



# The Galapagos Initiative: Saving the Enchanted Islands

Dr Stephen J. Walsh

*Land iguana*

 Scientia



# THE GALAPAGOS INITIATIVE: SAVING THE ENCHANTED ISLANDS

The Galapagos Islands are facing increasing danger. Local and global forces – including tourism and climate change – threaten the fragile island ecosystems. The high number of unique plants and animals on the islands means that the loss of a Galapagos species may represent a global extinction event. The Galapagos Initiative, founded by **Dr Stephen Walsh** of the University of North Carolina at Chapel Hill and Dr Carlos Mena of the Universidad San Francisco de Quito, aims to save the Galapagos Islands with an innovative, sustainable strategy combining evidence from key interdisciplinary projects and a robust mapping and modelling program.

## Showcasing Evolution on Earth

The astonishing beauty of the Galapagos Islands, with its turquoise and gold beaches and its jagged volcanic landscape, is matched by the islands' incredible marine and terrestrial plant and animal species. Known as a living laboratory, the islands are home to hundreds of 'endemic' species – found nowhere else on Earth. Situated within three different ocean currents, the Galapagos Islands also host a spectacular wealth of marine species.

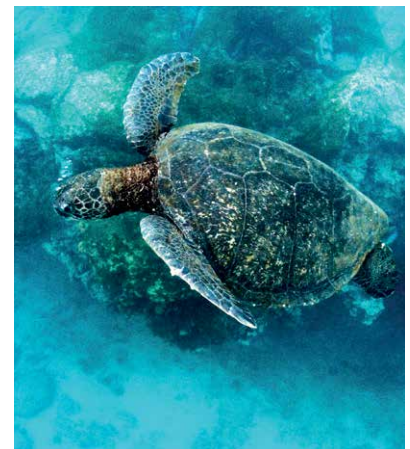
The 127 islands, islets and rocks making up the Galapagos archipelago were formed through volcanic and geological processes, and are situated around 1000 kilometres off the coast of Ecuador. The bio-physical processes shaping the landscape and the extreme geographic isolation led to the rapid evolution of plants and animals that survived the journey to the islands.

Included in the islands' incredible diversity and endemism are marine iguanas, giant tortoises, the most

northern species of penguin, enormous cacti, flightless cormorants, an array of mockingbird and finch subspecies, and even an owl, a flamingo, and a hawk species. It is little wonder then that the incredible diversity on the islands inspired Charles Darwin's theory of evolution – and forever shaped our understanding of life on the planet.

But the precious ecosystems and species of the Galapagos Islands are in peril. Island ecosystems around the world are changing, potentially irreversibly, due to complex social-ecological interactions operating across spatial and temporal scales. Rising ocean temperatures, extreme weather events, sea-level rise, tourism, population migration and development, and invasive species all act – and interact – to threaten the planet's vulnerable islands and their sustainability.

An increasing number of tourists are visiting the Galapagos Islands to interact with the iconic species and unique terrestrial and marine environments,



*Sea turtle*

while the islands' resident population is growing to support the tourist industry. Inevitably, conflicts have emerged between resource conservation and economic development. For example, changes in land use associated with development often degrade viable habitats that support the islands' wildlife. So well-known are these inherent difficulties that they have become known as the 'Galapagos Paradox' – we are quite literally loving the islands to death.





*Galapagos Science Center (lower right building) and Community of Puerto Baquerizo Moreno*

These issues are overlaid with the ongoing threats imposed by climate change. The impacts of warming temperatures, sea-level rise, and more extreme weather events are complex and difficult to predict – especially so for island ecosystems that often exhibit less resilience than mainland ecosystems. Determining the potential future of the islands, and how to save them, requires an innovative, interdisciplinary approaches that combine an understanding of the linked social, terrestrial, and marine sub-systems and an assessment of alternative tourism and climate change scenarios linked to plausible ecosystem responses.

Building on the long-term commitment of the University of North Carolina at Chapel Hill to researching the Galapagos Islands, Dr Stephen Walsh partnered with Dr Carlos Mena of the Universidad San Francisco de Quito in Ecuador to develop the Galapagos Initiative. The program includes research, education, and community outreach and engagement programs, with a focus on population, health and environment, to better understand the social, terrestrial, and marine sub-systems in the islands and their interactions.

The crowning achievement of the Galapagos Initiative has been the construction of the Galapagos Science Center (GSC), located on San Cristobal Island. The facility, which was officially dedicated in 2011, includes four specialised laboratories covering microbiology and genetics, marine ecology, terrestrial ecology, and spatial analysis and modelling. Projects conducted by the Galapagos Initiative scientists, staff, and students provide evidence that is helping to shape science and conservation strategies for the Galapagos Islands, and could help to conserve other fragile island ecosystems around the world.

### **Modelling Complex Interactions**

The Galapagos Islands are designated as a UNESCO World Heritage Site, a national park, and a marine reserve. The rapid growth of tourism since the 1970s has put the islands under increasing strain. Every year, thousands of tourists flock to the islands to enjoy its natural beauty, and the resident population has grown accordingly to support the tourism industry. In 2019, over 275,000 tourists visited the islands. The resident population tripled in the preceding 15 years, reaching around 35,000 in the same year.

The expanding human population has contributed to over-use of natural resources, replacement of native flora and fauna with invasive species, development into increasingly fragile environments, and a dramatic increase in energy consumption and waste production.

