Review

Can evolutionary design of social networks make it easier to be 'green'?

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The social Web is swiftly becoming a living laboratory for understanding human cooperation on massive scales. It has changed how we organize, socialize, and tackle problems that benefit from the efforts of a large crowd. A new, applied, behavioral ecology has begun to build on theoretical and empirical studies of cooperation, integrating research in the fields of evolutionary biology, social psychology, social networking, and citizen science. Here, we review the ways in which these disciplines inform the design of Internet environments to support collective pro-environmental behavior, tapping into proximate prosocial mechanisms and models of social evolution, as well as generating opportunities for 'field studies' to discover how we can support massive collective action and shift environmental social norms.

Harnessing the power of the crowd

The Internet has transformed how we obtain and share information, interact, display our identities, and perform tasks at home and at work. It expands our social networks and extends our reach, allowing collaboration at massive scales. Examples include the crowdsourcing of knowledge creation for Wikipedia.org and the classification of more than 50 million images of galaxies in year one of GalaxyZoo.org. In the environmental sciences, citizen-science projects now engage large crowds to collect biological data across the globe [1,2].

Our ability to engage in cooperative social and entrepreneurial activities has been further enhanced by social networking tools; such tools provide an increasingly fluid system of highways through which information and ideas travel, doing so with a speed and fidelity never before seen in human society. The question we raise in this review is: how might social networking be combined with citizen science and new understandings of human cooperation to support massive shifts in pro-environmental behavior and social norms? Progress toward answering this question requires the deliberate design and testing of new citizen-science Web applications informed by evolutionary biology, social psychology, and social networking research to support sustainable practices.

The successful design of Internet communities to support environmental collective action is a nontrivial problem. It is not for lack of trying that we have failed to achieve voluntary, substantive changes in how we consume and use resources; there are numerous examples of 'green' social networks that have simply failed to take hold (Figure 1). Neither are the potential effects small. Universal adoption of 17 practices to reduce carbon emissions could reduce the national carbon footprint of the United States by 7.4% without downgrading quality of life [3]. This reduction is equivalent to the national emissions for all of France. The potential for small acts to make a big difference when summed over a large crowd argues for more research on how we can tap into prosocial behavior to address conservation problems household by household [4]. Citizen-science projects provide a trustworthy scaffolding for purposeful, conservation-based social networks because they are grounded in science and provide both leadership and opportunities for entrepreneurial action. We argue that their established methods for collecting and managing environmental data can be augmented with social networking to support pro-environmental collective action, providing unique opportunities for both theoretical and applied research in evolutionary behavioral ecology and social psychology as they relate to conservation behaviors.

The social Web's capacity to support collective behavior

The social Web has emerged at a time when direct human effects on ecosystems are so great that we have effectively entered a new geological epoch [5]. With seven billion people on the planet, never before have the collective behaviors of individuals been so important [6]. Although we face such formidable problems as population growth, climate change, landscape change, and changes in the chemistry of our oceans and terrestrial systems, we are also in the possession of tools that can tap into prosocial tendencies on a global scale. These tools, if designed based on evolutionary understandings of human cooperation, have the potential to sustain shifts in behaviors and social norms at scales sufficient to generate meaningful, positive effects [7].

