Engineering With Nature®

Using Nature-Based Solutions to Support the Sustainability and Resilience of Department of the Navy Installations and Missions

MCAS Yuma Engineering With Nature Workshop, March 1-3, 2022
Workshop Report
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Foreword

Using Nature-Based Solutions To Improve Resilience at Department of Defense Facilities

For more than 10 years, the Engineering With Nature® (EWN®) Program of the U.S. Army Corps of Engineers has worked to accelerate innovation and delivery of nature-based solutions (NBS) to solve critical engineering challenges and enhance resilience. These solutions also deliver multi-faceted economic, environmental, and community co-benefits. The progress achieved over the last decade has been the result of many projects, partnerships, technical advancements, and communication investments. EWN is continuing to evolve and develop new strategies to meet new challenges. This report highlights the unique challenges and opportunities for utilizing NBS at Department of Defense (DoD) installations in the Desert Southwest.

The proposed solutions highlighted in this report use NBS to harness the power of nature to support mission sustainment and resilience in the harsh, arid climate of the Desert Southwest. At the same time, these solutions provide considerable opportunities to explore the integrated nature and co-benefits of carbon sequestration, biodiversity, and water resources.

The examples here are only a glimpse of the much larger potential for use of NBS at DoD installations. They demonstrate a range of possible NBS that could be developed or envisioned for installations facing diverse natural hazards and challenges. The risks produced by combinations of natural hazards, climate change, and aging infrastructure systems are increasing; and the need and opportunity for innovation and action to create resilient systems continues to grow. Coordinated investment in built and natural infrastructure is needed to sustain readiness and mission resilience across DoD. We hope these examples will continue to encourage and inspire thought and conversation.

Developing and integrating the natural infrastructure associated with DoD’s 25 million acres of land and water will reduce risks, build resilience, and support the well-being of DoD service members and civilians. Meeting these challenges will require us to continue finding new ways of addressing complex problems, exploring new solutions, and embracing change and adaptation.

The EWN Program looks forward to continuing to engage, collaborate, and partner with the DoD to develop NBS that support readiness and resilience for its missions.

Jeffrey K. King, Ph.D., P.E.
National Lead for Engineering With Nature
U.S. Army Corps of Engineers
Foreword

Climate change is reshaping geostrategic, operational, and tactical environments with significant implications for U.S. national security and defense. As conveyed in Department of the Navy (DON) Climate Action 2030, the Department is considering the effects of climate change at every level of the enterprise and building resilience accordingly.

The DON manages, trains, and operates on over 4.5 million acres that span the nation and the globe from coastal and island installations to forests, grasslands, and deserts. We leverage the power of nature in these ecosystems to train and test, to sustain our infrastructure and capabilities, and to preserve critical habitat for a wide range of species. Nature also provides important green spaces that benefit the physical and mental health of our forces, increasing personnel resilience as well as providing rest and relaxation opportunities for the entire base community, contributing to quality of life.

Navy and Marine Corps facilities across the Southwest are already experiencing the impacts of climate change. Drought, wildfires, dust, and extreme flooding events are impacting our infrastructure, water supplies, and training and testing events, as well as our people and defense communities. The Engineering With Nature team has engaged interdisciplinary teams that bring capabilities and expertise not normally resident at the installation level and, working closely with DON regional and installation experts, we are better able to tackle this complex problem set and develop meaningful, scaled solutions.

At the Desert Southwest workshop, hosted at Marine Corps Air Station Yuma, we brought together a wide range of subject matter experts and stakeholders to share their knowledge and weigh in on the difficult questions and opportunities facing DON installations in arid regions. We learned together, identified barriers and opportunities, and together began developing the relevant toolkit of nature-based solutions that will deliver enduring resilience.

The impacts climate change is having in the Desert Southwest represent some of the most challenging problem sets that we as a nation, as well as the rest of the world, will have to confront in learning how to thrive in this new era. Our collaboration with the Engineering With Nature Program has helped us build a strong foundation from which we will move forward in delivering resilience solutions in this critical region for the DON.

Deborah Loomis
Senior Advisor to the Secretary of the Navy (Climate Change)
Department of the Navy
The Department of the Navy (DON) recognizes that climate threats will increasingly set the context for military installations and operations, with negative impacts on mission resilience and readiness. Failing to acknowledge the consequences of climate change can incur high costs in terms of budget, recovery, and detriment to mission capabilities.

To explore the regionally common climate shocks and stressors and potential nature-based solutions (NBS), Engineering With Nature (EWN®) and DON hosted a workshop at Marine Corps Air Station (MCAS) Yuma, Arizona, in March 2022. The workshop focused on critical climate change impacts and increasing natural disaster issues affecting the desert Southwest.

Participants included subject matter experts who are actively addressing climate vulnerabilities in the desert Southwest region, including:

- Drought, heat, winds, wildfire, desertification, and earthquakes
- Water quantity and quality
- Groundwater recharge challenges
- Dangers of flash flooding and the need for erosion control
- Climate-related and anthropomorphic shocks and stressors to vegetation and habitat

The key findings and recommendations that arose from the workshop were divided into four categories (pilot projects, partnerships, programs and studies, and policy and funding) and sorted by short-, medium-, and long-term timelines.

The workshop explored the use of EWN solutions such as check dams to slow runoff, increase infiltration, encourage revegetation, enhance biodiversity, increase carbon sequestration, improve air quality, and reduce heat island effect. Soil improvements from composting and regenerative agriculture were also explored. Case study examples were provided where implementation and use of livestock on rangelands can result in better soil fertilization, increased water capture, expanded plant and animal biodiversity, carbon sequestration, and reduced erosion, dust, and desertification.

A detailed table summarizing the recommendations is provided in Appendix A.

“Many global operational missions are accomplished and/or sustained from DoD installations. Changing climate provides an opportunity to reevaluate use of regional approaches that allow for flexibility to adjust to changing conditions while providing an appropriate level of standardization for resilience, efficiency, and costs.”

-- Line of Effort 3: Resilient Built and Natural Installation Infrastructure
Climate Adaptation Plan 2030
Department of Defense
Military installations in the desert Southwest are grappling with the challenges posed by a range of natural hazards, such as drought, heat, winds, wildfire, desertification, earthquakes, sudden flooding, and soil erosion.

To explore the challenges and potential solutions, Engineering With Nature (EWN®) and the Department of the Navy (DON) hosted a workshop at Marine Corps Air Station (MCAS) Yuma, Arizona, in March 2022. The workshop focused on critical climate change impacts and increasing natural disaster issues affecting the desert Southwest. It featured subject matter experts who are actively addressing climate vulnerabilities in the region. Climate vulnerabilities were explored through a series of breakout group exercises that included identifying shocks and stressors, opportunities and constraints, and potential solutions to mitigate vulnerabilities and increase mission assurance and resilience.

Representatives from the U.S. Navy, the U.S. Marine Corps (USMC), U.S. Army Corps of Engineers (USACE), Engineering Research and Development Center (ERDC), academia, and the private sector met to consider and identify opportunities for using NBS to support the sustainability and resilience of installations and missions. The workshop was conducted and facilitated by the USACE’s EWN Program in partnership with Jacobs, a global engineering and solutions company. Workshop participants included installation personnel, resource managers, scientists, engineers, landscape architects, resilience planners, and stakeholders.

**NOTEWORTHY DEFINITIONS**

In his introduction to the DON’s Climate Action 2030 report, Carlos Del Toro, Secretary of the Navy, emphasized the importance of the DON’s role, saying:

“…the Department of the Navy will take on the urgency of the climate crisis and harness our power to make change – as an environmental leader and a market driver.”

The report went on to provide definitions of several important concepts and terms, including the following:

**Adaptation:** Adjustment in natural or human systems in anticipation of or response to a changing environment in a way that effectively uses beneficial opportunities or reduces negative efforts. *Source: DoD Directive 4715.21, Climate Change Adaptation and Resilience*

**Mitigation:** Measures to reduce the amount and speed of future climate change by reducing emissions of heat-trapping gases or removing carbon dioxide from the atmosphere. *Source: DoD Climate Adaptation Plan and U.S. Global Change Research Program*

**Natural Infrastructure:** Naturally occurring landscape features and/or nature-based solutions that promote, use, restore, or emulate natural ecological processes. *Source: Environmental Defense Fund*

**Resilience:** The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions. *Source: Office of the Chairman of the Joint Chiefs of Staff, DoD Dictionary of Military and Associated Terms*

The full text of the Climate Action 2030 strategy document can be found [here](#). *Source: Department of the Navy, Office of the Assistant Secretary of the Navy for Energy, Installations, and Environment. May 2022. Department of the Navy Climate Action 2030. Washington, DC.*
The goal of the workshop was to provide awareness-building exercises and group discussions to identify potential large-scale EWN solutions that could be implemented on DON installations or executed with the assistance of stakeholders in the larger community. Workshop outcomes and products will be used to identify opportunities for follow-on efforts.

This report is intended to capture and summarize the insights and findings of the workshop and to lay the groundwork for prioritizing next steps and an action plan.

**NATURAL HAZARDS FOR U.S. MILITARY INSTALLATIONS IN THE DESERT SOUTHWEST**

Natural hazards that are being faced by communities and installations in the desert Southwest include:
- drought/limited water supply,
- intense heat,
- desertification,
- high winds,
- wildfire,
- sudden flooding and erosion, and
- earthquakes.

**RESILIENCE FOR MILITARY INSTALLATIONS**

A 2019 report evaluated the risk and vulnerability of 79 installations to climate change and extreme weather.* Of the installations reviewed, 43 are at risk from drought, 36 are at risk from wildfires, and 18 installations were Navy. Drought and wildfire are presenting increasing threats to western U.S. military installations and mission readiness. These and other climate-related hazards demand that we take a systems approach to EWN solutions.

NBS can lead to increased, broad-based resilience on military installations. Some of the benefits of using NBS are:

- **Scalable**, which reduces cost and allows for adaptation over time as environmental conditions continue to evolve
- **Self-healing** following storm events or other environmental hazards, which means mitigating or avoiding costly maintenance and repairs that conventional infrastructure can incur
- **Healthy and therapeutic**, enhancing personal well-being of the people who work, train, and live at DoD facilities through environmental and social benefits.

EWN CRITICAL ELEMENTS

EWN’s purpose is to intentionally align natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through an integrated land management approach.

With recent advances in the fields of engineering and ecology, there is an opportunity to combine engineering and natural systems into a single collaborative and cost-effective approach for infrastructure functions and responsible environmental management. Triple-win outcomes are achieved by systematically integrating social, environmental, and economic considerations at every phase of an EWN project. The results are innovative and resilient solutions that are more socially acceptable, viable and equitable, and, ultimately, more sustainable.

EWN has defined four critical elements of its mission as:

- Mission Assurance
- Using Natural Processes
- Broadening Benefits (triple bottom line and co-benefits)
- Promoting Collaboration (stakeholders, funding, and community)
ADVANCING THE USE OF NBS

NBS can effectively address some of the environmental and climate-related challenges and opportunities facing the DoD in the 21st century.

Different definitions of NBS or EWN approaches and related terms (e.g., natural infrastructure, ecosystem-based approaches, and green infrastructure) have been used by organizations engaged in these activities. The common element among these definitions is the focus on conservation, restoration, and engineered replication of nature for the benefit of mission assurance, people, and ecosystem services.


In October 2021, the EWN Program published Engineering With Nature: Supporting Mission Resilience and Infrastructure Value at Department of Defense Installations, in conjunction with Jacobs, with a focus specifically on how EWN approaches have been successfully applied to mitigate shocks and stressors that threaten mission readiness on DoD installations.

Additional EWN publications to advance understanding and use of NBS in the United States and around the world are forthcoming. These and other resources provide tangible examples of NBS that can be used alone and in combination with conventional engineering solutions to address human-made natural hazards to diversify the benefits achieved through infrastructure on DoD installations.
Workshop Objectives

Objectives of the workshop included:

- sharing and reviewing information about proven natural hazards and vulnerabilities that DON western installations are experiencing now or are likely to experience in the future;
- sharing knowledge and information about NBS currently being used to support the resilience and sustainability of installation missions;
- using facilitated dialogue, applicable project examples, and a series of exercises to demonstrate use of NBS strategies and placement of NBS to reduce vulnerabilities;
- collaboratively identifying challenges and prioritizing an initial set of concepts, technical approaches, and potential NBS; and
- documenting workshop proceedings and outputs for follow-on consideration and potential future actions.

On the first day of the workshop, the meeting was convened with a welcome and opening remarks from Col. Charles Dudik, Commanding Officer, MCAS Yuma; Deb Loomis, Senior Advisor to the Secretary of the Navy (Climate Change); and DON staff. A workshop introduction was provided by Dr. Todd Bridges, National Lead, EWN.

Representatives from each installation provided an installation overview. Installations included MCAS Yuma, Naval Air Weapons Station China Lake, Naval Air Station Fallon, and Marine Corps Air Ground Combat Center Twentynine Palms. Two featured presentations provided insights on rangeland management and addressing wildfire consequences. Hollie Schmidt, Director of Resilience and Sustainability Business Advisory for Jacobs, presented an overview of climate shocks and stressors, and attendees participated in breakout groups for a facilitated discussion of Department of Defense (DoD) installation resilience challenges and vulnerabilities to climate-related risks.

THREE KEY INTEGRATED COMPONENTS OF CLIMATE RESILIENCE

The workshop focused on the need to address the integrated nature of carbon sequestration, biodiversity, and water resources as part of mission sustainment and resilience in the desert Southwest and other arid regions. Efforts to encourage EWN projects that support natural vegetation and biodiversity will lead to better groundwater recharge, address erosion during flash flooding, and create opportunities for carbon sequestration.
The second day of the workshop featured presentations on solutions for recharging groundwater; transforming deserts into thriving landscapes; and regreening the desert through rangeland and agricultural regeneration techniques for managing land, soil, and water. A facilitated breakout session was held to explore current and future opportunities for using NBS and conventional solutions. Additionally, the workshop attendees conducted a site visit to an MCAS Yuma flight training area, followed by a plenary discussion led by Dr. Todd Bridges on observations from the site visit and potential uses of NBS. The day concluded with a presentation on managing soil, land, and water.

The final day of the workshop included a featured presentation on how composting can be used to create better soil conditions and regeneration, contribute to biodiversity, reduce waste, and enhance the potential for carbon sequestration. Participants engaged in a facilitated breakout session to discuss installation-specific opportunities for NBS demonstration or implementation projects. The workshop closed with a review of overall findings, actions items, and next steps.

Featured presenters included:

- Dr. Chris Haring, Research Engineer U.S. Army ERDC (Managing Wildfire Consequences),
- Becca Muenich, Assistant Professor, Environmental Engineering School of Sustainable Engineering and the Built Environment, Arizona State University (Managed Aquifer Recharge),
- Dr. Laura Norman, USGS, Supervisory Research Physical Scientist, USGS, Western Geographic Science Center (Natural Infrastructure in Arid Settings),
- Dr. Ryan Busby, Research Ecologist, U.S. Army ERDC (Compost for Climate Resilience),
- Cole Bush, Regenerative Agriculture Advocate, Educator, and member of the California Board of Forestry and Fire Protection Range Management Advisory Committee (Shepherding Landscapes),
- Gabe Brown and Alejandro Carrillo, Understanding Ag, (Understanding Ag and Bringing a Ranch Back to Life)
Additional workshop presentations and discussions were led by:

- Colonel Charles Dudik, Commanding Officer, MCAS Yuma
- Commander Gareth Montgomery, Director of Installation & Logistics, MCAS Yuma
- Deb Loomis, Senior Advisor to the Secretary of the Navy (Climate Change)
- Dr. Todd Bridges, National Lead, EWN Program, USACE, ERDC
- Jacque Rice, Natural Resources Program Lead, Headquarters, USMC
- Jennifer Oelke Farley, Environmental Planning and Conservation Office of the Deputy Assistant Secretary of the Navy (Environment and Mission Readiness)
- Randy English, Conservation Manager, MCAS Yuma
- Christy Wolf, Conservation Program Manager, Naval Weapons Station Fallbrook
- Vanessa Shoblock, Natural Resource Specialist, NAVFAC Southwest, EV
- Brian Hennan, Supervising Environmental Protection Specialist, Marine Corps Air Ground Combat Center Twentynine Palms
- Hollie Schmidt, Director, Resilience + Sustainability, Business Advisory, Jacobs

A site visit to the F-35 Auxiliary Landing Field was led by William Sellars, Yuma Range Director; Randy English, Conservation Manager; Jeremy Pennell, Staff Biologist; and Blake Hash, Outdoor Recreation Planner.

See Appendix B for the workshop agenda and handouts and Appendix C for speaker presentations.
EWN Concepts

This section presents the potential EWN design concepts that were identified during the workshop. Several of these strategies are interrelated and have synergies that need to be assessed and implemented with the systems approach that is the guiding framework of EWN.

