SOCIAL EVOLUTION FORUM

An Evolutionary Approach to Sustainability Science

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Most of the ecological challenges facing humanity today have arisen as the result of interactions between individuals, their societies, and the environment. This is true at many scales—from the worldwide carbon emissions threatening the global climate to pollution of a nearby stream from backyard chemical runoff. Of course, one of these problems is easier to solve than the other—but why? And what can we learn from one that can guide our attempted solution to the other?

Beginning to answer such a fundamental question requires a consideration of theory. Theory allows us to draw general conclusions from a broad set of similar cases and use them to describe or predict outcomes in future instances. For example, we might ask what general lessons we can learn from traditional fishery management systems in pre-colonial Fiji; national environmental policy in Bhutan; or litter regulations in the United States. Below, we present a theoretical framework developed by Waring et al. (2015) to help clarify sustainability research and policy.

Cultural evolutionary theory provides a useful framework for studying social-ecological change and for designing policy to achieve sustainability in social-ecological systems. There are a number of reasons why this is so. Current social-ecological systems theory—or 'sustainability theory'—does not consider or include endogenous cultural dynamics (Caldas et al. 2015). Instead, it is largely based on our understanding of ecological systems and ecological change, disregarding what we know about cultural dynamics from the outset. This is a big gap, because we now know a great deal about the complex internal dynamics of human culture.

Furthermore, human culture and cooperation are inextricably intertwined (Boyd and Richerson, 2009). This is crucial because virtually all challenges in achieving environmental sustainability are cursed with social dilemmas in which the best solution for individuals is not the best solution for the group. The solution to social dilemmas is, of course, cooperation. We now know a great deal about

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cooperation as well (Henrich 2004; Nowak 2006).

Finally, and most fundamentally, sustainability theory should be able to explain the emergence and persistence of sustainable states in social-ecological systems.

This approach to social-ecological systems is mainly informed by our knowledge of ecological dynamics and does not include the cultural and social mechanisms and processes that operate independently of external drivers such as economic and ecological forces. Such processes include fundamental social factors such as identity formation and the inheritance of beliefs, values and preferences, which influence human decisions and actions throughout life. Cultural evolution is useful here, too, because cultural evolution is generally modeled using tools from evolutionary game theory that describe the requirements for a given behavior, such as a cooperative environmental behavior, to become an evolutionarily stable strategy. Thus, the tools of cultural evolution are well suited to describing conditions for the invasion (emergence) and stability (persistence) of sustainable behaviors—and that is what is most lacking from sustainability theory.

Cultural evolution is a simple concept with a few important elements. Evolution, in general, carries three requirements—variation, inheritance, and selection. Cultural evolution is a description of how culture changes over time as a result of these requirements. Although genetic evolution operates on genetically-encoded traits, cultural traits—such as behaviors, customs, and beliefs—are encoded in human minds. Cultural traits vary, and naturally, different cultural traits result in different outcomes for those who adopt them. When those outcomes influence how often those traits spread through imitation and other mechanisms, they undergo a type of natural selection. Usually bad ideas don't catch on. However, cultural inheritance is very different from biological inheritance. Genetic inheritance typically proceeds via the passing of genetic information from parent to offspring. This is called "vertical" inheritance, and genetic vertical inheritance is the result of reproductive choices of the parent. By contrast, with cultural evolution, the recipient of adaptive information typically initiates cultural transmission—we imitate individuals and traits we deem successful or somehow worthy. We constantly, and strategically, copy adaptive behavior from others. For instance, we often imitate our peers through "horizontal" cultural inheritance.

Scientists in many disciplines use cultural evolution to explain patterns of change in culture over time. Importantly, cultural evolution tends to occur at a faster rate than biological evolution—meaning that human societies adapt to environmental changes more quickly through social and behavioral change than through genetic adaptation.

Rapid cultural adaptation is crucial to the formation of human societies. When

a human population inhabits a particular environment, individuals gain a rich knowledge of the best natural resources, types of shelter, food processing and survival strategies. This adaptive information accumulates over the generations, so that individuals benefit from many lifespans' worth of costly learning. As a result, human lifestyles, institutions, and behaviors are often very well-adapted to managing their natural environments.

Cultural evolution helps us understand this accumulated cultural adaptation and is, therefore, useful in solving social-environmental problems. An important aspect of cumulative cultural adaptation is the role of the group. Although some culturally learned behaviors are adaptive for individuals, others are advantageous for the groups in which those individual reside. Groups are an important and central feature of human life everywhere. Groups may be civil, military, religious, social or economic in nature, but they are often small (less than 200 people) and share a common goal or social identity. But, groups vary, as do their behaviors, rules, and systems for organizing themselves to accomplish shared tasks. Differences in the cultural traits between groups provide another opportunity for natural selection to operate. Of course, groups with traits better suited to their environments or to group competition tend to prosper and spread while others decline. However, group-level selection does not function only through demographic change such as group formation, growth, and dissolution, but also includes the effects of differential imitation and migration between groups. If a certain group is imitated more than others, the cultural traits of that group spread. So just as warfare can cause selection for improved military strategies, economic competition between companies can cause selection for improved business strategies. Both types are considered part of the simple and ubiquitous process of cultural group selection (Richerson et al. 2014).

Group-level selection is important for another reason as well—it is the most general force for the emergence of cooperation. When individuals compete, individually adaptive behaviors proliferate. In the environmental domain, this often means individuals extract more resources than is best for their group or the longevity of the resource. But when groups compete, cooperative and coordinated groups win and group-functional behaviors proliferate. In the environmental domain, group functional behaviors will often include resource conservation, because groups who exhaust resources, or who waste energy over internal resource conflict, fare more poorly than those who simply conserve and share. We are so accustomed to living with group-functional traits that we may rarely perceive them. But, cultural group selection is a potential cause of the cooperative traits that we see in society every day, such as charitable donations, taking turns, politeness norms, queuing behavior, team sports, and military strategy, to name just a few. For an extensive review of the evidence for cultural

group selection, see Richerson et al. (2014).

Of course, in real life, individuals compete within teams even while teams compete to win. How can we predict the results of evolution then? Worse yet, in real life, there are often many more than two relevant levels of organization. Individuals reside in towns, towns in states, states in nations and nations join multinational alliances. Then there are households, corporations, and sports leagues. How can we possibly predict human behavior if evolution happens on all those levels simultaneously? Multilevel selection theory gives us the conceptual tools to begin. Multilevel selection theory provides statistical methods to track evolution across multiple levels simultaneously (Okasha 2006). Using these tools, it becomes possible to follow the action and ask "where is evolution happening the most?" or more precisely, "is there a dominant level of selection?"

If selection between groups is stronger than selection between individuals within groups, we should expect group-functional behavior to emerge, and vice-versa. By empirically estimating the dominant level of selection, scientists and practitioners can gain insight into the dynamics of the social systems in which they work. Are cooperative, group-functional behaviors likely to emerge? Perhaps, if groups are strong, varied, compete regularly, and are keenly aware of each other's strategies. Will a certain policy be adopted by a given organization? Perhaps not, if there are only a few organizations that exhibit only a little trait variation who do not pay close attention to the matter, and the benefits and costs of the policy are hard to determine.

All of this leads to a simple conclusion: if we want to explain the existence of a particular behavior, we need to identify the level of selection most likely to have produced it. Assuming that the behavior was culturally selected, what level of organization would have most likely been responsible? Although there is no guarantee that cultural change is due to selection, it may often be. Thus, by identifying the level of selection most relevant for a given trait, as well as the processes of variation and transmission that influence it, we can gain a robust understanding of its historical development and likely future trajectory.

The strength of cultural multilevel selection as a theoretical framework is demonstrated by its ability to both describe the underpinnings of events in the past while also allowing generalized lessons to predict potential outcomes in the future. To demonstrate the framework, we turn to Fiji, Bhutan, and the United States.

In pre-colonial Fiji, generally speaking, people survived by subsistence fishing. People were organized by family connections into clans, which in turn were organized into chiefdoms that held exclusive territories. Because subsistence fishing is labor-intensive, individuals tended to minimize their harvesting effort while satisfying the needs of their household. At the chiefdom level, selection

likely favored rules to prevent overharvesting because of the need to have plentiful fish stocks in periods of upheaval, such as attempted invasion by neighboring chiefdoms or tropical storms. Moreover, evidence suggests that war between villages tended to be settled in favor of the defending villages, creating a selection for laws within chiefdoms to sustain their populations from the fisheries within their own territory and avoid engaging in conquest.

The historical resilience of the Fijian social-ecological system becomes apparent when we consider the disruption following colonization. Once Fiji was opened to a global fishing market, new incentives emerged to maximize harvests, while the old chiefdom system of governance was supplanted by the nation-state. In pre-colonial Fiji, fishing restrictions tended to help chiefdoms, and chiefdoms were likely the dominant level of selection for fishing rules generally. Meanwhile, overharvesting behaviors were minimized. After colonization, as the social controls of the chieftains were eroded, the dominant level of selection for fishing behavior changed from chiefdom to individual harvester. Individual harvesters, incentivized to maximize their harvests by the nation-state's response to the global market, tended to overharvest and as a result have entered an ecological crisis. The history of fishing restrictions in Fiji shows how characterizing the dominant level of selection provides a way to hypothesize more accurately about the influence of policy changes across organizational levels.

