SER News

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Letter from SER Executive Director Bethanie Walder

Dear SER Members,

In June, SER's board and staff met outside of Yellowstone, Montana for our annual board meeting combined with a strategic planning retreat. In addition to the retreat, many of us arrived early for a field trip to learn about attempts to re-establish native vegetation in semi-arid ecosystems – the goal for all three sites we visited was/is to provide winter forage for wildlife.

The challenges we discussed and the approaches being tested (with varying levels of success) were broadly representative of the four main articles in this issue of *SERNews*, all of which address the theme of dryland restoration.

The sites we visited provided a good illustration of the complexities and challenges to ecological restoration in dryland ecosystems. As one of the articles in this issue of SER News points out, dryland restoration requires both a comprehensive understanding of such systems and a comprehensive approach to the projects. The articles in this issue come from the desert southwest of the United States, Kuwait and Africa. Our authors look at the diversity of challenges that arise in desert restoration, as well as a variety of approaches to solving those challenges, from cryptobiotic crust protection, to seed-based restoration, to using livestock as a restoration tool.

In the southwestern United States, for example, researchers are developing successful methods for cultivating and then transplanting cryptobiotic crusts – an approach that could rapidly increase the speed of dryland restoration.

The first article from Kuwait outlines the challenges for using seed-based restoration methods, and introduces a new model for identifying the successional state that target areas are likely to transition to. The second Kuwaiti article outlines how Ecological Preserves can protect dryland ecosystems, provide sites for experimental research, and perhaps most importantly, provide opportunities to educate the public about dryland ecology, protection and restoration.

The final thematic article in this issue of *SERNews* takes more of an agroecology approach. It discusses possible methods for using aggressive livestock management tools to restore forage damaged by an overabundance of termites. This article points out that, in some instances, livestock can be an important tool for restoring forage and agricultural productivity. And when agricultural productivity is maintained/sustainability is achieved, land degradation decreases.

Many thanks to all of the authors in this issue of *SERNews.* Thanks especially to SER Board Members Samira Omar and Swidiq Mugerwa for their contributions to this thematic discussion of dryland restoration. Samira was also kind enough to provide a broad, global context to the theme in her introduction on arid land restoration.

We would also like to thank SER Board Members Nancy Shaw and Dan Spencer for coordinating pre and post-meeting field trips in and around Yellowstone National Park in conjunction with SER's board/staff meeting and retreat. In addition to the pre-meeting field trip discussed above, we also had a post-meeting field trip to learn about how wolf reintroduction to Yellowstone has changed riparian vegetation.

The wolf field trip provided an interesting contrast to our pre-meeting excursion. While the first trip looked at human interventions and intensive management activities to remove invasive plants and restore native plants, the wolf trip considered the extirpation and then reintroduction of a native species and the cascading restorative effects on native plant communities, especially in riparian areas.

Together, the two trips made for interesting bookends to our retreat and helped provide a strong grounding for our work. A big thank you to Roy Renkin and Rick McIntyre from Yellowstone National Park, Tom Keck from the Custer Gallatin National Forest, retired plant materials specialist Larry Holzworth, and long-time SER member Pat Burke for their assistance with our field trips.

Roy Renkin of the Branch of Vegetation and Resource Operations at Yellowstone National Park leading us on a tour of four restoration sites in Yellowstone National Park. The sites are a part of an ongoing project to convert former agricultural lands from mixtures of Eurasian annual weeds and seeded crested wheatgrass (Agropyron cristatum) to mosaics of native plant communities capable of providing wildlife habitat.

Rick McIntyre, a Biological Technician for the Yellowstone Wolf Project, has been observing wolves in Yellowstone National Park every day since their reintroduction in 1995. Rick gave SER's board and staff a great history of the wolves in Yellowstone as we observed a pack outside their den from this spotting scope.

Spending two days in the field provided some additional benefits to our meeting. While the field trips led to some very interesting discussions about restoration, they also reminded us about the intrinsic values and benefits of this work, especially as we watched (through spotting scopes) the 8 pups and 10 adult wolves of the Junction Butte wolf pack playing, eating and relaxing around their den in the early morning sun. What an inspirational reminder of the extraordinary potential of ecological restoration!

Happy Reading,

Letter from SER Board Member Samira A.S. Omar

To the SER global family,

The past half-century has witnessed the conversion of some nine million km^2 of the world's arid lands into desert. This has affected the livelihoods of more than 100 million people around the world, resulting in increased poverty and migration to urban centers. Arid land ecosystems continue to experience pressure from growing populations and a changing climate, the effects of which are manifested as sand encroachment, frequent dust storms, soil erosion, degradation of vegetation cover, salinization, among several others. Nevertheless, these arid land ecosystems continue to be an important source for goods and services to a variety of users in the form of feed for livestock, shelter and refuge for wildlife, recreational opportunities, and preservation of cultural heritage. They also produce a number of globally important commodities and are a critical source of genetic diversity in wild crop relatives.

With an ever-increasing population, particularly among inhabitants of arid regions, more pressures are expected on land and water resources, which will undoubtedly contribute to more ecosystems degradation. Thus, there exists an urgent need for action to develop appropriate measures to restore dryland ecosystems. These challenges must be addressed in the context of ecological restoration and returning ecological functionality to these systems.

In the years to come, more research and innovations in science and policy will be needed to restore arid ecosystems. Earnest research efforts are currently underway around the world, some of which are included in the articles featured in this issue of *SERNews*. On the policy side, there has been increased interest in improving climate change policies that: reflect the needs of

arid region inhabitants, implement sustainable energy systems, improve livelihoods and reduce poverty and, most importantly, integrate ecosystem conservation/restoration values with economic policy. Although these solutions present major challenges in terms of widespread implementation, I am confident that global cooperation among stakeholders will make it possible to overcome any obstacles.

Sincerely,
Samira A.S. Omar
Board Member of SER

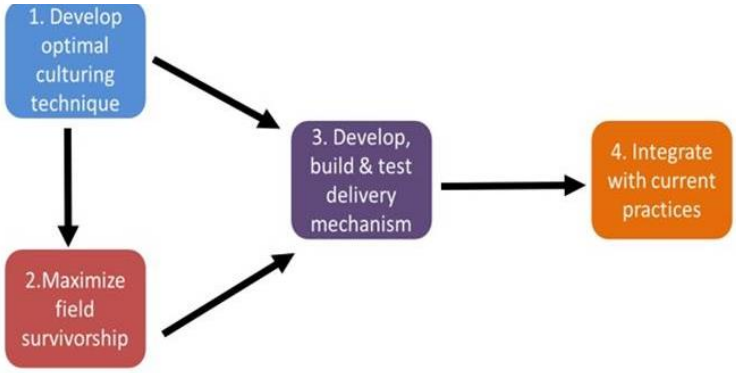
Samira Omar is the Director General of Kuwait Institute for Scientific Research (KISR) and Principal Research Scientist. She is a Board Member of the Society for Ecological Restoration.

