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RESEARCH ARTICLE

Ethical considerations of urban ecological design and planning experiments

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Societal Impact Statement

It is increasingly common for plant scientists and urban planning and design professionals to collaborate on interdisciplinary teams that integrate scientific experiments into public and social urban spaces. However, neither the procedural ethics that govern scientific experimentation, nor the professional ethics of urban design and planning practice, fully account for the possible impacts of urban ecological experiments on local residents and communities. Scientists that participate in design and planning teams act as decision-makers, and must expand their domain of ethical consideration accordingly. Conversely, practitioners who engage in ecological experiments take on the moral responsibilities inherent in generation of knowledge. To avoid potential harm to human and non-human inhabitants of cities while maintaining scientific and professional integrity in research and practice, an integrated ethical framework is needed for urban ecological planning and design.

Summary

While there are many ethical and procedural guidelines for scientists who wish to inform decision-making and public policy, urban ecologists are increasingly embedded in planning and design teams to integrate scientific measurements and experiments into urban landscapes. These scientists are not just informing decision-making – they are themselves acting as decision-makers. As such, researchers take on additional moral obligations beyond scientific procedural ethics when designing and conducting ecological design and planning experiments. We describe the growing field of urban ecological design and planning and present a framework for expanding the ethical considerations of socio-ecological researchers and urban practitioners who collaborate on interdisciplinary teams. Drawing on existing ethical frameworks from a range of disciplines, we outline possible ways in which ecologists, social scientists, and practitioners should expand the traditional ethical considerations of their work to ensure that urban residents, communities, and non-human entities are not harmed as researchers and practitioners carry out their individual obligations to clients, municipalities, and scientific practice. We present an integrated framework to aid in the development of ethical codes for research, practice, and education in integrated urban ecology, socioenvironmental sciences, and design and planning.

KEYWORDS
ecological design, ecological planning, professional ethics, research ethics, social ethics, urban ecology

1 | INTRODUCTION

Ecological science has many practical applications for conservation, restoration, and ecosystem management. Over the more than century-long history of the discipline of ecology, relationships between scientists and practitioners in land and resource management have taken many forms. Consequently, there are a range of models of scientific practice with regard to applied ecological research, from strong separations between scientists and activities that could be perceived as advocacy (Lackey, 2007; Nielsen, 2001) to highly integrated models in which scientists and stakeholders co-produce knowledge in translational ecology (Chapin, 2017; Jackson et al., 2017), use-inspired and knowledge-to-action frameworks (Clark et al., 2016; Opdam et al., 2013; Wall et al., 2017; Wittmayer & Schäpke, 2014), design projects coupled with experiments (Evans, 2011; Felson & Pickett, 2005), and participatory or community-engaged research (Krasny et al., 2014; Luz, 2000; Shirk et al., 2012). These various collaborative models of scientist-practitioner interactions use somewhat different terminology, but generally describe practices in which ecologists and natural resource managers or other professionals cooperate in some fashion to develop and analyze research questions, experiments, and resulting data that directly inform management, planning, and design decisions.

Over time, as human populations have rapidly increased and land use change has accelerated, collaborative models of ecological science have shifted from systems with minimal human influence to focus on areas with denser human populations. Contemporary ecological studies more frequently occur in locations that are highly visited, intensively designed or managed, or cultivated specifically for human use (McDonnell, 2011). As a result, experiments in close proximity to human residents are an integral part of urban ecology and commonly include a significant human dimension, since ecological experiments or their outcomes may impact local residents, visitors, or other stakeholders (Felson & Pickett, 2005). In order to study human-dominated systems, ecologists now commonly collaborate with researchers from various sub-disciplines of the social sciences to study socioecological, socioenvironmental, or coupled human-environment systems (Childers et al., 2015; McPhearson et al., 2016; Pataki, 2015). Increasingly, these studies are taking the form of co-designed urban landscapes that serve a dual role as scientific experiments as well as public urban spaces (Childers et al., 2015; Felson et al., 2013; Felson & Pickett, 2005).

