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An Information-Theoretic Approach to Modeling the Major Drivers of Pro-Environmental Behavior
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Abstract: Researchers attempting to identify and understand the so-called drivers of public concern for the environment and engagement in pro-environmental behaviors have conceptualized and modeled numerous theoretical constructs. This has made it hard to establish generalities across studies regarding the causal ordering of relationships between these constructs. This study reviews some of the major constructs employed within this area of research, and uses an information-theoretic approach to assess six models that position these constructs within different causal orderings to predict general pro-environmental behavior (G-PEB). The results indicate that environmental values and general environmental beliefs are distal drivers of engagement in G-PEB, and form the foundation—or primary motivational base—for environmental identity, concerns, attitudes, and norms that—directly and more proximally—influence this broad set of behaviors. This suggests that effective policies and interventions need to target both the proximal and distal influences on behavior, as well as the contexts and structures that support shared values and primary beliefs within a society or culture. Recommendations for ways that researchers could better understand individuals and their behaviors impacting the environment more deeply, both systematically and socio-ecologically, are suggested.

Keywords: pro-environmental behavior; value–belief–norm; environmental identity; environmental attitudes; New Ecological Paradigm; reasoned action

1. Introduction
Increasing our understanding of the drivers of public concern for the environment and engagement in pro-environmental behaviors (PEBs) is vital for designing and instituting individual and collective responses that can help mitigate the impacts of global climate change [1–3]. Over the last several decades, a number of theoretical constructs and explanatory models have been developed to increase our knowledge about these drivers, within a broad and expanding body of research [4,5]. However, a recent review by top researchers in the field concluded that the extensive knowledge that has been produced in this area may be “falling short of its potential” ([6], pp. 3–4). This suggests a need for not only generating new knowledge, but also better understanding and reassessing our current constructs and models. It is clear that constructs such as environmental values, beliefs, identities, norms, and attitudes have been conceptualized and measured in numerous ways across different studies, often without clear theoretical or conceptual guidance or direction [4]. Furthermore, efforts to deploy these constructs in explanatory models have (1) targeted a diverse and wide-range of PEBs without providing a strong theoretical, conceptual, and/or ecological rationale guiding their selection; (2) only recently begun to assess how identity may play a role in driving PEB; and (3) relied almost exclusively on null hypothesis significance tests to assess the relationships between the constructs in a model. This has limited our ability to generalize findings across studies and accumulate knowledge about the individual and
collective factors influencing behaviors aimed at reducing one’s overall energy use and impact on the environment and others.

Walton and Jones [7] used an information-theoretic multi-model comparative approach to examine the ways in which the newly hypothesized construct of ecological identity (ECO-ID), combined with two established constructs (i.e., self-transcendence values and the New Ecological Paradigm) [8,9], to drive engagement in a broad set of PEBs, referred to here as general pro-environmental behavior (G-PEB). The present study builds upon and extends their work by using a similar methodology to identify the most plausible causal ordering of the most commonly used constructs to explain PEB. First, we provide an overview describing these major constructs and models. We then detail the measures and the information-theoretic approach that we used for the selection and testing of six models. Next, we analyze and compare these models in order to determine the best-fitting and most parsimonious model for predicting G-PEB. We conclude with a discussion of the implications of these findings and the benefits of using general measures of PEB and information-based approaches for model selection in this area of research.

2. Major Theoretical Constructs Used to Understand and Predict PEB

Much of the work needed to build a stronger theoretical and empirical base of knowledge in this area of inquiry is through the definition and clarification of the concepts, constructs, and models used by researchers [4,10,11]. To this end, this section examines the theoretical and conceptual foundation of some of the major constructs and models typically used to predict PEB.

2.1. Environmental Concern

Public concern for the environment—or simply, environmental concern (EC)—has been conceptualized and measured in a multitude of ways [4,12,13]. Some researchers define it simply as a person’s worries about the severity of environmental problems [14,15], where worries are emotionally charged cognitions based on an evaluation that some domain of life is being threatened or degraded from its desired state of existence [16]. Others define EC more broadly to “... reflect the degree to which people are aware of environmental problems, believe they are serious and need attention, are willing to support efforts to solve them, and actually do things to contribute to their solution” ([17], p. 878; see also [4,18,19]). Dunlap and Jones [4] proposed that EC be treated as a “multifaceted construct”, and conceptually divided it into two major components: environment and concern. They pointed out that researchers can create indicators drawn from the conceptual “universe of environmental issues” (e.g., water pollution, resource depletion, climate change)—or the environment component—and from the conceptual universe of expressions of concern (e.g., cognitive, affective, conative, and behavioral responses to environmental challenges)—or the concern component. Both universes are expanding as the scale, magnitude, and costs of environmental impacts change, as newer forms of environmental problems emerge, and as a result of the many ways in which humans view and respond to them. This means that the ways researchers select, combine, and contextualize facets from both universes are innumerable, as are the conceptualizations and measures used to gauge this broader construct of EC.

