REACTIVATION OF COASTAL DUNEFIELDS IN EQUATORIAL BRAZIL: AEOLIAN PROXIES FOR CLIMATE-LANDSCAPE INTERACTION

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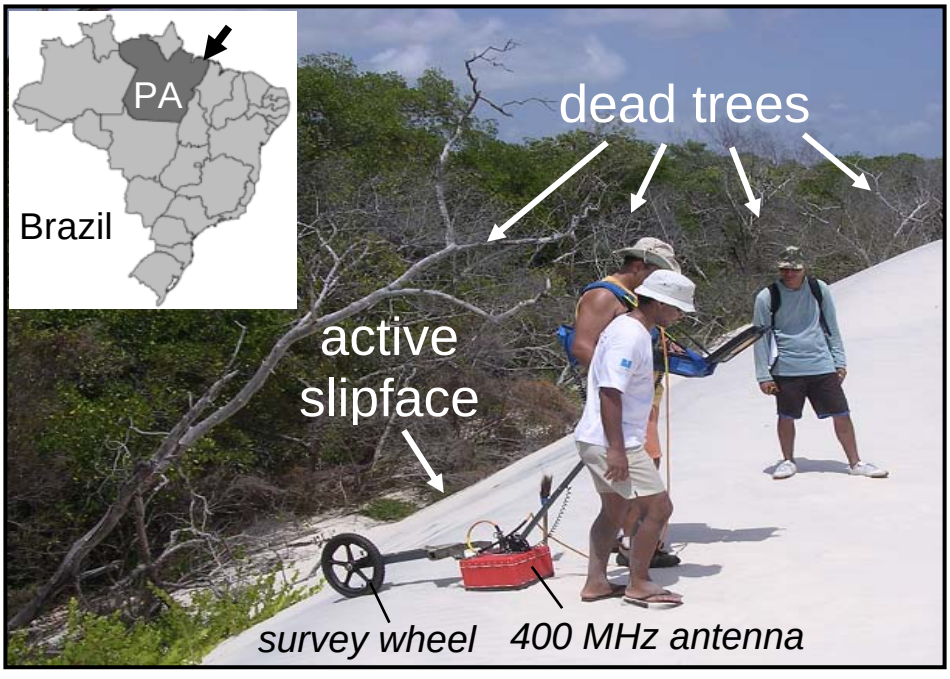
Summary of Results

As part of the OCCI-funded Project #32031215, fieldwork was conducted in the Pará State, equatorial Brazil. The database included more than 20 linear kilometers of high-resolution ground-penetrating radar (GPR) images and sediment cores for groundtruthing geophysical data and obtaining samples for dating. Radiocarbon dates analyzed at NOSAMS facility, yielded a wide range of ages from 4,500 years BP to modern. A new set of optical dates indicates that two main coastal dune ridges at Salinópolis (Praia do Maçarico) have partially infringed on dense interdunal wetlands and experienced a period of aggradation within the past 80-90 years. At Atalaia, large reactivated transverse and parabolic dunes at have been migrating over coastal roads and mangrove forests over at least the past 150 years. In geophysical images of a parabolic dune, numerous high-amplitude hyperbolic anomalies produced by buried trees contrast with steeply landward-dipping slipface reflections. Due to water table elevation, the lower older part of the dune sequence has been stabilized in the blowout area. Similarly, interdunal lake has partially arrested the migration of a transverse dune ridge, while the adjacent segment continues to advance onto a sparsely vegetated plain. Farther east, the seawardmost dune generations at Ajuruteua were established in the past 200 years and are backed by relict dunes associated with former shoreline positions dating back to late Holocene (1,000-2,500 years BP). Our preliminary data indicate that whereas this region has high precipitation, it experienced episodes of rapid (average: 1-2 m/year) migration of massive dunes (10-20 m high), which continues locally at the present time. The regional dune reactivation may in part be related to periods of decreased precipitation and increased easterly winds, with possible links to ENSO episodes. Aside from their implications to coastal evolution, accurate reconstructions of dune dynamics on decadal to centennial time scales should be integrated into coastal development and management strategies.