There is a rich literature on the ethical dimensions of ecological experiments to avoid harm to non-humans such as local wildlife, flora, and rare and endangered species (Crozier & Schulte-Hostedde, 2015; Farnsworth & Rosovksy, 1993; Parris et al., 2010). Furthermore, when studies explicitly include or engage human subjects, they are subject to procedural ethics, for example, responsible conduct of scientific research toward human subjects (Schienke et al., 2011), and potentially to other best practices for conducting community-engaged research (Mikesell et al., 2013; Ross et al., 2010). However, in this paper we argue that there are additional ethical concerns beyond procedural ethics that are increasingly important in urban ecological studies and experiments, particularly studies that involve ecological and social scientists in urban planning and design. As the domain of ecology has expanded into cities and settlements, scientists, urban planners, and landscape architects have begun weaving collaborative experiments into the built environment with urban and landscape designs that serve both scientific and social functions (Orff, 2016; Reed & Marie-Lister, 2014). This is a type of knowledge and sustainability solutions co-production (Akpo et al., 2015; Lemos et al., 2018; Norström et al., 2020; Pohl et al., 2010) in which collaborative teams of scientists and practitioners each take on additional responsibilities and moral obligations that extend beyond the traditional domains of their disciplines. We will provide a brief overview of these types of studies, define some of the basic ethical issues inherent in ecological design and planning experiments, and examine the ethical dimensions of this type of research from the lens of three different disciplines: ecology, social science, and the professional practices of urban planning, urban design, and landscape architecture. Drawing on frameworks from various disciplinary traditions (Table 1), we offer an integrated approach for scientists who engage in ecological design and planning experiments that considers the unique ethical obligations of scientist-practitioners.

2 | ECOLOGICAL PLANNING AND DESIGNED EXPERIMENTS: A HYBRID OF SCIENTIFIC INQUIRY AND PROFESSIONAL PRACTICE

Historically, ecological experiments have largely been removed from human social interactions, with dedicated research sites or experimental plots that experienced limited or controlled visitation from the public. When the aim of an ecological experiment is to learn about the functioning of the non-human world, research sites or plots may be fenced off or hidden from public view. In this case, there may be little direct influence of an ecological experiment on the local community or general public. However, as the scope of ecology has expanded to include the built environment and various interactions between people and nature, it has become more difficult, and less desirable, to conduct scientific studies and experiments that are closed off from places of human habitation, visitation, and social and cultural interactions. In fact, the potential educational value of the experiment for teaching people about ecology is missed by this approach. Furthermore, interactions between people and

TABLE 1 Existing frameworks relevant for the ethics of integrated urban ecological planning and design experiments

Category	Subcategory	Frameworks	References
People	Researchers		
	Direct research participants		
	Clients		
	Primary stakeholders (people and groups who can influence the success of the project)		
	Secondary stakeholders (people and groups affected by the project)	Social ethics	Crozier & Schulte-Hostedde, 2015
	Human Communities	Community-Engaged Research	Ross et al., 2010; Mikesell et al., 2013
	Social-Ecological Systems		
Non-Humans	Individuals	Animal ethics	Singer, 2009; Korsgaard, 2018
	Populations/Species/Communities	Environmental ethics	Callicott, 1986; Parris et al., 2010; Newman et al., 2017
	Ecosystems	Environmental ethics	Farnsworth & Rosovsky, 1993; Rolston, 1994
	Sites	Professional ethics	Marcuse, 1976; Vernon, 1987
Epistemic	Professional integrity		
	Production of credible knowledge		
	Epistemic justice	Epistemic Justice	Fricker, 2007
Design planning	Aesthetics	Environmental Aesthetics	Carlson, 2002
	Design quality	Landscape design	
	Feasibility		

The shaded areas show entities historically neglected by one or more perspectives, but of particular interest in design + research projects.

urban nature are often the object of study in urban ecology, which requires experimental designs in which people and/or the built environment engage with the non-human components of urban or human-dominated ecosystems (Childers et al., 2015; Felson & Pickett, 2005; Grimm et al., 2000; McPhearson et al., 2016; Pataki, 2015).