Restoring the Living Skin of the Earth: Biocrusts in Dryland Restoration

Contributed by Kristina E. Young, Anita Antoninka, Peter F. Chuckran, Henry S. Grover, Kyle Doherty, and Matthew A. Bowker - Forest-Rangeland Soil Ecology Lab, Northern Arizona University, Flagstaff, Arizona, USA

An estimated 10-20% percent of drylands worldwide have been severely impacted by activities such as grazing, mining, agriculture, and energy development. Thus, critical ecosystem functions and components have been dramatically affected in these systems. Chief among them are biological soil crusts (biocrusts), the "living skin" of the Earth's drylands (Figure 1). Biocrusts are a community of lichens, mosses, algae, and cyanobacteria living on the top few millimeters of the soil surface. In dryland systems, biocrust can be the dominant ground cover, performing many important functions. By aggregating soil, biocrusts make sediment less erodible. Biocrusts also have a large influence over many ecosystem services, such as water infiltration, vascular plant establishment, and carbon and nitrogen cycling. Because biocrusts are so critical to dryland function, their inclusion in dryland restoration is necessary to return full ecosystem functioning to damaged drylands. In Dr. Matthew Bowker's Forestry-Rangeland Soil Ecology Lab at Northern Arizona University, our primary goal is to include biocrusts in the restoration picture. Here, we share our progress and plans for restoring biocrusts using the following approach: 1) Develop optimal culturing techniques; 2) Maximize field survivorship; 3) Develop, build and test field delivery mechanisms; and 4) Integrate techniques with current restoration practices.

Figure 1



1. Developing optimal culturing techniques

Numerous restoration projects have included the field collection and redistribution of biocrust organisms, with varying degrees of success. One of the biggest hurdles to successful biocrust restoration is moving away from field collections and redistribution, to culturing (cultivating) and increasing biocrust biomass *ex-situ*. Our first successes in this realm occurred with early successional biocrust community members, primarily cyanobacteria and green algae. Our approach has focused on culturing mosses, lichens and cyanobacteria, which has allowed us to culture the early successional members in concert with a broader swath of the functional groups in the community. Biocrust mosses promote soil aggregation, water capture and soil fertility. Lichens "armor" the soil against erosion and add soil fertility via photosynthesis and nitrogen fixation (Figure 2).

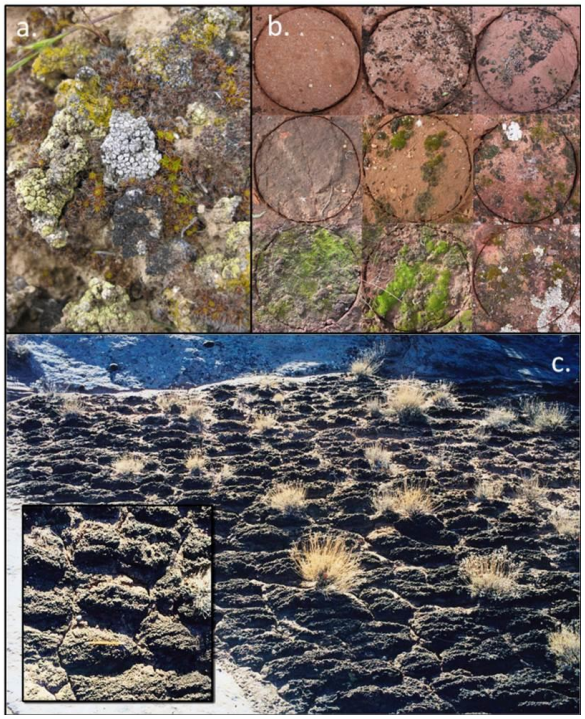


Figure 2: **a.** Biocrusts are composed of mosses, lichens, cyanobacteria, and other biota. **b.**abundance, composition, spatial pattern, and therefore, function of biocrusts differs among locations. **c.** In undisturbed drylands, biocrusts can cover the large majority of the soil surface.

We have successfully cultured several important dryland mosses in our greenhouse-based culture system. In our best treatments, we were able to build full biocrust communities, including mosses, light and dark cyanobacterial crusts and some lichens in just a few months (Figure 3). We measured chlorophyll (a proxy for biocrust activity) and N_2-fixation (common in some dark cyanobacteria and the photosynthetic component of some lichens). We found carbon and nitrogen fixation were high, and comparable to mature biocrusts in the field. In another experiment, we attempted to culture lichens and mosses, alone and in combination. In some experiments, we were able to culture certain moss species in only weeks. We successfully grew to culture the common, early-colonizing, nitrogen-fixing lichen, *Collema sp.*, increasing its growth by 400% in only four months. Perhaps even more interesting, all combinations of lichen and moss species grown with *Collema* did better than when grown alone. In current experiments we are attempting to culture other species of interest and optimize productivity by testing different soil substrates, and methods to enhance shade and humidity. Our findings to date suggest that culturing biocrust organisms is commonly possible, and sometimes very fast.

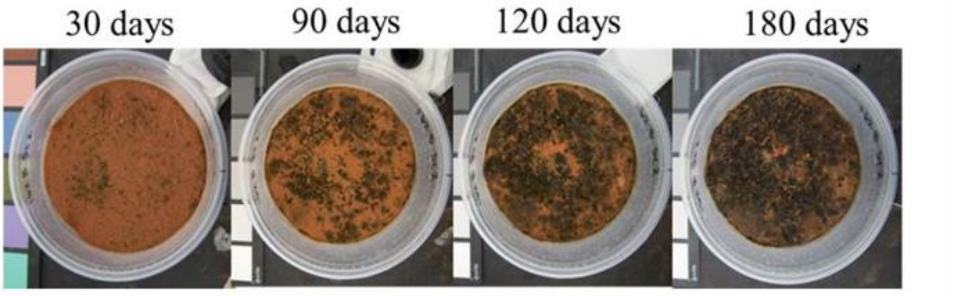


Figure 3. Photo series (in # of days) showing the growth of biocrust cultures started from moss fragments. Cultures grew into mature biocrusts - including all functional groups - in just a few months.

2. Maximizing Field Survivorship

The next step in developing a technology to use biocrusts as a restoration tool is to determine how to maximize field survivorship of cultured biocrusts. To better understand the factors contributing to the success of biocrust establishment and restoration in the field, we established an experiment at the Canyonlands Research Center in southern Utah in October of 2015. This study tests the benefits of using 'hardened' (as with nursery plants, we tested slow introduction of biocrusts to field conditions in an effort to maximize survival) or 'unhardened' greenhouse-grown biocrust inoculum paired with habitat modifications to reduce field stress, including watering and a jute cloth application. Preliminary results suggest that hardened, and temporary watering do not have an effect on early biocrust development. However, jute cloth has shown initial success in stabilizing the soil surface, potentially providing the groundwork for greater biocrust development. We plan to continue to monitor the success of these treatments, as these early results may not be proper indicators of long-term biocrust development.

Figure 4. Images of the greenhouse-field amelioration trials at the Canyonlands Research Center. Plots were inoculated with hardened or unhardened greenhouse grown biocrust, or not at all. a.) In experiment 1, inoculum was treated with combinations of no habitat amelioration, jute cloth and 2-weeks of watering. b.) In Experiment 2, inoculated and control plots were bordered with straw.

