USDA-ARS
Rangeland Wind Erosion Research and Modelling

R. Scott Van Pelt – WEWC, Big Spring, TX
Ted M. Zobeck – WEWC, ‘retired’
Nicholas P. Webb – JER, Las Cruces, NM


For over 5 decades, ARS has been a leader in wind erosion model development

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- 1998 – RWEQ (Fryrear et al.)

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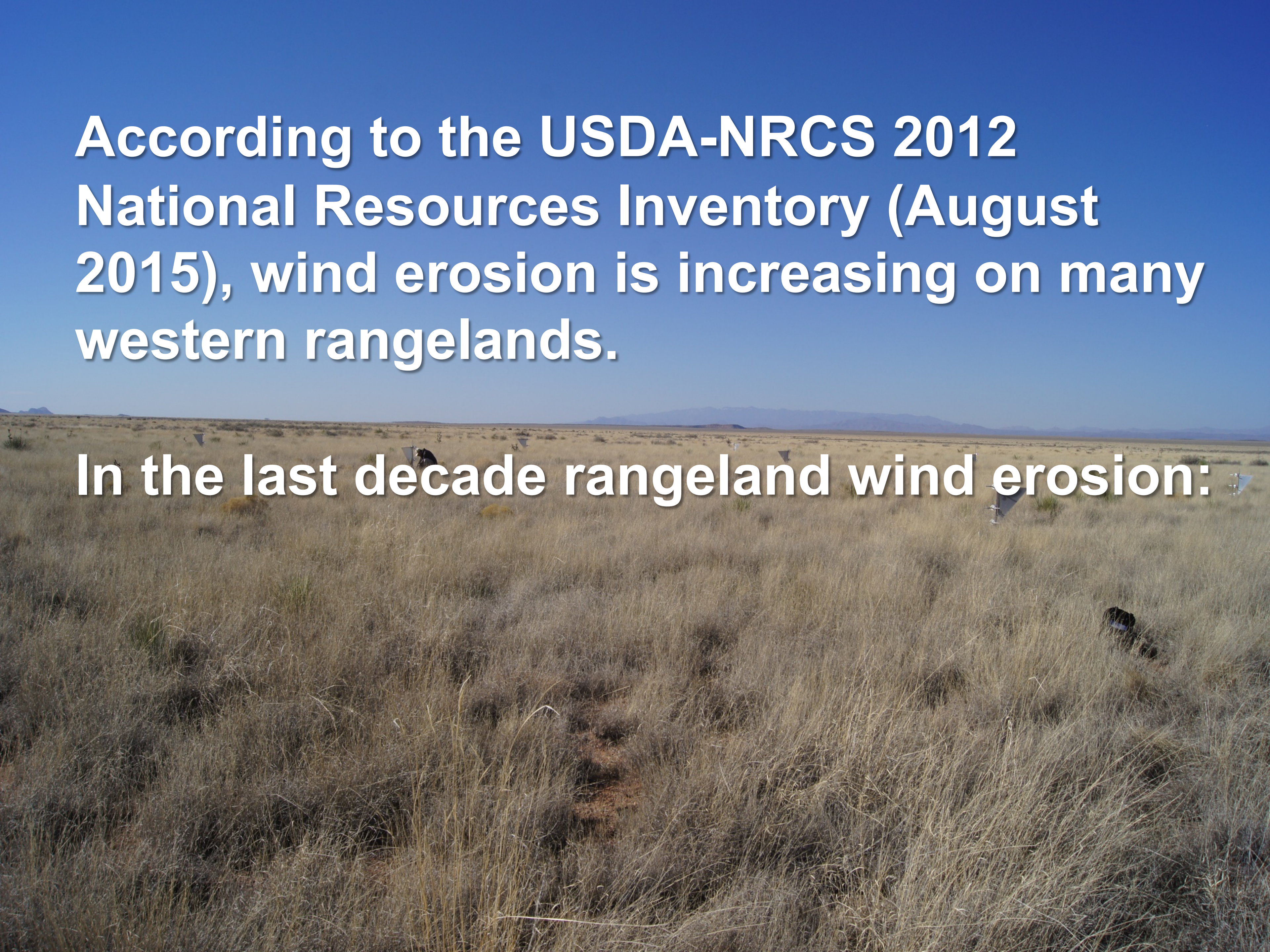
- 1965 – WEQ (Woodruff and Siddoway)
- 1998 – RWEQ (Fryrear et al.)
- 2008 – WEPS (Skidmore et al.)

