LARGE ROUGHNESS ELEMENT EFFECTS ON SAND TRANSPORT, OCEANO DUNES, CALIFORNIA

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BACKGROUND

- Roughness elements are known to modulate sand transport by wind
- Very sparse roughness can increase erosion
- At a critical roughness density ($\lambda = (n b h)/S$) of 0.012 roughness begins to suppress sand transport due to shear stress partitioning effects
- As $\lambda$ increases, sand transport decreases
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When the roughness elements are tall, transport efficiency is reduced to a much greater extent.
Purpose

- Present data from a study of sand transport by wind across a coastal sand sheet area that was modified by roughness

Bale dimensions: 1.17 m long × 0.4 m high × 0.6 m wide

Area = 5000 m²

Roughness configuration to achieve target 50% reduction:

\[ NSF = 0.0004 \lambda^{-1.871} \]

(Gillies et al., 2006)

NSF = 0.5, requires \( \lambda = 0.022 \) (%cover = 3)

Number bales = 210

Centre – Centre Distance = 4.9 m

Row to Row Distance = 4.9 m
Sand trap and bale rows

A
1
3
5
7
9
11
13
15
17
19

B

C

D

E

F

300° magnetic

C - Cox Sand Catcher
B - BSNE trap
S - Sensit
A - Anemometer mast
RESULTS

Wind Speed

- Wind Speed (m/sec)
- 4/12/2011 0:00 - 5/7/2011 0:00
### RESULTS

#### Sand Flux

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Period</th>
<th>NSF Near Downwind Edge</th>
</tr>
</thead>
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<tr>
<td></td>
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<td>End</td>
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<td>18:00</td>
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<tr>
<td>1-May</td>
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<tr>
<td>2-May</td>
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</tbody>
</table>
RESULTS

- Sand Flux Change with Downwind Distance

**CSC**

**BSNE**
The sand flux decreases with downwind distance.
The reduction in sand flux increases more rapidly with downwind distance as $\lambda$ increases.

The diagram shows the relationship with the equation $b = 0.019 \ln(\lambda) + 0.077$ for Jornada and $b = 0.018 \ln(\lambda) + 0.072$ for Oceano, with $R^2 = 0.97$ for Jornada and $R^2 = 0.95$ for Oceano.
As $\lambda$ increases, sand transport decreases

$\text{NSF} = 0.004 \lambda^{-1.878}$

$R^2 = 0.92$
For the same $\lambda$, sand transport can be decreased to a greater degree if the roughness is tall.
For the same $\lambda$, sand flux is reduced by 48% by using large roughness elements ($\sim 0.38$ m)
For the same $\lambda$, sand flux is reduced by 68% by using 1 m high roughness elements
CONCLUSIONS

- Sand transport scales with $\lambda$
- Element height has a demonstrable effect on sand transport efficiency and it is suggested here that the relationship is a power function between $h=0.1$ and $h=1$ m
- The height effect results from the increasing interaction of the element with the full range of saltation path lengths, with the vertical scale being more important than the horizontal scale
- Theory suggests that associated dust flux will decrease as the cube of the change in sand flux (will vary by individual site)
CONCLUSIONS

- The presented relationships offer a means to design better control measures for suppressing sand transport and associated dust emissions.
- These relationships can be used to set design criteria based on available resources and available resources.