In a second experiment we tested methods used in China to successfully stabilize sand dunes using implanted straw borders. We had success enhancing biocrust development with a vertically implanted (~15 cm) straw border in an experiment in the Great Basin Desert, and are currently testing this method in conjunction with hardened or unhardened greenhouse grown inoculum at the Canyonlands Research Center (Figure 4).

To encapsulate the wide range of climatic conditions across drylands, we also set up two experiments in regions of the Southwestern United States dominated by monsoonal patterns, using field-collected and greenhouse-grown biocrusts. It appears the intensity of the monsoons have limited the success of our field applications thus far, implying more work to be done to ensure successful restoration in drylands across a wide variety of environments.

3 & 4. Delivery mechanisms and integrating with current practices

Even as we are refining production and field-readiness of biocrust restoration materials, we must think strategically about how this product might be used. Humans have been managing vascular plants on the landscape for millennia, but intentional management for biocrust is in its infancy. One strategy for advancing biocrust technologies is to adapt seed plant technologies already in use. Beginning in Fall 2016, in conjunction with MPG Ranch in Montana, we will adapt three existing seed dispersal technologies to fragments of moss plants: hand broadcast, shallow drill "seeding," and broadcast with imprinting. If such meso-scale efforts prove effective, potential larger-scale dispersal strategies might include aerial dispersal, or approaches analogous to hydro-seeding. Adaptation of seed technologies would allow for simpler integration of biocrust into the existing restoration framework. The current restoration, rehabilitation, and stabilization practice is largely built around introduction of desired vascular plants, removal of unwanted

organisms, and erosion control. Unpacking potentially complicated interactions between introduced biocrust and plant materials is a major information need, as are the synergies between physical erosion control and biological erosion control using biocrusts.

Conclusions

Understanding and restoring ecosystem function has never been more important than in this time of global change. Drylands are no exception. Through further work exploring cultivation practices, field reintroductions, delivery mechanisms, and integration with current practices, biocrust restoration may become an important component of dryland restoration. Indeed, groups around the world are currently working on a variety of different aspects of biocrust rehabilitation. Researchers in China have seen remarkable success in cultivating cyanobacteria on large scales, while researchers in Portugal are working towards using biocrust to restore eroding banks in reservoirs. The basic idea of biocrust restoration can also be applied to different ecosystem types, such as our work exploring moss restoration after fires in ponderosa pine forests as an emergency soil stabilization strategy. In the face of large-scale environmental change, biocrust restoration may be a tool to ensure resilient dryland communities. By spreading the word of biocrusts' importance to dryland systems, continuing collaborative research and working closely with land managers, large-scale rehabilitation of biocrusts may become an integral part of the future of dryland restoration.

Strategies for Restoring Arid Land Ecosystems in Kuwait

Scientists at the Kuwait Institute for Scientific Research (KISR) are working to develop strategies for restoring the highly degraded arid land ecosystems within Kuwait's borders. They are tackling the problem from multiple angles and coming up with creative solutions that may serve as international examples for restoration of dryland systems around the world. Below are two articles from KISR scientists that explain some of the theory, challenges, and techniques behind their efforts.

Native Plant Enhancement and Seed-based Restoration in Kuwait's Arid Environment

Contributed by Samira A.S. Omar, Narayana R. Bhat, and Faisal K. Taha - Kuwait Institute for Scientific Research, 24885 Safat, 13109, Kuwait

Most countries in the Middle East (ME) region, including Kuwait, have a hot, arid to hyperarid climate with an average annual precipitation of 70-140 millimeters (mm). Water demand is growing rapidly due to population growth, but the region lacks sustainable renewable natural water resources, making it the most water-stressed area in the world. According to both World Resources Institute and World Bank estimates, water resource availability in this region will shrink to less than half of the current level by 2035. The ME is also witnessing unprecedented land degradation and desertification caused by drastic reductions in perennial vegetation cover and ever-increasing pressure on the land from expanding human and livestock populations.

In general, desert ecosystems are fragile, have low biomass production, and are vulnerable to widespread deterioration from both natural and anthropogenic factors. While overgrazing is considered to be the primary cause of vegetation degradation in Kuwait and the region, other factors such as camping, agricultural expansion, off-road driving and industrial practices are contributing to continued deterioration of native vegetation. In addition, the Iraqi occupation of Kuwait and the military activities associated with the two Gulf Wars have inflicted severe damage on the natural environment. Native vegetation is an important source of sustainable benefits in the form of low-cost feed for livestock, genetically diverse sources of seed, and material for medicines, energy, and organic matter. In the ME region, native vegetation significantly reduces soil erosion by wind and water, and enhances infiltration of water into the soil. Since native plants of the ME endure extreme conditions of prolonged drought, high temperatures and soil salinity, they also serve as valuable gene pools for abiotic stress-tolerance research. In the sections below, we highlight some of the research and efforts underway to restore and conserve the native vegetation of Kuwait.

Plant Succession under Arid Conditions

In order to describe ecological succession in Kuwait's native plant communities, Dr. Samira Omar has proposed the Range Succession and State/Transition (RSST) model (Fig.1) The RSST model consists of seven states (boxes) and 16 transitions (arrows). The climax, or stable, perennial species occur at the upper levels of the model and hence, the range condition improves as systems move up the model. In contrast, at the lower levels of the model, annual species dominate (or the ground becomes denuded) and range conditions deteriorate. Natural occurrences (precipitation, drought, soil erosion and sand accumulation) and human-induced disturbance (e.g., logging of woody shrubs, camping, off-route vehicle use and grazing) cause changes in vegetation that can shift the succession states to lower levels.

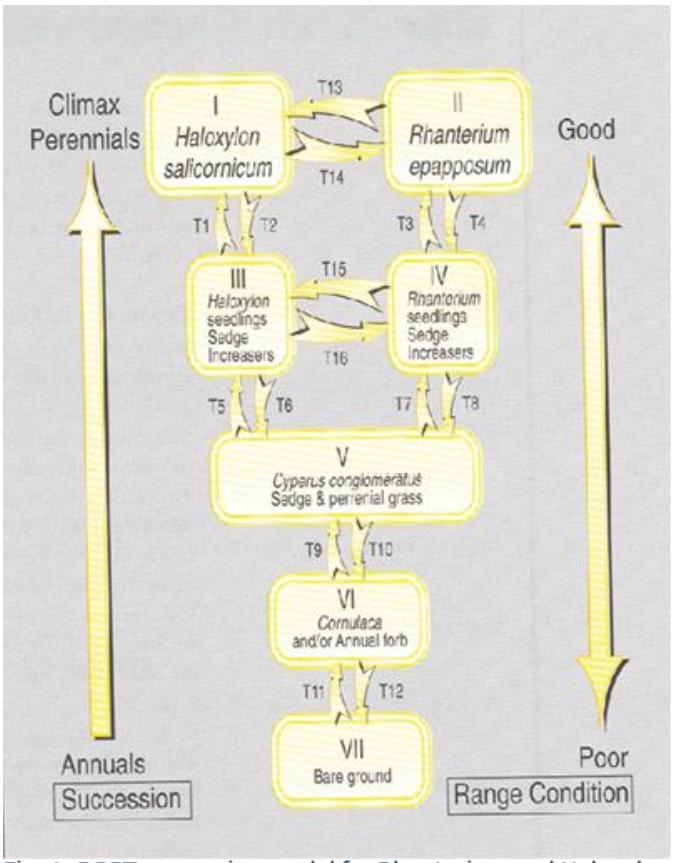


Fig. 1. RSST succession model for Rhanterium and Haloxylon community types: I-VII refer to successional stages; and T1-T14 refer to transitional periods (Source: Omar, 2000).

