Slope Evolution at Calvert Cliffs, Maryland
Measuring the Change from Eroding Bluffs to Stable Slopes

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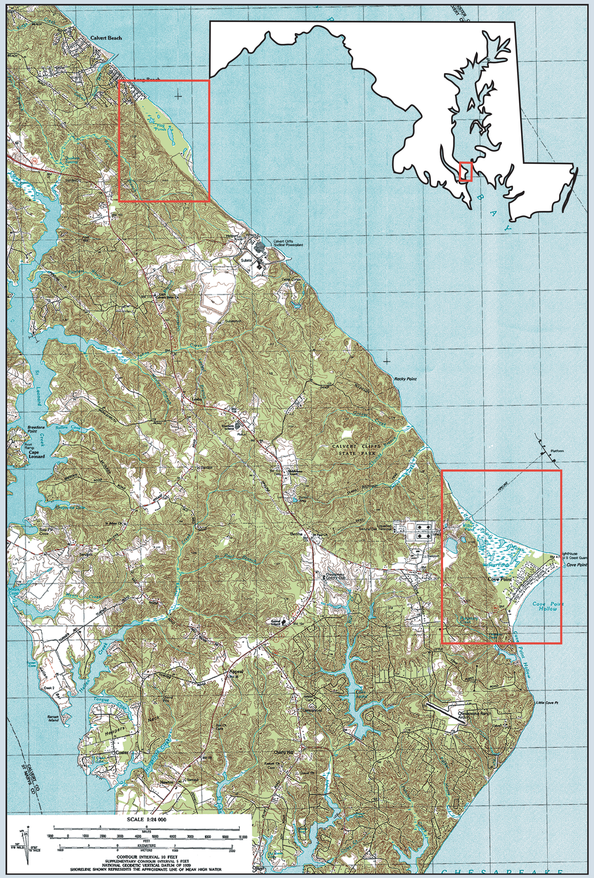
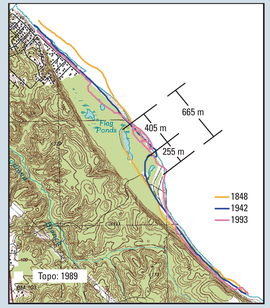
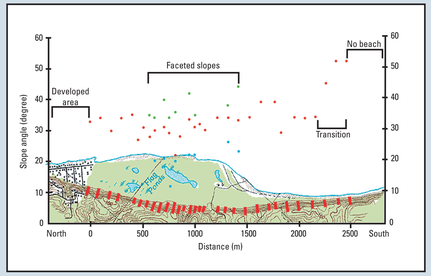


The Calvert Cliffs extend for approximately 50 km along the western Chesapeake Bay shoreline. The bluffs directly adjacent to the bay generally have very narrow or no beach material (0-3 m) and little to no vegetation on the face. These bluffs have a historically uniform erosion rate of 0.3-0.6 meters per year (Pilkey 1989) and are susceptible to collapse and slumping. Our study sites, Flag Ponds Nature Park and Cove Point which are migrating in the southerly direction, are highlighted by the red boxes. Flag Ponds Nature Park is a characterized by freshwater ponds, wooded wetlands, and wooded uplands. Cove Point is a truncated cuspate foreland characterized by ridge and swale topography. The offshore bluffs inland of Cove Point are also heavily vegetated.



The historic shorelines (supplied by the Maryland Geological Survey) enabled us to estimate the migration rate of Flag Ponds. From 1848 to 1993, Flag Ponds moved at a rate of 4.6 meters/year. From 1942-1993 the rate of movement was 5 meters/year and from 1848-1942 the rate was 4.3 meters/year.

An aerial view of Flag Ponds. The ridge line is apparent behind the marsh area.



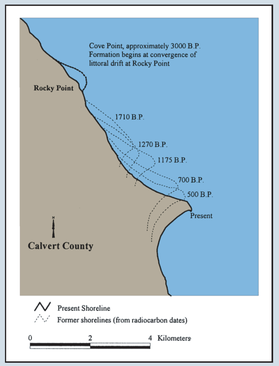
This diagram of the slope angles shows the changes that occur as Flag Ponds migrates southward. This natural sand barrier stabilized the position of the bluffs by protecting and hindering the toe slope erosion by wave action. Because of anthropogenic influences to the north of Flag Ponds such as the development of Long Beach and Calvert Beach, the natural erosional patterns have been altered and the expected bluff exposure to wave action does not occur. The stabilized slopes range approximately from 25 degrees to 37 with a mean of 31 degrees behind the sand barrier and 15 to 20+ degrees higher in the transitional zones. The cliff areas with "no beach" are influenced by direct wave action at the toes and have slope angles of approximately 70 degrees.

