Evolving designer ecosystem sheds light on unintended consequences

September 3 2008

Amidst the semi-arid stretches of Phoenix, a visitor might blink twice at the sight of a sailboat cutting across the horizon. Tempe Town Lake, on the northern edge of Arizona State University (ASU), is just one of a multitude of lakes, small ponds, canals and dams combining flood control, water delivery, recreational opportunities and aesthetics, and altering perception of water availability and economics in the area.

What are the consequences of such human-made tinkering with land cover and hydrology on surrounding native ecosystems and biodiversity? This question forms the backdrop for a case study proffered by an ASU research team and published in the journal *BioScience,* which found that one of the most profound impacts of urbanization is the "reconfiguration of surface hydrology."

Lead author John Roach, now with Simbiotic Software in Missoula, Mont., ASU professors Nancy Grimm and J. Ramon Arrowsmith and other former graduate students mapped water resources and connectivity and tracked land-use change in the Indian Bend Watershed (IBW). The researchers, associated with the Central Arizona-Phoenix Long Term Ecological Research project (CAP-LTER) and the Integrative Graduate Education and Research Training (IGERT) in Urban Ecology funded by the National Science Foundation, found that construction of artificial lakes and canal systems along with extensive groundwater pumping have had "unintended impacts on nutrient cycling."

"As Phoenix grew from a small settlement to the large urban center it is today, it built an extensive canal network to bring water from the Salt, Verde, and Colorado rivers to agricultural fields and city taps," says Roach. "While these canals enabled farmers to grow crops in the desert, they also cut across stream channels, disrupting the flow of water and sediments from tributary networks to the main channel. In pristine streams, sandbars and other patches created where these sediments collect are often ideal places for nutrient cycling. By starving streams of their historic supply of this material, canals accidentally alter the way nutrients are cycled in stream ecosystems."

Humans have altered water systems in the Phoenix area as far back as 300 B.C. The Hohokam people constructed an extensive series of canals for irrigation in the region (until 1450 AD). A new group of settlers arrived in the 1860s and immediately began building "ditches" or simple irrigation canals. Construction continued through the 1900's as dams were built to harness the Salt and Verde rivers and the canal system was expanded to bring more land under cultivation. As the area became more urban, flood control became more important, necessitating construction of the Indian Bend Wash greenbelt, one of the first non-structural flood management structures in the United States. These activities altered surface water availability, dramatically increasing the timing and spatial distribution of stream flow.

"Prior to these alterations, channel systems like those of Indian Bend Wash were ephemeral, storm precipitation-driven systems with only a limited connection to the groundwater (via loss from the channel bed)," notes Ramon Arrowsmith, professor with School of Earth and Space Exploration in ASU's College of Liberal Arts and Sciences. "Now, the surface and subsurface hydrologic network is short circuited with water entering the channel from well and canal sources, and water leaving by important evaporation, seepage, and canal redirection."

The authors emphasize how modern urban water systems shatter any limitations imposed by the topographic contours of a region. The Central Arizona Project cuts a blue swatch across the Sonoran Desert and subdivides watersheds, to deliver a reported 1.7 × 109 m3 per year (or 1.5 million acre-feet) of surface water to the area. In addition, the pumping of ground water has dropped the water table 90 meters and connected surface and subsurface flows, "not only increasing the spatial and temporal availability of water, but having the unintended effect of increasing the flux of NO3 through urban waterways by returning nitrogen leached from historic fertilizer applications to surface flows."

One concern is the potential impact on riparian species, the "integrity of native ecosystems and the continued delivery of goods and services from these ecosystems."

Streams in deserts are often overlooked in their importance because of their ephemeral nature; however, streams in general have been shown to be critical to the removal of excess nitrogen from agricultural fields and waste water run-off from urban areas. Denitrification, a bacterially-mediated process, converts nitrate to nitrogen gas, which then is released harmlessly to the atmosphere. High nitrogen loads from urban areas can overwhelm streams' capacity to remove nitrates and the resulting pollution of downstream rivers has been linked to the proliferation of coastal dead zones.

"We were surprised by how frequently the concentration of nitrate in surface waters was determined by the turning of a tap," Roach notes. "Because the groundwater below the greater Phoenix ecosystem contains a lot of nitrate, when groundwater wells are tuned on, the concentration of nitrate in the canals and streams receiving this water goes up. This nitrogen, in turn, can act as fertilizer, stimulating unwanted growth and producing changes in what the stream looks like that are independent of the decision to deliver more water to city lawns."

The present study underscores the importance of understanding the structure and function of natural streams and arid ecosystems and how they are impacted by human-altered systems, water distribution and design. The authors point out that the unintended consequences "must be carefully evaluated – especially in arid and semiarid cities – if managers are to have any hope of mitigating them."

Grimm, a professor in the School of Life Sciences and member of the Global Institute of Sustainability at ASU, sums their study up: "Our findings contribute to answering the more general question of how fundamental ecosystem services – those processes of ecosystems that provide a natural resource or regulate properties of the resource, for example – change when people make large alterations to streams during the course of urban development. Perhaps our case study will help define how to best design such ecosystems to meet the need to provide multiple services – in this case, protection from flooding, recreation, and regulation of nutrient concentrations reaching downstream systems."

Source: Arizona State University

Citation: Evolving designer ecosystem sheds light on unintended consequences (2008, September 3) retrieved 25 April 2024 from
https://phys.org/news/2008-09-evolving-ecosystem-unintended-consequences.html