Sustainable management of coastal sand dunes to human activities and natural disasters in Oregon, the United States

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Introduction

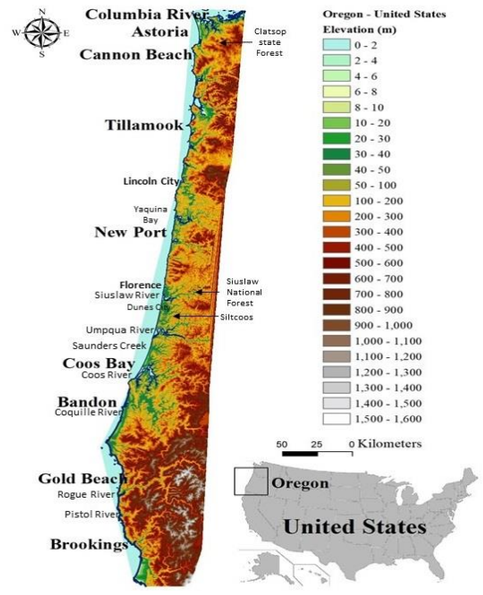
Dune destabilization became a socio-economic issue as Euro-Americans settled in Oregon in the 19th century. Non-native Ammophila arenaria and Ammophila breviligulata were widely used for stabilization from the early-20th century. As non-native beachgrasses turned invasive causing the loss of biodiversity and habitats, their removal became the focus to regain the active dunes to support the natural processes of the ecosystem.

Objectives

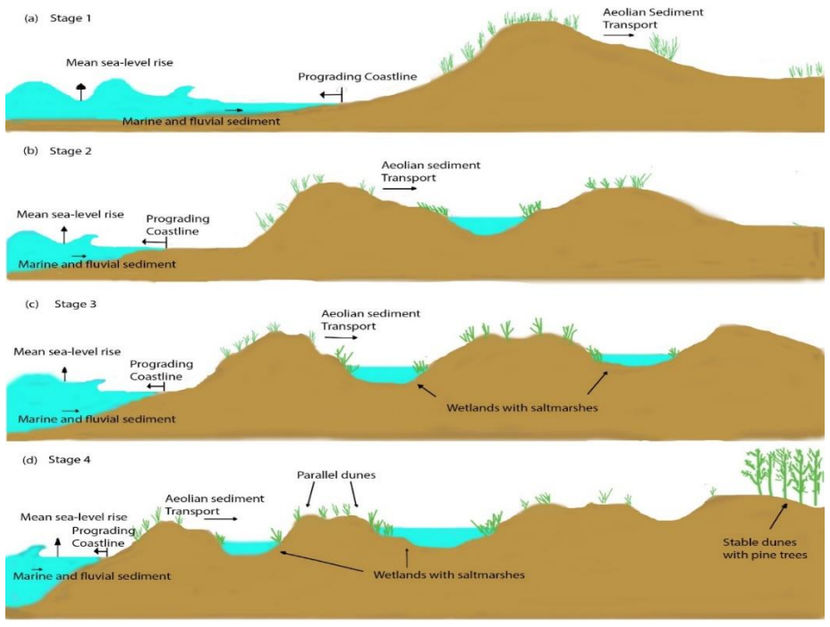
To understand the response of coastal sand dunes to natural hazards (e.g. sea-level rise), human activities (e.g. settlement, urbanization and animal husbandry) and dune management initiatives (e.g. planting of non-native beachgrasses) in Oregon in the United States during two contrasting periods: 1) from the 19th to late-20th century and 2) from there to the early-21st century.

Methodology

The Drivers-Pressures-State-Impact-Response (DPSIR) framework was adopted to understand the policies developed to manage coastal sand dunes and their consequences in Oregon in the United States, during two contrasting periods: from the 19th to late-20th century and from there to the early-21st century. A combination of historical data and scientific literature was used for this study.



Dune evolution due to natural and human activities including dune management initiatives