**Water Capture**

- Implement **check dams**/flow control in streams that are known to damage assets; address in a large systemic/watershed approach
- Restore **natural storm flow**, reduce incision of desert washes, and increase spreading of flow to increase percolation
- Repair and **restore riparian habitat**
- Combine **gabion structures** within impact areas to contain water and increase infiltration; construct **leaky dams** of rocks and mud structures that leak water and slow flows
- **Divert seasonal flow** to catch basins to increase percolation
- Promote **water infiltration** to recharge aquifer
- Enhance **groundwater recharge** at local/small scale (beneficial reuse)

**Benefits of Check Dams and Retention Structures**

Use of check dams to slow the flow of water after rapid rainfall decreases sheet flow and increases infiltration into the ground. Revegetation will result in better habitat and increased biodiversity and ultimately carbon sequestration.

**Water**

- Slow water and reduce floods
- Support surface water and restore perennial flow
- Increase infiltration and recharge aquifers

**Soils**

- Stabilize soil and reduce erosion
- Reduce nonpoint source pollution, capture ordnance
- Carbon sequestration

**Vegetation**

- Encourage plant growth
- Create habitat for animals

*Excerpted from Dr. Laura Norman, Natural Infrastructure in Arid Settings, Presentation for the U.S. Department of Defense, February 22, 2022.*

*Photo courtesy of Dr. Laura Norman, U.S. Geological Survey*
• Harvest water (including use of recycled or greywater, dew condensation) on the installation to grow food instead of food inputs off installation (on-base community gardens)
• Maximize capture of cantonment stormwater for increased percolation
• Expand capacity of water sources to ensure water availability to wildlife during droughts
• Create long-term water security plan

**Design Measures for Water/Carbon Storage**

• Implement desert design features such as permeable pavement
• Re-engineer range roads to reduce incisions and erosion
• Design infiltration basins and contour catchments
• Utilize nature-based structural design to reflect the heat (e.g., Saguaro cactus)
• Use smart hardscapes (high Solar Reflectance Index value) to reduce heat capture
• Retrofit roof drainage for beneficial use of rain on roof surface and design green roofs with native species

**Water Conservation**

• Reduce irrigation and use efficient irrigation methods by changing zoning permits, discouraging lawn sprinkler systems, and restricting sprinkling of transportation routes to grey water only
• Reduce evaporation by implementing cover story (shade) of vegetation along irrigation canals
• Enhance leak detection systems
• Maximize beneficial water reuse
• Use regionally native plants and xeriscaping to eliminate supplemental watering needs
• Assess water supply, water quality, and soil impacts of agricultural land leases

**Policy Advances in NBS**

Recent actions from the federal government have placed a spotlight on and accelerated awareness of NBS. In January 2021, President Joe Biden issued Executive Order (EO) 14008, “Tackling the Climate Crisis at Home and Abroad.” This EO paved the way for the development of the DoD’s Climate Risk Analysis and the DoN’s Climate Action 2030 guidebook.

The EWN Program, and NBS in general, also received major support with the issuance of EO 14072, “Strengthening the Nation’s Forests, Communities, and Local Economies,” on April 22, 2022. Additionally, the White House issued an NBS Roadmap and NBS Resources Guide in October 2022.

The EWN supports the DoD and DoN in implementing their visions for future climate resilience and mission readiness, as laid out in these publications.


*Department of the Navy, Office of the Assistant Secretary of the Navy for Energy, Installations, and Environment. May 2022. Department of the Navy Climate Action 2030. Washington, DC.*

Vegetation Biodiversity/Carbon Storage

- Revegetate “hot spots” in the watershed to reduce dust
- Use crop dusting irrigation to stabilize inoculum and foster seed germination
- Map vegetation to identify maximum potential for post-disaster recovery strategy
- Reclaim degraded land through holistic land management and amendments
- Implement regenerative grazing management (cattle/sheep/goats); conduct a browse preference study, research needs, review published management strategies, address scaling and logistical concerns, and implement herd health and tracking confirmation
- Use non-mechanical treatment of fuel breaks
- Incentivize use of agriculture for carbon storage
- Implement composting program to capture food waste with on-base restaurants, grocery stores, municipal start-up recycling green waste services, beginning with local municipality
- Combine compost with highly managed grazing rotation for soil improvement and regeneration
- Control and manage invasive species through integrated natural resource management plans
- Use umbrella species whose conservation is expected to provide protection to many naturally co-occurring species
- Reduce and eliminate chemical and biocide use
- Promote no-till and low-till practices, contour plowing, and keyline plowing
- Anticipate future ecologies and use adaptive management practices to design intervention for future scenarios; develop ecosystems-based resilience strategies
- Convert grass/greenspace to functional ecosystems

**Soil Improvement, Dust, and Fire Control**

- Apply biological soil amendments
- Create water capturing zone with fill, compost, and amendments using pavement and vegetation
- Reduce soil compaction by addressing the root causes
- Look at U.S. Department of Agriculture agricultural soil classifications for restoration potential
- Restore the cryptogenic crust
- Use bio-cementation to stabilize soils and add organic matter
- Enhance understanding of soil health, living soil layers, and hyperbolic zone and the value for and impacts on the mission
- Consider use of streams as potential fire breaks where appropriate
The following table summarizes the top-tier short-, medium-, and long-term recommendations that emerged during workshop collaboration. These recommendations do not reflect agency positions or actions. Proposed solutions by benefit category and additional detailed findings and recommendations are provided in Appendix A.

<table>
<thead>
<tr>
<th>Pilot Projects</th>
<th>Short-Term Implementation (0 – 3 Years)</th>
<th>Medium-Term Implementation (3 – 5 Years)</th>
<th>Long-Term Implementation (5+ Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Align in-progress projects to the EWN framework</td>
<td>• Develop desert Southwest Playbook with toolbox, checklist of EWN applications</td>
<td>• Sustain partner engagements on NBS</td>
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<td></td>
<td>• Implement best practices for erosion reduction (e.g., modify drainage and install check dams)</td>
<td>• Deploy NBS Innovation Hubs at selected installations</td>
<td>• Develop NBS Analysis Tool to quantify benefits</td>
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</table>

<table>
<thead>
<tr>
<th>Partnerships</th>
<th>Short-Term Implementation (0 – 3 Years)</th>
<th>Medium-Term Implementation (3 – 5 Years)</th>
<th>Long-Term Implementation (5+ Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Identify existing partnerships and potential new partnerships to create comprehensive stakeholder pool</td>
<td>• Leverage regional partnerships to develop, implement and fund NBS initiatives (e.g., Western Regional Partnership)</td>
<td>• Explore grazing/regenerative agriculture partnership opportunities</td>
</tr>
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<td></td>
<td>• Create a stakeholder management strategy</td>
<td>• Collaborate with other agencies to elevate existing efforts regarding restoring fire/burn areas and implementing water conservation, dust control and agricultural practices</td>
<td>• Coordinate with Tribal governments on restoring fire/burn areas and integrating Traditional Ecological Knowledge</td>
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<tr>
<td></td>
<td>• Identify and communicate appropriate funding sources for NBS implementation</td>
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<td>• Identify opportunities for composting with local municipality and creating community gardens</td>
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<tr>
<td>Programs &amp; Studies</td>
<td>Policy &amp; Funding</td>
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<tr>
<td>• Explore carbon sequestration for arid environments with resilience benefits through NBS</td>
<td>• Leverage the current Unified Facilities Criteria (UFC) language regarding resilience</td>
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<td>• Utilize resilience war game at installation level to inform Program Objectives Memorandum funding priorities</td>
<td>• Enforce resilience planning in required master plans</td>
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<tr>
<td>• Measure carbon sequestration key performance indicators based on biomass, photosynthesis, endangered species, infiltration rates, soil temperature, plant diversity, soil microbiology, and water quality</td>
<td>• Incorporate resilience components into development of all Department of Defense 1391s</td>
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<tr>
<td>• Study alternatives for circular economy of water, including water recycling for wastewater and greywater, as well as beneficial use of rainfall (blue roofs and ground-level decentralized storage)</td>
<td>• Issue installation or regional specific memos to design for climate shocks and stressors for water, biodiversity, and carbon</td>
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<tr>
<td>• Conduct check dam and wetland restoration demonstration study</td>
<td>• Identify opportunities to streamline National Environmental Policy Act consultations and permitting for resilience projects</td>
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<tr>
<td>• Initiate on-base composting program; send to off-base agriculture demonstration study</td>
<td>• Revise UFC and other required planning studies</td>
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<tr>
<td>• Develop enterprise-wide mechanism for capturing and communicating progress</td>
<td>• Prioritize ranking for projects with resilience measures</td>
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<tr>
<td>• Implement large-scale regenerative landscape project</td>
<td>• Create guidance on cross-functional integration for master planning, facilities, environmental, natural resources, and public works</td>
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<tr>
<td>• Train veterans to be holistic land managers to implement large-scale grazing</td>
<td>• Consider opportunities for innovative financing to incentivize resilience investment</td>
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<tr>
<td>• Conduct check dam and wetland restoration demonstration study</td>
<td>• Establish international agreements on climate resilience (e.g., to adjudicate geoengineering, cloud seeding for drought response)</td>
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</tbody>
</table>
The next steps for the DON/EWN effort include virtual meetings to develop and refine potential projects in the Southwest. Through facilitated breakout sessions, installation personnel will work with EWN experts to identify NBS for highlighted shocks and stressors, potential benefits and co-benefits, partnerships, timelines for implementation, and funding opportunities. Installations will be encouraged to identify pilot projects or ongoing projects that can be broadened to further support mission assurance.
# Appendix A. Matrix of Workshop Comments

## MCAS Yuma, EWN Workshop, March 1-3, 2022

### Summary of Themes

#### Projects:

<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desert Southwest Playbook</td>
<td>Create a &quot;Toolbox&quot; or &quot;Playbook&quot; or &quot;Checklist&quot; of EWN applications for desert Southwest</td>
</tr>
<tr>
<td>Database of installation ecology</td>
<td>Create a database of DoD installation ecosystem and geography</td>
</tr>
<tr>
<td>DoD Summit on NBS</td>
<td>Conduct a DoD summit on NBS</td>
</tr>
<tr>
<td>NBS analysis tool</td>
<td>Create modeling and benefit analysis tool for NBS</td>
</tr>
<tr>
<td>Native plant seed bank</td>
<td>Create a native plant seed bank</td>
</tr>
<tr>
<td>Biomimicry</td>
<td>Conduct a biomimicry process evaluation in Southwest region and arid environments</td>
</tr>
<tr>
<td>Mapping refugia</td>
<td>Map climate refugia at species and community levels</td>
</tr>
<tr>
<td>Xeriscaping</td>
<td>Create a xeriscaping strategy playbook for installations in the desert Southwest</td>
</tr>
</tbody>
</table>

#### Studies:

<table>
<thead>
<tr>
<th>Study</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proof-of-concept studies</td>
<td>Historical context - hypothesis testing/proof of concept studies; historical context plus adaptation studies</td>
</tr>
<tr>
<td>Soil improvements/carbon sequestration</td>
<td>Soil carbon sequestration study at massive scale through check dams and wetland restoration</td>
</tr>
<tr>
<td>Soil mapping</td>
<td>Advanced aerial mapping of soil mineralogy for optimal NBS placement</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Study methods to reduce groundwater use</td>
</tr>
<tr>
<td>Stormwater</td>
<td>Study and methods of stormwater capture; demonstrate proof of concept</td>
</tr>
<tr>
<td>Vegetation mapping</td>
<td>Forest/vegetation mapping to identify maximum potential, post-disaster strategy recovery</td>
</tr>
<tr>
<td>Grazing study</td>
<td>Cattle/sheep/goat grazing management study to address browse preferences and research needs; review published management strategies; address scaling and logistical concerns; confirm methodologies for herd health and tracking.</td>
</tr>
</tbody>
</table>
Programs:

<table>
<thead>
<tr>
<th>Program</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resilience wargame</td>
<td>Use resilience wargame at installation level to identify good ideas for funding; develop Program Objectives Memorandum</td>
</tr>
<tr>
<td>Innovation hubs</td>
<td>Create NBS innovation hubs at select installations or regions</td>
</tr>
<tr>
<td>Program communication</td>
<td>Develop enterprise-wide mechanism for capturing and communicating progress</td>
</tr>
<tr>
<td>Measure NBS Success</td>
<td>Identify key performance indicators and measure carbon sequestration; measure results based on biomass, photosynthesis, endangered species, infiltration rates, soil temperature, plant diversity, soil microbiology, and water quality</td>
</tr>
<tr>
<td>Regenerative landscape</td>
<td>Develop ecosystem-based resilience; implement regenerative landscape and communicate non-monetary benefits</td>
</tr>
<tr>
<td>Bird/aircraft management</td>
<td>Work with Airfield Management regarding bird/wildlife aircraft strike hazard</td>
</tr>
<tr>
<td>Veteran training/grazing operations</td>
<td>Train veterans to be holistic land managers to implement large-scale grazing operations in approved areas</td>
</tr>
<tr>
<td>Composting</td>
<td>Implement base-wide composting program for food and green waste</td>
</tr>
<tr>
<td>Solid waste/recycling</td>
<td>Integrate solid waste recycling and morale/welfare/recreation activities with natural resource programs</td>
</tr>
</tbody>
</table>

Partnerships:

<table>
<thead>
<tr>
<th>Partners</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partners outside the fence</td>
<td>Wastewater reuse may need to include partners outside the fence</td>
</tr>
<tr>
<td>Adjacent landowners</td>
<td>Build partnerships with DoD-adjacent property owners</td>
</tr>
<tr>
<td>Surrounding agriculture agencies</td>
<td>Work with surrounding agriculture to reduce their water use</td>
</tr>
<tr>
<td>City of Yuma</td>
<td>Create compost alliance with the City of Yuma</td>
</tr>
<tr>
<td>School outreach</td>
<td>Work with school districts to kickstart neighborhood efforts and community gardening, vermiculture, dung beetle farms, etc.</td>
</tr>
<tr>
<td>Tribal coordination</td>
<td>Integrate Traditional Ecological Knowledge in general; work with Tribal partners on restoration of burned areas with native plants on ranges</td>
</tr>
<tr>
<td>Regional partnership</td>
<td>Build regional partnership for dust and fire management</td>
</tr>
<tr>
<td>Other agencies</td>
<td>Combine with other agencies’ restoration efforts</td>
</tr>
<tr>
<td>EWN Alliance</td>
<td>Implement EWN Alliance for desert Southwest</td>
</tr>
<tr>
<td>Partnerships within DoD and USACE</td>
<td>Build agency-level partnerships across DoD and USACE</td>
</tr>
<tr>
<td>BLM</td>
<td>Work with BLM regarding grazing management</td>
</tr>
</tbody>
</table>
## Policies:

<table>
<thead>
<tr>
<th>Policies</th>
<th>Development Specific Strategies for Carbon Sequestration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon sequestration</td>
<td>Develop installation specific strategies for carbon sequestration</td>
</tr>
<tr>
<td>Funding change</td>
<td>Insert good ideas for funding in DON's funding list, change funding scheme at higher level, create scheme that gives bonus points/higher weighting for climate resilience projects that support mission</td>
</tr>
<tr>
<td>Funds for climate adaptation plans</td>
<td>Identify funds specifically for the projects in the context of climate adaptation plans (need to be woven into existing plans)</td>
</tr>
<tr>
<td>Taxes</td>
<td>Create carbon tax or water use tax; give homeowners rebates for savings</td>
</tr>
<tr>
<td>Incentives</td>
<td>Change incentives to favor NBS</td>
</tr>
<tr>
<td>Remove roadblocks</td>
<td>Identify the existing policy process, outline the steps, and identify roadblocks that can be removed to accelerate EWN projects. Look for ways to deconflict (e.g., U.S. Department of Agriculture example). Congress and National Defense Authorization Act sets funding and policy, administration issues Executive Orders, Federal and State agencies (partners) carry out regulations. Agencies carry out regulations that address clean water, historic preservation, and biological and air emissions (greenhouse gases).</td>
</tr>
<tr>
<td>Integration across disciplines</td>
<td>Create guidance on cross functional integration for master planning, facilities, environmental, natural resources, and public works</td>
</tr>
<tr>
<td>DON's design and construction process</td>
<td>Need climate resilience requirements and threat assessments in design and construction requirements process, planning, National Environmental Policy Act (NEPA), as well as operations and maintenance</td>
</tr>
<tr>
<td>NEPA streamlining</td>
<td>Streamline NEPA; pursue programmatic approach</td>
</tr>
<tr>
<td>NEPA Categorical Exclusion</td>
<td>Utilize Categorical Exclusions for natural resources for resilience projects</td>
</tr>
<tr>
<td>Integrated Natural Resource Management Plans</td>
<td>Provide guidance to Natural Resource Managers; integrated natural resource management plans don’t stop at developed facilities</td>
</tr>
<tr>
<td>UFC</td>
<td>Update the UFC on natural infrastructure resilience</td>
</tr>
<tr>
<td>Drought response</td>
<td>Consider opportunities for innovative financing to incentivize resilience investment Establish international agreements on climate resilience (e.g., to adjudicate geoengineering, cloud seeding for drought response)</td>
</tr>
<tr>
<td>Range clearing mitigation</td>
<td>Mitigate costs of clearing operational ranges</td>
</tr>
</tbody>
</table>
The integrated nature of carbon sequestration, biodiversity, and water resources can be harnessed with NBS and can serve to support mission sustainment and provide resilience in the desert Southwest region. The following table provides some solutions that highlight resilience targets related to the water, carbon, and biodiversity.

