Cracking the egg: how a nested framework illuminates the challenges of comparative environmental analysis

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Stratospheric ozone loss is on course to become a solved environmental problem, with all significant producing countries (including China and India) undertaking complete phaseouts of ozone-depleting substances. The universal concurrence and speed with which ozone loss has been addressed are sometimes heralded as signs that effective international agreements on other problems of the global commons are just around the corner. But progress on many other issues has been strikingly limited. Is ozone the exception, rather than the rule, and if so why? Here we present one way to illuminate why some environmental problems are more tractable than others by consideration of a "nested" (vs. non-nested) framework.[1] We will refer to nesting as having three components: intellectual, societal, and institutional. Intellectual nesting refers to the academic communities that study the roots of the problem as well as possible solutions. Societal nesting refers to the sectors of human actors and activities that are associated with the problem. Institutional nesting describes the types of governance or management structures that could address the problem. *We define a fully nested environmental problem as one for which the science of the problem is rooted within multiple, disparate disciplines, and for which the causes, impacts, and solutions are nested within different sectors of society and government.* Within these definitions, we discuss marine biodiversity loss as an example of a deeply nested environmental problem, climate change as a mostly nested environmental problem, and ozone depletion as a much less nested environmental problem.

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[1] Nested governance schemes are an established part of the common pool resource literature (*e.g.* Ostrom, 1990, 2012), where the use of the term "nesting" or "polycentricity" generally refers to the spatial scale of governance (e.g. grassroots to national); our focus here is broader.

Marine biodiversity loss encompasses diminishing diversity at the genetic, species, and ecosystem levels. One threat to marine biodiversity is habitat degradation, which has many causes, including physical disturbance from bottom trawling and pollution released into the ecosystem, leading to a nested set of scientific and societal actors and activities involved with the problem. Trawling impacts are studied by fisheries scientists and marine ecologists, while trawling activities are usually regulated by fisheries management agencies. Pollution, on the other hand, is often land-based, is the focus of water, soil, and watershed scientists, and may be regulated by coastal municipalities. Thus, habitat degradation is nested within a wide range of both fishing and land-based activities, is studied by diverse intellectual communities, and has deep institutional nesting of management strategies. This is only one facet of marine biodiversity loss.

Climate change is arguably less intellectually nested than marine biodiversity loss, but is very strongly societally and institutionally nested. The dominant source of anthropogenic climate change is human emissions of carbon dioxide, implying less intellectual nesting regarding the scientific basis of the primary problem than marine biodiversity loss. The societal and institutional aspects of climate change, however, are particularly strongly nested. For example, the impacts of climate change create distinct challenges in different geographic areas and sectors of society: for some the biggest threat is sea level rise; for others, it is an increased frequency of drought. The industries and institutional bodies involved in the emissions of carbon dioxide range extremely broadly and cross many sectors. For example, the transport of goods across a large distance by any given mode of transportation involves the producer of the good, the transportation service, the manufacturer of the vehicle, the buyer of the good, the producer of the fuel consumed by the vehicle and the regulator of the market in which that fuel is sold. This creates nesting that spans a vast set of actors and activities.

Ozone is a much less nested environmental problem. The science behind ozone depletion primarily involves atmospheric chemistry (albeit with important links to stratospheric dynamics, health, and ecosystem sciences), creating a clear intellectual center for ozone depletion science. The great bulk of the ozone-depleting chemicals were manufactured by a single non-nested industry already subject to regulation for other chemical products they made, so that management precedents within non-nested institutions already existed in many countries. At an early stage consumers and governments attacked the problem using a simple and nearly non-nested strategy by limiting the use of these chemicals in spray cans.

By categorizing environmental problems as intellectually, societally, and institutionally nested or non-nested, one can gain a basic understanding of some key complications to progress in addressing them. Is extensive nesting an insurmountable barrier to progress? Challenges of intellectual nesting, while great, have been reduced by scientific assessments (*e.g.*, of ozone depletion and climate change) that bridge nested disciplinary divides and form epistemic communities (*e.g.* Haas, 1991). The intellectual nesting of biodiversity loss is beginning to be addressed through the Intergovernmental Platform on Biodiversity and Ecosystem Services. Strong societal and institutional nesting affect the efficacy of regulatory institutions and international treaties designed to address these problems, but have seldom been formally assessed. If societal and institutional nesting were to be assessed in a manner similar to the assessment of science, progress on nested issues could likely advance. We hope this framework for the comparative analysis of nested environmental problems will prove useful as we work towards creative solutions.

Literature Cited:

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