The actively eroding coastal bluffs of the Calvert Cliffs, Maryland enables us to understand the centennial-scale development of stable slopes from near vertical eroding bluff faces. The Calvert Cliffs, which are comprised of Miocene-aged sandy silts, silty sands, and clayey silts are situated along the western Chesapeake Bay shoreline. The dynamic wave action at the toes of the bluffs encourages rapid sloughing from bluff faces and maintains slope angles around 70 degrees and relatively constant bluff-retreat rates of 0.3-0.6 meters per year.

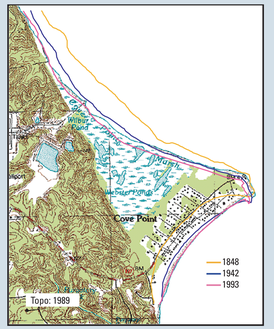
The naturally stabilized slopes inland from Cove Point and Flag Ponds are preserved as "fossil" bluff lines. The orientation of the inland bluffs are very similar to the actively eroding bluffs, indicating that the protected bluffs were once influenced by direct wave action. As the prograding cuspate foreland at Cove Point and the spit complex at Flag Ponds migrate south, the southward bluffs become protected from wave action as new beaches are deposited at the bluff toes. The wave action is reinitiated on the northern end of Cove Point as the cuspate foreland passes. The anthropogenic changes to the shoreline to the north of Flag Ponds prevent this from happening at that locale.

In order to document the rate of change from the steep eroding faces to the low-angle vegetated slopes, we measured slope angles at intervals along the fossil bluff line. The slopes along the fossil bluff line were generally in the 25-37 degree ranges with a mean of approximately 31 degrees. This consistency of slope angles suggests that steep, actively eroding bluffs were quickly changed to stable slopes by landslides and slumping once they were protected.

Because we have determined the migration rates of Cove Point and Flag Ponds of 1.3 m/yr and 4.6 m/yr, respectively, we are able to ascertain that it only takes a couple of decades for the actively eroding bluffs slopes to stabilize to 31 degrees once toe erosion has ceased. As the Calvert Cliffs region of Maryland has been undergoing rapid development, it is important to recognize that the landform evolution of the bluffs is on the decadal instead of the centennial scale, placing the rate of slope failure on a human scale.

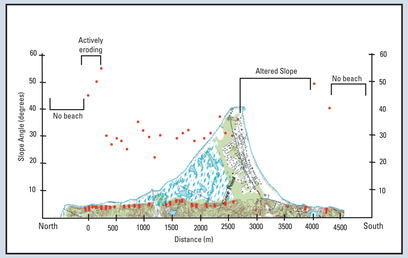


The ridge and swale topography of Cove Point represents relict beach ridges, which are former foreland fronts. Carbon-14 dating of swales between the beach ridges shows the complex to span 1700 years of progressive migration history. (Beardslee 1997)



Historic shorelines (supplied by the Maryland Geological Survey) illustrate the recent migration of Cove Point. Because of the non-linear movement of Cove Point, we have used the Beardslee (1997) migration rates of 1.3 meters/year.

These photographs taken north of Point illustrate the migratory history of the area. As the slope protection migrates south (left) the bluffs become exposed to wave action (right).



This diagram of the slope angles at Cove Point depicts the changes that occur as the foreland migrates. The natural sand barrier migration to the south of Cove Point protects and hinders the toe slope erosion by wave action therefore, stabilizing the position of the cliff. The stabilized bluffs range in slope from 25 to 37 degrees with a mean 31 degrees. Concurrently on the northern end, the once sheltered vegetated bluffs become exposed to wave action which actively erodes the toes. Those slopes directly adjacent to the protected slopes are in transition to becoming the high angle bluffs. These bluffs in the transitional zones under the influence of wave action are generally 15-20+ degrees steeper than those protected by a natural sand barrier. The cliff areas with "no beach" are influenced by direct wave action at the toes and have slope angles of approximately 70 degrees.

Active erosion at the north end of Cove Point.

Much of the Calvert Cliffs such as the southern end of Cove Point and the northern end of Flag Ponds support privately owned waterfront communities and businesses. This is a typical example of development at the eroding bluffs.

Many of the residences in the Calvert Cliffs area have installed a variety of erosion control measures such as groins, bulkheads, and rip-rap. This is one example of such measures at the south end of Cove Point.

More erosion control south of Cove Point.

U.S. Geological Survey Open-File Report 02-332