<table>
<thead>
<tr>
<th>Resilience Target</th>
<th>Themes</th>
<th>Resilience Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Check dams at watershed scale</td>
<td>Check dams/flow control in streams that are known to damage assets at a large systemic/watershed scale</td>
</tr>
<tr>
<td></td>
<td>Crop dusting irrigation</td>
<td>Crop dusting irrigation to stabilize inoculum and foster seed germination</td>
</tr>
<tr>
<td></td>
<td>Dew condensation</td>
<td>Harness dew condensation</td>
</tr>
<tr>
<td></td>
<td>Dust hot spots</td>
<td>Revegetation or other management of dust &quot;hot spots&quot; in watershed</td>
</tr>
<tr>
<td>Irrigation</td>
<td>Stop engineering nature: change zoning permits, outlaw sprinkler systems for lawns and along transportation routes, especially if not using grey water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduce irrigation and use efficient irrigation methods</td>
<td></td>
</tr>
<tr>
<td>Irrigation</td>
<td>Address evaporation and cover story (shade) of vegetation along irrigation channels</td>
<td></td>
</tr>
<tr>
<td>Leak detection</td>
<td>Create a leak detection system in water conveyance</td>
<td></td>
</tr>
<tr>
<td>Leaky dams</td>
<td>Rock wood mud structure that leaks water</td>
<td></td>
</tr>
<tr>
<td>Range roads</td>
<td>Re-engineer range roads to reduce incision due to erosion</td>
<td></td>
</tr>
<tr>
<td>Stormwater</td>
<td>Combine gabion structures within impact areas to keep ordnance from going down stream</td>
<td></td>
</tr>
<tr>
<td>Stormwater</td>
<td>Maximize capture of stormwater for increased percolation and promote groundwater recharge by using solutions such as infiltration basins and permeable pavements</td>
<td></td>
</tr>
<tr>
<td>Stormwater</td>
<td>Restore natural storm flow patterns: &quot;Slow the flow,&quot; increase spreading of flow (reduce incision of desert washes)</td>
<td></td>
</tr>
<tr>
<td>Stormwater</td>
<td>Contour catchments</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>Maximize reuse of treated water</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>Harvest water to grow food instead of food inputs from outside installations</td>
<td></td>
</tr>
<tr>
<td>Resilience Target</td>
<td>Themes</td>
<td>Resilience Solutions</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------</td>
<td>----------------------</td>
</tr>
<tr>
<td><strong>Carbon</strong></td>
<td>Agriculture for carbon storage</td>
<td>Incentivize carbon storage in agriculture</td>
</tr>
<tr>
<td></td>
<td>Carbon sink</td>
<td>Increase sediment water carbon sink</td>
</tr>
<tr>
<td></td>
<td>Biomimetic design</td>
<td>Use biomimetic structural design to reflect the heat (similar to Saguaro cactus)</td>
</tr>
<tr>
<td></td>
<td>Electric vehicles</td>
<td>Shift culture to increase electric vehicle use on installation</td>
</tr>
<tr>
<td></td>
<td>Emissions -generators</td>
<td>Increase efficiencies to reduce generator emissions</td>
</tr>
<tr>
<td></td>
<td>Emissions -vehicles</td>
<td>Reduce civilian vehicle use on installation</td>
</tr>
<tr>
<td></td>
<td>Food waste</td>
<td>Implement organic waste collection</td>
</tr>
<tr>
<td></td>
<td>Fuel break treatment</td>
<td>Utilize non-mechanical treatment of fuel breaks</td>
</tr>
<tr>
<td></td>
<td>High Solar Reflectance Index</td>
<td>Use High Solar Reflectance Index materials to reduce heat capture</td>
</tr>
<tr>
<td><strong>Biodiversity</strong></td>
<td>Invasive species</td>
<td>Control and manage invasive species</td>
</tr>
<tr>
<td></td>
<td>Species management</td>
<td>Use umbrella species and productive communities</td>
</tr>
<tr>
<td><strong>Water, Carbon</strong></td>
<td>Composting soil</td>
<td>Add compost to soil with highly managed rotation</td>
</tr>
<tr>
<td></td>
<td>Plowing</td>
<td>Promote contour plowing and keyline plowing</td>
</tr>
<tr>
<td></td>
<td>Soils</td>
<td>Promote no-till and low-till practices</td>
</tr>
<tr>
<td><strong>Water, Biodiversity</strong></td>
<td>Agriculture</td>
<td>Reduce and eliminate chemical and biocide use</td>
</tr>
<tr>
<td>Resilience Target</td>
<td>Themes</td>
<td>Resilience Solutions</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Water, Carbon, Biodiversity</td>
<td>Adaptive management practices</td>
<td>Anticipate future ecologies and use adaptive management practices to design intervention for future scenarios</td>
</tr>
<tr>
<td></td>
<td>Floodplain restoration</td>
<td>Restoration of seasonal floodplains and riparian habitat</td>
</tr>
<tr>
<td></td>
<td>Grazing</td>
<td>Use adaptive grazing</td>
</tr>
<tr>
<td></td>
<td>Green roofs</td>
<td>Use green roofs with native species</td>
</tr>
<tr>
<td></td>
<td>Green space</td>
<td>Convert lawns to functional ecosystems</td>
</tr>
<tr>
<td></td>
<td>Infrastructure/roads</td>
<td>Change infrastructure instead of roads (MCAS Yuma)</td>
</tr>
<tr>
<td></td>
<td>Land management</td>
<td>Reclaim degraded land through holistic land management and amendments</td>
</tr>
<tr>
<td></td>
<td>Revegetation</td>
<td>Revegetate disturbed areas (infiltration and dust control)</td>
</tr>
<tr>
<td></td>
<td>Shade</td>
<td>Plant local and appropriate trees to provide shade over water surfaces to reduce water loss</td>
</tr>
<tr>
<td></td>
<td>Soil amendment</td>
<td>Apply biological soil amendments; mine waste streams of base restaurants and grocery stores for compostable material to amend soil (and avoid solid waste disposal fees)</td>
</tr>
<tr>
<td></td>
<td>Soil and water</td>
<td>Amend soil to increase water absorption capacity</td>
</tr>
<tr>
<td></td>
<td>Soil compaction</td>
<td>Address the root causes of compaction</td>
</tr>
<tr>
<td></td>
<td>Soil restoration</td>
<td>Review restoration potential based on USDA soil classification system</td>
</tr>
<tr>
<td></td>
<td>Soils</td>
<td>Restore cryptogamic crust</td>
</tr>
<tr>
<td></td>
<td>Soils</td>
<td>Use biocementation to stabilize soils and add organic matter</td>
</tr>
<tr>
<td></td>
<td>Standardize and deploy land management practices</td>
<td>Deploy large-scale and standardized land management practices that are repeatable across installations</td>
</tr>
<tr>
<td></td>
<td>Streams as firebreaks</td>
<td>Use streams as fire breaks, where appropriate</td>
</tr>
</tbody>
</table>
## Agenda for F2F Natural Infrastructure Workshop

### February 28, 2022: Travel to Marine Corps Air Station (MCAS) Yuma

### March 1, 2022: Day 1 (All times listed are Mountain Standard Time)

<table>
<thead>
<tr>
<th>Time</th>
<th>Action</th>
<th>Lead or Speaker</th>
</tr>
</thead>
</table>
| 0800 - 0830 | Arrive MCAS Yuma  
The Club / Bldg #1200                             | Col. Charles Dudik, Commanding Officer, MCAS Yuma  
 or CDR Gareth Montgomery, Director of Installation & Logistics, MCAS Yuma  
 Ms. Deb Loomis, Senior Advisor to the Secretary of the Navy (Climate Change)  
 Ms. Jacque Rice, Natural Resources Program Lead  
 Headquarters, U.S. Marine Corps  
 Ms. Jennifer Oelke Farley, Environmental Planning and Conservation Office of Deputy Assistant Secretary of the Navy (Environment and Mission Readiness) |
| 0830 - 0900 | Welcome and Opening Remarks                                             | Dr. Todd Bridges, National Lead Engineering With Nature® Program, US Army Corps of Engineers and Senior Research Scientist (ST), Environmental Science, US Army Engineer Research and Development Center |
| 0900 - 0920 | Introduction and Workshop Orientation                                   |                                                                                                     |
| 0920 - 1000 | Overview of Installations (10 min presentation using provided slide template / 10 min Q&A) | Mr. Randy English, Conservation Manager, MCAS Yuma  
 Ms. Christy Wolf, Conservation Program Manager, Naval Weapons Station, Fallbrook |
| 1000 - 1020 | Break                                                                  |                                                                                                     |
| 1020 - 1100 | Overview of Installations (Continued) (10 min presentation using provided slide template / 10 min Q&A) | Ms. Vanessa Shoblock, Natural Resource Specialist, NAVFAC SW, EV  
 Mr. Brian Hennan, Supervising Env. Protection Specialist, Environmental Affairs, MAG TFTC ISD |
| 1100 - 1115 | Natural Infrastructure Talk #1: Shepherdling Landscapes (10 Minute Talk / 5 Minute Q&A) | Ms. Cole Bush, Shepherdess, Regenerative Agriculture Advocate, Entrepreneur, and Educator |
| 1115 – 1130 | Introduction to Breakout Sessions (Please see Section “Instructions for Breakout Groups and Group Assignments” for more details and Group Assignments) | Ms. Hollie Schmidt, Director, Resilience + Sustainability Business Advisory P+PS Americas, Jacobs |
| 1130 – 1300 | Lunch                                                                  |                                                                                                     |
| 1300 – 1430 | Facilitated Breakout Session 1: Installation Resilience Challenges and Vulnerabilities |                                                                                                                                 |
MARCH 2, 2022: (All times listed are Mountain Standard Time)

<table>
<thead>
<tr>
<th>Time</th>
<th>Action</th>
<th>Lead or Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>0800 – 0830</td>
<td>Arrive MCAS Yuma</td>
<td></td>
</tr>
<tr>
<td>0830 - 0900</td>
<td>Reflections about Day 1 / Activities for Day 2</td>
<td>Dr. Todd Bridges</td>
</tr>
<tr>
<td>0900 – 0915</td>
<td>Natural Infrastructure Talk #3: Managed Aquifer Recharge</td>
<td>Dr. Becca Muenich, Assistant Professor, Environmental Engineering, School of Sustainable Engineering and the Built Environment</td>
</tr>
<tr>
<td>0915 - 1045</td>
<td>Facilitated Breakout Session 2: Current and future opportunities for using conventional and natural infrastructure (Please refer to Worksheets for Additional Details)</td>
<td></td>
</tr>
<tr>
<td>1045 – 1130</td>
<td>Breakout Group Report Outs for Session 2 (10 Minutes for Reporting and 10 Minutes for Q&amp;A)</td>
<td></td>
</tr>
<tr>
<td>1130 – 1300</td>
<td>Lunch Talk #4: Understanding Ag</td>
<td>Mr. Gabe Brown and Mr. Alejandro Carrillo, Understanding Ag</td>
</tr>
<tr>
<td>1200 – 1300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1300 - 1320</td>
<td>Breakout Group Report Outs for Session 2 (10 Minutes for Reporting and 10 Minutes for Q&amp;A)</td>
<td></td>
</tr>
<tr>
<td>1320 - 1345</td>
<td>Break and Transfer to Vehicles for Site Visit</td>
<td></td>
</tr>
<tr>
<td>1345 - 1530</td>
<td>MCAS YUMA</td>
<td></td>
</tr>
<tr>
<td>1530 - 1545</td>
<td>Break</td>
<td>Dr. Todd Bridges</td>
</tr>
<tr>
<td>1545 – 1600</td>
<td>Plenary Discussion Specific to Site Visit and Natural Infrastructure</td>
<td></td>
</tr>
<tr>
<td>1600 - 1615</td>
<td>Natural Infrastructure Talk #5: Land Management and Water Security (10 Minute Talk / 5 Minute Q&amp;A)</td>
<td>Mr. Ricardo Aguirre, P.E., CFM, AP, Director of Land Management and Water Security, Executive Director of Drylands Alliance Addressing Water Needs (DAAWN), WEST Consultants, Inc.</td>
</tr>
<tr>
<td>1615 – 1630</td>
<td>Close Out of Day 2</td>
<td>Dr. Todd Bridges</td>
</tr>
<tr>
<td>1630</td>
<td>Adjourn</td>
<td></td>
</tr>
</tbody>
</table>


### MARCH 3, 2022: (All times listed are Mountain Standard Time)

<table>
<thead>
<tr>
<th>Time</th>
<th>Action</th>
<th>Lead or Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>0800 – 0830</td>
<td>Arrive MCAS Yuma</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The Club / Bldg #1200</td>
<td></td>
</tr>
<tr>
<td>0830 - 0845</td>
<td>Reflections about Day 2 / Activities for Day 3</td>
<td>Dr. Todd Bridges</td>
</tr>
<tr>
<td>0845 – 0900</td>
<td>Natural Infrastructure Talk #6: Compost for Climate Resilience</td>
<td>Dr. Ryan Busby, Research Ecologist, US Army Engineer Research and Development Center</td>
</tr>
<tr>
<td></td>
<td>(10 Minute Talk / 5 Minute Q&amp;A)</td>
<td></td>
</tr>
<tr>
<td>0900 - 1000</td>
<td>Facilitated Breakout Session 3; Installation specific follow-on NI demonstration/implementation project opportunities (Please refer to Workbook for Additional Details)</td>
<td></td>
</tr>
<tr>
<td>1000 – 1010</td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>1010 – 1130</td>
<td>Breakout Group Report Outs for Session 3 (10 Minutes for Reporting and 10 Minutes for Q&amp;A) • Group 1 • Group 2 • Group 3 • Group 4</td>
<td></td>
</tr>
<tr>
<td>1130 – 1200</td>
<td>Review of Workshop Findings, Action Items and Next Steps</td>
<td>Dr. Todd Bridges</td>
</tr>
<tr>
<td>1200</td>
<td>Adjourn</td>
<td></td>
</tr>
</tbody>
</table>
## Breakout Session #1

### Installation Shocks and Stressors that Create Vulnerability at our Installation

*What are the largest sources of uncertainty concerning Nature-Based Solutions (NBS), performance, and management (including Operations & Maintenance)? How might an increased understanding of ecosystem services provided by NBS be used in decision-making in desert communities (for example, understanding performance of different features)? Please provide your rationale, succinctly. Given these levels of uncertainty, what specific physical, ecological, or social processes/science should be targeted and considered in order to advance the use and integration of NBS into desert infrastructure strategies?*

*Please provide your rationale, succinctly below and turn in your completed workshop to your facilitator by the end of the workshop.*

<table>
<thead>
<tr>
<th>Attendee Name:</th>
<th>Agency:</th>
<th>Small Group #:</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

**What are the largest sources of installation Shocks and Stressors?**

- **Earthquakes**
- **Wildfire**
- **Flooding**
- **Other**

**How might an increased understanding of ecosystem services provided by EWN be used in decision-making in desert communities?**

*(with rationale):*

*Given uncertainty, what specific physical, ecological or social processes/science should be targeted to promote use of EWN?*

<table>
<thead>
<tr>
<th>Physical</th>
<th>Ecological</th>
<th>Social</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>
Breakout Session #2

Opportunities and Challenges for Nature-Based Solutions

What types of challenges do you encounter when trying to execute infrastructure projects?

What technical, policy, organizational, cultural, procedural challenges/obstacles are holding back progress toward resilient/sustainable installations?

How could pursuit and application of nature-based solutions be undertaken to address these challenges/obstacles?

Please provide your rationale, succinctly below and turn in your completed workshop to your facilitator by the end of the workshop.

<table>
<thead>
<tr>
<th>Attendee Name:</th>
<th>Agency:</th>
<th>Small Group #:</th>
</tr>
</thead>
</table>

What types of nature-based solution projects is your organization currently conducting? Please provide name of effort, location, description and entities involved.

