Variable earth material, backshore erosion, and mitigation at Lewisville Lake, Texas

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Introduction

Backshore erosion is a maintenance and environmental concern at many lakes worldwide. This process degrades land while increasing turbidity that harms aquatic ecosystems. The problem is amplified in multi-purpose lakes, as displaced sediment and brush take up storage, thus compromising critical flood control and water supply services. Measuring rates of backshore erosion can help prioritize stabilization efforts to enhance lake function. A recent study involving satellite imagery and field observations examined shoreline erosion at Lewisville Lake in north-central Texas, U.S.

Study Area

Lewisville Lake is impounded by an earthen dam on the Elm Fork of the Trinity River in north-central Texas (Figure 1). This multi-purpose lake controls flooding while supplying water and supporting recreation. The lake loses approximately 540 acre-feet of capacity each year from stream deposition and eroding backshore (TWDB, 2007). As the lake (periodically) approaches and exceeds maximum normal operating level, waves attack the backshore shelf. Winds are prevalent from the south-southeast (SSE), with a directional mode of 20 degrees east of south (S20E). The main branch of the lake also aligns approximately S20E, thus amplifying wave fetch and energy.

Vulnerable, SSE-facing segments of backshore consist of two Upper Cretaceous bedrock formations (Woodbine and Eagle Ford) and Quaternary alluvium. The Woodbine consists of loose to moderately-well cemented sand and laminated sandy clay. Fissile clayey shale makes up the Eagle Ford. Quaternary terrace deposits of sand, gravel, and clay discontinuously cover bedrock along the backshore.

