> **Understanding how to manage the interactions between insects and ecosystems is vital to ensure sustainability of ecosystem services**

It's a bug's life

Entomologist **Dr Timothy Schowalter**, from Louisiana State University, investigates the intrinsic links between insect populations and the provision of ecosystem services essential for human survival. Viewing their population dynamics as a vital indicator of ecosystem health opens the possibility of using these data for improved management of global resources. In pursuit of this aim, Dr Schowalter and colleagues organise influential symposia alongside renowned international conferences to draw together researchers in this field.

Natural ecosystems provide a variety of services on which humans, and other organisms, depend for survival and well-being. These services can be categorised as those which provide material benefits such as food, water and other resources; those which provide some sort of cultural benefit through recreation or other aesthetic values; or support services and regulation such as pollination, soil formation through decomposition, and biological control from predator–prey/parasite–host relationships.

THE BENEFIT OF BUGS

Nevertheless, ecosystems have also been viewed as producing "disservices" (pests, litter, diseases, animal attacks, allergens, floods and storms). However, many of these are in fact induced by management practices (such as deforestation and concentration of agricultural crops), which negatively impact on the ability of the ecosystem to function effectively. Because insects affect ecosystem services in a variety of ways, positively and negatively, their dynamics might be seen as a barometer of ecosystem functionality.

Understanding how to manage interactions between insects and ecosystems is vital to ensure sustainability of ecosystem services, while minimising disservices. This is the focus of Dr Schowalter's research, which has both a local and a global dimension in the collection of data and the impact of its findings.

IN IT FOR THE LONG HAUL

Using the direct experimental study of insect populations in specific locations, alongside reviews of relevant literature, Dr Schowalter takes a longer-term view of the elements affecting resource provision and insect population characteristics. This long-term approach is critical to the assessment of ecosystem services and the effect of climate change, and Dr Schowalter highlights the importance of the platforms provided by the US Long-Term Ecological Research (LTER) Program and the International Long-Term Ecological Research (ILTER) network (with sites in England, throughout Europe and many other countries).

During studies conducted over the past 27 years in Puerto Rico following hurricane damage of a forest ecosystem, Dr Schowalter and colleagues found that arthropod populations (including spiders and mites, as well as insects) showed substantial changes following the event. Initially there might be a rise in detritivores (species which feed on decaying matter), for example, as the abundance of this food source increases. Conversely, as new growth begins, this may favour a rise in populations of sap-sucking arthropods.

The key to this research, however, was its duration. Monitoring the ecosystems over the long-term showed that the reductions in certain species caused by the hurricane event persisted for many years. Despite other events occurring which might have favoured the resurgence of these creatures, their earlier loss or severe reduction was difficult to overcome. This has far-reaching implications, as it shows that any habitat disruption has the potential to affect arthropod populations long into the future. As Dr Schowalter himself says: "This reinforces the need to consider historical legacies when seeking to understand responses to disturbance."

A NOT SO MODERN PROBLEM

Changes in land use due to agricultural and urban expansion, pollution, and climate change all have the potential to alter the balance of these complex ecosystems for decades to come. As human populations rely on the correct functioning of these ecosystems for essential services, it is vital to understand how our activities might exacerbate, and how we might mitigate, these effects.

From studies of previous civilisations, such as the Maya of Central America and others in Mesopotamia, accumulating evidence shows that their fall was often preceded by rapid changes in land use and the failure of essential ecosystem services, that exacerbated the effects of drought. Reflecting on this during a trip to visit ancient Maya sites, Dr Schowalter noted that, "if 1000 years of forest development is not sufficient [to erase a civilisation's influence from a site]… how do we know if the "natural" ecosystems we use as baselines are truly natural, and does it matter?"

All ecosystems are affected to some degree by human activity, as global climate and atmospheric composition impact on systems remote from the source of change. Dr Schowalter concludes that there is benefit in comparing environments which have been more and less affected by human activity. In doing so, scientists can assess the current impact of human activity on ecosystem structure, function and the services it provides. He says: "Our greatest contributions to contemporary environmental policy will be to demonstrate how human activities and environmental policy alter ecosystem integrity and the capacity to provide essential services on which we depend."

