Anthropogenic Modifications Influence the Interactions Between the Geomorphology and Biogeochemistry of an Urban Desert Stream

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Abstract

We used historic aerial photography to document geomorphic changes resulting from the development of Indian Bend Wash, Scottsdale, AZ. Catchment land use shifted from prehistoric agriculture (14th C) to desert and again to agricultural fields in the early 20th C. Beginning in 1955, suburban development has expanded from the mouth to headwaters of the wash, followed by greenway creation. This development has produced a shift in vegetation from desert scrub and mesquite bosques to a community dominated by low grasses and widely spaced trees. The geomorphic modifications of the floodplain interact with catchment-wide land use changes to alter sediment transport and deposition, spatial and temporal patterns of nitrogen storage, and vegetative community dynamics.

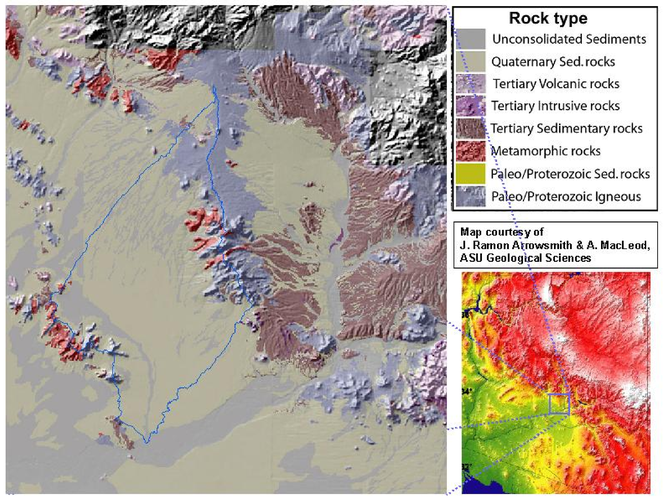

Fig. 1. Map of Indian Bend Wash watershed (left panel) highlighting important geomorphic features and rock types. The watershed's boundary is outlined in blue. Indian Bend Wash is a tributary of the Salt River that lies just west of the Verde River in Central Arizona as indicated in the topographic map in (lower right panel). Hystorically, as with the surrounding streams, patterns of nitrogen availability were largely driven by the interaction of surface and subsurface compartments as water flowed in and out of the course alluvium.

Introduction

Geomorphology and hydrology are important drivers of biogeochemical patterns in 'pristine' ecosystems (Fig. 1). As urbanization proceeds this underlying structure is often extensively modified. We hypothesize that these changes have important ramifications for ecological patterns and processes. We offer support for this hypothesis by first documenting how development has proceeded in Indian Bend Wash. We then provide an example of how new geomorphologic features may affect the cycling of nitrogen through this ecosystem.

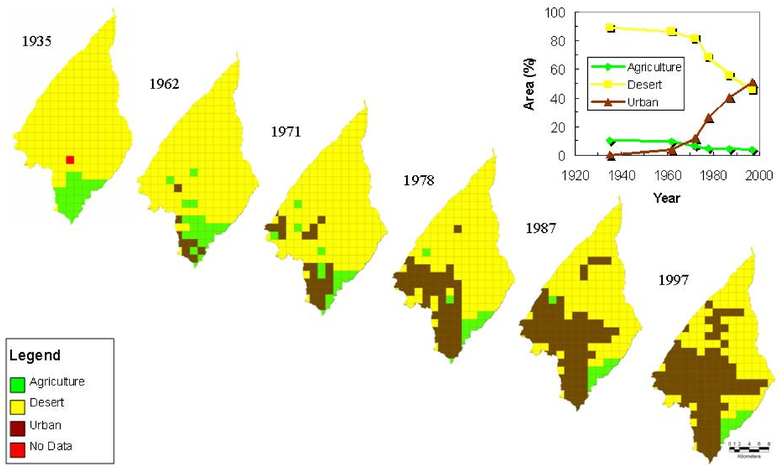

Fig. 2. Maps highlighting land-use change in IBW over 62 years. In each frame, the cells are one mile square, the average block size in Scottsdale, AZ. Land use in each cell was determined from aerial photographs with each cell being assigned to the category of the dominant cover class. Development has proceeded from the south and, as can be seen from the graph in the upper right panel, there has been a steady conversion of desert and agriculture land cover to municipal uses.

Results/Discussion

How has development proceeded in IBW?

