

Invasive species under global change – signs from a homogenized world

GUEST ESSAY by Phoebe Barnard¹ Wilfried Thuiller and Guy Midgley (Climate Change Research Group, South African National Biodiversity Institute)

The world is changing at a dizzying pace – seemingly faster each day. Although we seldom detect it from one day to the next, we all have small moments of shock when we return to an area long since left, and suddenly realize the scale of change.



Namibia's former President, Sam Nujoma, left the country to help coordinate an armed struggle for independence in 1960. When he returned nearly 30 years later, he was appalled to realize the extent of deforestation in his home region – which had been largely undetected by those he left behind. This moment of sad epiphany eventually drove Nujoma to champion a number of integrated environment and development projects in the country. Environmental change had been noticed by an influential person – a rare, and for Namibia pivotal, event.

Global environmental change, risk and vulnerability

Global environmental change has been a fact of life on earth for millennia, even aeons. It is, after all, what enabled our planet to evolve and become habitable. But with our huge human population, the relentless consumption and affluence of many, and our predilection for settling in natural hazard zones – beachfronts, floodplains, fire-prone forests and shrublands, tornado and cyclone flight paths, volcanic slopes – things are getting serious now. Between three and four billion people live in coastal areas around the world, one billion of them at sea level or less than 5 m above. And we are pressurizing our natural areas more and more. Over 1.35 billion live in globally recognized biodiversity hotspots and high-biodiversity wilderness areas. Along with human settlement go many other direct drivers of environmental

change – habitat fragmentation, biotic invasion, and land conversion. Indeed, ecologists are starting to talk about these issues together with climate change as the 'lethal cocktail' of threats to biodiversity.

Vulnerability of ecosystems and societies from natural hazards has been heightened almost exponentially in the last century, by global climate change and the twin pressures of human population growth and the growing world economy^{2,3,4}. Insurance companies are starting to specialize in natural hazards coverage⁵. Risk and uncertainty are fundamental facts of life for planners, but the stakes have grown dramatically in the past hundred years.

Invasive species and the steamroller of globalization

A century ago, people didn't speak of 'alien species,' much less invasive species. Fruit trees, cereal crops, ornamental flowering species, livestock and rabbits from home were comforting to settlers transplanted far across the globe, and some of these imports made the difference between survival and starvation to migrants – whether Polynesian, British, Vietnamese or Israeli. They had positive values. Dick Mack⁶ and A.W. Crosby⁷ have written of the cultural imperative that drives humans to propagate familiar species during colonization. Even today, many alien species introductions are perceived favourably by most people. Only once highly invasive, with direct impacts on other cultural or economic values, do people's perceptions start to change. The introduction of *Prosopis* to Kenya, for example, was initially welcomed, and only when it started to take over floodplains used for grazing livestock did people reconsider its value.

Box 1

"It is clear that invasive alien species and anthropogenic climate change are individually two of the greatest threats to ecosystem structure, function, integrity and the services they provide – their synergistic impacts are relatively unknown but a major cause for concern."

GJ Masters, CABI Bioscience, & GF Midgley, Climate Change Research Group, South African National Biodiversity Institute⁸

Now, with 6.2 billion people on the planet, many trading and traveling freely between continents, with ten billion gallons of ballast water moving around the world per year and thousands of passenger flights per day, the homely trickle of comfortably familiar garden and farm species has become a devastating flood of intentional and unintentional species introductions. Transported into new habitats via old pathways (e.g. wooden pallets) and newer ones (e.g. internet-based catalogue sales in 'exotic pets,' seeds and cuttings, ballast tanks of intercontinental cargos), the problem has become almost impossible to measure, never mind regulate. The new cultural imperatives of free trade, consumerism and the allure of an affluent, instant-gratification society where one can get anything, anywhere, anytime are combining with serious consequences for invasive species management. Faced with these powerful realities, many people on the street question why we bother trying to stem the tide. And in a world with difficult challenges and disparities, it is important for us to ask ourselves those same questions, and to marshal enough data to make our case for continued and expanded action.

Climate change and invasive species

Many of us can see intuitively that climate change will affect the way that we manage biological invasions. The question is how. Our understanding of the synergistic effects of global warming on biological invasions is still pretty basic. A 2004 report on this subject for The World Bank and Global Invasive Species Programme by Greg Masters and Guy Midgley⁸ concluded that although this issue is urgent, it is little studied (Box 1). The science of such impacts is still very new, though developing fast. We know enough to say with

Box 2.

"Climate change is going to shuffle the ecological cards that determine which climatic conditions occur where, and which species are most likely to be players in the game. Many rare and endangered species have restricted distributions and may be particularly vulnerable to climate change, opening up new possibilities for non-native species to invade the "new" ecosystems that will be formed under different climate conditions. The disappearance of the Pleistocene mega-fauna undoubtedly was due at least partly to climate change, and I for one would hate to see our planet's strange and magnificent life forms replaced by cosmopolitan mundane forms such as cattle, goats, and dogs. Diversity helps make life on our planet worth living, and the threats posed by climate change will require vigorous action from all of us. "

Jeffrey A. McNeely
Chief Scientist, IUCN – The World Conservation Union

some confidence, however, that the combined effects of climate change, land use change and globalization will accelerate the ecological homogenization of our world⁹. For those of us who value diversity, whether biological or cultural, this is an appalling prospect (Box 2).

We know that both climate change and invasive species have increasing ecological, economic and social impacts^{10,11}. The synergies between them are likely to be strong, but are difficult to predict in detail (Boxes 2, 3). For a start, since ecological disturbance favours many invasive species, we can be reasonably sure that disturbance caused by climate and land use changes, through extinctions and other ecosystem alterations, will often facilitate invasion. And we can be pretty certain that some alien species which are currently non-invasive, or only mildly invasive, will be 'triggered' by climate changes, so that they become significantly invasive in certain ecosystems, even to the point of transforming them. At about this point, confidence dissipates. We may also find, for example, that other species will become less invasive due to climate change. But many invaders have ecological traits

Box 3.

