Large Roughness Element Effects on Sand Transport, Oceano Dunes, California

J.A. Gillies[1], N. Lancaster[2], E. Furtak-Cole[1]

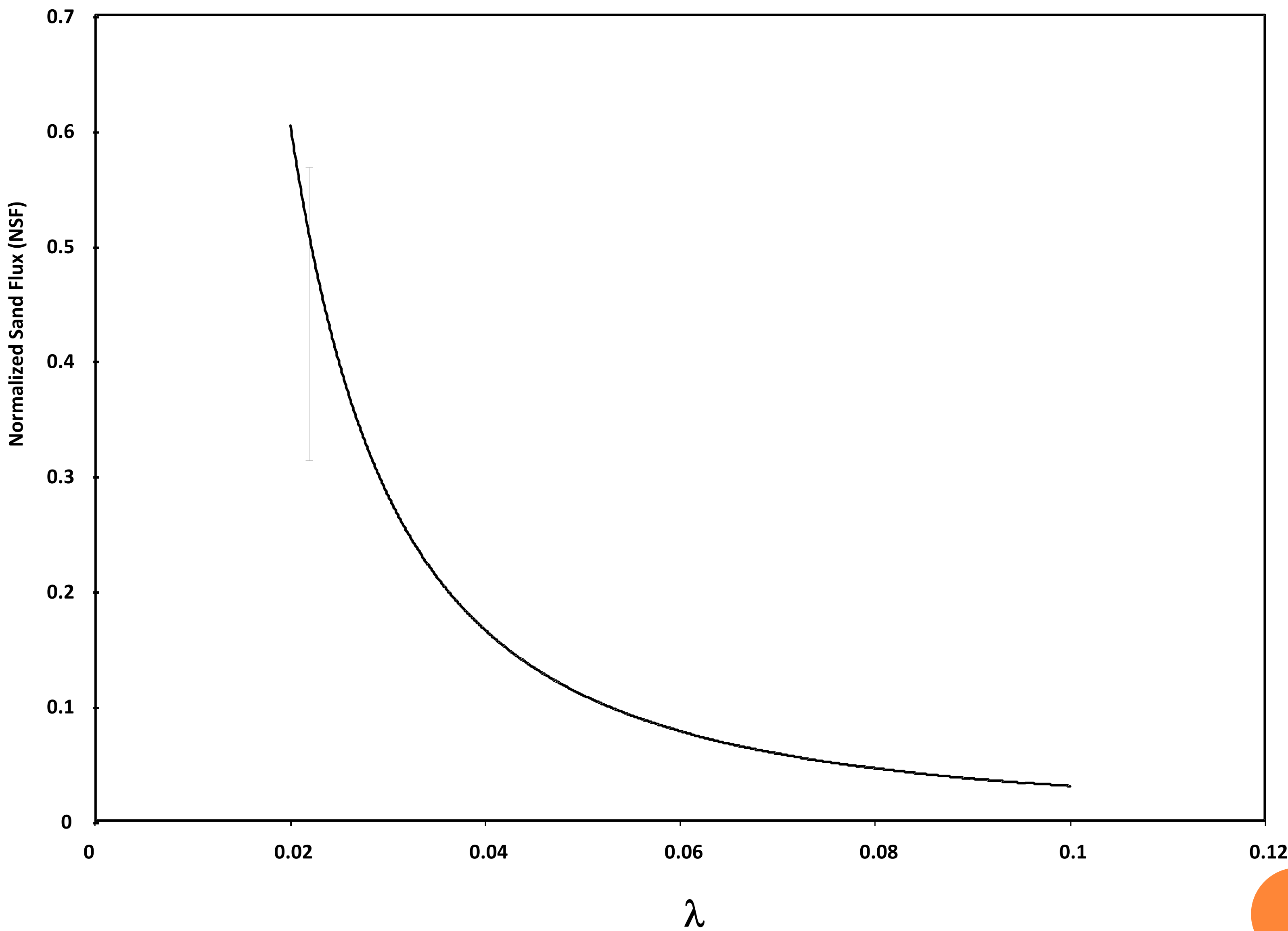
[1]*Division of Atmospheric Sciences*

[2]*Division of Earth and Ecosystems Sciences*

Desert Research Institute, Reno NV USA

BACKGROUND

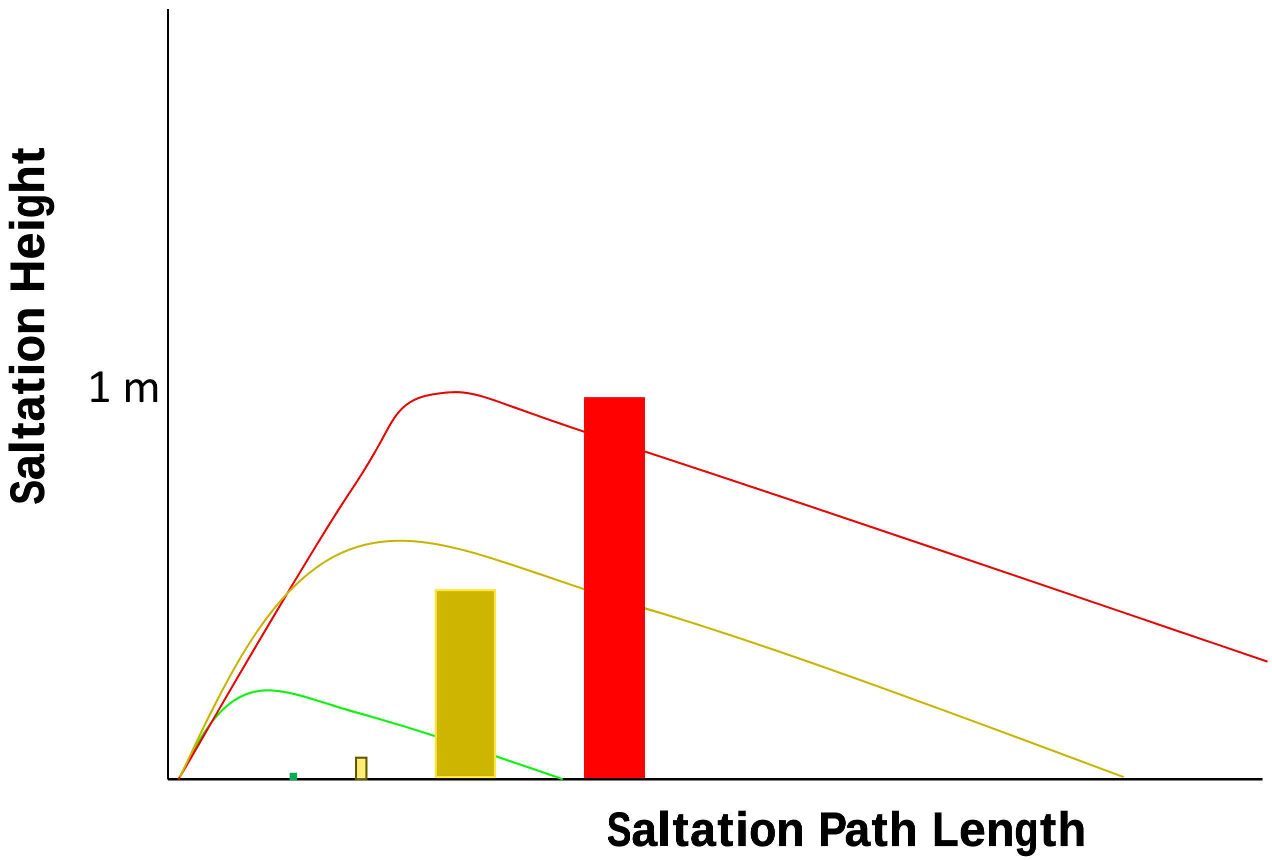
- Roughness elements are known to modulate sand transport by wind
- Very sparse roughness can increase erosion
