RAMPS Objectives (in more detail)

RAMPS will provide scientifically credible research and management-relevant information in support of five primary objectives. These objectives are prioritized based on their need, the ability of RAMPS collaborators to conduct the research, and available RAMPS resources. Future objectives will be developed by RAMPS collaborators to meet growing research needs and as funding opportunities become available.

Objective 1) Synthesize restoration assessments and monitor results to identify best management practices for successful restoration in the arid conditions of the Southwest

Problem to be addressed: A major shortcoming of restoration is that practices are infrequently evaluated or monitored in a way that does not provide managers and practitioners with information that could enhance the effectiveness of subsequent restoration efforts. A synthesis of restoration outcomes has enormous potential to prevent failed approaches, which are often repeated, resulting in the expenditure of more time and resources (Clewell and Rieger, 1997). This integration includes consideration of unique biophysical conditions of the restoration site, economic costs, and climatic conditions following restoration and information on how the site was prepared, plant and soil materials used, and protocols executed on the ground to maximize restoration success.

RAMPS solution: We will synthesize scientific and management records of restoration treatments, including information on the location of the restoration site, practices used, and treatment outcomes. This information will come from from DOI monitoring programs (National Park Service/U.S. Fish and Wildlife Service Inventory and Monitoring Program, Bureau of Land Management Assessment, Inventory, and Monitory Strategy), the Land Treatment Digital Library (http://ltdl.wr.usgs.gov), scientific papers, management reports, field visits to monitoring plots, and other sources that document vegetation, soil, and associated ecosystem recovery. We will statistically evaluate standards for restoration success, identify where restoration treatment efforts have succeeded and failed, and determine the biophysical characteristics and management practices that led to those outcomes. Meeting this objective will provide managers with information on effective restoration practices for their disturbed sites.

Objective 2) Provide decision-support tools to inform when and where environmental conditions are likely to be suitable for restoration

Problem to be addressed: Revegetation and soil stabilization following land degradation are constrained by low and variable precipitation, extreme temperatures, high winds, and low soil fertility in dryland regions (Bainbridge 2007). These limitations make restoration efforts difficult and result in extremely low (often < 5%) success rates (Sheley and others 2011). Perennial vegetation can take decades to recover to pre-disturbance conditions and more time may be required to form pre-disturbance species assemblages and associated ecosystem properties (Webb and others, 1980; Abella, 2010; Munson and Lauenroth, 2012).

RAMPS solution: Environmental conditions limit restoration success in dryland regions, so we will develop tools to assess and describe the probability of success for specific seeding and/or planting operations based on climate and resource availability at the restoration site. For example, a RAMPS tool could assess the likely success of a seeding or planting operation in the current year based on near-term forecasts of climate and soil water conditions. The tool can quantify how soil water availability determines regeneration success for key, widely utilized restoration species and integrate this knowledge with existing drought forecast products. Meeting this objective will improve the probability of restoration success through an assessment of when resource availability is likely sufficient for plant germination and establishment, and decreases the probability that mangers will plant during times that are likely to result in failure.

Objective 3) Develop and disseminate information for deciding locally appropriate seed mixes and native plant materials

Problem to be addressed: A common reason restoration attempts fail in drylands is because they do not utilize locally suitable seed and plant materials. Plants that are poorly adapted to the environment in which they are seeded or planted cannot establish and persist and sustain a viable plant community. Furthermore, non-native species and cultivars are frequently used in restoration attempts with deleterious effects to diversity and ecosystem function. Managers require research and the delivery of information on suitable seed mixes and plant materials needed for effective restoration in the arid Southwest.

RAMPS solution: We will provide guidance on the availability and use of seed for local restoration efforts, including the identification of appropriate ecotypes to maximize restoration success. When possible, we will determine climatically suitable seed zones and use real-time inventory data to match available seed source to seeding site, leveraging off existing efforts such as the Bureau of Land Management's Native Plant Program, and aligning with the goals of the National Seed Strategy. We will also identify species that will be resilient at restoration sites under predicted climate regimes by determining their suitable climate space (area that has a climate in which a species can live) in the future. Meeting this objective will allow managers to identify appropriate seed sources and will provide guidance on where to source seed for local restoration projects.