These were cropland models for uniform bare, cropped, or residue covered fields

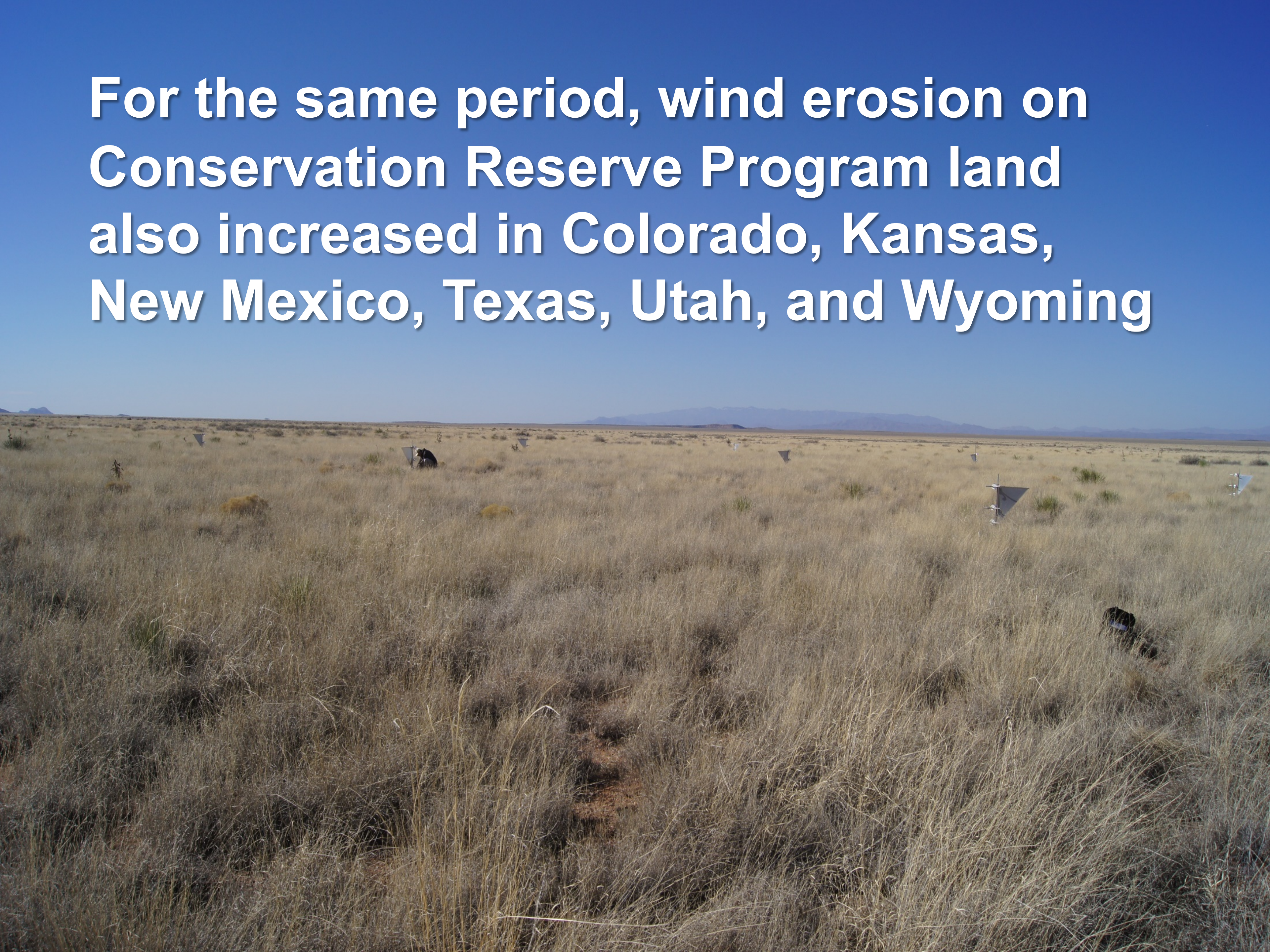

Rangelands are not uniform surfaces

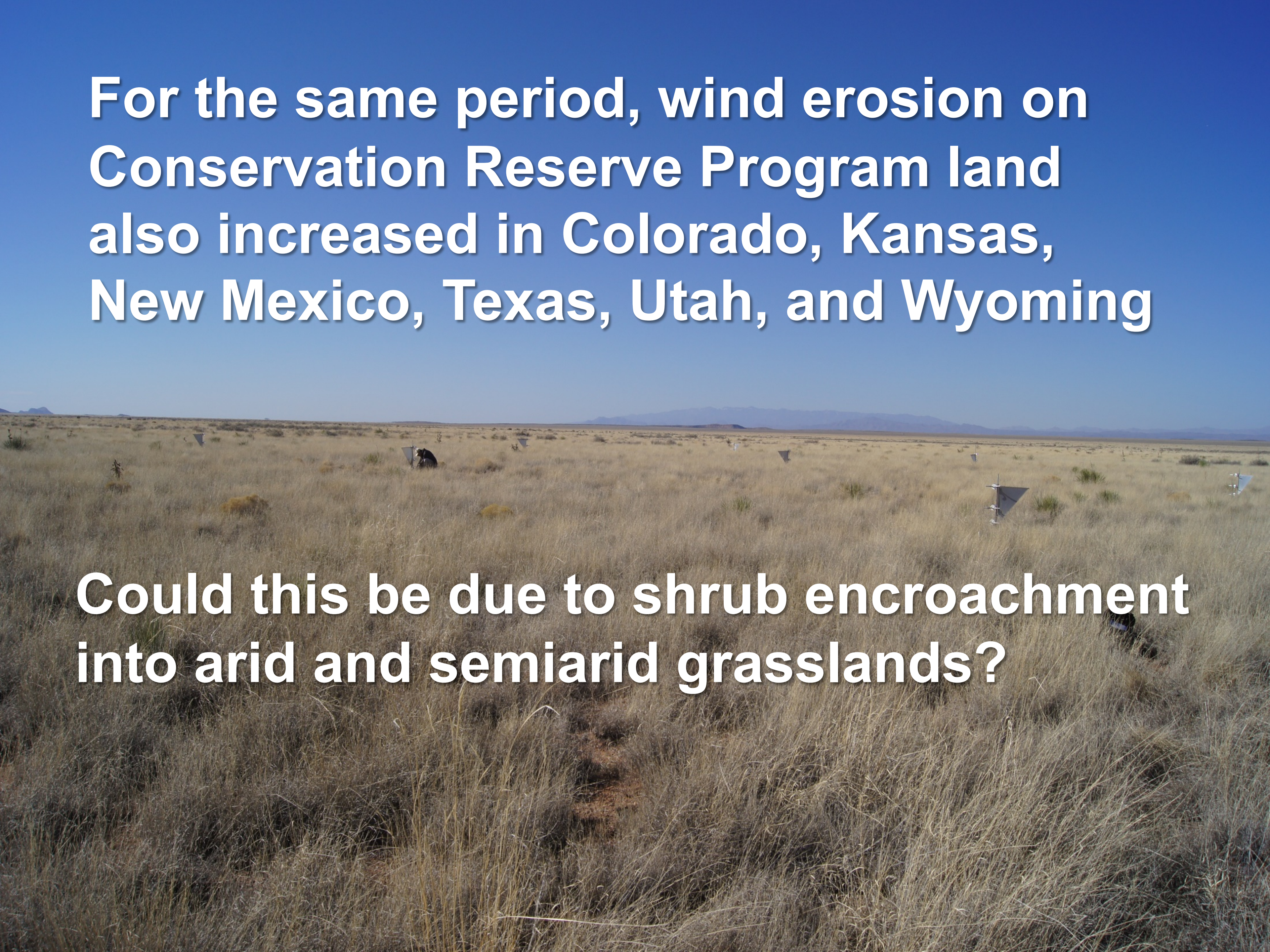

According to the USDA-NRCS 2012 National Resources Inventory (August 2015), wind erosion is increasing on many western rangelands.
In the last decade rangeland wind erosion:

According to the USDA-NRCS 2012 National Resources Inventory (August 2015), wind erosion is increasing on many western rangelands.

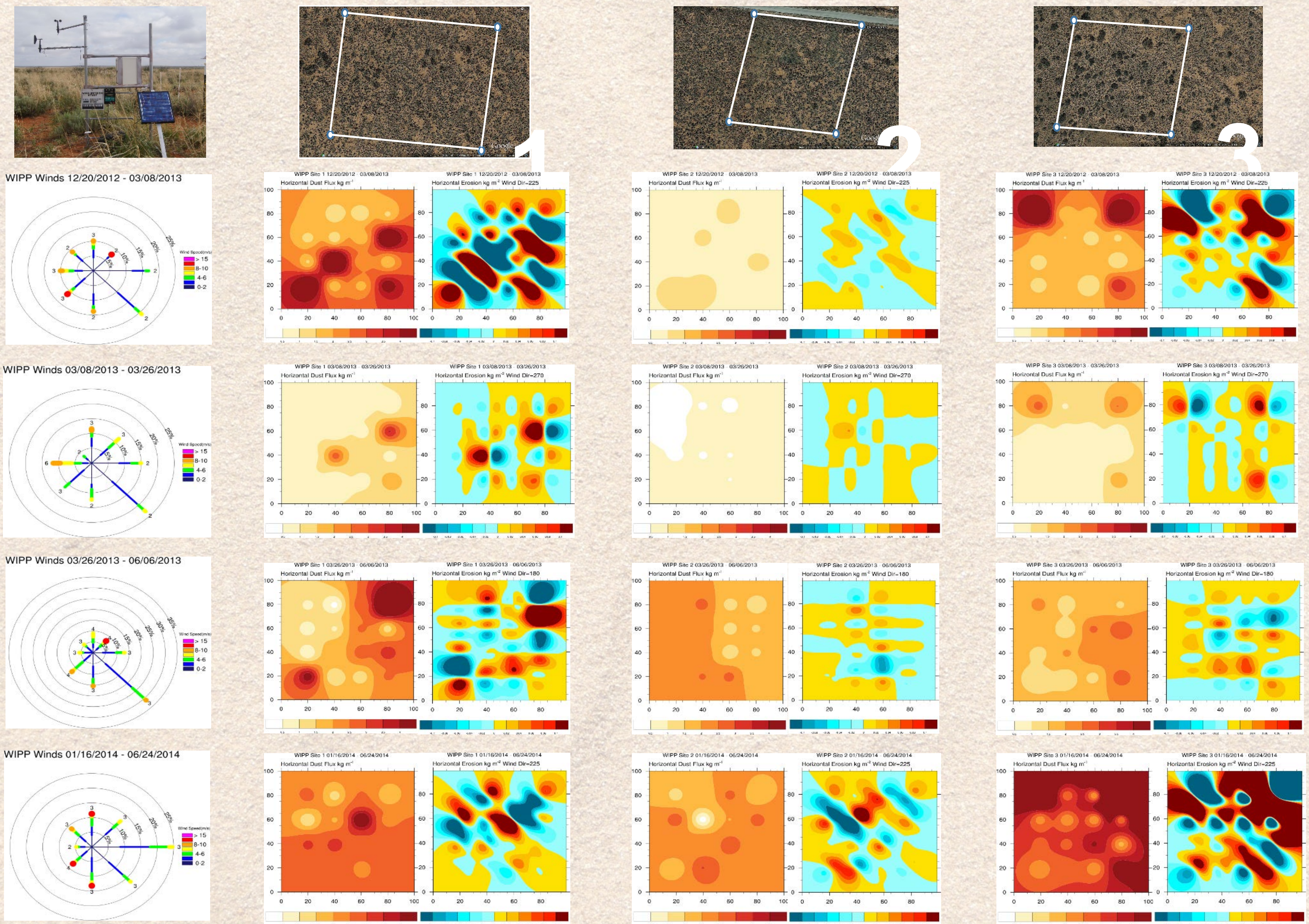
In the last decade rangeland wind erosion:

- Tripled in New Mexico
- Quadrupled in Texas
- Increased to a lesser degree in: Arizona, Colorado, Kansas, Nebraska, Utah, and Wyoming


For the same period, wind erosion on Conservation Reserve Program land also increased in Colorado, Kansas, New Mexico, Texas, Utah, and Wyoming


For the same period, wind erosion on Conservation Reserve Program land also increased in Colorado, Kansas, New Mexico, Texas, Utah, and Wyoming
Could this be due to shrub encroachment into arid and semiarid grasslands?