A parallel case is Bhutan's national environmental policy. Historically, Bhutan has faced a series of direct and indirect external threats and pressures, which have tended to accelerate the emergence of solidarity and a strong social identity. In response, the Bhutanese government has fostered a distinct religious and cultural identity through the encouragement of Buddhist influence in daily life. Strong social solidarity has included a Buddhist philosophy, environmental values, and the institution of Gross National Happiness (GNH)—instead of the widely-used Gross National Product (GNP)—as the primary indicator of national wellbeing. With this framework as the primary indicator of national success, development and economic activity have placed significant emphasis on sustainable use of natural resources and protection of environmental features, even when such considerations may inhibit economic growth.

Changes in the levels of selection are observable in each of the major shifts in Bhutanese culture in recent history. Before unification, competition between ethnic groups fueled warfare and led to higher rates of resource extraction. However, the persistence of existential threats at a national level led to the development of a national identity and the emergence of a monarchy, unifying disparate communities. With this consolidation came less autonomy at the individual and community levels, but also less warfare and greater cooperation. Unification also solidified a governance system based on Buddhist beliefs and

ethics, which in turn led to the creation of the GNH model. Importantly, had external threats not driven Bhutan to unify politically, it appears that the GNH and related environmental conservation policies would never have emerged.

Describing Bhutan's development in terms of multilevel selection is useful—but what can we predict about its future? One important trend could be the recent transition from monarchy to parliamentary democracy. This institutional shift—the product of cultural transmission—could lead to the development of political parties that may shift the dominant level of selection, in terms of policy, to the partisan level instead of the national level. If parties cooperate within themselves but compete in parliament, there could be serious implications for Bhutan's future sustainability-oriented efforts, along with other changes. On the international level, however, the strength of cultural transmission will determine if other countries—or perhaps other groups at different scales—copy Bhutan's unique practices.

Another useful example comes from the development of litter mitigation policy in the United States. Crucial to this case study is the appearance of competing, overlapping organizations—in this instance, private corporations and public government. Here the multilevel selection framework can be applied to both types of organization, revealing how their historical interactions created the conditions we see today.

With the widespread use of disposable packaging, especially for foodstuffs marketed to buyers for consumption in vehicles, came litter. Littering poses a classic social dilemma because individuals face negligible consequences for littering, while society as a group incurs a substantial cost from the aggregate result—trash everywhere. Policy responses to such a problem often vary greatly, making them ripe for selection. Two different types of organization—private corporations and public government—responded to the littering problem in different ways.

For democratic governments in the United States—particularly at the municipal and state levels—a number of policy options are available to tackle litter. Banning or limiting the production of disposable packaging, which constitutes the bulk of litter, is relatively inexpensive; managing and collecting litter from the environment is substantially more costly. Therefore, it is cheaper and easier for governments to create policy attempting to prevent litter at the source—the producer. However, for corporations that profit from selling products delivered in disposable packaging, such a policy would be problematic.

Although states and municipalities moved to implement bottle deposit policies and other measures to curb litter by limiting waste production, a number of food and beverage companies banded together to form a public advocacy supergroup, Keep America Beautiful, Inc. (KAB) to encourage individuals to take responsibility

for their own cleanup. Waring and coauthors suggest that the resulting process followed an evolutionary course.

There are a number of selective influences at play in this example. Individuals cooperate through democratic governments to solve the problem, producing regulations that were mimicked by other municipal and state governments. The potential costs of reusable packaging incentivized corporations to cooperate to find a way to avoid those costs. The resulting industry supergroup, KAB, operated by creating pressure at the individual level to accept personal responsibility for the litter problem, thereby attempting to change cultural norms and lead to relaxed regulation at the corporate level. This example demonstrates that when different types of organization—such as corporations and governments—share a single environmental domain, the outcomes depend result from a coevolution of strategies between both organizational types. In this case, the best environmental solution, reusable packaging, was forfeited because corporations adapted more rapidly to their own challenge than citizens and governments did to theirs. As a result, governments at all levels now handle a greater cost of waste handling than they would otherwise have.

What these cases illustrate is the ability of cultural multilevel selection to draw generalized conclusions from different actual examples, and describe these lessons in such a way that they can be used to predict and potentially preempt related challenges in the future. Estimating the dominant level of selection for a given behavior or norm, while accounting for broader cultural context, is a proper first step for attempting to solve collective action problems related to sustainability. Context is key, however—for example, in Fiji, selection at the national level weakened rules and social norms that encouraged resource conservation, while in Bhutan the opposite seems true. This is because Bhutan's GNH is a national-level policy, while traditional Fijian fishing restrictions were at the chiefdom level. This difference explains why a similar selective regime—at the level of the nation—resulted in different conservation outcomes, and underscores the importance of determining where the strength of selection is greatest. Successful interventions must therefore respond to both context and selection.

The case studies of Waring and coauthors are meant to illustrate the role cultural multilevel selection might play in truly evaluating on-the-ground social-ecological systems and sustainability challenges. That task is the next step in developing a cultural evolution science of sustainability. However, the signature of cultural multilevel selection is very common. We can see it when we watch individual opinion and state policy feedback on each other in a cascade that results in a policy change at the federal level on issues such as same sex marriage, alcohol prohibition, or marijuana legalization (Tribou and Collins 2015). We can

see it in the spread of sports strategies between players and teams in national sports such as hockey and football. We can see it happen as costly voluntary environmental practices percolate through industries (Prakash and Potoski 2006). And, we can observe the emergence of climate policy, such as carbon emissions regulations, as individual opinion shifts and policies spread between states and nations. In each of these cases, there are cooperative social dilemmas that make the best individual strategy conflict with the best group policy, but, despite the conflict, group-focused solutions can emerge and do. Cooperative solutions are not guaranteed, but applying cultural multilevel selection can help us understand how they emerge and guide us toward more effective interventions and more lasting solutions.

Ultimately, the value of cultural multi-level selection will be determined by its applicability and predictive power in disparate cases. As a theoretical framework, cultural multi-level selection provides a rubric for organizing causal processes that matter in the evolution of social-ecological systems. And, at its heart, there is a prediction of great importance. It is this: if the strength of selection on groups for resource conservation is stronger than the strength of selection on individuals for greater consumption, costly conservation practices and group-beneficial policies are likely to emerge.

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Commentaries

David Sloan Wilson. *Make Way for the Next Generation of Cultural Evolutionists*

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Thank heavens for next generations. If it weren't for young people pressing for change, change would occur much more slowly than it does. In his book *Brain and Culture: Neurobiology, Ideology, and Social Change*, Yale psychiatrist Bruce E. Wexler gives this commonplace observation a neurobiological explanation. The amazingly plastic human brain adapts to its environment and engages in niche construction during development but then rigidly clings to the status quo during adulthood. Adults who retain youthful flexibility are rare.

Timothy Waring and Ethan Tremblay's focus article, which is based on a multi-authored article[1] published in the academic journal *Ecology and Society*, represents the next generation of cultural evolutionists. They regard the great controversies of the previous generation, such as the legitimacy of multilevel selection as a theoretical framework, as over (go here for more) and they are eager to move on to new challenges. They are also eager to leave the Ivory Tower and use the scientific tools that they have learned to use to improve the quality of life in a practical sense.

Sustainability is an excellent example of how cultural evolutionary theory can add value to a topic that is obviously important for human welfare and has already attracted the attention of the best and brightest minds employing other

perspectives. As Waring and Tremblay describe in their target article, current sustainability science is strong on ecological dynamics and complex systems thinking but light on cultural dynamics and evolutionary thinking. Evolutionary thinking is new and important in the biological realm, even before we get to cultural evolution. Most sustainability scientists do not sufficiently appreciate that genetic evolution can operate on ecological time scales, so that the parameters governing ecological dynamics cannot be assumed to remain constant over time. In addition, when genetic evolution does not keep pace with environmental change, a sophisticated knowledge of evolution is required to understand the mismatch between adaptations to past environments in the current environment (go here for more).

Cultural multilevel selection adds another layer of complexity that is essential for addressing sustainability issues. The iron law of multilevel selection is: "Adaptation at any given level of a multi-tier hierarchy of units requires a process of selection at that level and tends to be undermined by selection at lower levels." The reason that unsustainable practices are so common is because they benefit lower-level units at the expense of the higher-level good. Seeing this clearly can go a long way toward designing social environments at all scales that allow sustainable practices to increase in frequency in a Darwinian world, as described in a previous SEF target essay by Norwegian biologist Dag Hessen and myself, titled "Blueprint for a Global Village."

That's all very good in theory, but how about it practice? One of the main strengths of Waring and Tremblay's focus article is that they apply CMLS theory to real world examples such as the conservation and exploitation of marine resources in Fiji, the enlightened social and economic policy of Bhutan, and the successful campaign to reduce littering in America. Applying the same theoretical framework to diverse examples is second nature for an evolutionist but not for most policy experts, who work in isolated communities that do not share a common theoretical framework. Since helping to start the Evolution Institute in 2007, I have interacted with hundreds of policy experts of all stripes. Most of them are open-minded about evolution but have no training and want to know how it adds value to their current perspectives. That's a fair question and case studies such as these are beginning to provide solid answers.

