Science and Technology Group
Annual Report FY2020

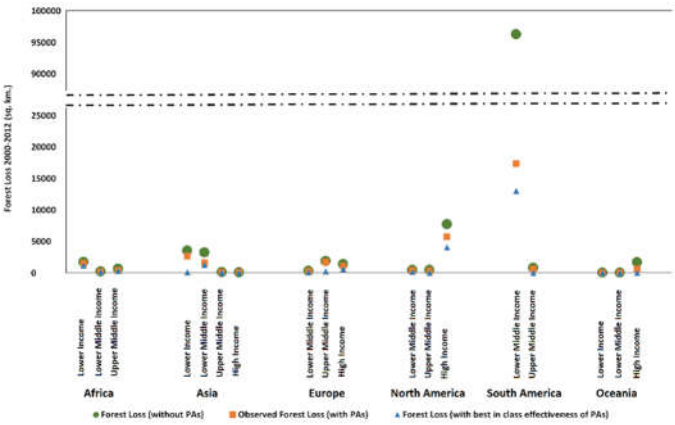
Payal Shah
Science and Technology Associate

1 Introduction

My research focuses on issues related to ecological conservation in marine and terrestrial areas. I use economic theory and statistical methods, combined with tools from ecology and biogeography, to evaluate the impact of conservation policies on protecting biodiversity and ecosystems and to develop optimal strategies for conservation efforts in the face of climate change. Climate change threatens species diversity and ecosystem services and causes uncertain changes in future spatial patterns of conservation-related outcomes. This uncertainty makes it difficult to implement standard conservation and land management paradigms. My research will develop new methods for effectively managing the spatial and temporal risk that climate uncertainty creates and guide conservation and adaptation planning decisions for a range of ecological settings.

2 Activities and Findings

1. What determines the effectiveness of protected areas?



Establishing protected areas is a cornerstone of global conservation policy targeted at preservation of species and ecosystems and mitigating the impacts of climate change. We use a high resolution global data of forest cover loss from 2000 to 2012 to evaluate the effectiveness of global protected area network. In figure 1, we illustrate the protected area impact on reducing forest cover loss by region and income group.

We then use machine learning methods to evaluate the key determinants of protected area effectiveness. In figure 2, we show the results for based on regression tree and bagging tree methods. We find that higher agricultural pressures, lower economic growth rates and better governance are associated with greater PA effectiveness.

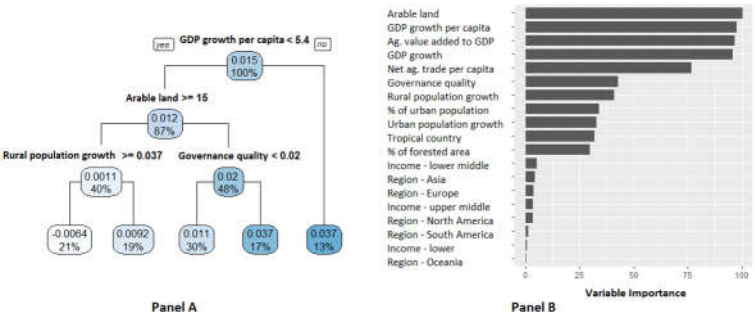


Figure 2

2. Managing climate change risk in systematic conservation planning with limited information

Systematic conservation planning is used for identifying optimal spatial conservation actions and priorities for biodiversity and ecological conservation. Recent advances in systematic conservation planning make use of modern portfolio theory to address the challenges posed by climate change uncertainty. However, these methods are difficult to implement for conservation planning problems at a finer scale when the information on future climate

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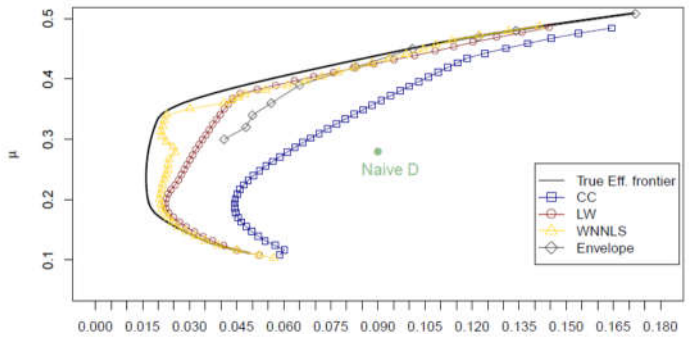

Figure 3

scenarios is limited. We identify three statistical approaches - Constant Correlation Model, the Ledoit-Wolf approach and the WNNLS approach - that can overcome the lack of sufficient information and enable the use of modern portfolio theory for fine scale conservation planning (see Figure 3). We illustrate the use of the three methods for identifying efficient portfolio allocation strategies using case studies of wetland conservation planning in North America and coastal conservation planning in Australia. These methods are applicable for a broad range of conservation planning scenarios where the ecological outcome faces climate uncertainty.

3 Collaborations

1. Project: Optimal selection of protected areas in the face of climate change
   Collaborator: Fumiko Ishihama, Researcher, National Institute for Environmental Studies
2. Project: Okinawa watershed modeling to identify terrestrial "hot spots" impacting coral reefs
   Collaborators: Evan Economo, Assistant Professor, OIS Graduate University
   Satoshi Mitarai, Associate Professor, OIST Graduate University
3. Project: Optimal conservation planning and climate change uncertainty
   Collaborators: Amy Ando, Professor, University of Illinois at Urbana-Champaign
   Glenn Guntenspergen, Research Ecologist, United States Geological Survey
4. Project: Determinants and implications of global protected area effectiveness
   Collaborators: Kathy Baylis, Associate Professor, University of Illinois at Urbana-Champaign
   Jonah Busch, Chief Economist, Earth Innovation Institute
5. Project: Multidimensional risk diversification for invasive species management
   Collaborators: Charles Sims, Associate Professor, University of Tennessee
   Amy Ando, Professor, University of Illinois at Urbana-Champaign
6. Project: Fine scale conservation planning with limited climate change information
   Collaborators: Valentin Popov, Lecturer, University of St. Andrews
   Jonathan Rhodes, Professor, The University of Queensland
   Rebecca Runting, Lecturer, University of Melbourne

4 Publications and other output

4.1 Invited Seminar

July 2020: Application of portfolio theory to conservation planning with climate change uncertainty, National Institute of Environmental Studies, Tsukuba, Japan (via zoom).

4.2 Publication

Yamaguchi, Rintaro and Shah, Payal. 2020. Spatial Discounting of Ecosystem Services. Resource and Energy Economics, 101186.

5 External funding

1. Kakenhi Early Career Scientists 1, April 2019- March 2021