Example of a Geophysical Study at Atalaia Beach

As part of the regional study, a large active parabolic dune along the coast of Pará State, northern Brazil, was analyzed using aerial photography and imaged with high-resolution GPR (400 MHz) to map the subsurface facies architecture and point-source anomalies.

Dune Stratigraphy

Subsurface images reveal a series of closely-spaced tangential-oblique reflections, which are dipping landward beneath the entire imaged profile of the active dune (stoss side, crest, and upper slipface). Though it was not possible to image the entire slipface due to its steepness and dense vegetation, part of the upper slipface shows similar reflector geometry to that imaged beneath the dune crest (Fig. 2A). The steeply-dipping reflections in the upper part of the record represent grainflow deposits and grade into grainfall horizons lower in the sequence. Truncated and down-lapping reflections represent reactivation surfaces on former dune slipfaces and are common in aeolian sequences (Fig. 2B; Buynevich et al., 2010). The dielectric contrast responsible for individual reflection is likely due to slight textural variations and heavy-mineral concentrations in aeolian sands. The latter were observed on dune surface and in shallow trenches through several reactivated dunes in Atalaia region.

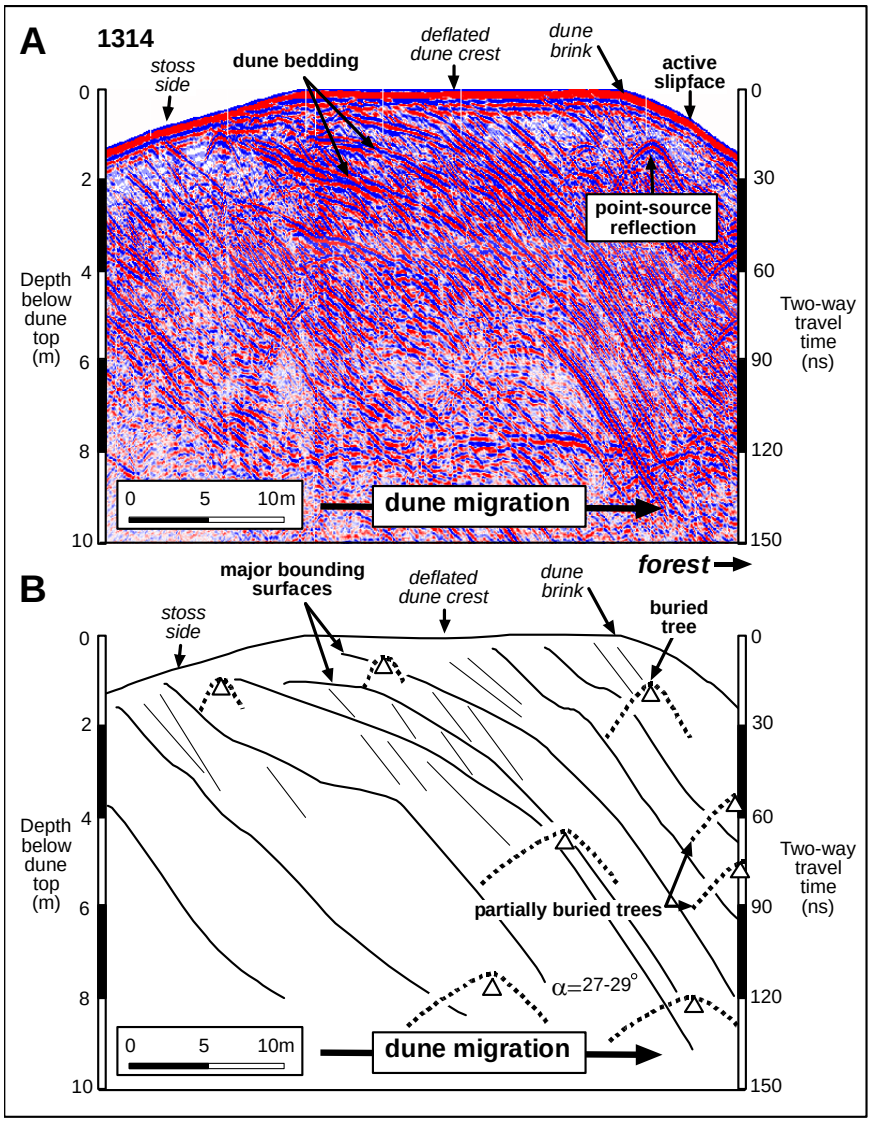


Figure 2. A) Landward segment of GPR profile 1314 over the top of a parabolic dune showing part of the active slipface. The steep landward-dipping reflections represent former dune slipfaces (lateral migration surfaces). Strong hyperbolic reflections are point-source targets. B) Interpretation of the geophysical profile showing major bounding surfaces and high-amplitude hyperbolic reflections (dashed lines). Triangles denote the locations of buried targets. Time scale is in nanoseconds (1 ns= 10^{-9} seconds).

Subsurface Anomalies

The analysis of a radar signal response to a recently buried object of known dimensions is an important first step in assessing the type of subsurface reflection patterns. The GPR image clearly shows several hyperbolic reflections that contrast with surrounding and overlying aeolian strata (Fig. 2B). The anomalies occur at a depth of 1–8 m below the dune surface and several partial hyperbolas along the downwind edge of the transect were correlated with the partially buried trees protruding from the lower part of the slipface. Smaller shallow reflections are also found on the stoss side of