The RSST model can help identify and predict the successional state to which rangelands will transition under certain disturbance conditions, and an appropriate management strategy can then be developed using that information. For example, if a given rangeland system currently exists at State VI but managers wish to maintain it at State V, a reduction in livestock numbers may be sufficient to restore the native vegetation to the desired state. States I and II are of maximum conservation value for wildlife and habitat quality. In general, the overall period required for moving from State VII to State I or II will likely range from 20 to 30 years under intensive restoration/rehabilitation and above average precipitation.

Seed-Based Restoration of Kuwait's Native Vegetation

Since the native vegetation in most ME countries is severely degraded with several key species becoming extinct or endangered, there is an immediate need for restoration and subsequently adopting a sustainable management strategy that strikes the right balance between protection and use. An integrated rehabilitation strategy involving improvements in soil surface properties (ground roughening, creation of micro-catchments) and organic content, reseeding and transplanting keystone species, adopting precision seeding techniques, providing supplemental irrigation at initial stages of establishment, and efficiently managing herbivores will significantly accelerate the recovery process. Adequate precautions must be exercised while implementing these strategies to avoid unintended detrimental impacts. For example, application of excess irrigation water can lead to water logging and salinization under arid conditions.

Considering the urgency for developing effective strategies and scientific approaches to restore damaged arid ecosystems to their predisturbance condition, the Kuwait Institute for Scientific Research (KISR) has identified "Documenting Terrestrial Biodiversity and Developing Strategies for Degraded Ecosystems" as one of the main goals of the "Desert Agriculture and Ecosystems (DAE)" research program under the current strategic plan. The main purpose of these efforts is to restore/conserve, maintain, and sustainably utilize Kuwait's terrestrial biodiversity. Furthermore, scientists at KISR have undertaken a number of re-vegetation studies to rehabilitate areas impacted by military activities, oil pollution, gravel quarrying, off-road travel, and overgrazing. Seeds and acclimatized seedlings of native and naturalized plant species were used to re-vegetate these areas. Innovative irrigation systems were administered in the first two to three years to improve seed germination and seedling establishment. Vegetation assessments were conducted in re-vegetated, non-re-vegetated and reference sites to evaluate the success of these projects. The re-vegetation strategies employed in these projects were very effective in improving species richness, biomass production and recovery of keystone native species. Based on the findings of these studies, KISR recommends the following strategy for rehabilitating the region's degraded terrestrial ecosystems:

- Reduce or eliminate the causes of degradation (overgrazing, off-road travel, pollution, etc.).
- Initiate soil improvement processes (reduce soil erosion, improve soil organic matter and nutrient status).
- Undertake measures to improve microsite water availability and nutrient cycling (reduce runoff, improve soil infiltration capacity by pitting, ripping, terracing, establish microcatchments).
- Reduce detrimental ecosystem interactions while increasing synergies among ecosystem components (establish key species and ameliorate micro-environmental conditions, reduce interspecies competition, integrate soil, vegetation and landscape level strategies).

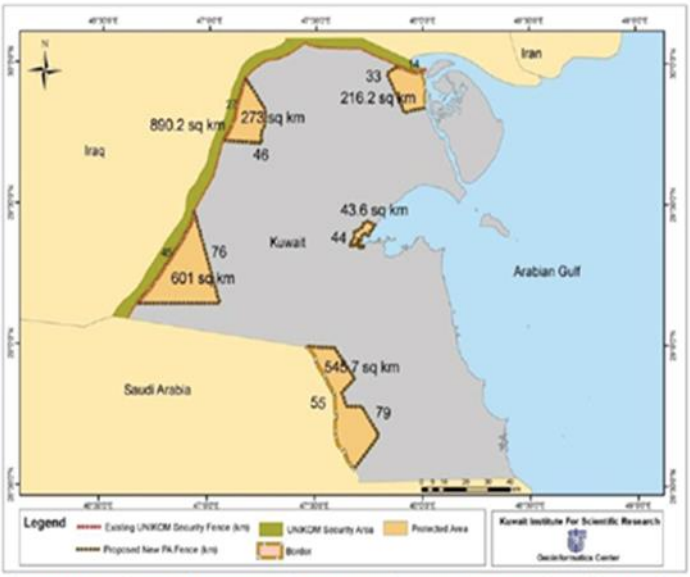


Fig. 2. Locations of proposed protected areas in Kuwait with total area (km2) and the approximate perimeter length (km) of each protected area.

The recommendations from these studies formed the basis for finalizing various claims under the United Nations Compensation Committee (UNCC) as a result of the Iraqi war and consequently paved the way for approval of significant financial, environmental awards to Kuwait. Now, several large-scale revegetation projects covering a total area of 1,659 square kilometers (km^2; 79.2 km^2 of active revegetation) are underway in Kuwait (fig. 2).

Establishment of Protected Areas for Restoring Native Plant Communities

In 1975, KISR fenced off approximately 20 km^2 of severely degraded land in southwest Kuwait, restricting livestock access and halting all detrimental activities. Perennial woody shrubs were absent or overgrazed in this area prior to the establishment of the exclosure. The recovery of shrub vegetation, especially *Rhanterium epapposum* was striking, with cover values for both shrubs and annuals exceeding 25% after nearly 40 years. In 2003, an additional 20 km^2 was added to this reserve (Fig. 3). Additionally, a 20 km^2 exclosure was established in an oilfield in northeast Kuwait. Vegetation cover, biomass production, and species diversity inside the exclosure improved significantly as a result of restricted human, domestic animal, and wildlife access.

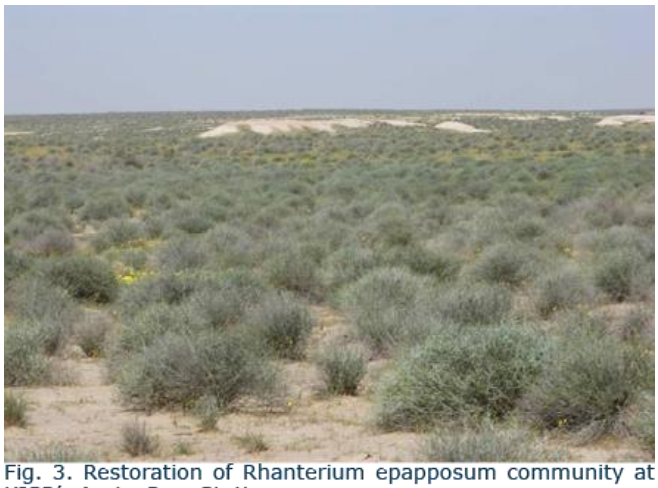


Fig. 3. Restoration of Rhanterium epapposum community at KISR's Agric. Res. Station.

