I am a natural resource economist. My primary research focus is designing and analyzing practical approaches for addressing risk and uncertainty in natural resource management. I have concentrated on management settings in which the standard net benefit maximization cannot be applied due to a lack of reasonable estimates of the values of key events – like species extinction or climate catastrophes. My dissertation implements and evaluates new dynamic programming methods for a viable control approach to attack management problems like these.

My Dissertation Research

In *Safety First and the Holding of Assets* (1952), Roy knew that economic agents approach uncertainty in the way an orienteer desires to escape a hostile jungle. His representative investor is concerned with avoiding disaster and cares little about "whether a little more of this or that will yield the largest net increase in satisfaction." The safety first concept is the unifying driver of the prescriptive behavior in each of my essays.

The standard economic approach to natural resource management involves maximizing the difference between the present value of long-run benefits and costs, whether we are thinking about live species, water, or fossil fuels. But when certain disastrous outcomes are difficult to value – such as the extinction of a species – a reasonable alternative often observed in policy is the viable control approach: seek an acceptably small likelihood of the outcome, ideally at the smallest possible management cost. These probability constraints, which involve joint outcomes over a number of periods, undermine the Markov property essential to typical solution techniques. I've developed a shadow value approach that fills the modeling gap for solving these types of problems.

Disastrous outcomes, such as the population collapse of an endangered species, are particularly hard to value, but my approach can shed some light on the benefits implied by a conservation goal. As a social planner problem, the shadow value viability approach involves identifying the loss from extinction that drives enough conservation effort to ensure survival with a given confidence. In *Safety in Numbers* (2019, in Land Economics with coauthors), I apply the method to the conservation of the Humpback Chub in the Grand Canyon, a fish under threat due to predation and competition from non-native species. Here, I focus my efforts on two questions: (1) "what population abundance should we aim for in order to avoid a minimum viable threshold?" and (2) "what is the implied value of non-attainment?" This paper is the first to describe the technical benefits of the viable dynamic programming algorithm that powers my dissertation, and lays some of the groundwork for my job market paper.

In my job market paper, I provide a practical policy solution for the integrated management of the California drift gillnet swordfish fishery and the protection of the endangered leatherback turtle. The current approach to protecting the leatherbacks employs inflexible management tools like marine protected areas and specific gear requirements that pose unnecessarily high costs to the fishery. Alternatively, market-based instruments provide greater flexibility for how fishers choose to avoid bycatch and encourage the adoption of new information and technologies, thus lowering opportunity costs. However, no current theory tackles the setting of market-based instruments for bycatch when the benefits of preservation are unknown. I extend the shadow value viability approach to inform bycatch instruments that incentivize socially-optimal fishing behavior among decentralized fishers. This research pushes the theoretical frontier of fisheries management and provides an immediately applicable solution for the integration of commercial and conservation objectives in contemporary fisheries.

In my third essay, I address popular concerns with integrated assessment modeling. Viable control, in this context, replaces the maximization of intergenerational utility with a probabilistic climate constraint (such as limiting the likelihood of crossing the 2°C threshold outlined in the Paris Agreement to 15%). This relieves results from their dependence on assumptions about key "policy" parameters and loss functions, and importantly places focus on preventing tail events (the language suggested by scientists and used in policy). The shadow value of crossing the 2°C threshold – the expected present damage due to future disaster – yields the *viability cost of carbon*, an alternative social damage measure consistent with this viability goal.

Two early endeavors into resource management under uncertainty provided inspiration for the methods developed in my dissertation. Cropper's *Regulating Activities with Catastrophic Environmental Effects* (1976) highlighted the trade-off between the risks of future catastrophe and the costs of competing economic values. Her focus on tail risk was revamped by Montgomery, Brown, and Adams in *The Marginal Cost of Species Preservation,* (1994) who asserted that we ought to be *explicitly* choosing some minimum tolerable likelihood of success. Shadow value viability is an output-rich solution method that elaborates on these important lessons. My research uses advances in analytical and numerical methods to revitalize neglected ideas like these and put them to practical use in natural resource management.

Future Direction

The time I've spent thinking about what resource managers *should* do has given me several ideas for *descriptive* studies. For example, one potential challenge of ecosystem-based fisheries management became evident while working on my job market paper. Integrated management of multiple species can correct certain ecological externalities, but simultaneously open the door for additional human ones. While regularly prescribed, a total allowable catch for endangered populations is often very low and thus indivisible, and fishers that may have the rights to fish a commercial species are forced into a common property situation on the whole. Even those holding guaranteed quota for a valuable species will race to exercise them before a fishery closes, ignoring the full effect of their behavior on the length of the fishing season. The recent promotion of ecosystem-based management presents several case studies to study this behavior.

Additionally, I would like to continue studying other dimensions of behavior in response to uncertainty. For example, an interesting behavior exhibited by politicians, CEOs, and natural resource managers is the limiting of a planning horizon in response to an ambiguous future. In cases with Knightian uncertainty, there may be a grand horizon over which one wishes to optimize, but only a short horizon where any calculus is truly conceivable; this confines their optimization problem within a rolling window and produces drastically different prescriptions of "optimal behavior." I believe this solution concept is particularly apt to tackle problems with dynamic systems that are expected to change over time due to climate change.