What types of challenges do you encounter when you execute infrastructure projects?

<table>
<thead>
<tr>
<th>Technical:</th>
<th>Operational:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Funding:</td>
<td>Innovation:</td>
</tr>
<tr>
<td>Policy:</td>
<td>Approvals:</td>
</tr>
<tr>
<td>Cultural:</td>
<td>UFC:</td>
</tr>
</tbody>
</table>

What types of nature-based solution projects present the best opportunities for DON and its stakeholders and partners (considering research priorities, policy, planning, permitting issues, construction, operations, etc.)?
## Breakout Session #3

### Priority Nature-Based Solutions Collaborative Projects

What future Nature-Based Solutions (NBS) projects would you prioritize for collaboration by USACE and DON? Existing projects that can be leveraged should also be included. When considering your priority project(s), what key aspects or elements of these collaboration projects should be taken to advance the collaborative efforts?

Please provide your rationale, succinctly below and turn in your completed workshop to your facilitator by the end of the workshop.

<table>
<thead>
<tr>
<th>Attendee Name:</th>
<th>Agency:</th>
<th>Small Group #:</th>
</tr>
</thead>
</table>

What future Nature-Based Solutions projects would you prioritize for collaboration by USACE and DON, other partners and stakeholders?

<table>
<thead>
<tr>
<th>Name of Effort:</th>
<th>Existing?</th>
<th>Yes:</th>
<th>No:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location(s):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaborators Involved:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description of Key Aspects:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Next Step(s):</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name of Effort:</th>
<th>Existing?</th>
<th>Yes:</th>
<th>No:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location(s):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaborators Involved:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description of Key Aspects:</td>
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<tr>
<td>Next Step(s):</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Name of Effort:</th>
<th>Existing?</th>
<th>Yes:</th>
<th>No:</th>
</tr>
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</tbody>
</table>
Appendix C. Workshop Presentations

Pre-Workshop Presentations

Dr. Todd Bridges: Engineering With Nature®, Pursuing a New Arrangement with Nature

Engineering With Nature®: Pursuing a New Arrangement With Nature

Dr. Todd S. Bridges
Senior Research Scientist (ST), Environmental Science
National Lead, USACE Engineering With Nature®
Todd.S.Bridges@usace.army.mil

Navy-Marine Corps Workshop, Yuma
February 22, 2022
1900-2000: The Century of Infrastructure (US)

- 4,071,000 miles of roadway
  - 47,182 miles in the Interstate system
- 149,136 miles of mainline rail
- 640,000 miles of high-voltage transmission lines
- 614,387 bridges
- 90,580 dams
- >30,000 miles of flood levee
- 155,000 public drinking water systems
- ~5,000 military installations
- 926 ports, 25,000 miles of navigation channel


The San Joaquin Valley, California
The West's Climate Change Conundrum

Rapid intensification of the emerging southwestern North American megadrought in 2020–2021

A previous reconstruction back to 800 is indicated that the 2000–2018 soil moisture deficit in southwestern North America was exceeded during one megadrought in the late-1600s. Here, we show that after exceptional drought severity in 2021, ~60% of which is attributable to anthropogenic climate trends, 2000–2021 was the driest 23-pr period since at least 800. This drought will very likely persist through 2022, matching the duration of the late-1600s megadrought.

Engineering With Nature®

...the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaboration.

Key Elements:
- Science and engineering that produces operational efficiencies
- Using natural process to maximum benefit
- Increase and diversify infrastructure value
- Science-based collaboration to organize and focus interests, stakeholders, and partners

"The mission of US Army Corps of Engineers is to deliver vital public and military engineering services; partnering in peace and war to strengthen our nation’s security, energize the economy and reduce risks from disasters. Engineering With Nature supports this mission which is why it will always be an important initiative for the Corps." LTG Scott A. Spellman, 55th Chief of Engineers, Commanding General, USACE

www.engineeringwithnature.org
Engineering With Nature: USACE Proving Grounds

- Galveston District
- Buffalo District
- Philadelphia District
- Mobile District
- San Francisco District
- St. Louis District
- South Pacific Division

Nature-Based Solutions:
Conserving, restoring, and engineering nature for the benefit of people and nature

An Example: Trees as Infrastructure!
- Shaded surfaces can be 20-45°F cooler
- Evapotranspiration plus shading can reduce peak summer temperatures by 2-9°F
- Reducing wind speed and winter heat loss from buildings by 10-50%
- Improve local air quality
- Increase water infiltration, reducing surface water run-off
Leveraging Nature for Engineering Value: Mangroves

Florida Mangroves Study:
- Used an insurance industry catastrophe model to quantify the flood reduction benefits of mangroves across Florida
- During Hurricane Irma:
  - Mangroves averted $1.5 billion dollars in flood damages to properties
  - 25% savings in counties with mangroves
  - >600,000 people living behind mangrove forests saw reduced flooding across Florida

Horseshoe Bend Island, Atchafalaya River, Louisiana, USA

Project Awards:
- 2015 Western Dredging Association Award for Environmental Excellence
- 2017 Western Dredging Association Award for Climate Change Adaption
- 2017 Dredging and Port Construction Award for Engineering with Nature
- 2020 USACE Green Innovation Award

Groundwater Recharge: Gilbert Riparian Preserve

Appendix C: Workshop Presentations
Military Installation Resilience: Built + Natural Infrastructure

“Built and natural infrastructure are both necessary for successful mission preparedness and readiness.”

EWN, Applied to Tyndall Air Force Base for Coastal Resilience

- EWN Podcast Season 1, Episode 3: BG Melancon
- Winner: 2021 UK Environment Agency Flood & Coast International Excellence Award
“Revolutionizing” Practice Through Nature-Based Solutions

- Policy development
  - Engagement with policymakers
  - Policy/procedure “modernization”
- Engagement, partnering, and teaming
  - Within USACE, e.g., EWN Proving Grounds
  - With other organizations inside and outside government
- Innovation
  - Creating a vision of the future
  - Establishing goals, targets and conditions
  - New science and engineering and tools for delivery
- On-the-ground projects and demos
  - Across the spectrum of applications and project development (i.e., from planning to operations)
  - Scaling up nature-based solutions
- Strategic communications
  - Individual research papers
  - Communication tools, e.g., EWN Atlas Vol 1 and 2
  - Education, e.g., academic curricula, training

EWN BCA Policy Research: Overview

Current federal alternative evaluation process does not comprehensively value economic, environmental, and social benefits. These constraints screen out or exclude Nature-Based Solutions (NBS) and could lead to outcomes inconsistent with the Administration’s priorities around community resilience and equity.

Approach:

- **Summarize** historical and current alternative evaluation policies and practices
- **Identify** 6 historical planning studies that considered NBS alternatives suitable for case study analysis
- **Review** updated valuation methods and planning frameworks that incorporate environmental and social benefits
- **Analyze** case studies using updated methods and exploratory analysis to look beyond current policy constraints
The Power of Co-Development and Demonstration

Seven Mile Island Innovation Laboratory

- Collaboration and partnership that is building first-of-their-kind NBS projects in coastal New Jersey
  - Began in conversation
  - Accelerated by a storm (Sandy)
  - Progressed through piloting
  - Now in full-scale implementation

The Network for Engineering With Nature (N-EWN)

- Multi-sector network supporting innovation
  - Types of partners: public and private sector
  - Research - gov't, academic, private
  - Industry practitioners
  - Project owners
- Aligning research with the needs of practice
- Grounding approach in real projects
- EWN education: curricula and training
- Experiential learning for students - systems thinking, cross-disciplinary training
- Freely flowing communication and knowledge sharing
- Accelerate implementation

www.engineeringwithnature.org; https://n-ewn.org/
EWN Solutions for the Heartland

- Establish collaborative EWN enterprise
- Pursue EWN field demonstrations
- Launch EWN communications platform

Research focus areas
- EWN opportunities inventory
- Agricultural applications
- Water resource (river/reservoirs) uses
- Water quality role
- Extreme weather/climate variability effects
- Energy-water nexus possibilities

Collaborative R&D enterprise tasks
- Public/private partnership development
- Incorporation of social sciences
- EWN curricula/graduate certificate
- Continuing education opportunities
- Workshops, symposia, seminars
- Webinars, videos, publications
- Documentary film

EWN Science, Engineering, Technology: Capability Targets

- Fundamental processes
  - Sediment transport through and around coastal NNBF
  - Long-term performance of features
  - Quantifying multi-purpose benefits of nature-based solutions
  - Processes contributing to system-scale resilience

- Physical and numerical modeling
  - Planners, stakeholders and decision-makers
  - Engineering design
  - Operations and maintenance

- Reliable, cost-efficient monitoring technologies
  - Measuring system evolution
  - Infrastructure/feature performance
  - Informing system adaptation

- Guidance development
  - Across applications: navigation, water supply, flood, drought, etc.
  - For planning, design, construction, O&M

- Demonstration/pilot projects to innovate/learn
  - Learn by doing
  - Collaboration to evolve organizational culture and practice
  - Produce evidence at field scale
  - Fuel the “power of the story”
The EWN® Toolkit for: Coastal Storm (CSTORM) Modeling System

• Toolkit allows for rapid representation of EWN features within a coastal and fluvial numerical model background.

• The user will have a geospatially rectified background image (i.e. from satellite or similar) to reference while working in the mesh editing environment.

• A simple set of tools for creating polygons and layers of polygons, in which to represent EWN features will be available.

• Each EWN feature will come with an options tab or drop down menu to adjust various parameters for that feature (i.e. density of vegetation, Manning’s n values, and bathymetry) that will be stored in a look up table.
NNBF for FRM: Overarching Observations

- Natural features and landscapes have always contributed to flood resilience.
- The function and success of FRM measures and systems are related to scale.
- Sustainable FRM systems will include combinations of conventional, natural, and nature-based elements.
- The flexibility and adaptability of NNBF are useful for achieving flood resilience.
- NNBF can increase and diversify the value provided by infrastructure.
- Innovation in practice will be key to addressing future problems and opportunities.
- Policies need to be developed to guide and expand the use of NNBF.
- Coordination, collaboration, and partnership will fuel successful implementation of NNBF.
Appendix C. Workshop Presentations

Designing for EWN: Sabine to Galveston, TX

https://ewn.el.erdc.dren.mil/designs.html

US Army Corps of Engineers • Engineer Research and Development Center

Communicating Nature-Based Solutions

www.engineeringwithnature.org

US Army Corps of Engineers • Engineer Research and Development Center
Nature and Human Well-Being

- Science supports positive health effects of engagement with nature:
  - Physical health
    - Blood pressure
    - Healing
    - Immunity
    - Etc.
  - Mental health
    - Cognitive function
    - Anxiety
    - Depression
    - Socialization
    - Etc.

Nature experience reduces rumination and subgenual prefrontal cortex activation

“it is a scientific fact that the occasional contemplation of natural scenes... is favorable to the health and vigor of men...”

Frederick Law Olmsted (1822-1903)

Some Practical Aspects of “Revolutionizing” Practice Through EWN and Nature-Based Solutions

- NBS are relevant across multiple hazards and infrastructure contexts
- Co-develop a shared vision of the solution with communities from the BEGINNING
  - Shape and support vision THROUGHOUT
  - Landscape architects to help communicate vision
  - Engage and communicate with others!
- Diversify benefits to make solutions palatable for communities.
  - Communities live with the solution for 99% of time when the project is NOT under a storm load
  - USACE must expand benefits evaluation procedures, per James’ memo (5 Jan 2021) and beyond
- Partner with industry, other agencies to iteratively develop engineering guidance, where needed
- “Hang-ups” to be overcome: Must NOT...
  - Think either/or (structural v. natural), but AND
  - Consider nature as a “frill” on an economic plan
  - Use uncertainty to excuse systematic/procedural bias

Appendix C. Workshop Presentations
The Spectrum

“Wild and Free-Flowing Nature”

“Tamed and Conquered Nature”

Achieving Nature-Engineering Balance

- Vision for sustainable systems
- Community needs and values
- Collaboration across boundaries
- Communication with others
- Innovation in engineering
- Enabling policy

US Army Corps of Engineers • Engineer Research and Development Center

Duwamish River, WA 1800s

San Joaquin Valley, CA 1800s

Duwamish River, WA today

San Joaquin Valley, CA today
Arid lands > terrestrial biome on Earth
Arid: ”without moisture; extremely dry; parched”
Ephemeral streams only flow after rains
Hydrology studies are challenging
Droughts

(Image credit: NASA Earth Observatory / Lauren Dauphin)

Flood Hazards
Climate Change :: Aridification

This increased risk of flooding during periods of extreme precipitation and megadrought condition creates the need (& opportunity!) for climate resilience!

Climate Adaptation vs. Mitigation

ADAPTATION: respond to a changing environment

MITIGATION: efforts are made to reduce greenhouse gas (GHG) emissions


NATURAL INFRASTRUCTURE IN DRYLAND STREAMS

Photographs where blue arrows portray direction of flow:

a) leaky weirs (photo by Josiah Austin);
b) gabion (photo by Andrea Prichard (Norman et al., 2010b);
c) check dams (photo by Jeremiah Liebowitz);
d) one-rock dams (photo by Deborah Tosline (Tosline et al., 2020a));
e) trincheras (Photo by Valer Clark); and
f) a beaver dam!


The Original Engineers

BEAVER DAM

AMERICAN BEAVER (CASTOR CANADENSIS)


Airborne Beavers Fight Floods

Human-made Natural Infrastructure

CHECK DAMS AND GABIONS


Aridlands Water Harvesting Project

Determine efficacy of various Rock Detention Structures (RDS)
Appendix C. Workshop Presentations


2.) Work with partners to determine where new structures should be.....

- For flood prevention?
- For vegetation and habitat improvement?
- To “heal” the land?
- For groundwater recharge?
- For erosion control?
- For increasing water quality & quantity?
- To armor landscapes?
- For climate regulation?

Sky Island Restoration Cooperative

Appendix C. Workshop Presentations
Appendix C. Workshop Presentations

<table>
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<th>Channel Impacts</th>
<th>Cuesta Blanca</th>
<th>Capulines</th>
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<td>9,268,617</td>
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<tr>
<td>w/ feature</td>
<td>2,964,995</td>
<td>3,869,279</td>
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<tr>
<td>Difference</td>
<td>5,553,609</td>
<td>5,399,338</td>
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Wetland Restoration: Increased Vegetation

- Over a 27-year time period, we documented that vegetation is maintained and improved at structures, despite drought conditions, and
- This was evidenced extending up to 5km downstream and 1 km upstream!


56
**Aquifer Recharge**


**Phoenix, AZ ➔ Climate Regulation**


Appendix C. Workshop Presentations

Monitoring Streamflow
Hydrology of Streams Restored with Check Dams

监测溪流流量
恢复溪流的水文

Evan Gwilliam
Ecologist
National Park Service

Fletcher Brinkerhoff,
Hydrologic Technician
Arizona Water Science Center

表：监测溪流流量 - 结果

|                        | 未受干扰/控制 (RC) | 水流量
|------------------------|-------------------|------------------|
|                        | Q体积 (总立方米) | 降水 (月度总水文量 * 水域) | 水流量%
| 7月                    | 12,950            | 3,768,480         | 3.35 |
| 8月                    | 38,120            | 3,488,560         | 1.68 |
| 9月                    | 34,284            | 1,011,780         | 33.9 |
| 10月                   | 1,726             | 9                  | 0     |

表：受干扰/控制 (TF)

|                        | 水流量
|------------------------|------------------|
|                        | Q体积 (总立方米) | 降水 (月度总水文量 * 水域) | 水流量%
| 7月                    | 0                | 1,258,690         | 0     |
| 8月                    | 18,561           | 1,107,540         | 1.68 |
| 9月                    | 27,560           | 322,960           | 8.53 |
| 10月                   | 855              | 0                | 0     |

Hydrologic Models – Soil and Water Assessment Tool (SWAT)

Erosion Control → Water Purification

Table 2: Model results (assuming unlimited): average dry
wetlands and estimates of treatment on watershed.

<table>
<thead>
<tr>
<th>Site (ha)</th>
<th>Avg Flow (m³/s)</th>
<th>Avg net soil loss (USLE tons/year)</th>
<th>Avg sediment yield (CDR = 0.45-0.01, tons/year)</th>
<th>Avg sediment yield (% check dams tons/year)</th>
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<td>0.07</td>
<td>75.0</td>
<td>356-403</td>
<td>178-242</td>
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<td>0.18</td>
<td>30.7</td>
<td>1420-1936</td>
<td>714-998</td>
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Legend
- Avg. Soil Loss (USLE: tons/year)
- 0 - 20
- 21 - 60
- 61 - 136
- 137 - 228
- 229 - 383
- Hydrology
- Subwatershed Boundary


Analyzing Soil Samples

- Sampled Stable isotope ratios of carbon and nitrogen ($\delta^{13}C$ and $\delta^{15}N$)

We conservatively estimated the potential mean annual capture of Soil Organic Carbon by check dams in the Turkey Pen Watershed (recall ~>2000 check dams/769 ha) to be ~200-250 metric tons/ha. 


