USGS Project: Recoverability and Vulnerability of Desert Ecosystems

FUTURE DIRECTIONS OF RVDE FOR THE MOJAVE DESERT

2003-2008

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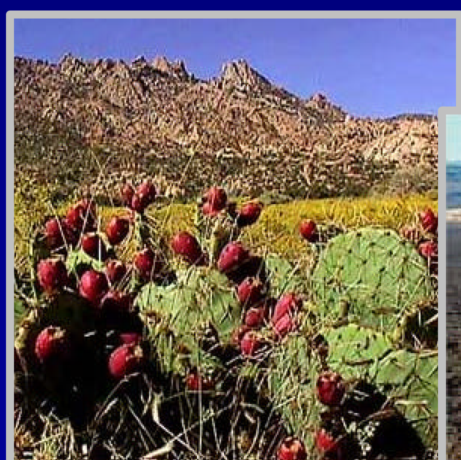

U.S. Department of the Interior
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GOAL OF RVDE

To provide tools for land management decisions in desert ecosystems, based on improved understanding of the complex relations among biological and physical attributes and processes and how they influence vulnerability and recoverability

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GOAL OF RVDE

To use process-based geospatial models to spatially describe ecosystem attributes and to model changes that are expected to result from management actions

IMPORTANT MOJAVE DESERT ATTRIBUTES AND PROCESSES

- Disturbance history
- Visual aesthetics
- Soil structure
- Soil compaction
- Biological soil crusts
- Rodents
- Reptiles
- Large mammals
- Desert annuals
- Riparian ecosystems
- Invasive species
- Total plant cover
- Species composition
- Wind erodibility
- Water erodibility
- Threatened and endangered species
- Overland flow hydrology
- Habitat fragmentation

MAJOR THRUSTS OF RVDE RESEARCH

- Analysis of historical climatic and ecological changes
- Using surficial geology, particle size, and soil-moisture modeling to predict soil compaction vulnerability and recovery
- Use the same attributes to predict biological soil crusts and wind erodibility
- Evaluate the potential for natural recovery of soils and perennial vegetation following severe disturbance

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VULNERABILITY OF THE MOJAVE ECOSYSTEM

- Soil compaction results from many common land uses, increases soil erosion, decreases productivity
- Surface disturbance affects soil structure and biological soil crusts, increasing wind erodibility
- Decreases in vegetation cover and structure affect soil erosion and wildlife populations

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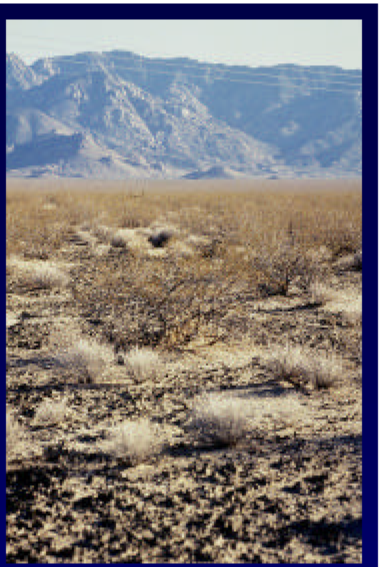
ELEMENTS OF ECOSYSTEM VULNERABILITY

SOIL COMPACTION

- Compaction increases runoff and soil erosion, impedes root growth, slows revegetation of disturbed sites
- How much compaction affects plant growth?
- Compaction is related to soil texture and soil moisture, so vulnerability can be spatially mapped and predicted

ELEMENTS OF ECOSYSTEM VULNERABILITY

BIOLOGICAL SOIL CRUSTS



- BSC stabilize surfaces against wind and water erosion and are a source of nitrogen in ecosystems with few nitrogen fixers.
- Lichen cover is predictable and mappable.
- Total cover, irrespective of species composition, may become re-established in less than a century at wetter microsites.

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ELEMENTS OF ECOSYSTEM VULNERABILITY

INVASIVE SPECIES

- Do we know and can we spatially model the pathways for exotic plant invasions?
- What are the effects of exotic species on native species (annuals and perennials)?
- Can invasive species cause irreversible changes in vegetation type?

ACTIVE RESTORATION AND NATURAL RECOVERY

- Much of the management emphasis in the Mojave ecosystem focuses on active restoration of disturbed sites that are not severely eroded
- Natural recovery is not commonly considered a viable option because the time frames are thought to be prohibitively long
- RVDE research has concentrated on natural recovery of disturbed sites without severe erosion and where on-going disturbance is minimal

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ELEMENTS OF ECOSYSTEM RECOVERY

VISUAL ERASURE

On some young geomorphic surfaces, disturbances may be visually erased from a distance in less than a century. However, disturbance can still be measured.

(Skidoo townsite, abandoned 93 years)

1906

1999

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ELEMENTS OF ECOSYSTEM RECOVERY

SOIL COMPACTION

- Compaction recovery requires about 80-120 years for typical Mojave Desert surface soils
- Recovery is climatically driven (wetting-drying cycles)
- Compaction influences initial reestablishment of total vegetation cover
- Long-term and subsurface effects of compaction are unknown.

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ELEMENTS OF ECOSYSTEM RECOVERY

BIOLOGICAL SOIL CRUSTS

- Cyanobacteria recovers relatively quickly
- Species composition, particularly when lichens are present, may require millennia
- What conditions are required for crust recovery?

