RMA

The Resource Modeling Association is an international association of scientists working at the intersection of mathematical modeling, environmental sciences, sustainability sciences, and resource management. We formulate and analyze models to understand the dynamics of natural resources and promote their sustainable management.

RMA Newsletter Fall 2023

Organizers

Patrick Gourley
Kamal Dai

University of New Haven

Keynote Speakers

Robert O. Mendelsohn,
Eli Fenichel,
Biswo Poudel,
Junjie Wu

Abstract submission opens:
January 15, 2024
Abstract submission ends:
March 15, 2024

Table of Content

PRESIDENT'S COLUMN

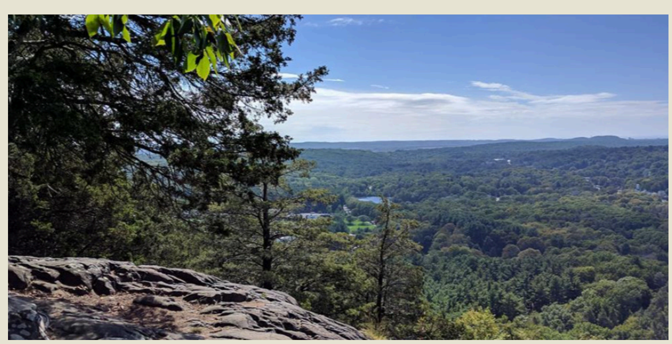
by Krishna Paudel

I first attended the World Conference on Natural Resource Modeling at Utah State University, Logan, Utah, in 2001. At that time, I was a new assistant professor of agricultural economics at Louisiana State University interested in applying dynamic optimization to solve natural resources management problems. Conferences of agricultural economists address several issues related to agriculture, but I was searching for an association that focused on solving natural resource management-related problems using optimization problems. Resource Modeling Association was the ideal place to address my curiosity and meet like-minded people. WCNRM brings people from mathematics, economics, ecology, forestry, fisheries, and other areas who are interested in modeling natural resources using mathematical modeling. Since my first conference attendance in Logan, I have served the association and attended its conferences several times. Attending the conference has been the highlight of my annual activities - I look forward to attending the WCNRM. In addition to my personal journey, I am immensely proud to have contributed to the RMA's global reach by playing a pivotal role in bringing the conference to Guangzhou, China in 2018.

We have an excellent journal and an outstanding association. As in the past, we need continuous involvement from members to make the association vibrant. Our members and authors in the association's Natural Resource Modeling journal can solve environmental resource problems such as climate change, land and water quality degradation, forest, fish, wildlife and biodiversity depletion. Our conference wildlife venues are always excellent, and the number of attendees is just right to grow our professional network.

Assuming the role of president of this outstanding association is a profound honor. Frank vanLangevelde has done an outstanding job serving as association president for the last three years. He will continue to serve the association as past president and advise me about the association's different functions. One of those significant functions is organizing an annual conference. The last conference in Amsterdam was a success, and we look forward to the 2024 conference in New Haven, Connecticut. The conference will be on June 10-13, 2024, and our local hosts are Professors Kamal Dai and Patrick Gourley of the University of New Haven. Professors Dai and Gourley have organized a fun-filled field trip you do not want to miss. I extend a warm and sincere invitation to all of you to actively participate in this conference by presenting your research papers and posters. The conference offers an exceptional opportunity to augment your professional network and to play an integral role in addressing global challenges related to natural resource management. I look forward to your presence in New Haven, Connecticut, USA, next year.

Sincerely, **Krishna P. Paudel**
Deputy Director for Research and Communications
Economic Research Service
U.S. DEPARTMENT OF AGRICULTURE
https://scholar.google.com/citations?user=fx8FQtoAAAAJ&hl=e



Best student presentation prize WCNRM Amsterdam

Bargaining around the prey-refuge, by Guillaume Bataille.

Aix Marseille Univ, CNRS, AMSE, Marseille, France. Email: guillaume.bataille@univ-amu.