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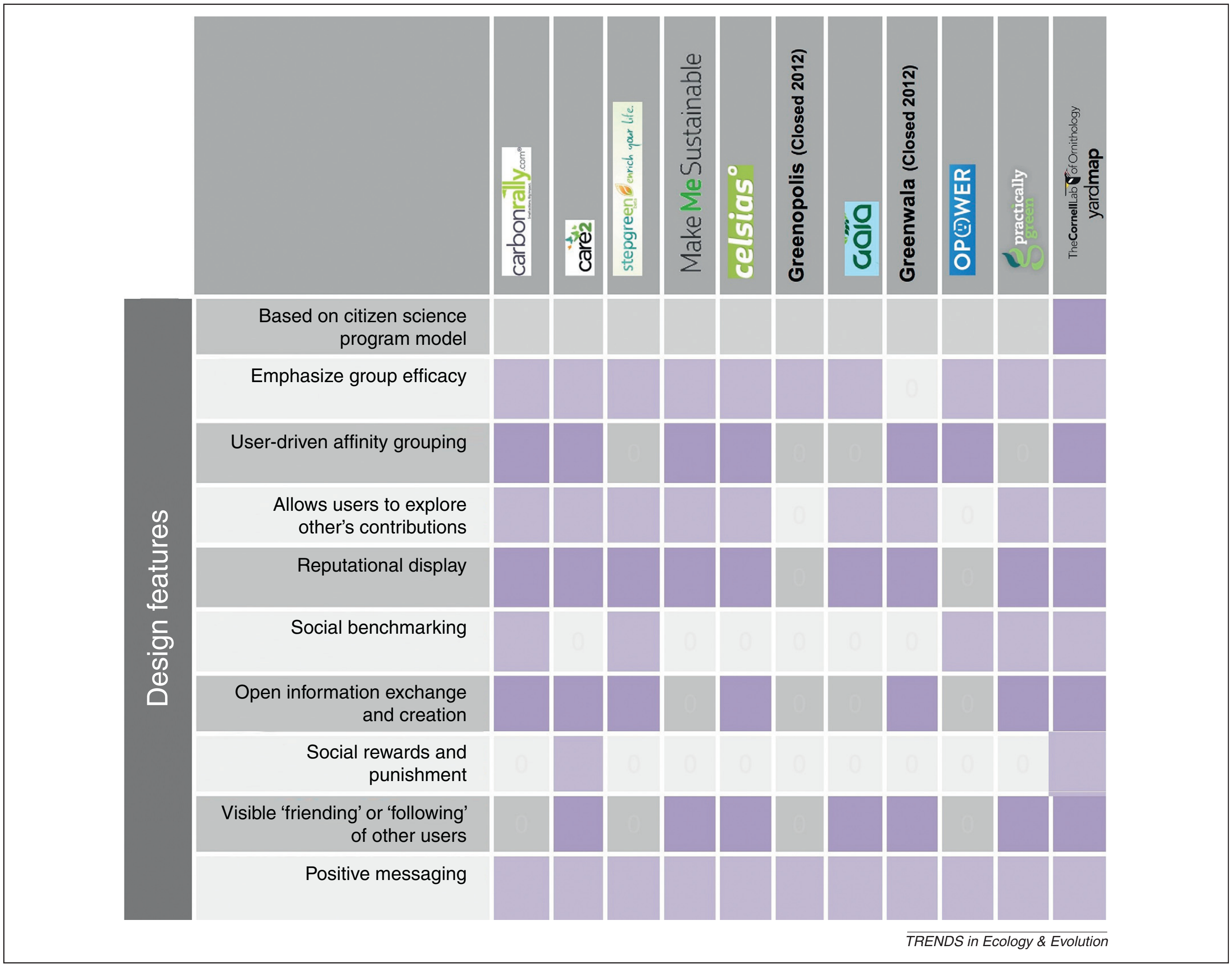

Figure 1. Graphic showing which features are included in a sample of online green social networks. Features correspond to hypothesized aspects of green networks that are most likely to facilitate and sustain collective action.

Our thesis is that to be effective in supporting collective changes in pro-environmental lifestyles, Web environments must harness both ultimate and proximate drivers of cooperation. These terms describe different levels at which behaviors can be analyzed; hypotheses do not compete across levels but are complementary, and both levels are important for understanding what sorts of behavioral changes are feasible. Ultimate drivers of cooperation explain why people have evolved to cooperate and what fitness benefits cooperation provides. Proximate drivers are the built-in, underlying mechanisms that humans possess to achieve cooperation, ranging from how cognition, attitudes, motivations, and emotions play into social life to how people use social information when adhering to social norms, managing their reputations, or copying the behaviors of others. In order to test theoretically informed hypotheses and design field experiments that will lead to new insights, Web environments must allow researchers to introduce interventions that are thought to facilitate collective action. These interventions, when informed by research on how prosocial behaviors play out in face-to-face and computer-mediated interactions, can make a real difference if they prove effective in large citizen-science networks.

