DR THOMAS FICKERT

Monitoring mangroves

Following the massive destruction caused by Hurricane Mitch in 1998, mangrove forests on the Island of Guanaja, Honduras, have begun the slow process of regeneration. **Dr Thomas Fickert** sheds light on his research in this area

To begin, could you explain why we should value mangroves? What are their ecological and economic benefits?

Aside from their characteristic beauty, mangroves afford many important direct and indirect benefits. Mangrove forests not only provide habitat for many highly adapted and often rare animal species, they also grant human beings with countless ecosystem services: fishing, wood, nutrient cycling, preventing coastal erosion and the siltation of the coral reefs. These in turn are economically important for tourism as dive sites. Mangroves also provide vital protection from natural hazards such as hurricanes and tsunamis, and ensure maintenance of water quality.

What are the specific aims of this project focusing on the Island of Guanaja, Honduras and how is it supported? Why does the study focus on this region?

The research project, which has been funded twice by the German Research Foundation (Deutsche Forschungsgemeinschaft – DFG), deals with the regeneration of mangrove forests on Guanaja after a severe storm disturbance caused by Hurricane Mitch in October 1998. The hurricane had a low track speed and remained very strong for almost three days near Guanaja. Many ecosystems on the island suffered severe damage but the mangrove forests were particularly exposed to wind and wave action.

The specific aims of this project are to document the state of recovery of mangrove forests on Guanaja in regular intervals. By this means it will be possible to assess differences in the regeneration between more exposed, windward sides, and less exposed, leeward sides of the island, and to test whether the former mangrove areas of Guanaja follow a commonly suggested 'autosuccession' (whereby species life-history traits and longevity are more significant than competitive ability), or whether shifts in species composition and vegetation structure occur during regeneration.

Can you offer a brief outline of the methodology by which you aim to achieve your scientific objectives?

The study employs line-transects from the seaward side to the transition to terrestrial formations at six different mangrove areas on Guanaja. The transects were established, GPS-surveyed and flagged in 2005; this was repeated in 2009 to document changes. Long-term monitoring is intended, with re-surveys of all transects at regular five-year intervals in the future. Along the transects – a total of 1,900 m – the occurrence of all living species is recorded at a resolution of 0.1 m. These raw data are merged afterwards to adjoining 10 m segments and distance values are converted to groundcover values for standard statistical analyses.

Has your latest assessment yielded any surprising results?

The study is designed as a long-term monitoring project, so true results are not expected before the completion of a couple of re-surveys. An initial surprise has been the fact that different successional pathways occur close to each other. It is a widespread assumption that, in species-poor mangrove forests, regeneration after disturbance follows a development called autosuccession, where the same tree species present before the disturbance resume dominance during the regeneration process. That is unlike most terrestrial forest types where different successional stages occur. In particular, the herbaceous stage within the mangrove regeneration on one site on Guanaja contradicts the assumption of a universal autosuccessional pathway within disturbed mangrove forests.

What are the biggest threats currently facing mangroves? How can we reverse this trend?

The biggest threat to mangrove forests worldwide comes not from natural agents like storms or tsunamis but by direct and indirect action of man. Accelerated sea level rise tied to climate warming, and proceeding faster than the ability of the trees to adapt, might be a severe problem in the near future and will reduce the area of mangrove forests substantially.

An even greater threat is the ubiquitous conversion of mangrove forests and the overexploitation of their natural resources all over the world. 35 per cent of the original mangrove area disappeared within the last three decades alone. With a mean annual loss of 2 per cent at the current deforestation rate (in comparison, the commonly highlighted annual deforestation of tropical rain forests is only 0.8 per cent) mangroves will no longer exist in 2100! Ironically, 4.3 million scientific papers on mangroves are projected to be published at that point. It is highly doubtful that increased awareness could counteract this trend.

In light of these facts, what ultimate impact do you hope this work will have?

I hope to gain a better understanding of the trajectories of successional pathways in mangrove regeneration after hurricane disturbance with the re-sampling strategy employed. The state of regeneration at the six different mangrove areas of the tiny island of Guanaja shows remarkable differences depending on wind exposure a decade after the hurricane impact. Thus, a general uniform successional pathway for the wind-disturbed mangrove forests on Guanaja does not seem to exist, and that is probably true for Caribbean mangroves in general.

DR THOMAS FICKERT

Successional trajectories of Caribbean mangroves

With funding from the German Research Foundation, a novel long-term study is underway in the Caribbean. The research project – led by the **University of Passau** – is already beginning to reveal how mangrove regeneration is a more varied and complex process than previously thought

THE TINY BAY Island of Guanaja, just off the northern coast of Honduras, attracts visitors from all over the world to its beautiful sandy beaches and temperate climate. This inviting gem in the Caribbean boasts mangrove forests, coral reefs, turquoise waters and a diverse array of marine life such as dolphins and turtles. Every year many tourists arrive to make the most of the perfect conditions for diving, snorkelling and fishing. But this idyllic and relaxing location also hosts bouts of tropical storms and hurricanes during its wettest season, from October to January.