1) Simplified stages of sand dune evolution in Oregon, United States

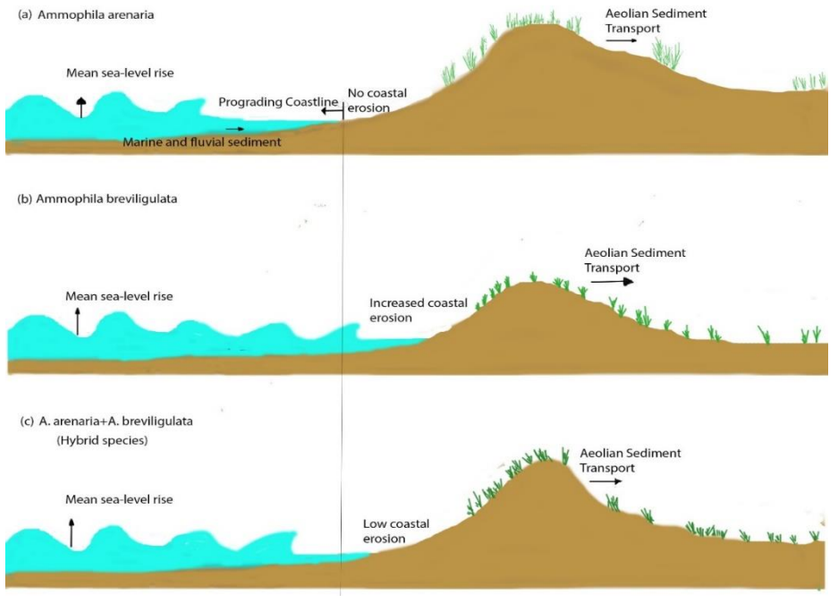
When the first dunes were formed along the Oregon coastal stretch from Heceta Head north of Florence to Cape Arago just south of Coos Bay, they would have been an active resulting landward movement of sand by wind (Fig 1a, Stage 1).

When sand is moved landward from such active foredunes, new inland dunes are developed where aeolian sand is deposited due to the loss of momentum (Fig 1b, stage 2).

Furthermore, the youngest dunes that are nearest to the Ocean were developed around 7000 years (Courtney Cloyd, Oregon Encyclopedia). This observation can be related to the Holocene glacier melting, as the sea level rose relatively rapidly until about 6,000 years ago (Ruggiero, 2013). There was certain native vegetation cover over them (Fig 1c, Stage 3).

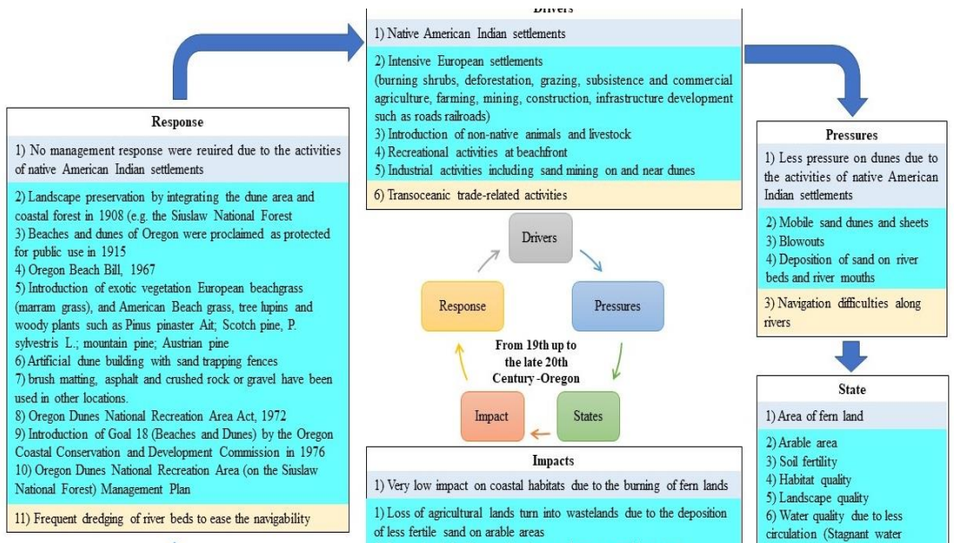
These processes resulted in different dune forms including parallel dunes. Wind scouring resulted in deflation plains which were ideal for lake and saltmarsh development. The limiting factor for landward dune development is the loss of momentum of aeolian sand, thus, creating stable dunes with forests (Fig 1d, stage 4).

The threat of coastal flooding due to climate-induced sea-level rise and storm surges would depend on the type of dominant beachgrass that covers the surface of dunes (Fig. 2)