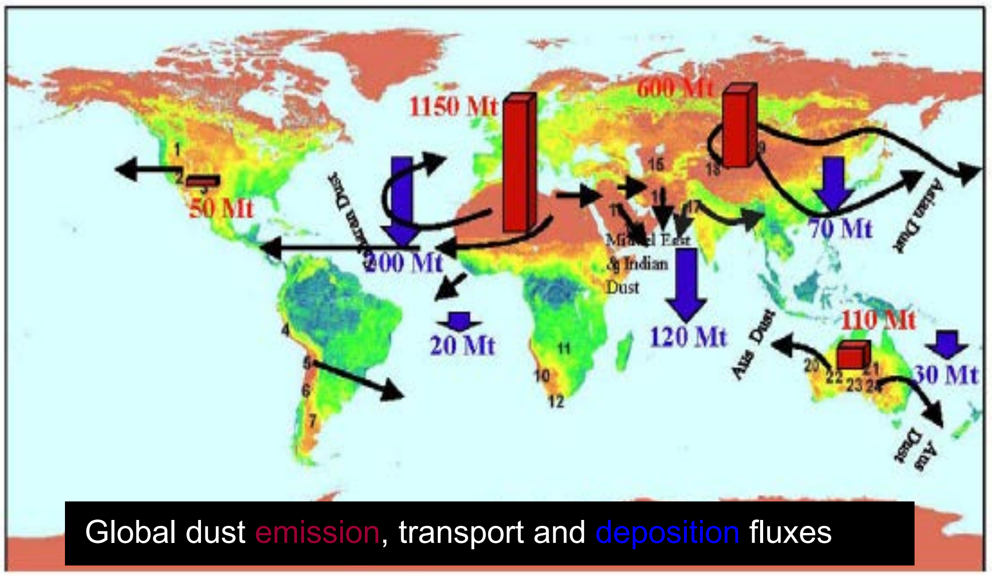
In April 2012 we initiated a study to measure horizontal mass flux and, hopefully, redistribution in SE New Mexico



1
2
3
WIPP Winds 12/20/2012 - 03/08/2013
WIPP Site 1 12/20/2012 - 03/08/2013
Horizontal Dust Flux kg m-1
Horizontal Erosion kg m-2 Wind Dir=225
WIPP Site 2 12/20/2012 - 03/08/2013
WIPP Site 3 12/20/2012 - 03/08/2013
WIPP Winds 03/08/2013 - 03/26/2013
WIPP Site 1 03/08/2013 - 03/26/2013
Horizontal Erosion kg m-2 Wind Dir=270
WIPP Site 2 03/08/2013 - 03/26/2013
WIPP Site 3 03/08/2013 - 03/26/2013
WIPP Winds 03/26/2013 - 06/06/2013
WIPP Site 1 03/26/2013 - 06/06/2013
Horizontal Erosion kg m-2 Wind Dir=180
WIPP Site 2 03/26/2013 - 06/06/2013
WIPP Site 3 03/26/2013 - 06/06/2013
WIPP Winds 01/16/2014 - 06/24/2014
WIPP Site 1 01/16/2014 - 06/24/2014
WIPP Site 2 01/16/2014 - 06/24/2014
WIPP Site 3 01/16/2014 - 06/24/2014
Wind Speed(m/s)
> 15
8-10
4-6
0-2

Big Challenges for Aeolian Research

Accelerated wind erosion, soil loss, croplands, dust emission, air quality, land use change, land cover change, desertification, climate change mitigation and adaptation, agricultural intensification, rangelands, transportation, land degradation, deserts, dust on snow, energy development, off-road recreation, military activity, drought…

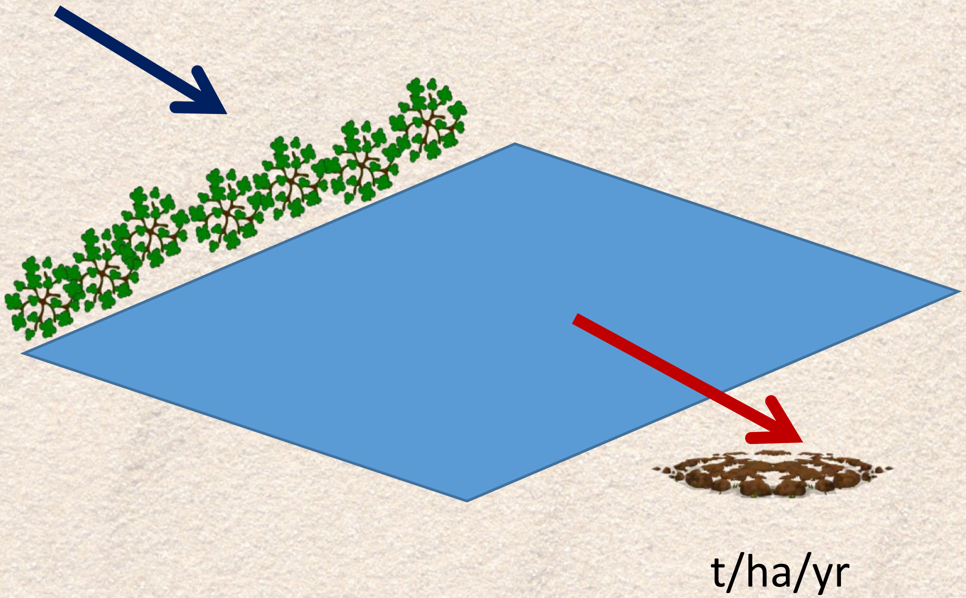


[Shao et al. 2011]

How can aeolian research, including measurements, monitoring and models, be improved to have greater relevance and impact for policy, planning and decision making?

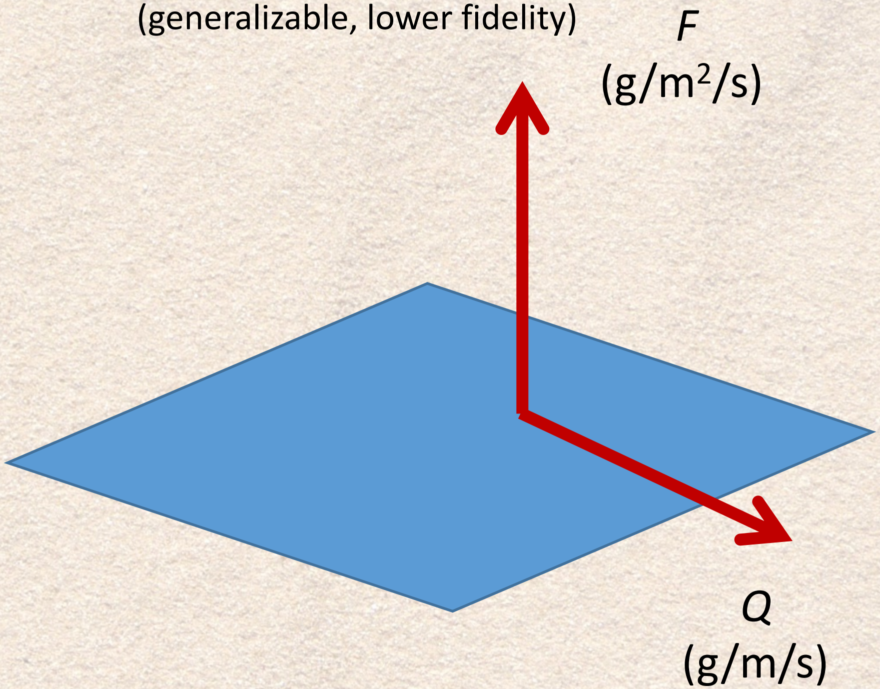
No generalizable model that meets user needs.

Wind Erosion Models
(high fidelity, not very generalizable)



Output = Soil Loss

Dust Emission Models
(generalizable, lower fidelity)



Output = Horizontal mass flux (*Q*)
Output = Vertical mass flux (*F*)

Processes related, but different. We currently have no robust models for predicting sediment flux AND soil loss across land use and land cover types.

Models not tested across land use and land cover types – model uncertainty unknown.

- Data appropriate for calibrating and testing models available from few locations.
- Data represent point measurements, often in a bare agricultural field.
- Models rarely tested for different vegetation structures, distributions, and soil textures and surface conditions.

Implications for Management and Policy

- Robust models and monitoring methods are needed to support wind erosion management and policy decisions.

- Models and methods need to meet user needs:
  - Provide relevant outputs
  - Provide measure of uncertainty

- Supported by field measurements that enable:
  - Improved understanding of process
  - Using statistically robust sampling designs
  - Long-term data collection and analyses
  - Across land use and land cover types under different management

A Solution: Long-Term, Standardized and Networked Aeolian Research.

The National Wind Erosion Research Network

Motivation:

- Establish a National Wind Erosion Research Network to address critical challenges for aeolian research and management in the US.

Objectives:

- Support basic research underpinning models and management.
- Improve availability of decision-support tools for managers/agencies.
- Facilitate collaboration to increase impact of science, planning and policy.

Implementation:

- Largest, most geographically diverse (LULC) network for long-term aeolian research.
- Standardized methods.
- Intensive and robust sampling design.
- Open access.

winderosionnetwork.org

Network Partners

USDA Agricultural Research Service, Natural Resources Conservation Service

- Develop knowledge (science) and technologies to support sustainable agriculture and ecosystems.
- Investigate land use, land cover change, climate change impacts on soil resource and agricultural production.