I end this commentary on a somewhat pessimistic note. In their target essay, Waring and Tremblay state that "usually bad ideas don't catch on." I am struck by how often bad ideas *do* catch on for reasons that can be understood in terms of cultural evolutionary theory. In addition to ideas that are selected at lower levels and are bad at higher levels, the entire psychological machinery underpinning cultural evolution evolved by genetic evolution in the context of small groups and can break down in large-scale society. There is a "cultural system dysfunction

hypothesis" comparable to the immune system dysfunction hypothesis that has begun to attract widespread attention in medical circles (go here for more).

My pessimism is based in part on a bitter experience—a program for at-risk high school students that was highly successful in a randomized control trial and still didn't survive or spread because of instabilities in the larger public school system (go here for more). If we want best practices to spread in modern social environments, then the entire machinery underpinning cultural evolution will need to be socially constructed in a way that interfaces with our genetically evolved psychological mechanisms and past products of cultural evolution. That's a daunting job that can't even be envisioned without a sophisticated knowledge of evolutionary theory. The next generation of cultural evolutionists is arriving just in time.

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Joe Brewer. *Commentary on "An Evolutionary Approach to Sustainability Science"*

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It is such a breath of fresh air to read Timothy Waring and Ethan Tremblay's article *An Evolutionary Approach to Sustainability Science*. Let me begin by saying that I consider cultural evolution to be essential for tackling the global ecological crisis—for all the reasons laid out in their writings and a few more I would like to elaborate here.

But first, I couldn't help noticing that Waring and Tremblay's writing style was a bit more academic and technical than a lot of blog posts read by mainstream audiences. For readers who are less familiar with the terminology of cultural evolutionary studies, I offer a brief recap of what they said in concise form:

Human societies are made up of stories, beliefs, practices, knowledge, and tools. These things can vary within groups and between groups, creating all the conditions necessary for evolution to unfold in time. All that is needed is

variation, inheritance, and selection for culture to be "Darwinian"—meaning that among the variety of possibilities some are passed on and others aren't from one generation to the next. Take this key insight and apply it to environmental problems and you'll see how important the *level of selection is* for making sense of policy solutions for managing environmental resources.

Why does this matter? Because every real-world human setting has motivations and incentives playing out at different scales. Individuals, families, neighborhoods, municipalities, chiefdoms, nation-states, etc. A powerful tool from cultural evolution is known as *Multi-Level Selection* and it comes with clear ways to measure how much each level contributes to the evolutionary patterns of a given situation. Waring and Tremblay offered several examples of this to show how powerful Multi-Level Selection is for managing fish stocks, promoting societal well-being, and keeping litter off the streets.

I have also been developing a framework for the ecological crisis that makes use of cultural evolution, that I flesh out fully in *Tools for Culture Design: Toward A Science of Social Change?*. The definition I give for culture design is this:

> Culture design is the integrated practice of (a) treating cultural change as a complex adaptive system; (b) studying the mechanisms and drivers of cultural change, including trend analysis and emergent social behaviors; (c) applying design frameworks based on this approach to identify operating parameters for social systems and (d) guiding the evolutionary process of social change toward safe zones within these operating parameters.

Clearly this is resonant with the perspective offered by Waring and Tremblay. What I would like to offer in this commentary is an extension of their argument by describing how the related field of cognitive linguistics offers additional granularity into the "selection criteria" for specific policy frameworks. Several years ago, I co-authored an article with Evan Frisch called *Why Environmental Policy Needs a Cognitive Dimension* that shows how this works.

We offered an imagined scenario where comprehensive climate regulations were adopted by the United States. Since the policy was created in the standard manner—what George Lakoff and I call "material policy" (as contrasted with the often invisible and unacknowledged component of "cognitive policy")—no consideration was given to the social norms, mythic narratives, tribal identities, and shared beliefs that make up different political camps.

These semantic features of culture give people meaning and help structure how they perceive, comprehend, and navigate their social worlds. As such, they are very important! When we unpack the semantics of culture as it relates to

public policy, it becomes clear that some ideas are a better fit to a given context than others. This is another place where all the criteria are met for Darwinian evolution to take place—variation of ideas, heritability differences between the ideas, and some kind of selection mechanism that causes some ideas to persist and spread better than others.

As an example, consider two different ways of thinking about markets. One common way to think about markets is that *they are completely natural and operate according to the laws of nature*. Another common way to think about markets is that *they are tools created by people to serve an economic purpose*. These are different "semantic frames" for the meaning of markets.

The success of a climate policy will depend in part on which conception of markets is used and how people in the society where the policy is implemented think about markets. One idea may be more fit than the other. And it might not be the case that the same policy works in different places—even if the Multi-Level Selection criteria laid out in Waring and Tremblay's article holds, i.e. that the appropriate level of selection has been identified for proposing an effective solution, it may be rejected by society. Even a good idea won't work if people refuse to adopt it. And their willingness to adopt an idea requires that it fit with the cultural ecology of shared meaning-making.

What we get when we combine cognitive linguistics with cultural evolution in this way is a much richer approach to cultural studies. It becomes possible to treat culture as a complex adaptive system (a requirement for both my approach and that advocated by Waring and Tremblay). And it also lets us look at selection criteria in levels of governance AND as cultural understandings. Meld the two approaches and we see how powerful this can be.

I don't claim this is a full account of what is needed. It is merely one extension of the strong case made in Waring and Tremblay's article to show that a great deal is known about the evolution of social systems. And we are going to need to integrate and synthesize this knowledge in order to navigate the many systemic threats now confronting humanity.

Dustin Eirdosh. *The Tragedy of Commonsense Project Management: Multilevel Thinking as a Core Competency for Sustainability Scientists*

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Sustainability scientists around the world seek to address the *tragedy of the commons* across diverse social-environmental contexts, yet, ironically, we are all too often blind to another, perhaps more personal, social tragedy that we may be generating in the pursuit of these noble objectives. What I have come to call the *tragedy of commonsense project management* refers to the use of social intuition rather than methodological reasoning for the design of research project groups, and implementation of interventions for sustainable resource management. That is to say, although a good deal of sustainability science is conducted with a respectable level of scientific rigor, when these same scientists are tasked with managing the research project itself, or designing a bridge between knowledge and policy (interventions), "science" is then viewed, too often, as having run its course.

In this commentary on Waring & Tremblay's focus article, I make the argument that their Cultural Multi-Level Selection (CMLS) framework applies not only to the natural resource dilemmas studied by sustainability scientists, but also to the very project groups we must manage around these important research topics.

I want to highlight the tragic irony of utilizing commonsense to drive applied research projects on common-pool resources through a brief case study on zebu fodder harvesting in Madagascar. I'll conclude by reflecting on the need for the CMLS framework to be utilized more strategically within sustainability science curricula to cultivate new competencies among young researchers across disciplines. In short, the causal understanding of multilevel social dynamics must come to be regarded as a *core competency* among sustainability scientists in the twenty-first century if we are to move past commonsense project management and towards the reliable development of effective strategies for the commons of our world.

A Case Study of Commonsense and the Commons of Madagascar

Madagascar is the only country in the world whose real per-capita wealth has decreased dramatically since the 1960's despite the absence war or violent conflict (World Bank 2015). Corruption is rife, from the scale of classrooms and communities to police and politicians. Land-use issues of all sorts entail

entanglements of traditional rights at the most local level to the 'neo-colonial' claims of international industrialists. The challenges that face this biodiversity hotspot are one multi-level cooperation dilemma after another.

A recent research project was tasked with developing an international, interdisciplinary study on the sustainability of the harvesting practices of zebu (cattle) herdsmen for a specific regional fodder species, samata (*Euphorbia stenoclada*). Samata is an endemic Euphorbia species that is harvested for cattle feed in open-access, wild growth contexts and increasingly cultivated in privatized, small-farmer settings. The ~5-year project included a phase of basic research (~3.5 years), followed by ~18 months development of applied, collaborative interventions to promote regional capacity-building around identified sustainable management solutions.

The Waring et al. (2015) article in *Ecology & Society* highlights several 'routes for interventions' into sustainability policy based on the integrated insights of a CMLS framework. The first two of these intervention routes are particularly relevant for this case study because their explicit rejection among these researchers in Madagascar led to a range of new problems rather than solutions. Waring et al. argue that (1) *targeting the appropriate level of selection* and (2) *altering the level(s) of selection* offer two central tools within the emerging CMLS toolkit. I'll highlight here how social intuitions, combined with a misunderstanding of CMLS theory, led this project in Madagascar towards a commonsense solution with questionable impact on the commons in question.

The primary investigator of this zebu fodder topic discovered that, unsurprisingly, classic social dynamics of privatization and escalating wealth inequality were occurring within the context of increasing resource (zebu fodder) scarcity in conjunction with the well-known lack of effective governance among the rural villages being studied. Interestingly, this investigator also discovered that, although any single village was unable (in fact, unwilling) to effectively monitor or regulate exploitation of the fodder resource by "outsiders," these out-group herdsmen were coming from a limited set of neighboring villages. The investigator became strongly pessimistic about finding *any* viable solution, arguing that if an *individual village* cannot delineate or monitor who has access rights to the resource, there is little hope in evolving an effective governance scheme.

Although this investigator was mired in pessimism about the possibility of identifying an effective intervention, her larger research project (composed of multiple working groups) was still accountable for the development of an intervention based on the original research. In this context, two divergent intervention strategies emerged during the early planning stage of the final year for implementation.