This conceptual variation impacts our cumulative knowledge about EC, and it may reflect the fact that EC is not a firmly grounded theoretical construct, but rather a domain-specific construct (see [11]). This multicomponent and broad conceptualization of EC is largely modeled on the outdated classical tripartite and omnibus conceptualization of attitude objects. In this way, EC has often been used interchangeably with environmental attitudes and the New Ecological Paradigm, diminishing its theoretical and conceptual specificity and utility (for reviews, see [18,20–23]).
2.2. Environmental Attitudes

As mentioned above, the classical tripartite conceptualization of an attitude object is an outdated view of attitudes, and continuing to use it to measure EC is problematic [24]. Most contemporary attitude theories such as the Reasoned Action Approach [11] highlight the utility of restricting the boundaries of attitude to an evaluative dimension, while the affect, cognition, and conation components are viewed as separate response systems (see [11,25]). The Reasoned Action Approach (RAA) is Fishbein and Ajzen’s reformulated version of the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB). We use the acronym RAA in the rest of this paper to generically refer to the general theoretical framework they use to support these models. From this perspective, only evaluative responses (e.g., good/bad, desirable/undesirable, wise/foolish) to specific objects, policies, problems, and activities impacting the health and wellbeing of the socio-ecological environment would be considered environmental attitudes; while, EC may be best conceptualized as distinct from attitudes and instead represent an affective (i.e., emotional or somatic) response to environmental impacts (see [13,23,26,27]).

2.3. Environmental Values

Environmental values have been conceptualized in many different ways. However, most contemporary researchers define them as fundamental and enduring beliefs that an individual has about broad desirable goals or end-states of existence, and modes of conduct for attaining them [8,28,29]. In this way, they are trans-situational goals worth striving for that guide people’s lives—such as freedom, equality, and unity with nature—and the desirable ways for attaining them, such as being independent, broadminded, and protecting nature (see also [30]).

In contrast to ecological valuation studies which use economic and ecological concepts and theories to investigate and estimate value, studies of environmental values generally draw upon social and psychological concepts and theories to examine how values are organized, prioritized, and shape individual and collective responses to environmental challenges. Research on environmental values has particularly utilized Schwartz’s value dimension of self-transcendence within multivariate models predicting PEBs. For example, the value–belief–norm (VBN) model demonstrates that those who place higher priority on self-transcendence values have stronger altruistic and biospheric value orientations that guide their lives, personal norms, and behaviors toward supporting environmental protection (see [31–35]). Self-transcendence values—such as the world of beauty, unity with nature, benevolence, and social justice—direct our attention toward concern for the welfare of other people, nature, and all living things [29]. Thus, engaging in PEBs can be viewed as a way to express one’s deeply held “environmental values”, and performing them can help to validate, prioritize, and routinize them among the general public, groups, organizations, and institutions.

2.4. Environmental Beliefs

Environmental beliefs are perceived associations or cognitive–emotional links between some characteristics, qualities, or attributes and an attitude object, such as a person, group, policy, concept, physical object, or “any discriminable aspect of an individual’s world” including a behavior ([36,37]). Environmental beliefs can range from being more specific and concrete (e.g., buying a hybrid car will create less pollution) to more general and abstract beliefs about the limits to growth, the fragility of nature’s balance, human domination of nature, and the possibility of an ecological crisis [7] (see also [4]).

The New Ecological Paradigm (NEP; [9]) scale taps into these general and more primary (or primitive) ecological beliefs, which together represent fundamentally different ways of seeing the planet, its ecology, and humanity’s place within it. The NEP is the most widely used measure to gauge these beliefs, and numerous studies have established its validity, reliability, and ability to help predict PEBs across multiple societies and cultures [9,18,20,23,38]. Given the growing evidence of its public endorsement, it has been
deemed the “organizing anchor” of an emerging environmental belief system [39], and has helped researchers to document this type of paradigmatic change around the world.

2.5. Environmental Norms

Social norms reflect informal internalized codes and rules of conduct that people widely view as being “normal”, commonly approved, and/or expected to follow (see [40]). They are shared by members of a group or organization, and help to maintain and promote group cohesion, order, and values (see [10,41,42]). Given this, environmental norms are what people are expected to do by themselves or with others to help support and maintain environmental protection and ecological restoration. There are several types of norms that are typically used in research on PEB; most draw from either Fishbein and Ajzen’s approach (RAA) or Schwartz’s norm activation model (NAM; [11,36,43]).

According to Ajzen [36], a perceived norm (PCN) is the overall perception of social pressure to engage or not engage in a behavior. It is determined by two types of normative beliefs: In relation to the environment, injunctive normative beliefs are a person’s subjective probability or expectation that significant or important referents (e.g., partner, family, climate scientists) would approve or disapprove of engaging in behavior impacting the environment (e.g., eating less beef, driving less). Descriptive normative beliefs are a person’s subjective perception or expectation of the probability that the same referents actually perform the PEB under question. Given the above, the RAA demonstrates that when all things are equal, people who feel greater social normative pressure to engage in PEBs are more likely to do so.

The concept of a personal norm (PN) stems from Schwartz’s research on altruism, his norm activation model (NAM), and reformulations of it employed in the value–belief–norm (VBN) model (see [10,31,34,44–46]). PNs differ from the injunctive and descriptive norms discussed previously because they are based on internalized personal standards rather than on externalized social standards of what others may think is “normal” conduct [43]. PNs influence behavior when the negative consequences of not acting are known to the person (i.e., awareness of consequences) and when they attribute personal responsibility (i.e., ascription of responsibility) for these consequences [44,46]. Researchers employing the VBN model have often conceptualized PNs as “moral personal norms”, and view PEBs as “altruistic” acts that are undertaken as a result of ethical reasoning and situational or contextual aspects of a setting that help activate these norms [31,47].

2.6. Environmental Identity

Over the last few decades, researchers have tried to conceptualize and measure different facets of the self to better understand the ways in which people identify and connect to nature, their concern for the environment, and behaviors and activities in which they engage to protect and sustain it. This small but growing number of studies exploring self-environment relations try to understand the role that internalized representations of the self play in helping people psychologically and socially relate to nature, and respond and adapt to significant environmental changes [7]. Many of the constructs developed to tap into these self–environment relations are grounded in theories of identity, and focus on how people define themselves by their connection to nature and by their shared kinship and membership with nature, both directly and indirectly, through social relationships that link them to it.