- At a critical roughness density (λ=(n b h)/S) of 0.012 roughness begins to suppress sand transport due to shear stress partitioning effects
- As λ increases, sand transport decreases



As λ increases, sand transport decreases

BACKGROUND

- **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 m^2

Roughness configuration to achieve target 50% reduction:

$$NSF = 0.0004\ \lambda^{-1.871}$$

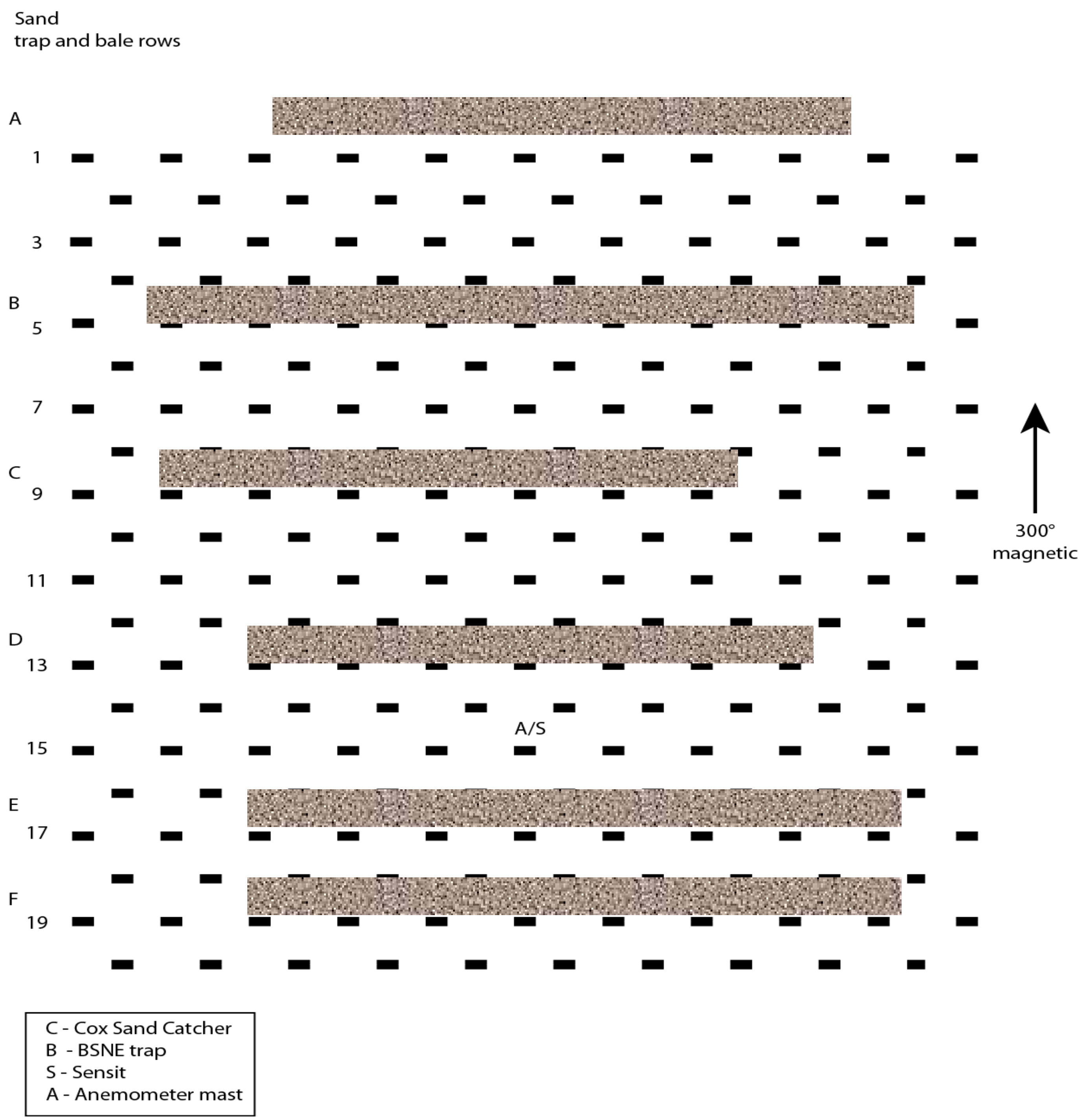
(Gillies et al., 2006)