Bureau of Land Management and US Geological Survey

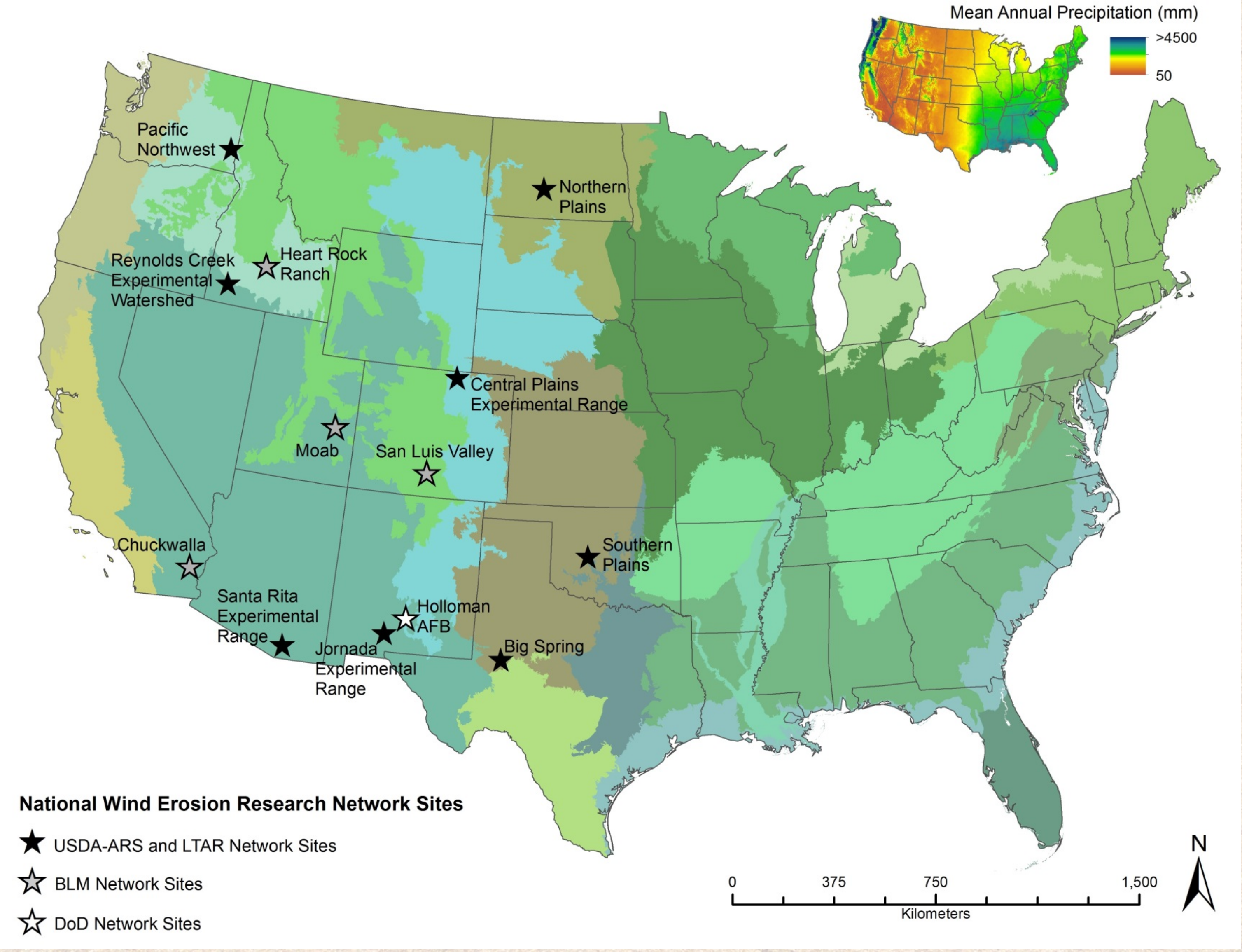
- Managing soil loss, dust emission (air quality), impacts on ecology and society on multi-use public lands (grazing, energy development, recreational activities)

Department of Defense

- Decision support tools – numerical weather prediction.

Integrated with the USDA Long-term Agro-ecosystem Research (LTAR) network.

Current National Wind Erosion Research Network Sites

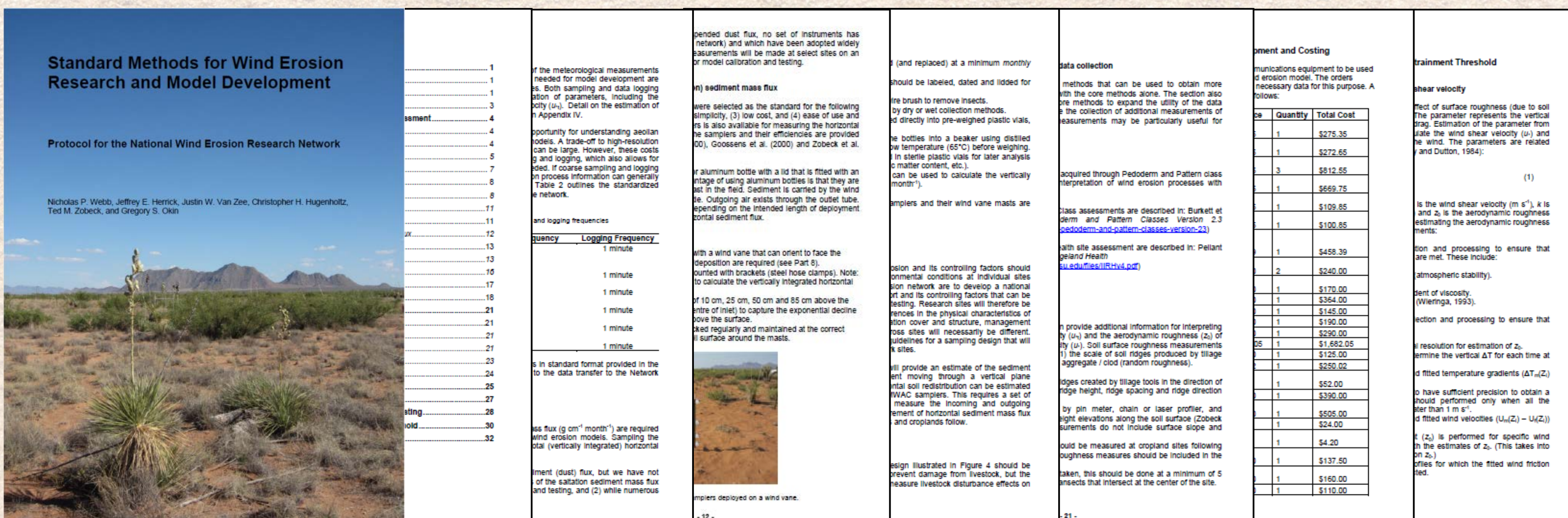


National Wind Erosion Research Network Sites and Farm Resource Regions

Network Standard Methods Protocol

- A standard methods protocol was developed for the Network.
- The protocol defines:
  - Site instrumentation
  - Sampling design and data collection methods and frequencies
  - Data storage and management.

Standardisation of the measurement methods and data analysis is important for cross-site assessments of wind erosion controls and processes.



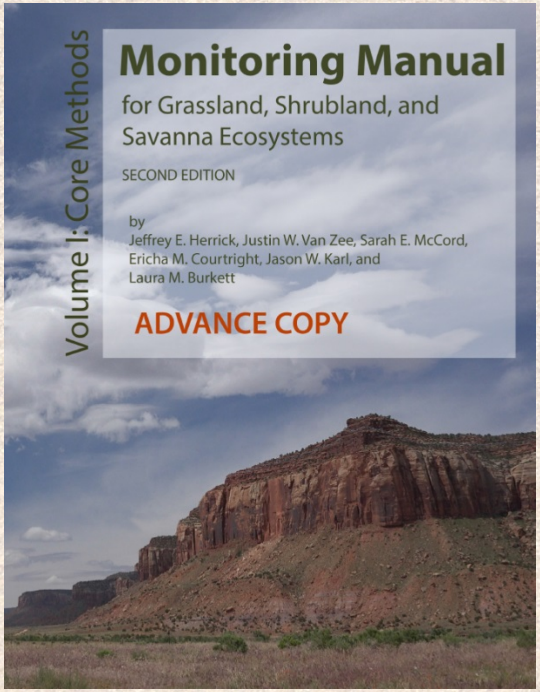
Network Standard Methods Protocol

Standard meteorological methods:

- Consistent with WMO standards.
- Follow conventions adopted by the aeolian research community.

Standard vegetation and soil methods selection criteria:

- Simple, rapid and repeatable without bias.
- Nationally adopted by the NRCS (NRI) and BLM (AIM) for monitoring.