Strategy A consisted of developing a "comic book" that promoted "sustainable harvesting" (i.e., harvesting only some fodder from each tree) as the "rational" management approach which individual herdsmen should adopt.

Strategy B was focused on developing an accessible curriculum on common-pool resource dynamics (sensu Wilson et al. 2013; Waring et al. 2015) for the village schools and farmer groups that would facilitate bottom-up discussions around potential policy solutions.

Implementation of strategy A was a forgone conclusion. Strategy B was discussed and adopted through a majority consensus of project members early on in this final implementation stage as a complementary approach to strategy A. This dual-strategy approach was deemed unacceptable to some proponents of strategy A. In response, a particularly strong personality within the strategy A group engaged project authorities outside of the democratic decision-making process, insisting that the project proceed only with strategy A, the comic book focused on individual behavior change as a "rational choice."

This top-down decision-making resulted in significant strife within the project group itself, causing multiple members of the team to disengage from the overall intervention design. At the time of implementation, even remaining members directly engaged in the intervention planning expressed severe skepticism at the potential efficacy of the comic book, inviting comments such as "I don't think this will really do anything" and "…maybe the farmers will wipe their butts with it." Early evaluations indicate that farmer comprehension and interest is in line with this speculation.

For many in the sustainable development community, this case study is almost not worth noting. Projects are mismanaged due to internal conflict all the time, and interventions are routinely ineffective. What I want to draw attention to is the homologous challenges between the project management and the intervention design. In both cases, social intuition and rigid disciplinary thinking prevented the *identification of the appropriate level of selection*, as well as *altering the level of selection* towards valued outcomes (the routes of intervention identified in Waring et al. 2015).

That is, while the project itself was perceived by outsiders (and stakeholders) as a functionally-integrated unit, this was far from the case according to perceptions within the various project working groups. Leadership within the project explained this lack of social cohesion by stating, "the project is simply too large," yet, with a team comprised by ~50 individuals, clearly, humanity has historical precedent for this scale of cooperation. What was lacking, from a CMLS perspective, was a coherent plan for identifying and altering the appropriate levels of selection during different stages of the project (see Fig. 1). In the absence of appropriate group-level mechanisms, the 'strong personality' who favored

strategy A co-opted selection pressure towards his interests in a highly predictable fashion. In steering the evolution of group dynamics towards strategy A alone, and away from project-level cooperation, the intervention lost out on critical interdisciplinary perspectives that could have increased its efficacy.

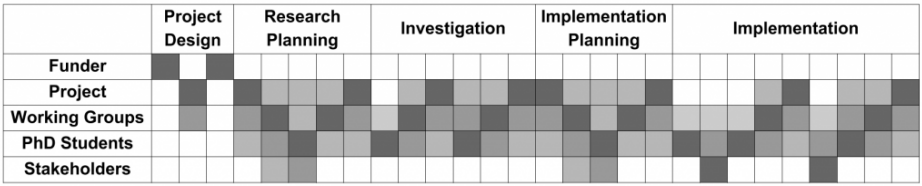

Figure 1. A Generalized Model of Cultural Selection Dynamics for Sustainability Science Project Groups. The CMLS framework of Waring and colleagues applies not just to common-pool resource dilemmas, but to the research project groups themselves. This draft diagram adapts the graphic models of the environmental case studies presented in Waring et al. (2015) to a highly generalized and theoretical representation of cultural selection requirements across different stages of a typical applied research project group within sustainability sciences. Both within and between each project stage, the appropriate level of selection may vary significantly. By mapping a project's projected cooperation requirements at the outset of a project, participants may better understand the appropriateness of respecting autonomy and coordination during different stages. This may allow group members to plan mechanisms for appropriate levels of cooperation (sensu Wilson et al. 2013) or may simply provide helpful framing of commonsense discussions on these often difficult-to-manage social dynamics.

The comic book intervention itself posited the core problem as rooted in the individual-level selection of behavioral variation (i.e., if only each individual herdsman would rationally harvest less, sustainability would be achieved), despite the project's own research pointing towards inter-village cooperation as the requisite scale of cooperation. By ignoring these CMLS dynamics in both project management and intervention design, this project simultaneously created a hostile working environment among colleagues while steering the conversations among natural resource users in precisely the wrong direction. The tragedy of commonsense project management is not something the commons of Madagascar can afford to experience much longer!

Cultivating Competencies in the Sustainability Science Curriculum

It could be argued that those in the project above simply should have made stronger rational arguments in favor of CMLS dynamics, but I will argue that in this case rational argumentation did not stand a chance against the intuitive sway of prevailing commonsense. The Evolution Institute may be able to assemble top researchers, a mountain of empirical evidence, and a stunningly coherent synthesis of human sciences to support the CMLS framework, but if sustainability scientists are not receiving the training needed to develop the knowledge, skills, and attitudes required of cultural evolutionary theory, this work will fall on deaf ears. Indeed, the competencies required to engage Waring and colleagues' framework are diverse, nuanced, and complicated, even among this new generation of cultural evolutionists. To succeed, we will need to engage professional curriculum designers and evolutionary educators in identifying the core competency needs for multi-level thinking in the human sciences and work strategically to integrate this training across the extant disciplines of sustainability science.

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Anthony Biglan. *Why Sustainability Needs Preventative Science*

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Timothy Waring and Ethan Tremblay's theoretical analysis of an evolutionary approach to sustainability science is useful for clarifying the contextual influences on sustainable practices. In that regard, it may be helpful to connect this

theoretical analysis to some specific problems of sustainability that must be addressed if catastrophic climate change is to be prevented.

The beauty of an evolutionary analysis is that it can pinpoint malleable contextual variables that affect the behaviors of individuals and the actions of groups or organizations (Biglan & Hayes, 2016). This is not to say that one must pursue such an agenda—one can analyze contexts affecting cultural processes for the purpose of having an effective predictive model. However, if our intention is for our science to contribute to the prevention of harmful outcomes, identifying malleable influences of the process that threaten us can enable practical action. Nowhere can there be a greater need for such analyses than in developing strategies to combat climate change.

One way of looking at the current situation is that there has been a higher and more effective level of organization on the side of preventing reductions in the use of fossil fuels than there has on the side of taking effective action to reduce its use. (The use of fossil fuels is not the only factor affecting climate change, but it is perhaps the biggest and it is one for which the main contextual influences have been delineated.)

The role of the fossil fuel industry and its allies in preventing effective public policy are well documented. A recent review of the evidence by Dunlap & McCright (2015) shows that a network of organizations has quite effectively blocked policies that would prevent or mitigate climate change. In addition to the fossil fuel industry, the network consists of related industries (e.g., auto manufacturing), a network of conservative think tanks, conservative media outlets, and other conservative interests that advocate for free market economics and minimal government regulation generally (Dunlap & McCright, 2015).

The network evolved out of completely understandable efforts by businesses to protect their interests. The generic practice of scanning the environment for threats and opportunities to the future wellbeing of the organization is well established (Helms & Nixon, 2010). It has been selected by its benefit to groups and organizations in avoiding harm to the organization and ensuring that its revenue is sustained. In a market system, practices are especially fine-tuned to their impact on profits. Indeed until the advent of the B Corp, all publicly traded corporations in the U.S. have been at risk of shareholder lawsuits if they failed to take actions to protect their profits.

Over the past century company practices that involve marketing, public relations, and efforts to prevent harmful government action have been selected by their success. A particularly relevant and well-documented example is provided by the Tobacco Industry, which was an early innovator in marketing its product and subsequently in influencing public opinion to believe that cigarettes were not harmful (U.S. District Court, DC, 2006) , and preventing restrictions on

their marketing practices (Biglan, 2004).

Efforts to prevent reduction of fossil fuel consumption are strikingly similar to the tobacco industry's actions. According to The Los Angeles Times, just as tobacco industry research showed in the 1950's that cigarettes cause cancer, research done by Exxon scientist in the 1970s concluded that global warming was occurring and was caused by human action. The company's research was focused on the possible benefits of global warming for making it easier to drill for oil in the Arctic. Yet, in 1990, Exxon's Board stated that "examination of the issue supports the conclusions that the facts today and the projection of future effects are very unclear." And according to the New York Times and Dunlap & McCright (2015) the company continued to support organizations and political candidates engaged in sowing doubt about climate change and opposing policies that would prevent CO2 emissions. Whether the fossil fuel industry continues to directly fund deniers is unclear, since the network of organizations funding much of the opposition to effective climate policy has developed corporate entities that are not required, under current law, to reveal their donors (Brulle, 2013).

What are the selecting consequences for these practices? The protection of investments. Current estimates are that in order for us to avoid possibly irreversible changes in the earth's atmosphere, about 80% of the currently known coal and oil reserve must remain in the ground [McKibben]. It is completely understandable that groups and organizations that stand to lose this much of their assets would take the actions that they have taken.

There is a network of organizations worldwide that are working to change public opinion and to get policies adopted that will prevent these catastrophic outcomes. We can measure their success by the state of public policy.

One reason for this may be the power of market forces to influence effective action. That is, corporations are finely attuned to the contingencies in the market place and are thus well organized to take action to avoid negative consequences. The practices of groups and organizations trying to prevent climate change are not as precisely organized by market contingencies since the outcomes they seek to achieve cannot be measured as precisely and their funding is not a direct result of their taking effective action on the problems they are addressing (Biglan, 2011). That is, their fundraising is not directly contingent on their success in affecting outcomes (Biglan 2009). (Ironically, this analysis is consistent with conservative arguments of the power of market forces. The problem is that, as David Sloan Wilson has shown, market forces do not necessarily select practices that are to the benefit of the larger society.)