To facilitate the integration of scientific experiments into the built environment, both social and ecological scientists are increasingly collaborating with professional planners and landscape or urban designers to incorporate the principles of experimental design into the construction of urban spaces at the outset of landscaping, redevelopment, or construction projects (Childers et al., 2015; Felson, Oldfield, et al., 2013; Pickett et al., 2016). This practice is not limited to urban contexts, but has rapidly advanced in urban ecology under frameworks of "designed experiments" (Felson & Pickett, 2005), ecological planning or ecological design (Ahern, 2013; Rothfeder, 2017), "ecology for cities" (Pickett et al., 2016), landscape ecology and design (Nassauer & Opdam, 2008), sustainability science (Clark et al., 2016) and co-design of policies between researchers and policy-makers (Trencher et al., 2014). In all of these models, it is common for scientists to play a role in collaborative teams that actively transform human-occupied spaces by planning or designing greenspace, green infrastructure, sustainability policies, or other solutions to socioenvironmental problems.

As described by Felson and Pickett (2005), designed experiments are collaborative design projects in which landscape architects and/or urban designers work in tandem with scientists to integrate scientific experiments into site design. In this model, scientists participate in decision-making in multiple phases of the design process, including contracting, site evaluation, and site design, and conversely, designers participate in scientific experimentation (Felson, 2016; Felson, Pavao-Zuckerman, et al., 2013). Ahern et al., (2014) describe a similar process at larger scales that includes collaborations with urban planners as well as site designers, while Childers et al., (2015) framed collaborative processes between ecologists, designers, planners, engineers, and residents as "the urban-design ecology nexus." Notably, we distinguish here between collaborative models in which scientists co-produce knowledge or co-design scientific studies with stakeholders, versus *embedded models* in which scientists are embedded in design/planning teams and contribute directly to design and decision-making. Moser (2016) noted that the term "co-design" has been used in both contexts – to refer to the design of collaborative scientific studies as well as the co-design of policies – but these two models have different implications for scientific and procedural ethics. In the former, scientists inform policy-makers or designers who are solely empowered to make decisions through the collaborative design of user-inspired or actionable scientific studies. In the latter, scientists themselves participate in making decisions that directly influence and even transform the built environment or contribute to policy actions by participating in design or decision-making teams.

With this latter role may come substantial responsibilities, given the close relationship between form and function in the built/

designed environment and human well-being. For example, it is well documented that the addition of greenspace to cities in the U.S., Europe, and China has been associated with gentrification processes that exclude vulnerable populations and contribute to housing affordability problems in dense urban areas (Bryson, 2013; Dooling, 2009; Rigolon & Németh, 2018; Rutt & Gulsrud, 2016; Wolch et al., 2014). If scientists collaboratively participate in expansions of urban greenspace through collaborative experiments, design, or planning projects with local municipalities, they bear some moral responsibility for the impacts of those projects on marginalized communities. Consequently, scientists need frameworks, guidelines, or codes of practice that help navigate decision-making about the broader social impacts of experiments, even if the scientific methods do not explicitly include research on human subjects.

Here we argue that embedded models, in which scientists participate in both knowledge generation as well as tangible design and decision-making about landscape change, have added new ethical dimensions to considerations about the responsible conduct of ecological research. By shaping experiments as design interventions and contributing to design or planning teams, scientists are not merely informing decision-making – *they are themselves acting as scientist-practitioners*. From an ethical standpoint, this implies that participants in embedded models of ecological planning and design take on the moral obligations of researchers as well as those of professional practitioners of design and planning. We will consider these obligations from the standpoint of conventional responsible conduct in ecological research, the protection of both human subjects and communities, and the professional responsibilities of urban practitioners.

3 | ECOLOGICAL DIMENSIONS OF ETHICS

Many ecologists have traditionally shied away from practices in which scientists are closely intertwined with decision-making due to concerns about compromising scientific integrity, trust, and objectivity (Lackey, 2007; Nielsen, 2001). It is possible, and for some scientists desirable, to entirely constrain ecological science to non-human concerns. Consequently, the codes of ethics of scientific societies such as the Ecological Society of America (ESA) are largely non-human-centered, and focus on scientific integrity, procedural professional ethics, and the protection of natural environments. For example, as of May 2020 the ESA code of ethics stated that:

> Ecologists will conduct their research so as to avoid or minimize adverse environmental effects of their presence and activities, and in compliance with legal requirements for protection of researchers, human subjects, or research organisms and systems.

