METER
ENVIRONMENT

UNRAVELING THE EFFECTS OF DAMS IN COSTA RICA

Thirty years ago, in Costa Rica's Palo Verde National Park, the wetlands flooded regularly and eco-tourists could view thousands of waterfowl. Today, invasive cattail plants cover portions of the wetland which has subsequently dried up and become colonized by hardwoods. Consequently, the number of birds has fallen dramatically.

Some people blame the dams built in the 1970s which introduced hydrological power and created a large irrigation district in the remote region. Dr. Rafael Muñoz-Carpena, Professor and University of Florida Water Institute Faculty Fellow and his research team are performing environmental studies on the wetlands, trying to unravel the effects of the dams and how to revert some of the damage. Rafael explains, "We have a situation where modern engineering brought about social improvements, helpful renewable resources, and irrigation for abundant food production. But the resulting environmental degradation threatens a natural region in a country that depends on eco-tourism."

ARE THE DAMS RESPONSIBLE?

Dr. Muñoz-Carpena says because of lack of historical data it's difficult to untangle and separate all the factors that have caused the environmental degradation. He adds, "Thirty years ago Palo Verde National Park was part of a large wetland system which was important to all of Central America because it contained many endangered species and was a wintering ground for migratory birds from North America. The Palo Verde field station on the edge of the wetland, operated by the Organization of Tropical Studies (OTS), attracted birdwatchers and wetland scientists from all over the world."

In the 1970's, with international funding, a dam was built in the mountains to collect water from the humid side of Costa Rica in order to generate hydroelectric power. It was clean, abundant, and strategically important. With the water transferred to the dry side of the country, a large irrigation district was created to not only produce important crops to the region like rice and beans, but to distribute the land among small parcel settlers.

Over the years, however, the wetland area slowly degraded to the point where its Ramsar Convention wetland classification is under question. Rafael says that understanding the causes of the degradation, the impacts of the human system, and how the natural and human systems are linked, is the big question of his research, and there are many factors to consider. “The release of the water, ground and surface water (over)use, agriculture, human development, and a larger population are all factors that could contribute to this degradation. Everything compounds in the downstream coastal wetlands. In collaboration with OTS and other partner organizations and universities, we are trying to disentangle these different drivers.”

A LACK OF HISTORICAL DATA

One of the challenges the researchers face is to gather a sufficient amount of temporal and spatial information about what happened in the past forty years. There are no public repositories of data to tap, and the information is spotty and hard to access. Rafael says, “Thanks to the collaboration of many local partners, we have been able to gather enough information to stitch together a large database out of a collection of non-systematic studies. The biggest challenge is to harmonize data that has been collected by different people in non-consistent ways.” This large database now contains the best long-term record possible for key hydrologic variables: river flow, groundwater stage, precipitation, and evapotranspiration.

The team is also using remote sensing sources to try to obtain time-series data for land-use and vegetation change, and will have those data ground-truthed through instruments that are collecting similar time-series data. Rafael says, “The idea is to build a network that will allow us to overlap some of the previous data sources with our own, validate and upscale the ground data with remote sensing sources, enabling us to put together a detailed picture of what happened.”

THE DATA CHALLENGES OF REMOTE LOCATIONS

The team began collecting data, as part of a joint effort with the Organization of Tropical Studies (OTS) research station. However, typical sensors require constant supervision and frequent visits, which imposed a burden on the station staff. There was also the risk of losing data if a sensor malfunction went undetected between monthly visits. Rafael says, “Sometimes access was not possible due to floods or scheduling issues, so there was a high risk of losing information. To fix the problem (thanks to a National Science Foundation grant awarded to OTS) we integrated the sensors into a system that gives us remote access on a daily basis. This allows us to see the status of the instrumentation in near real-time, and thus coordinate with OTS to replace sensors if needed.”

The stations are now outfitted with METER soil moisture and salinity sensors

CONNECTIVITY ISSUES

The team had a difficult time finding internet connectivity because the area is so remote. After trying several solutions, they finally built their own cell towers. The stations are now outfitted with METER cellular-enabled data loggers in conjunction with rain gauges and METER soil moisture and salinity sensors. The stations also include a standing well to measure surface and river water levels and monitor flooding stages. These are coupled with shallow water table wells, installed below the surface at 3 to 5 meters. Rafael says, “These are tidal rivers, so we get a lot of activity up and down. We look at river data in conjunction with inland responses to try and get an idea of the influence of the river on the shallow groundwater nearby. All these data feed into a database that researchers and stakeholders can look at.”

ZL6 data logger

INTERNAL DRIVERS

Dr. Muñoz-Carpena says because of the lag in the environmental response, it is not immediately clear to the general public that the wetland behavior is the result of what is happening upstream. People fail to see a connection. Therefore unraveling the data in a way that is clear is the first challenge of the project. He adds, “There are also internal drivers such as park management changes that compound the effects of the dams. Originally park managers tried invasive plant control with fire and cattle. Now they control the invasive with blade-rigged tractors that mow the cattail. But this is a highly expensive and temporary measure with recurrent costs, which provides no definitive solution to the cattail invasion. It’s important to understand the changes are not just the result of what’s happening locally. We need to find permanent solutions by tracking down the root of the problem.”