Clayton [48] suggests that most constructs that have been developed to explore identification with nature and the environment can be classified into one of four forms of environmental identity: The construct of environmental self-identity helps to characterize those who define themselves as members of a group of people who engage in particular PEBs (e.g., I am a green consumer). An environmentalist identity describes those who define themselves as members of a social movement or political group that advocates for environmental protection, equity, and sustainability (e.g., I am an environmentalist). Environmental identity (EID; [49]) is used to describe those who characterize themselves
as integrated members of a distinctly non-human group—the natural environment—and stresses an individual’s perceived relationship with nature. Ecological identity (ECO-ID, [7]) attempts to integrate each of these forms of identity into a broader and more general construct representing an emerging set of internalized ecological sensibilities that transcend mere concern for environmental protection and traditional views of the self, society, and environment as separate things, to a wider, deeper, and ideal type of identification. ECO-ID has three features: The sameness feature describes internalized pro-ecological definitions of the self that operate across the personal, role, and group bases of identity. The second feature, differentiation, describes the stigmatization of personal characteristics, roles, and groups viewed as anti-ecological. The third feature, centrality, describes the ranking in relative importance that an ecological identity has within one’s broader concept of the self, and the likelihood that it is activated across various socio-contextual settings (see [7] for more detail).

2.7. Pro-Environmental Behavior and Intention

Like the other constructs, there are numerous conceptualizations and measures used to examine actions, practices, and other human activities thought to negatively or positively impact the environment. However, the most frequently used term to describe engagement in these types of activities is pro-environmental behavior (PEB; see [35,50]). PEB can be performed by individuals or collectively within a variety of situations and contexts, and can be done in the past, present, or planned for in the future (i.e., intentions). They can be performed frequently (e.g., commuting via public transportation), less frequently (e.g., purchasing energy-efficient home appliances), or once in a while (e.g., planting a tree). They can also be distinguished by the difficulty or ease of their performance, and by the magnitude of their impact on the individual, others, and the environment (i.e., behavioral impacts). Lastly, PEB can be operationalized on a continuum from specific to general, and as either a single action (i.e., single-act behavioral criterion) or as multiple acts (multiple-act behavioral criterion) [11].

Most studies use self-reported acts, or intentions to act, obtained from mail, online, or field surveys [35]. They usually do so by trying to identify factors that are internal to the individual that drive PEB (such as the constructs reviewed here). However, individuals wanting to perform or engage in a PEB may face barriers that lay outside of their volitional control or ability. For example, external conditions may exist that make it harder to perform a given behavior (e.g., not having access to curbside recycling). These structural, cultural, institutional, and/or contextual conditions can also encourage individuals to engage in PEB (e.g., providing curbside recycling; increasing the availability of local markets for processing and buying recycled goods). Some of these behavioral barriers are captured by Fishbein and Ajzen’s [11] theoretical construct of perceived behavioral control (see below). Studies that have examined the impacts of both internal and external factors make it clear that reducing environmental degradation is related to individual and collective decisions that are shaped not only by individual motivations, but by a variety of factors external to the individual [51].

3. Theoretical Models Used to Predict PEB

Over the last few decades, much of the research in this area has converged around variants of one or two theoretical models that draw largely from Schwartz’ work on norms and values (see [30,44,45,52]) and/or from Fishbein and Ajzen’s [11,53] reasoned action approach (RAA) for predicting behavior.

Stern, Dietz, et al.’s (1999) value–belief–norm (VBN) model draws from the work of Schwartz on values and his norm activation model (NAM; see Figure 1). It assumes that those who place higher priority on self-transcendence values have stronger altruistic and biospheric value orientations that guide their lives. Those who have these orientations will also have pro-environmental beliefs about the world and the environment. These broad generalized beliefs (such as those tapped by the NEP) are posited to then influence specific
beliefs about harmful consequences (awareness of consequences) to someone or something of value associated with a given behavior, policy, or practice. If one also ascribes personal responsibility (ascription of responsibility) for relieving this harm to the valued other, a personal norm is then activated, and the individual is more likely to engage in the behavior thought to mitigate the harm (see Figure 1). This sequence of the direct effects of values on general beliefs, and their indirect effects on the activation of norms and behavior, has stood up to empirical testing on a wide array of PEBs (see [31–35,47]).

![Norm Activation Model](image)

**Figure 1.** Value–belief–norm model of environmental behavior based upon M. Stern’s [54] graphic presentation of the VBN model (see also [32]). Reprinted/adapted with permission.

The other most common theoretical model used to explain PEB stems from the earlier and later reformulated work of Fishbein and Ajzen [11,53]. The reasoned action approach [11] is grounded in the notion that one’s intention to engage in a given behavior is the best predictor of actually doing it. Intention is driven by one’s attitude toward the behavior (AB), perceived norm (PCN), and perceived behavioral control (PBC), which are derived from beliefs and information that a person possesses about performing the behavior (see Figure 2). AB is defined as one’s favorable or unfavorable evaluation of engaging in a targeted behavior. It is determined by behavioral beliefs, i.e., one’s thoughts about the perceived outcomes of performing the behavior, and the likelihood of those outcomes occurring (outcome expectancies or belief strength). PCN estimates the overall perceived social pressure to engage in a given behavior, and is determined by two types of normative beliefs: As noted above, injunctive normative beliefs are a person’s perceptions that significant or important referents (e.g., family, coworkers, environmental scientists) would approve or disapprove of engaging in the targeted behavior. Descriptive normative beliefs are a person’s perceptions that these referents are themselves performing (or not performing) the targeted behavior. PBC estimates an individual’s overall ability to execute the behavior in question. It is determined by two components or control beliefs: one set of beliefs is related to a person’s perceived capacity to execute a given behavior, and the other to a person’s beliefs about whether they have autonomy over whether they can execute the behavior or not. Since it is difficult to assess actual behavioral control (ABC), PBC is typically used as proxy measure for both, while still acknowledging the potential for ABC to moderate intention when there is a significant difference between PBC and ABC.
This basic framework has been used successfully to explain PEB in a number of behavioral domains, such as travelling and transportation, energy saving, and recycling (see [55]). In addition to these proximal influences on behavior, Fishbein and Ajzen suggest that researchers may want to consider more distal or background factors as well—especially if they believe that the population in question has different experiences and beliefs because of them, or in behavioral domains where they have been found to be important (for example, the impact of ecological values or beliefs on PEB). The background factors listed in Figure 2 are just a small sample of the almost unlimited number of variables that can potentially influence behavioral, normative, and control beliefs. These and other types of broad dispositions are thought to have only indirect and limited impacts on specific behaviors, and they are often not operationalized in studies using the reasoned action approach (see [11], pp. 221–253).

