Climate change and land-use effects on atmospheric dust in the western United States

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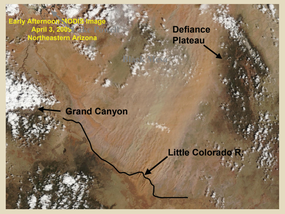
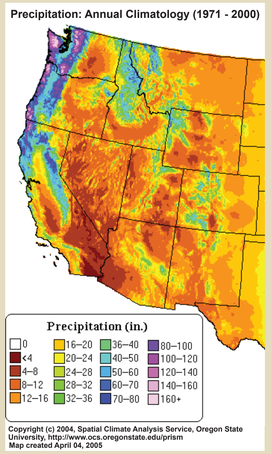
Most atmospheric dust in North America is generated from drylands





- Arid and semi-arid lands (drylands) compose nearly all of the Great Basin and Mojave Desert regions
- Drylands are among the Nation's most sensitive regions to climatic change and land-use practices.
- Combinations of natural factors (such as short-term climatic change) and greatly expanding population, especially in the Southwest, place unprecedented pressures on our dry landscapes and their ecological resources.

Dust generated by wind storms and other factors is important:

Indicator of landscape changes—past, ongoing, future

Management of ecosystems
- loss of soil and its fertility
- nutrient additions where dust is deposited (e.g., mountain soil and lakes)

Degradation of visibility in protected viewsheds and transportation corridors

Human health
- respirable particulate matter; toxic metals; pathogens; organic compounds (herbicides, pesticides)

Earlier and faster snow melt where dust falls on snowpack

USGS studies of dust in North America focus on understanding:

- Sources of dust
- Factors and conditions that promote or suppress dust emission
  - natural settings
  - settings affected by human activities since European settlement
- Effects of dust on human health and communities
- Effects of dust emission and deposition on ecosystems
- Effects of dust on snowmelt

Comprehension of dust emission and its effects requires understanding interactions among:

- Geologic processes, settings, materials
- Vegetation dynamics
- Climate
- Human health and health risks
- Hydrology
- Human activities

Settings, sources, causes of dust

Natural + disturbed
- Sparsely vegetated landscapes
- Alluvial (and flood / hurricane) deposits
- Dry lakes & playas

Disturbed
- Agricultural lands
- Grazed lands
- Smelting, ore processing
- Mining
- Burned areas (including "rehabilitated")
- Urbanization, other industry, transportation
- Recreation (dirt roads)
- Military installations / activities
- Energy exploration & extraction

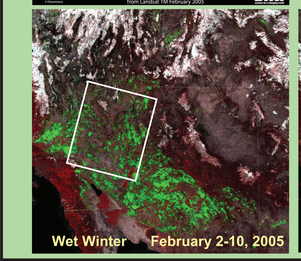
Dust properties and components that can affect human health
- Particulate matter (PM); particle sizes PM10, PM2.5
- Nasty minerals (asbestiform minerals — amphibole asbestose; erionite)
- Metals & metalloids
- Herbicides/pesticides, fertilizers, etc.
- Pathogens (bacteria, viruses, fungal spores)

Dust emission related to vegetation change

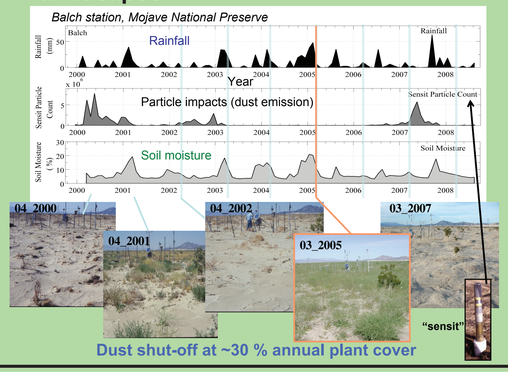
Conditions and controls — vegetation dynamics, amount & timing of precipitation, wind focus, biologic soil crusts, sediment availability, disturbance histories

Vegetation response to climate

Mapping wind-erosion vulnerability of south-western landscapes—maps conveying annual-plant distributions



Dust emission from sparsely vegetated landscapes



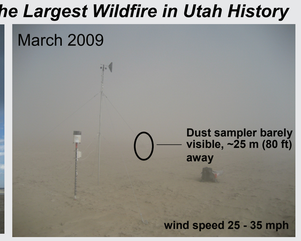
Dust shut-off at ~30 % annual plant cover