- Urban land uses have steadily replaced agricultural and desert land cover (Fig. 2).
- Canal construction has hydrologically severed the watershed into three basins (Fig 3).
- Increased imperviousness has increased flashiness and reduced sediment loading (Fig. 3).
- Flood control efforts have introduced novel geomorphic surfaces (e.g. lakes and greenbelts; Fig. 4).

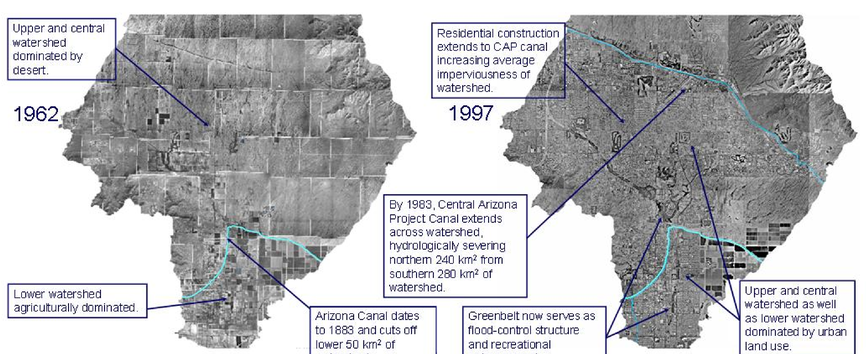

Fig. 3. Composite aerial photos of the southern half of the IBW watershed contrasting the extent of urbanization in 1962 and 1997.

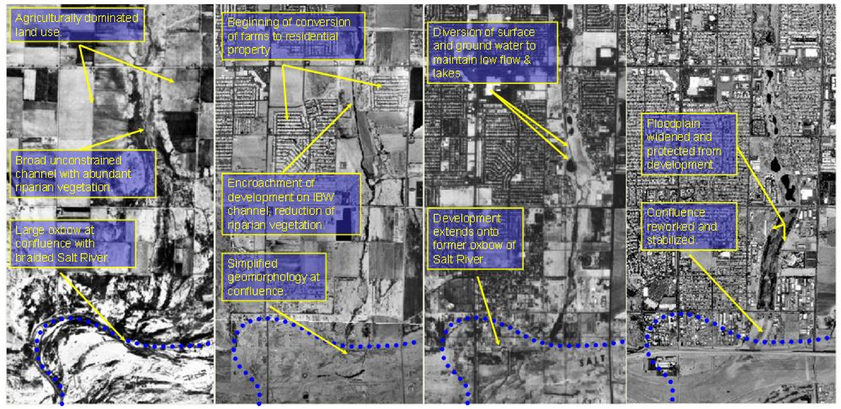

Fig. 4. Aerial photo sequence highlighting geomorphic modifications of the southern reach of IBW and its confluence with the Salt River.

Results/Discussion

How do these modifications affect biogeochemical process within IBW?

- Canals redistribute surface water across the landscape and change the scale of surface-subsurface interactions.
- Novel geomorphic structures like lakes act as hot spots for nitrogen retention and transformation (Fig. 5).

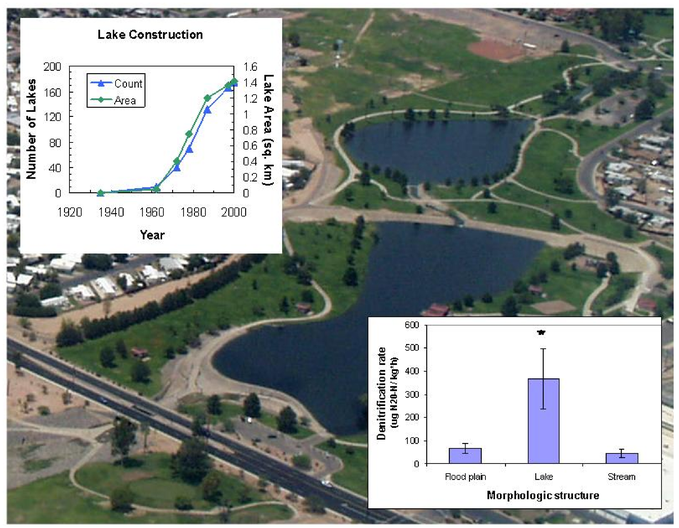

Fig 5. Lakes have become increasingly important features in IBW. The upper-left panel shows the increase in the number and total surface area of lakes in IBW. These lakes may be important sinks for nitrogen. The lower-right panel shows how potential denitrification rates varied between upper lake in the above photo, the adjancent floodplain and the stream flowing into the lake.