This analysis brings me back to the conclusion I have stated in previous essays on This View of Life: We need to forge an unprecedented coalition of corporations, foundations, non-governmental organizations, and governments

that are joined together around the goal of ensuring human wellbeing and organized by the emerging understanding of what human beings need to thrive. By "human wellbeing" I do not mean some loose notion of everyone being "alright." Rather, we can define human wellbeing clearly and precisely in public health terms as the prevalence of psychological, behavioral, and health disorders in a populations and the environmental conditions that are well-established influences on these conditions. In *The Nurture Effect*, I describe the key features of the environments needed to nurture wellbeing and the programs, practices, and policies that can increasingly ensure that people live in such environments.

I don't say much about climate change in the book, but since writing it, I have been studying the ways in which climate change threatens wellbeing. It is clear that the widespread implementation of programs, policies, and practices, that prevention and treatment sciences show can nurture wellbeing, will not be sufficient, if we fail to prevent catastrophic changes in our physical environment. For we will have millions of people fighting over diminishing resources and stressed by catastrophic storms, unlivable heat, and diminishing food supplies.

I haven't figured out how we can build the grand coalition we need. But I invite you to join the Nurture Network so that collectively, we can figure it out and build what is needed.

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John Gowdy. *Making Cultural Evolution Even More Evolutionary: Comment on Waring and Tremblay*

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Waring and Tremblay have articulated the essential role of evolutionary analysis in addressing the many global environmental crises we face. Their contribution is particularly important in that it broadens evolutionary thinking to include non-genetic evolution and concepts like multi-level selection and biased cultural transmission. In this brief comment, I make the case that the evolutionary perspective on policy needs to be broadened even further by learning from cultural evolution in other species and by recognizing that the conflict between what's best for the individual and what's best for the group goes both ways—what's good for the group is not necessarily good for the individual.

Darwin evoked the ire of Victorian society by asserting that humans are subject to the same laws of the natural world as other species. Using several distinct lines of evidence, from molecular genetics to morphology to the fossil record, contemporary biology has established that humans share a common ancestor with all other life forms on the planet. We share 99% of our DNA with our closest relatives, chimpanzees and bonobos. The genetic code of all living organisms, from bacteria to humans, is basically the same. All credible biologists share the view that humans are not a unique physical creation. But when it comes to culture, there is still a widespread belief that humans hold a special place in the universe. My colleague Lisi Krall and I have called this "the false allure of human exceptionalism." It is still common for serious scholars to assert that humans have a "moral psychology" not present in other animals, or that human emotions are unique, or, as most of my fellow economists believe, human ingenuity and technology allows us to ignore the environmental constraints faced by other species. But in fact, other species have cultural traits that are transmitted and modified according to many of the same rules that apply to human societies. Carl Safina has documented some of these in his recent book *Beyond Words—What Animals Think and Feel*. For example, killer whale families form "pods" whose members use a unique set of specific vocalizations not used by other pods.

Several pods are organized into "clans" that use a set of vocalizations unique to that clan. Moreover, clans that occasionally socialize, called "communities," use vocalizations unique to that community. Communities do not socialize with other communities. There is abundant evidence that many species have complex social structures, complex communication structures, and shared cultural values. Yet, we have been reluctant to put these on a par with human institutions. Safina (page 281) writes:

> We're obsessed with filling in the blank of a Mad Libs line that goes: "____ makes us human." Why? Scratch and sniff the "what makes us human" obsession and you get a strong whiff of something that could fit into that blank: our insecurity. What we're really saying is "Please tell us a story that distances us from all other life." Why? Because we desperately need to believe we are not just unique—as all species are—but that we are so very special, that we are resplendent, transcendent, translucent, divinely inspired, weightlessly imbued with eternal souls. Anything less induces dread and existential panic.

Social animals, from wolves, to elephants, to killer whales, have evolved a variety of forms of social organization and leadership styles to deal with the same problems humans face—how to make a living, and how to most effectively structure group behavior to insure continuity and cohesion. Culture is not unique to humans and we should expand our universe of examples of cultural evolution.

Theories of group selection evolved from discussions about the evolution of altruism. When natural selection is viewed only from the perspective of an individual's genes, pure altruism seems impossible. Altruism reduces the fitness of an individual, and altruists lose out in the struggle for survival. But the survival of many species depends on the survivability of the group they belong to. If the group doesn't survive, then neither does an individual within that group. So selfish individuals may outcompete altruistic individuals, but groups with more altruists outcompete groups with fewer altruists. One lesson is that what's good for the individual may not be good for the group. The positive social implications of this insight are obvious. It pays to cooperate and be nice to others. This is a major theme in the cultural evolution literature.

But there is also a dark side to the "sacrifice for the good of the group" story. One of the most successful major transition in evolutionary history is the emergence of ultrasociality—mega-societies characterized by a complex division of labor and highly coordinated economic activities. Ultrasocial insects comprise only 2% of insect species yet they comprise over half of total insect biomass.

Likewise, humans comprise most of the earth's vertebrate biomass. But ultrasociality comes at a cost, both for ecosystems and for the individuals within the superorganism. Ultrasocial entities, like bee hives, function as superorganisms and the individuals that compose them are expendable for the good of the group. Humans are not ants or termites, but we can see that human society is well along the path to ultrasociality.

Today, the global market economy can be seen as a kind of ultrasocial superorganism whose goal of economic growth and expansion takes precedence over the well-being of individuals. More and more, the natural world, human individuals, and human institutions are being harnessed to feed the economic growth machine. Waring and Tremblay point to the change in fishing methods in Fiji to illustrate the importance of group-level institutions for sustainability. One side of the story is that group-level institutions worked to ensure sustainable fishing in traditional Fiji society. With the introduction of markets, the social controls imposed by chiefs were eroded, and the incentives for individual fisherman promoted overharvesting. Group-level cooperation gave way to competition among individuals. But another interpretation is that small-group institutions that promoted sustainability gave way to the higher-level needs of the market superorganism. Individual behavior came to be driven not by community needs but the needs of an even higher-level entity—the market economy. Unlike local communities in traditional societies, the sustainability of the global market is not dependent upon the sustainability of any particular ecosystem or species.

The policy implications of human ultrasociality are profound. The most important perhaps is that the invisible hand of the market arises not from bottom-up individual actions but rather from the top-down requirements of the global economy. Insect biologists call this "control without hierarchy." Causation is downward, not upward. The needs of the market override the well-being of individuals. The Market becomes the ultimate information processor and ultimate allocator of human labor and resource allocation. The neoliberal economist and co-founder of the Mont Pelerin Society, Friedrich Hayek, stated this clearly:

> It was men's submission to the impersonal forces of the market that in the past has made possible the growth of civilization… The refusal to yield to forces which he can neither understand nor can recognize as the conscious decisions of an intelligent being is the product of an incomplete and therefore erroneous rationalism. It is incomplete because it fails to comprehend that co-ordination of the multifarious individual efforts in a complex society must take account of facts no individual can completely survey.

Hayek was correct to view the market economy as a complex, continually-evolving product of natural selection. But he failed to see that what is good for the market superorganism is not necessarily good for the individuals that comprise it. "Freedom" should mean more than submitting to the will of the market. Humans did not become "more free" as the constraints imposed by traditional societies were broken. They became more constrained as their well-being and survival depended on the requirements of the market economy. Neoliberalism is the philosophy of an ant colony, not of a desirable human society. The market may be a "natural" evolutionary system, but "natural" does not mean "good" from a human perspective and evolution cannot ahead. We need to recognize that "group beneficial" outcomes are not the same as "superorganism beneficial" outcomes. As Waring and Tremblay argue, sustainable environmental policies do not spontaneously appear without active policy direction. But the conflict between sustainability and the market's insatiable need for growth and resources should be acknowledged.

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Jeremy Brooks. *The Complexity of Social Groups and Sustainable Development*

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It's an exciting time to be involved in the dynamic and relatively new field of sustainability science, and Waring and Tremblay have made a strong case for placing evolutionary approaches at the center of this field. As an environmental social scientist who still considers himself to be fairly new to the world of CMLS, I appreciate Waring and Tremblay's distillation of a complex framework and their

efforts to demonstrate its usefulness as a tool for analyzing global sustainability problems. This article is yet another contribution to early efforts (e.g., Beddoe et al. 2009; Safarzynska et al. 2012; Wilson 2011) to apply cultural evolutionary thinking to important local and global issues.

In my opinion, the authors' most valuable contribution is not necessarily their articulation of what CMLS theory *is* (which was nicely aided by Joe Brewer's commentary) but their illustration of what CMLS *can do* as a tool for understanding sustainable social-ecological system dynamics. Waring and Tremblay's straightforward application of the CMLS framework is an effective step towards demonstrating the utility of cultural evolutionary frameworks for scientists, practitioners, and policy makers who are open to the application of evolutionary thinking but are uncertain about how to use it to inform policy or to design robust empirical studies. However, it is also important to note that we are still in the early stages of developing a more complete and clear understanding of CMLS and providing useful tools for scholars, practitioners, and policy makers at multiple scales of human organization. Waring and Tremblay's short historical analyses are a necessary first step at this stage of the development of the CMLS framework and it is an important step towards making CMLS one of—if not *the*—foundational framework for the emerging applied science of sustainability.