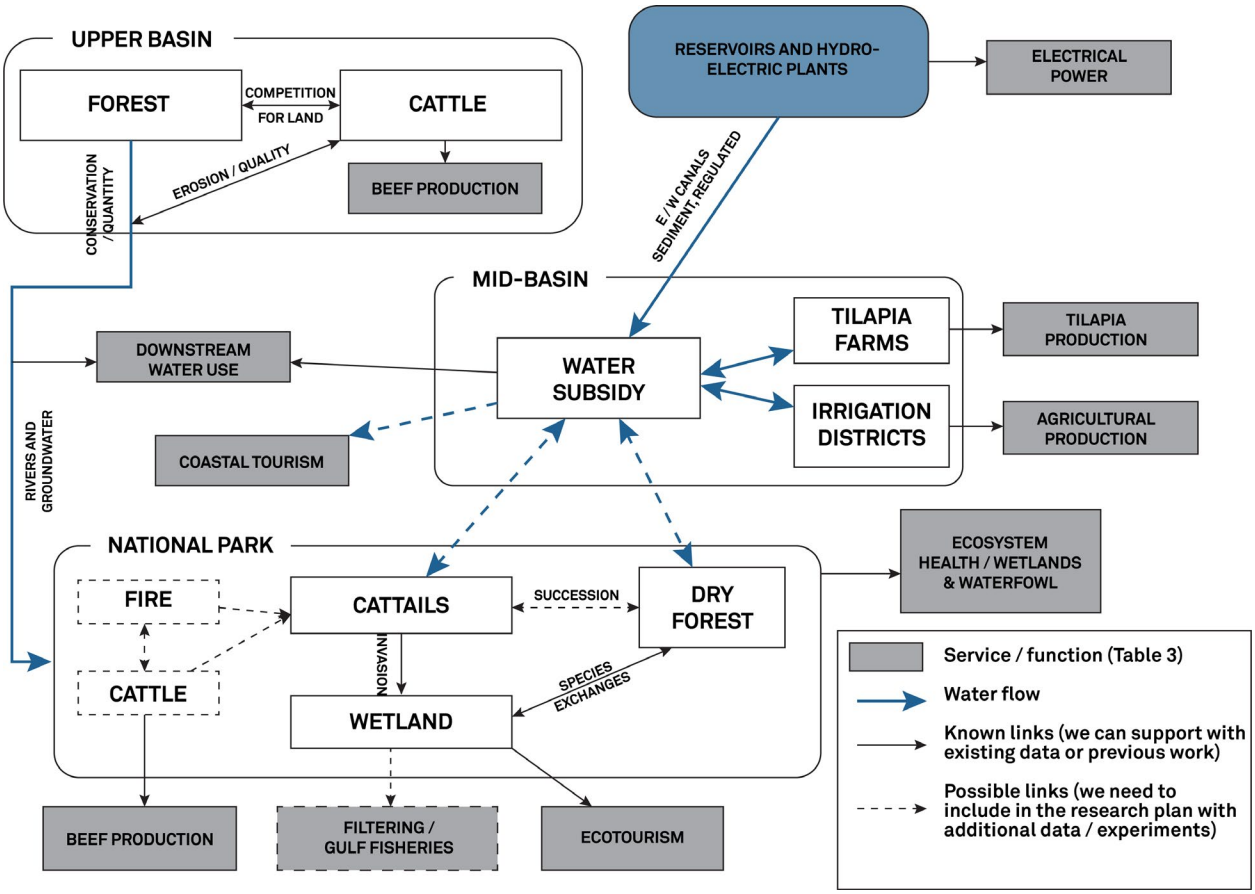

Figure 1. Conceptual representation of the Palo Verde National Park in the context of the Tempisque watershed system

PLANTS ARE NOT THE ONLY INVASIVES

Cattails are not the only invaders that plague the wetlands. Rafael explains, “The other problem is that there is trafficking going on in the park. The men see these data

logger boxes with silver antennas, and they think it's a camera, so they break off the antennas. We are now putting up signs that say, 'This is not the government watching you. This is research to protect your environment,' but we are afraid the next time they will break the boxes and everything that goes with them. We won't have the manpower or the financial resources to go down there and fix the data loggers for another six months."

WHAT'S NEXT?

Over the last three years the team has collected a high-resolution database of fifteen- to thirty-minute timed steps, with over 100 soil moisture sensors deployed in twelve spatially-distributed monitoring stations around the park. With that data, Rafael's team is conducting exploratory types of analysis to study not only potential drivers of change, but also the cause of the drivers. They want to understand potential initiatives they could introduce to make the system more sustainable. Rafael says, "Once we develop integrated hydrological models and test them for the conditions in Costa Rica, hopefully we can understand the behavior in the past and forecast some different scenarios for the future." Because many regions in the world suffer the impacts of interbasin water transfer, this research can inform future research policy at a broader scale.

See a map of the instrumentation network within the Palo Verde National Park.

Discover METER soil sensors and data loggers