Objective 4) Assess the benefits and outcomes of restoration practices relative to their financial costs

Problem to be addressed: Economic consideration of restoration efforts is of primary concern to management agencies that have limited resources. The amount of resources committed to restoration projects does not typically weigh the benefits versus the costs of a given restoration approach. Evaluation of the economic and ecological benefits of effective restoration treatments relative to the cost of implementation can help managers select viable restoration strategies.

RAMPS solution: We will use restoration market tools (e.g., Nelson and others, 2009) to evaluate the costs of planning, seed/plant materials, equipment, and time to conduct restoration practices relative to the benefits of ecosystem services provided. When possible, we will weigh the costs and benefits of implementing different treatments (e.g., seeding native vs. non-native plant species) and quantify the economic costs associated with restoration failures. Meeting this objective will allow managers to maximize restoration effectiveness by promoting the more efficient use of time and resources.

Objective 5) Create frameworks and tools that support monitoring of restoration treatments

Problem to be addressed: Restoration and rehabilitation treatments are frequently conducted to conform to environmental laws and regulations, but often lack an effective monitoring framework to determine if treatments have been successful in recovering desirable plant, soil, and ecosystem properties. Frameworks and tools that support restoration monitoring are critical to help inform adaptive management decisions, ensure that resources were effectively spent, provide early warning signs that indicate whether recovery is on track, and guide future restoration efforts.

RAMPS solution: We will help create frameworks and tools to support restoration monitoring activities in the Southwest. We will help managers and practitioners develop performance criteria to measure restoration success (including the provision of biodiversity and ecosystem services), assess departures in plant and soil conditions from baseline conditions, project future recovery trajectories, determine suitable sampling designs, and scale-up plot-based monitoring to the landscape-level. Meeting this objective will

ensure progress in planning and implementing restoration, and provide guidance on whether treatments were effective.

LITERATURE CITED

Abella, S.R., 2010, Disturbance and plant succession in the Mojave and Sonoran Deserts of the American Southwest: International Journal of Environmental Research and Public Health, v. 7, p.1248-1284.

Bainbridge, D.A., 2007, A guide for desert and dryland restoration: new hope for arid lands: Island Press, Washington, D.C., 416 p.

Clewell, A., and Rieger, J.P., 1997, What practitioners need from restoration ecologists: Restoration Ecology, v. 5, p. 350-354.

Munson, S.M., and Lauenroth. W.K., 2012, Plant community recovery following restoration in semiarid grasslands: Restoration Ecology, v. 20, p. 656-663.

Nelson, E., Mendoza, G., Regetz, J., Polasky, S., Tallis, H., Cameron, D.R., MA Chan, K., Daily, G.C., Goldstein, J., Kareiva, P.M., Lonsdorf, E., Naidoo, R., Ricketts, T.H., and Shaw, M.R., 2009, Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales: Frontiers in Ecology and the Environment, v. 7, p. 4-11.

Seager, R., and Vecchi, G.A., 2010, Greenhouse warming and the 21st century hydroclimate of southwestern North America: Proceedings of the National Academy of Sciences. v. 107, p. 21277–21282.

Sheley, R.L., James, J.J., Rinella, M.J., Blumenthal, D.M., and DiTomasso. J.M., 2011, A scientific assessment of invasive plant management on anticipated conservation benefits, *in* Briske, D.D., ed., Conservation benefits of rangeland practices: assessment, recommendations, and knowledge gap: Allen Press, Lawrence, KS, p. 291–335.

U.S. Census Bureau, 2015, Ten U.S. cities now have 1 million people or more; California and Texas each have three of these places: U.S. Census Bureau, accessed June 24, 2016, at http://www.census.gov/newsroom/press-releases/2015/cb15-89.html.

U.S. Census Bureau, 2016, Five of the nation's eleven fastest-growing cities are in Texas, Census Bureau Reports: U.S. Census Bureau, accessed June 22, 2016, at http://www.census.gov/newsroom/press-releases/2016/cb16-81.html.

Webb, R.H., and Wilshire, H.G., 1980, Recovery of soils and vegetation in a Mojave Desert ghost town, Nevada, USA: Journal of Arid Environments, v. 3, p. 291–303.