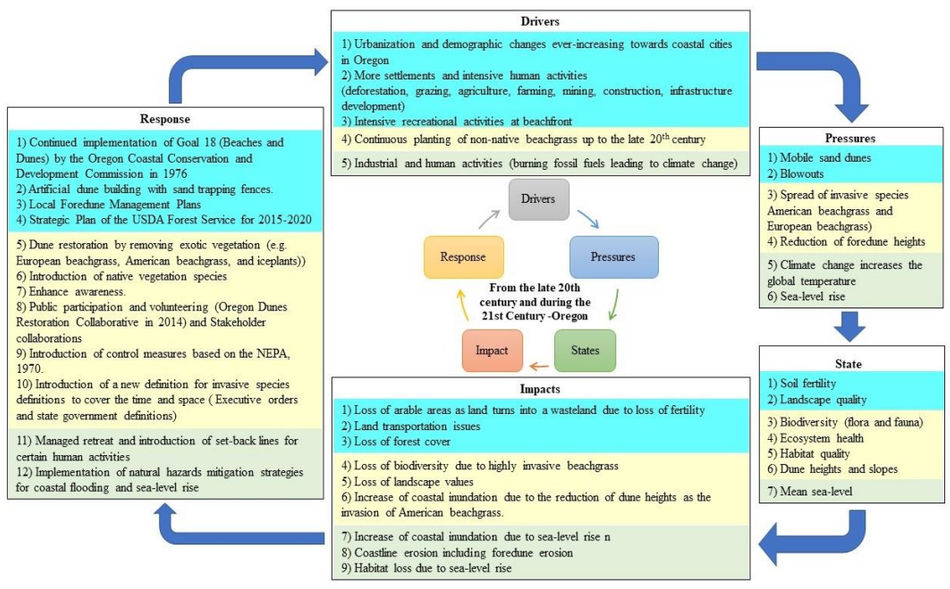


2) Response of dunes to different species of beachgrasses

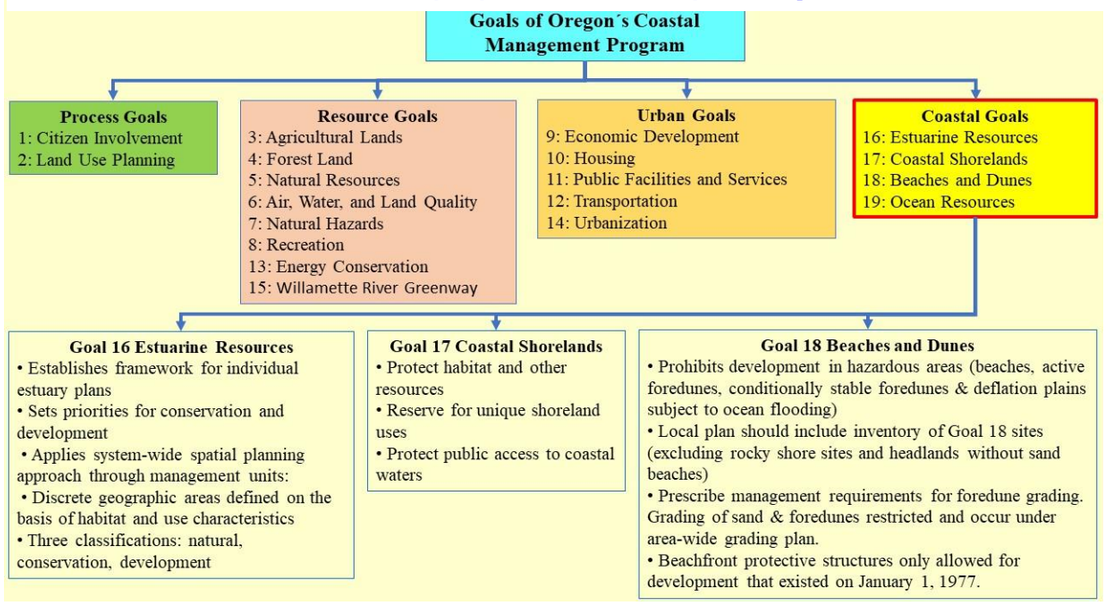
DPSIR analysis of sand drifting from the late 20th to the 21st centuries



DPSIR analysis of sand drifting from the 19th to the late 20th centuries



Policy framework: State goals of the Oregon Coastal Management Program (Based on Snow 2019; Spangler, 2019a, b; Reed et al., 2019)



According to Goal 18, all uses should be based on the capability and limitations of beaches and dunes and the adverse effects they might have on the sites and adjacent areas. It introduces setback lines that prohibit any development including residential, commercial or industrial buildings in dune environments prone to ocean hazards including ocean flooding.

All actions on dunes should be regulated to minimize the resulting erosion, including the destruction of vegetation and the construction of shore structures.

Cities and counties had to establish local coastal plans, setting special zoning or overlay zones that required any proposed development or dune intervention needed approval by local authorities.

Nevertheless, many foredune areas were occupied for residential purposes before the plans and these could still be developed.

Conclusions

- The DPSIR analysis allowed a better understanding of different factors affecting coastal sand dunes and their implications for the sustainable management of such ecosystems in Oregon, United States.
- As a result of the lack of understanding of the total impact of certain dune management initiatives, policy developers have implemented contrasting dune management policies in Oregon since the 1930s. Dune stabilization efforts since the early 20th century led to the spread of invasive grasses and their removal campaigns since the late 20th century increased flooding with sea-level rise.
- Dune management policies must be developed by considering that human responses lead to new drivers, pressures and impacts. For sustainable management of sand dunes, policies require balancing efforts to mitigate coastal flooding while regaining the native biodiversity.

Reference

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