**Figure 2.** Based on Fishbein and Ajzen’s [11] graphical representation of the reasoned action approach. Reprinted/adapted with permission.

4. Research Design, Model Development, Selection, and Testing

The theories and research reviewed above provide important insights into the complex ways in which these commonly used constructs and models may help explain engagement in PEB. First, on a basic level, it is clear that there are both direct (or proximal) and indirect (or distal) drivers of behavior (cf., [5,56]). For instance, theory and research using the reasoned action approach (RAA) suggests that “background factors” such as environmental values may indirectly influence a particular behavior via specific beliefs, attitudes, and norms that one holds about the targeted behavior [11]. Similarly, research using the value–belief–norm (VBN) theory demonstrates that values and general ecological beliefs (e.g., those measured by the NEP) are also distal influences on behavior, operating through more specific beliefs about environmental problems and feelings of normative pressure to address those problems [32]. Still, these theoretical frameworks use different rationales and constructs to identify factors influencing PEB. The NAM and VBN were developed to explain personal and internalized normative influences on PEB resulting from one’s
beliefs about the consequences of not acting to mitigate harm incurred by something of value (e.g., the individual, other humans, and non-human others). Alternatively, within the RAA, one’s beliefs, attitudes, and norms drive PEB through a person’s perception of the benefits and externalized social acceptance they are likely to obtain by engaging in the specific activity [11].

Although these models have improved our understanding of the drivers of PEB, our ability to use them to generalize findings across studies has been limited [6]. The present study proposes that researchers can further improve our understanding of these drivers by (1) conducting research that tries to integrate these constructs and models, (2) using alternatives to null hypothesis statistical testing (NHST) in model assessment and selection, and (3) giving more attention to the prediction of general sets of PEB than to specific PEBs.

There are several recent notable attempts to integrate these constructs and models (e.g., [47,57,58]), but they have not included the key constructs of environmental concern and ecological identity. Given this, our study includes these with other major constructs associated with the NAM, VBN, and RAA in our modeling of general pro-environmental behavior (G-PEB). Secondly, efforts to model PEB using the NAM, VBN, RAA, or some combination of them have relied almost exclusively on a null hypothesis significance testing (NHST) approach to factor analysis (FA) and structural equation modeling (SEM) in order to assess the utility of the model for explaining PEB. Although useful within a particular research context, NHST has been the subject of many critiques, particularly with regard to its limitations for model development and selection [59–61]. For example, NHST approaches center on comparing a single alternative hypothesis to a null hypothesis. The alpha criterion used to decide whether to accept or reject the null hypothesis (conventionally \( p < 0.05 \)) merely represents the probability of obtaining the data being analyzed, under the presumption that the null hypothesis is true [60]. It should be noted that this tells us nothing about the probability that the stated alternative hypothesis is true—just that (given the data at hand) it is unlikely that the null hypothesis is true. This leaves open the distinct possibility that multiple alternative hypotheses (as opposed to the single alternative being tested via NHST) may, to a greater or lesser extent, accurately reflect the data. This has led some to conclude that NHST is “uninformative in most cases, and of relatively little use in model or variable selection” ([62], p. 913).

Alternative approaches, such as information-theoretics, have been developed to address model selection and testing limitations associated with NHST, and they are beginning to be used in studies modeling the drivers of PEB (see [7,47] for recent examples). Information-theoretic approaches are designed to compare multiple models (either within a single dataset, or across multiple datasets) to identify the combination of variables that best approximates the data [62]. The present study employs structural equation modeling (SEM) within an information-theoretic approach to model selection [63] to assess six models derived from past research that represent different causal orderings of constructs routinely used to predict PEB. This can identify which causal ordering of the constructs best approximates the study data.

Lastly, most of the efforts to model the drivers of PEB have focused on predicting specific PEBs. However, efforts to model specific behavior do not usually take into consideration social and structural barriers, specific contextual conditions, and nuanced differences between individuals and their life circumstances. Indeed, two individuals may be similarly motivated to do things that can positively impact the environment, but their opportunities and resources, as well as the structures and conditions in which they are embedded, will no doubt influence the specific PEB(s) they can or cannot engage in. This issue has led some to argue that “ecological behavior should be measured generally, if possible, and not specifically” because “the concrete choice of a specific behavior becomes either situationally dependent and somewhat arbitrary” ([64], p. 417).

