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Archival photographs showing land use history in the Luquillo WEBB study area

Clearing of forest, Luquillo mountains, 1930's.

Oxen teams were used throughout the central mountains of Puerto Rico to clear forest in small plots (typically several hectares of less). Economically valuable hardwoods were removed first. After forest was removed, subsistence (root vegetables, plantains) and cash (tobacco, sugar cane) crops were alternated during the year 'round growing season. (photograph from International Institute of Tropical Forestry, U.S. Forest Service, Rio Piedras, Puerto Rico).

Woman cutting fuelwood, 1945.

Forest clearing occurs with varying intensities and for several purposes. Cutting and gathering of fuelwood was required for food preparation in the 19th and early 20th centuries in the Luquillo mountains and elsewhere in the central mountains of Puerto Rico. (photograph from International Institute of Tropical Forestry, U.S. Forest Service, Rio Piedras, Puerto Rico).

Rural family, 1940's, Toro Negro area of Luquillo mountains, Puerto Rico.

Subsistence farming families living on small plots of steeply sloping land in the mountains of Puerto Rico were forced to over-utilize their land. The eventual exhaustion of soil resources was a contributing factor leading to the abandonment of farmland and migration to San Juan and cities of the United States. (photograph taken by F.H. Wadsworth, from International Institute of Tropical Forestry, U.S. Forest Service, Rio Piedras, Puerto Rico)

Landscape, central mountains of Puerto Rico.

Intensive agricultural and grazing land use resulted in mosaic of pasture, small subsistence plots and patches of secondary forest on steep hillslopes. (photograph from International Institute of Tropical Forestry, U.S. Forest Service, Rio Piedras, Puerto Rico).

Landscape with tobacco barn, central mountains of Puerto Rico.

By the middle of the 20th century 94 percent of the 9,000 km2 island of Puerto Rico had been deforested[1]. The island began to industrialize in the 1950's and agricultural land use declined. By the late 1980's, about 35 percent of the island was forested. (photograph from International Institute of Tropical Forestry, U.S. Forest Service, Rio Piedras, Puerto Rico).

([1]Birdsey, R.A., and Weaver, P.L., 1987, Forest area trends in Puerto Rico: U.S. Dept. of Agriculture, Forest Service Research Note SO-331, 5 p.)

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Puerto Rico WEBB Site Photographs

View upstream, of the Cayaguás river, at USGS station 50051310, October, 1997, showing Antioch College student using bedload sampler. Note the widened channel caused by the increased discharge resulting from Hurricane Hortense which struck Puerto Rico on September 10, 1996. Peak flow in this 26.4 square kilometer basin was 360 cubic meters per second and had a recurrence interval of 12 years. Rainfall accumulation in the watershed associated with the Hurricane exceeded 600 mm in a 24-hour period and had a recurrence interval of 100 years. The difference in recurrence intervals between peak discharge and rainfall accumulation is explained by the broad, low amplitude hydrograph that characterized the Hurricane runoff. Transport of large amounts of sand-sized bed material since the Hurricane has caused bed aggradation of 1 meter at the gaging station. Average annual suspended sediment yield measured at this station during the 1980's was 2,850 metric tonnes per square kilometer. During the 1990's, a series of low-runoff years reduced the average annual suspended sediment yield to 750 metric tonnes per square kilometer.

Tertiary granodiorite bedrock outcrops along the Cayaguas river channel in massive exposures known as core stones. These large deposits are derived from bedrock that has been exposed by stream channel incision during the Quaternary. Note hat for scale.

Intensive agricultural practices have contributed to high rates of soil erosion on hillslopes in the Cayaguas watershed. Bare soil exposed in the foreground has been prepared for Ñame (*Dioscorea rotundata*), a root crop. Plantains (*Musa sp.*) are visible on the hillslope in the background. The soil type is Pandura loam, an Inceptisol (Typic Eutropept). These small family-run agricultural plots are typically plowed with oxen teams, then planted and weeded by hand.