Cooperation and environmental goods

Early studies of environmental collective action supported a negative perspective on the human potential for cooperative management of environmental goods [8,9]. Many environmental goods, such as air quality or climate, can be modeled either as public goods or common goods. Public goods are non-excludable, meaning everyone can use them, and non-rivalrous, meaning one person's use does not preclude another's. Common goods are also non-excludable but are rivalrous in that the resource is gradually depleted as the number of users increases. In considering householders' contributions to environmental goods as a collective action, it makes sense to see contributions in terms of restraint, such as reduced use of water, energy, and pesticides, and restoration, such as planting native trees or investing in other enhancements to habitat for wildlife.

Cooperative management of common and public goods is a classic social dilemma because the strategy of cooperation that yields the greatest payoff for the group is not in the self-interest of individuals. This result, known as the ‘zero contribution thesis’, is based on the mathematical impossibility of maximizing short-term self-interest and group interest at the same time [9]. Without the external enforcement of rules, rational self-interest renders public and common goods vulnerable to free riding, cheating, defection, and, potentially, collapse of the resource, a phenomenon known as ‘the tragedy of the commons’ [8,10,11]. In spite of this, both in real life and in a large number of behavioral games, people contribute far more than expected on the basis of short-term self-interest [11].

High levels of cooperation can be tied to an evolutionary history in which humans lived in small groups where cooperation was fundamental to the survival of an individual and its kin [7,12]. Comparison of Western contemporary societies with Tanzanian hunter-gatherers indicates that we retain many of the very same features of cooperation that were critical for survival and reproductive success in small ancestral social networks [13]. In many contexts, ranging from political views to innovation, health, and happiness, we are influenced not just by immediate friends but by friends of friends of friends, a pattern known as the ‘Three Degrees Rule’ [7]. Human behaviors, including cooperative behaviors, are contagious in social networks, especially among individuals who are no more than three degrees apart.

Today, social costs and benefits are widely recognized as playing a substantial role in structuring the relative payoffs of cooperation and competition, and we see widespread recognition of the role of reputation in sustaining cooperation in public and common goods contexts [11,14–16]. Although evolutionarily stable cooperation is still difficult to achieve at large scales, evolutionary stability is made more likely: (i) when group members have repeated interactions and thus an ability to retaliate against free-riders [17]; (ii) when people can choose when and with whom to cooperate [11,18–20]; and (iii) when inter-group competition aligns the genetic interests of group members [21]. Each of these possibilities is likely to be augmented in electronic social networks. Recent evolutionary theory has unveiled not only the social and environmental conditions that promote evolutionarily stable cooperation but also the conditions that speed up the appearance of cooperators (e.g., altruistic volunteers) in time [22]. For example, evolutionary game theory shows that such volunteers, that is, ‘brave leaders’ who secure social benefits for the group at a cost to themselves, emerge sooner in smaller groups than in larger groups [22]. Thus, prosocial volunteerism can emerge sooner when electronic networks are strategically subdivided into smaller subnetworks.

Reputation and sensitivity to third-party assessment

People are more likely to form ties and cooperate when others are similar to themselves in both electronic and real-life social networks [23,24]. The possibility of breaking ties with non-cooperators (one mechanism for punishing defection) and forming new ties with cooperators appears to foster cooperation in experiments with humans [25]. Where ties persist, reputation is a critical mediator of cooperative interactions [16,26–28] in that individuals who cheat, defect, or free-ride will experience peer-to-peer punishment [15,29], whereas those who cooperate will receive social rewards [30]. People are willing to pay a cost to punish others [31], and they are extraordinarily sensitive to reputation [15,27,32–34] and to social norms comparisons, including the ‘norm of reciprocity’, as seen in conventional gift exchange [35]. Violations of social norms can cause embarrassment and negative reputational consequences [11,36,37].

Current research on indirect reciprocity, in which people only need to interact once and can decide whether or not to cooperate on the basis of what they see others do, indicates that the requirement of repeated interactions is not always necessary [26]. Cooperation can be maintained when people cooperate with others they observe cooperating or when they cooperate with new people on the basis of having been the recipient of a different party’s cooperative act [26]. Sensitivity to third-party assessment, which underlies cooperation in indirect reciprocity and some public-goods games [38], can be triggered with visual symbols of human peer-policing or surveillance, as when an image of watching eyes decreased free-riding and increased the level of monetary contributions that people made at a communal coffee and tea station [39]. New models of cooperation and accompanying experiments suggest that reputation, social rewards, and punishment by peers are more powerful at promoting cooperation than are institutional rewards and sanctions. In some situations, strong institutional governance is thought to undermine cooperation [14].