In this clause, the environment receives a higher level of protection than humans and research organisms: ecologists are obligated to avoid or minimize harm to the environment writ large, but they are only required to ensure that the treatment of people and other organisms meets legal requirements. Adverse impacts to people, communities, and non-humans that are not regulated are not considered in this framework. The elevation of environmental over human concerns has a long history in ecology and related disciplines that have considered the ethical standing of organisms and ecosystems, particularly sentient non-human animals (Korsgaard, 2018; Singer, 2009), species (Callicott, 1986; Rolston, 1994), biodiversity (Newman et al., 2017; Reyers et al., 2012; Soulé, 1985), and ecosystems and landscapes (Leopold, 1949; Rolston, 1994). Unlike other stakeholders, these non-human entities cannot represent their interests and rights in research and design projects, and procedures for institutional review of research protocols typically do not consider the impacts of destructive sampling and other research methods on wildlife and ecosystems. Given ecologists' expertise regarding non-human biota and ecological processes, ecologists have a duty to represent the value of non-human stakeholders in research and decision-making alongside their own interests as researchers.

More recent ethical statements from scientific societies concerned with applications of ecological science, such as the Society of Ecological Restoration (SER), explicitly include *improving* environmental conditions, such as biodiversity, as a primary objective. In addition, the SER mission extends even further toward normative objectives by aiming to improve human wellbeing, under the assumption that ecosystem resilience and human wellbeing are interrelated (Nassauer & Opdam, 2008). This is highly relevant for ecological planning and design research, because designed urban landscapes and the built environment often serve a primary purpose of benefiting people, communities, and other urban functions. Therefore, altering the built environment through scientific experimentation may have consequences for human wellbeing – both positive and negative.

As a result, the ethical domain of ecology, which has traditionally been centered on the epistemic goals of science, and to some extent the well-being of non-human organisms and ecosystems, must be expanded in planning and designed experiments to include various human concerns (Figure 1). Fortunately, there are many lessons to be learned from human-centered research disciplines, including both social science and biomedical research, in incorporating human concerns into research practice, even when humans are not explicitly the object of study.

4 | SOCIAL AND PUBLIC HEALTH DIMENSIONS OF ETHICS

When humans are the object of study, procedural ethics governing human subjects research apply, with well-established frameworks and protocols for protecting people from harm. The foundation of ethical research on human subjects has been the Belmont Report (The National Commission for the Protection of Human Subjects of Biomedical & Bevahioral Research, 1979), which was commissioned in response to prominent abuses of vulnerable populations in medical research. It suggests three principles which should guide ethical