Carbon Sequestration and Storage

... Equivalent to what is stored in wetlands

Aridlands :: Wetlands

These are freshwater wetlands (ciénegas)

distinct ecosystems, flooded by water
Climate Related
Ecosystem Services of Rock Detention Structures

✓ Flood regulation
✓ Erosion regulation
✓ Habitat Provisioning
✓ Water regulation, purification, and provisioning
✓ Carbon sequestration and storage
✓ Social value
✓ Climate regulation

Natural Infrastructure in Dryland Streams
Create Regenerative Wetland Sinks
a.k.a. Soil Water Carbon Sinks

More Water Availability
- Increased water volume
- Increase water quality
- Increase infiltration
- Extended seasonal runoff

More Healthy Vegetation
- Extended growing season
- More Photosynthesis
- Deeper and more plentiful Roots

More sediment trapped
- More soil productivity
- More water storage
- More carbon storage
- Less NPS pollutants downstream (clearer water)

Transpires water out of its leaves to condense on the inside of the bottle. Water drips (rains) back into the soil.

The plant takes water up through its roots. https://www.inspiremore.com/david-latimer-bottle-garden/

Nature-based Solutions: Regenerating Riparian Areas

July 20, 2021: Drought Monitor

Federal and Tribal riparian areas in Arizona

**COSTS***

33,182 ha X ~$2,210 per ha = $73M

33,182 ha / 2.6 check dams/ha = >86K check dams

For comparison, climate-related disasters in Arizona spurred Legislation of **$100M** for recovery and support efforts to help deal with damages related to post-fire flooding in **2021** (Office of the Governor, 2021).

**BENEFITS**

- sequester the soil storage
- maintain or increase vegetation and biomass
- extend growing seasons
- mitigate floods
- promote lateral flows and onsite storage of water
- control erosion and nonpoint source pollution, improving water quality
- reduce ambient temperatures

>-1000 job-years & >$160M of economic output to local, regional, and national economies

*all calculations are approximated based on previous research*

---

For comparison, climate-related disasters in Arizona spurred Legislation of **$100M** for recovery and support efforts to help deal with damages related to post-fire flooding in **2021** (Office of the Governor, 2021).

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Appendix C. Workshop Presentations

Where:
- \( L \): Length of swale (m)
- \( S_i \): Initial existing slope ratio of the swale (rise/run)
- \( S_e \): Desired effective slope of the enhanced swale (between 0.005 - 0.01, rise/run)
- \( h \): The average effective height of the check dams in m (excluding foundations) (suggest you use \( y \), calculated above)

\[
\frac{2600 \text{ m}}{3 \text{ m}} = \frac{234}{3} = 78 \text{ check dams will be installed}
\]
Watershed Restoration

Long-term maintenance and re-tooling
Combination of structures, depending on conditions
Lots and lots of structures (thousands)
Installed by people trained in restoration
Based on prioritized needs (erosion control, recharge, habitat provisioning, flood detention, etc..)


Appendix C. Workshop Presentations

Want to learn more about the science and access publications? [https://usgs.gov/WGSC/Aridlands]

Want to learn more about partnerships and practices on the US-Mexico border? USGS Public Lecture in March, posted online: [https://www.usgs.gov/media/videos/pubtalk-32021-a-jaguars-field-dreams]

Want to contact me? Laura M. Norman, lnorman@usgs.gov [https://www.usgs.gov/staff-profiles/laura-m-norman]

Thank you!
Hollie Schmidt: Defining the Installation of the Future After a Natural Disaster Using Nature Based Solutions at Tyndall Air Force Base

INTRODUCTION

Task Lead for the Tyndall Air Force Base Rebuild Program

In this role, Hollie facilitated stakeholder engagement and outreach, served as the on-site coordinator, and led a large multi-disciplinary technical team while championing nature-based resiliency solutions. She led the infrastructure strategy, updates to the Installation Facilities Standards and the integrated land management approach for the reconstruction of Tyndall AFB.

Hollie Schmidt is the Director of the Resilience & Sustainability Business Advisory for the Americas with the Advance Planning Group at Jacobs. She is a landscape architect and master planner with 27 years’ experience specializing in strategic planning and executive level decision facilitation for private and public sector clients. She leads large-scale, complex mega-projects facilitating diverse teams of planners, urban designers, landscape architects and the full spectrum of technical and engineering experts.
Appendix C. Workshop Presentations

Ongoing Work with USACE ERDC EWN

USACE ERDC EWN & JACOBS RELATIONSHIP

1. Tyndall Air Force Base Rebuild
   Integrated EWN design solutions for the natural and built environment

2. Co-Published EWN Atlas
   Supporting Mission Resilience and Infrastructure Value at Department of Defense Installations

3. Tyndall Coastal Resilience Strategy
   Definition of Pilot Projects, Stakeholder Engagement, Funding Strategy, Implementation Plan

4. EWN DoD Facility Adaptation Planning
   3-Year Contract for vulnerability assessments at DoD Installations that can be mitigated with EWN solutions
In October 2018, Tyndall Air Force Base was hit with a category five hurricane which resulted in damage to 100% of its assets. The goal of this project was to rebuild the base to be more resilient, sustainable, and smart to be an Installation of the Future.
Appendix C. Workshop Presentations

What. Components and Aspirations.

Components of an Installation of the Past

BUILDINGS
Mission Critical
Mission Support

ENABLING INFRASTRUCTURE
Transportation + Mobility
Airspace Logistics
Access + Connectivity
Utilities + Technology
Public Works

Components of an Installation of the Future

BUILDINGS
Mission Critical
Mission Support

LAND INFRASTRUCTURE
Land Use + Site Layout
Integrated Land Management
Environmental Considerations
Engineering With Nature
Natural Capital

ENABLING INFRASTRUCTURE
Transportation + Mobility
Airspace Logistics
Access + Connectivity
Utilities + Technology
Public Works

PEOPLE
Warriors + Families
Veterans, Civilians + Community
Wellness + Wellbeing
Recruitment + Retention
PROGRAMMATIC ECONOMIC ANALYSIS

UPFRONT COST
PRE-MICHAEL
$303M
$214M horizontal
$89M vertical

CURRENT PROGRAM
$393M
$292M horizontal
$101M vertical

$90M
23% increase

Current Program:
BREAKEVEN POSSIBLE
Year 11 (2033)
given uncertainties
1.2% higher over 30 yrs

Higher NPV Results

Lower Major Replacement Costs
$16M lower over 30 yrs

Lower Annual O&M Costs
$3M or $90M lower over 30 yrs

Doubling of Non-Financial Scoring Factors
2X

REBUILD PROGRAM
Design Wind Speeds & Building Envelope Protection Memo

<table>
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<th>Risk Category</th>
<th>Design Wind Speeds</th>
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<tr>
<td>III</td>
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<tr>
<td>IV</td>
<td>170 mph</td>
</tr>
<tr>
<td>V</td>
<td>203 mph</td>
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Design Flood Elevation (DFE) Memo

Design Flood Elevation (DFE) is defined as the minimum elevation to design above considering (at least) the Basic Flood Elevation (BFE).

- For the G-19 College & Community Center, the DFE is 19.34 feet above Mean Sea Level (MSL).
- For the North Complex, the DFE is 14 feet above MSL.

Minimum Design Flood Elevation
- 19’ Support District (S of HW 98)
- 14’ Flightline District (N of HW 98)
## INSTALLATION FACILITIES STANDARDS: PERFORMANCE STANDARDS

### Tyndall Air Force Base

### Executive Summary

#### INSTALLATION FACILITIES STANDARDS

- **Performance Standard:**
  - **Description:**
    - Performance standard:
      - Rebuild Design Intent

#### Architectural Systems

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<th>Description</th>
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<td>Rebuild Design Intent</td>
<td>Nature-based solutions and related envelope elements.</td>
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#### Nature Based Solutions

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<th>Description</th>
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<tbody>
<tr>
<td>Rebuild Design Intent</td>
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### Appendix C. Workshop Presentations

- **Tyndall Air Force Base**
- **Executive Summary**
  - INSTALLATION FACILITIES STANDARDS: PERFORMANCE STANDARDS
  - Tyndall Air Force Base
  - Rebuild Design Intent
  - Nature Based Solutions
  - Coastal Resilience

### Jacobs

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### INSTALLATION FACILITIES STANDARDS

- **Jacobs**
- **Tyndall Air Force Base**
IFS UPDATE

1. IFS REBUILD APPENDIX
2. IFS PARENT UPDATE
3. LANDSCAPE MASTER PLAN

NATURE BASED INFRASTRUCTURE + LANDSCAPE MASTER PLAN
Appendix C. Workshop Presentations

NATURE BASED INFRASTRUCTURE (NBI)

NBI Myth Busting

- MILCON will not pay for landscape, it will never get installed
- Landscape is “nice to have” and should not be installed at sacrifice to the mission, it has no value
- The base will not maintain NBI solutions
- Nature Based Infrastructure costs more and requires more maintenance

- Landscaped areas attract snakes, bears and mosquitoes
- Landscaped areas are a security concern
- Proposed solutions will restrict or constrain future development and pose a threat to mission

LANDSCAPE MASTER PLAN

Utilities

- Maximize use of underground pipes, expressed by reduced stormwater infiltrating, increased roads, and grid-like surface resilience
- Use natural, nature-based improvements must be considered by their distinct roles to solve larger needs, and their distinct roles to solve larger needs

- Locate trees to avoid all utility clear zones and easements
- Integration between aesthetics, economy, and utility infrastructure concerns is between design and execution to break-up impervious surfaces

- Utility Clear Zone
- Easement

- Integrations between aesthetics, economy, and utility infrastructure concerns is between design and execution to break-up impervious surfaces
LANDSCAPE MASTER PLAN

Stormwater Management

Prioritization and Implementation

The map on this page illustrates the mobility system considered part of the MILCON reconstruction, as well as long range mobility investments to position Tyndall as an installation of the future.

The renderings below show how the initial investment from MILCON can be enhanced in concert with mission growth and increased investment in alternative mobility options.
Coastal Zone Site Furnishings

- Use interpretive signage to include educational and directional information, such as cultural & historical content, coastal & environmental conservation, wildlife habitat & dune restoration, installation of the future reconstruction.

- Minimize disturbance by limiting the use of lighting, using turtle friendly lighting, elevating boardwalk to allow wildlife, water and air pass through.

- Revegetated dunes help to reduce flood and erosion risk, provide wildlife habitat.
TYNDALL Design Guidance

https://www.tyndallifs.com/

A04. Authority

This procedure relates to the U.S. Department of Defense Unified Facilities Criteria (UFC) program, which strives to deliver standard, coordinated, comprehensive, complete, and cost-effective design and construction solutions across all military installation agencies. The year’s guidance also follows the Air Force Corporate Facilities Standards (ACFS), an enterprise wide facility program for design and construction.

This Landscape Master Plan was developed during the 2022-2023 validation of the TYNDALL AFB Infrastructure Facilities Standard (IFS), the next generation plan. The IFS is an enterprise wide facility program for design and construction. The IFS is intended to provide a common set of standards for all military installation agencies and is intended to reduce life-cycle costs and improve the overall performance of infrastructure assets.

The TYNDALL Design Guidelines provides a method for developing a design guidelines for TYNDALL AFB. This guideline is intended to be used by the TYNDALL AFB Design Team and the TYNDALL AFB Design Team may use the guidelines for developing their own design guidelines.

A05. How to Use This Document

This document is intended to be used by the design team to develop a TYNDALL AFB design guidelines. The guideline should be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 1 - General

This section provides an overview of the TYNDALL AFB design guidelines and the guidelines are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 2 - Design Criteria

This section provides a list of criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 3 - Site Design

This section provides a list of site design criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 4 - Landscape

This section provides a list of landscape criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 5 - Access Management

This section provides a list of access management criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 6 - Water Resources

This section provides a list of water resources criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 7 - Lighting

This section provides a list of lighting criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 8 - Pedestrian Navigation

This section provides a list of pedestrian navigation criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 9 - Signage

This section provides a list of signage criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 10 - Traffic Management

This section provides a list of traffic management criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 11 - Electrical Systems

This section provides a list of electrical systems criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 12 - Mechanical Systems

This section provides a list of mechanical systems criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 13 - Architectural Design

This section provides a list of architectural design criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 14 - Construction

This section provides a list of construction criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 15 - Operations and Maintenance

This section provides a list of operations and maintenance criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 16 - Environmental

This section provides a list of environmental criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.

Section 17 - Cost

This section provides a list of cost criteria that should be considered when developing the TYNDALL AFB design guidelines. The criteria are intended to be used as a reference for the development of the TYNDALL AFB design guidelines.
Appendix C. Workshop Presentations

COASTAL RESILIENCE OTHER TRANSACTIONAL AUTHORITY (OTA)
STAKEHOLDER ENGAGEMENT

http://tyndallcoastalresilience.com/

ONE COMMON THEME - CONTINUE TO PURSUE PILOTS AND FUNDING

THANK YOU
**Day 1 Presentations**

Randy English: MCAS Yuma Intro Slides

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**Installation Overview**

- **Area of Responsibility**: 1.2 Million Acres
  - MCAS Yuma
  - Cannon Air Defense Complex (CADC)
  - Barry M. Goldwater Range – West (BMGR-W)
  - Chocolate Mountain Aerial Gunnery Range (CMAGR)

- **Major Sites**
  - MCAS Yuma
  - 1,717 Facilities (PRV $3.8B)
  - 4 Runways / 5 VTOL Pads
  - 859 On-Base PPV Single/Multi Family residences
  - 128 Off Base PPV Apartments
  - Camp Billy Machen (R-2507) (8 buildings 2 heli-pads)
  - CADC (3 Tenant commands ~1000 Marines within the R-2301)
  - BMGR-W & CMAGR

- **Outlying Airfields**
  - AUX II (BMGR-W)
  - KNOZ (BMGR-W)
  - CADC UAV Strip

- **Shared Airfield w/Yuma Airport**
  - MCAS Yuma
    - Provides Fire/Crash/Rescue services
    - Maintains Runways, Taxiways, and Airfield lighting
    - Provides Air Traffic Control services
    - Maintains Airfield Security

Assistant Secretary of the Navy (Energy, Installations & Environment)
“Unique” MCAS Yuma

- Marine Corps’ Premier Aviation Training Facility
- Third largest range complex in CONUS
  - MCAS Yuma maintains 60% of USMC owned range space
- Busiest USMC Air Facility (173,840 Operations – CY 2020)
- Fourth busiest Naval Air Facility (NAS Meridian, NOLF Imperial Beach, NAS Kingsville, MCAS Yuma)

Top Line Natural Hazard Challenges and Potential Natural Infrastructure Opportunities Associated with the Installation

- Restoring CMAGR/BMGR-W road topography to natural conditions that facilitate natural water flow supporting vegetation communities and providing resilience against higher intensity flooding events associated with climate change.
- Increasing number and capacity of wildlife water sources and forage plots to reduce water hauling operations by state wildlife agencies and volunteer groups.
- Mitigating the clean-up costs and potential hazards resulting from UXO dispersal as a result of less frequent, but more intense precipitation events due to climate change.
- Desert topography impacted by border barrier installation with minimal erosion control implementation.
Locations on Installation where Risks from Natural Hazards are Greatest

Assistant Secretary of the Navy (Energy, Installations & Environment)
Previous Interventions that have been Proposed to Mitigate Natural Hazards

- Removing barriers created through road maintenance to restore streamflow.
- Utilizing physical barriers to curtail disturbance and allow natural recovery.
- Increasing storage capacity of existing wildlife waters and expanding distribution of wildlife water availability.
- Utilizing contract support for UXO cleanup along siphons.

Existing environmental concerns/challenges (T&E species, contaminants, water quality)

- 1.2M acres, of which only 18% surveyed for cultural resources.
- 1,063 miles of approved roads.
- One endangered species (Sonoran pronghorn), one threatened species (Mojave desert tortoise), and two species managed under a Candidate Conservation Agreement: flat-tailed horned lizard (FTHL) and Sonoran desert tortoise.
  - 219,115 acres of protected Sonoran pronghorn habitat
  - 187,842 acres of Mojave desert tortoise critical habitat
  - 114,800 acres of the Yuma Desert Management Area for FTHL
- Average annual precipitation of 3.5”.
- On-going road maintenance and interdiction activities by U.S. Customs and Border Protection on a regular basis.
  - Uncalculated disturbance.
Current ‘nature-based’ amenities on the installation that benefit soldiers, families, and civilian workforce

- Martinez Lake Recreational Site which includes housing, RV spots, boat/jet ski rentals, boat launches, and fishing pier (1 hr drive from main station).
- Multiple recreational parks in base housing, walking trails, children’s playgrounds, picnic areas, and multi-use sports field.
- 75% of the BMGR-W open to recreational access with permit.
  - 26K active user accounts in permitting system.
  - Visitors to the BMGR-W typically seek a more rustic experience as opposed to a park-like experience with improved trails, bathrooms, picnic areas, etc.