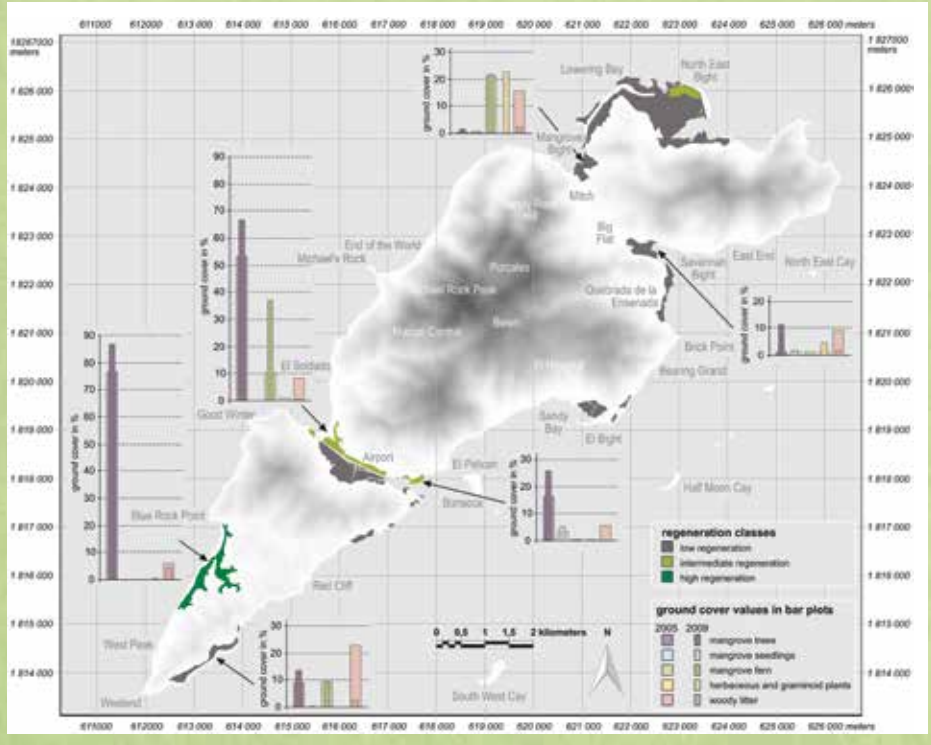
In October 1998, Hurricane Mitch – one of the fiercest Atlantic storms of the 20th Century – struck the region. Guanaja was particularly hard-hit, and endured three days of ferocious wind and rain. Happily, the number of casualties on the island was low but the widespread destruction of its vegetation was impossible to avoid; 97 per cent of the island's mangrove forests were damaged. The mangroves lost leaves, buds and twigs, and suffered broken stilt-roots and stems.

In 2005, Doctor Thomas Fickert established a research project to investigate the regeneration of Guanaja's mangroves. In this study, he is recording the slow process of regrowth at regular intervals to find out how Hurricane Mitch affected the vegetation structure and species composition of the mangrove forests. As rising sea surface temperatures will only increase the intensity of future storms, this is a timely investigation into how mangroves recover from such damage and the limits of their regeneration.

A NOVEL APPROACH

Funded by two grants from the German Research Foundation (DFG), Fickert enjoys the support of local institutions in Honduras and the Bay Islands and his colleagues within the Department of Physical Geography at the University of Passau.

FIGURE 1. Digital elevation model of Guanaja; mangrove areas and their respective regeneration classes (low, medium, high) are overlain. The bar charts indicate changes in ground cover values between 2005 and 2009, separately diagrammed for mangrove trees, mangrove seedlings, mangrove fern, herbaceous and graminoid plants and woody litter.



Mangrove forests worldwide have an uncertain future due to conversion and overexploitation as a natural resource by the local population, and the potential impacts of global warming. By understanding more about mangroves and their regeneration, their conservation and restoration can be better enforced, maintaining the valuable services they provide, from food to medicine and natural coastal protection.

In 2005, six main areas of mangrove forest were selected for the study. Transects were set up in each area and the vegetation within them was carefully sampled in the first step of a long-term effort to monitor its regrowth. Fickert is confident that this sampling method is perfect for achieving the aims of the research: "The GPS-surveyed and flagged transects can be relocated sufficiently precisely and the high-resolution data (with a sampling accuracy of 0.1 m) perfectly document the change in groundcover of vegetation and the establishment of seedlings with time".