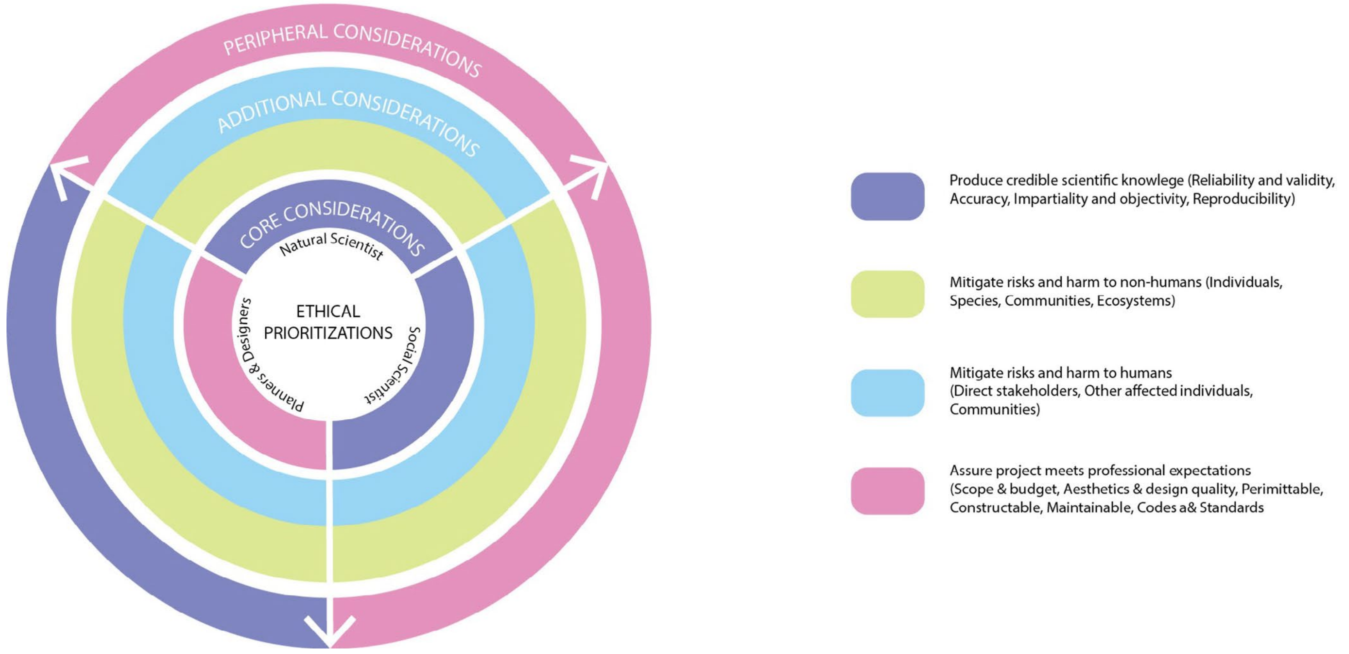

FIGURE 1 Ethical prioritizations for natural scientists, social scientists, and practitioners participating in urban ecological planning and design experiments. The inner-most ring indicates the core ethical considerations of individuals in those disciplines as they have been historically prioritized. The middle two rings indicate additional ethical considerations that have become more relevant as each discipline expanded into more applied work at the interface of knowledge generation and practice. The outer-most ring represents areas of ethical consideration that are typically not explicitly prioritized within each discipline, but ought to be considered as part of urban ecological planning and design experiments

human-subjects research: autonomy, beneficence, and justice. These principles are well established and there are requirements by many institutions for researchers to submit human subjects research protocols for approval and oversight. However, the Belmont principles focus on individual research participants, and research in a public setting has additional ramifications at the community level, in that there may be social or cultural impacts of ecological experiments that affect particular groups of people. Therefore, researchers and ethicists have explored how these principles might be adapted to apply to communities, with the aim of guiding more ethical community-engaged research (CEnR).

For ecological planning and design experiments, the ethics developed for CEnR are a particularly apt model. Like social scientists and ecologists engaged in projects involving both design and research, researcher-practitioners in public health and other applied scientific fields find themselves balancing knowledge production, stakeholder values, and interventions aimed at improving communities. Lessons learned from CEnR and specific applications such as Community Based Participatory Research (CBPR) may be relevant for ecological planning and designed experiments. Notably, most ethicists agree that the Belmont principles are insufficient for CBPR (Mikesell et al., 2013). Additional considerations are necessary to frame ethical research that has implications for human communities. For example, ethicists and researchers agree that respect for autonomy in the CEnR context requires more than merely acquiring informed consent from participants. Additional aspects of autonomy include respect for community interests and values, community involvement in interpreting results, and open recognition of the value of lay communities' contributions to successful research. In addition, Mikesell et al., (2013) present an expanded understanding of the principle of beneficence. In addition to maximizing benefits and minimizing harms to individual participants, CEnR requires considering benefits and harms to participating communities. This might require creating a community-level risk-benefit analysis that assesses potential risks and benefits to communities, such as the risk that research reinforces negative stereotypes about the community, undermines its political authority, or disrupts community structure and function (Ross et al., 2010). Considerations of non-maleficence also take on an expanded role in CEnR, as restrictions on harm are not only part of risk analyses, but are also needed to prevent harming one group to the benefit of another.

Finally, in CEnR special issues of justice emerge. These include issues of fairness between different community stakeholders, and balancing burdens and benefits among community participants. CBPR researchers also emphasize that community benefits should be prioritized over researcher benefits (Mikesell et al., 2013). This may require creating organized structures to represent the voice of informal communities (Ross et al., 2010). Merely consulting with members of an unstructured community group is insufficient, because as individuals, these community members will generally lack the power or prestige to negotiate on a level playing field with researchers. Justice can thus require that researchers help unstructured stakeholder groups designate formal representatives, rather than merely performing informal community consultations.

This approach may help avoid some of the pitfalls of well-intended urban greening projects that are poorly received by local communities because they were not adequately consulted about their specific needs and values in advance (Carmichael & McDonough, 2018).