NSF=0.5, requires λ = 0.022 (%cover = 3)

Number bales = 210

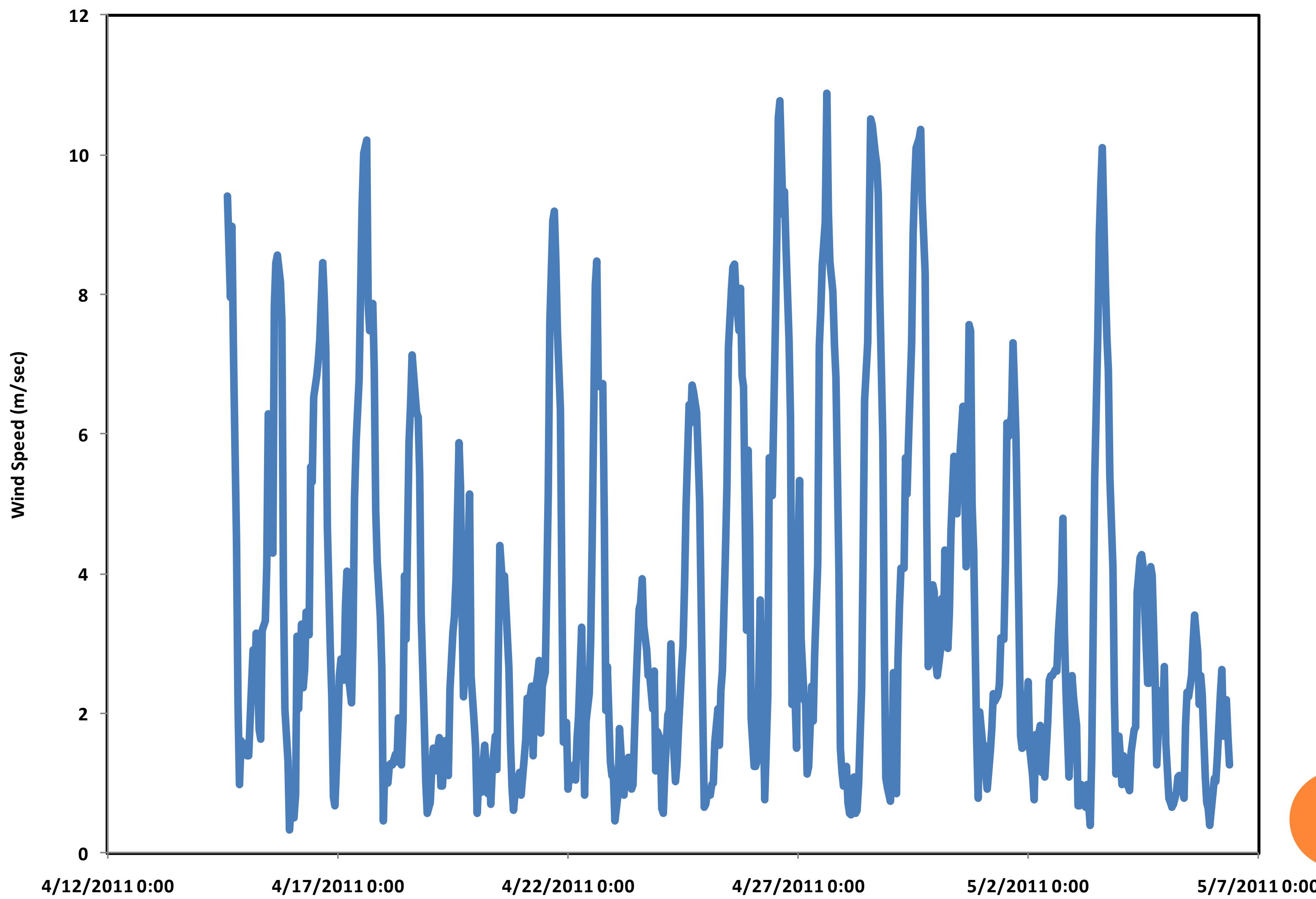
Centre – Centre Distance = 4.9 m

Row to Row Distance = 4.9 m


Sand
trap and bale rows
A
1
3
B
5
7
C
9
11
D
13
A/S
15
E
17
F
19
300°
magnetic
C - Cox Sand Catcher
B - BSNE trap
S - Sensit
A - Anemometer mast