These protected areas provide opportunities for conducting plant succession studies, demonstrating the impact of human, and collecting data on the type and amount of vegetation supported under various disturbance categories.

Seed Collection, Mass Propagation and Seed Enhancement Studies

The main bottleneck in re-vegetation projects is the shortage of seeds and planting materials of keystone native species. KISR is using a two-pronged approach to address this challenge: 1) collecting seeds from natural populations in the desert and maintaining those seeds in a restoration seed bank for use in future restoration projects; and 2) undertaking intensive artificial seed production (seed farming) to meet shortages in seed supply. Additionally, research on seed banks and herbariums is also underway to support ongoing research activities. KISR has developed a protocol to enhance seed germination and improve establishment of seedlings in the field for several species by adopting precision re-vegetation techniques (Fig. 4).


Fig. 4. Rehabilitation of degraded dryland ecosystem by reseeding.

KISR is playing a lead role in increasing our understanding of the causes of degradation, while simultaneously testing new practices for restoration. Their work has implications for dryland restoration throughout the world.

Ecological Preserves and Restoration: Kuwait's Efforts in Restoration of Degraded Ecosystems and Creating Public Awareness

Contributed by Faisal K. Taha, Narayana R. Bhat, Majda K. Suleiman and Brian Collett - Kuwait Institute for Scientific Research, 24885 Safat, 13109, Kuwait

Ecological preserves (EP) are areas in Kuwait where representative and unique natural ecosystems (flora, fauna, land features and ecological phenomena) are preserved for scientific research and educational uses. They also serve other purposes: 1) protecting rare and endangered plants and animals in their natural habitats; and 2) preserving unique, rare or outstanding botanical, zoological, paleontological, archeological or geological phenomena while supporting and perpetuating important genetic resources. They provide the landscape for developing and promoting environmental consciousness among people and offer outdoor laboratories and hands-on classrooms for studies about the natural environment. Ecological preserves also serve as benchmarks against which environmental changes can be measured. Ecological preserves are not created for outdoor recreation and hence, should not be confused with parks or other recreational areas. Most ecological preserves, however, are open to the public for passive, non-consumptive, observational uses. Parks and ecological preserves, although serving somewhat different purposes, complement one another. Together, they provide a wide range of opportunities for people to experience and learn from the natural world and optimally do so by matching the relative level or intensity of use with the system’s degree of sensitivity, thereby not exceeding the carrying capacity of the resource.

The Kuwait Institute for Scientific Research (KISR) is in the process of establishing the first EP in Kuwait and the region at its Agricultural Research Station in Kabd to conserve and protect Kuwait's native flora and fauna, to create a venue for public awareness, and to conduct essential research that celebrates and promotes Kuwait’s rich environmental heritage. As such, this facility will: a) function as a ‘biological park’ for the conservation and promotion of arid land plant and animal species; b) serve as a center for the restoration of degraded habitats; and c) serve as a center of learning and passive recreation for the general public and students. Additionally a wildlife center proposed as part of the EP will allow visitors to see how plants and animals are interacting components of the same habitat. Although this EP is being developed as a regional facility catering to education at the local level and ecotourism at a regional level, it will also serve the international community with regards to arid land ecology, landscape restoration, renewable energy, and water use.

KISR’s EP proposal was discussed and endorsed by the participants at the International Symposium on Native Plant Production organized jointly by KISR, Kuwait Foundation for the Advancement of Sciences (KFAS) and Society for Ecological Restoration (SER) in Kuwait in November 2014. The EP will be located within a larger area managed by KISR near Kabd. This core area of this site was set aside by the Kuwait Government in 1975. It was eventually expanded to 40 km2 to allow for ecorestoration activities. The EP itself, when fully operational will encompass approximately 20km2 of the overal KISR site at Kabd.

The overarching vision for this EP is to establish a fully viable desert habitat restoration area that allows ongoing ecological and restoration research while also enabling the people of Kuwait to fully appreciate and value their natural heritage and cultural history. The EP will provide a modern sustainable facility where visitors can see, firsthand, examples of fully restored natural habitats in a single setting.

The EP will be composed of a demonstration native plant nursery, a desert garden/habitat walk and habitat tour, a research and visitor center, and a wildlife center. Up to eight major plant community types will be represented across the EP, depending upon specific site conditions. Two of the native plant communities that will be present include Cyperetum dominated by *Cyperus* (below; right) and Rhanterietum dominated by *Rhanterium* (below; left).

Ecological Preserve as a Botanical Institute

The main purposes of Kuwait's Ecological Preserves are to:

- *conserve* all aspects of the terrestrial botanical diversity of Kuwait,
- *demonstrate*, through techniques/ strategies and sound science, the restoration of various degraded habitats,
- *assist* in achieving the conservation of Kuwait's natural resources by encouraging and reinforcing respect for the natural environment through effective interpretation of botanical displays and development of formal curricula and training programs.
- *promote* Kuwait's ethnobotanical heritage through various interpretive media and formal and informal educational displays and programs.
- *conduct* ongoing research and restoration activities that ensure the continued survival of extant plant species and their habitats.

EP as Restoration Center

With the immediate requirements that exist for habitat restoration, the EP will serve a critical function as a key part of a habitat restoration center by developing appropriate techniques/strategies for seed multiplication/propagation such as using its gene bank facilities. Consequently, KISR will cooperate and work with other agencies like the International Union for Conservation of Nature (IUCN) and several other international organizations that can advise and assist with the implementation of holistic restoration efforts.

Little is known about either the propagation or the cultivation of Kuwait's native flora. Increasing knowledge on these topics is essential for the successful reestablishment of native ecosystems at the EP and throughout Kuwait.

EP as Learning and Recreation Center

With its broad range of components, the EP will work towards being an accessible venue where the general public and students can experience Kuwait's wealth of natural resources. This in turn will help promote public awareness about the conservation of Kuwait's desert habitats and flora through demonstration and active participation by students and others in a 'learn-by-doing' approach – especially in relation to the nursery and restoration work. The EP will work with Kuwait's educational community to develop the appropriate curriculum for this increased focus on natural resources and conservation. As a public attraction, the EP can serve as a destination and provide for recreation and tourism amidst its natural settings, programs and displays.

Conclusion

Because of the magnitude of the project and the new operational territory that this endeavor presents to KISR, the planning and implementation process has adopted a careful approach that requires a fully evaluated concept both organizationally and physically prior to any groundbreaking for its development. Currently, the EP is in the planning and development stages at KISR's site in Kabd. Funding has been approved by KISR Management as part of a countrywide initiative for research and development. Funding will be allocated on an annual basis for five years beginning in 2016/2017. Completion of the Kuwait EP is expected in 2020.