As Waring has noted in personal communications, CMLS is a "data-hungry" framework that involves understanding complex social and ecological interactions that occur over time and across multiple scales of organization. As such, careful thought and resources will need to be devoted to developing empirical studies and modeling approaches (e.g., Safarzynska 2013) that allow for tests of hypotheses derived from this framework. There are, however, challenges to moving towards a forward-looking, predictive science of sustainability that is informed by CMLS. With this commentary, I discuss two such challenges related to the importance of group structure and group dynamics. I finish with one additional insight about sustainable development in Bhutan.

As Waring and Tremblay note, group dynamics are critically important. Group structure is a foundational feature of human social life, which can facilitate cooperation when individuals sort themselves in ways that allow them to share the benefits of cooperative action with likeminded others. We use cultural markers to signal membership in, and distinction from, social groups, and we conform to the norms that are common in a given group. The features associated with group structure ultimately guide our social interactions and, in some ways, shape who we learn from and imitate and how cultural variants are transmitted and change.

But social group dynamics are incredibly complex, particularly in modern societies. We are all members of multiple social groups that exist at multiple

scales of human organization. Our social identity is context dependent and multi-dimensional (Smaldino *forthcoming*), greatly complicating our understanding of how behaviors and norms spread. Which social identity is salient for which behaviors? How does divergence among the norms that are prevalent in the different groups with which we identify affect our behavior and the spread of norms? How do group structures, social signals, behaviors, social norms, physical infrastructure, and economic forces co-evolve and what does this mean for sustainability (Brooks and Wilson 2015)?

Developing robust empirical applications of CMLS theory for sustainability science is daunting in the face of such complexity. Progress in this field will require us to confront this complexity but it is by no means an insurmountable obstacle. This is not a new point and it is one that Waring and Tremblay certainly recognize. I simply want to be explicit about this challenge and I present it as an opportunity for future work. For those who suggest that true progress towards a more sustainable society will require broad cultural change, working with the complexity of social groups and exploring the dynamics and mechanisms of cultural evolution is critical.

A second comment related to group structure and dynamics pertains to the potential dark side of group identity. The Bhutan case presented by Waring and Tremblay illustrates how within-group cooperation can emerge from between-group conflict. External entities (some of which were nation states and some of which were ethnic groups) were perceived to be threats to Bhutan's existence as a sovereign nation. These perceived threats lead to a clear articulation of the need for a shared national identity:

> "Our independence, sovereignty and security will continue to be dependent upon the assertion of our distinctive Bhutanese identity [...] The emergence of Bhutan as a nation state has been dependent upon the articulation of a distinct Bhutanese identity, founded upon our Buddhist beliefs and values, and the promotion of a common language…This identity, manifest in the concept of 'one nation, one people', has engendered in us the will to survive as a nation state as well as the strength to defend it in the face of threats and dangers." (Planning Commission Secretariat 1999a: 8)

However, solidification of this distinct identity came at the expense of certain freedoms for ethnic communities in Southern Bhutan that did not share many of the cultural traits of other Bhutanese groups. Efforts to promote unity and a shared cultural identity included designating a national language (Dzongkha), reemphasizing an ancient set of cultural standards that included a national dress

code and standard forms of etiquette (Rinzin 2006; Ura 2004), and removing Nepali language instruction from Bhutanese schools (Schappi 2005). These reforms lead to ethnic conflict and violence in Southern Bhutan and the subsequent eviction of Nepali immigrants and, allegedly, Bhutanese citizens of Nepali ethnic descent (Hutt 2003; Priesner 1998; Schappi 2005). I raise this point not as a critique of CMLS or of Waring and Tremblay's focus article, but instead to note that emphasizing group identity as a means of generating cooperation can have severe consequences. Indeed, in the original article, Waring et al. (2015:9) note the need to avoid ethnocentric solutions/institutions and suggest that the "…CMLS perspective gives us a means to explain their (ethnocentric institutions) emergence and persistence, and to strategically avoid situations that could lead to their emergence."

A final note on sustainable development in Bhutan is that the challenges Bhutan faces as it attempts to maximize Gross National Happiness (GNH) are not just a result of political change (the transition from monarchy to democracy). Important social and economic changes are also emerging as part of the development process. In past 10-15 years, the pathways for cultural transmission have increased in Bhutan as a result of the growth of tourism, international travel by Bhutanese, and access to television and internet. The Bhutanese are now much more likely to be exposed to different values systems, ideals, and lifestyles that may oppose the ideals promoted by GNH. These ideals include achieving "…a balance between the spiritual and material aspects of life…" and deliberately choosing "…to give preference to happiness and peace, even at the expense of economic growth, which we have regarded not as an end in itself, but as a means to achieve improvements in the well-being and welfare of the people" (Planning Commission Secretariat 1999b: 19).

As the Bhutanese become exposed to consumer culture, the question is whether their social identity as Bhutanese citizens, and the degree to which this identity is linked with the philosophy behind GNH, can persist in the face of consumerism and materialism (Brooks 2013). The adoption of "Western" lifestyles and ideals and the potential erosion of traditional Bhutanese cultural norms and practices may reduce the cultural differences between Bhutan and other nations which could shift the dominant level of selection and reduce the efficacy of GNH as a sustainable development approach.

Conversely, and Waring and Tremblay allude to this, at the same time that individuals may be adopting and modifying "Western" values, lifestyles, and consumption patterns, the ideals of GNH are spreading at the policy-level. Several nations have taken notice of GNH and its emphasis on well-being and sustainable development including the French, British, German, Canadian, and Chinese governments. The Bhutanese government has also worked to place GNH on the

global agenda through international meetings on well-being and a resolution for the United Nations General Assembly (see Brooks 2013).

In short, Waring and Tremblay have provided a very useful primer on the application of CMLS theory to understanding the emergence and persistence of sustainable social-ecological systems. They have taken a first step and the opportunity exists to make substantial progress in applying evolutionary perspectives to the numerous challenges related to sustainability.

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Carl P. Lipo. *Comment on Waring and Tremblay*

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Despite an explosion of Darwinian evolution-based models for explaining patterns of cultural phenomena, evolutionary thinking has made only limited contributions to applied studies of human communities such as those focused on promoting sustainable practices and public policy. A number of hurdles contribute to the relatively nascent status of evolutionary models applied to community action and planning. First, the rejection of nineteenth-century notions of Social Darwinism continues to taint the idea that evolutionary models might be productively used to explain the differential persistence of human behavior and social structures. Second, community planning has traditionally been founded upon common sense notions of causation. Many planning efforts assume that individuals follow a rational decision process and that change comes from the production of compelling information. In this sense, our common sense is consistent with Lamarckian mechanisms of change, and we hold that Darwinian processes are limited to the "natural world." This isolation of humans from nature combined with a commitment to rationality obscures the potential that evolutionary models have for constructing explanations and shaping social outcomes. Third, and importantly, we have relatively few examples that can serve as exemplars for how evolutionary thinking can be employed in public planning, policy, and action.

Despite these challenges, Waring and Tremblay are among a growing group of scholars (e.g., Wilson 2011, Wilson et al. 2014) who argue that evolutionary thinking may hold the key to our ability to not only explain the past but also shape our future. The need for effective tools that can conceptualize and systematically effect social change could not be more immediate, especially in the

domain of sustainability. Among the many long-term societal issues that plague our contemporary world, few are as pressing as the need for establishing sustainable practices in the production and consumption of vital resources such as energy and food. Over the past 150 years, we have witnessed the profound impact of economic growth that has been entirely based on the mining of the natural environment. Over the past 30 years, concern over sustainability has grown tremendously; interest in sustainable practices parallels but also out-paces societal interest in climate change and global warming (Figure 1). As a society, we worry about our future, and most people generally acknowledge that contemporary practices favoring short-term gains over long-term stability cannot persist over the long run. Consequently, a clear challenge exists for establishing a means by which we can shape the behavior of individuals, communities, companies, and governments so that they make choices considering the future health of the environment and the long-term well-being of all stakeholders rather than maximizing immediate pay-offs.

Yet, for the most part, efforts at promoting sustainable practices have not yielded substantial change in the way individuals behave or how communities are structured. Changing behavior at the scale of communities or organizations that have traditionally relied on non-sustainable practices is obviously a grand challenge. Those seeking to promote change must overcome the fact that in many contemporary economic and social contexts, it pays for individuals to act in their own selfish, short-term interests. Thus, many traditional strategies for changing populations, such as advertising, are ineffective. Although advertisers devise effective strategies leading to increases in individual-scale consumption of products in a population, marketing messages that promote anti-consumption have led to only marginal changes in daily practices. Mass marketing of sustainability has led many to accuse current attempts at promoting sustainable systems as simple "greenwashing" activities that have little to do with altering the behaviors of individuals at the scale of a community or organization (e.g., Laufer 2003). Significantly, we have yet to seriously address the factors that shape patterns of individual behavior, and we have failed to consider how social structures might be employed to encourage behavior favoring sustainable practices over non-sustainable ones, particularly over the long run. Instead, we rely on the assumption that arguments based on logic, data, or moral stances will spur populations to do the "right thing." At the same time, we hope that technological changes such as improvements in the efficiency of alternative energy sources will make the problem of non-sustainability simply go away. Wishful thinking, indeed.

