Transdisciplinary doctoral training to address global sustainability challenges

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1 Introduction

Global sustainability challenges, such as climate change and the plastics crisis, converge across disciplines and involve diverse stakeholders. Given the magnitude and interconnected nature of sustainability challenges, problem-solvers must be trained across disciplines. The United Nations Brundtland Commission’s report “Our Common Future” articulated a definition of “sustainability” in the context of development: “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [1]. Although interdisciplinary research teams are common, doctoral training traditionally focuses on gaining depth in a narrow frame. Transdisciplinary research offers an alternative. Jean Piaget defined transdisciplinary scholarship in 1970 as research that “would not only cover interactions or reciprocities between specialized research projects but would place these relationships within a total system without any firm boundaries between disciplines” [7].

Here we propose a roadmap for transdisciplinary doctoral training in the sustainability sciences

Transdisciplinary doctoral training is necessary to produce solutions-driven sustainability research, especially given that a 2015 Elsevier report notes that sustainability science is less interdisciplinary than the global average [6,8]. While calls for transdisciplinary research have
increased \cite{9,10}, few discuss a practical approach to transdisciplinary doctoral training. The roadmap proposed here may help trainees to better contribute to the community of practice (e.g., policymakers, nongovernmental organizations) while furthering sustainability science. We close by discussing the outcomes of transdisciplinary doctoral training on individuals, the academy, and society.

2 A roadmap for transdisciplinary doctoral training

The roadmap proposed highlights three pillars to structure Ph.D. training: research lenses, network, and quality control (Fig 1). These features are not unique to a transdisciplinary Ph.D., but the content varies significantly from a discipline-bound Ph.D. We refer to the research lenses as the disciplines that probe complex environmental challenges. The network includes the individuals with whom the trainee learns, formally and informally, within and outside the university. Quality control refers to the metrics used to ensure adequate training and fulfillment of Ph.D. requirements outside of those defined by the university.

3 Discussion

3.1. Research lenses

Defining the research lenses used during the Ph.D. contributes to delineating learning and research goals. The research lenses identified vary based on the environmental problem that is
the dissertation’s focus. For example, at Duke, a Ph.D. focused on plastic pollution mitigation utilized research lenses in public policy to examine societal responses to plastic pollution and the fields of environmental toxicology and marine biology to evaluate the ecological effects of plastic pollution on marine animals. This experience led to the initiation of a sustainability science research program focused on marine plastic pollution. A similar approach can be used for other sustainability challenges. Fisheries management may involve fields ranging from economics to vertebrate biology, and migratory species management could utilize concepts from law as well as population ecology. Another example includes a Ph.D. focused on the use of unmanned aircraft systems in conservation research, which involves the fields of engineering, geospatial analysis, and marine biology.

Defining the research lenses early on during the Ph.D. enables trainees to select mentors, target coursework, and build skillsets. Initially, it may be helpful for trainees to produce a few disciplinary dissertation chapters. Synthesizing across disciplines takes fundamental knowledge and improves with experience. Including a synthesis dissertation chapter refines transdisciplinary learning and furthers sustainability science.

### 3.2. Network

A cross-disciplinary network is essential. The Ph.D. committee should include members to guide the trainee in each research lens. One of the greatest challenges for transdisciplinary research is communication and respect between disciplines [2]. We suggest ensuring committee-wide interest and respect for transdisciplinary research as much as possible.

Expertise outside the academic committee is needed to ensure real-world applicability. Doctoral training should include direct research experience with practitioners engaging with the environmental problem that is the dissertation’s focus. University centers, institutes, and clinics may provide an avenue for this, as was the case in the author’s experience, which enabled collaborations with local and international nongovernmental organizations. Research with development agencies, businesses, or local organizations expands perspectives, grows networks, and provides organizations with academically-rigorous research.

### 3.3. Quality control

Most academics have not undergone transdisciplinary training, so ensuring transdisciplinary Ph.D. quality can be challenging for a standard disciplinary committee [11,12]. Thus, the Ph.D. committee members must reflect the research lenses of the Ph.D. Quality control is the network’s purview, including the doctoral committee and outside experts, which is the same as in siloed Ph.D. training. The perceived differences are due to difficulties in communication and respect across disciplines.

Although scientific publications in discipline-specific journals would be suitable for disciplinary competence, limiting outcomes to journal publications is a narrow metric. Understanding and evaluating non-traditional products (e.g., policy reports, patents, transdisciplinary journal articles) is essential and may yield increased creativity in solutions-driven research [13,14]. A practical example of this includes preparing a report that undergoes peer review within an institution’s processes (e.g., World Bank, United Nations), co-authoring a study with community partners, or successfully filing a patent. Success metrics beyond scientific publications broaden academia’s reach and impact.

### 4 Outcomes

The Ph.D. is the beginning of the journey. Research has shown that interdisciplinary doctorates in the United States are more likely to be non-tenure-track academics (from 2004 to
Due to the short-term nature of postdoctoral employment and low salary compared to the cost of living (in the U.S.) [15], those who self-identify as interdisciplinary researchers may be dissuaded from pursuing academia [14], posing risks to academia by the loss of these researchers to other sectors. Further research showed that interdisciplinary scientists were more likely than disciplinary peers to create new firms, license or patent technology, co-produce research, and provide research services [13]. Incorporating non-traditional evaluation metrics (e.g., Rao-Stirling diversity index, patents, social media shares) into promotion and tenure packets would aid in institutionalizing transdisciplinary research [6,14].

Conclusion

New funding opportunities call for transdisciplinary sustainability research. Conservation postdoctoral fellowships, such as the David H. Smith Conservation Research Fellowship and the Liber Ero Postdoctoral Fellowship, provide research experiences with practitioners. Other broad funding calls, such as the National Science Foundation’s Convergence Research and Dear Colleague Letters, invite transdisciplinary research [14]. The South American Institute for Resilience and Sustainability and Accelerator at Stockholm University provide space for discipline-free encounters [6]. Transdisciplinary doctoral training equips scholars to creatively tackle urgent environmental problems [14] and will grow in necessity in the future.

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