Wind and Water Sediment Transport Under Climate Extremes and Land Management Practices

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Soil Erosion: Ecological Implications
Soil Erosion: Ecological Implications

Soil Erosion

Ecological Implications
- Soil Productivity
- Nutrient Loss & Redistribution
Soil Erosion: Ecological Implications

- Soil Productivity
- Nutrient Loss & Redistribution
- Litter Decomposition
- Soil Biota
Soil Erosion: Ecological Implications

Soil Erosion

Ecological Implications
- Soil Productivity
- Nutrient Loss & Redistribution
- Litter Decomposition
- Soil Biota
- Desertification
- Vegetation Change

Grassland ➔ Desert ➔ Shrubland
Soil Erosion: Wind & Water Components

The Ecology of Dust

Field et al. (2010) Frontiers Eco & Environ
Soil Erosion: Wind & Water Components

Towering mesas of sandstone formed by wind and water erosion.
NRCS Photo NRCSAZ86001

Monument Valley, AZ
Soil Erosion: Wind & Water Components

Water-driven Transport → Total Soil Erosion → Wind-driven Transport

Vegetation Dynamics

Monument Valley, AZ

Towering mesas of sandstone formed by wind and water erosion.
NRCS Photo NRCSAZ86001
Soil Erosion: Wind & Water Components

San Joaquin Valley, CA

60 cm of soil loss in a single wind event in San Joaquin Valley (Wilshire et al. 1981)
Soil Erosion: Climate Extremes

Climatic Conditions
(Wet / Dry Extremes)

Water-driven Transport

Total Soil Erosion

Wind-driven Transport

Vegetation Dynamics

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60 cm of soil loss in a single wind event in San Joaquin Valley (Wilshire et al. 1981)
Soil Erosion: Climate Extremes

Climatic Conditions
(Wet / Dry Extremes)

Water-driven Transport

Wind-driven Transport

Total Soil Erosion

Vegetation Dynamics
Soil Erosion: Land Management Practices

Climatic Conditions (Wet / Dry Extremes)

Water-driven Transport

Total Soil Erosion

Wind-driven Transport

Vegetation Dynamics (Land Management Practices)
Wind-driven Transport

Climatic Conditions
(Wet / Dry Extremes)

Water-driven Transport → Total Soil Erosion → Wind-driven Transport

Vegetation Dynamics
Climate Extremes

Climatic Conditions
(Wet / Dry Extremes)

Water-driven Transport

Wind-driven Transport

Total Soil Erosion

Vegetation Dynamics
(Land Management Practices)
Land Management Practices

Climatic Conditions
(Wet / Dry Extremes)

Water-driven
Transport

Wind-driven
Transport

Total Soil
Erosion

Land Management Practices
Wind-driven Sediment Transport

Climatic Conditions
(Wet / Dry Extremes)

Water-driven Transport

Total Soil Erosion

Wind-driven Transport

Vegetation Dynamics
Wind-driven Sediment Transport

Climatic Conditions
(Wet / Dry Extremes)

Water-driven Transport

Total Soil Erosion

Wind-driven Transport

Herbaceous

Bare

Shrub
Water-driven Transport

Wind-driven Transport

Total Soil Erosion

Climatic Conditions (Wet / Dry Extremes)

Herbaceous

Bare

Shrub
Wind-driven Sediment Transport

Climatic Conditions
(Wet / Dry Extremes)

Water-driven Transport

Total Soil Erosion

Wind-driven Transport

Herbaceous

Bare

Shrub

Herbaceous
Wind-driven Sediment Transport
Wind-driven Sediment Transport
Shrub-Dominated Patch

Wind Direction

Horizontal Dust Flux
IN

Horizontal Dust Flux
OUT

BSNE Height

1.00 m

0.50 m

0.25 m

0.08 m
Bare Patch (<10% cover)

Horizontal Dust Flux
IN

Wind Direction

Horizontal Dust Flux
OUT

BSNE Height
1.00 m
0.50 m
0.25 m
0.08 m
Wind-driven Sediment Transport

- Capture / Production Efficiency (%)
  - Ambient
  - Bare
  - Grass
  - Shrub

- Patch Type
- Capture
- Production
Effects of Disturbance

Climatic Conditions (Wet / Dry Extremes)

Water-driven Transport → Total Soil Erosion → Wind-driven Transport → Total Soil Erosion

Herbaceous (Land Management Practices) → Bare → Shrub → Bare → Herbaceous

Herbaceous
Bare
Shrub
Shrub
Effects of Disturbance

![Graph showing effects of disturbance on patch types]

- **Undisturbed**
  - Bare
  - Grass
  - Shrub

- **Capture**
  - Production
Effects of Disturbance

![Bar chart showing the effects of disturbance on capture and production efficiency for different patch types.](chart.png)
Effects of Disturbance

Capture / Production Efficiency (%)

<table>
<thead>
<tr>
<th>Disturbed Patch Type</th>
<th>Undisturbed Patch Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare</td>
<td>Bare</td>
</tr>
<tr>
<td>Grass</td>
<td>Grass</td>
</tr>
<tr>
<td>Woody</td>
<td>Woody</td>
</tr>
</tbody>
</table>

Effects of Disturbance:
- Disturbance significantly affects capture and production efficiency across different patch types.
- Bare patches show a decrease in efficiency, especially in disturbed conditions.
- Grass patches show a higher efficiency in undisturbed conditions compared to disturbed ones.