We offer a measure of behavioral engagement representing a more inclusive and broader set of general pro-environmental behaviors designed to potentially cover more of the behavioral domain of PEB (see [4,65–67]). Our study operationalizes the measure of
general ecological behavior (see below) to reflect a behavioral category (i.e., a category of behaviors) in which the situational, contextual, temporal, and other elements of behavior are left unspecified (see [11]). This view of behavior is akin to Bourdieu’s [68] theory of social practice, which views behavior less as a result of an abstract rationalist logic of choice, and more as being grounded in one’s practical and generalized experiences over time. According to Bourdieu, these experiences, in turn, fashion dispositions and relatively stable tendencies and evaluations of different clusters of behaviors. This conception of behavior as clusters of social practices has been increasingly used within health disparities research (e.g., [69–71]), and it may help improve studies of PEB.

5. Candidate Models

This section details the rationale for the development of the six “Candidate” models assessed in this study. This is a necessary step when using information-theoretic approaches to compare multiple models, because the candidate models should be grounded in theory and past research, and not simply reflect “data-dredging” (see [61]). Below, we draw upon past research to identify six candidate models (CM1–CM6) that arrange the constructs reviewed above in different causal orderings in order to explore the ways in which these constructs may combine to drive broad and overall engagement in a set of general pro-environmental behaviors (G-PEBs). The work of Ajzen and Fishbein (2010) has demonstrated the utility of predicting a multiple-act behavioral criterion (such as G-PEBs) using indicators corresponding to the same level of generality. Consequently, in each of the candidate models, we use general measures of each construct so that the level of generality of our predictors corresponds with the level of generality of our behavioral criterion.

Research using the VBN and the RAA supports the idea that environmental values and general ecological beliefs (i.e., the NEP) are distal drivers that indirectly influence engagement in PEB. For instance, the VBN model assumes that environmental values directly influence one’s general environmental beliefs (i.e., the NEP), both of which indirectly influence PEB through more specific beliefs (e.g., AC) and norms. However, recent research suggests that values may not be causally prior to general environmental beliefs, but instead may operate interdependently with them to directly drive ecological identity [7]. Because of this, we model both self-transcendence values and the NEP as distal and indirect drivers of G-PEB in all of the candidate models below, but in three of the candidate models we position self-transcendence values as causally prior to the NEP (CM4–CM6) and not causally prior in the other three (CM 1–3).

Because ecological identity and environmental concern have not typically been included in past modeling of PEB, it is less clear where they may fit in relation to these other more established constructs. Recent studies have shown that environmental identity (or ecological identity) may act as an intervening influence between environmental values, the NEP, and PEB [58,72]. However, another recent study integrated constructs from the RAA and VBN, and found that environmental values and the NEP are causally prior to environmental identity, but that environmental attitudes and norms intervene between identity and PEB [58]. This result finds support in a long tradition of research in the broader social psychology literature, which suggests that attitudes and norms may be the outcomes of internalizing a given identity (e.g., [73–75]). Alternatively, however, there have been a multitude of studies using the RAA, which have found that measures of environmental self-identity operate alongside attitudes and norms as proximal and direct drivers of PEB (see [55]).

Because of these mixed findings from past research, in this study, ecological identity is modeled as more proximal to behavior than self-transcendence values and the NEP in each of the candidate models below, but it is sometimes modeled as causally prior to environmental attitudes and environmental norms, while other times it is modeled alongside attitudes and norms as a direct driver of PEB.

Lastly, given the more narrow conceptualization of environmental concern used in this study (i.e., affect, concern, or worry about a set of general environmental problems),
it is modeled as more proximal to G-PEB than self-transcendence values and general environmental beliefs (e.g., the NEP). However, as with ecological identity, it is sometimes modeled as a causal driver of environmental attitudes and environmental norms (CM3 and CM6), while other times it is modeled alongside attitudes and norms as a direct driver of PEB (CM1, CM2, CM4, and CM5).

In sum, insights gained from past theory and research yielded six candidate models for predicting G-PEB. Figure 3 illustrates Candidate Model 1 (CM1), which is a three-level model that positions general environmental beliefs (e.g., the NEP) and self-transcendence values as the most distal variables influencing G-PEB; ecological identity, environmental concern, environmental attitudes, and environmental norms are modeled as more proximal and intervening variables influencing engagement in general environmental behaviors.

![Figure 3. Candidate Model 1 (CM1).](image)

Figure 4 illustrates Candidate Model 2 (CM2), which is a four-level model that, again, positions general environmental beliefs (e.g., the NEP) and self-transcendence values as the most distal variables influencing general environmental behavior. Ecological identity is positioned as an intervening influence on environmental concern, environmental attitudes, and environmental norms, which are then modeled as the most proximal drivers of engagement in general environmental behaviors.

![Figure 4. Candidate Model 2 (CM2).](image)

Figure 5 illustrates CM3, which is a four-level model that, again, positions general environmental beliefs (e.g., the NEP) and self-transcendence values as the most distal variables influencing general environmental behavior. However, it positions both ecological identity and environmental concern as intervening variables influencing environmental attitudes and environmental norms, which are then modeled as the most proximal drivers of engagement in general environmental behaviors. Figures 6–8 illustrate modified versions of Candidate Models 1–3, such that self-transcendence values are positioned causally prior to general environmental beliefs (e.g., the NEP), as they are in models using VBN.
6. Measures and Results