RESULTS

- **Wind Speed**



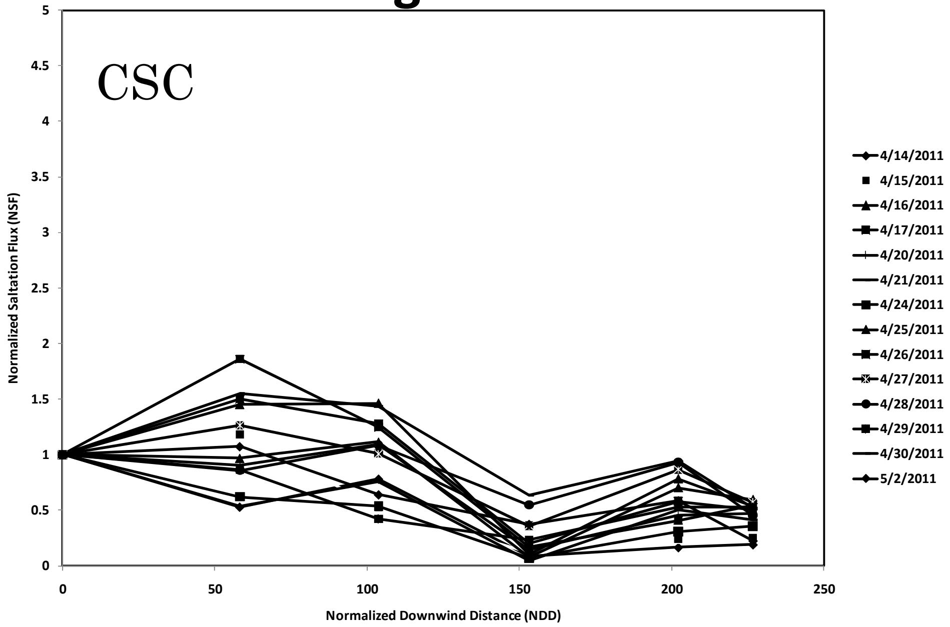
RESULTS

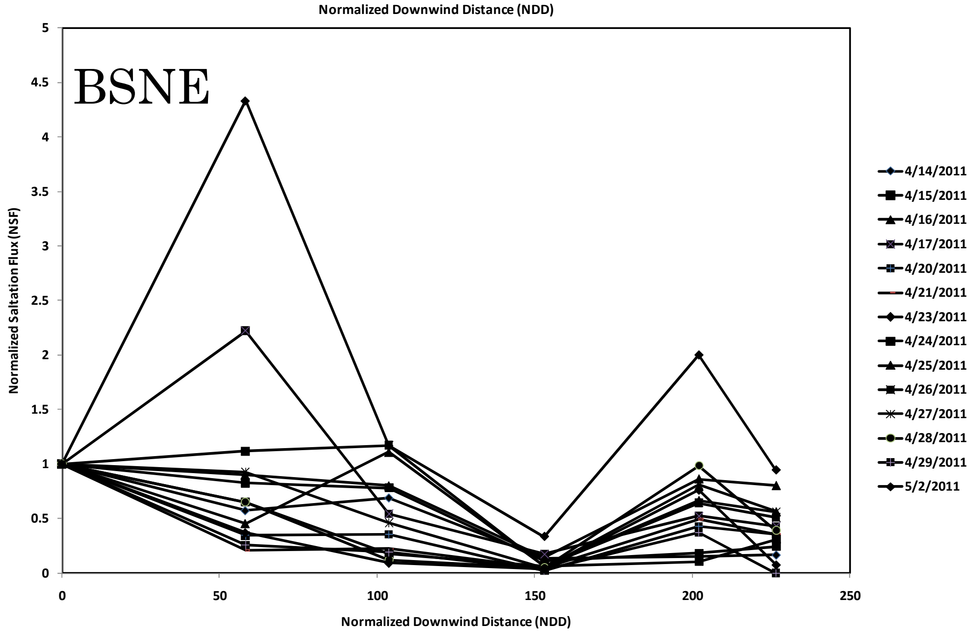
- Sand Flux

	Event Period				NSF Near Downwind Edge	
Date	Start	End	Duration	Avg. WS ($m\ s^{-1}$)	CSC	BSNE
15-Apr	12:35	18:00	5:25	6.90	0.19	0.16
16-Apr	9:55	17:25	7:30	6.91	0.25	0.24
17-Apr	8:35	17:50	9:15	7.42	0.54	0.80
18-Apr	11:45	16:20	4:35	5.88	0.55	0.43
21-Apr	13:00	18:30	5:30	7.26	0.47	0.36
22-Apr	12:10	16:30	4:20	6.25	0.41	0.35
24-Apr	12:55	18:25	5:30	6.86	N/A	0.94
25-Apr	9:50	18:30	8:40	7.20	0.36	0.31
26-Apr	10:05	18:40	8:35	8.27	0.60	0.56
27-Apr	9:00	18:45	9:45	7.58	0.51	0.51
28-Apr	9:15	18:35	9:20	7.97	0.57	0.56
29-Apr	8:10	17:00	8:50	8.25	0.45	0.39
30-Apr	10:15	16:55	6:40	5.63	0.53	0.00
1-May	13:20	16:25	3:05	6.43	0.52	N/A
2-May	9:55	16:55	7:00	7.50	0.22	0.07