The marine habitat plays a crucial role in species survival, offering vital resources for reproduction and growth while providing protection from predators. Biologists emphasize the protective benefits of habitats as an essential ecosystem service for species (Selwood and Zimmer (2020)). These protective places, namely prey refuges, are distinct from Marine Protected Areas, where human predation is prohibited. Despite established ecological theory on prey refuges (e.g McNair (1986), Wang and Wang (2012)), their economic implications remain underexplored. Prey refuges, such as coral reefs and mangroves, offer shelter to prey species, altering population dynamics by reducing predation rates. This, in turn, indirectly affects the economic incentives for fishers targeting either prey or predators. This study has two main goals: firstly, to assess how the introduction of a prey refuge, which safeguards a fixed proportion of the prey stock, affects the behaviors of prey and predator fishers in a standard bioeconomic fishing model. Secondly, to investigate the mechanisms behind using artificial refuges to enhance the economic efficiency of fisheries by safeguarding a larger share of the prey stock.

To tackle this challenge, I develop a two-step game theoretic model where two specialized fishers exploit a two-species predator-prey ecosystem. This model combines cooperative and non-cooperative elements. Fishers initially engage in cooperative negotiations to determine the refuge size, and then act independently when exploiting the ecosystem based on the agreed-upon prey-refuge size. This "coopetition" approach (see Nalebuff & Brandenburger (1996)) denotes cooperative behaviors among competitors, where cooperation is about the prey refuge size, but cooperation regarding harvest is excluded. In order to engage in cooperation at the initial stage, fishers must form rational expectations about how a prey refuge will impact their future actions, necessitating a backward-solving approach.

The primary findings can be summarized as follows: First, a unique feedback Nash equilibrium in linear strategies exists, and an increase in the share of protected prey reduces catch rates of both prey and predator fishers. Second, considering the Nash bargaining approach with transferable utility (TU), the cooperative solution gives to each asymmetric players their disagreement payoffs i.e., payoffs in the absence of the artificial refuge, in addition to half of the cooperative surplus. Through stylized examples, it is shown that: (i) in the absence of prey-refuge costs, the prey-refuge size is chosen such that the marginal benefit for the prey harvester equals the marginal cost for the predator harvester; (ii) when the prey refuge becomes costly, this diminishes the cooperative surplus and reduces the optimal prey refuge size chosen by fishers until no agreement is reached; (iii) relaxing the TU assumption can still lead to strictly Pareto-improving outcomes without transfers. In summary, this paper suggests that artificial prey refuges could represent a second-best strategy which improve the economic efficiency of a fishery by bolstering the protection of specific trophic levels. Therefore, it requires less monitoring compared to conventional harvest agreements.

- The non-cooperative outcomes

The bioeconomic model, drawing upon Koulovatianos (2023), explores simultaneous harvesting by two specialized fishers in a two-species ecosystem, as in Fischer & Mirman (1992). The dynamics of prey and predator stocks denoted by x(t) and y(t) reads:

$$\dot{x}(t) = A_x\sqrt{x(t)} - \delta_x x(t) - b_x\sqrt{(1-r)x(t)y(t)} - h_x(t),$$
$$\dot{y}(t) = A_y\sqrt{y(t)} - \delta_y y(t) + b_y\sqrt{(1-r)x(t)y(t)} - h_y(t),$$

where, for each species s, A_s relates to the natural growth, $h_s(t)$ is the harvest, and δ_s is a natural mortality rate while b_s represents predator consumption and conversion rates. In line with biological literature (Ma et al. (2009)), the prey refuge r safeguards a fixed proportion of the prey stock from predators. The resulting payoffs from harvesting are assumed to be as follows:

$$U^s\left((h_s(t))_{t\geq 0}\right) = \int_0^\infty 2\sqrt{h_s(t)}e^{-\rho t}dt$$

