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Results from Community Based Fuels Monitoring: Management Implications from a Case Study from Payne's Creek National Park, Belize, Central America

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Introduction

Payne's Creek National Park (PCNP) in Southern Belize is a conservation keystone connecting the protected areas of the Maya Mountain Conservation Corridor to the sea. The Pine woodlands and savannas of PCNP are important habitat for a number of species of concern such as the Endangered Yellow-Headed Parrot (YHP) (Miller 1997, Clay 1999, BirdLife International 2018). Several communities adjacent to this protected area depend upon forest products for their livelihood from bordering Deep River and Swasey-Bladen Forest Reserves.

Fire use is common in Southern Belize. Fire is used to improve forage for wildlife and clear forest for planting crops. As population increases, the frequency and extent of fire use is impacting the economy and the ecosystems that people depend. Community members and protected area managers must suppress some wildfires which occur in the dry season because they are threatening life and property.

There is limited government support to suppress wildfires. With minimal institutional firefighting capacity, the communities must bear the responsibility of solving the problem of wide spread severe fires. As fire occurrence increases, crops are lost and structure are threatened as well as the ecosystems on which the communities depends.

Management objectives of PCNP focus upon reducing the threat of severe wildfires on the ecosystem of the Endangered YHP. To create future habitat, managers require strategies to reduce mortality of Caribbean Pine, their primary nesting habitat. The Darwin project (Conserving pine woodland biodiversity in Belize through community fire management) was designed to assist the communities and protected area managers with fire monitoring techniques to evaluate best practices for fuel management in this pine savanna ecosystem and adjacent broadleaf forest. Community members and protected area staff from Toledo Institute for Development and Environment (TIDE) collaborated with fire ecologists to develop protocols to monitor fire management objectives. Three variables were chosen: pine (*Pinus caribaea*), palmetto (*Acoelorrhaphe wrightii*) and cycad (*Zamia prasina*). They were selected based on their ecological and economic interest.

Pine regeneration is important to local economies. Sustainable logging supports jobs within the study area. Within Southern Belize, pine lumber is an important building material. For biodiversity, mature and dead standing large diameter pines are important nest and roosting sites for the YHP (Russell 1964, Nash 2004). The YHP prefers dense stands of pine adjacent to woodlands and palmetto populations. These sites offer cover from predators and access to the palmetto berry and other food sources.

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Palmetto grows in patches throughout the landscape. These patches provide hiding and cover to a variety of wildlife. They also provide an important source of shade in open grasslands and woodlands of the study area. Field observations suggest a large array of species use palmetto. Flowering palmetto attracts insects to nectar and pollen and those species who feed upon them. The berries are eaten by a variety of wildlife including the YHP. The trunks and fronds of the palmetto are an important building material by Maya and Creole peoples. Berries are collected and sold for cash income for the international botanical market.
Cycad grows upon the ground. Cycad (*Zamia prasina*) is listed as Critically Endangered on the IUCN Red List (Stevenson 2010). This cycad exists within the study area. Because of its threatened status, it was included in the monitoring variable. The impacts of management and long term conservation will benefit from monitoring this species response to fire and forest management practices.

Severe large-scale wildfires threaten both pine regeneration through direct heat mortality on seedlings and consume palmetto florescence and berries. In contrast, low-intensity burns have ecological benefits such as nutrient cycling, carbon sequestration, and increased pine seedling survival (Kellman *et al.* 1985, 1987, Myers *et al.* 2006).
Wildfires are generally of anthropogenic origins, ignited by community members for various purposes in and near protected areas within the study area. Some wildfires are beneficial for preventing more severe dry season fires depending on fuel and weather conditions. Protected area managers may use these wildfires to meet management objectives when they occur within predetermined prescription (van Wahtendonk 2007). Prescribed fires can be management-ignited fires, human-caused, or lightning ignition as long as prescription parameters are met (Miller 2003). Management ignited fires require a written plan and approval from the Belize Forest Department. These fires are implemented to reduce the risk of severe dry season fires and impacts on the ecosystems.

Methods

Since the impacts of severe wildfires were identified as a significant threat to biodiversity and livelihoods, understanding the effects of fire is a critical social and land management inquiry. The following questions were assessed as the most important to achieve management objectives for PCNP:

What are the fire effects on pine regeneration, palmetto productivity, and cycad populations?

Are there management methods to diminish negative impacts of fire on the studied variables?

To answer these questions and to understand the impacts of management ignited prescribed fires as well as wildfires, community-based survey teams along with Protected Area managers and students from the University of Belize installed 14 permanent monitoring plots (50x20m) and repeatable photo-points to evaluate fire impacts on pine regeneration, cycad population and palmetto distribution and abundance. The plot locations were randomly placed. Sites without pine and palmetto were rejected. The data collection consisted in recording the location, live status pre and post burn and number of each of the monitoring variables: pine trees, poles and seedlings (based on DBH measurements), palmetto patches and seedlings, and cycad stems.

Information on the flowering/fruiting status of the palmetto patches was also recorded, as well as char height on pine trees to record flame length to characterize fire intensity relational to the height of the pine seedlings.
During each monitoring session, repeatable and quantifiable photo points were collected from the plot center to visually monitor changes over time (Figure 1).