GLOBAL PROBLEMS REQUIRE INTERNATIONAL SOLUTIONS

To this end, Dr Schowalter has teamed up with his colleagues, Dr Jorge Noriega and Dr Teja Tscharntke, to organise symposia which run alongside major international conferences, such as the International Congress of

Tim and Catherine Schowalter sitting near the top of a pyramid at the ancient Maya city, Kohunlich
© 2017 by the Ecological Society of America: Schowalter, T.D. 2011. What is a "natural" ecosystem? Frontiers in Ecology and the Environment 9(6): 358

Entomology which met in Orlando, Florida last year. Drawing together early career researchers and internationally renowned entomologists alike, these symposia aim to forge new collaborative interactions which will impact land management decisions and policy making in the future.

Taking the broad discussion of insect functions within ecosystems as their theme, the team has successfully given an overview of the range of services provided by insects in the regulation of ecosystems. In addition, they have opened the debate on the disservices associated with insect populations, which are an important aspect of the human experience. Insect damage to crops, and distress caused to people through disease and discomfort, are major drivers of insect management policies which do not always consider the disruption which might ensue.

Pulling all this together to inform policy makers and prompt scientific advances is no easy task, especially considering the global reach and significance of the subject matter. Dr Schowalter and his colleagues are certainly on the right track with their approach, which has international scope both in its research and the dissemination of expertise.

The nub of the issue is timing. Dr Schowalter poses the question: "The ancient Maya were sophisticated enough to conserve forest resources through at least twelve centuries but ultimately may have exceeded the carrying capacity of their environment. How long will our more advanced technology delay similar consequences?"

In studying some of the smallest co-inhabitors of this planet, Dr Schowalter is helping us to learn how to manage our activities so those consequences might be further postponed.

Q&A

How did you first get hooked on insects?
I collected insects, as well as leaves, fossils and other biological paraphernalia as early as I can remember, at least by five years old. I also reared caterpillars and kept snakes, lizards, etc., encouraged by my parents. My Mom was even cool with the snakes. I was fascinated by the diversity of insects, as well as other species around my home: I still am.

Why do you think such seemingly insignificant creatures are so important?
Insects are the most numerous organisms on the planet (well, next to bacteria and fungi). There are more than one million described species and best estimates place the total at around ten million. They represent 60–90% of all species in terrestrial and freshwater ecosystems, and their biomass (total mass of all individuals per unit area) frequently equals or exceeds that of more conspicuous vertebrates. Their sheer numbers ensure that many species, such as bark beetles and honey bees, can attract sufficient numbers to food resources to be important tree killers (usually aided by tree injury or stress) and pollinators, respectively. However, like all organisms, their survival depends on a balance between energy and nutrient acquisition and energy and nutrient expenditure. If climate or land use changes increase energy requirements beyond what is available, individuals will fail to survive and reproduce, and the species will disappear.

In what ways does human activity affect insect populations?
Land use changes, such as deforestation, ecosystem fragmentation or conversion to agriculture or cities, increase the distance between insect populations and other suitable habitats and resources. Insect dispersal ability is widely recognised, but most species are adapted to distances over which they have needed to disperse over millennia. For many species >90% of individuals may move no further than a few metres in their lifetime, which makes them vulnerable to land use changes that place greater distance between remnant populations and the next suitable landscape patch. Also, climate change is forcing many species to move toward the poles or higher elevations, as temperatures warm. There is less land area available toward the poles or tops of mountains, so as species approach the limits, they will run out of available habitat. On the other hand, many species, including crop pests and mosquitoes, are favoured by deforestation and land use changes that provide more standing water and access to hosts. Climate change is also relaxing limits imposed by cold temperatures on development and survival of "cold-blooded" pests, including disease vectors such as mosquitoes and fleas, that are likely to become more abundant in a warmer world.

Our efforts to suppress "pests" also affect abundances of both pests and non-target species, such as pollinators. Honey bees, bumble bees, and many other species, are highly vulnerable to pesticides, and their disappearance is threatening pollination services worldwide. In many cases, "pests" are products of our own activities, such as moving infested materials globally (across natural barriers to dispersal) in trade materials. This is how Formosan subterranean termites, bed bugs, red imported fire ants, Argentine ants, European wood wasp, Colorado potato beetle, Asian tiger mosquito, yellow fever mosquito, etc., have been moved around the world, causing serious crop, structural, and human health problems. These species have required enormous economic investments for control, which also has serious human health and environmental consequences.

However, if we were able to eliminate all mosquitoes, for example, we would potentially lose a number of insectivorous birds that feed on other insects seasonally, but rely on the availability of mosquitoes during other times. Also, many mosquito species are predators of other mosquitoes and should be considered allies, but are killed along with our targets. The disease vectors themselves are important bacteriovores in aquatic ecosystems, and their disappearance would upset the balance of bacterial growth. If we could target the invasive species without undermining native species, that would advance our overall goals.