Existing and relevant data sources that could help inform study

- GIS: 30cm Satellite Imagery Data, Vegetative Mapping Data, special status species layers, soil mapping (just starting w/ USDA).
- Regional weather station data.
- Camino Del Diablo Restoration Study funded by Cabeza Prieta NWR.
Key partners that would be interested in the NI study


- **Non-Government Organizations:** Friends of the Sonoran Desert, Desert Wildlife Unlimited, Yuma Valley Rod and Gun Club, Safari Club International, Desert Bighorn Sheep Society, Friends of the Desert Mountains, Yuma Conservation Garden, Sonoran Institute, and the Cabeza Prieta Natural History Association.

- **Tribal Nations:** Cocopah Indian Tribe, Quechan Indian Tribe, Agua Caliente Band of Cahuilla Indians, Ak-Chin Indian Nation, Colorado River Indian Tribes, Fort Mojave Indian Tribe, Gila River Indian Community, Thohono O’Odham Nation, Torress Martinez Desert Cahuilla Indian.

Any Additional Information to Share

- BMGR-W, in conjunction with neighboring lands (BMGR-E, Cabeza Prieta, Organ Pipe Cactus National Monument, and associated BLM lands) represent the largest tract of relatively unfragmented Sonoran desert habitat left in existence.

- Over the last 20 years, the CMAGR has produced the highest Mojave desert tortoise densities per square kilometer. Densities calculated via annual Line Distance Sampling.

- MCAS Yuma leases 1,392 acres of agricultural land adjacent to the installation for Bird Air Strike Hazard (BASH) mitigation and generation of additional revenue streams to support conservation efforts on the CMAGR/BMGR-W.

- Only USMC F-35 Fleet Carrier Landing Practice (FCLP) facility on West Coast.
Installation Overview

- NAWS China Lake supports the Naval Air Warfare Center Weapons Division’s state-of-the-art and one-of-a-kind laboratories and facilities that deliver irreplaceable weapons development for the Department of the Navy.
- Airspace R-2508 – 20,000 square miles
- NAWSCL ranges extend over 1.3 million acres, majority within the Mojave Desert ecoregion.
“Uniqueness” of NAWSCL

- The installation is the Navy's largest single landholding, representing 85 percent of the Navy's land for RDAT&E use and 38 percent of the Navy's landholdings worldwide (larger than Rhode Island).
- Makes up 12% of CA Airspace
- Within Mojave Desert (three sub regions the northern; central and western Mojave) and extends in the north into the Great Basin Desert (colder, higher proportion of precip as snow)

Locations on Installation where Risk(s) from Natural Hazards is/are Greatest.
Top Line Natural Hazard Challenges and Potential Natural Infrastructure Opportunities Associated with the Installation

- Over-draft Aquifer (Sole Source of Water)
  - Increased wind borne dust impacts air quality and visibility.
  - Dune formation in ranges.
  - Ground subsidence affects infrastructure and test facilities.
- Increased Fire Risk/Invasive species spread cycle
- Increased Temperatures/# of days above 115/120
- Increased Drought (fire hazard contributor)
- Increased weather intensity (wind/dust storms, lightning storms, flash floods, etc.)
- Earthquakes

Locations on Installation Where Risk(s) from Natural Hazards is/are Greatest.

- Desert Tortoise/Joshua tree habitat areas (valleys/floors, 700,000 + acres on ranges)
- Mountain ranges (Inyo Towhee in Argus Range; pine/pinyon juniper, oak species)
- Natural and fed seeps on the North Range valley floor (tui chub presence)
- Washes/streams/springs (high biodiversity)
Previous Interventions (if any) that have been Proposed to Mitigate Natural Hazards

- 1. Vegetation mapping to assess fire risk (in progress)
- 2. Implement fire/fuel management (nascent)
- 3. Water conservation
  - Infrastructure
  - streams/springs
- 4. Raven Management Plan
- 5. REPI Projects
- 6. Installation Resilience Study (in Progress)

Existing environmental concerns/challenges (e.g., T&E species, contaminants, water quality, etc.)

- Three federally listed species (desert tortoise, inyo CA towee, mohave tui chub)
- Increased wildfires
- Tectonic activity that could affect aquifer
- Declining water quality (Over 50% brackish water)
‘Nature-based’ Amenities present

- Golf Course
- Desert playa for wind racing
- Military Housing - trails, playgrounds, etc.
- B Mountain hiking
- Limited Petroglyph Tours

Existing and relevant data sources that could help inform study

- Integrated Natural Resources Management Plan
- Comprehensive Land Use Management Plan
- IWVGA Groundwater Sustainability Plan
- Earthquake Recovery (OICC)
- Cultural Resources Management Plan
- Indian Wells Valley Ground Water Management Plan
- Ongoing Listed species management plans
Key partners that would be interested in the NI study

- The Nature Conservancy (TNC)
- Trust for Public Lands (TPL)
- Bureau of Land Management
- National Park Service (Joshua Tree NP)
- National Forest Service
- Kern, Inyo, San Bernardino Counties
- City of Ridgecrest
- Indian Wells Valley Groundwater Authority (IWVGA)
- Desert Advisory Council
- Fellow Desert installations (29 Palms, Ft Irwin, EAFB)
- California Department of Fish and Wildlife
- Tribes

Any Additional Information to Share

- NAWSCl grazed via BLM leases for decades with cessation in 2000 and termination in 2004 due to incompatible land use.
- NAWSCl has wild horse and burros, of which the horse herd is protected
  - Centennial management area within China Lake
  - Burros called for removal in 1983
  - Populations above established herd levels
  - Annual issues with roundup/management/range
Captain Troy M. Searcy: Marine Air Ground Force Training Command Marine Corps Air Ground Combat Center

- Integrated
- Combined Arms
- Unrestricted Maneuver
Climate

1. Arid - ca. 100mm ppt/y
   - Recovery time - long
2. Change in SW - Warming
   - Aridification, soils, ecosystem
3. Rain: Winter > Summer (sporadic)
4. Streams in SW
   - MCAGCC ephemeral v. intermittent

Ecosystems

1. Arid - inherently variable, time & space
2. Riparian
   A. Ephemeral or Intermittent Stream
   B. Ecological Functions
      i. Landscape and hydrological connections, energy dissipation, sediment mobilization, storage, transport, and deposition, nutrient cycling, floral and faunal communities
3. Training mission
   - Topography, transit, cover, staging, facilities
1. Heat & extreme heat
2. Drought
3. Wind & dust storms
4. Flashfloods
5. Rare
   A. Earthquakes
   B. Wildfires
Interventions (if any) that have been Proposed to Mitigate Natural Hazards

1. SDM & climate refugia modeling
2. Mapping
   - Vegetation, canyon and washes
3. Habitat restoration
   - TES, invasive spp., riparian corridors
4. Stabilize soil, vegetation & trophic levels (e.g., cryptogams)
   - Carbon Sequestration
   - Air quality
   - Landscape function
5. Synergy

Existing environmental concerns/challenges (e.g., T&E species, contaminants, water quality, etc.)

1. Desert tortoise: ESA, RASP
2. Habitat & ecosystem degradation
3. Soil erosion and compaction
4. Air quality
Current ‘nature-based’ amenities on the installation that benefit soldiers, families, and civilian workforce.

1. Training – Limits amenities to cantonment
2. Walking trails at Mainside (cantonment)
3. Small parks and picnic areas
4. Ball fields, golf course, OHV park

Existing and relevant data sources that could help inform study

1. In-progress, recurring
   A. Climate & disturbance modelling
   B. Canyon and wash inventory (ongoing and future)
   C. Vegetation maps (updated ~ every 5 years)
   D. Non-native invasive plants

2. Existing - soil maps

3. Needed:
   A. Surface hydrology & flow maps
   B. Erosion maps
Key partners that would be interested in the NI study

1. Government Organizations
   A. Regulators – USFWS & CDFW
   B. Neighbors and partners – BLM & NPS
   C. DoD installations – MCAS Yuma, Marine Corps Logistics Base Barstow, Edwards Air Force Base, Fort Irwin National Training Center, Naval Air Weapons Station China Lake

2. Institutional cooperators (e.g., Universities of California, Florida, Toronto)

3. Non-profit organizations (e.g., Desert Tortoise Council, MD Land Trust)
NAS Fallon and Fallon Range Training Complex (FRTC)

Background Information

NAS Fallon and Fallon Range Training Complex (FRTC)

- Located in Northern Nevada ~ 240,000 acres of BLM withdrawn and Navy owned lands.
- Consists of both open and closed lands
- Navy's premier integrated strike warfare training facility
- NAS Fallon Mission: to provide the most realistic integrated air warfare training support available to carrier air wings, Marine air groups, tenant commands, and individual units participating in training events, including joint and multinational exercises, while remaining committed to its assigned personnel.
Top Line Natural Hazard Challenges and Potential Natural Infrastructure Opportunities Associated with the Installation

- 1. Wildland Fire Management on the FRTC
- 2. BASH concerns at NASF airfield
- 3. Storm water drainage improvement on main station
- 4. Water rights and wetland habitat improvement opportunities in Dixie Valley
Locations on Installation Where Risk(s) from Natural Hazards is/are Greatest.

(Bulleted List of Natural Hazards and Some Details Included on this Slide)

- 1. Wildland Fire risk is greatest at B17
- 2. BASH risk is greatest around main station

Previous Interventions (if any) that have been Proposed to Mitigate Natural Hazards

- 1. Wildland fire management plan currently in development for FTRC ranges
- 2. USDA BASH biologist full time on site
- 3. Wildlife Hazard Management Plan identifies projects to reduce wildlife attraction to airfield
Existing environmental concerns/challenges (e.g., T&E species, contaminants, water quality, etc.)

- 1. Currently no T&E species on installation
- 2. Bighorn sheep and Pinyon habitat protection a priority for wildland fire management on B17
- 3. NAS Fallon irrigation ditches included in Carson River Mercury Superfund site
- 4. Carp can be found in irrigation ditches; attracts flocks of Pelicans to agricultural fields around airfield, creates major BASH issues.

Current ‘nature-based’ amenities on the installation that benefit soldiers, families, and civilian workforce. Examples include: walking trails, picnic areas, kayak launch, fishing piers, etc.

- 1. Nature Trail on main station; open to public
- 2. Dixie Valley Training Area is open to public for outdoor recreation: hunting, fishing, camping, OHV.
- 3. Dixie Valley Settlement ponds stocked for fishing by NDOW- open to public.
- 4. Horse Creek parcel open to public for outdoor recreation and access point to Wilderness Study Area in the Clan Alpine Mountains
Existing and relevant data sources that could help inform study

- 1. Integrated Natural Resources Management Plan
- 2. Draft NAS Fallon Wildland Fire management Plan
- 3. BASH Plan and Wildlife Hazard Management Plan
- 4. Wildlife Hazard Assessment

Key partners that would be interested in the NI study

- 1. Sikes Act partners (USFWS, NDOW, BLM)
- 2. Tribes
- 3. NV Division of Conservation and Natural Resources
- 4. Churchill County
Cole Bush: Shepherding Landscapes

Presented by Cole Bush of Shepherdess Land & Livestock Co.
March 1st 2022, Yuma, Arizona
Using Natural Infrastructure to Support Sustainability and Resilience of Installation Missions

Shepherding Landscapes
Prescribed Herbivory as a Climate Beneficial Solution

Cole Bush
Shepherding Animals, People, Projects

- First-generation agrarian + land steward
- Agroecology + Sustainable Development background
- Owner Operator of Shepherdess Land and Livestock Co. LLC
- Entrepreneur, Educator, Advocate, & Consultant
- California Rangeland Advisory Committee, CA Board of Foresters

Responsible for the design, development, and management of prescribed grazing projects on thousands of acres of private, public, and preserved lands with commercial-scale herds of small ruminants throughout California.
Prescribed Herbivory is the intentional use of domestic livestock to remove, rearrange or convert vegetation on wildlands and/or the WUI to reduce the losses and costs associated with wildfires and to enhance the ecological condition of forests, rangelands, and watersheds.

* Other names of this grazing approach include, targeted grazing, managed grazing, contract grazing, to name a few.

Herbivores are essentially self replicating “biological masticators” that can turn biomass into lunch and then into soil organic matter.

IMPACTS INCLUDE:
- REDUCTION OR REMOVAL OF VEGETATION THROUGH GRAZING &/OR BROWSING
- ANIMAL IMPACT THROUGH TRAMPLING
- DUNGING & URINATING
  --> FERTILIZING + BUILDING SOM
**ANIMAL CONSIDERATIONS**  
**BROWSERS VS GRAZERS**  
**WHAT’S THE DIFFERENCE?**

*Small ruminants consume approx. 4% of their body weight and drink 5-2 gallons of water per day*

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**BENEFITS & CONSIDERATIONS WHEN TO USE PRESCRIBED GRAZING**

- Air Quality, when compared to the use of prescribed fire
- Noise, when compared to mechanical operations
- Steep Slopes, hard to access areas or presence of poisonous plants
- Soil Compaction and surface disturbance concerns
PRESCRIBED GRAZING as a Climate Beneficial Solution to enhance Ecological Resilience and Fire Safety

- FIRE FUEL REDUCTION + DEFENSIBLE SPACE
- INVASIVE SPECIES MANAGEMENT
- HABITAT RESTORATION + BIODIVERSITY
- WATERSHED + MINERAL CYCLE FUNCTION
- ALTERNATIVE TO FOSSIL FUEL DEPENDENT MACHINERY & CHEMICAL TREATMENT
- BYPRODUCT--->FOOD + FIBER

The GRAZING Rx
What are you treating?
Symptom or Systemic Cause

- **Species + Breed Selection**, browsing vs grazing
- **Number of animals** in the herd, flock, or flerd
- **Density**, # of animals in given grazing area
- **Duration**, how long is the treatment based on density and impact goals
- **Time of year**, seasonality of treatment, early season vs late season, growing season vs dormant season
FIRE FUEL REDUCTION
DEFENSIBLE SPACE

Fine Fuels Reduction Project Grazing Rx
- Mixed-species herd of 400 sheep & goats
- 1 acre paddock per day
- 45 degree slope
- Vegetation type: primarily annual grass
  (East Bay Regional Parks District, July 2015)
HABITAT RESTORATION

Canada geese near the Edward M. Brigham III Alkali Lake Sanctuary, Spiritwood, ND. Photo: Brian Chepulis/Audubon

Article

Rangeland Land-Sharing, Livestock Grazing’s Role in the Conservation of Imperiled Species

Sheila Barry 1,2,∗ and Lynn Huntsinger 1,∗

1 University of California Agriculture and Natural Resources, San Jose, CA 95112, USA
2 Environmental Science, Policy and Management, University of California Berkeley, Berkeley, CA 94720, USA
∗ Correspondence: sherry@ucanr.edu (S.B.); huntsinger@berkeley.edu (L.H.). Tel.: +1-510-206-3106 (S.B.)

Abstract: Land sharing, conserving biodiversity on productive lands, is globally promoted. Much of the land highest in California’s biodiversity is used for livestock production, providing an opportunity to understand land sharing and species conservation. A review of United States Fish and Wildlife Service listing documents for 282 threatened and endangered species in California reveals a complex and varied relationship between grazing and conservation. According to these documents, 51% or 143 of the federally listed animal and plant species are found in habitats with grazing. While livestock grazing is a stated threat to 77% (124) of the species sharing habitat with livestock, 79% (99) of the species are said to be positively influenced, with considerable overlap between species both threatened and benefitting from grazing. Grazing is credited with benefiting flowering plants, mammals, insects, reptiles, amphibians, fish, crustaceans, and bird species by managing the state’s novel vegetation and providing and maintaining habitat structure and ecosystem functions. Benefits are noted for species across all of California’s terrestrial habitats, except alpine, and for some aquatic habitats, including riparian, wetlands, and temporary pools. Managed grazing can combat anthropogenic threats, such as invasive species and nitrogen deposition, supporting conservation-reliant species as part of land sharing.