Graphical representation shows the comparison of capture and production efficiencies between disturbed and undisturbed patches for different types (Bare, Grass, Woody).
Wind-driven Sediment Transport

Climatic Conditions
(Wet / Dry Extremes)

Water-driven Transport ➔ Total Soil Erosion ➔ Wind-driven Transport

Vegetation Dynamics
Climate Extremes

Climatic Conditions
(Wet / Dry Extremes)

Water-driven Transport

Wind-driven Transport

Total Soil Erosion

Vegetation Dynamics
(Land Management Practices)
Climate Extremes

Climatic Conditions
(Wet / Dry Extremes)

Water-driven Transport -- Total Soil Erosion -- Wind-driven Transport

Vegetation Dynamics
(Land Management Practices)

Field et al. (2009) Aeolian Research

Increasing Sediment Transport Capacity

Mean Annual Precipitation (mm)

Arid | Semi-arid | Sub-humid | Humid

Aeolian Dominance

0 250 500 750 1000 1250 1500
Climate Extremes

Climatic Conditions
(Wet / Dry Extremes)

Water-driven Transport → Total Soil Erosion

Wind-driven Transport

Vegetation Dynamics
(Land Management Practices)

Increasing Sediment Transport Capacity

Mean Annual Precipitation (mm)

Arid Semiarid Sub-humid Humid

0 250 500 750 1000 1250 1500

Aeolian Dominance

Fluvial Dominance

Field et al. (2009) Aeolian Research
Climate Extremes

Climatic Conditions
(Wet / Dry Extremes)

Water-driven Transport

Total Soil Erosion

Wind-driven Transport

Vegetation Dynamics
(Land Management Practices)

Increasing Sediment Transport Capacity

Mean Annual Precipitation (mm)

0 250 500 750 1000 1250 1500

Arid
Semiarid
Sub-humid
Humid

Aeolian Dominance
Fluvial Dominance
Aeolian-Fluvial Interactions

Field et al. (2009) Aeolian Research

Vegetation Dynamics
(Land Management Practices)
Climate Extremes

Climatic Conditions
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Vegetation Dynamics
(Land Management Practices)

Increasing Sediment Transport Capacity

Mean Annual Precipitation (mm)

Arid
Semiarid
Sub-humid
Humid

Aeolian Dominance
Fluvial Dominance
Aeolian-Fluvial Interactions

SRER Study Site

Field et al. (2009) Aeolian Research
3 study plots (50 x 50 m)

Each plot contained:

- Six self-orienting dust samplers
- A pair of sediment check dams (bordered 3 x 10 m and non-bordered)
3 study plots (50 x 50 m)

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3 study plots (50 x 50 m)

Each plot contained:

- Six self-orienting dust samplers
- A pair of sediment check dams (bordered 3 x 10 m and non-bordered)

Sediment collection:

- Sample collection every 7 – 14 days
- Sediment oven-dried at 60°C
Climate Extremes

Cumulative precipitation (mm)

Baseline

Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul
Climate Extremes

Cumulative precipitation (mm)

- Wet/Dry Extremes
- Baseline

July, August, September, October, November, December, January, February, March, April, May, June, July
Climate Extremes

- 5th Wettest August (114 mm)
Climate Extremes

- Wettest August (114 mm)
- Driest 9 Months (< 20 mm)
Water-driven Transport: Climate Extremes
Wind-driven Transport: Climate Extremes

- Wet/Dry Extremes
- Baseline

Wind-driven transport (g m$^{-1}$ d$^{-1}$)

Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul
Climate Extremes

Field et al. (2011) J Soil & Water Conservation
Climate Extremes

Climatic Conditions
(Wet / Dry Extremes)

Water-driven Transport

Total Soil Erosion

Wind-driven Transport

Vegetation Dynamics
(Land Management Practices)
Land Management Practices

Climatic Conditions
(Wet / Dry Extremes)

Water-driven Transport → Total Soil Erosion → Wind-driven Transport

Land Management Practices
12 study plots (50 x 50 m)

Four treatments:
1. Control
2. Livestock Grazing
3. Prescribed Fire
4. Livestock Grazing + Fire
Land Management Practices

Water-driven Transport

Year 1

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Water-driven Transport (g m^{-1} d^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burn+Graze</td>
<td>a</td>
</tr>
<tr>
<td>Burn</td>
<td>a</td>
</tr>
<tr>
<td>Graze</td>
<td>b</td>
</tr>
<tr>
<td>Control</td>
<td>b</td>
</tr>
</tbody>
</table>

Note: The graph shows the comparison of water-driven transport for different treatments in Year 1.
Land Management Practices

**Water-driven Transport**

**Wind-driven Transport**

Field et al. (2011) Ecological Applications
Land Management Practices

Water-driven Transport

Wind-driven Transport

Field et al. (2011) Ecological Applications
Land Management Practices

Water-driven Transport

Wind-driven Transport

Field et al. (2011) Ecological Applications
Summary: Wind-driven Transport

Climatic Conditions
(Wet / Dry Extremes)

Water-driven Transport

Total Soil Erosion

Wind-driven Transport

Vegetation Dynamics
(Land Management Practices)
Summary: Climate Extremes

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Water-driven Transport

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Total Soil Erosion

Vegetation Dynamics
(Land Management Practices)
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Climatic Conditions
(Wet / Dry Extremes)

Total Soil Erosion

Water-driven Transport

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Vegetation Dynamics
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