While these principles drawn from CEnR inform urban ecological design and planning projects, there are other distinctive ethical issues associated with these projects that should also be considered. Ecological and social dimensions of experiments can intersect, requiring an expansion of ethical domains into the consideration of the rights of non-humans. For example, in an urban ecological design context, it may be unethical to destroy some types of either rare or culturally valued species or landscapes to create an ecological experiment (Calkins, 2012). Although the terminology for social and community ethics is still evolving (Hall et al., 2017; Herkert, 2005; Ladd, 1980; Schienke et al., 2011), we contend that ethical frames within CEnR may be combined with ecological ethics to extend ethical considerations for urban ecological applications (Figure 1).

5 | PRACTITIONER DIMENSIONS OF ETHICS

A key feature of ecological planning and designed experiments is that all members of collaborative teams participate in the creative ideation process, and therefore all act as planners/designers (Ahern et al., 2014; Childers et al., 2015; Ogden, 2013). Therefore, some obligations of designers, planners, and practitioners apply to researchers who contribute to decisions about the designed and built environment. Notably, urban planners, designers, and other communities of practice have their own professional codes of conduct that articulate ethical obligations toward local residents such as “working to expand choice and opportunity for all persons, recognizing a special responsibility to plan for the needs of the disadvantaged and to promote racial and economic integration (American Planning Association, https://www.planning.org/ethics/ethicscode/). Similarly, the American Association of Landscape Architects pledges that “members shall continually seek to raise the standards of aesthetic, ecological, and cultural excellence” (https://www.asla.org/ContentDetail.aspx?id=4276) and “support the creation of affordable house choices in livable communities” (https://www.asla.org/ContentDetail.aspx?id=4308), in addition to a number of other tenets focused on promoting human well-being.

These obligations emerge from the specific objectives of urban planning and design professionals. Rather than knowledge generation, these professions focus on public health and safety, economic considerations, and design quality, including aesthetic values (Figure 1). Researchers who help create ecological planning and designed experiments must also consider these factors in the final experimental design. Although ecologists will typically lack the aesthetic expertise and design and construction knowledge of the designers and architects they work with, appreciation of what makes a beautiful and functional landscape may be facilitated by accurate ecological knowledge (Carlson, 2002), such that ecological knowledge supports effective design interpretations. A xeriscaped garden which initially strikes someone as unexciting may come to seem beautiful as that person learns how it engages with the local biota and ecological conditions and is more sustainable than well-watered landscapes. Hence, local ecological knowledge, combined with experimentation, can inform what is aesthetically valuable when local ecological features are combined with social norms such as orderliness (Nassauer, 1995). Ecologist-designer/planners thus have a responsibility to both inform the aesthetic decisions of their designer collaborators, and help ensure that end-users have access to aesthetically relevant ecological knowledge.

Another important consideration in urban ecology is that public landscapes play a role in creating community values and commitments. This adds an additional layer of opportunities and challenges for scientist-practitioners engaged in design and planning. Consider historical monuments such as a Holocaust memorial, a statue of a Confederate general, or a placard celebrating a civil rights march. Nguyen (2019) argues that monuments function in part to express existing community values, but also to encourage a certain set of values and thus shape the community going forward. A public display against fascism, for instance, would express the values of some present-day citizens, but also aims to commit the future community of the city to a particular set of actions and values. These processes might be clearest in the form of monuments, but they can be relevant in any sort of designed landscape. Replacing an indigenous ecosystem with public parks resembling the landscapes of colonizers’ homelands, for instance, encourages a community to adopt the value structure of the colonizers. Managing the flora of a riparian space to make it inimical to temporary occupation by unsheltered homeless commits the community to a particular attitude towards people facing homelessness. Researchers involved in designing and researching urban spaces thus need to consider not only how landscapes realize stakeholder values, but also how they express and reshape them.

Finally, socioecological research in urban communities requires extra consideration of transparency during the process as well as around how results are disseminated. Communication of scientific results is an obligation in many scientific codes of conduct. For example, as of May 2020 the ESA code of conduct states:

> Ecologists will, to the extent practicable, engage meaningfully with the communities in which they practice to promote teaching, learning and an understanding of their study; broaden the participation of underrepresented groups; enhance local infrastructure for research and education; and disseminate results broadly to benefit the local community.

