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Enhancing Wind Erosion Monitoring and Assessment for U.S. Rangelands

By Nicholas P. Webb, Justin W. Van Zee, Jason W. Karl, Jeffrey E. Herrick, Ericha M. Courtright, Benjamin J. Billings, Robert Boyd, Adrian Chappell, Michael C. Duniway, Justin D. Derner, Jenny L. Hand, Emily Kachergis, Sarah E. McCord, Beth A. Newingham, Frederick B. Pierson, Jean L. Steiner, John Tatarko, Negussie H. Tedela, David Toledo, and R. Scott Van Pelt

On the Ground

- Wind erosion is a major resource concern for rangeland managers because it can impact soil health, ecosystem structure and function, hydrologic processes, agricultural production, and air quality.
- Despite its significance, little is known about which landscapes are eroding, by how much, and when.
- The National Wind Erosion Research Network was established in 2014 to develop tools for monitoring and assessing wind erosion and dust emissions across the United States.
- The Network, currently consisting of 13 sites, creates opportunities to enhance existing rangeland soil, vegetation, and air quality monitoring programs.
- Decision-support tools developed by the Network will improve the prediction and management of wind erosion across rangeland ecosystems.

Keywords: dust, air quality, soil health, network, Long-Term Agroecosystem Research.

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Wind erosion is a major contributing factor to rangeland soil degradation. The process is highly sensitive to variability in soils, weather, and climate, which influence wind erosivity, protective vegetation cover levels, and soil susceptibility to entrainment and transport downwind (see Box 1 for definitions of terms). Wind erosion is also highly sensitive to patterns of land use and land management, which influence vegetation cover and soil erodibility. While croplands have been the focus of wind erosion research in the United States for many years, wind erosion impacts in U.S. rangelands and the effects of management practices on erosion rates are now widely recognized. Episodes of drought and changing land use pressures have significantly impacted dust emissions following the expansion of ranching and agriculture into the American West.[1] Dust concentrations monitored across the United States (1995–2014) show a trend of increasing dustiness, particularly in the southwest.[2] The Dust Bowl of the 1930s is perhaps the most dramatic example of how inappropriate management practices, unchecked during intense drought, can result in massive regional wind erosion.[3]

Locally, wind can redistribute and erode soils resulting in the loss of fine soil particles and resources such as nitrogen, phosphorous, and carbon (Fig. 1), thereby impacting soil quality and soil health. These changes can influence ecosystem dynamics and alter provision of ecosystem services. Dust emissions may be localized or associated with dust storms that can travel thousands of kilometers, impacting biogeochemical cycles,[5] the hydrologic cycle, and climate.[6] Wind erosion and dust emissions also directly impact human systems. For example, dust degrades air quality, transports fungal spores (e.g., causing Valley fever) and aggravates respiratory diseases affecting human health,[7] and reduces visibility impacting transportation and tourism (Fig. 2). Dust deposition on snowpack in mountainous areas can change the surface albedo and increase the rate of snowmelt, affecting runoff and water supplies.[8] Managing wind erosion and dust impacts has become a significant challenge for natural resource managers because 1) the impacts are so diverse and widespread, and 2) changing land use pressures make wind erosion difficult to anticipate and manage or avoid.

Many land uses and natural disturbances in U.S. rangelands can increase wind erosion depending on how they are managed. Livestock grazing, oil, gas and alternative energy development, graded road networks, off-road vehicles, abandonment of croplands due to changing water availability or economic factors, expansion of exurban developments, and

Box 1
Definitions of Terms Used to Describe Wind Erosion Processes

Aeolian – processes relating to or arising from the action of the wind.
Entrainment – to lift and transport (soil grains) by the flow of a fluid (the wind).
Dust emission – the entrainment of fine soil particles and aggregates (dust), typically regarded as being smaller than 62.5 μm in diameter (e.g., silt and clays).
Dust deposition – the settling of dust particles to the land surface under the force of gravity or in rainfall.
Particulate matter (PM) – solid and liquid particles in the air, comprising the particulate portion of aerosols. PM_{10} particles have an aerodynamic diameter < 10 μm and may be inhalable.
Saltation – the movement of soil grains and aggregates along the soil surface in a leaping or hopping motion, typically larger than 62.5 μm and within ~1 m of the surface.
Sediment mass flux – the mass of soil grains in saltation and/or suspended in the air (dust) per unit length or area per unit time; often separated into saltation (g m^{-1} s^{-1}) and dust (g m^{-2} s^{-1}) components.
Wind erosion – the net loss of soil from an area, considered the sum of all saltation and dust emission out of the area (loss) and deposition (gain) of sediment into the area from upwind sources (e.g., t ha^{-1}).

wildfire are examples of common land use change and disturbances that can increase wind erosion. These activities often have overlapping and competing management needs that must be met within policy and regulatory frameworks that determine resource condition, erosion targets, and air quality standards (e.g., 1977 Clean Air Act and National Ambient Air Quality Standards). Routine monitoring and assessment of wind erosion and dust emission can help inform resource management and policy decisions to help minimize wind erosion.