Prosocial mechanisms governing reputation-based cooperation

Recent findings indicate that human beings exhibit cognitive, behavioral, emotional, and neurological mechanisms that function to support reputation-based cooperation (Box 1). These include proximate mechanisms that generate strong responses to inequity and motivate individuals to restore equity when a line has been crossed [40]. People make equitable decisions, not just because they fear social consequences; they also do so in anonymous situations in which there are no repercussions of being selfish [41]. Neuroscience research combining behavioral games with functional magnetic resonance imaging has shown that making equitable decisions and having an aversion to inequity on the part of others engage neural structures in the brain that are associated with intrinsic rewards (e.g., pleasure) [42–44]. Such ‘intrinsic’ rewards of prosociality are not limited to humans; they are also found in tufted capuchins (*Cebus paella*) [45]. Together, this body of research points to prosocial, proximate mechanisms that, if supported in online environments, can lead to scalable increases in pro-environmental behavior (Box 1).

Overcoming proximate barriers to pro-environmental behavior

The fields of communication, economics, and social psychology have been at the forefront of discovering potential barriers to pro-environmental behavior [46]. Designing effective, simple, universally successful interventions has proven difficult [47–50]. First, even people with strong pro-environmental attitudes often choose not to act on the basis of situational factors such as cost or normative factors

Box 1. Mechanisms that function to support reputation-based cooperation

- Proximate mechanisms involving social cognition and social emotions support cooperation and exhibit sufficient activity in computer-mediated interactions to be effective in online environments [40].
- *Sense of fairness.* Inequity aversion or aversion to unreciprocated cooperation or unfair offers helps to increase the social costs of defection.
- *Sensitivity to norms violations.* Helps to stabilize cooperative behavior and allows individuals to detect less-engaged members of a social group.
- *Impulse control.* Cognitive mechanisms that increase adherence to social norms and reduce selfish behavior.
- *Ability to learn.* Remembering the generosity and trustworthiness of others.
- *Painful social emotions.* For example, envy of others whose competitive status is elevated, guilt and fear associated with betrayal, shame at violating social norms, and pain in response to ostracism.
- *Intrinsic neurological rewards.* Social approval, praise, mutual cooperation, helping others, experiencing compassion, and generosity (even toward anonymous others) activate neurological structures associated with pleasure and subjective value.
- *Drive to restore equity.* A mechanism for restoring cooperation.
- *Tendency to choose similar partners.* Facilitates conditional cooperation by maximizing social returns.

such as low expectations that others will join in the activity [48,51–54]. Interventions designed to mitigate situational factors, such as lack of access, lack of knowledge, and lack of funding, are popular because they are intuitive and relatively simple, but emphasizing awareness, subsidies, and convenience rarely results in widespread adoption. For instance, people report high costs as the reason that they fail to purchase high-efficiency appliances or gas-efficient vehicles, but programs designed to subsidize costs have done little to increase environmental purchasing. Campaigns to raise awareness have not improved these outcomes, and some have even proven counterproductive. For example, a California utility company spent more money advertising insulation upgrades on television than it would have cost to install new insulation in the target homes themselves [55]. Communications designed with an awareness of evolved prosocial mechanisms could provide the support required to increase the effectiveness of incentives.

As in other contexts (e.g., [56]), use of negative or fear-based messages tends not to elicit increased interest in taking pro-environmental action [57], indicating a need to craft messages that are not too threatening or to couple fear-based messages with effective and readily implemented response recommendations [58]. Most people believe they have little self-efficacy when it comes to positively influencing the environment and believe that their actions have no substantial impact [59]. Calculating a carbon footprint, as is popular on myriad websites (but only three of the projects in Figure 1), can reinforce feelings of insignificance. When it is necessary to convey negative messages, communications focusing on dangers for non-human organisms (e.g., birds for birdwatchers) can elicit increased interest in taking action, as can positive messages focused on group-efficacy and group identity [60]. As actions are stored as data and participants can visualize their cumulative effects in real time, citizen-science environments can be designed to bolster a sense of group efficacy.