Figure 1: Photo monitoring of pre and post fire changes in fuels in Payne's Creek National Park
Source: Tricone and Anderson (2018a)

A field manual describing methods to establish the plots and collect data was developed (Tricone and Anderson 2018b), using the modified Whittaker plot design (Avi 1984) and US National Park Service Fire Monitoring Handbook as a reference (USDI National Park Service 2003).
In additional to the 14 permanent monitoring plots, 16 palmetto monitoring points were selected based on their proximity to communities known to harvest palmetto berries. The monitoring points were placed in two adjacent reserves (Swasey-Bladen & Deep River Forest Reserves) to PCNP to provide an assessment of fire effects on palmetto production around the communities. Data collection of palmetto patches consisted in recording their status (burned, unburned), in counting the number of live, dead and cut palmetto trunk, the number of dead, fruiting and flowering stalks, and the average number of seeds on a representative stalk.

Results

The data collected suggest management ignited fire and specific fire behavior characteristics are important to meet community and ecological objectives:
- The ICUN Red Listed cycad appears relatively common and resilient to fire impacts. Monitoring data indicates this species recovers through res-sprouting readily after fire.
- The survival of palmetto inflorescence is impacted by fire through direct consumption by high intensity fire. The cash economy of palmetto berry harvest depends upon
fire management strategies which enhance the production of berries and protects future berry crops for communities and wildlife. Burning during seasons where florescence and fruit are absent avoid direct impacts and reduces fuel loading for periods when florescence and berries are present thus reducing the risk of direct mortality.
- There are fire effects that are harmful for the future production of pine seedlings future economic and construction material depend upon. The destruction of pine seedlings will reduce future habitat of the YHP thus diminishing the value of the site for tourism.
- The results suggested a role of the shrubs in protecting the pine seedlings (Figure 2). Managers are cautioned to use ignition techniques and timing of fires to reduce mortality on shrubs. Burning with low intensity fire and creating patches of burned and unburned are recommended

to retain shrub cover to raise ambient relative humidity and decrease flame lengths and heat per unit area.

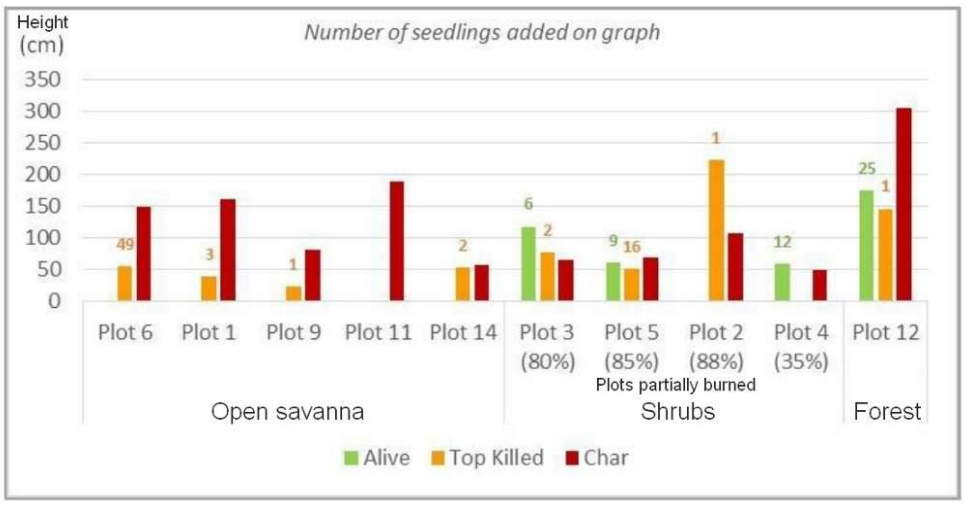

Figure 1: Graph suggesting the importance of the vegetation surrounding the pine seedlings (open savanna, shrubs and broadleaf forest) on their post burn survival. The plots constituted by the shrubs were only partially burned after fire (see percentages on plot name). We can note that all seedlings were burned in open savanna where the max char height (average 128cm) is greater than in other vegetation types. On sites with shrubs present, where max char height was smaller (average 73cm) and plots partially burned, pine seedling survival was higher than in open, wiregrass (*Aristida spp*) dominated areas. In the burned forest plot, most seedlings survived regardless the high max char height within the plot.
Source: Tricone and Anderson (2018a)

Discussion

Using adaptive management, the fire effects monitoring data allow managers to evaluate ignition techniques to reduce flame length and severity and contribute to seedling survival. Managers have used these data and developed prescribed burn techniques to increase pine seedling survival in PCNP by reducing the intensity and severity of ignition patterns in shrub-dominated ecotones. Using community members and TIDE field staff enabled learning and skill acquisition. Community based science and monitoring efforts such as this serve as a nexus between TIDE and the communities near PCNP. The implementation of integrated fire management serves as an excellent communication tool between protected area managers and villages within the region (Myers 2006, Rodríguez-Trejo et al. 2011). Escaped agriculture burns have been reduced by over 50% since the initiation of this study with a result of decrease in threats to life and property (Muschamp M pers. comm., Terrestrial Manager, TIDE).

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