This statement obliges scientists to participate in community engagement and equitable modes of science education. In an urban context, particular attention must be paid to the means of carrying out this obligation. As with CEnR in the biomedical context, in some situations it may be appropriate for community representatives to play a role in disseminating results. Local communities may also have special knowledge and relationships with the land and biota involved in urban ecological planning, such as indigenous knowledge (Steel & Whyte, 2012), and these communities' perspectives on the interests of non-human stakeholders should stand equally alongside those of researchers.

Given the place-specificity of the research, the ethical demands on dissemination may also go beyond this. If the results of a research and design project in one community is taken to be generally applicable without appropriate consideration of local social and ecological conditions, this could lead planners in other communities to model other projects on these results without going through the same process of local community engagement or otherwise considering local context. Likewise, respect for autonomy and acquisition of consent will take on unique dimensions in the urban ecology context. The scope of who is affected by ecological design will extend beyond land owners and immediate users of the landscape. Informed consent from all stakeholders and beneficiaries will thus generally not be feasible, and researchers will need to find alternative means to ensure that all relevant parties are considered. What this entails will depend on the type and scale of the project, but may include traditional informed consent for some parties, community consults with others, and surrogate advocacy for stakeholders unable to play an active role in design and research, such as non-human stakeholders.

6 | AN INTEGRATED APPROACH

The ethical considerations shown in Figure 1 are very similar for ecologists, social scientists, and practitioners. They differ only in priorities and perspective. Collaborating on ecological design and planning teams and playing multiple roles as scientist-practitioners requires expanding one's core domain of ethical and professional obligations to encompass the perspectives and obligations of the other disciplines. Yet, in each domain there remains a core area of expertise. Critically, as these types of ecological design and planning experiments become more prevalent, it will be imperative to incorporate these expanded ethical frameworks not only into research and professional practice, but also into education and training of emerging scientists and professionals. We conclude with three specific suggestions for implementing these recommendations. These suggestions are not exhaustive, and may complement other approaches to navigating research ethics in ecological design and planning.

Our first suggestion begins from the observation that the ethical demands on planner/researchers are sometimes partially incompatible and require tradeoffs. Epistemic values such as the production of scientific knowledge are best achieved through careful control of variables, but respect for the autonomy of communities as well as urban design considerations, municipal codes, and other constraints of urban landscaping and construction projects might require leaving some human variables uncontrolled, or to otherwise compromise principles of experimental design. For example, the MillionTreesNYC, a tree planting initiative in New York City, was designed by the New York City Department of Parks and Recreation (NYCDPR) including the Natural Resources Group, working with consultants. The program started with the Reforestation Plan for New York City focusing on public parkland. The team included the consultants (EDAW|AECOM) as well as scientists from Yale University who introduced experimentation and research as components of the design project (Felson, Oldfield, et al., 2013). The project attracted additional researchers from other institutions and disciplines. Research questions include the outcomes of experimental afforestation in a public park (Oldfield et al., 2013) and impacts of compost amendments and interplanting of selected shrub and tree species on soil conditions and tree growth (Ward et al., 2021).

Highlighting the tradeoffs in multiple and sometimes conflicting ethical and professional considerations, during the design of this integrated experimental restoration plan the NYCDPR embraced the research agenda as a sub-component of the larger planting agenda only up to a point. The original request for proposals included a request for monitoring research focusing on post-construction tree survival. The goals of the NYCDPR were to successfully implement a reforestation effort with low tree mortality and at low cost. Survival was critical, fueled by a recent die-out in a nearby NYCDPR planting. Embedding research through a designed experiment was seen as value-added; however, the NYCDPR recognized that the results of the research would not impact the MillionTrees implementation itself, only later projects. Participants also debated the need for control sites - a cornerstone of experimental design. In the end, allowing natural succession to take place in control sites was seen as undesirable because the plots would look "weedy," which could be construed as neglect by local residents and visitors. This was not socially accepted within parkland. Stakeholders were also concerned about the prospect that some experimental planting strategies could fail or lead to sub-par tree growth. Residents raised concerns about losing public space to newly reforested land. As the project progressed towards implementation, the contractor raised concerns about the logistics of setting up the plots. To balance the needs of experimentation with the needs of the client and the values of local residents, the researchers negotiated compromise solutions. For example, rather than randomly laying out amended plots, they clumped the plots into blocks for ease of implementation (Felson et al., 2014). Consequently, compromises to the scientific process were made to establish planting plans and site designs that were acceptable to the municipal government and the local community, but still allowed researchers to advance urban socioecological research.