After nearly two centuries of cropping, high soil erosion rates have degraded the soil resource in the Cayaguas watershed and areas of steep hillslopes are now commonly used for grazing of cattle. On average, about 2.5 hectares of grassland are required for each grazing animal. The hillslopes in this photograph show evidence of well developed cow terracettes' created by cattle moving on preferred paths parallel to the slope contour. Also visible in the photograph are amphitheatre-shaped landslide scars dating from the early 20th century which are common on hillslopes in this watershed. Scar frequency averages 109 per square kilometer of watershed surface area. Much of the soil and saprolite eroded by the mass wasting remains in storage in deposits 2 to 3 meters thick on footslopes and small (zero-order) valley bottoms such as that shown here.

View of a landslide scar on a grass-covered hillslope in the Cayaguas watershed. Although most landslide scars in the watershed have become revegetated with pasture grasses, patches of bare soil remain and contribute to the high sediment yields of the watershed.

A typical view of the Cayaguas watershed showing patchwork of secondary forest and heavily-grazed pasture. Corestones, 2 to 3 meters in diameter, are visible along the floor of this ephemeral stream valley.

A landslide scar associated with Hurricane Hortense rainfall of September 10, 1996. The 600 mm storm triggered numerous landslides such as this one, which delivered about about 300 cubic meters of soil and saprolite directly to the Icacos river channel in the Luquillo Experimental Forest. Landslides are the source of most of the average annual suspended sediment yield, 525 metric tonnes per square kilometer, for this forested 3.26 square kilometer watershed.

View of the Icacos river near the USGS gaging station (50075000), in the Luquillo Experimental Forest, showing large core stones in the channel. A vegetated cap of saprolite rests on top of the core stone in the center of the photograph. The saprolite presence attests to the brevity of peak discharges in this small (3.26 square kilometer) watershed where high discharge events are not uncommon but sustained flow is measured in minutes to a few hours only. The saprolite deposit, first noted more than 10 years ago, has therefore not been eroded, despite mean annual runoff of 3.9 meters.

View upstream, of the Cayaguas river, at USGS station 50051310.

This river drains a 26.6 km^2 area south of San Lorenzo, Puerto Rico, and is a tributary of the Río Grande de Loíza. Bedrock in the watershed is Upper Cretaceous granodiorite, which weathers to sand and clay, providing an ample sediment load transported along the bed and in suspension. Mean annual runoff is 1,326 mm and the maximum recorded instantaneous discharge (since gaging began in 1977) is 374 m^3/s, measured during Hurricane David, August 31, 1979. As of 1995, aproximately 65 percent of the basin is in pasture, 23 percent was forested, and the remainder was in crops and small clusters of houses.

Tributary to the Rio Mameyes, USGS station 50065500.

This forested 17.8 km^2 watershed, located in the northeastern part of the Luquillo Experimental Forest, is underlain by volcaniclastic bedrock which weathers to massive boulders. Mean annual runoff is 2,798 mm and the maximum recorded instantaneous discharge (since gaging began in 1967) is 581 m^3/s, measured during Hurricane Hugo, September 18, 1989. Average annual suspended sediment yields from this and comparable rivers in eastern Puerto Rico draining forested watersheds are typically 100 to 200 metric tons per square kilometer.

Landslide scar near PR Highway 191 in the Icacos watershed, Luquillo Experimental Forest. Note large quartz-diorite boulders, also known as core stones, imbedded in saprolite. Saprolite is *in situ* weathered or partially weathered bedrock.

Rainfall-triggered landslides are an important source of sediment exported by rivers in the Luquillo Mountains. Landslide debris contributes approximately 50 percent or more of the annual sediment yield of the Icacos and Mameyes river basins.