Proximate drivers of pro-environmental behavior

Social psychology provides important clues for how placing conservation issues within a social-networking environment can help to support pro-environmental behavior. A substantial body of evidence indicates that descriptive social norms play a large role in determining people's environmental behavior. In a well-known study of hotel towel reuse, people were much more likely to reuse their towels when told that 75% of previous hotel guests had reused theirs than when told that reusing towels helps the environment [61]. In general, conveying that others actually engage in pro-environmental behaviors (the descriptive norm) has stronger behavioral effects than conveying that people should do so (the injunctive norm) [62].

Social influence is also apparent in behavioral economics research, which indicates that purchasing decisions are based on social status and relative, rather than absolute, material wealth [63]. In many contexts, this moves people toward ever-higher levels of consumerism. Online or off, when communities become more green, green behaviors can become the new social norm, and investment in green behavior can begin to function as a costly signal of status [64]. In one study, the use of solar panels added about 3% to the expected sale price of a house, but in communities with a higher percentage of registered Toyota Priuses, which indicate a green social norm, the price of houses with solar panels was proportionally higher [65]. The idea that green purchases act as cooperative signals is further supported by a study of homeowners, many of whom installed solar panels on the less-effective, shady sides of their houses just to make their investments more conspicuous to their neighbors [66]. These findings suggest that it is possible to shift green norms, which can then produce cascading positive effects on pro-environmental behaviors in social networks.

The nature of social interaction in online social networks

Given the importance of social rewards and punishment to sustained cooperation, it is reasonable to question whether cues and information delivered in online social networks are sufficiently potent to support collective action. This question arises, in part, from various studies, including behavioral games, demonstrating that face-to-face interactions are more potent than computer-mediated interactions [67]. Early research suggested that computer-mediated communications tend to be task-oriented and egalitarian but impersonal [68]. Impersonality was attributed to the filtering out of cues by electronic media [69]. Although facial expression, body language, vocal tone, touch, and complex pairings of these different modalities are missing in computer-mediated transactions, the 'cues filtered out' idea was challenged by a more general 'social information processing' perspective, which examined critically the methods used to demonstrate impersonality [68]. Although exchange of social information may be slower in computer-mediated interactions, potency is not necessarily limited, providing there is enough time to communicate.

Walther and colleagues proposed that given time, people learn new ways to convey online what is communicated nonverbally offline (e.g., by using emoticons to communicate facial expressions of emotion) [70].

Experiments measuring individual levels of trust, generosity, reciprocity, tendencies to punish, reputational sensitivity, and tendencies to cooperate or not indicate that computer-mediated interactions elicit many of the same patterns of cooperation that are important in real life [40]. Although face-to-face experience appears superior at generating cooperation in behavioral games and also allows participants to better predict whether their partners will cooperate, a large number of behavioral experiments indicate that high levels of cooperation can be achieved via communication without face-to-face interaction [40,71]. When participants in behavioral games think they are engaging in social exchanges with real people via computers, they demonstrate social cognition with regard to partner choice, whom to trust, the potential for punishment, and the long-term rewards of cooperation [40,72]. Experiments also indicate that people interacting on computers exhibit prosocial emotions, such as feeling good when they experience social approval or mutuality, experiencing the 'warm glow' of generosity, fear of betrayal, inequity aversion, and status-related emotions, such as envy [40,43]. In addition, the experience of being ignored or excluded in minimally social online environments ('cyberostracism') elicits negative affect and reduced feelings of belonging [73] and increases neural activation in areas of the brain associated with the experience of physical pain [74,75]. Together, this research suggests that electronic social networks can support the proximate mechanisms underlying human prosocial behavior and peer-policing to support collective action (Box 2).

Social networks not only increase the number of connections people have, they make connections, actions, and reputations visible and enable people to form homophilous groups [7]. People tend to form strong ties (bonding ties) with similar others, creating pockets of social contagion. Weak ties (bridging ties) spread ideas and actions (memes) broadly, especially through influential people (leadership effects) [22,76]. Cooperative social norms and behaviors exhibit high degrees of social contagion online [7]; this should be especially true when individuals have a large number of strong connections [77] and are connected to other highly connected people [7]. These special properties of social networks are thought to have enabled the rapid social and political changes in the 'Arab Spring' [78].