ELEMENTS OF ECOSYSTEM RECOVERY

RODENT POPULATIONS

- Rodents can withstand certain types of disturbances (fire) because of stored food reserves.
- Relationships between granivores and recovering vegetation is not well understood. Rodents may follow successional sequence or may influence it.
- Rodent populations "recover" quickly, may drive successional sequences, and may recovery in much less than a century. Is the species composition is keyed to food sources?

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ELEMENTS OF ECOSYSTEM RECOVERY

TOTAL PERENNIAL COVER

- Total cover decreases soil erosion rates (wind and water), increases soil nutrients, and provides cover for wildlife.
- For most Mojave Desert plant associations, total vegetation cover is restored in about 80 years.
- The trajectory may be linear or curvilinear, depending upon the type of disturbance.
- In some associations (*Atriplex*), cover may rise higher than ambient undisturbed conditions.

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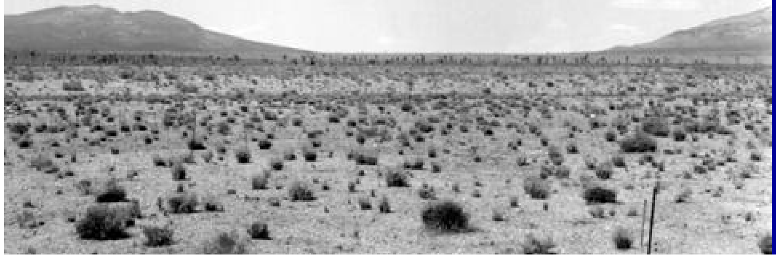
ELEMENTS OF ECOSYSTEM RECOVERY

Processes Controlling Vegetation Recovery

- Life-history strategies and recoverability of perennial vegetation
- What are the seed dispersal mechanisms and the fate of seeds in recovering ecosystems?
- Determine the role of desert annuals – native and non-native –in the recovery process

1964



2001

ELEMENTS OF ECOSYSTEM RECOVERY

SPECIES COMPOSITION RECOVERY

- Recovery of species composition is a function of patch geometry – narrow disturbances may recover more quickly than wide ones.
- The intensity of disturbance is important (root-crown sprouting).
- Species composition may recover in less than 100 yrs in 2-species systems (*e.g., Larrea-Ambrosia*).
- Species composition may require thousands of years in *Coleogyne* or other higher-elevation ecosystems.

Where We Are Going

PHYSICAL PROCESSES

- Refine maps of surficial geology and particle size
- Refine spatial models of effective moisture (precipitation, wetting-drying cycles)
- Scale local models of compaction vulnerability to a region (*e.g.*, Mojave National Preserve)
- Validate biological soil crust models, extend model to new areas, and validate wind erodibility model

Where We Are Going

ECOSYSTEM PROCESSES

- Evaluate the direct ecological impacts of roads: vectors for invasives, dust production, road kills, changes in overland flow patterns, ecosystem fragmentation
- Refine models for vegetation dynamics and recoverability and test the resulting maps
- Analyze and document fire history and fuels/hazard model

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Where We Are Going

REGIONAL ANALYSIS TOOLS

- Refine temporal and spatial maps of land-use history for the Mojave Desert
- Test applicability of remotely sensed data for regional ecosystem attributes
- Develop an integrated decision tool based on the project's accomplishments, develop a project database
- Add socioeconomic aspects of the Mojave Ecosystem into our future modeling scenarios

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Where We Are Going

ECOSYSTEM MONITORING

- Develop new protocols for ecosystem monitoring in a dynamic desert ecosystem
- Determine what ecosystem attributes are truly “vital signs” versus what is easily measured
- Evaluate new remote sensing techniques and platforms for “scaling up” plot-scale monitoring to landscapes

Where We Are Going

IMPROVE TOOLS FOR MANAGERS

- Integrate and interact vulnerability and recoverability models at landscape scales
- What is the best way to communicate complicated scientific information and data to land managers?
- What is the best format/venue/interface for tools that would enhance the usability of spatial models to land managers?

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LESSON 1: Recovery is Complicated

- The Mojave ecosystem has many different attributes that recover at different rates
- There is no one "recovery time" that applies to all attributes
- Recovery and restoration are moving targets because the ambient geomorphic processes and undisturbed vegetation changes
- Recovery is a function of geomorphic surface, changing climate, and type of disturbance
- Therefore, recoverability can (and should) be spatially modeled

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LESSON 2: Recovery Depends on Ambient Ecosystem Conditions

- Undisturbed vegetation changes significantly in response to climatic fluctuations (no more "static ecosystem" label for Mojave Desert)
- Interactions among recovering entities may affect future recovery rates
- Anthropogenic influences (*e.g.*, water use, fire, exotics, air pollution) are changing the face of the Mojave ecosystem and its processes
- What are the key ecosystem attributes to monitor?

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LESSON 3: Ecosystem Function, Vulnerability, and Recoverability Depends on Geology and Water

- Knowledge of geomorphic surfaces and soil structure is paramount to any understanding of how the Mojave ecosystem functions and responds to disturbance
- Geomorphic surface, soil structure, and texture controls soil moisture, which in turn controls vital ecosystem processes.
- Understanding surficial particle size is one key to spatially modeling ecosystem processes.

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LESSON 4: Predicting Ecosystem Response Requires System-Level, Interdisciplinary Models

- Mojave ecosystem is an abiotically driven system with multiple feedbacks between the physical and biological realms
- Most of the controlling factors are spatially distributed
- If the processes can be quantified (big IF in some cases), then geospatial tools can be developed that would be useful to managers

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