As such, a fundamental question is how many people – both tourists and residents – can the islands support before the environment is severely degraded. Dr Walsh explores this question through the emerging theory of ‘biocomplexity’. As he explains, biocomplexity ‘conceives the world as consisting of self-organised systems, either reproducing their state through negative feedbacks with their environment or moving along trajectories from one state to another as a result of positive feedbacks.’

‘It encompasses the complex interactions within and among ecological systems, the physical systems on which they depend, and the human systems with which they interact,’ he adds.





*Galapagos penguins*

Dr Walsh and Dr Mena used this theoretical context to guide the development of two spatial simulation models. Their ‘dynamic systems model’ examines environmental and human population factors and their interactions, while their ‘agent-based model’ examines how the decisions made by individuals relate to large-scale system changes. For example, the decision to switch from fisheries-based employment to tourism-based employment is made by individuals, but contributes to the overall growth of the resident population.

Their findings suggest that the islands are close to reaching their limit. ‘If tourism continues to grow at the pace of the past two decades, depending on the type of growth, in a few years there will be limited to no open space and amenity resources to ensure that every tourist visiting the Galapagos experiences nature tourism at a high standard of quality,’ explains Dr Walsh.

Over time, most of the islands’ tourism business has been dominated by external companies, with only a small proportion of the profits and high-level tourism jobs benefitting local residents. This is a source of social inequality. Through his model, Dr Walsh explored alternate strategies that allow economic development to occur in sustainable ways. ‘If residents retain control of business opportunities and high-paying tourism jobs, the industry may become the envisioned bridge to a robust and satisfying livelihood with lower environmental impacts for many more residents,’ he says.

### **Land Cover and Land Use Changes**

Increasing globalisation and a changing climate are among the dominant forces that are shaping and altering island ecosystems. Their effects often manifest through changes in land cover or land use – for example, transforming natural habitats into agricultural or urban environments.

Dr Walsh and his colleagues reviewed 30 years of research and investigated the social-ecological drivers behind changes in land cover and land use on islands across the world. Satellite remote sensing allowed the team to map and examine patterns and trajectories of these changes across space and time. Projected land cover and land use change patterns for the year 2100 demonstrate that islands are disproportionately affected in comparison to mainland ecosystems.



*Marine iguanas*

By applying his dynamic systems model to the Island of Santa Cruz – one of four inhabited Galapagos Islands – the researchers identified the expansion of the tourism sector and economic development on the Ecuadorian mainland as the main drivers of change in land cover and land use. In 2019, 7.8% of the island’s surface was degraded by direct and indirect human activities. If tourism continues to expand at the current rate, this area will double in size within just 20 years.

Although Dr Walsh and his colleagues identified a set of core processes that lead to changes in land cover and land use on islands, they found considerable variability between islands relative to their geographic location, degree of isolation, and landscape morphology. Their findings illustrate that analysis and modelling appropriate for one island’s social-ecological system may not be appropriate for another.

The researchers aim to further investigate the strengths and limitations of this approach by generalising their dynamic systems model for islands, developed in the Galapagos Islands, to Hawaii and Puerto Rico as test cases. Dr Walsh suggests that developing the core model further, through the addition of components that are sensitive to particular island features, could help improve its applicability and accuracy for other island systems. ‘The research moves us closer to recognising the core issues important to islands, while retaining the local context and place-based conditions that serve to mediate social-ecological relationships,’ he says.

### **Into the Future**

In addition to their interdisciplinary research, Dr Walsh and the Galapagos Initiative have developed and recruited institutions into the International Galapagos Science Consortium, created important links with the Galapagos National Park, and attracted and trained scientists and students from around the world. By cultivating strong connections and a skilled team, the Galapagos Initiative has ensured that this important work will continue well into the future – and transform the current trajectory for these precious islands, where island ecosystems are sustained by a more complete understanding of the social-ecological stressors that threaten the Galapagos Islands and other similarly challenged island setting around the globe.

# Meet the researcher



## Dr Stephen J. Walsh

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Dr Stephen J. Walsh is the Lyle V. Jones Distinguished Professor in the Department of Geography, the Director of the Center for Galapagos Studies at the University of North Carolina at Chapel Hill (UNC), and Co-Director of the UNC-USFQ Galapagos Science Center (GSC), Galapagos Archipelago of Ecuador. He co-founded the Galapagos Initiative, forming a strategic partnership with the Universidad San Francisco de Quito (USFQ), Ecuador. The initiative includes the 2011 construction of the 20,000-square-foot Galapagos Science Center on San Cristobal Island, Ecuador, a facility that hosts an extensive and intensive program of integrated and interdisciplinary science. The Galapagos Initiative emphasises research, education, and community outreach and engagement, achieved through studies conducted in the GSC labs – genetics and microbiology, marine ecology, terrestrial ecology, and spatial analysis and modelling. Through linkages forged among UNC, USFQ, GSC, and the Galapagos National Park, a DNA-pipeline was created for the genetic sequencing of collected biological samples to support a host of molecular studies of iconic, native, and introduced species in the Galapagos Islands. Other programmatic advances include the development of a Galapagos bio-bank, marine expeditions throughout the Galapagos Marine Reserve, and annual UNC Study Abroad programs for undergraduate students. In 2012, Dr Walsh launched a book series on the Galapagos Islands with Springer Nature and nine books have been published thus far in the series. In addition to informing conservation efforts for the Galapagos Islands, Dr Walsh's research is providing a global template for the study of other conflicted and challenged island ecosystems. His main research interests include human-environment interactions, coupled human-natural systems, and cutting-edge geographic methods, including, remote sensing, geographic information systems, and spatial analysis.

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### KEY COLLABORATORS

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