The first results states that there exists a Feedback-Nash equilibrium such that, $h_s(t) = \omega_s x(t)$, where simultaneous harvesting occurs. Moreover, I show that fishers' exploitation rates ω_s decline as the refuge size r increases. As a result, with an increasing proportion of prey being protected, the prey fisher tends to reduce its fishing pressure because the competition with natural predators becomes less significant. Surprisingly, the predator fisher also reduces his harvest to protect the predator stock from depletion due to reduced food availability. The non-cooperative equilibrium payoffs of the fishers are thereby dependent on the refuge parameters, allowing them to anticipate how the refuge affects their payoffs:

$$U^s(r) = 2\sqrt{\omega_s^{NE}(r)} \int_0^\infty e^{-\rho t} \sqrt{s(t,r)} dt$$

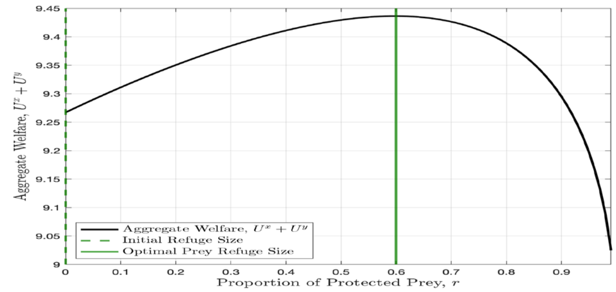
- The cooperative Nash bargaining solution

Since both fishers rationally make expectations on the effect of the prey-refuge size on their future flows of payoffs, a natural question is the following : are there efficient and equitable agreements on the size of the refuge? More specifically, I ask two questions: (i) are there any gains associated with cooperation about building a specific refuge size? If yes, (ii) how should this surplus be shared among fishers? In the TU setting, the condition under which there exists some positive cooperative surplus (CS) when choosing a specific refuge size r can be summarized as follows :

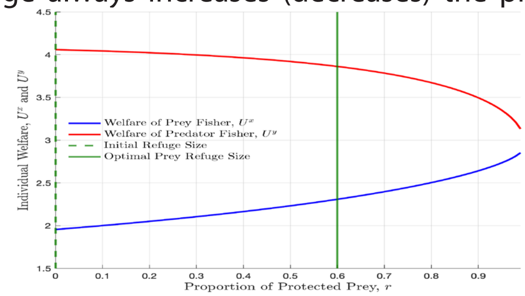
$$\exists\, \mathcal{CS} > 0 \iff \max_r \sum_{s \in x,y} U^s(r) - \Phi(r) > \sum_{s \in x,y} U^s(0)$$

where Φ(r) is a strictly positive and convex cost associate with the refuge construction. According to the Nash bargaining axiomatic approach, satisfying this condition leads to an agreement to construct a refuge of size r* that solve the left-hand side of previous inequality. Since transfers are allowed, both fishers obtain their outside option, $U_s(0)$, in addition to half of the cooperative surplus CS. To illustrate these findings, the following graphs depict results for an example with no prey refuge cost, i.e., Φ(r) = 0 :

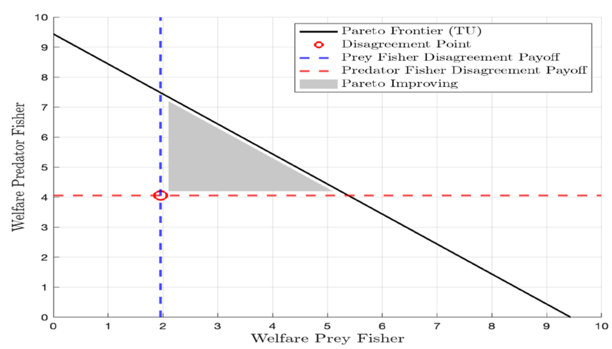
Figure (1) depicts an inverted U-shaped relationship between the size of protected prey and fishery overall welfare, with welfare increasing in protection level, until a threshold point is reached. This non-linear relationship arises due to the need for a balance between the economic benefits derived from enhanced protection and the economic costs associated with reduced access for predators. Of course, prey refuges impact differently the prey and the predator fisher as shown



in Figure (2). This example shows that the size of the prey refuge always increases (decreases) the prey (predator)