The Role of Livestock in Restoring Vegetation on Termite-degraded Grasslands of Uganda, Africa

Contributed by Swidiq Mugerwa - National Livestock Resources Research Institute, Tororo, Uganda

Rangeland ecosystems occupy 43% of Uganda's total land area and support over 40% of the country's human population. In addition, these systems are home to 55% and 42% of indigenous and exotic cattle respectively, and serve as habitat for a substantial number of small ruminants, pigs and poultry. Over half of the households occupying the country's rangeland ecosystems depend on livestock production for their livelihood and nearly all of the milk and beef production in Uganda originates from these rangeland ecosystems.

Unfortunately, rangeland ecosystem productivity is steadily deteriorating, thereby undermining its capacity to support current livestock numbers and sustain the increasing demand for livestock products and services. Many habitats within the ecosystem are severely degraded due to a number of factors including overgrazing, indiscriminate tree harvesting and surges in termite activity, among others. While restoration to native conditions in these rangelands is not feasible due to reliance of Ugandans on livestock production, the restoration of ecosystem processes in order to maintain high-functioning rangelands is a critical goal for researchers. The complex combination of primary and secondary factors contributing to ecosystem degradation has made

attempts at restoration challenging; however, recent research has led to new, innovative approaches that have experienced success in addressing termite-caused degradation by using livestock.

While subterranean termites are undoubtedly recognized as important ecosystem engineers that drive nutrient cycling and contribute to improved soil productivity, the same animals have caused degradation of the rangeland ecosystem through devastation of herbaceous vegetation, leading to formation of extensive bare surfaces that facilitate extraordinarily high rates of surface runoff and soil erosion. The steadily increasing damage wrought by native termites has been attributed to a number of causes including the depletion of termites' preferred food sources such as litter, and dropping populations of natural enemies and predators. Studies have noted that in some rangeland habitats, termites can consume up to 90% of the available herbaceous biomass. This not only leads to steep competition for feed resources between termites and livestock, but also results in formation of new - and expansion of already existing - bare surfaces that alternate with patches of sparse herbaceous vegetation.

In order to improve ecosystem productivity and subsequent capacity to support livestock production, several research efforts have been directed towards the restoration of herbaceous vegetation on denuded and sparsely vegetated surfaces. In one such effort, soil surfaces were ploughed to improve water infiltration and different inorganic fertilizers were applied at varying levels upon which reseeding with difference pasture species was conducted. Pasture seedlings established successfully but their life was short-lived as termites completely consumed them a few weeks post-emergence. These results implied that in this particular ecosystem, termites not only contribute to denudation, but also constitute a major barrier to vegetation restoration.

Livestock have been erroneously blamed as the sole contributors to degradation of many dryland ecosystems through overgrazing and the associated trampling of herbaceous vegetation. However, they play a fundamental role in vegetation recovery on denuded bare surfaces, particularly in termite-infested rangelands. As such, the most successful restoration technique implemented in the course of research efforts involved the use of livestock as a key component of the restoration treatment. The technique involved the judicious construction of night enclosures on degraded bare surfaces (Photo a) using branches of highly colonizing woody or invasive woody species as a temporary fence. Cattle were continuously confined in these mobile enclosures at night until a layer of approximately five centimeters of animal manure accumulated on the soil surface (Photo b). This was done during the dry season. The treated area was kept free of animals until pastures were established and started producing seed to restore the soil seed bank.

On the onset of rains, grass seedlings started to emerge from the manure (Photo c) and vegetation in the entire experimental plot was eventually restored (Photo d). Researchers observed that the quantity of accumulated cattle manure influenced the speed and success of the restoration process. This technique improved pasture dry matter production from zero to 4500 kilograms/hectare. The increase in dry matter production led to improvement of the area's carrying capacity from zero on bare surfaces to 1.6 livestock units (LU) per hectare. The technique was also associated with the improvement of soil pH from 3.4% to 5.8%, soil organic matter from 1.3% to 3.1% and soil nitrogen from 0.07 % to 0.20 %.

Photos: A) Degraded bare land, B) Manure accumulation on bare land, C) Sprouting of Cynodon grass stolons land, and D) Herbaceous cover restored in grazing.

The success of this restoration technique can be largely attributed to multiple services provided by the livestock. They delivered free fertilizer in the form of manure, which helped to restore soil productivity. In addition, they thoroughly mixed the manure into the soil through trampling, thereby increasing nutrient availability within the rooting zone. The livestock manure also delivered a free source of pasture seed as a result of the animals' diet. As a result of all of these services, the termites shifted their foraging away from the grass seedlings to the cattle manure, hence relieving the seedlings from termite attacks.

Society News

Dear Colleagues,

The week of June 13th found your SER staff and board in Montana for our annual board meeting along with two days of strategic planning. Many thanks to Maryanne Mott and the B Bar Ranch in Emigrant, Montana, for hosting our retreat. The exceedingly gracious staff and stunning beauty of the ranch was the perfect setting to nurture the energy, excitement and productivity of the time our group spent together as we envisioned where we want the Society to be in 2021. We'll share more about our strategic planning in a few months.

This past year, SER has been closely involved with the Convention on Biological Diversity and the capacity-building workshops they are hosting around the world. In April, Dr. Carolina Murcia traveled to Bogotá, Colombia to represent SER at a Latin American workshop to support the achievement of the Aichi Biodiversity Targets. The workshop facilitated an exchange of experience and knowledge among the participants as they shared best practices with experts in the field, including approaches to incorporate biodiversity into national plans and frameworks for implementation. Dr. Murcia's presentation (in Spanish only) is available on the CBD website. At

the end of this month, Nigel Tucker will represent SER at a similar capacity-building workshop in Thailand for selected subregions of Asia. Many thanks to Carolina and Nigel for their excellent work and for representing SER at these workshops.

In other Society news, we have updates from INSR, the International Network for Seed-Based Restoration, Chapter News, information about upcoming conferences and we're thrilled to welcome another SER Student Association – this one at Virginia Commonwealth University in Richmond, Virginia.

Finally, as we mentioned in the last edition of *SERNews*, SER is in the process of transitioning to a new database as well as updating our website. We're undertaking these projects so we can better serve you – to provide you with improved networking opportunities and give you access to a fantastic suite of restoration resources.

As we move forward with this transition, we want to hear from you. What tools would you find valuable? For example, are you interested in guidelines/advice for grant applications? Best practices for working with government agencies and communities? How to find an expert who may have research information that would be helpful for a project you're working on?

Drop me a note and let me know. Your feedback is important. You can reach me at marguerite@ser.org. I look forward to hearing from you.

Best,

Marguerite Nutter
Membership & Communications Director

SER Section Update: International Network for Seed-Based Restoration (INSR)

Contributed by Nancy Shaw

SER's newest Section, The International Network for Seed-Based Restoration (INSR), links seed research with seed use by providing science delivery to seed collectors, producers and restorationists globally. In addition to the website, the Section has recently established a Subreddit site (Name: Native Seed, Title: Native Seed for Restoration) to facilitate internet discussions of issues pertaining to all aspects of native seed use – genetics, seed biology and technology, seed harvesting, cultural practices, certification, testing and restoration strategies as well as links to seed-related news and events. We welcome your participation in these discussions.