We used web-based survey data obtained from a random sample (N = 497) of undergraduate students at a large public university in the Southeastern US to assess the six models. (We oversampled students who were members of an environmental organization to ensure a sufficient number of these students were included in the analysis). A total of 497 completed and useable surveys were returned (70 members and 427 nonmembers.) A 14-item general environmental behavior (GEB) scale (α = 0.91), asked survey respondents to indicate the frequency (from 1 = rarely to 5 = almost always) with which they engaged in a number of pro-environmental practices aimed at reducing their overall energy and resource use, and their impact on the environment and others. The well-established 15-item (α = 0.83) New...
Ecological Paradigm (NEP) scale [9], was used to measure general environmental beliefs about the relationship between humans and nature. Responses were scored on a five-point Likert scale, with higher scores reflecting a stronger endorsement of these primary environmental beliefs (reverse coded when applicable). Eight items ($\alpha = 0.85$) from the Schwartz values survey [76] were used to tap into universalism values (or “the understanding, appreciation, tolerance, and protection for the welfare of all people and of nature”) representing the self-transcendence value (STV) dimension of his theory of basic values ([30] p. 523). The ecological identity scale (EIS) [7] contains 18 items ($\alpha = 0.91$), and is scored on a five-point Likert scale ranging from 1 = “strongly disagree” to 5 = “strongly agree”. Items were coded (reverse coded if applicable) so that higher scores reflected a stronger ecological identity or ECO-ID. A measure of general environmental concern (GEC) contained 11 items ($\alpha = 0.91$), and assessed respondents’ concerns and worries about a range of environmental issues and impacts. All were scored on a five-point Likert scale ranging from 1 = “Not at all concerned” to 5 = “Very concerned” (The items comprising the EIS, the GEC scale, and the GEB were derived from focus group meetings with leaders from a variety of environmental organizations) [7]. The measure of general environmental attitude (GEA) contained four items ($\alpha = 0.91$), each on a five-point Likert, scale with higher scores reflecting a more positive attitude toward engaging in GEB. Two of the GEA items assessed respondents’ attitudes toward “doing things to decrease your overall impact on nature, the environment, and others”, while the other two items assessed respondents’ attitudes toward “doing things to decrease your overall energy and resource use”. The measure of general environmental norm (GEN) contained two items ($\alpha = 0.84$) designed to measure injunctive normative beliefs (e.g., people think I should engage in GEBs) and descriptive normative beliefs (e.g., people like me engage in GEB). Items measuring GEA and GEN were scored on a five-point Likert scale, with higher scores indicating stronger pro-environmental attitudes and norms.

Principal component scores from each scale were used to represent each construct. Table 1 reports the results of Cronbach’s alpha ($\alpha$) reliability analysis and principal component analysis (PCA) conducted on them (see the Supplementary Materials Tables S1–S7 for exact item wording and more detailed PCA results for all measures in the analysis). These results demonstrate that each scale in the analysis has a high degree of internal consistency (reliability), with Cronbach’s alpha ($\alpha$) ranging from a low of 0.83 for the NEP scale to a high of 0.91 for the GEB, the EIS, the GEC, and the GEA. The first PC extracted for each construct explains an acceptable amount of variance across all items in the scale, and each item loaded strongly on the 1st PC of its respective scale; This reflects what Dunteman (1989) refers to as a size factor. Following Walton & Jones [7] we also tested for discriminant validity between each of the constructs to ensure each was measuring a unique conceptual domain. No significant overlap between measures was found. See [77]).

Table 1. Principal component analysis and reliability testing for constructs in the analysis.

| Construct                          | PCs Extracted | Variance Explained | Scale Items | Cronbach's Alpha ($\alpha$) |
|-----------------------------------|---------------|--------------------|-------------|-----------------------------|
| General Environmental Behavior GEB | 3             | 48%                | 14          | 0.91                        |
| Environmental Beliefs NEP         | 3             | 30%                | 15          | 0.83                        |
| Self-Transcendence Values STV     | 1             | 48%                | 8           | 0.85                        |
| Ecological Identity (EIS)         | 3             | 41%                | 18          | 0.91                        |
| General Environmental Concern GEC | 1             | 56%                | 11          | 0.91                        |
| General Environmental Attitude GEA | 1             | 78%                | 4           | 0.91                        |
| General Environmental Norms GEN   | 1             | 86%                | 2           | 0.84                        |

As noted above, information-theoretic approaches can be used to determine the most plausible explanatory model given the data at hand. This approach is statistically grounded in the work of Akaike [78,79]. The Akaike information criterion ($AIC$) is used to identify the most plausible and parsimonious model within a set of candidate models. Models that produce lower $AIC$ scores represent better fitting and more parsimonious models of the data. Furthermore, models in a set can be ranked through a transformation of model $AIC$
scores into Akaike weights ($\omega$), which are used to interpret the probability that a given model is, in fact, the best approximating model within the set of models assessed. Results of the analysis are presented in Table 2. Of the models considered in the analysis, Candidate Model 1 (CM1; see Figure 3) was the best approximating and most parsimonious model ($AIC = 198.6$). CM1 estimated ($K = 6$) parameters, and positioned general environmental beliefs (e.g., the NEP) and self-transcendence values (STV) as distal drivers of engagement in general environmental behaviors, with ecological identity, general environmental concern, attitudes, and norms acting as (single-level) intervening influences. The next best approximating model (CM2; $AIC = 282.7, \Delta AIC = 84.1$; see Figure 2) estimated ($K = 8$) parameters, and modeled general environmental beliefs (e.g., the NEP) and self-transcendence values (STV) as distal drivers of engagement in GEB, with two levels of intervening variables. The first, and causally prior, intervening influence was ecological identity, which drives engagement in general environmental behaviors indirectly through general environmental concern (GEC), attitudes (GEA), and norms (GEN). Models 4, 5, and 6 positioned self-transcendence values causally prior to general environmental beliefs (e.g., the NEP), and produced $AIC$ scores that were notably larger (reflecting a poorer fit to the data) than those of CM1 and CM2. These relatively large differences in $AIC$ across the models were also reflected in the high $AIC$ weight produced for CM1 ($AIC(\omega) = 0.999$). This suggests that there is a 99% or greater probability that CM1 is the best approximating model within the set of candidate models assessed, and a very low probability (less than 1%) that any of the other models is better at representing the data. We also calculated $R^2$ values for each candidate model to gain a sense of the proportional reduction in the error of measurement (i.e., variance explained), in each of the models. $R^2$ values closely aligned with the $AIC$ model rankings with CM1 explaining 45% of the total variance and CM2 explaining 34% of the total variance (CM1, $R^2 = 0.449$; CM2, $R^2 = 0.339$; CM5, $R^2 = 0.319$; CM4, $R^2 = 0.196$; CM3, $R^2 = 0.131$; CM6, $R^2 = 0.129$).