DIMA

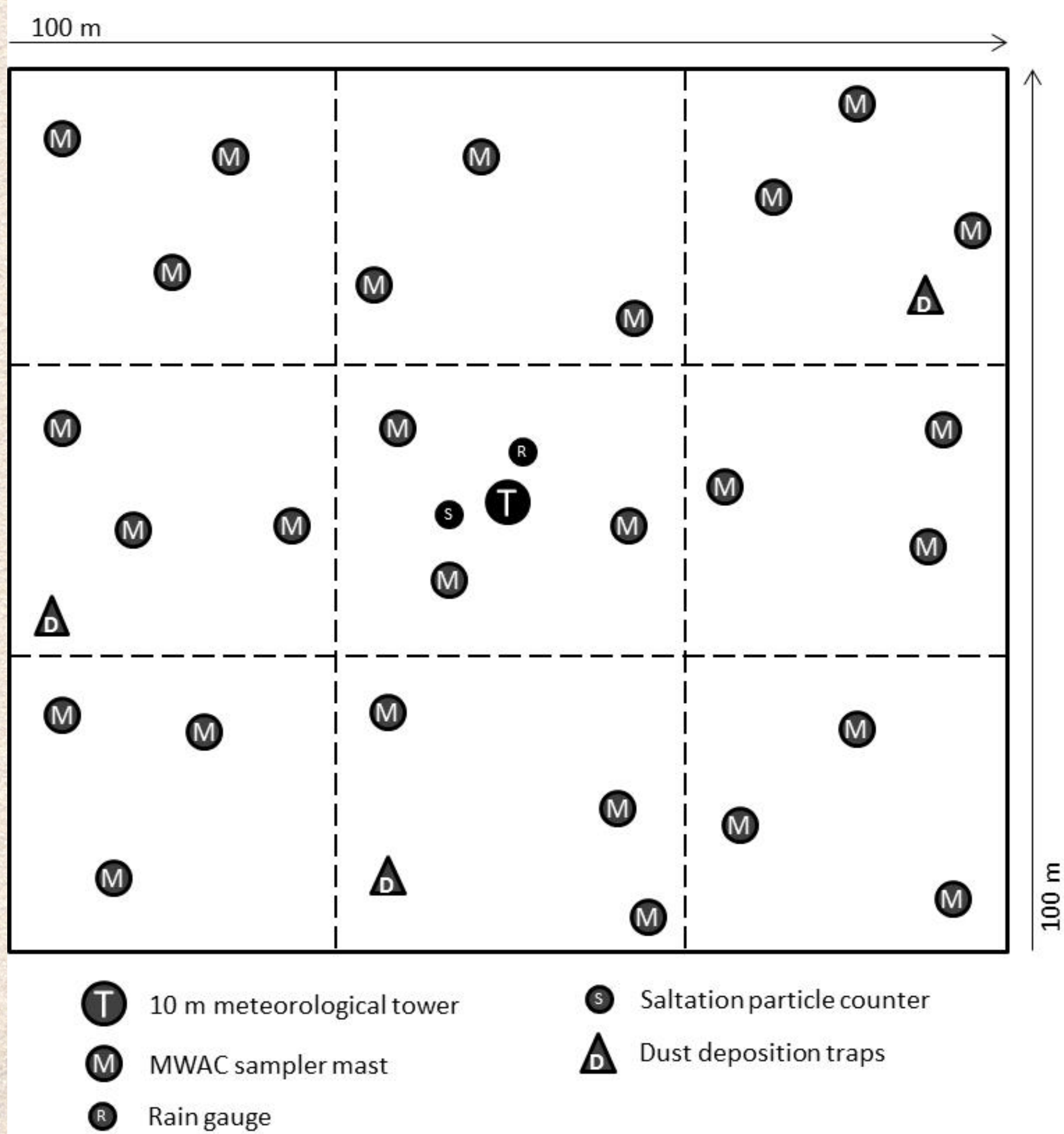
Database for Inventory, Monitoring & Assessment

Supporting data collected at >30,000 locations across the United States

Site Instrumentation Layout and Sampling Design

A stratified random sampling design to measure the horizontal sediment mass flux *(Q)* at each site.

- Reliable estimate of transport rates to establish model uncertainty.
- Confidence in measure of transport within and among land use/land cover/management types.
- Spatial measure of transport needed to develop model of E_N.



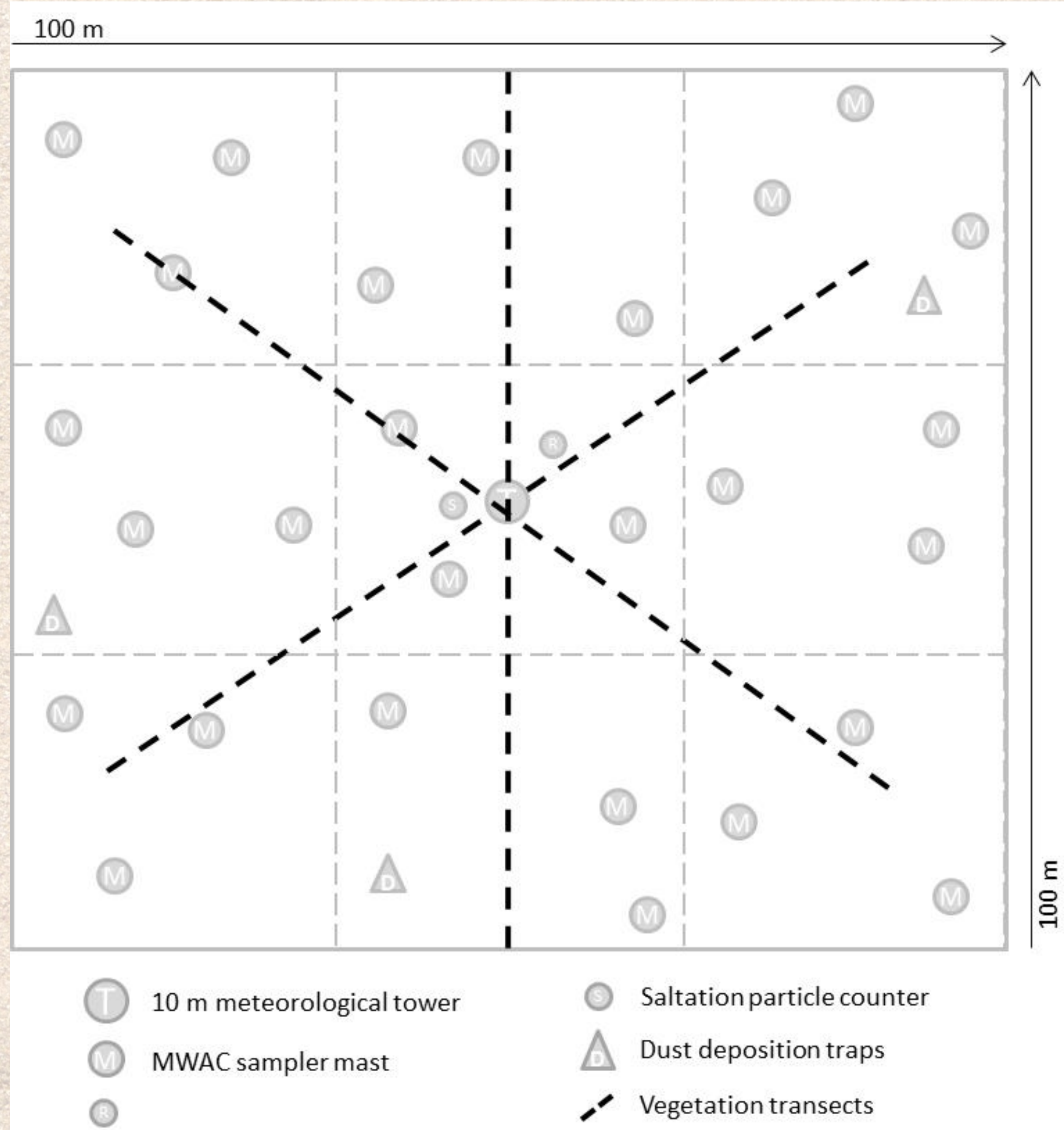
Meteorological Measurements

10 m instrument mast on which are mounted:

- Six anemometers
- One wind vane
- Three air temperature sensors
- Relative humidity sensor
- Data logger enclosure
- Solar panel
- Rain gauge (tipping bucket)
- Sensit – saltation flux sensor
- Time-lapse camera
- Communications antenna

Vegetation Transects – LPI, Canopy Gap, Height

- Vegetation data:
  - Cover
  - Distribution
  - Height
- Soil surface properties.
- Photo points.
- 3 x 100 m transects.
- Measured 4 times per year.
- Relate to directional aerodynamic roughness (z_0) at each site.