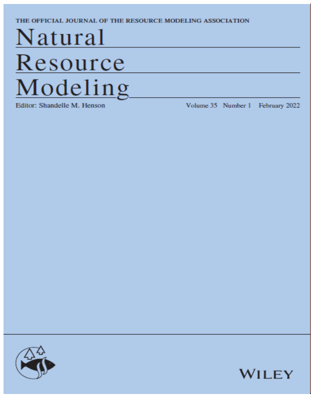


fisher's welfare but with smalls marginal impacts when its size is small enough. Within this context, the intuition is that the agreement on the prey-refuge size would be such that the marginal cost for the predator fisher equals the marginal gain for the prey fisher. Figure (3) represents the cooperative surplus of both fishers. It shows that the cooperative solution is such that both fishers receive their respective disagreement payoffs, and they equally divide the shaded area through transfers.



To enhance the robustness of my results, in the paper I extend the analysis to: (i) alternative solution concepts for the cooperative outcome; (ii) non-transferability of the welfare; (iii) various cost structures for prey-refuge construction; and (iv) scenarios involving positive initial prey-refuge size, allowing for the possibility of (de-) construction over existing refuges.

Bibliography on last page of the RMA newsletter.



Natural Resource Modeling

Editor In Chief Column

by John Hearne

1 Introduction

The latest edition of the journal covers a diverse range of problems comprising applications related to forestry, stormwater, soil, and watersheds. Further details are provided below together with titles that will appear in a subsequent issue. Please visit our journal's homepage:
https://onlinelibrary.wiley.com/toc/19397445/2023/36/4
or google "natural resource modeling". Access is free and so are all downloads.

2 Issue of November, 2023

- It is not often that the forecasts of a model are revisited 20 years later. Lee Badger published "A Global Model of Population-Resource Interaction" in this journal in 2003. In an interesting letter, he contrasts his projections with realised historical values.
- Climate and technology changes affect forest growth. The authors establish the importance of taking these changes into account in decisions about the time to harvest.
- A setting in Tehran is used to demonstrate the practical importance of the authors' research in finding nature-based solutions for stormwater management.
- This research deals with water and soil as natural resources in the Rift Valley Basin of southern Ethiopa. Methods are used to identify subwatersheds most vulnerable to soil erosion and hence to be prioritised for landuse and land cover initiatives.
- The authors employ several Operations Research methods to develop an approach to integrated watershed management.
- The results of this work allow for general interpretations of the direction and magnitude of potential shifts in forest carrying capacity with obvious management implications.

3 Recent articles

The following is a list of titles that will appear in a subsequent issue of NRM.

• When profitability meets conservation objectives through biodiversity offsets
• Maximum sustainable yield as a reference point in the presence of fishing effort that follows an ideal free distribution
• Paying for forest carbon: Cost-effectiveness of the Verified Carbon Standard (VCS) remuneration scheme
• Evaluating feedback dynamics between poaching and population with an application to Indian tigers
• Measurement error effects on estimates from linear and nonlinear regression whole-stand yield models

4 Prospective authors

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RMA New Officer
President Krishna Paudel

Krishna P. Paudel is deputy director for research and communications in the Resource and Rural Economics Division at the USDA's Economic Research Service (ERS) in the USA.

Krishna received a Ph.D. degree in agricultural economics from the University of Georgia, an M.S. degree in agricultural economics from Auburn University, and a B.Sc.Ag. degree in agricultural sciences from Tribhuvan University, Nepal.

Krishna focuses on water quality and quantity, technology adoption, and international development economics. Krishna has served agricultural economics and other affiliated professions in several roles, such as editor of the Journal of Agricultural and Applied Economics and president of the Southern Agricultural Economics Association. He serves as an associate editor for Natural Resource Modeling journal and editor for the Journal of Water Resource Planning and Management. Krishna was the Gilbert Durbin Endowed Professor of Agricultural Economics at Louisiana State University before joining ERS in 2021.

End of Page 4: References of paper by Guillaume Bataille

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RMA Social Medias

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