Keywords: livestock grazing; species conservation; land-sharing; invasive species; nitrogen deposition; conservation-reliant species
Watershed & Mineral Cycle Function

Research Article

Loss of biodiversity and hydrologic function in seasonal wetlands persists over 10 years of livestock grazing removal

Jaynee T. Marty

Ecological restoration provides a means to increase biodiversity in ecosystems degraded by natural and human-induced changes. In some systems, disturbances such as grazing can be key factors in the successful restoration of biodiversity and ecological function, but few studies have addressed this experimentally, especially over long time periods and at landscape scales. In this study, we excluded livestock grazing from plots within a grassland landscape containing vernal pools in the Central Valley of California for 10 years and compared vernal pool hydrology and plant community composition with areas grazed under an historic regime. In all 10 years, the relative cover of native plant species remained between 5 and 20% higher in the grazed versus ungrazed plots. This effect was particularly prominent on the pool edges, though evidence of invasion into the pool basins was evident later in the study. Native species richness was lower in the ungrazed plots with 10–20% fewer native species found in ungrazed versus grazed plots in all years except the first year of treatment. Ungrazed pools held water for a shorter period of time than pools grazed under an historic regime. By the ninth year of the study, ungrazed pools took up to 2 weeks longer to fill and drain down 1–2 weeks sooner at the end of the rainy season compared to grazed pools. The results of this study confirm that livestock grazing plays a key role in maintaining biodiversity and ecosystem function in vernal pools.

Keywords: invasive species, land management, vernal pools, wetland restoration
Vernal pool wetlands respond to livestock grazing, exclusion and reintroduction

Julia S. Michaels | Kenneth W. Tate | Valerie T. Evrinner

Abstract

1. In disturbance-induced ecosystems, the removal of disturbance can lead to losses of diversity and sometimes irreversible changes in community composition. It is important to identify the thresholds at which these shifts can occur, and to understand the reversibility of these shifts. We examined this question in a vernal pool ecosystem that evolved within a context of grazing disturbance.

2. We compared adjacent vernal pool wetlands in annual Mediterranean grasslands under three grazing management strategies: continuous grazing (100% cover), long-term exclusion (100% cover) and 1 year of reintroduced grazing. We also placed whether grazing treatments altered plant characteristics that are likely sensitive to plant community composition, and how these relationships changed with environmental conditions.

3. Reintroducing grazing to vernal pools led to increased diversity and native cover, but the effects on native cover were more immediate than on diversity. We identified several local and stochastic mechanisms related to this pattern, including changes in competition dynamics that favor small clumped native shrub and increases in heterogeneity of shrub cover that make soil moisture more available to plants.

4. Synthesis and application. Our results show that reintroduced grazing at moderate stocking rates can have significant effects on plant communities after just 2 years and can increase native cover more quickly than overall diversity. Our findings suggest that the negative effects of long-term grazing exclusion in vernal pools may be reversible, but that land managers interested in restoring diversity should plan to monitor beyond the first two years of grazing reintroduction.

ALTERNATIVE TO FOSSIL FUEL DEPENDENT MACHINERY + CHEMICAL TREATMENT
EVALUATION
Is this the right tool for the job?

- Project goals
- Vegetation characteristics
  - Species Composition
  - Height
  - Diameter
  - Density
- Infrastructure - Roads, Water, Containment
- Environmental Characteristics
- Scale of project
- Transportation
- Proximity to public, operations, predation

ROI MEASURED IN IMPACT

- Acres Impacted
- GHG Off-Set Carbon Sequestered
- Chemical Use Diverted
- Herd Growth
- Meaningful Jobs Created

- Fire Hazard Reduction
- Invasive Species Management
- Alternative to fossil fuel dependent machinery
- Monitoring Metrics COHRT-PARN + Fire adaptive Lab (UC Davis)
- Eliminate or reduce use of glyphosate
- Annual Breeding Program increases herd size
- Size of herd correlates with scale of impact
- Vocational training for new urban shepherds as land stewards
- Education + Experiential Learning
COST STRUCTURES

1. **Cost per head per day** – contract grazers gives quote based on the number of head per day for the duration of the project.
   *ex. 800 head for 60 days at $.50 hd/per day= $24,000*

2. **Acreage fee** with set number of head.
   *ex. 20 acres at $950 an acre = $19,000*

*Additional costs such as, transportation or “flushing” of weed-free forage may be presented.*

**Considerations determining cost of services:**
- Scale of project - acreage
- Duration / Time-Frame
- Seasonality
- Complexity – access, slope, veg type/density, sensitivities

National Prescribed Grazing rates vary greatly. In California average rates range between $850-1,200 per acre.

Rates are determined by many variables and considerations. Rates can be reduced at certain times of year or with land access to off-season operations.
Selecting the appropriate grazing contractor who has experience with the scale, landscape, community, and ecology of the site is essential to achieve project goals.

This includes selecting the right species, breed, and class of animal.

CONCLUSION

Prescribed grazing is an effective management tool for:

- reducing fire fuels,
- targeting invasive species,
- supporting resilient watersheds,
- maintaining biodiversity,
- and creating and maintaining native wildlife and plant habitat.

Success of grazing prescription treatments will require collaborative planning with livestock operators, science-based monitoring and adaptive management with clear goals.

Studies that incorporate site- and species-specific research would help to better understand effects of specific grazing activities in various contexts, climates, and ecosystems.
Cole Bush
Shepherdess Land and Livestock Co. LLC
shepherdesslandl.co / brittanycolebush.co
bcb@shepherdesslandl.co
(858) 688-3351
Chris Haring: Managing Wildfire Consequences

**ENGINEERING WITH NATURE**

**Natural Infrastructure Talk #2: Managing Wildfire Consequences**

Chris Haring, PhD, P.G., CFM
March 1, 2022
Research Physical Scientist
River Engineering Branch-Coastal and Hydraulics Lab
Engineering Research & Development Center (ERDC)
US Army Corps of Engineers

**Engineering With Nature**

...the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaboration.

Key Elements:
- Science and engineering that produces operational efficiencies
- Using natural process to maximum benefit
- Broaden and extend the benefits provided by projects
- Science-based collaborative processes to organize and focus interests, stakeholders, and partners

www.engineeringwithnature.org

US Army Corps of Engineers • Engineer Research and Development Center
NNBF ENGINEERING PERFORMANCE

Levee Setbacks
Benefits/Processes
- Decreased flood levels and velocities
- Reduced frequency of maintenance and repair on levee
- Reduced navigation maintenance
- Reduction in erosion/sediment and O&M costs
- Increased recreational, cultural, and educational opportunities

Performance Factors
- Amount of new floodplain affects hydrologic loading
- Alignment options for improved hazard mitigation
- Hydrologic goals of project with increased floodplain connection
- Collaboration with stakeholders and other Federal agencies

Naturalization of Channel Design
Benefits/Processes
- Reduced frequency of maintenance on levee and restoration projects
- Naturalization of flow regimes and floodplain reconnection
- Ecological benefits to floodplain habitat
- Reduction in erosion/sediment and O&M costs
- Increased recreational, cultural, and educational opportunities

Performance Factors
- Type of practice determines hydrologic loading
- Practice determines options for improved hazard mitigation, erosion control, and streambed and bank stability
- Collaboration with stakeholders and other Federal agencies
- Sediment management options

Watershed Treatments
Benefits/Processes
- Naturalization of hydrologic systems
- Reduced navigation maintenance
- Reduction in O&M costs
- Increased recreational, cultural, and educational opportunities
- Reduced frequency of maintenance and repair on levee and restoration projects

Performance Factors
- Watershed management options determine effects on hydrologic loading
- Practice determines options for improved hazard mitigation, erosion control, and streambed and bank stability
- Collaboration with stakeholders and other Federal agencies
- Sediment management options

Albuquerque District-Santa Clara Canyon
Managing Wildfire Recovery

Santa Clara Pueblo Wildland Fire Restoration Areas

Legend
- Santa Clara Pueblo
- Restoration Areas
- Restoration
- Proposed Restoration
- Historic Restoration
- Surface Fuel Treatment
- Water Source Nuisance
- Post-Construction
- Prescribed Burn Line
- Prescribed Burn Line
- Post-Construction
- Water Source Nuisance
- Historic Restoration
- Proposed Restoration
- Restoration
- Restoration Areas
- Santa Clara Pueblo

Appendix C. Workshop Presentations
Appendix C. Workshop Presentations

Santa Clara Canyon-Damage

Santa Clara Canyon-Damage
Santa Clara Canyon-Damage

Santa Clara Canyon-Recovery
NNBF Applications
Santa Clara Canyon, NM

- Gabion Valley
  Grade Control
  Structures

- Wetland & Erosion
  Control

- Bottomless Culvert
NNBF Applications
Santa Clara Canyon, NM

- Wood structures
- Rock onsite
- Combination
DOTS Report Recommendations

1) Continue EWN-NNBF Channel Stabilization Measures
2) Modify some of the NNBF design & installation
3) Gabon valley grade control structures: consider lifespan and future stability of Santa Clara stream channel grade
4) Rio Grande Restoration recommendations
5) Gather new LiDAR, geologic mapping and other data

Next Steps:
A) Regional Sediment Management Proposal: submitted in 2018, meeting on May 8th to discuss re-scoping
B) FluvialGeomorph application: test assessment tools on pre-and post LiDAR wildfire datasets
C) Test LiDAR Change Analysis: Compare pre to post fire LiDAR
Tools to Assess Offsite and Cumulative Benefits

- **SON:** Tools to Assess Offsite and Cumulative Benefits in Watershed Assessment
- **Need:** Illinois Basin Restoration (IL519) was designed, in part, to retain sediments in upland streams to protect bottomland floodplain and backwater habitat from sediment impacts. A benefit metric evaluating sediment reduction from watershed stabilization is needed.
- **Purpose:** Develop rapid watershed analysis tools for USACE Planning Studies. Tools will prioritize sites offering the greatest downstream sediment reduction benefits:
  1) navigation (reduced dredging)
  2) flood risk management (floodway maintenance)
  3) ecosystem restoration (aquatic and floodplain habitat)

Watershed Planning Approach: Goals & Objectives

**Goals:**
- Provide a USACE Planning method for rapid watershed assessments by developing geomorphic analysis tools using high resolution terrain data and existing empirically based fluvial geomorphic principles
- Develop a USACE Ecological Planning model based on rapid watershed assessment metrics to define restoration and mitigation benefits

**Objectives:**
- Develop a suite of planning analysis tools to rapidly assess and identify sediment sources, pathways, and sinks for watershed analysis.
- Use existing geomorphic principles to develop metrics for analyzing LiDAR-derived channel, floodplain, valley, and watershed characteristics.
- Develop an approach to relate channel, floodplain, valley, and watershed characteristics to Ecosystem Restoration (ER) habitat evaluation and benefits.
Create Terrain and Extract Channel Dimensions

Workflow: Rapid Watershed Assessment for Un-Gaged Streams

**FluvialGeomorph Toolbox**
- GIS analysts follow the workflow
- Use the ArcGIS FluvialGeomorph toolbox tools to complete each task
- R used in the background to perform calculations, graphing, and reporting

**Diagnostic Role of the Estimate Bankfull Elevation Report**

The purpose of this report is to help select a bankfull elevation for channel analysis on un-gaged streams.

- Detrending standardizes all cross-sections within a reach to the same elevation scale
- Detrending allows for reach-wide comparison of channel cross-section elevations and dimensions
- Helps compare a bankfull elevation that best matches specified regional curve defined bankfull channel dimensions
- Helps distinguish between candidate geomorphic bankfull indicators via cross-section interpretation
- Documents the PDT decision making process
Regional Curve Goodness of Fit Graph

Compares how closely all cross-sections within a reach match the regional curve estimate for candidate detrended bankfull elevations.

Mean Average Error (MAE) between the measured cross section dimensions and the regional curve estimates.

For example:
MAE decreases as detrended bankfull elevations approach ~104. Therefore, 104 has the best fit to the regional curve for this reach.

Reach Hydraulic Geometry Graph

Innovative solutions for a safer, better world
From the previous slides we saw that for this reach detrended elevation 104 minimized mean average error between measured cross-section dimensions and estimates from regional curves.

- This approach helps to distinguish between multiple geomorphic indicators.
- Allows geomorphic indicators to be rapidly compared between cross-sections.
- Helps ensure consistency in bankfull indicator selection throughout a reach.

Standardized cross-section graphs permit rapid identification of salient stream features and conditions.

- Since the bankfull elevation was estimated to be 104 for this reach, this cross section appears to be entrenched.
- The red circle clearly indicates the presence of a levee preventing access to the floodplain.
Reach Metrics Graph

Standard reach metrics are calculated and specialized graphs are created to:
- compare related metrics
- aid rapid interpretation
- facilitate PDT integration of disparate metrics

Predicting Fish Habitat using FluvialGeomorph

Research Question
Can fish habitat (measured using fish community data) be predicted using fluvial geomorphic characteristics?

Dependent Variables
Fish community data collected for the MN Index of Biological Indicator (IBI) will be used as response variables (e.g., species richness, IBI, etc.).

Independent Variables
FluvialGeomorph calculated metrics will be used as predictor variables (e.g., W/D, entrenchment ratio, slope, sinuosity, stream power, etc.).

Current Efforts
Preparing terrain data and calculating FluvialGeomorph metrics for a stratified sample of ~100 MN IBI sampling sites.
Project Developments

- **Project Planning**
  - Stream channel delineation methods identified need for Regional Curves: Ecoregion specific regional curves were created for use estimating conditions in ungauged streams/reaches.
  - Developing Minnesota River terrain data for FluvialGeomorph analysis of fisheries data (IBI)
  - Developing channel planform measurement methods for analysis of physical floodplain, valley, and watershed metrics (IL, MN, NM, CA, OR)

- **Reporting**
  - Tech Note #1 (In review): Rapid Watershed Assessment Planning Tools Based on High Resolution Terrain Analysis
  - Tech Notes #2 & #3 (draft form)
  - Develop as ecological benefit evaluation model
  - Develop (2-3) Technical Reports/Manuals on tool usage
  - Develop multiple (6) Technical Notes describing channel and watershed tools/metrics

Summary: Watershed Assessment Planning Tool

- Developed and continue to refine and test a new watershed assessment tool-Fluvial Geomorph
- FluvialGeomorph is an R package based GIS toolbox to make watershed planning and assessments efficient, cost effective, and less-time consuming.
- Tools will be transferable wherever appropriate terrain data exists.
- Testing in different regions of US (Albuquerque & Portland Districts)
- Assessing Minnesota River Fisheries habitat data and the ability to predict habitat relationships from FluvialGeomorph
**Managed Aquifer Recharge**

A nature-based solution for dynamic landscapes

Rebecca Muenich, Arizona State University

---

**What is MAR?**

- Suite of methods to help maintain, enhance, and secure groundwater resources under stress
- Intended to counteract historical misuse of aquifers
- Different kinds:
  - Streambed channel modifications
  - Water “spreading”
  - Recharge wells
  - Reservoir releases
  - More...

Appendix C. Workshop Presentations

**History of MAR**

- ~60 years in the making
- Originally called artificial recharge
- Sites all over the world and growing


---

**MAR in Arizona**

- Commonly water spreading
- Began in 1960s in Arizona
- Often tied to storage of Colorado River (CAP) water, but happening with other resources like Salt River Project
- Helps store discharges where they can’t discharge, or store credits during excess for future use
- Many facilities use wastewater
- Overseen by ADWR

https://storymaps.arcgis.com/stories/70f626809f0d84e228c0f32aef4222dda
https://new.azwater.gov/ama
Riparian Preserve at Water Ranch (Gilbert)

- Effluent recharge basin in Town of Gilbert, AZ
- Organized into 7 recharge basins
- Allowed to infiltrate on average of 10 MGD
- Popular birding, recreational, community spot
Appendix C. Workshop Presentations

Wet v. Dry

Research at the Preserve
- Groundwater and vadose zone modeling
- Solute and pathogen transport
- Student field days!
ASU-EWN Ongoing & Related Work

• Generally, integrating data science with hydrological sciences
  • Coordinating agricultural land MAR and reservoir operations (Muenich, Liu)
  • Modeling Flood-MAR in the San Joaquin Valley (Xu, Mascaro, Low)
  • Improved data integration and visualizations (Candan)

• Developing educational methods to expand EWN
Understanding Ag

What Have WE Learned In 79 Years?

Timpas, Colorado, Jan 12, 2014

April 14, 1935
Disrupted Soil Ecosystem

This soil is naked, hungry, thirsty and running a fever!

Symptom: Poor Soil Structure

Forest SOM = 4.3%

Soybean monoculture SOM = 1.6%

20 cm layer
Our Ecosystems Are A Reflection Of Us!

We Can Regenerate Our Soils!
• Our Management (Stewardship) Makes The Difference!

• Every decision we make has compounding and cascading effects!

How Do We Heal Our Soils?
By Practicing Regenerative Agriculture!
What is Regenerative Agriculture?

- Farming and ranching in synchrony with nature to Repair, Rebuild, Revitalize and Restore ecosystem function starting with life beneath the soil and moving to all life above the soil.