Sensitivity to these tradeoffs between conflicting values and interests will be a necessity for researchers embedded in design and planning projects. There is no general solution for resolving tradeoffs between conflicting values. Instead, given that natural scientists, social scientists, and designers each emphasize complementary morally-relevant entities and aims (Figure 1), our first suggestion is that representatives from each discipline should have equal voice in navigating ethical tradeoffs in collaborative projects.

When it comes to dealing with ethical conflicts, no collaborator should be seen as a mere consultant or otherwise secondary to the larger plan. If representatives of each professional background maintain equal footing, this will help balance tradeoffs between the values and entities in conflict, such as multiple project goals, budget constraints, timelines, and regulatory requirements. For example, a master planning process for a riparian corridor within the University of Utah Research Park was initiated by ecologists who wished to restore the lower reach of the urbanized stream to a similar condition as its undisturbed upper reach, which was located in a protected nature preserve. When it became clear that such a restoration goal would require minimizing human access to the urban stream reach, ecologists agreed to compromise on some restoration goals in order to further community and social goals of providing equitable access to riparian greenspace and promoting active transportation with new streamside trails. The resulting stream revitalization plan (http://cepd.cap.utah.edu/2019/01/red-butte-creek-strategic-vision/) initiated a participatory co-design process involving ecologists and other scientists, landscape architects, and real estate managers to integrate scientific experimentation into re-landscaping along the stream. Ecologists were able to establish replicated plots to study stormwater infiltration in experimental bioswales, but compromised on features that detracted from aesthetic considerations, were costly to construct, or could conflict with local ordinances (for example, an ordinance against features that collect standing water for more than 72 h). Researchers on the design team also surveyed occupants of the adjacent building to ensure that the experimental design was compatible with the needs of human occupants for a functional social space. In this process, researchers were integral members of the team representing not only the epistemic values of scientific experimentation, but also working to understand the human and social needs of local residents and resolve conflicts between restoration, knowledge generation, and human access to greenspace.

In addition to the work of collaborative teams, our second suggestion is a call to action to researchers as individuals. Research embedded in design and planning is cutting edge at the present, but will be increasingly common as scientists tackle the pressing problems raised by rapid urbanization, social inequities, and environmental change. Today's embedded researchers are thus the tip of a long spear, and have a responsibility to help establish a tradition of sound ethical practice. We hope this paper helps researchers identify possible oversights and ethical blind spots, so that they can both educate themselves and give thought to how to build responsible practices into their collaborative projects. This may require consulting with experts in research ethics, and giving voice to possible ethical pitfalls in their projects, even when doing so is not their primary responsibility in the project.

Finally, our third suggestion is a call to action to the various disciplines with members involved in embedded research/design projects. These disciplines, and their professional organizations, should act sooner rather than later in expanding their professional ethics infrastructure to account for embedded research. A critical aspect of this infrastructure is support for training on the topic for both established scholars and students. In general, expanded ethics training has broad support across environmental science faculty across the United States (Hall et al., 2017). Furthermore, examples, such as the "Values and Responsibility in Interdisciplinary Environmental Science" curriculum (http://eese.msu.edu) address this perceived need, are available for use now, and have been empirically assessed to determine their effectiveness (Hall et al., 2017). To institutionally support students, the codes of ethics of salient professional organizations should be updated to reflect the socioecological implications of knowledge production and practice.

Embedded research is an exciting development for ecologists, social scientists, designers, and planners, but it also presents new social and ecological risks. In other disciplines, such as the biomedical sciences, enormous mistakes were made that caused great harm before sound ethical principles were established and widely adopted. The socioecological research community can and should avoid harm to urban residents, communities, and ecosystems by elaborating and adopting sound ethical frameworks now, at an early stage of this research. Fortunately, there is a rich literature and professional ethical codes from many allied disciplines that can form the basis for an integrated framework of ethical urban ecological design and planning. We hope that the frameworks presented here can aid in the development of a widely accepted set of ethical codes for research, practice, and education in urban ecology, socioenvironmental sciences, and urban design and planning.

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AUTHOR CONTRIBUTIONS

D.E.P and C.G.S. planned and designed the research. S.J.H., A.J.F., and J.E. made additional contributions to the research. All authors contributed to writing the manuscript.

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