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Does the Bruun Rule Work?

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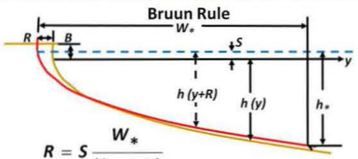
The Bruun Rule

The Bruun Rule (1962) provides a relationship between sea level rise and shoreline retreat, and has been widely applied by the engineering and scientific communities to interpret shoreline change and to design beach stabilization projects. The Bruun Rule assumes that all sand removed from the upper profile is deposited offshore as sea level rises.

However, attempts to verify the Bruun Rule based on field measurements have proven quantitatively inconclusive, in part due to the "noisiness" of the data. This, along with further examination of the processes associated with relative sea level rise (see also Dean and Maurmeyer 1983; Davidson-Arnott, 2005), has brought attention as to whether the Bruun Rule is based on a complete consideration of the underlying processes. Here we propose a modified form of the Bruun Rule that accounts for both landward (Aeolian and overwash transport) as well as seaward transport of sand.



$$R = S\frac{W_*}{(h_* + B)}$$

R = shoreline retreat
B = berm crest elevation
W_* = horizontal dimension of active profile
S = relative sea level rise
h = depth at any location along profile
h_* = depth of closure
y = cross-shore distance

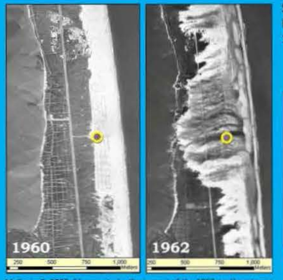
Bruun, P. 1962. "Sea-level rise as a cause of shore erosion," *Journal Waterways and Harbors Division*, vol. 88(1-3), 117-130.

Davidson-Arnott, R.G.D. 2005. "A conceptual model of the effects of sea level rise on sandy coasts," *Journal of Coastal Research*, 21(6), 1166-1172.

Dean, R.G., and Maurmeyer, E.M. 1983. Models for beach profile response." In: Komar, P.D. (ed).," Handbook of Coastal Processes and Erosion. Boca Raton, FL: CRC Press, 151-166.

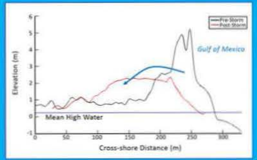
Contradictory Evidence to the Bruun Rule

Examples of Overwash Transport



South of Dewey Beach, DE Following "Ash Wednesday" 1962 Storm (from McCarty 2009)

McCarty, E. 2009. "A case study: the impact of the 1962 northeaster on Delaware's Atlantic Coast," MSc. Thesis, University of Delaware, 163 p.

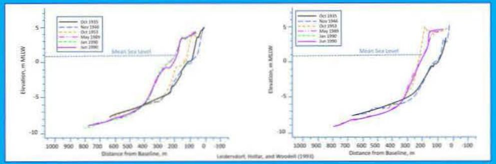


Dune cross-sections on Santa Rosa Island, FL prior to and after Hurricane Ivan (2004)

Examples of Profile Lowering Offshore

Santa Monica Beach, Station 366+33
Profile response over 55 years (includes beach nourishment)

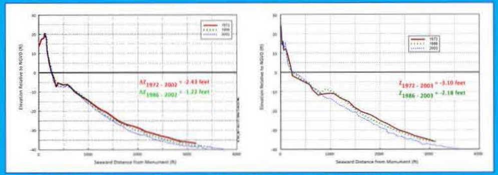
Venice Beach, Station 254+00
Profile response over 57 years (includes beach nourishment)



Leidersdorf, C.J., Hollar, R.C. and Woodell, G. 1993. "Beach Enhancement Through Nourishment and Compartmentalization: The Recent History of Santa Monica Bay," in: Beach Nourishment Engineering and Management Considerations, D.K. Stauble and N.C. Kraus, eds., *American Society of Civil Engineers*, pp. 71-85.

Monument R-192, Brevard County, FL

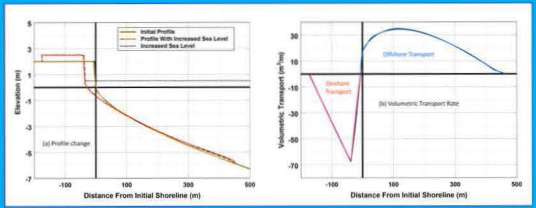
Monument R-60, St. Johns County, FL



Data from Florida Department of Environmental Protection, Bureau of Beaches and Coastal Systems, http://www.dep.state.fl.us/beaches/data/his-shore.htm

Modified Bruun Rule

The Modified Bruun Rule incorporates landward transport (due to Aeolian and overwash transport) and seaward transport as a function of relative sea level rise. Diminishing berm crest elevation as a function of rising sea level is incorporated, a morphologic change that is not usually considered in the Bruun Rule.



Example (a) profile change and (b) volumetric transport including overwash and seaward transport

Shoreline Recession:

$$\frac{dR}{dt} = \frac{W_*}{h_* + B(t)}\frac{dS}{dt} = \frac{W_*}{h_* + B_o - S}\frac{dS}{dt}$$

Solution to Shoreline Recession Equation:

$$R = W_*\, \ell n\left(\frac{h_* + B_o}{h_* + B_o - S}\right) \approx \Delta S\frac{W_*}{h_* + B_o}$$

With landward deposition of volume V_D:

$$R = (W_* + V_D / S)\, \ell n\left(\frac{h_* + B_o}{h_* + B_o - S}\right) \approx S\frac{W_* + V_D / S}{h_* + B_o}$$

For only landward transport, critical recession, R_{Crit} and associated volume, V_{Crit} are a function of previously-discussed parameters as well as the profile scale factor, A:

$$R_{Crit} = W_* - \left(\frac{h_* - S}{A}\right)^{3/2} \qquad V_{Crit} = RB_o - SW_* + \frac{3}{5}A\left(W_*^{5/3} - (W_* - R)^{5/3}\right)$$

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Conclusions

- Profile response must include landward transport of sediments, as evidenced by:
  - Overwash deposits
  - Aeolian deposits
  - Profile deepening offshore
  - Lack of evidence for offshore deposits
- Profile response to relative sea level rise depends on:
  - Excess or deficit of sand in profile
  - Potential for overwash during storms
- Increasing relative sea level will increase likelihood for overwash

Implications of Modified Bruun Rule

- Landward and seaward transport both contribute to beach recession
- Need to develop a greatly improved understanding of the dynamics of beaches; i.e., what governs long-term offshore versus onshore transport and deposition?
- Data for landward transport and deposition not readily available

Uncertainties and Unknowns

- Resolution of offshore datums in older surveys

Additional Data Needs

- Field data on beach response to storms
- Volume and distribution of landward and seaward deposits
- Long-term data sets of profile response

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