Testable hypotheses for using the Internet to facilitate environmental collective action

In her final year, Ostrom [79] made a plea for more field studies of cooperation to extend current knowledge beyond the laboratory and behavioral games and into the real world. The hypotheses that we discuss in this review are in need of field testing to discover the social Web's capacity to amplify real life environmental collective action beyond what is possible using conventional communications tools. Interventions that are hypothesized to drive pro-environmental behavior in online environments, which are listed in Figure 1, can only be field tested by first integrating them into project designs and engaging a large participant base. In general, we suggest the following guidelines, which can be reframed as specific, testable hypotheses for how to develop Internet platforms to resolve social dilemmas in support of environmental collective action:

- Create rich, citizen-science Web platforms that are explicitly tied to sense of place [80], translate the best science, and gather people through a common interest that bridges a wide range of ideological groups.
- Integrate social networking into project designs to decentralize governance. Research on collective action suggests that weak governance can work well [11], providing that the environment can support reputational mechanisms.
- Craft messages carefully, avoid fear appeals, and display visualizations that highlight self and group efficacy, social identity, and joint sense of purpose. Foster individual identity and efficacy by allowing individuals to compare their efforts with clear, specific

Box 2. Properties of online social networks that amplify potential for large-scale cooperation

- *Between-group competition.* Competition between groups via contests can increase potential for within-group cooperation [21].
- *Connections.* Increased number of connections to others (degree) [7,14].
- *Density.* The sheer density of network ties is thought to foster cooperation [82].
- *Diversity.* Weak ties that connect people to dissimilar others foster innovation and collective intelligence, and enhance leadership effects [22,81].
- *Fidelity.* Electronic social networks transfer information with a high level of fidelity via exact replication, averting the filtering of information during transfer; this is in contrast with spoken interchange, which has less fidelity [83].
- *Homophily.* Tendency to connect with and have strong ties to similar others, which increases social capital and persistence of engagement [14,84].
- *Influence.* Potential for leadership or influence facilitated by homophily, bonding (strong) ties, and number of bonding and bridging ties [7,84].
- *Opportunities for social rewards and punishment.* Electronic networks allow people to distribute social rewards (e.g., friend, like, interact frequently or comment) and mete out punishment (e.g., dislike, reduce level of interaction or 'tie strength', hide comments of friends, and, more rarely, unfriend).
- *Rapid diffusion.* Weak ties increase transmission of ideas and information [82].
- *Reputational mechanisms.* Reputation can be displayed using leaderboards, badges, or metrics calculated from behavior in electronic social networks [85].
- *Small-world phenomenon.* With only a few weak ties, the path connecting individuals to a large share of the other individuals in a network is extremely short; also known as 'six degrees of separation' [86].
- *Social contagion.* Imitation of and social influence on others within three degrees; behavioral cascades through the network [7,87].
- *Soft governance.* In citizen-science networks, project leaders organize activities, but the structure also allows leadership to emerge from the participant base [2].
- *Transparency.* Connections, actions, badges earned, place on leaderboard, identity, number of friends, social identity, and frequency of interactions are all potentially visible in electronic social networks.

Box 3. Description of YardMap.org, a socially networked citizen-science project designed to support pro-environmental behaviors

YardMap.org is a citizen-science project that allows participants to use simplified mapping tools to make their residential practices visible in a Google Map interface. First, they outline and name a site, which can be a residential property, school, park, or corporate campus. Then they specify set of characteristics for their site, including whether they let a cat outdoors, whether they use herbicides or pesticides, the structural diversity of their plantings, and where their property sits along the urban-to-rural gradient.

After a site is characterized, participants cover the entire site with abutting polygons representing habitat types (such as forest, lawn, grassland, vegetable garden and water features). These data can be used to automatically calculate relevant summary statistics, such as percentage of lawn size, behind the scenes (lawn reduction is one of YardMap's goals). Each polygon can be characterized further, depending on what type of habitat it is representing. For example, a lawn polygon can be characterized for 'irrigation frequency', 'mower type', 'clippings management', or whether it is 'native'. These data constitute detailed information about each polygon that can be used to better understand how people are managing their land and how management changes over time as participants are exposed to new sustainable practices.