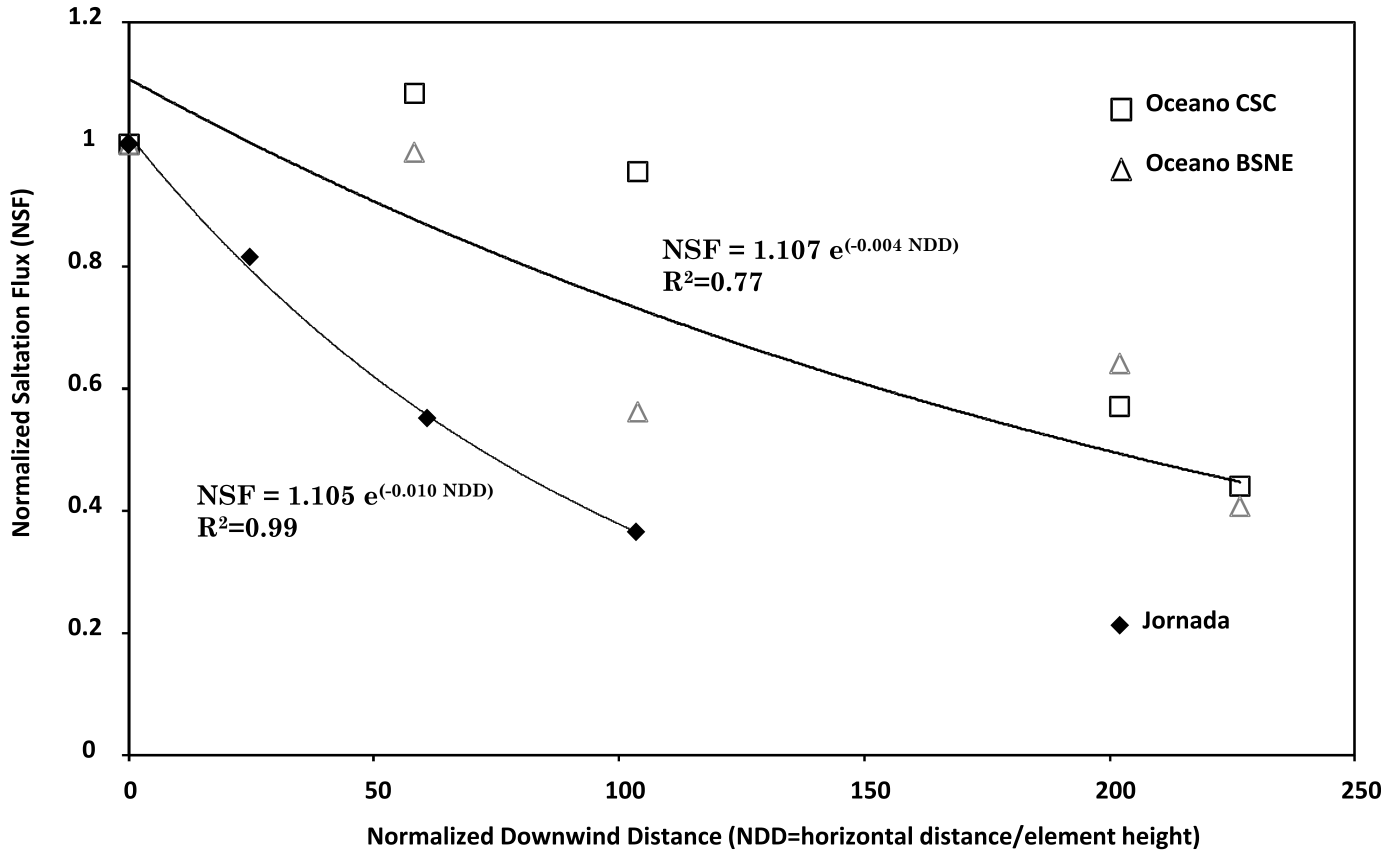
RESULTS

- **Sand Flux Change with Downwind Distance**

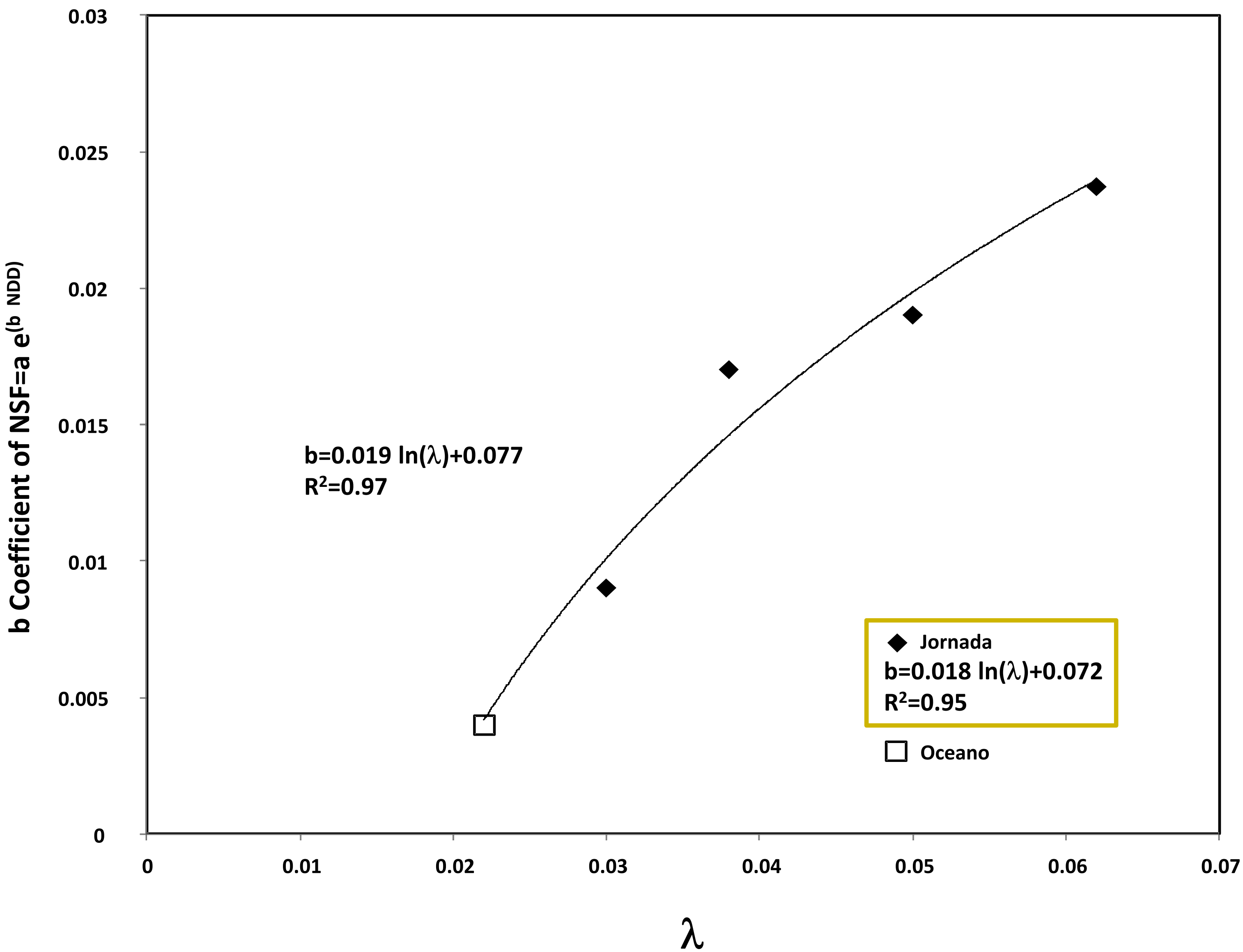