Data Management and Data Portals

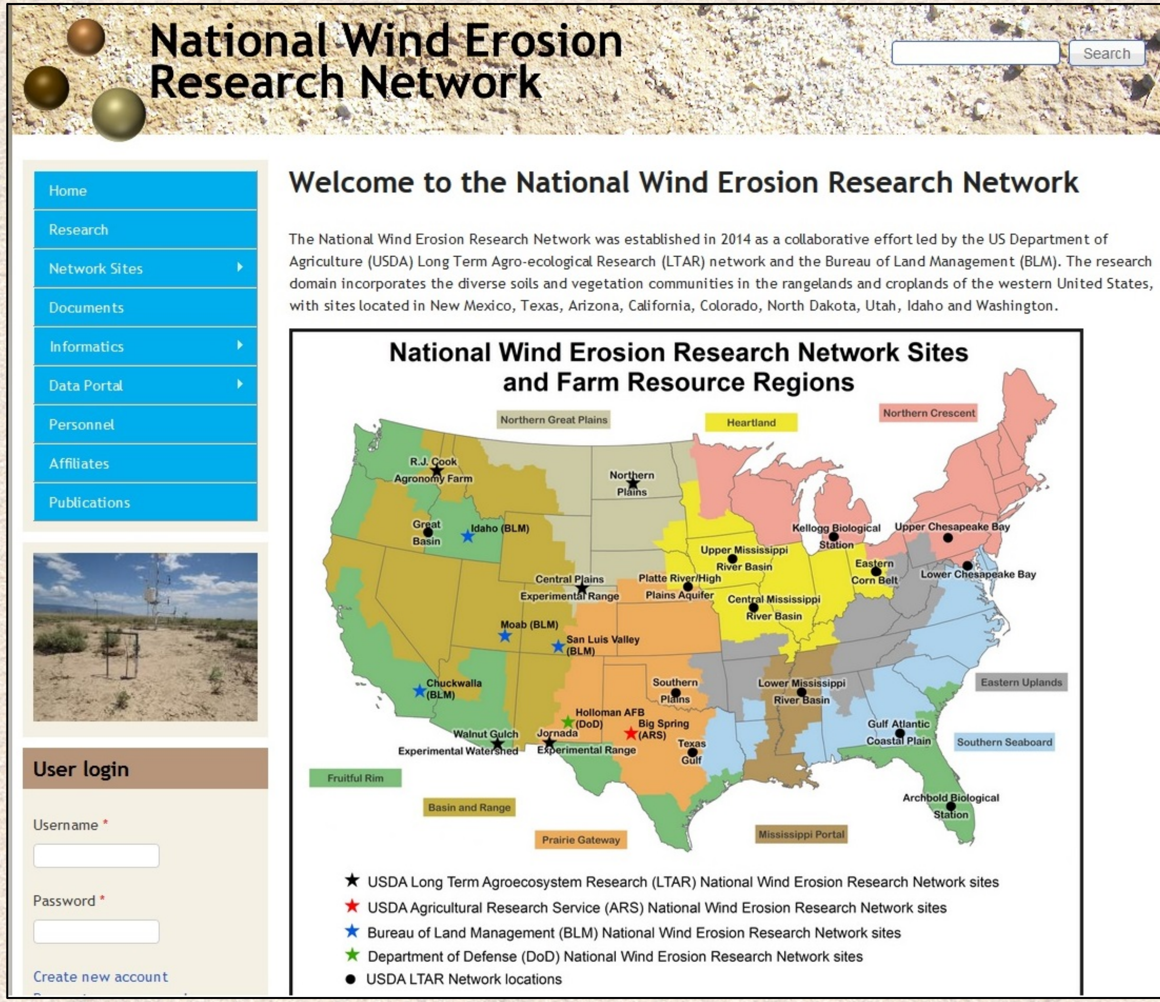
Network data managed at the Jornada Experimental Range, NM.

Meteorological data

- Wireless transfer
- Near real time availability
- Open access

All other data

- Access database – DIMA
- Available to collaborators
- Open access after 3 years



http://winderosionnetwork.org/data-portal/access-data

Remote Sensing of Environment 114 (2010) 1462–1470

Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

Estimating aerodynamic resistance of rough surfaces using angular reflectance

Adrian Chappell [a,*], Scott Van Pelt [b], Ted Zobeck [c], Zhibao Dong [d]

[a] CSIRO Land and Water, GPO Box 1666, Canberra, ACT 2601, Australia
[b] Agricultural Research Service, United States Department of Agriculture, Big Spring, TX, 79720, USA
[c] Agricultural Research Service, United States Department of Agriculture, Lubbock, TX, 79720, USA
[d] Key Laboratory of Desert and Desertification, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, No. 320 West Donggang Road, Lanzhou 730000, Gansu Province, PR China

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Wind erosion
Sheltering
Erodible
Flow separation
Drag
Wake
Aerodynamic resistance
Aerodynamic roughness length
Shadow
Illumination
Ray-casting
Digital elevation model
Roughness density
Frontal area index
Angular reflectance
Bi-directional reflectance

ABSTRACT

Current wind erosion and dust emission models neglect the heterogeneous nature of surface roughness and its geometric anisotropic effect on aerodynamic resistance, and over-estimate the erodible area by assuming it is not covered by roughness elements. We address these shortfalls with a new model which estimates aerodynamic roughness length (z_0) using angular reflectance of a rough surface. The new model is proportional to the frontal area index, directional, and represents the geometric anisotropy of z_0. The model explained most of the variation in two sets of wind tunnel measurements of aerodynamic roughness lengths (z_0). Field estimates of z_0 for varying wind directions were similar to predictions made by the new model. The model was used to estimate the erodible area exposed to abrasion by saltating particles. Vertically integrated horizontal flux (F_h) was calculated using the area not covered by non-erodible hemispheres; the approach embodied in dust emission models. Under the same model conditions, F_h estimated using the new model was up to 85% smaller than that using the conventional area not covered. These F_h simulations imply that wind erosion and dust emission models without geometric anisotropic sheltering of the surface, may considerably over-estimate F_h and hence the amount of dust emission. The new model provides a straightforward method to estimate aerodynamic resistance with the potential to improve the accuracy of wind erosion and dust emission models, a measure that can be retrieved using bi-directional reflectance models from angular satellite sensors, and an alternative to notoriously unreliable field estimates of z_0 and their extrapolations across landform scales.

Aeolian Research 23 (2016) 63–78

Contents lists available at ScienceDirect

Aeolian Research

journal homepage: www.elsevier.com/locate/aeolia

Using albedo to reform wind erosion modelling, mapping and monitoring

Adrian Chappell [a,*], Nicholas P. Webb [b]

[a] CSIRO Land and Water, G.P.O. Box 1666, Canberra, ACT 2601, Australia
[b] USDA-ARS Jornada Experimental Range, Las Cruces, New Mexico, USA

A R T I C L E I N F O

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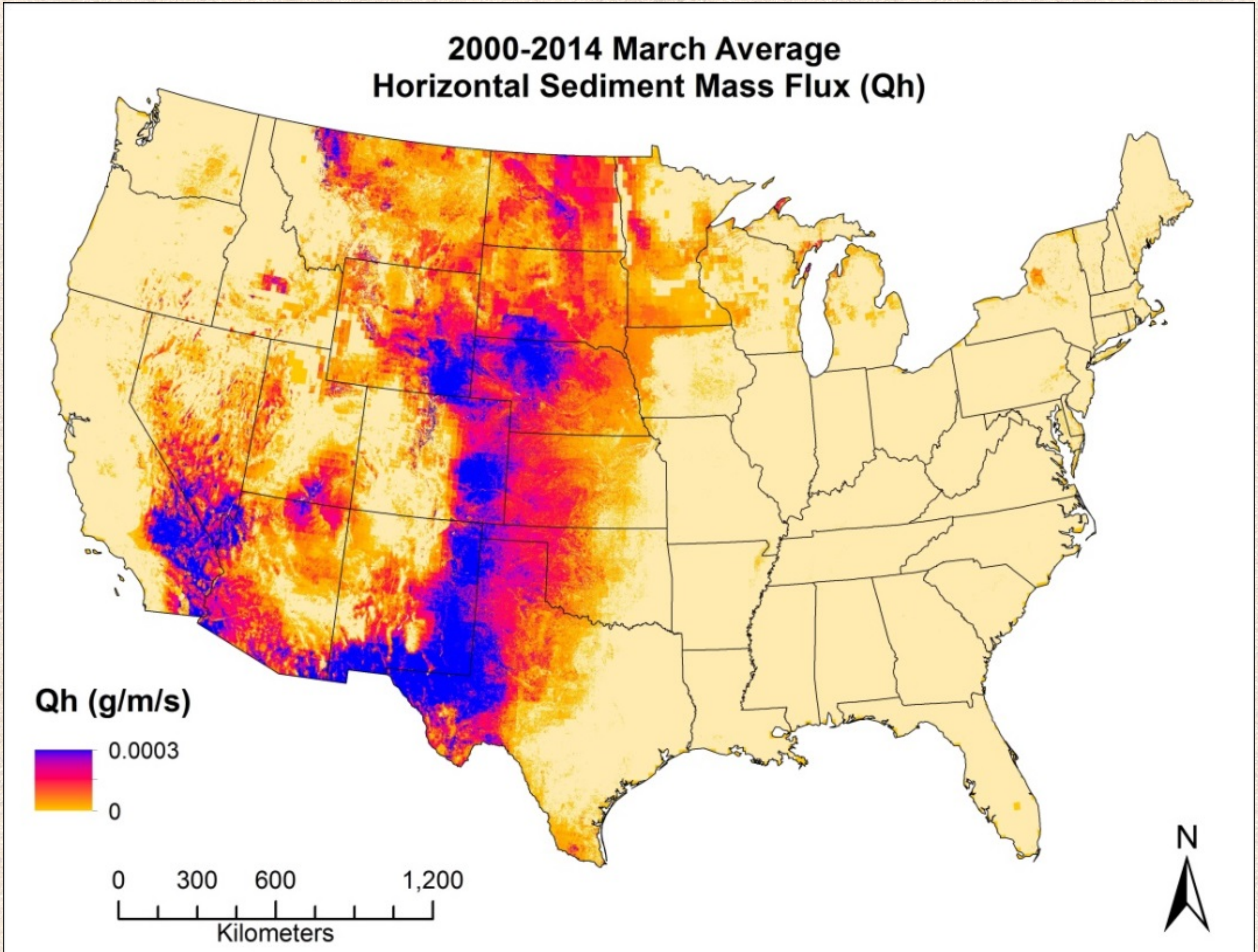
Accepted 29 September 2016

