I am an environmental economist studying the role of nature in production functions that affect human well-being, in addition to evaluating policies that aim to conserve and restore nature—drawing on my broad training in economics, causal inference, and the natural sciences, namely ecology. By combining quasi-experimental designs with ecology, I test hypotheses linking environmental economics and ecosystem theory on the benefits of well-functioning ecosystems. My work makes contributions across three themes in the nature–well-being nexus: (i) the costs to society from the well-documented declines in animal and plant abundance and diversity; (ii) the consequences of public policy that targets ecosystem conservation; and (iii) the relationship between industrial-scale animal agriculture and its impacts on the environment and wildlife populations.

My research targets the knowledge gap regarding the concerns ecologists have raised about "Biodiversity loss and its impact on humanity" (Cardinale et al. 2012), as extinction rates are considered to be 100 times higher than their background rates (Ceballos et al. 2015)—often referred to as the "biodiversity crisis" or the "sixth mass extinction." Biodiversity, a term that broadly captures the variety of living organisms, is considered to be a key determinant of ecosystem productivity and functioning, and thus of the ecosystem services from which people derive benefits.

Theory in environmental economics has emphasized three distinct channels that govern optimal decision-making when balancing economic growth and environmental conservation. First, the role of substitution in adapting to the decline of natural inputs (Solow 1993). Second, the importance of species-specific benefit parameters in allocating scarce conservation resources (Weitzman 1992). Third, the uncertain benefits a species provides, which might become known only after a sharp decline in its population that could be irreversible or costly to recover (Arrow and Fisher 1974). Taken together, these seminal papers question what determines the value of nature and the role public policy has in balancing trade-offs between preservation and economic growth.

Quantification of these long-standing theoretical questions has faced measurement and inference challenges. Cross-sectional or panel data on wildlife population levels are rarely available. Large-scale manipulation of ecosystems is constrained by both ethical and feasibility considerations. These obstacles limit our ability to infer the causal treatment effect of a change in ecosystem functioning. Consequently, empirical research in environmental economics has mostly relied on either contingent valuation that elicits the willingness-to-pay for nature, the use of back-of-the-envelope calculations to assess orders of magnitude, or correlational studies with limited causal interpretation.

In my work, I study revealed preferences to complement previously used stated preferences approaches. I overcome measurement and inference issues by harmonizing new sources of data, and by leveraging ecosystem shocks as sources of natural experiments. In connecting the knowledge domains of social and natural sciences, I provide clear examples for how sharp changes in the abundance of species or policies that protect them propagate to effects on agricultural production, environmental quality, human health, and economic growth. In what follows, I highlight papers that illustrate how my work expands our understanding of the themes described above.

1. The Social Costs of Biodiversity Losses

Understanding how changes in biodiversity generate costs or benefits to people is crucial for assessing the implications of additional economic activities that degrade biodiversity. Ecologists warn that disruptions to ecosystems can destabilize species interactions that help maintain ecosystem services. This is especially salient for "natural enemies," where a reduction in the population of one species can lead to an increase in another, potentially necessitating defensive expenditures to compensate for the degraded ecosystem function. Input substitution has been central to economic thinking about sustainability, yet such patterns have not been demonstrated empirically.

In **"The Economic Impacts of Ecosystem Disruptions: Costs From Substituting Biological Pest Control"** (*Science*, 2024), I provide large-scale evidence for that type of substitution between natural and human-made inputs in the context of biological pest control and insecticide use. My analysis uses the sudden and unexpected emergence of a wildlife disease, known as white-nose syndrome (WNS), which caused extremely high mortality among insect-eating bats in the United States (US), in a difference-in-differences research design. On average, mortality rates exceed 70%, with many local populations collapsing entirely. I compare counties that became exposed to the wildlife disease, before and after exposure, relative to counties not yet exposed—a natural experiment, approximating direct manipulation of local biological pest control.

I find that farmers increase their insecticide use by 31% following the bat die-offs. This result validates theoretical predictions by both ecologists and economists about the importance of bats in agroecosystems, and farmers' ability to compensate for their decline. However, this substitution toward insecticides—compounds that are toxic by design—raises concerns about health burdens on nearby human populations, as pesticide exposure has been associated with negative health impacts. I find that human infant mortality, a commonly used metric for public health in environmental economics, rises by almost 8% after the mortality shock to local bat populations. Additional analysis shows that counties experiencing more severe bat die-offs also experience larger increases in insecticide use, and higher infant mortality rates after WNS exposure. I also demonstrate that local socioeconomic conditions fail to systematically change along the expansion path of the wildlife disease, and as a result, do not attenuate the main effects. This work sparked additional research on the consequences of WNS (Manning and Ando 2022; Nakhmurina et al. 2026). Together, these findings demonstrate that while farmers can substitute for lost ecosystem services, this adaptation imposes substantial and previously underappreciated health costs.