“By the end of this century, climate change is likely to be the dominant driver of change to ecosystems. The expected changes in climate will accelerate the already high rates of establishment of invasive species and, as communities change in response to new climate regimes, blur the very line between what is ‘native’ and what is ‘invasive’.”

Walt Reid – Former Director: Millennium Ecosystem Assessment

that could be favoured by predicted climate changes. And with terrestrial plant invaders, we know that rising atmospheric carbon dioxide favours fast-growing plants and woody plants. This has major potential implications for invasive plants, especially woody encroaching species^{8,12}.



The many factors likely to influence the interplay of biotic invasion and climate change across varied landscapes and in the oceans are subtle. But it is very likely that climate suitability plays a key role in determining whether species will become invasive, and that climate, trade and tourism pressure together can predict this invasibility quite well in specific areas^{13,14,15}. We are starting to have a good handle on the predictors of invasibility, and now need increasingly sensitive models to factor in synergistic impacts under different climate scenarios. Some of the best ecologists and modellers will be needed to thrash this issue out, with rigorous testing of assumptions and predictions (Box 4).

Invasive species management in a changing world

Increasingly, for governments and organizations, globalization and global change are changing the centre of gravity of both environmental management and national development. Planning, policy development and management are becoming a lot more complex. Whereas in the past we could manage and plan in isolation, with the assurance that tomorrow would be much like today, we now need to gather data from different disciplines, talk to people in departments we’ve barely heard of, build scenarios and predictive models that enable us to paint pictures of what the future will look like, and try to chart a sensible response. Invasive species lend themselves well to this interdisciplinary sort of treatment and modelling – we are starting to understand the basics of their biology and behaviour in different novel environments, and more powerful spatially explicit models can start to help us understand how species distributions and invasions might respond to climate change and what would be the likely effects on invaded ecosystems. But the development of policy and legislation adequate to deal with uncertainties of the future, as well as realities of the present, is a tricky game, as South Africa, Japan and other countries have recently discovered.

Planning, policy and management, as well as becoming more complex, are also getting a lot more serious, with the stakes much higher than they once were. With both climate change and invasive species, we are approaching several points of no return. We are committed to a significant and momentous degree of global warming, no matter when we curtail our greenhouse gas emissions, due to the thermal inertia of the oceans^{16,17}. And with many invasive species in many places, the invasion has simply gone too far for eradication or management to be a cost-effective or sensible option¹¹. We need to demonstrate to planners and managers the necessity of investment in invasive species prevention, early detection and rapid-response, and the perilous consequences of inaction. With the complications of climate change factored in, we need to provide much

better and more sophisticated advice to managers about appropriate and strategic practical responses they can take in different circumstances.

Planning and management decisions can, sometimes literally, make the difference between life or death, economic prosperity or collapse, social well-being or strife. Environmental management, trade or customs decisions which do not tread circumspectly in light of the shifting sands of global change can add insult to the injury of ecosystems; economies and public health already at risk from myriad other factors.

The high stakes of global change

Invasive species, climate change, deforestation, human settlement and urban sprawl, habitat conversion and fragmentation, globalized trade, pollution – all these changes and others are adding insult to injury, suffocating ecosystems and marginalizing species. For humans, they can make life harder and more hazardous for the poor, and more expensive and hazardous for the rich who can buffer themselves from the worst effects. Of all these changes, global climate change is one of the hardest for us to predict or tackle. Its effects, we now know, are likely to be enormously destructive to biodiversity – largely because its pace is often likely to outstrip the capacity of species to evolve, especially in altered landscapes. And they will often be enormously expensive for human societies – largely because both poverty and affluence have made humans, their activities and their infrastructure, highly vulnerable.

The light at the end of this dark anthropogenic tunnel is, of course, that we are better equipped than ever before to deal with global change. International initiatives, financing, and expertise are all mobilized – or, at least, financing is starting to appear on the global mainstream political agendas. What is more of a bottleneck is the political and public will to make difficult choices about energy and resource consumption at the societal and personal levels, and make do with a bit less convenience or material wealth.

Box 4. GLOBAL CHANGE, BIODIVERSITY, ECOSYSTEMS AND SOCIETY IN AFRICA

A new African-European consortium, being developed by members of the South African National Biodiversity Institute, the Universities of York, Stockholm, Montpellier and the Witwatersrand, the Centre of Excellence in Birds as Keys to Biodiversity Conservation (University of Cape Town), the Centre of Excellence for Invasion Biology (University of Stellenbosch), and other partners is looking at the impacts of global change on African biodiversity, ecosystems and societies. Subject to funding, one of its components will investigate how biotic invasions, climate change, land conversion and fragmentation interact to influence biodiversity and ecosystem function in different parts of the continent. Africa is the continent most starkly vulnerable to climate change, and has among the least detailed information to feed into models. However, the teams are starting to tease apart these global change variables, and look at their synergistic impacts on biodiversity, ecosystems and human societies.

As Peter Raven of the Missouri Botanical Garden puts it, we are heedlessly stampeding towards a state of ecological catastrophe. Creeping changes which were viewed as positive progress a generation or two ago are now piling up – sometimes with devastating impacts on biodiversity, ecosystems, society and the economy. As scientists and planners, our responsibility is to apply our best minds and tools to understanding the synergistic impacts of these changes, and helping managers and decision makers respond appropriately. As consumers and citizens, however, our responsibility is to help all our fellow citizens appreciate the stark choices we face ahead.

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