The third layer is based on a palette of objects, which allows participants to provide information on their practices at a fine level of detail. Trees can be dragged onto the map and identified to species, gardens can be filled with icons for individually identified plants, water catchment systems can be placed just where they occur, and solar roof panels can be dragged onto rooftops.

Participants can peek at information about sites, polygons, and objects drawn by others and leave comments, ask questions, 'like' or 'follow' a site, or view photos and share information in comment fields. When people change their maps, these changes are visible in the social network. 'Seeds of Change' badges also appear in the social network's news feed, advertising that named participants have succeeded in adopting a specified set of sustainable practices, for example, 'Cat-free Zone', 'Green Power', 'Healthy Yard', and 'Soil Smith' badges. Participants can then click on the news feed to get to the relevant map.

After a map and its growing body of data are stored in the database, summary statistics and comparison tools can be developed, allowing participants to see where they fit next to specific benchmarks or social norms (see Figure 3A in main text) and making visible the number of people who are following them (see Figure 3B in main text). Because practices are stored as data, the application allows researchers to ask how new interventions or social network connections influence adoption of new behaviors. The social network itself provides opportunities to better understand attitudes via close analysis of discourse, including discourse related to controversial issues (e.g., keeping cats out of the wild).

benchmarks and display those efforts to others in the network. Foster group efficacy by allowing participants to visualize the collective effect of the crowd and by displaying new practices or solutions arising from collective intelligence [81].

- Make the social nature of the project apparent with visible following, friending, and scorekeeping so that participants can monitor their own connections, actions, and reputations, as well as those of others.
- Provide and test mechanisms for reputational display, reputational sensitivity, scorekeeping, social rewards, and punishment.
- Use online gamification to elicit competition, including leaderboards, benchmarks, and badges.
- Use machine learning, a computer science methodology related to artificial intelligence, to develop algorithms that expose noncooperators, such as cheaters or free-riders.
- Develop group functionality to divide networks into subgroups that compete with each other for extrinsic rewards tied to the group's contribution to the global public good; theoretically, encouraging inter-group competition can lead to potent within-group cooperation [21]. Allowing participants to form smaller subgroups should also reduce the average time until leaders volunteer within groups [22].

Field research is required to determine which design features of green networks can be successful, but the Web tools required to test these recommendations are costly to produce. We suggest that projects such as YardMap.org, a socially networked mapping environment, can serve as testing grounds for ideas on cooperative environmental stewardship (Box 3, Figure 2). YardMap is different from the other projects in Figure 1 in that it begins with the scientific and educational content of citizen science and taps into a popular earth-stewardship hobby that involves landscaping to support birds and other wildlife. Every activity is stored as data, allowing for the creation of dynamic tools to calculate where people are relative to benchmarks or social norms (Figure 3A). Following a beta launch in spring 2012, YardMap is being redesigned to test mechanisms underlying prosocial behavior with the aim of furthering understanding the Web's potential for supporting sustainable lifestyles and behaviors (Figure 3A,B).

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Figure 2. A completed YardMap showing site outline (yellow), polygons, and objects. See Box 3 for an explanation.