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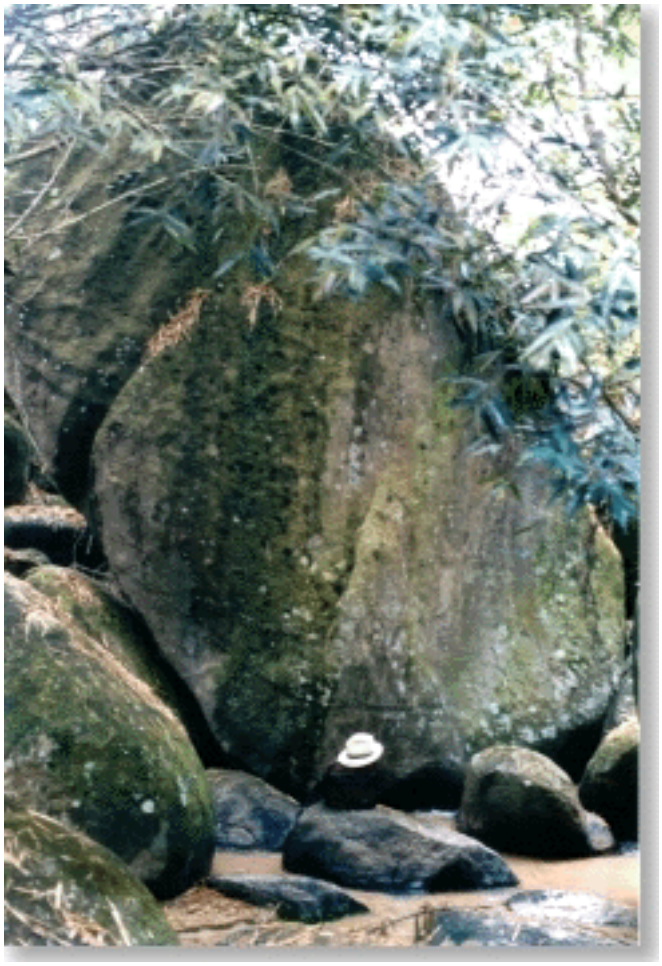