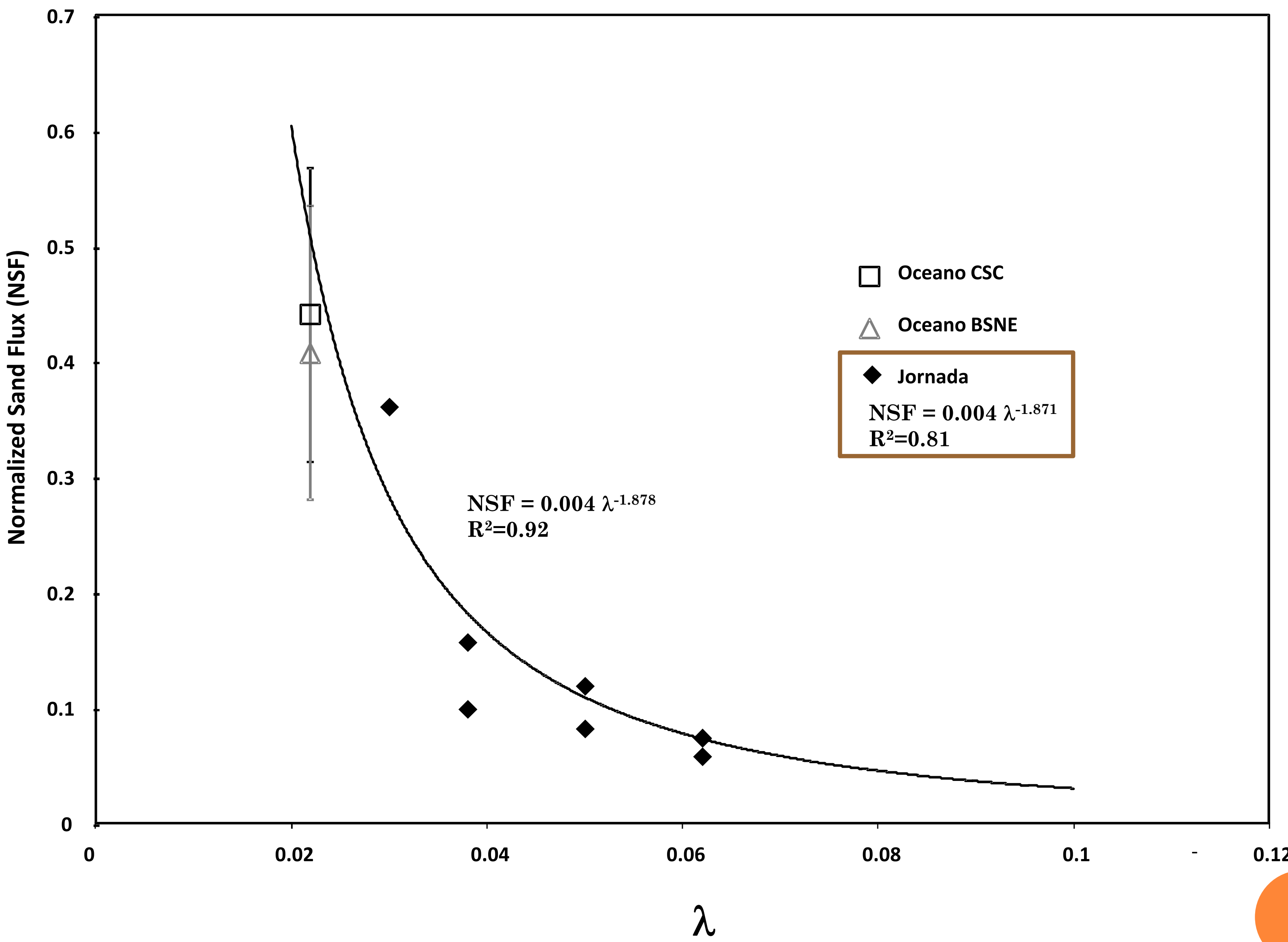
MEAN SALTATION REDUCTION WITH DOWNWIND DISTANCE



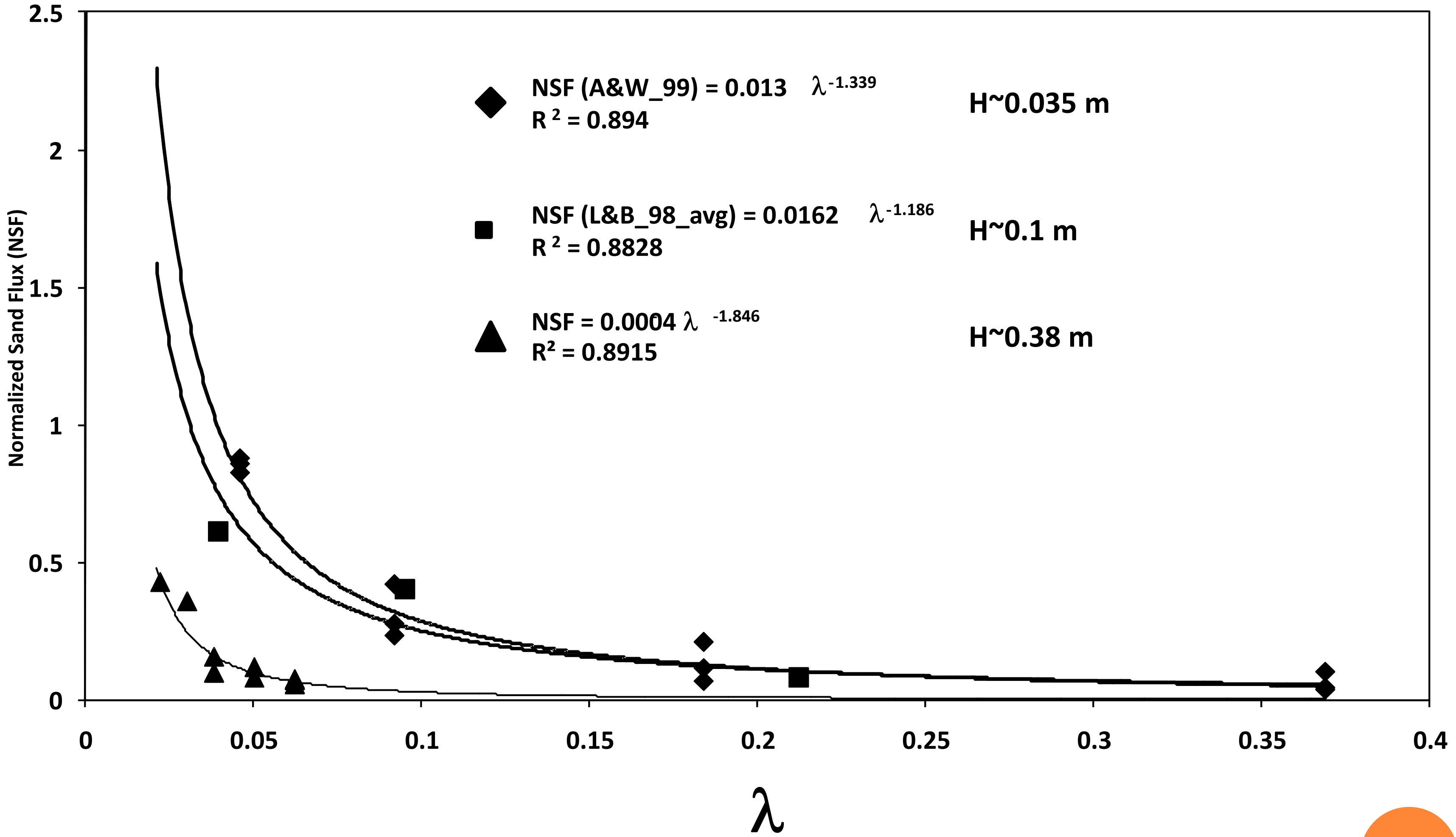
The sand flux decreases with downwind distance