Table 2. Multi-model comparison of candidate models for predicting general environmental behavior.

| Model Rank | Model | Exogenous Variable(s) | Intervening (Endogenous) Variable(s) | $K$ | $AIC$ | $\Delta AIC$ | $AIC(\omega)$ |
|------------|-------|------------------------|-------------------------------------|-----|-------|-------------|----------------|
| 1          | CM1   | NEP, STV               | EIS, GEC, GEA, GEN                 | 6   | 198.6 | -           | 0.999          |
| 2          | CM2   | NEP, STV               | EIS $\rightarrow$ GEC, GEA, GEN    | 8   | 282.7 | 84.1        | $5.4 \times 10^{-19}$ |
| 3          | CM5   | STV                    | NEP $\rightarrow$ EIS $\rightarrow$ GEC, GEA, GEN | 8   | 375.9 | 177.4       | $3.0 \times 10^{-39}$ |
| 4          | CM4   | STV                    | NEP $\rightarrow$ EIS, GEC, GEA    | 9   | 431.2 | 232.7       | $3.0 \times 10^{-51}$ |
| 5          | CM3   | NEP, STV               | EIS, GEC $\rightarrow$ GEA, GEN     | 10  | 481.8 | 243.3       | $1.5 \times 10^{-53}$ |
| 6          | CM6   | STV                    | NEP $\rightarrow$ GEC, EIS $\rightarrow$ GEA, GEN | 9   | 622.2 | 423.7       | $1.0 \times 10^{-92}$ |

Note: Structural equation models were fitted using the sem() package in R. "NEP" = New Ecological Paradigm; "STV" = self- transcendence values; "EIS" = ecological identity scale; "GEC" = general environmental concern; "GEA" = general environmental attitude; "GEN" = general environmental norm. $K =$ number of parameters estimated. $AIC =$ Akaike information criterion. $\Delta AIC =$ Change in $AIC$ from the best approximating model. $AIC(\omega) =$ $AIC$ weight, or the probability that a given model is the best model among those models in the set.

7. Discussion

The objectives of this study were to provide the reader with a review of several of the major constructs and models used to explain engagement in PEB, use this information to integrate them into a set of candidate models, and then identify the most plausible causal ordering of the constructs that best explains engagement in a set of general pro-environmental behaviors (G-PEBs). The results suggest that pro-environmental values (i.e., self-transcendence values) and beliefs (i.e., the NEP) are distal drivers of this broad type of behavioral engagement. Although past research has generally found values to be the “initial trigger” of PEB “giving rise” to general environmental beliefs and other drivers (e.g., [58], p. 148) these studies have relied almost exclusively on using NHST to predict engagement in a small set of specific behaviors, and none of them has included a comprehensive measure of self–environment relations such as ECO-ID. Our results suggest instead that pro-environmental values may be more directly related to G-PEB than to specific PEBs, and that they may also work in tandem with general environmental beliefs.
to serve as a primary motivational basis for the development of ecological identity, concerns, attitudes, and norms. We would assert that these types of primary values and beliefs, although “held in the minds of individuals”, are deeply embedded in multiple levels of social, cultural, historical, and ecological contexts and structures that transcend individuals and operate on a much broader level of abstraction (cf. [66], p. 778). Because of this, these primary ways of viewing and valuing the environment may be more stable, harder to change, and provide a fundamental way of understanding and engaging in PEB [30,66]. In contrast, ecological identity, concerns, attitudes, and norms influence general PEBs more directly, suggesting that they may be more variable across situations and contexts, and more subject to change. In this way, these proximal drivers may provide a more immediate and concrete way to express one’s primary environmental values and beliefs.

Overall, our results suggest that seeing and valuing the world more ecologically (primary environmental beliefs and self-transcendence values) gives rise to an internalized set of pro-environmental sensibilities (ecological identity), concerns and worries about environmental problems (environmental concern), positive evaluations of pro-environmental behaviors (environmental attitudes), and feelings of pressure to engage in them (environmental norms). Knowledge of both the proximal and distal drivers that motivate people to engage in G-PEBs should provide researchers and policymakers with a broader and deeper understanding of how individuals view and respond to socio-ecological conditions and changes. For instance, resource conservation approaches could be designed to help people build stronger internalized connections between their behavior and how they see themselves in relation to the environment and others (i.e., the proximal drivers of behavior; see [80]), and how both are linked to their primary values and beliefs (i.e., distal drivers of behavior). However, additional research is needed to examine how these internalized environmental values and beliefs are embedded within externalized socio-cultural contexts and structures that support or oppose their adoption and transmission within a given society, culture, or setting. This knowledge would allow us to develop conservation management practices and policies that not only work “within existing value (and belief) structures to introduce changes that effect conservation”, but could also potentially change these structures ([66], p. 778; parentheses added). In this way and others, building stronger internal and external connections between the self, others, and the environment may help people to develop a deeper sense of socio-ecological relationships, greater personal agency and accountability for their behavior and impacts, and a greater awareness of the structures and strategies needed to bring about a more just and sustainable future for all of Earth’s inhabitants.