In **"The Social Costs of Keystone Species Collapse: Evidence From The Decline of Vultures in India"** (*The American Economic Review*, 2024), co-authored with Anant Sudarshan, we provide evidence on how the collapse of a keystone scavenger species affected human health through sanitation and infectious disease. Vultures were inadvertently poisoned after cheap generic versions of a painkiller were adopted by livestock farmers, not realizing that carrion containing residue of the drug would be lethal to vultures. Because farmers in India rely on scavengers to remove dead animals from the environment, the sharp and sudden decline in vultures led to more livestock carcasses rotting in animal landfills, and to rising dog and rat populations—less effective scavengers than vultures—as competition for carrion declined.

Our difference-in-differences research design classifies districts in India as high- or low-suitability for the affected vultures using habitat range maps, and compares districts before and after the collapse of vultures. Our key finding is that all-cause human mortality increased by 4%. To attribute this change in human mortality to the decline in vultures, we implement a triple-differences analysis showing that the effect is driven by districts with high baseline livestock levels. We also use a large set of time-varying controls—which we establish do not change systematically with vulture suitability before and after their collapse—and still recover precisely estimated increases in all-cause death rates. Consistent with the proposed mechanisms, we document a rise in rabies vaccine sales (a proxy for dog populations), and a decline in water quality consistent with increasing numbers of rotting carcasses not consumed by vultures. Together with the bat die-offs study, this paper shows that biodiversity losses can increase human mortality through very different mechanisms—chemical inputs in one case and sanitation failures in the other.

In **"Campaigning for Extinction: Eradication of Sparrows and the Great Famine in China"** (*R&R at The Quarterly Journal of Economics*), co-authored with Qinyun Wang, Shaoda Wang, Xuebin Wang, and Yang You, we study how an intentional effort to eradicate a species contributed to one of the deadliest famines in history. In 1958, as part of the Great Leap Forward policies, China launched a national campaign to drive sparrows locally extinct, based on the belief that sparrows were crop pests because they fed on grain, rather than providers of biological pest control through their insect consumption. We use newly digitized county-level data on agricultural production, along with methods from ecology to calculate local suitability scores, proxying for baseline sparrow population levels. We find that rice and wheat output fell in the sparrow-suitable areas after the 1958 onset of the campaign. We then show that the central government's food procurement system amplified these losses, because officials incorrectly believed that the campaign was successfully raising grain output, resulting in higher death rates in sparrow-suitable areas. Reassuringly, sparrow suitability is uncorrelated with higher adherence to Great Leap Forward policies, supporting our interpretation of the results as the treatment effect of sparrow eradication.

Ongoing work further expands on documenting the long-run benefits that species can provide. In **"Local Value of Apex Predators: Evidence from a River Discontinuity"** (NBER WP #34377), co-authored with Anouch Missirian, Dominic Parker, and Jennifer Raynor, we estimate the long-term benefits of stable gray wolf populations. We use a spatial regression discontinuity design around the Saint Lawrence River in Canada, and find that the share of animal-related vehicle collisions is five percentage points lower north of the river, where the gray wolf has stable populations, relative to south of the river, where the gray wolf has been gone for over a century.

Across these four papers, I show that wildlife populations generate substantial, measurable benefits, and that their decline can increase human mortality through different pathways. The findings also underscore how substitution can either amplify or mitigate the social costs of biodiversity losses: compensating for bat population collapses with insecticides was instrumental in causing negative health impacts, while substituting for vultures (e.g., with animal burial, incinerators, or rabies vaccinations) was, and remains, prohibitively expensive. In the case of sparrows, insecticides were in short supply and allocated according to centrally planned decisions rather than realized pest pressure, preventing effective substitution and enabling policy maladaptation. The over century-long absence of Wolves south of the Saint Lawrence River, and persistent gap in the public safety of roads, demonstrates that it is difficult to substitute the keystone role of apex predators.