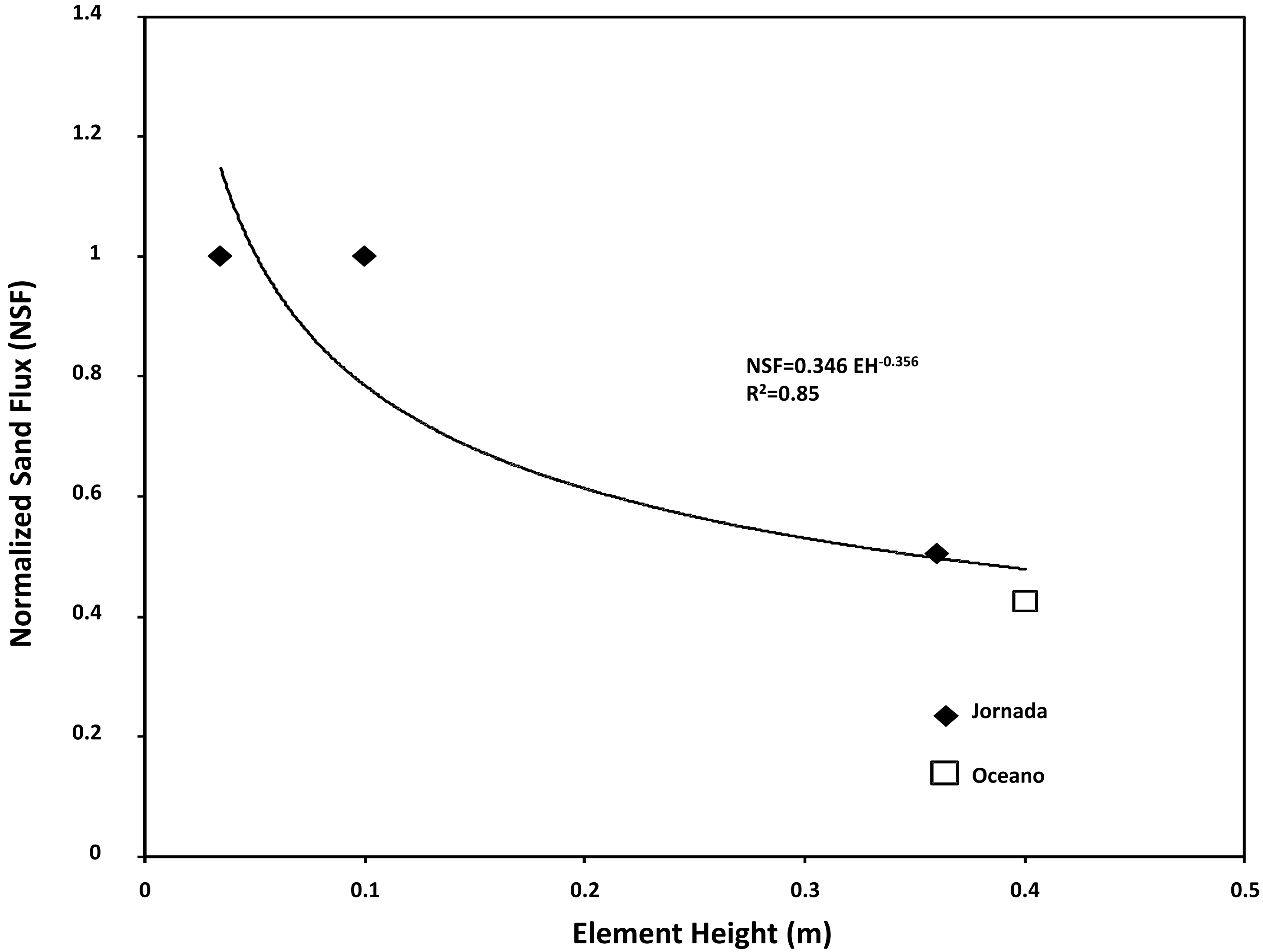
The reduction in sand flux increases more rapidly with downwind distance as λ increases