A B S T R A C T

Wind erosion and dust emission models are used to assess the impacts of dust on radiative forcing in the atmosphere, cloud formation, nutrient fertilisation and human health. The models are underpinned by a two-dimensional geometric property (lateral cover; L) used to characterise the three-dimensional aerodynamic roughness (sheltered area or wakes) of the Earth's surface and calibrate the momentum it extracts from the wind. We reveal a fundamental weakness in L and demonstrate that values are an order of magnitude too small and significant aerodynamic interactions between roughness elements and their sheltered areas have been omitted, particularly under sparse surface roughness. We describe a solution which develops published work to establish a relation between sheltered area and the proportion of shadow over a given area; the inverse of direct beam directional hemispherical reflectance (black sky albedo; BSA). We show direct relations between shadow and wind tunnel measurements and thereby provide direct calibrations of key aerodynamic properties. Estimation of the aerodynamic parameters from albedo enables wind erosion assessments over areas, across platforms from the field to airborne and readily available satellite data. Our new approach demonstrated redundancy in existing wind erosion models and thereby reduced model complexity and improved fidelity. We found that the use of albedo enabled an adequate description of aerodynamic sheltering to characterise fluid dynamics and predict sediment transport without the use of a drag partition scheme (R_t) or threshold friction velocity (u_{*t}). We applied the calibrations to produce global maps of aerodynamic properties which showed very similar spatial patterns to each other and confirmed the redundancy in the traditional parameters of wind erosion modelling. We evaluated temporal patterns of predicted horizontal mass flux at locations across Australia which revealed variation between land cover types that would not be detected using traditional models. Our new approach provided new opportunities to investigate the dynamics of wind erosion in space and time and elucidate aeolian processes across scales.


2000-2014 March Average
Horizontal Sediment Mass Flux (Qh)
Qh (g/m/s)
0.0003
0
0
300
600
1,200
Kilometers
N

IMPROVE
Interagency Monitoring of Protected Visual Environments
UCDAVIS
UNIVERSITY OF CALIFORNIA
BALA
MAKA
NOCA
OLYM
PASA
PUSO
SNPA
MORA
WHPA
CORI
MOHO
THSI
STAR
HECA
KALM
CRLA
REDW
LABE
TRIN
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GLAC
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MONT
GAMO
SULA
ULBE
FOPE
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LOST
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IMPROVE Sites
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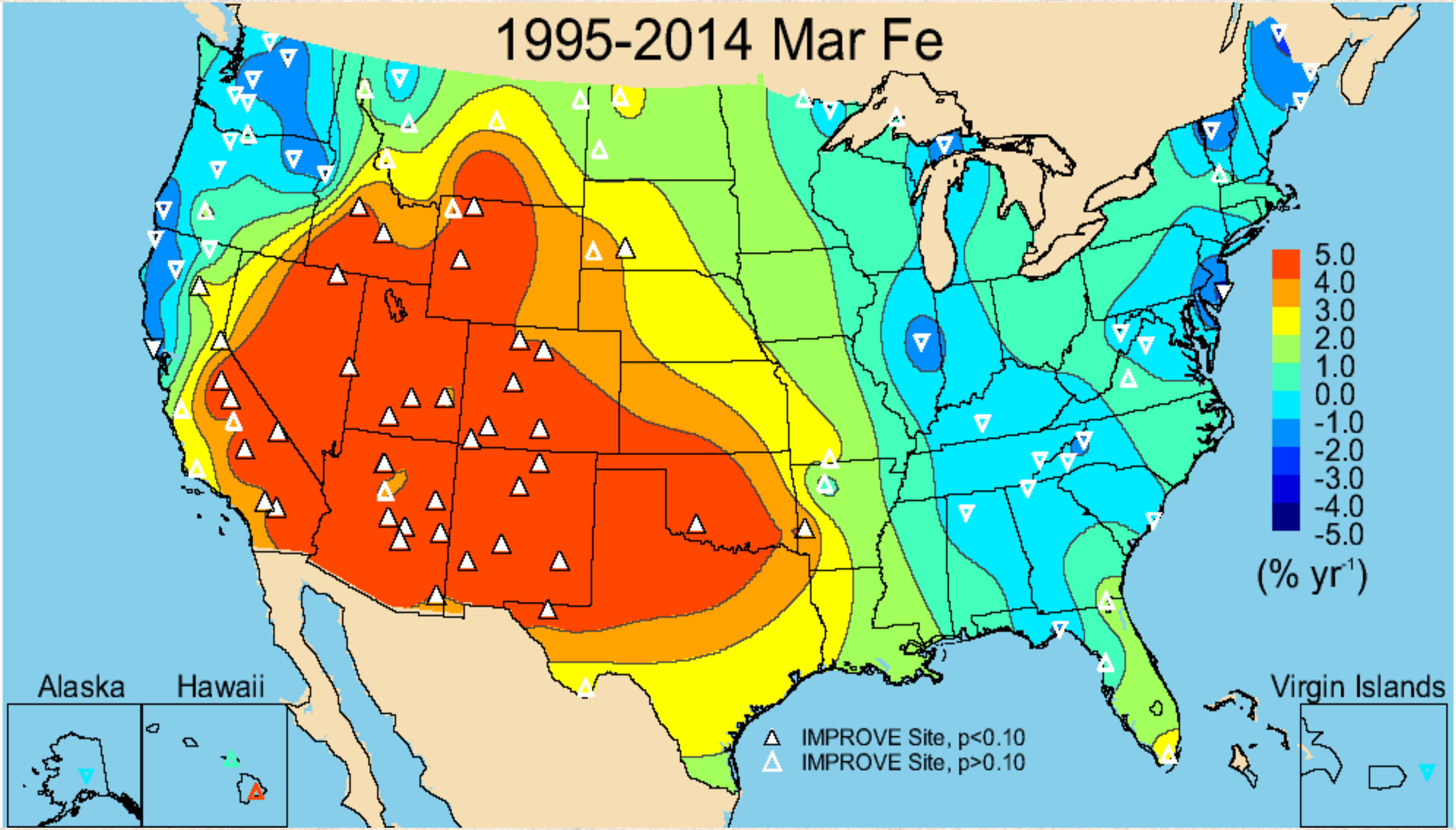
Effective 8/20/2014



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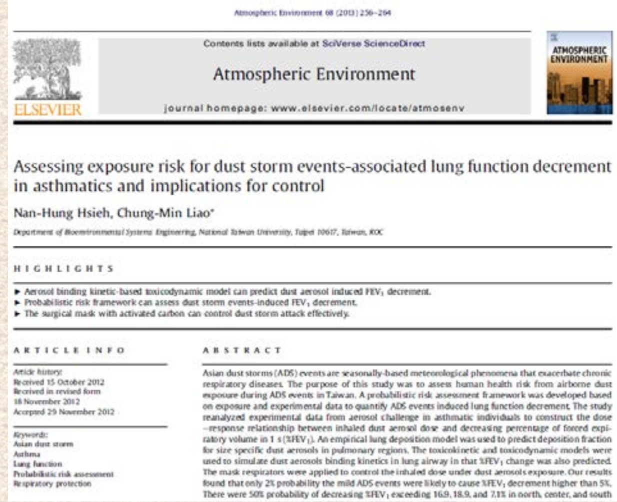
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
(% yr-1)
Alaska
Hawaii
Virgin Islands
IMPROVE Site, p<0.10
IMPROVE Site, p>0.10


Int J Biometeorol (2013) 57:1–19
DOI 10.1007/s00484-012-0541-y

REVIEW

Desert dust impacts on human health: an alarming worldwide reality and a need for studies in West Africa

Florence de Longueville · Pierre Ozer · Seydou Doumbia · Sabine Henry


Atmospheric Environment 68 (2013) 256–264

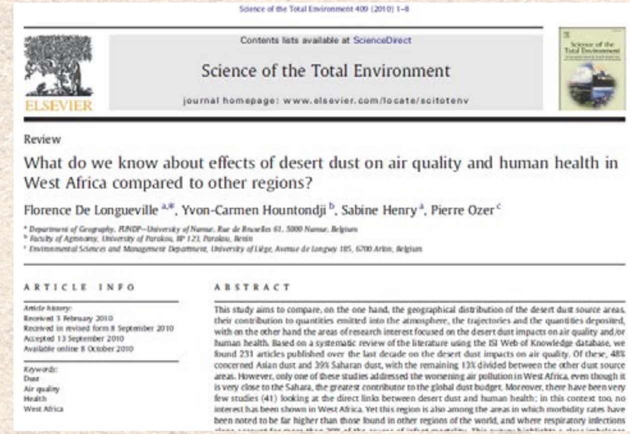
Contents lists available at SciVerse ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Assessing exposure risk for dust storm events-associated lung function decrement in asthmatics and implications for control

Nan-Hung Hsieh, Chung-Min Liao*


Science of the Total Environment 409 (2010) 1–8

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Review

What do we know about effects of desert dust on air quality and human health in West Africa compared to other regions?

