Science and Technology Group
Annual Report FY2023

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Science and Technology Associate

1 Introduction

In my research, I use economic theory and statistical methods, combined with tools from ecology and biogeography, to analyze social and environmental impacts of natural resource management policies, to formulate optimal strategies to address environmental challenges such as climate change, and to evaluate preferences for ecosystem services. The major contributions of my research have been in advancing fundamental knowledge of: (1) how to do efficient and optimal conservation planning to deal with issues of climate change uncertainty, and (2) how to quantify and measure the impact of conservation policy on ecological outcomes.

2 Activities and Findings

Robust conservation prioritization under climate change for alpine vegetations in Daisetsuzan National Park using portfolio optimization theory

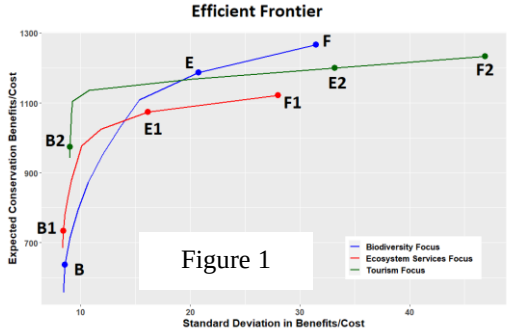
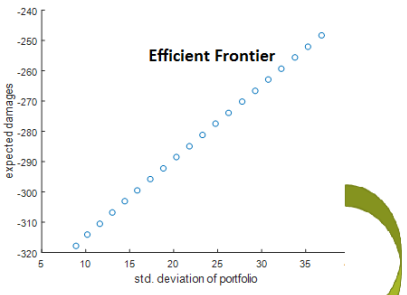
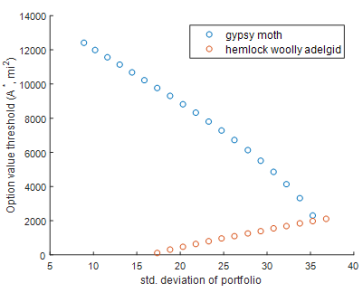


Figure 1

Daisetsu National Park is an important conservation region in northern Japan. The area is rich in alpine plant species that support biodiversity, provide a range of ecosystem services, and support the tourism industry. These alpine vegetations are expected to be particularly vulnerable to climatic changes. We evaluate the expected changes in four types of alpine vegetation (i.e. snow bed, fellfield, wilderness and shrubs) for three climate scenarios and two GCM models across the approximately 900 sq. km. study site. Our unit of observation is 1 sq. km. by 1 sq. km. grid. We then combine Marxan site prioritization with portfolio optimization to identify which grids are most important for conservation efforts (see figure 1 for preliminary results). This is the first study to conduct portfolio optimization at a fine scale and simultaneously combine the Marxan approach to arrive at optimal site selection output.



Stage 1: Species Diversification using Portfolio Optimization



Stage 2: Optimal Timing of Investment based on Real Options Model

A quasi-dynamic portfolio theory approach for invasive species management

Faced with a growing list of invasive species and limited budgets to respond to their impacts, state and federal agencies must prioritize control effort across a range of invasive species and often over multiple planning periods. We combine portfolio optimization and real options analyses to develop a "quasi" dynamic diversification approach that considers investments across different species and the optimal timing of such investment. Portfolio analyses identifies how a fixed budget should be allocated across species based on risk preferences. The optimal budget allocations identified are then used as an input in a real options model. Using this combined approach, we identify a portfolio that minimizes the spread risk for a given return and accounts for the influence of that risk on the option value (as seen in figure 2).

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3 Collaborations

1. Robust conservation prioritization under climate change for alpine vegetations in Daisetsuzan National Park using portfolio optimization theory
   Collaborators: Fumiko Ishihama (Researcher, National Institute for Environmental Studies)
   Oguma Hiroyuki (Researcher, National Institute for Environmental Studies)
   Amagai Yukihiro (Researcher, National Institute for Environmental Studies)
2. Multidimensional risk diversification for invasive species management: A quasi-dynamic portfolio theory approach
   Collaborators: Charles Sims, Associate Professor, University of Tennessee
   Amy Ando, Professor, University of Illinois at Urbana-Champaign
3. Project: Optimal conservation planning and climate change uncertainty
   Collaborators: Amy Ando, Professor, Ohio State University
   Mindy Mallory, Associate Professor, Purdue University
4. Risk and uncertainty in biodiversity conservation under climate change
   Collaborators: Charlotte Gerling (Post Doctoral Scholar, Brandenburg University of Technology)
   Martin Drechsler (Professor, Brandenburg University of Technology)
   Frank Watzold (Professor, Brandenburg University of Technology)
5. Empirical research on the effects of the SHEP approach on small-scale farmers in Ethiopia
   Collaborators: Hisako Nomura (Associate Professor, Kyushu University)
   Asmiro Abeje Fikadu (PhD Candidate, Kyushu University)
   Girma Gezimu Gebre (Postdoctoral Research Fellow, Ritsumeikan University)

4 Publications and other output

4.1 Publications:

- Gerling Charlotte, Drechsler, Martin, Wätzold, Frank and Shah, Payal. Risk and uncertainty in biodiversity conservation under climate change. Revise and Resubmit in *Review of Environmental Economics and Policy*.
- Fikadu, Asmiro Abeje, Gebre, Girma Gezimu, Shah, Payal, Takahashi, Yoshifumi, Mitsuyasu Yabe, and Nomura, Hisako. Heterogeneous Impacts of Horticulture Commercialization and Gender-based Decision-making on Smallholder Farmers' Income: Evidence from a Quasi-Experimental Study in Jimma Zone, Ethiopia. Under review at *Economic Analysis and Policy*
- Shah, P. and Nolte, C. 2023. Evaluating the heterogenous impacts of conservation easements on property prices across the conterminous United States. Revise and Resubmit in *Land Economics*

4.2 Seminar and Presentations:

- August 2023. Estimating the heterogenous impacts of conservation easements on property prices across the conterminous United States. g Asian Association of Environment and Resource Economics, Tokyo, Japan.

5 External funding

1. Kakenhi C (April 2024- March 2027)
   Project: Economic model of the spillover effects of protected areas on deforestation activity
   Funding Amount: $34,000
2. Japan International Cooperation Agency (JICA) Grant as Co-PI (April 2022 – March 2026)
   Project: Empirical research on the effects of the SHEP approach on small-scale farmers in Ethiopia