Thanks to the varied topography of Guanaja, it is likely that different patterns of regeneration will emerge between the six areas. This natural laboratory should provide a deeper understanding of a wide range of successional pathways among mangrove populations. Although many other studies have been conducted on the effects of hurricane damage on mangroves, this is one of the few to take a long-term prospective and commit to revisiting the same sites at regular intervals over a substantial period of time.

A WAITING GAME

The nature of this study means that conclusive results will not be available in the near future. The work itself involves painstakingly recording every single living species along each transect, including growth height and the amount of woody debris left from the hurricane. Any plants over 2 m tall are also measured in diameter. Changes are analysed using standard statistical methods. After a number of re-surveys this technique will build up a very clear picture of the changes and progress occurring in the vegetation. The study also takes into account soil chemical properties. With a multi-parameter measuring device, factors such as soil salinity and pH values were recorded every 25 m along the transects. Soil samples were also taken for laboratory analysis in order to reveal more about its texture and composition.

FIGURE 2. *Rhizophora mangle* seedling encountered along the transect in 2009 in El Pelican. Ground cover and growth height of species are recorded by every visit.

This natural laboratory should provide a deeper understanding of a range of successional pathways among mangrove populations

Before Hurricane Mitch, mangroves covered 243 hectares of Guanaja's bays and lagoons. Mangroves are notoriously species-poor ecosystems in the Caribbean with just three tree species, one transitional associate and one understory plant. In general, scientists hold the assumption that mangrove recovery follows the rule of autosuccession, where the same plants grow back to assume the dominance they had before damage occurred. After just two surveys, in 2005 and 2009, Fickert has already revealed a surprising variety of regenerative pathways that challenge this assumption.

Some of the mangroves, for example those that only suffered defoliation, are in extremely vital condition and are now approaching their pre-hurricane condition. In other areas, where the damage was greater, natural regeneration processes occur, sped up by humans bringing in seeds from nearby healthier areas. At one site, however, the soil conditions have probably been altered too drastically for mangrove regrowth to take hold. Instead, there is a widespread invasion by herbaceous plants rarely found in mangrove areas. The site could prove to be undergoing a conversion into a salt marsh, but it could also be just an alternative phase in the regeneration of the mangroves. The next survey is scheduled for 2014, but it will take some more surveys before Fickert's group can form a tangible conclusion.

A LONG-TERM COMMITMENT

The team's approach of studying mangrove regeneration over a long timescale means they will be able to spot trends which one-off surveys could never reveal. Despite the clear advantages of this method, Fickert believes it is rarely undertaken because of the nature of the international research environment: "Repeated sampling requires patience – an uncommon attitude of our current scientific era where the 'publish or perish culture' commonly causes research to be designed in such a way that publishable results emerge quickly". By working against the grain, he has created an important opportunity to deepen our understanding of vegetation dynamics in mangroves after destructive events like hurricanes.

The study has already revealed some surprising deviation from the expected redevelopment process of the mangroves. Hurricanes are likely to become even more intense as sea levels and temperatures change with the climate. Although the mangrove forests of Guanaja have shown remarkable resilience and recovery from hurricane damage in the past, those exposed to this storm have shown the most significant changes, with some potentially in the process of conversion to salt marshes. This study will provide valuable information on the likely future of endangered mangroves in the Caribbean and elsewhere. Yet, as anthropogenic pressure builds on mangroves worldwide, their future is far from certain.

INTELLIGENCE

THE STATE OF RECOVERY OF MANGROVE FORESTS ON THE BAY ISLAND OF GUANAJA

OBJECTIVES

Hurricane Mitch was one of the most intense Atlantic storms of the past century. Due to its low track speed off the northern coast of Honduras, the Bay Island of Guanaja was struck violently. Some ecosystems of the island regenerated quickly; others, such as mangrove forests, experienced high destruction and slow recovery within the first couple of years. Since then, depending on location (windward/leeward) and severity of destruction, different trajectories of regeneration and re-colonisation by plants occur.

The research on the regeneration of mangrove forests on Guanaja after Hurricane Mitch is designed a long-term monitoring project with re-surveys in five-year intervals to get a better understanding of the regeneration dynamics of these precious forests providing important ecosystem services for human beings.

KEY COLLABORATOR

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DR THOMAS FICKERT is a Research Associate at the chair of Physical Geography at the University of Passau, Germany. His research is focused on plant geography with a special emphasis on vegetation dynamics, disturbance ecology and succession. Beside the project on mangrove regeneration, a second focus is on primary succession in recently de-glaciated glacier forelands in the Eastern Alps also employing permanent plots.

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