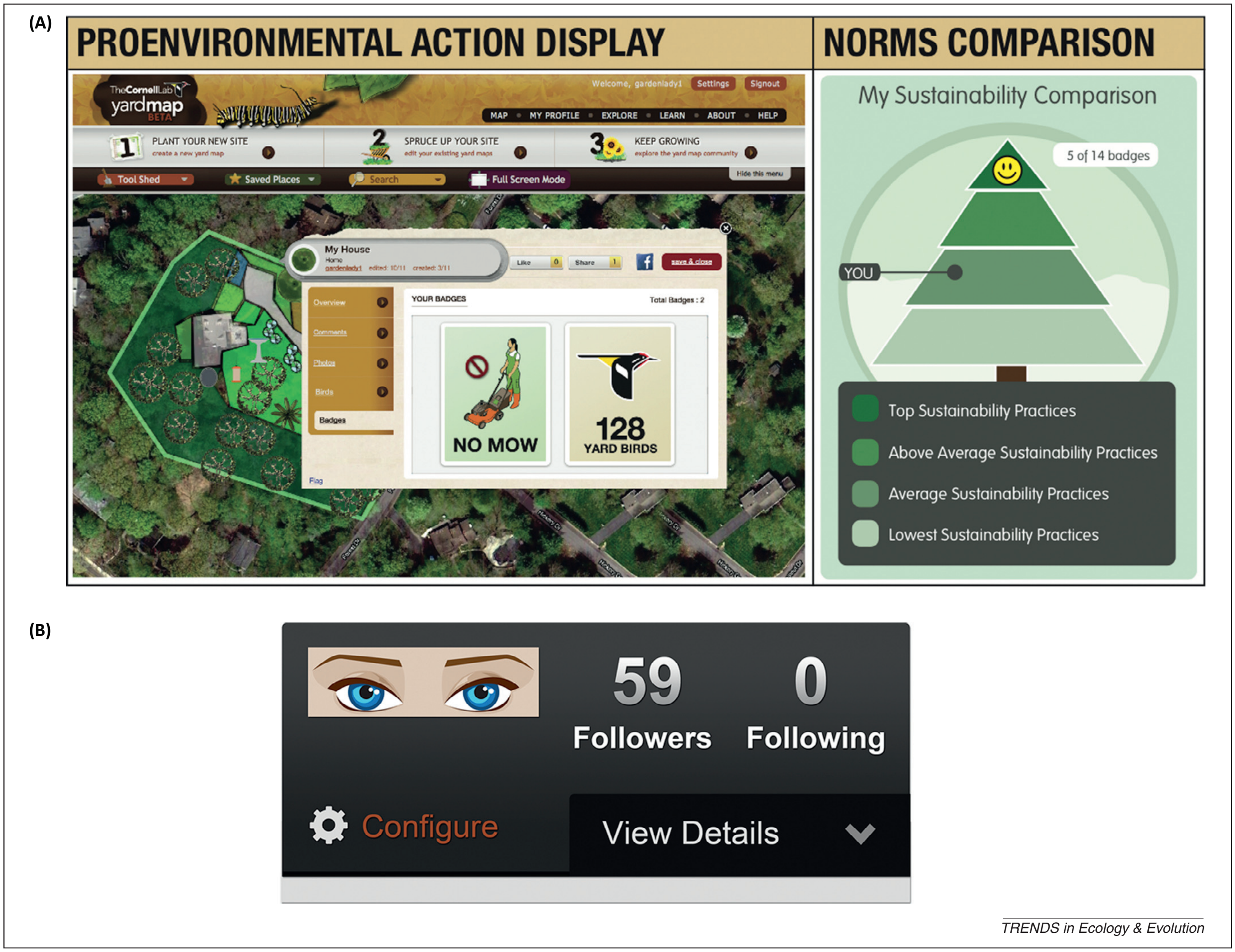

Figure 3. Interventions to test the efficacy of proximate drivers of prosocial environmental behavior in YardMap. (A) Experimental badge display and norms comparison designed for YardMap. On the left is a prototype of a badge display system designed to promote copying behavior (social contagion) and reputational mechanisms. On the right is a prototype of a social comparison tool that allows participants to see where they are relative to the norm (average) and to see that it is desirable to rise above the norm (smiley face). The expectation is that adding the smiley face will help to shift the social norm upward, reducing the likelihood that individuals will gravitate downward, not just upward, toward the norm [88]. **(B)** Enhancement of reputational effects. Example of an intervention designed to test the effect on cooperation of adding a visual image of eyes to the number of followers in YardMap's social network profile.

Concluding remarks

Electronic social networks are ripe for research that harnesses evolutionary theory and social psychology to better understand and design Web strategies to support cooperative pro-environmental behavior. This review suggests that to be successful, projects will need to provide opportunities for people to develop a social identity and group affiliation, assess their own relative status and the reputations of others, and visualize the collective's impact on the future. Also important will be providing opportunities for people to advertise their altruism, reward and punish others, and engage in game-like, between-group competitions.

For the first time in human history we have the potential to create tools that can support massive ideological communities focused on earth stewardship across vast geographic regions. This review is a call for the expansion of cross-disciplinary thinking and field studies to discover the Web's potential for providing robust support for the shifts in behavior and social norms that are required for tackling the householder's share of environmental stewardship, with the assumption that this is one way to grow earth-stewardship from the ground up, starting with households and moving into schools, workplaces, towns, cities, and government agencies.

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