2. Evaluating the Effectiveness and Costs of Conservation Policies

Faced with calls to slow and reverse biodiversity losses, policymakers have responded with a range of initiatives. I expand the body of work on the performance of environmental policies (e.g., the Clean Air Act, and the Clean Water Act) by studying how conservation policies perform at meeting their targets, and what costs they impose on other economic activities that become regulated by them. Specifically, my work focuses on two understudied national policies aimed at terrestrial and ocean biodiversity: the 1973 Endangered Species Act (ESA), and the 1996 re-authorization of the 1976 Magnuson-Stevens Act (MSA) as the Sustainable Fisheries Act.

In **Regulating Biological Resources: Lessons From Marine Fisheries in the United States** (*2nd round of revisions at The Review of Economic Studies*), co-authored with Kimberly Oremus, we evaluate the legal requirement to rebuild depleted US fisheries. Fisheries are a canonical example of open-access natural resources, and the ocean is the largest connected ecosystem on Earth. The 1996 reauthorization of the MSA introduced a requirement to rebuild depleted fisheries using a scientifically informed framework based on the concept of Maximum Sustainable Yield—the largest long-term average harvest. The debate around the efficacy of the MSA's threshold-based approach centers on whether the policy's apparent success is driven by mean reversion, and whether long-term revenue gains offset short-term losses due to catch restrictions.

Our empirical analysis compares stocks that enter rebuilding to either contemporaneous stocks in the EU or historical stocks in the US that fall below the biomass threshold but do not enter a rebuilding plan. We find that biomass only recovers in US stocks that enter rebuilding. Analyzing revenue data, we find that long-term gains compensate for the short-term losses experienced during the rebuilding period. In related work, **Underfished or unwanted?** (*Science*, 2023), co-authored with Kimberly Oremus, Jesse Jian Adelman, Seleni Cruz, Janna Herndon, Brad Sewell, and Lisa Suatoni, we find little evidence that the MSA results in underutilization of marine resources.

Turning to terrestrial biodiversity, my work on the ESA examines both labor market and land market consequences of species protections. In **"Labor market impacts of land protection: The Northern Spotted Owl"** (*Journal of Environmental Economics and Management*, 2021), co-authored with Ann Ferris, we find that employment reductions are present but much smaller than the numbers often cited in public discourse. In **"The Cost of Species Protection: The Land Market Impacts of the Endangered Species Act"** (NBER WP #33352), joint with Maximilian Auffhammer, David McLaughling, Elisheba Spiller, and David Sunding, we find no average effect on property values, which masks heterogeneity across locations and types of protections.

Ongoing work further demonstrates how the management of ecosystems can be crucial for human well-being even if its goal is to curtail species population level, rather than preserve them. In **"Valuing Disaster Prevention: Desert Locust Monitoring and Control"** (NBER WP #35215), co-authored with Joséphine Gantois, Amir Jina, Evelina Linnros, Gordon McCrod, Anouch Missirian, and Anna Tompsset, we study the social costs of locust outbreaks. Locust outbreaks decimate agricultural crops, leading to food security issues, and have been a stable and recurring event throughout most of Africa and some regions in Asia. Our analysis finds high benefit-cost ratios for the monitoring and control of swarm outbreaks.

These papers quantify previously unmeasured benefits and anchor industry costs in empirical analysis, rather than leaving them trivialized, ignored, or asserted without evidence.

3. Animal Agriculture, Wildlife Populations & Environmental Impacts

Animal agriculture in many parts of the world, including the US, has shifted from small farms with diversified production to large concentrated animal feeding operations that specialize in a single animal. On the one hand, large-scale monoculture farms offer efficiency gains, reduce land use per unit of output, and lower costs to consumers. On the other hand, operations generate substantial pollution in the form of animal waste, can spread and contract diseases from wildlife populations, and require growing investments to adapt to climate change. As part of a large USDA-NIFA-funded project, **"The Economic Disamenities and Health Impacts of Animal Feeding Operations' Practices in the United States,"** joint with Anthony D'Agostino and Claire Palandri, we study the multiple dimensions of impacts from animal agriculture. Our primary focus is testing whether the use of low-dose antibiotics in farm animals contributes to the rise in antimicrobial resistance in humans, through spillovers from farm to non-farm locations after severe weather events. A key contribution we make is building a national-level database on the location of animal feedlots. In related work, **"High-frequency data reveal limits of adaptation to heat in animal agriculture"** (*Science Advances*, 2025), co-authored with Claire Palandri, Ayal Kimhi, Yaniv Lavon, and Ram Fishman, we document damages and adaptation to hot days in the dairy sector. We report large declines in cow productivity, which persist even days after humid heat exposure, and that common adaptation only offsets about half of the observed negative impacts.

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