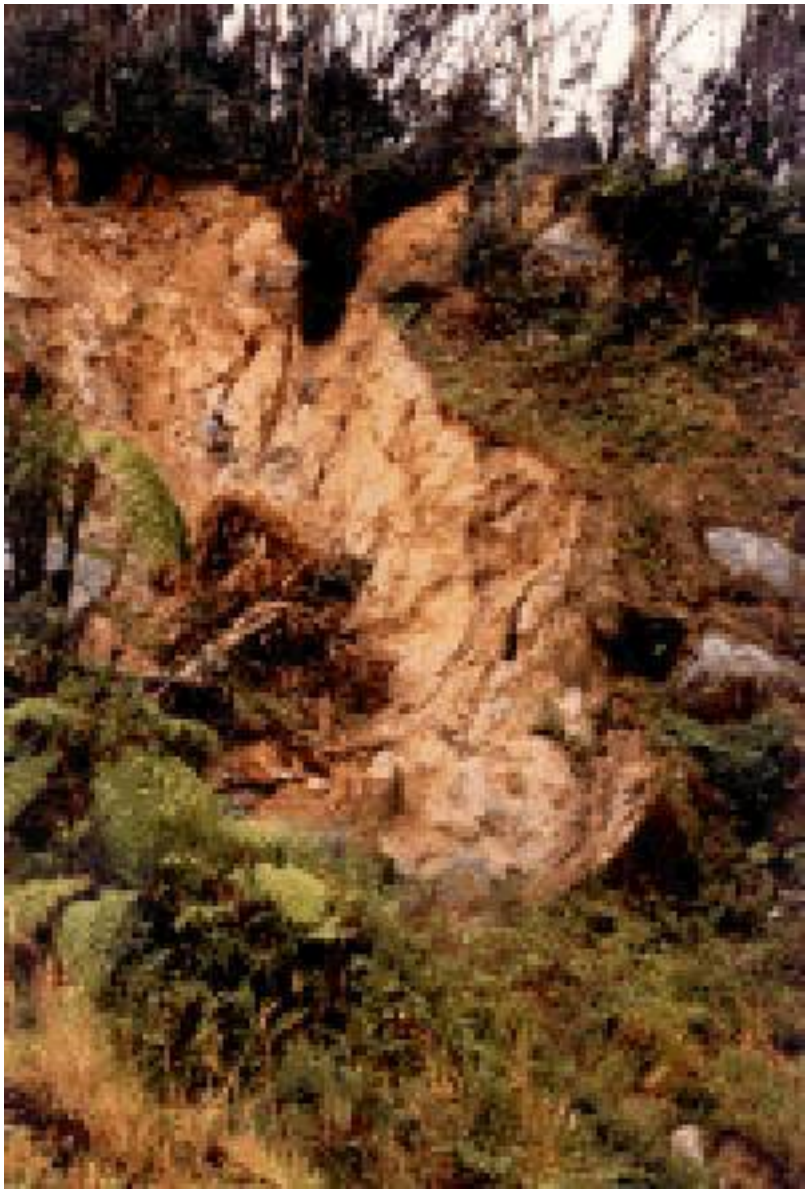

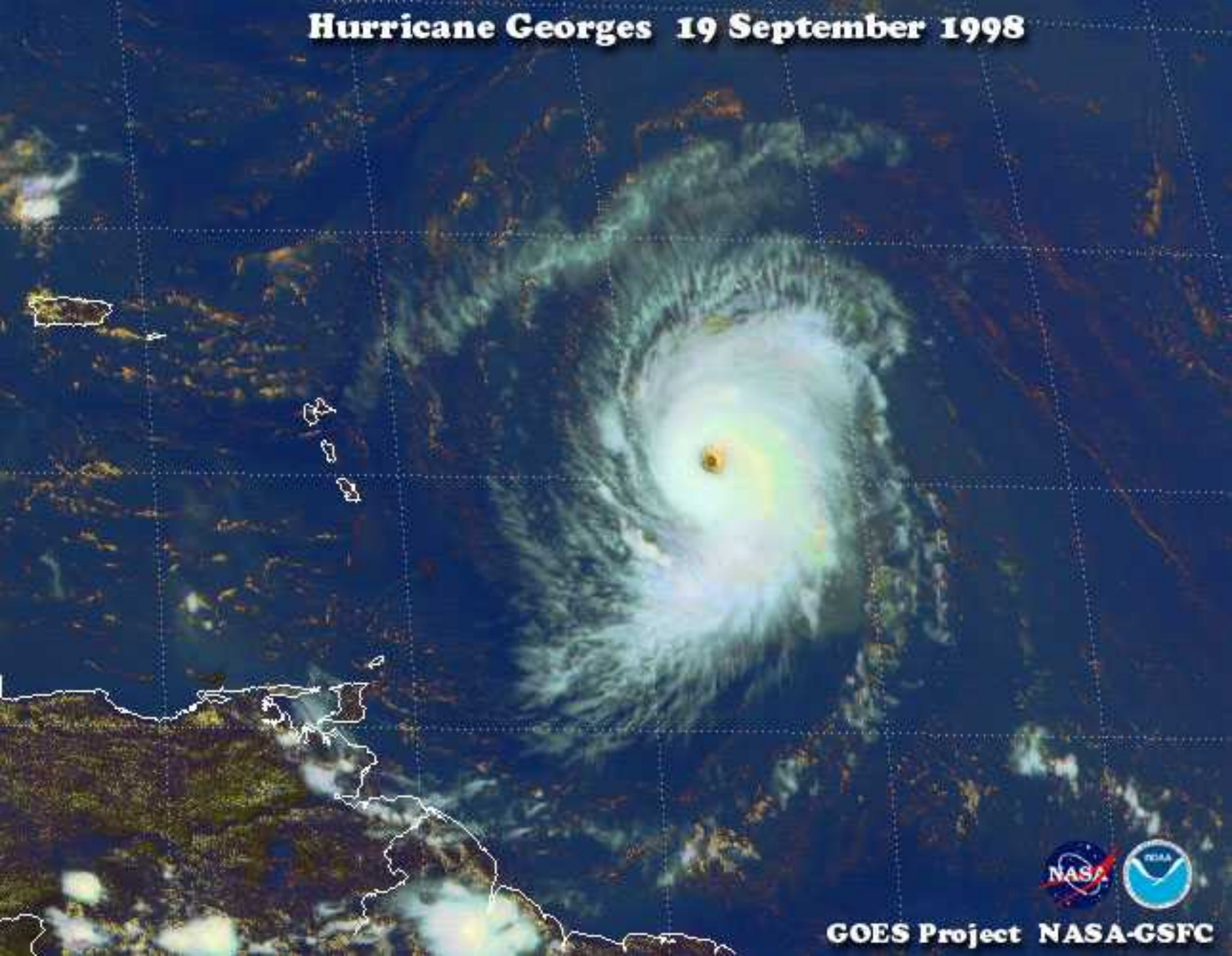
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