Taking into consideration this more integrative and comprehensive (or socio-ecological) view of individuals and their behavior may also help to address the tendency to focus primarily on specific and relatively low-impact behaviors [6]. For instance, the multiple-act general behavior criterion (GEB) employed in this study has certain advantages compared to those that are based on a single behavior or a small set of specific behaviors, such as those routinely employed in studies using the RAA, NAM, and VBN. First, because of its generality, this measure does not have to specify any of the possible conditions, contexts, and elements that could influence specific behaviors or small sets of specific behaviors. Instead, it is intended to assess a person’s broad engagement in a cluster of general pro-environmental behavioral practices, and should give a better indication of the likelihood that someone will engage in PEB when they have the opportunity to do so, and when the structural context permits.

Because we deployed a general behavioral criterion (GEB), the potential predictors of GEB were designed to correspond to the same level of generality (e.g., environmental values; the NEP; ecological identity; environmental concern, attitudes, and norms). Although specific behaviors such as the ones examined in studies using the NAM or VBN models have been shown to be related to general measures, such as environmental values and beliefs, theory and research demonstrates the utility of designing indicators and the behavioral criterion on the same level of generality [11]. Understanding this important lesson should help researchers to design measures of PEB that would better correspond to the variables
used in models, and enhance our understanding of the drivers of specific and general PEB. It is also important to note that the GEB and other measures used in this study (i.e., EIS and GEC) were derived from focus group meetings with leaders from a variety of environmental organizations, and that they have demonstrated strong constructive and predicative validity compared to those selected by mere face validity or the beliefs of the researcher (see [7]).

The GEB scale was designed to tap into a private ecological behavioral domain made up of individual or household practices, activities, behaviors, and choices, and not the types of actions and activities more associated with the public ecological behavioral domain (e.g., voting for pro-environmental candidates, supporting the reintroduction of native species). More research is needed to identify potential drivers of public PEBs, and how they may be related to or different from the drivers of private PEBs (see [81,82]). Both sets of actions can potentially impact the local, domestic, or global environments. However it is important to note that the perceived impacts of these actions may not be their actual impacts [81,82]. Regardless of which behavioral domains or behaviors are examined, it is critical for researchers to identify and choose behaviors that have a net positive actual impact over the short and long term [6]. Studies investigating energy, carbon emissions, and product life cycles, as well as habitat and ecological assessment studies, will help to identify behaviors that have the greatest net positive impacts, along with their associated difficulty, demands, costs, and inequities (see [6,83,84]).

A more deep and systematic (i.e., socio-ecological) understanding of individuals and behaviors impacting the environment may be made possible not only by reassessing our primary, taken-for-granted beliefs and values about the self, society, and the environment, but also by a willingness to explore new ideas and alternative approaches for understanding and predicting PEB. Indeed, in contrast to NHST, the information-theoretic approach allowed us to compare multiple models that incorporated constructs not typically included together, in causal orderings deduced from multiple theories and past research, to determine the most plausible and parsimonious model for fitting the study data. For example, the paradigmatic commitment to NHST within the social sciences in general—and PEB studies in particular—has led researchers to select models based on a (false) comparison between a hypothesized model and a single null model. This has limited our ability to integrate constructs across existing models, because typically only those constructs and the hypothesized relationships between them are included in model testing and selection (see [58,85]). Similarly, because the NAM, VBN, and RAA were developed without consideration of the impact that identity may have on behavior, constructs related to environmental identity have only recently been included in these models. When they are, researchers almost exclusively use the narrower form of identity, such as being a “recycler” or a “green consumer”, rather than more comprehensive and general constructs such as environmental identity [48] or ecological identity (see [7,55,86]). This is important because the more comprehensive environmental identity constructs better reflect the types of inter-group dynamics and issues of environmental justice that pervade polarizing environmental issues such as climate change. In this way, our study supports recent research [7,47] that has demonstrated the utility of information-theoretic approaches for modeling PEB.

Additional research using new data gathered from different populations and contexts is needed to further examine the causal relationships driving engagement in PEB in general, and in G-PEB in particular. Information-theoretic approaches should prove especially useful in achieving this objective, because they are dynamic and grounded in the idea that “All models are wrong but some are useful” (George Box, quoted in [62], p. 264). For instance, Reipe et al. [47] provided an illustration of how the causal ordering of the drivers of engagement in PEB may vary across cultural and situational contexts. This more dynamic way of modeling (and understanding) the drivers of behavior will be increasingly important given the anticipated variable impacts of climate change across regions and groups. Future research using the constructs operationalized and modeled in this study should provide greater insight into the ways in which these drivers influence engagement.
in PEB, and how to design policies and practices to support them in ways that are tailored to specific socio-ecological contexts and populations.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su142214668/s1, Table S1. The General Ecological Behavior (GEB) scale: Items, Component Loadings, Variance Explained & Internal Consistency. Table S2. The General Ecological Concern Scale (GECS): Items, Component Loadings, Variance Explained & Internal Consistency. Table S3. The General Ecological Attitude scale (GEA): Items, Component Loadings, Variance Explained & Internal Consistency. Table S4. The General Ecological Norm scale (GEN): Items, Component Loadings, Variance Explained & Internal Consistency. Table S5. The Self-Transcendence Values scale (STV): Items, Component Loadings, Variance Explained & Internal Consistency. Table S6. Principal Components Loadings for the Ecological Identity Scale (EIS), and features of Ecological Identity. Table S7. The New Ecological Paradigm (NEP) scale: Items, Component Loadings, Variance Explained & Internal Consistency.

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