In this paper we 1) identify strengths, weaknesses, and opportunities for existing programs that contribute to wind erosion monitoring and assessment in U.S. rangelands, and 2) address the role of the National Wind Erosion Research Network[8] as a mechanism for enhancing wind erosion monitoring and assessment capabilities. The Network can provide new opportunities for i) conducting basic research on wind erosion and dust emission processes at different scales in space and time, ii) development of new wind erosion monitoring and assessment approaches, and iii) improvement in decision-support tools for the prediction and management of wind erosion impacts across rangeland ecosystems.

Wind Erosion Monitoring and Assessment in U.S. Rangelands

Although historically there has been no centralized effort to monitor wind erosion, other programs provide information that can be used to support wind erosion monitoring and assessment in U.S. rangelands. For example, the Bureau of Land Management (BLM) Assessment, Inventory, and Monitoring (AIM) Strategy[10] and the Natural Resources

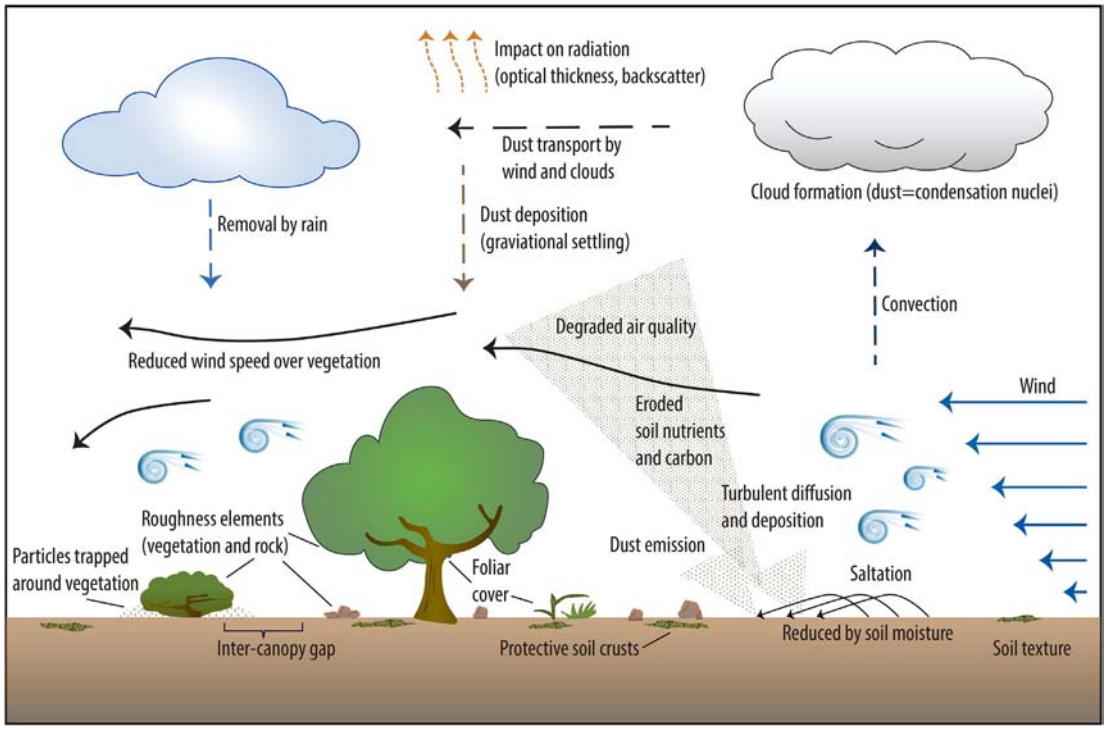

Figure 1. Schematic showing the physical processes that influence wind erosion and dust emission (after Lu and Shao[4]). Core indicators of the surface resistance to wind erosion include the amount of foliar cover, the size and distribution of intercanopy gaps, vegetation height, and soil surface properties such as texture and physical and biological crust cover.