Florence De Longueville [a,*], Yvon-Carmen Hountondji [b], Sabine Henry [a], Pierre Ozer [c]


Environment International 63 (2014) 101–113

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Review

Desert dust and human health disorders

Andrew S. Goudie

School of Geography and the Environment, University of Oxford, South Parks Road, Oxford OX1 3QY, United Kingdom


Environment International 47 (2012) 107–114

Contents lists available at SciVerse ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Review

Health effects from Sahara dust episodes in Europe: Literature review and research gaps

A. Karanasiou [a,*], N. Moreno [a], T. Moreno [a], M. Viana [a], F. de Leeuw [b], X. Querol [a]


Environ Geochem Health (2008) 30:339–343
DOI 10.1007/s10653-008-9162-0

ORIGINAL PAPER

Saharan dust clouds and human health in the English-speaking Caribbean: what we know and don't know

Michele A. Monteil

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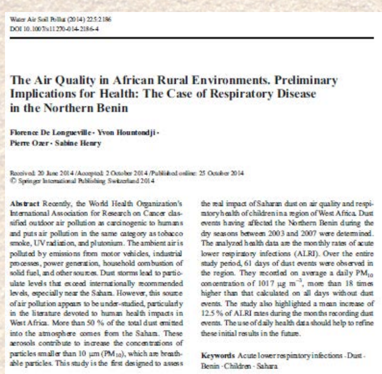
© Springer Science+Business Media B.V. 2008


Water Air Soil Pollut (2014) 225:2186
DOI 10.1007/s11270-014-2186-4

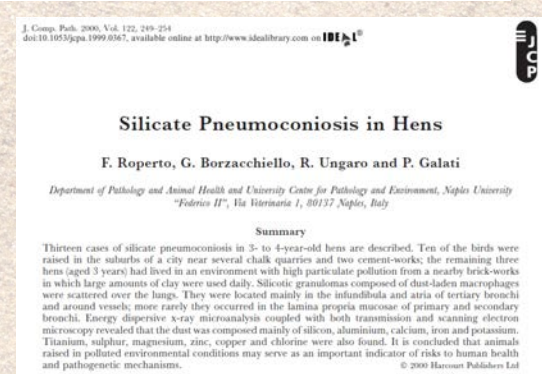
The Air Quality in African Rural Environments. Preliminary Implications for Health: The Case of Respiratory Disease in the Northern Benin

Florence De Longueville · Yvon Hountondji · Pierre Ozer · Sabine Henry


Human and Ecological Risk Assessment, 19: 1595–1617, 2013

ENVIRONMENTAL FATE ARTICLES

Saharan Dust Impacts on Air Quality: What Are the Potential Health Risks in West Africa?


J. Comp. Path. 2000, Vol. 122, 249–254

Silicate Pneumoconiosis in Hens

F. Roperto, G. Borzacchiello, R. Ungaro and P. Galati


Biodivers Conserv (2014) 23:1659–1667
DOI 10.1007/s10531-014-0690-x

ORIGINAL PAPER

Disturbance to desert soil ecosystems contributes to dust-mediated impacts at regional scales

Stephen B. Pointing · Jayne Belnap


Pediatr Infect Dis J, 2000;19:1189–96
Vol. 19, No. 12

Nontyphoidal *Salmonella* infections of children in tropical Africa

STEPHEN M. GRAHAM, FRACP, ELIZABETH M. MOLYNEUX, FRCP, AMANDA L. WALSH, MIBIOL, JOHN S. CHEESBROUGH, MRCPATH,* MALCOLM E. MOLYNEUX, FRCP AND C. ANTHONY HART, FRCPATH

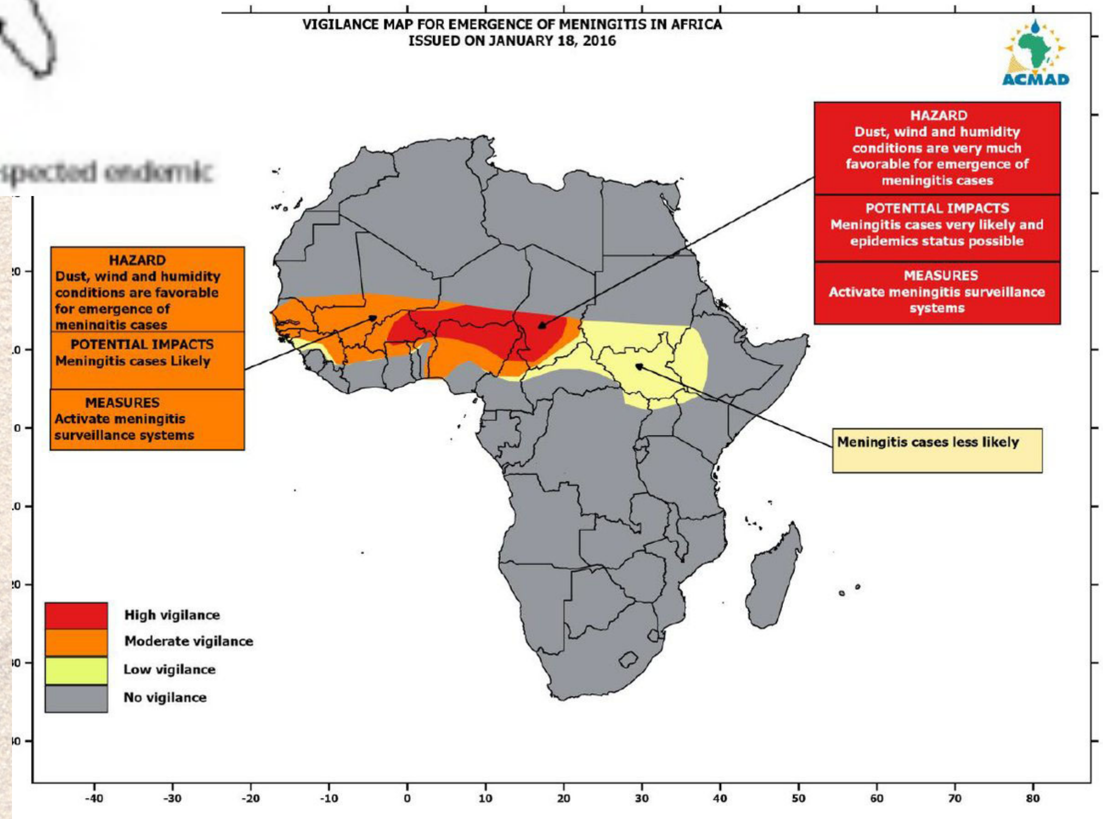
"I believe that as soon as haemoculture takes its lawful place in the routine diagnosis, not only of enteric tropical fevers, but also of quinine-resistant fevers of short duration, and that heterogeneous rubbish heap known as P.U.O., paratyphoid C will come to the fore as a frequent and widespread disease, calling for the same general preventive measures currently required for the other better known fevers of the enteric-parenteric group."

George Giglioli[68]

Extraintestinal infections caused by *Salmonella* spp. are a common cause of morbidity and mortality among

CLINICAL CONTEXT

In developed countries NTS is a recognized cause of acute gastroenteritis but extraintestinal infection is regarded as uncommon. However, NTS was consistently the most common cause of pediatric bacteremia and septicemia in studies from tropical Africa.[1–6] A study of community-acquired bacteremia in Rwanda isolated pathogens from 12% of 900 consecutive febrile (temperature >39°C) children attending an outpatient clinic.[2] *Salmonella typhi* predominated among children older than 5 years. *Salmonella enterica* serovar enter-



Vigilance map for emergence of meningitis in Africa

Summary

Summary

- USDA-ARS is a leader in wind erosion models for croplands

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- Rangelands present unique challenges to wind erosion model development

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- USDA-ARS is a leader in wind erosion models for croplands
- Rangelands present unique challenges to wind erosion model development
- Currently, USDA-ARS is developing a wind erosion model for rangelands using NWERN data and MODIS images (albedo).

Summary

- USDA-ARS is a leader in wind erosion models for croplands
- Rangelands present unique challenges to wind erosion model development
- Currently, USDA-ARS is developing a wind erosion model for rangelands using NWERN data and MODIS images (albedo).
- **We expect positive impacts to human and environmental health through improved land management decisions and early warning of potential severe dust storms.**

Questions?