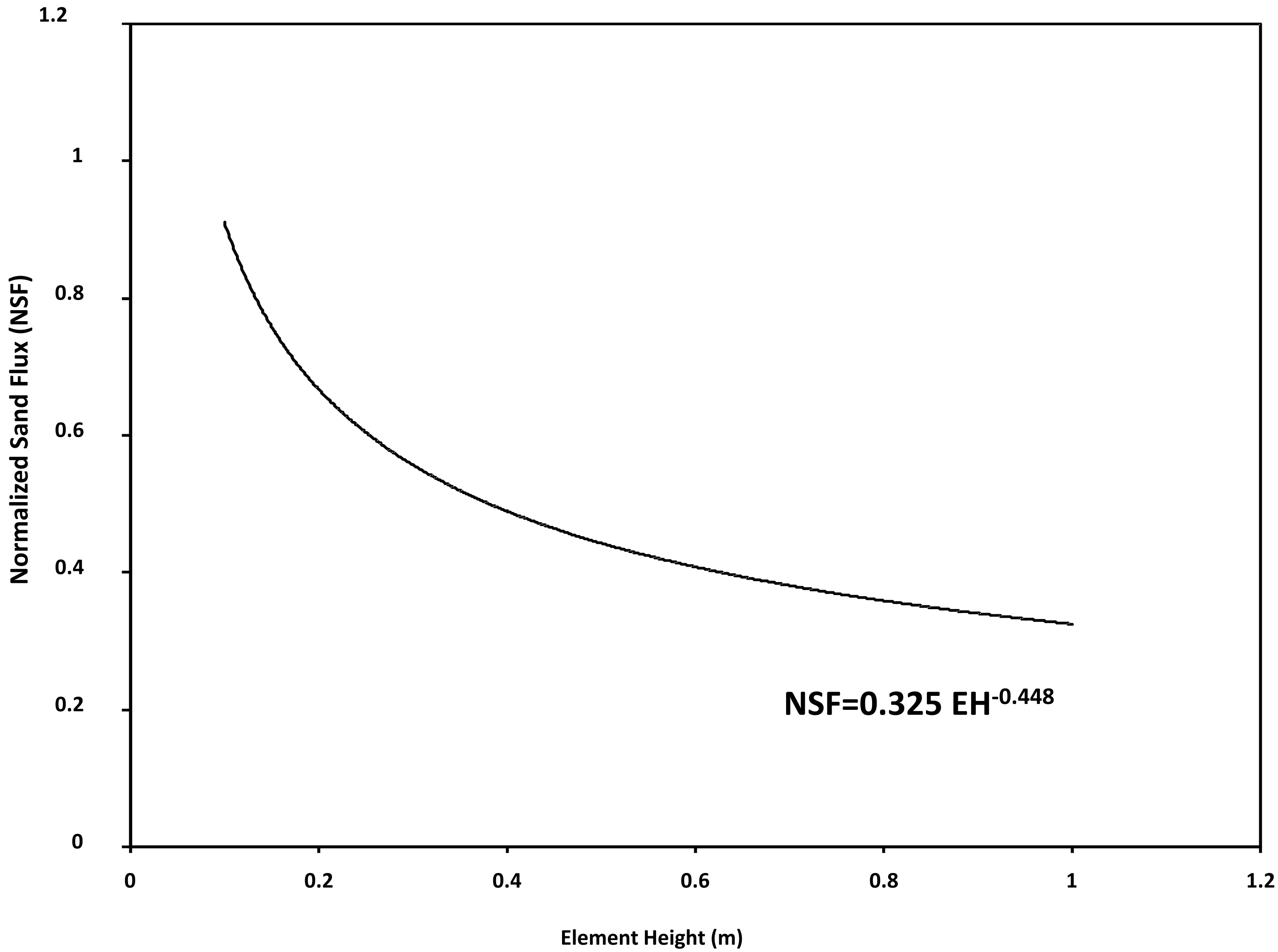
As λ increases, sand transport decreases



For the same λ, sand transport can be decreased to a greater degree if the roughness is tall



For the same λ, sand flux is reduced by 48% by using large roughness elements (~0.38 m)



For the same λ, sand flux is reduced by 68% by using 1 m high roughness elements

CONCLUSIONS

- Sand transport scales with λ
- 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**