It is in this context that Waring and Tremblay's article An Evolutionary Approach to Sustainability Science brings timely attention to the idea that

evolutionary thinking is directly applicable for studying contemporary communities and can make major contributions to an understanding of the conditions needed to form and sustain communities over the long run. Waring and Tremblay lay out a simple argument about the applicability of evolutionary principles for explaining cultural phenomena and then suggest that sustainability is fundamentally an evolutionary issue. In their model, sustainability is linked intrinsically to group-beneficial behaviors of individuals because these favor the persistence of cooperating communities. Central to their evolutionary model is the notion of *scale*; they recognize that sustainability comes from the aggregate and integrative patterns at the scale of groups that, in turn, contribute to the success of individuals at a lower scale. Individuals trade off gains that could be made for themselves for the benefits that come with group membership. Thus, they argue that the keys to sustainability are mechanisms that favor (or deter) cooperation among individuals within nested groups at greater scales. Sustainable communities, presumably, are those in which individuals behave to conserve resources, an altruistic action that requires one to trust that no one else will selfishly use the resources. Thus, group cooperation is central to sustainability and works when everyone benefits indirectly from their participation in aggregates at greater scales.

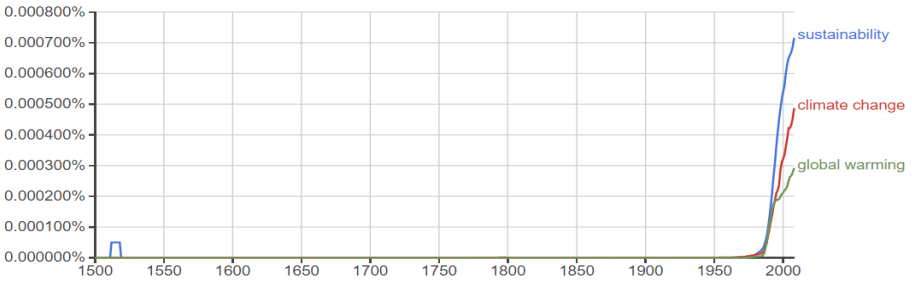

Figure 1. Comparative popularity in the terms "Sustainability," "Climate Change," and "Global Warming" in books published from 1960 to the 2015 from the Google Books N-Gram database (Michel et al. 2010).

Waring and Tremblay's approach makes explicit use of multi-level selection, though they phrase this discussion as "group selection." Individuals cooperate in such a way to benefit group members, and membership in the group confers benefits to all individuals. In a number of ways, their use of "group" language weakens their argument, and they might be better off using the more abstract "multi-level selection." Here is why: any particular group of individuals may or

may not be an inherently meaningful unit of analysis. From an intuitive perspective, we certainly perceive that we live in "groups" and act as if groups are clear, measureable phenomena. As examples of group-scale phenomena, Waring and Tremblay mention units such as "society," "organization," "governments," "parties," "chiefdoms," and "corporations." As anthropologists have long noted, however, the boundaries of any group depend on the question asked rather and are not intrinsic properties. Thus, we cannot simply treat groups as a given in the analysis. They must be groups *for the purposes of the analysis.*

In part, I think confusion over "empirically-assumed groups" versus "analytically-produced groups" has led to some of the criticism of group selection as a mechanism of change (e.g., West et al. 2007). Waring and Tremblay take an approach that furthers some of this confusion by arguing that group-selection is simply differential success of groups because "when groups compete, cooperative and coordinated groups win." This statement treats group selection as a simple analogy to the natural selection of biological entities. But although we can easily conceive of differential persistence of skin-bounded, organism-scale entities via birth and deaths, it is difficult to envision groups having such clear beginnings and endings. As aggregates, human groups shift, merge, reform, grow, and contract in a continuous fashion subject to ever-changing aggregate membership that is not at all analogous to the binary forms that living/dead organisms take.

The amorphous nature of groups does not imply that natural selection is inappropriate for explaining changes at scales beyond the organism. Cultural units are not empirically-bounded physical units at the levels of inheritance traits, individuals and aggregate phenomena. In the case of cultural variability, the units we use for describing and measuring change matter. In evolutionary analyses, groups must be defined in terms of aggregates that meaningfully interact and replicate at lower scales. Groups, then, are empirical entities identified though units representing a shift in classification level. Here, it is useful to distinguish scale from level. Scale represents the set of things that share physical inclusiveness. Level, on the other hand, is a conceptual property that consists of the set of units at the same definitional inclusiveness (Dunnell 1971). Level is a property of analysis. Although a group will always be an aggregate of things, a group of things may not meet the definition of the unit at any particular level of analysis.

This distinction suggests that the use of "multilevel selection" is preferable over "group selection" because it reinforces the idea that levels must be defined in the context of analysis, not assumed. The issue is more than just semantics. Perhaps the greatest challenge to those committed to an evolutionary approach to cultural phenomena and human behavior is to establish the units of measurement. As Lewontin (1974:9) pointed out: "we cannot go out and describe

the world in any old way we please and then sit back and demand that an explanatory and predictive theory be built on that description." In the case of cultural phenomena, we cannot simply assume the units of biology are the same for cultural and social entities at the individual and aggregate scale. Significantly, the problem gets more complicated the more inclusive the unit of analysis.

Waring and Tremblay (also Waring et al. 2015), illustrate their overall argument using fairly commonsense-framed examples of groups: Fijian fish harvesters, the Bhutanese government, United States municipalities and agencies. In general, these examples illustrate the potential that multi-level selection models might play in explaining why group-beneficial properties can persist despite conditions that tend to oppose these actions. What is not clear, at this point, is whether any of the groups identified in the examples are sufficient and necessary to the analysis. The next step must be to analytically determine the levels at which natural selection can be said to act based on the measurable heritable variation with performance differences—the essentials for any evolutionary unit to have meaning.

In their short article, of course, the examples are simply pointers to more comprehensive analyses that remain to be accomplished. Lacking a clear linkage between theory and the measurement units, however, their examples make the approach appear to be more of a heuristic than an evolutionary analysis. This is unfortunate: cultural evolution is more than a simple analogy to biological evolution, and although both share a theoretical framework, the tools and units involved in each have to be formulated independently. Lacking these components, it is difficult to say whether the multi-level approach, despite its satisfying embeddedness in evolutionary theory, is inherently better than alternative or traditional models, such as multi-scale systems or political economy theory. For some, the relatively limited depth to the analysis will make it difficult to imagine we are doing more than preaching to the converted. If the approach is going to go beyond the notion that politics operate at different scales, we must begin to build units and models for exploring and measuring the empirical expectations of changes in the structure of interaction at different scales.

Waring and Tremblay emphasize that group-beneficial behavior is generally linked to sustainability, though this need not be the case. For natural selection to operate, there must be a performance consequence to overconsumption of resources for entities at any scale. Traditionally, land-based entities, such as communities, states, and nations, have been tied to the resources in the space they inhabit. Thus, environmental impacts affect their performance relative to other competing entities. Multi-national corporate-scale entities, however, are notoriously ignorant of sustainable practices specifically because their overall success relative to competitors is not tied to any particular environment. As we

have seen in recent history, the ability to abandon any source of resources (labor, minerals, fish, oil) for another location anywhere in the world results in the selection for entities that can most efficiently extract resources, regardless of long-term consequences. Sustainability for entities of this scale is tied to group-beneficial traits that make extraction more efficient and/or thorough: obviously not the kind of "sustainability" meant by most. A big challenge facing the contemporary world is establishing an environment that selects for corporate entities that exhibit socially and environmentally-beneficial behavior at the scale of the planet. Solving this problem will go a long way towards achieving a sustainable future.

Another point that warrants some consideration is the relationship between contemporary populations and their degree of "adaptedness" to their current environment. Waring and Tremblay propose that humans are "well-adapted" to their environments due to the effects of natural selection and the cumulative nature of cultural inheritance. Natural selection, of course, simply favors variants that are sufficiently better (i.e., "good enough") in performance relative to the alternatives present at any point in time (Jacob 1977). The challenge for evolutionary researchers is to learn the detailed history of the local environment and to identify the competing variants that led to any particular outcome. We should not assume that any particular outcome provides an ideal model about best practices that can be successfully emulated elsewhere. In the case of shaping populations to favor group-scale attributes, we must seek to identify the conditions in any particular environment in which group-beneficial interaction confers sufficient advantages to individuals relative to those not participating. Given the nature of technological and environmental change, these advantages must constantly be adjusted to compensate for continually-innovating variants.

These comments are not intended to unduly criticize the work represented here: although there are certainly challenges in the way we measure and analyze cultural phenomena, the potential of an evolutionary approach to tackling the issue of sustainability is undeniably exciting. Waring and Tremblay have identified an area of investigation that presents not only a good case for multi-level selection applied to culture but also highlights some of the efforts needed to build a fully-formulated sustainability science. Despite the challenges, I have no doubt that the evolution-based studies represented here will result in significant contributions that may be vital to our future.

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Karolina Safarzynska. *Commentary on Waring and Tremblay*

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The Waring and Tremblay essay argues that cultural group selection offers a framework suitable for studying changes in socio-ecological systems as well as an evolutionary approach to sustainability science. Waring and Tremblay apply the framework to explain changes in harvesting in Fiji, national environmental policies in Bhutan, and littering in the U.S. They show that cultural group selection can explain past events while allowing for generalized lessons for the future.