Nature’s Way
Six Principles

- Nature always acts in context
- No mechanical and limited chemical disturbance
- Armor on the soil surface
- Thrives on diversity
- Living plants as long as possible
- Always with animals and insects
Four Ecosystem Processes

Energy Cycle

Water Cycle

Nutrient Cycle

Biodiversity

Plant and Soil are One
Ray Archuleta
Liquid Carbon Pathway

• This is the **ENERGY CYCLE**
• Plants take in CO2
• Photosynthesis occurs
• Converted to “liquid carbon”
• A portion of this is translocated to the roots
• Exuded into the soil

Credit to Dr. Christine Jones
Liquid Sun: Roots leaking exudates!

Which Feeds Biology!
Liquid Carbon Pathway

• A large part of this is consumed by bacteria which are consumed by protozoa and nematodes (predators).

• This is a part of the **NUTRIENT CYCLE**.
Enlarged Soil Aggregates

Glomalin and Hyphae

Dr. Kris Nichols, Microbiologist, ARS, Mandan, ND

Well Aggregated Soil

• More Pore Spaces
• More Biology
• Higher Water Infiltration Rates
• Higher Water Retention
• More Oxygen to Roots
• Easier for Roots to Access Nutrients
• Resiliency!
### Organic Matter and Available Water Capacity

**Inches of Water/One Foot of Soil**

<table>
<thead>
<tr>
<th>Percent SOM</th>
<th>Sand</th>
<th>Silt Loam</th>
<th>Silty Clay Loam</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0</td>
<td>1.9</td>
<td>1.4</td>
</tr>
<tr>
<td>2</td>
<td>1.4</td>
<td>2.4</td>
<td>1.8</td>
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<td>3</td>
<td>1.7</td>
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<tr>
<td>4</td>
<td>2.1</td>
<td>3.5</td>
<td>2.6</td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
<td>4.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Berman Hudson  
*Journal Soil and Water Conservation 49(2) 189-194*  
March – April 1994  
Summarized by:  
Dr. Mark Liebig, ARS, Mandan, ND  
Hal Weiser, Soil Scientist, NRCS, Bismarck, ND

- For every 1% increase in organic matter, soil can hold an additional 18,000 to 27,000 gallons of water per acre per 1 foot of the soil profile.

- This is key to water security!
The **WATER CYCLE** Depends On Mycorrhizal Fungi And Biology
Nature Thrives With Diversity
Brown’s Ranch

Topsoil Depth

3”

1993
No-till
1.7% OM

1995
Cash Crop Diversity
2.0% OM

2021
Regeneration including high diversity of plants, livestock and carbon. High nutrient densities
7.9% OM

327x72 to 494x369

DIRT TO SOIL

Brown’s Ranch Soil Building Cover Crop Integration 3.1% OM 1997
Cash Crop Diversity 2.0% OM 1995
No-till 1.7% OM 1993 2006
Multi-species Covers (Extended Growing Season) 4.2% OM 2010
Multi-species Covers/Livestock Integration 6.1% OM 2021

Regeneration including high diversity of plants, livestock and carbon. High nutrient densities 7.9% OM

Appendix C. Workshop Presentations
Our mission is to use our passion and experience to educate farmers, ranchers, businesses and communities in applying time-tested ecological principles to regenerate our living ecosystems, thereby restoring the health of all.
Currently Consulting On 30+ Million Acres

“Completely revolutionized our farm.”

GROW HEALTHIER SOIL, FOOD AND PROFITS

The Soil Health Academy will show you how.

Intensive On-Farm Instruction

Appendix C. Workshop Presentations
Alejandro Carrillo: Bringing a Ranch Back to Life

WHERE ARE WE LOCATED?

California
Arizona
New Mexico
Texas
Mexico
Chihuahuan Desert
HIGH TEMPS ON BARE GROUND
WE NEED TO DO MORE WITH LESS

Precipitation Las Damas Ranch

MOST OF THE RAIN FALLS IN THREE MONTHS.
Appendix C. Workshop Presentations
WHAT’S GOOD ABOUT OXIDIZED GRASS?

NO MIDDLE GROUND …
We are either going forward or backwards – it depends on our UNDERSTANDING of the natural processes.
LAS DAMAS CATTLE RANCH

OUR CONTEXT

- 30,000 ACRES NESTED IN THE CHIHUAHUAN DESERT IN NORTHERN MEXICO
- COW-CALF OPERATION WITH 550 COWS & 200 SHEEP
- AVERAGE YEARLY RAINFALL OF 10" ON THE LAST 20 YEARS
- WE USE ONLY SEA SALT FOR OUR COWS
- WE HAVE NOT USED ANY CHEMICAL, MECHANICAL OR SEEDING TO RESTORE NATIVE GRASSLANDS
- OUR ONLY TOOL TO REGENERATE GRASSLANDS IS COWS RATIONALLY MANAGED.
- WE ARE PART OF A REGENERATION NETWORK IN THE CHIHUAHUAN DESERT COVERING >2M ACRES
TOURING THE RANCH AND SORROUNDINGS AREAS

HOW NEARBY PROPERTY LOOKS LIKE IN SUMMER WITH 6" OF RAIN YTD
HOW OUR PROPERTY LOOKS LIKE IN SUMMER WITH 6" OF RAIN YTD

SAME DAY, SAME REGION, DIFFERENT MANAGEMENT, LAST SPRING
IT IS GREENER ON THE SIDE OF MY FENCE!!!
LATE SPRING

TOBOSA GRASS: PICTURE TAKEN SAME DAY IN WINTER UNDER SAME PRECIPITATION, BUT DIFFERENT MANAGEMENT
CLOSER LOOK AT THE SAME SPOTS OF THE PREVIOUS PICTURE. IF GRASS IS DEAD ON TOP, SOIL IS DEAD AS WELL.

TWO REALITIES DURING SUMMER LAST YEAR: SAME DAY, SAME REGION, SAME PRECIPITATION.
FROM BARE GROUND, TO WEEDS, TO ANNUALS & PERENNIALS ON A 6 YEAR PERIOD (12, 8, 8, 9, 10, 5, 11)

2015

FROM BARE GROUND, TO WEEDS, TO ANNUALS & PERENNIALS ON A 6 YEAR PERIOD (12, 8, 8, 9, 10, 5, 11)

2018
FROM BARE GROUND, TO WEEDS, TO ANNUALS & PERENNIALS ON A 6 YEAR PERIOD (12, 8, 8, 9, 10, 5, 11)

THERE IS MORE THAN ANIMAL IMPACT TO HAVE SUCH DRASTIC CHANGES ON 10” ANNUAL PRECIPITATION
DOES IT RAIN MORE IN REGENERATIVE RANCHES? THE 60/40 RAIN PATTERN

CLOUDS ARE THE FIRST LINE OF DEFENSE AGAINST HIGH SOIL TEMPS!
WATER INFILTRATION RATES: 
KEEPING WATER FOR GREENER PLANTS

HOW ABOUT THE SOIL ENGINEERS? 
DO THEY MAKE A DIFFERENCE?
WHAT BENEFIT AN OXIDIZED COW PIE BRINGS?

LET NATURE DO THE HEAVY LIFTING …
TWO THIRDS OR 66% OF EACH COW PIE IS BURIED IN THE SOIL BY DUNG BEETLES …

COW PIE WORKED BY DUNG BEETLES
RESPECTING NATURAL PROCESSES; HELPING NATURE HEAL HERSELF
TERMITES: NATURAL RE-CYCLERS
NOTHING GETS WASTED IN NATURE

TERMITES IN ACTION CONVERTING
OXIDIZED GRASS INTO NITROGEN
LOW MAINTENANCE HEREFORD COW

COWS ADAPTED TO THEIR ENVIRONMENT
COWS ADAPTED TO THEIR ENVIRONMENT

TAKING FULL ADVANTAGE OF WHAT IS OUT THERE. PRICKLY PEAR CACTUS EATEN
REGENERATION OF AN OPEN PIT MINE: FROM GRAVEL TO SOIL!
BELIEVE AND YOU WILL …
REFERENCES

Case Studies

- Restoring Native Grasslands in Northern Mexico — Nature Based Solutions | PBL Netherlands Environmental Assessment Agency
- Achieving 350% Net Revenue Increase with Beef Cattle in Arid Environments - Holistic Management International
- Las Damas Ranch Case Study - Understanding Ag

Documentaries

- Watch Sacred Cow | Prime Video (amazon.com)
- To Which We Belong
- Kiss the Ground
Land Management and Water Security
How to Deliver a Land Management Project as an Alternative to Traditional Engineering

Ricardo Aguirre, P.E., CFM, AP
Director of Land Management and Water Security
Executive Director of Drylands Alliance Addressing Water Needs (DAAWN) – The Arizona Savory Hub

Overview

• From Pipes Channels & Holes to Regenerative Practices
• First Principles Thinking
• Land Management Practices
• Project Delivery
• Management vs Technology
From Pipes, Channels & Holes in the Ground...

...to Regenerative Practices
First Principles Thinking

1800’s

Santa Cruz River Perennial Flow North of Tucson, late 1800’s

Today

Santa Cruz River Bordering the Roger Road Wastewater Treatment Facility

First Principles Thinking

Zimbabwe

![Zimbabwe Image]
First Principles Thinking

- Soil Organic Matter (SOM) and Soil Water Holding Capacity
- On average 1% of SOM can retain 20,000 gallons of water / acre

North Dakota - Courtesy: Gabe Brown

First Principles Thinking

- Conventional Grazing
  - Few animals
  - Large area
  - Long time (months-yrs)

- Holistic Planned Grazing
  - Many animals
  - Small area
  - Little time (hours-days)

Northern Arizona
First Principles Thinking

Land Management Practices

- Biological Soil Amendments
- Subsoil plowing
- Planned Grazing -> SCALABLE!
Project Delivery

• Phase 1 – Restoration Concept
  - Determine existing site conditions
  - Develop land plan alternative
  - Preliminary Cost Estimates

  Cochise County, Arizona (480 acres)

  New Mexico Department of Transportation (30,000 acres)

  Surface Disturbance Analysis of Lordsburg Playa & Adjacent Watershed

Project Delivery

• Phase 2 – Land Plan Improvements Installation
  - Research materials and final cost estimates
  - Installation (Fencing, Watering, and Handling)
  - Construction administration

  Cochise County

  New Mexico Department of Transportation
Project Delivery

- Phase 3 – Land management implementation
  - Soil biology plan
  - Monitoring and recording
  - Treatment management

New Mexico Department of Transportation

Project Implementation - Outcomes

From this

To this
Management vs. Technology

Decentralized Animal Impact

- **Cost**
  - Multi-six figure < $1 Million
  - Continual Management

- **Benefit**
  - Flood control
  - Groundwater recharge
  - Water Quality Mitigation
  - Improves Soil Loss
  - Dust Mitigation
  - Control wildfire feedstock
  - Heat Island

Centralized Expensive Infrastructure

- **Cost**
  - $Multi-Million
  - Continual Maintenance

- **Benefit**
  - Flood control only (symptomatic relief)

The 1403.2 cfs is now reflected as 227 ac-ft of recharge potential by taking the difference of the two hydrograph curves.
Questions
Yes, Compost is Great, but...

Composting DoD wastes diverts from landfills, decreases emissions, and saves $$
- Requires investment, infrastructure, management
- Then what?

The real benefit is what we do with it
Where is Compost Most Beneficial?

Military training diminishes soils:

- DoD soils are disturbed and compacted:
  - reduced organic matter
  - increased bulk density
  - lower water infiltration
  - lower water holding capacity
  - increased nutrient availability
  - increased erosion

Vegetation is diminished, soil is lost, habitat is reduced, and training is inhibited

**Compost alleviates all of these environmental quality/operational reductions**

---

Compost Improves Climate Resilience

Adding organic matter to soil improves soil health and ecosystem services provision

- Decreased bulk density (better vegetation, less runoff, less erosion)
- Increased water infiltration (less flooding, better water quality)
- Increased water retention (drought tolerance, less flooding)
- Increased root penetration (drought tolerance, landslide protection, fuel reduction)
- Increased nutrient retention and exchange, increased carbon sequestration, contaminant binding and decomposition, pH buffering, increased microbial diversity and function, soil aggregation, etc. (improved ecosystem function overall)
Compost and Soil Bulk Density

41 treatments averaged 22% bulk density reduction

Compost and Water Infiltration

18 treatments averaged 115% increase in water infiltration
Compost Incorporation vs. Mulch Application

<table>
<thead>
<tr>
<th>Unit</th>
<th>Incorporated</th>
<th>Mulch</th>
<th>Control</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>% percolation of 10” simulated rainfall</td>
<td>52%</td>
<td>85%</td>
<td>42%</td>
<td>Agassi et al. 1998</td>
</tr>
<tr>
<td>mm/min. infiltration</td>
<td>2.1 mm</td>
<td>1.7 mm</td>
<td>0.6 mm</td>
<td>Grogger et al. 2008</td>
</tr>
<tr>
<td>mm/min. infiltration</td>
<td>1.1 mm</td>
<td>1.0 mm</td>
<td>0.7 mm</td>
<td>Logsdon et al. 2017</td>
</tr>
<tr>
<td>time to runoff of 70 mm/h simulated rainfall</td>
<td>27 min.</td>
<td>51 min.</td>
<td>9 min.</td>
<td>Logsdon et al. 2017</td>
</tr>
</tbody>
</table>

10-15 tons/acre (0.25 inches thick) has a significant effect

Compost can be top dressed virtually anywhere, incorporated in highly disturbed areas undergoing restoration

How Important is This?

- ¼ inch absorbed over 100 acres is 680,000 gallons or 76 seconds of water currently flowing through the Grand Canyon

- Average US subwatershed is around 25,000 acres
  - ¼ inch absorbed = 170 M gallons
  - = 38 seconds of Mississippi River discharge into Gulf of Mexico

Bharati et al. 2002
Wide Ranging Impacts

Table 4: Total root length (m) per pot stratum as affected by soil bulk density in Stratum B. Total root length per pot computed by summing Strata means.

<table>
<thead>
<tr>
<th>Bulk density (Mg/m²)</th>
<th>Stratum A (0–4 cm)</th>
<th>Stratum B (4–14 cm)</th>
<th>Stratum C (14–24 cm)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>12.2</td>
<td>11.2</td>
<td>2.2</td>
<td>25.6</td>
</tr>
<tr>
<td>1.0</td>
<td>15.0</td>
<td>10.3</td>
<td>1.6</td>
<td>27.9</td>
</tr>
<tr>
<td>1.2</td>
<td>12.8</td>
<td>8.4</td>
<td>0.7</td>
<td>21.9</td>
</tr>
</tbody>
</table>

Houlbrooke et al. 1997

Sometimes Compost is Not the Answer

Compost is not beneficial everywhere
- Too much N can be a detriment
- C:N ratio very important for applicability
  - Too low causes restoration failure and selects for weeds
  - Too high causes plant starvation

DoD has some very unique, consistent organic waste streams for beneficial reuse
- Highly effective in situations where compost is not
**Pulverized Paper - The Secret to Healthy Soils?**

Soil Bulk Density to 20 cm Depth

<table>
<thead>
<tr>
<th>Treatment (tons/ac)</th>
<th>Bulk Density (g cm⁻³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.1</td>
</tr>
<tr>
<td>8</td>
<td>1.2</td>
</tr>
<tr>
<td>16</td>
<td>1.3</td>
</tr>
<tr>
<td>24</td>
<td>1.4</td>
</tr>
<tr>
<td>32</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Relative Planted Grass Biomass

<table>
<thead>
<tr>
<th>Treatment (tons/ac)</th>
<th>Planted Grass % Biomass (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>24</td>
<td>4</td>
</tr>
<tr>
<td>32</td>
<td>5</td>
</tr>
</tbody>
</table>

Soil Carbon Content to 20 cm Depth

<table>
<thead>
<tr>
<th>Treatment (tons/ac)</th>
<th>Soil Carbon (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>8</td>
<td>1.0</td>
</tr>
<tr>
<td>16</td>
<td>1.5</td>
</tr>
<tr>
<td>24</td>
<td>2.0</td>
</tr>
<tr>
<td>32</td>
<td>2.5</td>
</tr>
</tbody>
</table>

12 months

18 months

70 tons/year/installation

**DoD has no Shortage of Unique Organic Wastes**

TNT shipping boxes from an ammunition plant

- Disposal requires a $$$ hazwaste landfill
- Composting breaks TNT ring structure
- Compost can be used for soil cleanup or other needs
Army Food Waste Composting Pilot (2016)

FLW continuous feed, closed loop, 2 cubic yards per day rotary drum system

5:1 landscape to pulped DFAC food waste was ideal to maintain moisture and bulk density levels

Questions?