a win for ranchers, a win for fish, and a win for ecosystems.

This type of creative water management program for the public lands combined with improved conservation of water resources in cities and farms can form the basis of Utah's water policy into the next few decades. The Center for Water Efficient Landscaping in USU's Extension program provides high-resolution, real-time data to help businesses and landowners reduce their water footprint. Municipalities and agricultural groups can use remote sensing data on water use to pinpoint and mitigate excessive waste. WaterMaps, a water management and planning software tool, was developed at Utah State University by Dr. Joanna Endter-Wada with funding provided by city and county governments. Last year this program conserved over 170M gallons of water at a cost savings of \$250,000. New funding from cities will allow this program to expand to a host of new municipalities.

The second example I describe concerns the work of our extension biologists to form citizen groups to help manage public and private lands for the conservation of sage grouse. Dr. Terry Messmer and his colleagues have worked for the past 20 years to help ranchers graze cattle in ways that do minimal harm to ground nesting birds. Sage

Grouse, a species of special conservation concern, benefits from these community coalitions. Sage grouse populations in Utah have increased by 20% during the past two decades, a period during which the species has declined in most other parts of its home range. Terry's research has demonstrated that rest-rotation grazing systems work best at improving habitat for both cattle and sage grouse. The higher vegetation profile and greater insect abundance in lands managed by rotational grazing result in successful recruitment of sage grouse. Dr. Messmer's extension program works with over 800 landowners to mark fences to improve survivorship for these birds. This sage grouse restoration program was recently awarded The Wildlife Society's Group Achievement Award for 2016. Terry is the science advisor to the Utah Governor's task force on sage grouse management and provided data that assisted the Department of Interior's decision to delay potential listing of the Greater Sage Grouse as an endangered species. Terry's work with communities to increase sage grouse populations has saved the citizens of Utah millions of dollars by allowing ranchers to continue their livelihoods while improving habitat for one of the iconic birds of sagebrush ecosystems. These community-based approaches promote locally effective conservation achievements compared to less effective top-down dictates.

Another critical issue for public lands management in the west concerns wildfire. During the past decade wildfires have burned almost 10 million acres annually, at a cost of over \$1B, and resulted in the need to restore and re-seed close to 2 million acres of land each year. Dr. Jim Lutz has conducted detailed measurements on forested lands that have experienced varying levels of fire intensity. His results indicate that the fire regime varies in predictable ways according to climate, vegetation type, and landscape attributes. We are just beginning to use these findings to establish a land management fire policy for our state that will reduce the probability of extensive high-severity burns. Fire policy also needs to include fuel removal. Jim's research is helping our state to prioritize lands for fuel reduction based on current condition of flammability and on increasing the likelihood that some areas within fire perimeters do not burn. These non-burn areas can provide refuge for animals and act as a seed source for the post-fire landscape. Part of preventing undesirable consequences of fire involves managing

human activity. Development planning, zoning policy, building codes and insurance regulations can help mitigate the costs and consequences of fire when it occurs. These fire prevention activities will help reduce the cost of fire suppression. It will take public and private cooperation to position Utah communities to live with the fire that will eventually come to our landscapes.

Finally, I describe an exceptional extension program that provides education and assistance to landowners to use best management practices to improve water quality. Many small farms in Utah include animal feeding and dairy operations. The use of animals in confined areas leads to environmental problems with stream erosion and degraded water quality. Professor Nancy Mesner helps agriculturalists come into compliance with water quality regulations and develop best practices for animal stream access and manure management. Nancy and her extension team work with the Natural Resources Conservation Service to help individual landowners understand the concerns related to water quality, and then help these farmers apply for and receive federal funding to implement required changes to the animal feeding operations. Frequently these involve manure-handling infrastructure and fencing to regulate animal access to streams. The success of these programs is documented in a monitoring program that Professor Mesner runs in association with the Utah Division of Water Quality. Nancy's extension program is the central node that links landowners, state agencies, and the federal government to improve the quality of Utah's water resources.

In summary, the land-grant universities provide tremendous service to the citizens of their states. In addition to county and local extension programs, the Universities provide research on the most pressing societal issues and work closely with extension programs to implement programs and policies resulting from research findings. In colleges of natural resources, we often focus on issues relating to the management of public lands. In our case, extension programs are directed to individual citizens, but also to the state and federal agencies that manage the public lands. The integration of applied research and extension programming makes the land-grant universities one of the most effective and efficient entities to improve the quality of life for all citizens.