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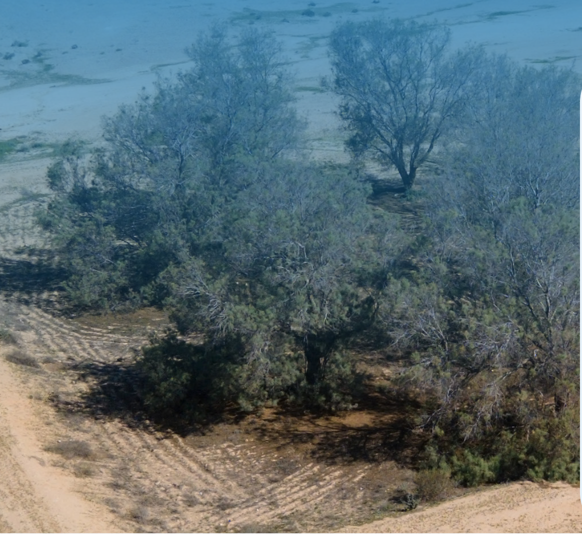
INTEGRATED EUROPEAN
LONG-TERM ECOSYSTEM, CRITICAL ZONE AND
SOCIO-ECOLOGICAL
RESEARCH INFRASTRUCTURE

Restoring Function, Reviving Resilience: Practical Solutions for Desert Ecosystem Recovery



The Message in Brief

Functional restoration provides a practical, science-based strategy to rehabilitate degraded and desertified ecosystems where full ecological recovery is not feasible (1,2). Rather than reconstructing historical ecosystems, it focuses on re-establishing essential functions—such as water regulation, soil stability, and vegetation productivity—that sustain life and livelihoods. Long-term research in the Israeli Negev Desert has shown that rebuilding key hydrological and ecological processes—especially the “source–sink” water networks that retain moisture and support vegetation—can effectively reverse desertification and restore vital ecosystem services (3). The approach offers a scalable solution for arid and semi-arid regions across Europe and globally, supporting commitments under the EU Green Deal, UNCCD, and UN Decade on Ecosystem Restoration.

Challenges and Current Status

Desertification is accelerating under climate change, threatening biodiversity, food security, and human wellbeing in drylands. Across the Mediterranean Basin, southern Europe, and the Middle East, water scarcity and land degradation reduce carbon sequestration, increase erosion, and undermine rural livelihoods.

Losing the Water Balance that Sustains Life

In dryland ecosystems, ecological degradation often stems from disrupted water redistribution processes—how rainfall flows, infiltrates, and supports vegetation. In the Negev Desert, long-term observations show that rainfall naturally concentrates in water-enriched soil patches(“sinks”) such as shrubs that sustain soil biota, and high productivity (3, 4). Human activities—such as overgrazing, deforestation, and unsustainable cultivation—destroy these moisture-rich zones, reducing biological productivity and accelerating erosion.

Beyond the Point of Natural Recovery

Functional degradation precedes structural collapse. Once natural source–sink networks are lost, ecosystems lose their capacity to self-regulate, trapping them in a degraded state. Traditional restoration that aims to recreate the full native community is often infeasible under harsher, drier climates (2).

Data Gaps and Policy Disconnects

Limited long-term data and fragmented assessments hamper effective policy action. Quantifying functional recovery—e.g. improved soil moisture, reduced runoff, or restored vegetation cover—requires long-term datasets, interdisciplinary expertise, and coordination between scientists, land managers, and policymakers. Addressing these challenges demands cross-scale cooperation, connecting local land users and research infrastructures such as eLTER with national and European strategies for ecosystem restoration, climate adaptation, and drought resilience.

Figure 1. Functional restoration in the Negev: upper – desertified area; lower – restored landscape with re-established vegetation and contour structures. Source: Google Earth; 10 Aug 2021; 31°17′53.24″ N, 34°48′36.58″ E.

Solutions and Opportunities

A Pragmatic Framework for Functional Restoration

Functional restoration provides a **pragmatic framework** to rehabilitate ecosystems that can no longer return to their original state. Instead of attempting to restore full species composition, the approach **rebuilds core ecological processes**—particularly water redistribution and vegetation–soil feedbacks—that underpin ecosystem services (1,3).

A Four-Step Path to Restoration

In the Negev Desert, the eLTER-affiliated LTER Israel network and partners such as Ben-Gurion University of the Negev and the Keren Kayemeth LeIsrael - Jewish National Fund (KKL-JNF) developed a **four-step model** (4):

1. **Identify key processes that regulate ecosystem function**, such as water flow, infiltration, vegetation–soil interactions (5,6).
2. **Detect degradation drivers**, including overgrazing, drought, and land-use change (7).
3. **Implement restoration actions**, rebuilding the source–sink network through contour lines, small dams, terraces, or re-vegetation (8).
4. **Assess and evaluate outcomes** using indicators such as soil moisture, productivity, and ecosystem service delivery (9).

Proven Results and Policy Relevance

This evidence-based model has proven **effective in reversing desertification trends and restoring landscape productivity**. By rebuilding water-retaining structures, degraded soils regain fertility, vegetation returns, and carbon sequestration increases—directly **contributing to climate mitigation and adaptation goals** (8).