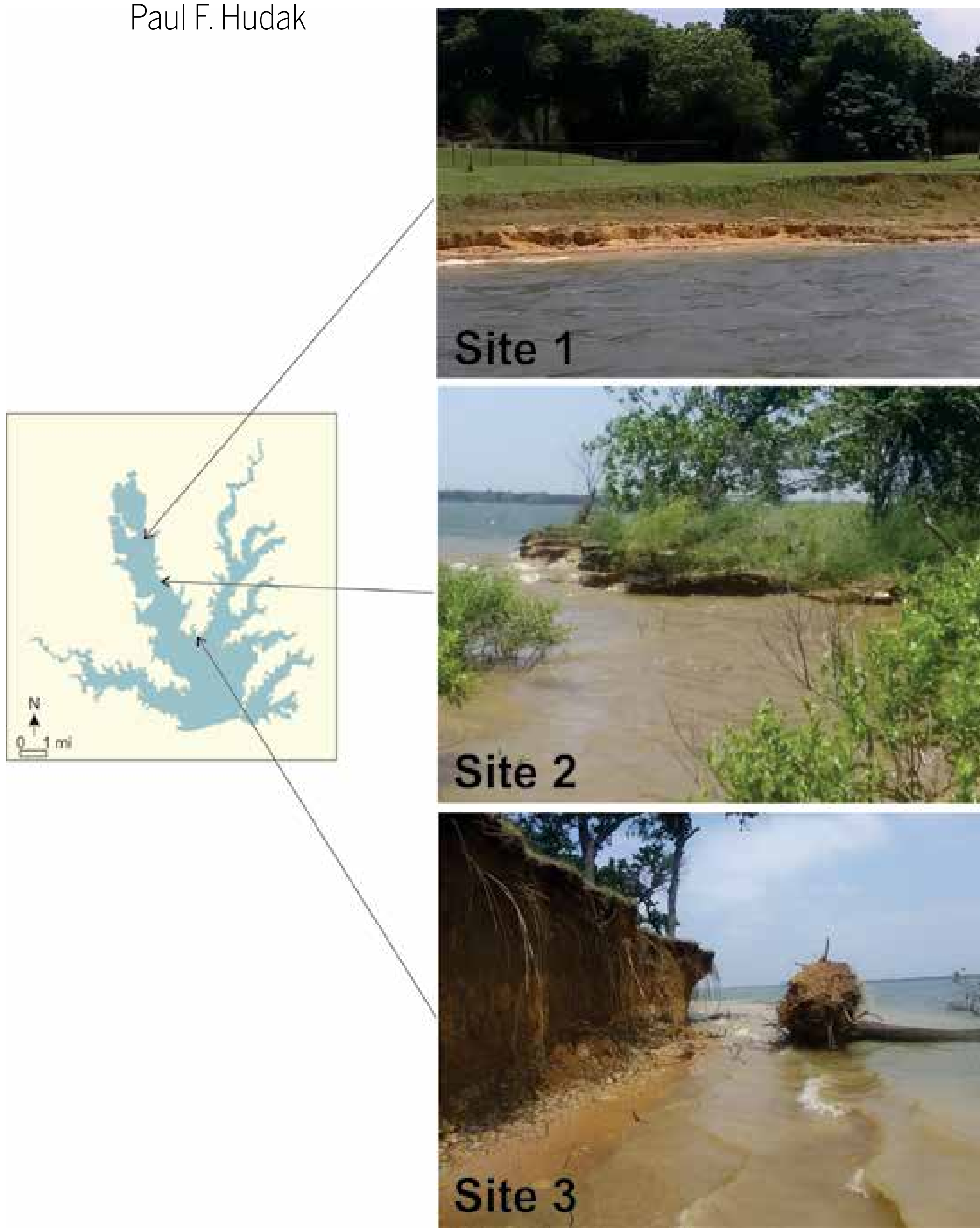


Figure 1. Sites 1 – terrace, 2 – sandstone, and 3 – shale.

Observations

Satellite images from February 2001 and 2024 were analyzed at three SSE-facing sites: one each in terrace deposits, sandstone, and shale (Figure 1). Images were obtained from Google Earth (Google Corporation, Mountain View, CA). Along S20E transects, digitized imagery produced erosion estimates of 3.2 feet/year for terrace deposits, 2.4 feet/year for sandstone, and 7.4 feet/year for shale. During field visits at high lake level, water was visibly turbid from silt and clay washed away from the shale and terrace backshore. Shale was further weakened by repeated wetting (swelling) and drying (shrinking) cycles, leading to extensive fragmentation. Vegetation also fell from the backshore into the reservoir (Figure 1). Ultimately, driftwood provides habitat but is also a significant boating hazard in the lake.

Limestone rip rap – typically, a rock blanket on landscape fabric – is used to slow erosion in the study area. However, waves tend to wash away sand and fine sediment beneath the fabric, which then sags and tears, causing rocks to subside and move downslope. Figure 2 shows the eastern edge of a 330-foot-long rock blanket at Site 1. Installed in 2020, the rock blanket has slowed erosion by about 0.7 feet/year when compared to adjacent, unprotected backshore. In 2024, rocks were added to fill gaps that formed in the original structure.

Better-prepared substrates beneath rip rap might lead to better outcomes. Such preparation might involve thorough compaction; wire mesh and sprayed concrete; or anchored geosynthetics less prone to sagging and tearing. Sturdy wire mesh around boulders (gabions) could prevent downhill movement but would still sag as the supporting substrate washed away. Hybrid approaches involving artificial structures such as gabions on augmented substrates, with intervening spots for native plants, might enhance aesthetics while providing better erosion control than sagging structures in the study area. For example, common buttonbush, which thrives along the wave-ravaged backshore, anchors soil while supporting various birds and insects.

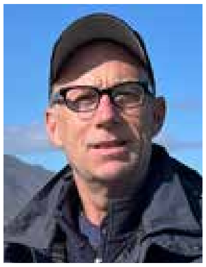
Conclusion

Earth material and prevailing wind orientation strongly influence rates of backshore shelf erosion at Lewisville Lake. Shale backshore receded 2.3 and 3.1 times as fast as terrace deposits and sandstone, respectively. A limestone rock blanket slowed the erosion rate by about 22 percent at a terrace site. Better substrate preparation and rock retaining features would likely perform better.

Figure 2. Rock blanket at Site 1; large (beige) rocks placed in 2020; smaller (grey) rocks added in 2024.

Reference

TWDB (Texas Water Development Board). 2007. Volumetric and Sedimentation Survey of Lewisville Lake. Texas Water Development Board, Austin, Texas.



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