Dust emission related to treatments of a large burned area

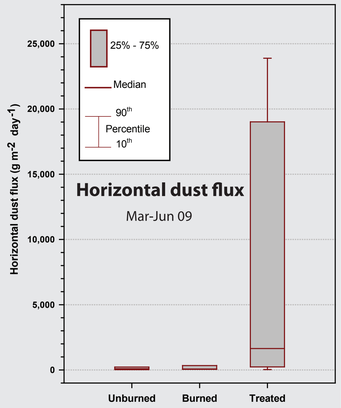
Conditions and controls

Soils – Lake Bonneville lake sediments
Climate – arid and windy
Landscape – high degree of wind exposure with wind corridors

Dust from Milford Flat—Site of the Largest Wildfire in Utah History



Horizontal dust flux at 1-m height, *just prior* to peak of storm > 234,200 g m^{-2} day^{-1}

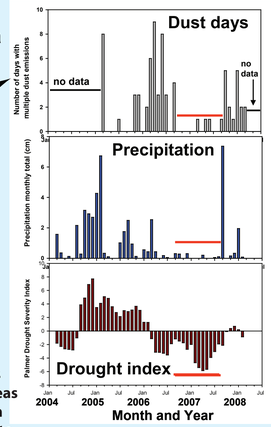


Dust emission from dry lakes

Conditions and controls—ground-water and surface flow; physical crusts and mineralogy, sediment availability, disturbance histories

Dust emission at Franklin Lake playa Mojave Desert

>14400 images from remote digital cameras triggered by strong wind



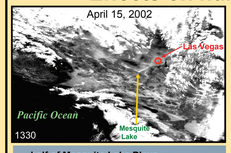
Monitoring over three years at Franklin Lake playa (a wet playa) in the Mojave Desert shows that wet periods promote dust emission, whereas aridity supresses dust emission. Relatively high precipitation rejuvenates evaporation leading to soft salty surfaces, which are vulnerable to wind erosion. Aridity leads to hard, thick salt crusts that resist wind erosion.

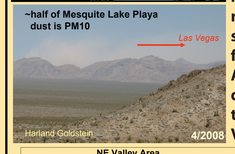
Physiologically based extractions in simulated biofluids to assess bioaccessibility of As, Cd, Cr, Pb, Mo, Sb, W Se, U, etc.

Evaporite-mineral dust may contain toxic elements with high bioaccessibility

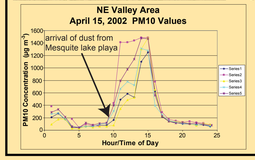
Some effects of dust

Effects on human health



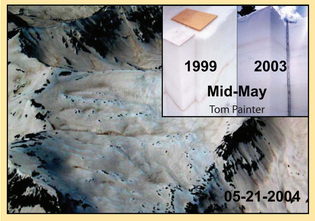


Densely populated areas in the American West, such as Las Vegas, experience heavy, recurrent dust fall related to locations of dust sources and topographic funneling of strong winds. Air quality in Las Vegas deteriorates when far-traveled dust reaches Las Vegas valley.

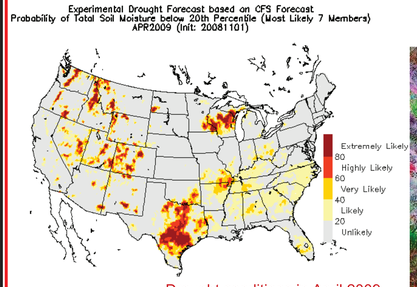


Effects on snowpack melting and water resources

- Decreases albedo of snow surfaces
- Triggers earlier and faster snow melt
- Leads to smaller late season water supplies



Prospects over a few seasons—consulting drought forecasts

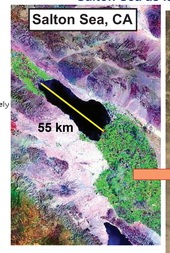


Drought conditions in April 2009 predicted in Nov. 2008

http://hydrology.princeton.edu/~luo/research/FORECAST/droughtprob.php

Prospects based on land management policies—more dust likely

Salton Sea – a future dust source

Water management policies dictate drying Salton Sea

Dust will affect human health near the Salton Sea as it does today elsewhere