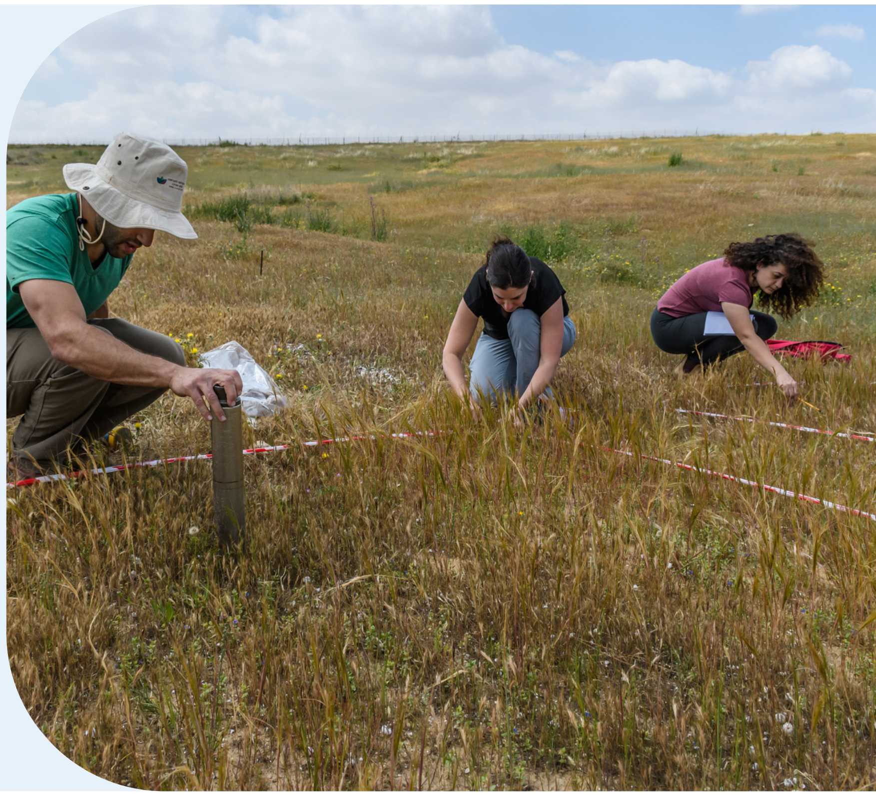
Scaling Up Across Regions and Policy Frameworks

The model's **simplicity and scalability** make it relevant for southern European drylands, Mediterranean islands, and semi-arid agricultural frontiers facing similar pressures. Functional restoration integrates well with EU policy frameworks—namely the Nature Restoration Law, Soil Monitoring Law, and Common Agricultural Policy (CAP) eco-schemes—while also supporting UNCCD Land Degradation Neutrality and SDG 15 (Life on Land).

How eLTER can help

eLTER contributes the scientific backbone for long-term, scalable restoration strategies by

- Providing multi-decade ecological and hydrological data;
- Supporting experimental and functional restoration studies;
- Facilitating socio-ecological integration and participatory monitoring;
- Linking local evidence to European and global policy frameworks;
- Promoting open, interoperable data for adaptive land management.



Ways Forward and Recommendations

Building on the insights gained from the Negev Desert and similar dryland systems (4, 5, 10), several actionable steps can guide policymakers, land managers, and research networks in scaling up functional restoration across Europe and globally:

1. **Assess functional state and degradation drivers.**

   Evaluate how water, soil, and vegetation interact under current conditions to identify critical process breakdowns.

2. **Apply process-based restoration.**

   Rebuild source–sink networks using low-cost interventions (e.g. contour furrows, terraces, stone lines) designed for local rainfall and geomorphology.

3. **Monitor functional recovery.**

   Track changes in soil moisture, vegetation cover, and carbon balance to measure progress toward restored ecosystem services.

4. **Integrate restoration into policy frameworks.**

   Embed functional restoration principles within national and EU-level land management strategies—linking them to CAP eco-schemes, drought resilience plans, and carbon farming initiatives.

5. **Strengthen research–policy interfaces.**

   Use infrastructures such as eLTER RI to connect scientists, land managers, and decision-makers, ensuring knowledge exchange and adaptive management.

Key Messages

- **Functional restoration** shifts the paradigm from rebuilding entire ecosystems to **reviving the processes that sustain them**.
- By restoring **water regulation, soil stability, and vegetation productivity**, it offers a **feasible and scalable pathway** to reverse desertification in arid and semi-arid regions.
- The **Negev Desert case study** demonstrates how targeted, process-based interventions can **restore functionality**, enhance resilience, and deliver **carbon and biodiversity co-benefits**.
- Embedding this approach in **EU and global restoration frameworks** can accelerate land recovery, strengthen **climate adaptation**, and contribute to the **EU Green Deal** and **UNCCD** goals for a land-degradation-neutral world.

We therefore recommend

- **Apply functional restoration models in arid and semi-arid landscapes.**
- **Integrate process-based indicators into EU and national restoration targets.**
- **Align restoration financing with CAP and carbon farming schemes.**
- **Support long-term observation networks like eLTER.**
- **Prioritise co-benefits for biodiversity, climate, and rural livelihoods.**

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