INSR recently exhibited at the SER Northwest meeting in Portland, Oregon and the SER Great Basin meeting in Boise, Idaho. Additional exhibits are planned for the 2016 SER Europe Conference in Freising, Germany and Seed Ecology V in Caeté, Brazil. INSR will develop special sessions on seed-based restoration for the 4th National Native Seed Conference scheduled for Washington, DC in February 2017 and the 2017 SER International Meeting in Brazil as well as at other venues. We are also planning a webinar series on seed topics. Kingsley Dixon will be

leading off with a webinar "Smoke and Germination" – check our website for updates on this. We welcome suggestions for session and webinar topics and speakers.

Don't forget, membership with INSR is free if you are an SER member. Click here to join!


Utah Sweetvetch Wyoming: A commercial seed production field of Utah sweetvetch (Hedysarum boreale) in Wyoming, USA. (Photo credit: Jim Cane)

Keep the Date: The First International Conference and Workshop on Native Seeds in Dryland Restoration is tentatively scheduled for April 2017. INSR is pleased to announce our first international meeting. We are finalizing the venue and can promise it is an exciting location with native seed production, large-scale restoration and a host of seed science. Watch for notification of the exact dates and location in a forthcoming issue of *SERNews*.

Meet Lanie Fung: SER's Social Media Intern

Lanie Fung is a graduate of the University of British Columbia and has recently completed her BSc in Ecological Restoration from British Columbia Institute of Technology. Lanie is managing SER's social media accounts this summer, so if you're not following us on Facebook or Twitter, now is the perfect time to do so! Lanie was the communications coordinator for "Smiling Over Sickness (SOS)," a UBC club that connects student volunteers with opportunities to help disadvantaged children. She managed SOS's website and Facebook accounts in addition to producing the organization's weekly newsletters. She also wrote a series of blog posts for UBC's official blog as part of a science communications course. We're excited that she'll bring her passion for ecological restoration and her social media skills to SER and our followers over the next few months.

SER Chapter News

SER Northwest Chapter Regional Conference

Contributed by The SERNW Program Committee: Michael Hughes, Allison Warner, Regina Wandler, Frank Reckendorf, Rolf Gersonde

SER NW held its regional conference "Monitoring Ecological Restoration: Measuring Change and Seeing Results" in Portland, Oregon April 4-8, 2016. We believe this was the largest meeting focused on restoration monitoring in the US -- 375 attendees participated in over 180 presentations and posters.

Monitoring is emerging as one of the most important scientific aspects of ecological restoration. Traditionally, restoration communities concentrate on getting projects implemented and the application of science primarily focuses on popular ecological theories, key concepts or novel techniques. Increasingly, however, a sustained interest in adaptive management and a growing emphasis of funding entities on getting results has elevated the scientific, social, cultural and economic importance of monitoring. Outcomes of the conference affirm this rising profile as a crucial scientific activity and a key element in the overall craft and evolution of ecological restoration.

Highlights of the conference included the opening social; "Art and Ecology Unite!" with presentations by local artists merging ecology and art; an eye-opening tribal perspective and history of the region by Greg Archuleta of the Confederated Tribes of Grand Ronde; an appealing pictorial review of pollinators and their roles and ecological interactions by our banquet speaker, author and lepidopterist, Robert Pyle; a thought-provoking discussion on trends in restoration by Eric Higgs of the University of Victoria; trendsetting ideas on how to build resilient communities through ecological restoration by Bobby Cochran; and a grounding presentation by the Forest Service's PNW Regional Soil Scientist, Karen Bennett, on using geology and soils to better understand restoration potentials across the landscape.

The Conference Committee extends its thanks to the sponsors, exhibitors, and partners for their support, including the Northwest Forest Soils Council, Northwest Association of Environmental Professionals, Center for Natural Lands Management, US Forest Service, Portland Metro and City of Portland, Eco-Unite!, and the student volunteers who assisted with keeping everything running so smoothly. Portland Area restoration professionals at Portland Metro and Portland Environmental Services offered attendees a great series of tours of local restoration sites and programs, with tours of forest restoration, stream and riparian restoration.

SER Great Basin Chapter and Great Basin Native Plant Project Joint Annual Meeting

Contributed by Matthew Germino, SER-GB President

On April 11 and 12, 2016, the Great Basin Chapter of the Society of Ecological Restoration co-hosted a two day meeting with the Great Basin Native Plant Program in Boise, Idaho. Day one featured presentations on research and management that covered a number of topics including genetics and climate change, development of native plant materials, and integrating ecophysiology studies into common garden approaches. An evening poster session featured even more restoration-related themes.

Day two featured a tour of a large area burned in August 2015 in the Owyhee Mountains of Southwest Idaho and Southeast Oregon, referred to as the Soda Fire. Much of the 285,000 acres burned in the Soda Fire received a variety of treatments in the months preceding the field tour with actions such as herbicide applications, seeding of a wide range of species and seed sources, and experimental trials of weed-suppressive bacteria. The Soda Fire is notable because it burned sagebrush steppe where spread of invasive annual grasses and loss of habitat for species such as Greater Sage Grouse are a concern. The Soda Fire rehabilitation project is the first in the region to have key elements of adaptive management, including engagement of diverse stakeholders and partners, extensive monitoring, and iterative retreatments over a five-year period. Over 50 federal and state agency specialists, university faculty, students, NGO staff from around the Great Basin participated in the field trip, bringing a wide range of experience and perspectives on research and management together. The tour visited several sites within two subregions of the Soda Fire that differed in resistance to invasion and resilience to fire impacts and in treatments received.

Observing a wind-erosion monitoring station where post-fire soil stability is being evaluated at a low-elevation salt-desert site that had been invaded by exotic annuals before the Soda Fire (photo credit: Francis Kilkenny, USDA Forest Service).

New Student Association – Virginia Commonwealth University

Contributed by Lisa Turner, co-founder of SER-VCU

In January 2016, graduate students in the Center for Environmental Studies and Department of Biology at Virginia Commonwealth University (VCU) in Richmond, Virginia, joined forces to create a new SER Student Association. Called SER-VCU, our group is now emerging as a campus leader for education, hands-on practice, and volunteering opportunities related to ecological restoration.

Volunteers at SER@VCU's oyster reef restoration event. VCU students and community members gathered in April to clean and bag recycled oyster shell for use in restoring oyster habitat in the Chesapeake Bay (photo credit: Melissa Davis).

VCU Environmental Life Sciences has a special relationship with ecological restoration as we are home to one of the largest tidal freshwater wetland restoration sites on the east coast. At the VCU Rice Rivers Center, located in Charles City County, Virginia, a 70-acre wetland restoration has been under way since 2011 in partnership with the Nature Conservancy and American Rivers. A wide array of research has accompanied the restoration as VCU scientists and graduate students study the ecology and biogeochemical processes in the wetland over time. Current research includes tracking the wetland's sediment

accretion rates in advance of rising sea levels, plant and microbial ecology, carbon and nutrient dynamics, reestablishment of anadromous fish runs in Kimages Creek, control of invasive species, avian conservation, and installation of an eddy covariance flux tower to measure greenhouse gas fluxes in the restored wetland.