the transect and are likely due to buried roots of ground scrub vegetation. The six full target reflections beneath the dune crest have high normalized signal amplitude values, ranging from 8.4 to 9.5 dB. To search for targets in older sections of the dune, GPR profile 1316 was collected along the base of the stoss side. Using automatic target recognition, a total of 66 point-source reflections were identified over a 200 m distance. Due to relatively low elevation of this area, most targets occur in the saturated part of the sequence. Normalized amplitude values for all targets on profile 1316 range from -23 to 10 dB, showing a general increase with depth and reaching amplitudes comparable to those imaged within the active dune from. These values are much higher than amplitudes of the individual points comprising continuous reflections: the water table (-65 to -49 dB) and a continuous reflection near the bottom of the record (-60 to -48 dB). The anomalies likely represent the remains of vegetation on the former floor of the maritime forest. Variations in the extent of coastal mangroves in the Amazon region during the late Holocene may also result in morphologically distinct subsurface horizons. The occurrence of most subsurface targets in the saturated part of the record highlights the importance of continuous geophysical imaging in areas where buried objects occur below the water table, making groundtruthing difficult.

Dissemination of Results

The preliminary findings from the project were presented at several international conferences and published in peer-reviewed journals, with future submissions planned as new chronological data are being analyzed.

Buynevich, I.V., Bitinas, A., Souza Filho, P.W.M., Pupienis, D., Asp, N.E., Goble, R.J., Kerber, L.E., 2011. Rapid coastal dune migration into temperate and equatorial forests: optical chronology of imaged upper slipface strata. *11th International Costal Symposium, Szczecin, Poland, submitted.*

Buynevich, I.V., Souza Filho, P.W.M., Asp, N.E., 2010. Dune advance into a coastal forest, equatorial Brazil: a subsurface perspective. *Aeolian Research*, p. 27-32. doi:10.1016/j.aeolia.2009.11.001.

Buynevich, I.V., Souza Filho, P.W.M., Bitinas, A., Asp, N.E., Pupienis, D., 2010. Aeolian sand invasion in coastal regions: geomorphological and geophysical aspects. *Proceedings of the 6th Schukin Conference: Geomorphological Processes and their Applied Aspects - Extended Abstracts,* Moscow State University, Moscow, p. 281-283.