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 consumed 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 involve joint outcomes over a length of time, which in the past has made viable control problems intractable. I've developed a shadow value approach that not only fixes this issue, but provides an estimate of the value of the policy goals that ultimately inform these constraints.

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. In *Safety in Numbers* (2019, in Land Economics with coauthors), I apply cost-effective viable control 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 most of the groundwork for my job market paper.

In my job market paper, I provide an economically-rational solution for the integrated management of commercial and compromised fish stocks in a multispecies fishery. Currently, the survival of threatened or endangered non-target species is an afterthought to commercial rent maximization, despite the political importance of this ecological goal. This leads to further-endangered stocks when catch cannot be monitored, or when it can, early closures that eliminate valuable commercial fishery rents. My model jointly estimates the shadow value of a long-run species viability goal and leverages this against the potential welfare generated by a commercial fishery. Balance can be achieved by manipulating the harvest cap or requiring a landings fee for commercial or non-target species. This provides us with a flexible policy function that responds to changes in each fish stock and maximizes commercial rents while satisfying the viability goal.

Indeed, this research pushes the theoretical frontier of fisheries management *and* provides an immediately applicable solution to part of the sustainability problem 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 marginal expected present damage due to disaster – yields the *viability cost of carbon*, an alternative social damage measure consistent with this viability goal.

My Dissertation's Contribution

Two early endeavors into resource management under uncertainty provided inspiration for the methods developed in my dissertation. First, Cropper's *Regulating Activities with Catastrophic Environmental Effects* (1976) tackled resource management under threat of environmental catastrophe. Her model sits in-between the worlds of deterministic optimal control and stochastic dynamic programming, an intellection that allowed us an informed look into disaster risk and its effect on current optimal economic activity.

Second, Montgomery, Brown, and Adams (in *The Marginal Cost of Species Preservation,* 1994) were early to realize that species preservation is a probabilistic outcome and should be evaluated by the marginal exchange of foregone land use values and the likelihood of species survival. They capture the spirit of this innovation with a tractable static model.

I see my contribution as 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

One of my career goals is to derive an analytically-tractable version of the dynamic programming algorithm outlined in my dissertation. This added transparency would help develop the theoretical intuition behind viable control and bridge the gap between my numerical method and the early works mentioned above. I think this effort will be the most effective in furthering the proliferation of what I think is an important, but nascent field.

Additionally, I want 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 of deep 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.