What can we do to reduce our impact on natural ecosystems?
The goal of integrated pest management (IPM) is to manage insect pests with minimal effect on non-target species or ecosystem services. Unfortunately, our knowledge is too limited to do this successfully. Our efforts to manage insects and ecosystems often seem like the nursery rhyme about the woman who swallowed the fly, then swallowed a spider to eat the fly, etc., until she swallowed a horse (not a good ending). The best recommendation is always to use the least toxin possible, and only as a last resort, and to manipulate ecosystems as little as possible.

We often can minimise pest problems by taking lessons from nature. Nature favours diversity. Diverse vegetation tends to have fewer pest problems, diverse landscapes impede spread of pest populations, and better regulation of trade materials could reduce international spread of invasive species. Simplifying ecosystems, such as plantation forestry and agricultural intensification, facilitates the population growth and spread of species that use these resources. Diversity of birds, mammals and reptiles can reduce the incidence of disease transfer to humans. Reducing bird or rodent diversity can increase the likelihood that mosquitoes or fleas will transfer to humans, increasing spread of disease.

What do you hope will be the impact of your work?
Obviously, I would like to see environmental policies change to protect biodiversity and sustainability of ecosystem services. Simplifying ecosystems will always favour population growth of species that no longer must expend most of their energy finding resources and will lead to decline of species that may no longer have all the resources they need for survival, including many species important for sustainability of ecosystem services. We simply don't know enough to predict which species are the linchpins, or keystone species as they are known, that maintain the integrity of ecosystem services, or that will sustain ecosystem services in a warmer climate. As an example, Australia had to spend millions of dollars on research and introduction of dung beetles that could scatter and bury introduced livestock dung, because dung accumulation in their absence discouraged livestock feeding and bred blood-feeding bush flies. In this regard, maintaining natural ecosystems within more diverse landscapes would provide insurance in the form of habitats that maintain biodiversity of native species that may be best able to survive climate warming and other changes.

I would like policymakers and the public to understand that sustaining delivery of ecosystem services is not optional but critical to human survival, and that sustainable delivery depends on the integrity of ecosystem processes that produce these services, not on our ability to extract them. All of our food and fresh water, and many of our building, medical and industrial materials are products of ecosystems. We are already paying some of the costs, in terms of climate change, pollution cleanup and insecticide-resistant mosquitoes and crop pests, of our parents' "good life", enjoyed by maximising use of ecosystem services. I hope we will leave ecosystems in a sustainable condition for our children and grandchildren instead of maximising our use of ecosystem services at their expense. Finally, I hope to help people to recognise the importance of insects, not just as pests or nuisances, but as the "tiny things that run the world", in the words of E O Wilson.

As humans rely on the correct functioning of ecosystems for essential services, it is vital to understand how our activities might alter the balance of complex ecosystems for decades to come

Detail

RESEARCH OBJECTIVES
Dr Schowalter focuses on determining both the positive and negative effects of insects on ecosystem services and how this links in to climate change.

FUNDING
National Science Foundation (NSF)

COLLABORATORS
Drs Teja Tscharntke, Georg-August-University, Göttingen, Germany, Jorge Noriega, National Museum of Natural Sciences, Madrid, Spain, Jung-Tai Chao, Taiwan Forestry Research Institute (retired), Wen-Jer Wu, National Taiwan University (retired), Margaret Lowman, California Academy of Sciences, Mark Hunter, University of Michigan, Steve Fonte, Colorado State University, Hang-Kwang (Hans) Luh, Oregon State University, Michael Willig and Steven Presley, University of Connecticut, and Jess Zimmerman, University of Puerto Rico and PI of the Luquillo Experimental Forest LTER Site.

BIO

Dr Schowalter has been a Professor and former Department Head at Louisiana State University Agricultural Center since 2003. He also works as the Associate Editor for both Journal of Economic Entomology and Frontiers in Ecology and the Environment. He is a former National Science Foundation Program Director, a former Vice President for Public Affairs and a Fellow of the Ecological Society of America, and a current member of the Governing Board for the Entomological Society of America.

CONTACT
Professor Timothy D Schowalter
Department of Entomology
Louisiana State University
Agricultural Center
Baton Rouge, LA 70803
USA
T: +1 225 578 1827
E: TSchowalter@agcenter.lsu.edu
W: http://www.lsuagcenter.com/profiles/tschowalter
W: http://www.entomology.lsu.edu/schowalter.html