Through organizing workshops, lectures and discussions, documentary screenings, field trips, and initiating hands-on restoration projects, SER-VCU hopes to foster undergraduate and graduate student interest in the field of restoration ecology; promote skills and experience acquisition for students and community members; and facilitate networking between researchers, practitioners, and students in the mid-Atlantic region. Building on the solid foundation of wetland restoration ecology emerging at the Rice Rivers Center, SER-VCU hopes to engage a wider community in learning about and becoming involved in restoration. With support from our faculty leader, Dr. Edward Crawford, and the Rice Rivers Center, VCU Life Sciences, and VCU Division of Student Affairs, SER-VCU plans to host our first fall restoration conference in November. At this two-day event, attendees will learn about ecological restoration in the mid-Atlantic and then be provided an opportunity to put their learning into practice with a day in the field.

SER-VCU is proud to be the first SER Student Association in Virginia, and we hope to connect with our sister universities around the state to build a broader, more diverse community within ecological restoration.

New SER Organization/Business Members

The following businesses and organizations became new SER members in April. Welcome!

Encap, Inc. Dekalb, Illinois, USA

Fundacion Guayacanal, Bogotá, Colombia

Indigenous Design Environmental Services, Victoria, Australia

Ethician Foundation, Huntsville, Texas, USA

SER Chapter Conferences & Events

SER Europe Conference 2016

Best Practice in Restoration
August 22-26, 2016 – Freising, Germany

The 10th European Conference on Ecological Restoration promises a friendly and exciting atmosphere to stimulate dialogue between restoration scientists, practitioners and policy makers, and to collaborate on the challenge of **Best Practice in Restoration**. Registration is now open.

SER New England Chapter Annual Conference

Ecological Restoration in a Changing Climate: Ecosystems, Adaptation, Infrastructure and Resiliency
October 14-15, 2016 – University of New Hampshire, Durham, NH

SER-NE invites you to submit an abstract for their annual conference on the role of ecological restoration values and practice in a changing climate. Land stewards, scientists, students and practitioners are all encouraged to attend and participate in the many activities planned, including presentations, a poster session, field trips and more.

SER Southeast Chapter Annual Symposium and Membership Meeting

Headwaters to Hightide: Expanding Opportunities for Restoration
October 19-21, 2016 Quincy, Florida

SER-SE invites you to submit an abstract for presentations as part of the technical sessions at their conference "Headwaters to Hightide: Expanding Opportunities for Restoration" October 18-21, 2016 in Quincy, Florida. They are especially interested in topics of Aquatic and Terrestrial Restoration, Invasive Exotics, Monitoring, Climate Change Implications, Adaptive Management, Ecosystem Services, Reference Sites, Practitioner Considerations, Education and Outreach, Endangered Species and New Ideas. You can find additional details about the submission guidelines on SE-SER's website.

SER2017 World Conference on Ecological Restoration

Linking Science and Practice for a Better World
September 2017 – Iguassu Falls, Brazil

The 7th SER World Conference on Ecological Restoration will take place in Iguassu Falls, Brazil from August 27-September 1, 2017. Be sure to mark your calendar for what promises to be a spectacular venue and spirited group of conference goers! Details are forthcoming.

Restoration Ecology, Editor's Picks

The May 2016 issue of *Restoration Ecology* (Vol. 24, Issue 3) is available online. Featured below are some Editor's Picks courtesy of Editor-in-Chief and Managing Editor of *Restoration Ecology*, Stephen Murphy and Valter Amaral.

Fuzzy rule-based decision support system for evaluation of long-established forest restoration projects

Anahí Ocampo-Melgar, Aida Valls, Jose Antonio Alloza and Susana Bautista

The evaluation of restoration projects is fundamental to increasing the probability of success by informing adaptive management to

address environmental and socioeconomic conditions, as well as political and legal situations. The problem is the lack, or imprecision, of available data on evaluation indicators, especially in long-term restoration projects. Here, the authors develop a decision support system that applies fuzzy logic to quantitative and expert-based qualitative data on several long-term forest restoration projects to evaluate restoration success. More importantly, this system could potentially be applied to any kind of restoration project, providing minimal information (even if vague and uncertain) exists for a variety of indicators.

Key biocultural values to guide restoration action and planning in New Zealand

Phil O'B. Lyver, Ashli Akins, Hilary Phipps, Viktoria Kahui, David R. Towns, and Henrik Moller

This paper calls for stronger consideration of the links between social well-being and the environment when planning restoration activities, with enhanced interest when indigenous communities are involved. Using the restoration of coastal forests in New Zealand as study sites, the authors observed that different biocultural values were expressed by individuals within and among different stakeholders groups: Māori people, community members of non-Māori descent and environmental managers also of non-Māori descent. Despite the differences, however, all converged on the importance of repairing socio-ecological systems, which could be successfully achieved with an effective pluralistic and cross-cultural approach. Priorities often need to be ranked in restoration projects and strategies, and economic valuation tools should be used with care. Indigenous communities tend to consider places, resources, and system services as invaluable and non-negotiable.

The effectiveness of different planting frameworks for recruitment of tropical rainforest species on ex-rainforest land

Singarayer K. Florentine, Catherine L. Pohlman, and Martin E. Westbrooke

Passive restoration may result in secondary rainforest, but the process is slow and not guaranteed. Biotic and abiotic factors may also determine the success of different restoration strategies to reinstate rainforests on pasturelands. Over two decades, pioneer monoculture, framework and maximum diversity methods were monitored in a restoration experiment in northeastern Queensland, Australia. Two clear outcomes of this experiment were that active restoration substantially accelerates the recovery of pastures into rainforest, and that framework and maximum diversity strategies produce better results than monocultures. The most appropriate restoration planting method is still debatable and the selection of which species should be planted must be careful and consider potential effects of recruitment diversity.

Can pollination syndromes indicate ecological restoration success in tropical forests?

Rafael Martins and Yasmine Antonini

Continuing with the tropical forest restoration theme, this study shows convincing evidence that yes, pollination syndromes are good indicators of ecological restoration of riparian tropical forests. Pollination is an essential ecosystem service expected in self-maintained ecosystems. As anticipated, the richness, abundance, and composition of pollination syndromes showed a seasonal pattern and were also related to age, width and species richness of the surrounding forest matrix. Though well correlated with ecological integrity, the richness of pollination

syndromes can lead to an underestimation of restoration success, in an environmental context, if considered independently of other ecological indices.

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In Case You Missed It

SER Webinar: How to Create and Sustain a State-based Ecological Restoration Division: The Massachusetts Model

As part of SER's recently launched webinar program, Tim Purinton, Samantha Woods and Paul Davis shared how the state of Massachusetts has created and sustained the Massachusetts Division of Ecological Restoration. The webinar was recorded on May 17th and can be viewed here.

We shared the following article from *Restoration Ecology* via Twitter and Facebook in June.

Restoration: What Does Success Look Like?

A new approach to how we evaluate ecological restoration projects has been proposed by researchers from Cardiff and Umeå Universities. The escalating extinction crisis shows that nature cannot support the pressure that humanity is placing on the planet, but can we ever restore damaged habitats and how do we know if we have succeeded?....read more

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