The essay constitutes one of the very few attempts that try to operationalize the cultural group selection framework by applying it to analyze empirical cases. The authors do a great job in disentangling forces operating at multiple levels in an attempt to identify the level at which interventions have the highest chance of breaking unsustainable patterns of behaviors.

I want to make a few remarks that occurred to me during reading the essay: (1) cultural group selection does not offer *the* theory of sustainability; (2) evolutionary theories offer different frameworks that are useful for studying sustainability problem; (3) cultural group selection is one such framework that is particularly suitable for studying changes in institutions and environmental policies.

There is no encompassing framework for sustainability science, and, I would argue, there is no need for one. Cultural group selection is one of many evolutionary frameworks that can provide insights to sustainability. It is now recognized that transitions to an environmentally sustainable economy is urgently needed. Key sectors where sustainability transitions are called for include transportation, energy, agriculture, water, fishery, and tourism. The need for such transitions derives from the persistence of structural problems in these sectors related to resource scarcity, oil dependency, and environmental problems—notably climate change. Some of these problems are clearly related to overcoming social dilemmas and inducing others to cooperate (e.g., restraining resource use), where individual behaviour is a source of externalities detrimental to the group.

However, many of the core sustainability problems today relate to oil dependency; solving these entails, or even requires, escaping lock-in of dominant technologies, introducing major technical innovations, and changing prevailing social practices and structures. Sustainability transitions require fundamental system changes at the different (interlinked) levels. Helpful in conceptualizing these processes is the approach called Multi Level Perspective (MLP), which defines a socio-technical regime as consisting of three levels: niches, regimes and landscapes, nested into each other in a hierarchy (Geels, 2002). Niches constitute protected space, where radical novelties (e.g., technological innovations, new social practices) emerge and have the opportunity to learn, develop, and gain a critical mass of adopters (Schot and Geels, 2007). At the regime level, societal groups, professionals, shared cognitive routines in an engineering community, and established industry practices create stable configurations along which technological trajectories unfold (Schot and Geels, 2007). Finally, landscape encompasses those features of the system that cannot be changed directly at the will of the actors, for instance, the material infrastructure, political culture, and social values. In this context, transitions can take different pathways of change, and many empirical studies have been conducted to identify recurring patterns and generalize lesson using the MLP. It has been shown that many of past transitions have occurred as a result of simultaneous processes taking place at multiple, intertwined levels (Geels, 2002). Therefore, in empirical studies it has not always been possible to identify a single or dominant level of selection.

In Safarzynska et al. (2012), we argue that evolutionary theories provide analytical frameworks that can offer insights to sustainability policies, and which can make existing theories of sustainability transitions more precise and complete. For instance, a co-evolutionary approach has been recognized as a key framework for studying changes in complex socio-ecological systems, institutions and behaviors, production and consumption patterns, and sustainability transitions (Kallis and Noogard, 2011). Along these lines, formal models of demand-supply coevolution have shown how consumer preferences change in the process of technological change and may lock-in the economy to environmentally unsustainable technologies. In this context, much attention has been devoted in evolutionary models to examine the mechanisms through which increasing returns may lock-in the system depending on the type of technological competition, phase of diffusion processes, strength of the network effect, etc. It has been suggested that un-locking policies are likely to be most effective in the early stages of system development. Empirical studies of the New Keynesian framework—another evolutionary framework that has been applied to study sustainability policies—have identified potential paths of changes in socio-technical systems that preserve diversity of options so as to avoid an early suboptimal lock-in. Finally, cultural group selection offers a useful framework to study changes in environmental policies in particular suitable to study power struggles over environmental policies (van den Bergh and Gowdy, 2009; Safarzynska and van den Bergh, 2010).

Waring and Tremblay's examples illustrate the usefulness of framing problems of environmental policies in terms of a multi-level selection. They are among first ones to derive concrete lessons from empirical studies using cultural group selection. Yet, the framework has not been applied to study wider changes in values and beliefs so far. To achieve sustainability, we need to understand how technologies, values and beliefs change together as an integrated system. The biggest challenge ahead lies in integrating insights from various evolutionary frameworks to have a more holistic view on changes needed to achieve sustainability.

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Vicken Hillis[1] and Bill Burnside.[2] *On the Needed Evolution of Sustainability Science*

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Waring and Tremblay lay a foundation for applying an evolutionary approach to sustainability science, focusing on cultural multilevel selection. The authors clearly explain the compelling logic: that if selection at the group level is stronger than selection at the individual level, then individually-costly, group-beneficial behaviors can evolve. We agree that evolutionary thinking has substantial potential to inform both sustainability science and effective environmental governance. Here we provide a caveat, confirm the importance of several points the authors raise, and close by questioning whether a multilevel selection approach can inform policy makers working on large-scale environmental dilemmas like climate change.

First, we agree that sustainability science lacks a unifying theory and typically neglects culture. This is partly historical, as much of the original impetus in sustainability research derives from natural scientists working on the limits to growth (e.g. Malthus 1798, Meadows 1972) and humanity's overuse of resources on planetary scales (e.g. Vitousek *et al*. 1986). More recent strains of sustainability science, such as Elinor Ostrom's work on common-pool resource governance (e.g. Ostrom 2014), do include aspects of endogenous cultural change, sometimes in an evolutionary framework, but also linked firmly to "external" drivers. Overall, however, we concur that most efforts to consider culture in sustainability science are fragmented, partial, and inchoate.

We worry, however, that the authors' focus on culture will appear to swing the pendulum to the other side. Economic forces reflect ecological flows of energy and materials, as they have throughout human evolutionary history, from barter among traditional foragers with different resource endowments to the characteristic coupling of energy use and economic growth among modern industrial nations (Brown et al. 2011). Waring's parable of changes in the Fijian fish-based system, in which market forces changed the likely dominant level of cultural selection from the chiefdom to the individual, supports this link. What we need, then, is neither better models of culture nor better models of the environment, but rather better integration of the state of the art in both fields. Genuinely coupled models with endogenous social and environmental dynamics promise to improve our understanding of these systems, guide the collection of new data and the use of existing data, and ultimately to inform policy making around environmental governance.

We second Waring and Tremblay's well-placed caution not to conclude that group selection necessarily promotes good environmental outcomes and societal well-being. Corporations, for example, are often under strong selection to maximize resource extraction. Military units are group selected to maximize destructive efficiency. Whether or not higher-level selection leads to environmental conservation thus depends on the details of a given case, as Waring and Tremblay illustrate in their examples. This caveat, then, underscores the importance of understanding both the general logic of evolution and the particulars of the specific case in question.

Cultural multi-level selection theory holds two key promises: 1) of bridging social and environmental systems in a consistent fashion using tested principles, and 2) of bridging scales, something many efforts fail to do. Consider the dangerous conundrum of migration to coastal cities amid rising sea levels and intensifying storms. Taken separately, the coastal climate system and social system seem at complete odds. But selection on behavior to maximize income, and associated consumption, favors urban living because earnings typically increase, on average, upon moving to an urban center. Pressures at larger scales, such as poorly conceived disaster relief, often compound the problem. A CMLS approach would suggest asking what forces are acting at different socio-environmental scales and how strongly. The promise of cultural evolutionary theory, generally, is to provide an inclusive framework tailor-made for crossing scales of socio-environmental patterns and processes, which historically have been difficult both to understand and to influence.

The greatest challenges are applying this framework to global-scale environmental issues and using it to inform specific policies. In the absence of planetary-scale competition, what higher-level competitive force can motivate

cooperation among countries around the world on issues like climate change? Adopting an evolutionary perspective doesn't imply that we have to (re)evolve cooperation from scratch in any particular instance. Our evolutionary history has already equipped us with a strong tendency towards conditional cooperation. This is evident from a large and growing body of behavioral experiments and observational case studies in the field. Put a group of individuals in a cooperative dilemma under the right conditions, and they very may well come together to form a well-functioning collective managing environmental resources sustainably. But global-scale interactions are different in a number of ways than the relatively small-scale (village or tribal) institutions studied by Ostrom (1990). To what extent Ostrom's design principles can be scaled up effectively to the global level remains an open question, but one that we desperately need to continue to address, as some scholars have begun to do (Dietz et al. 2003; Wilson and Hessen 2014).

We recently heard from an academic colleague back from a meeting of policy makers around the governance of the California Delta, a region struggling to manage the conflicting demands of water supply and ecosystem protection. Our colleague had been greeted at the meeting as "the guy with the answers," despite the fact that he had warned them in advance that he had more questions than answers. Our own experience supports the notion that policy makers don't want more questions; they want answers—clear and effective, delivered quickly. In today's world, where the challenges seem ever more pressing, who can blame them? Unfortunately, evolutionary thinking isn't a panacea to be waved like a magic wand over any and all issues, instantly resolving them. It does, however, provide a time-tested perspective that can inform any policy maker's decision-making.

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Adrian Bell. *Scratching the Surface of a Larger, Long-term Evolutionary Analysis*

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I recall reading a poster hung in the community hall of a small village in the South Pacific. On the poster were listed "development goals" sponsored by an external agency, one which suggested that locals should change and not value large numbers of children anymore. I was floored at the audacity of the foreign organization suggesting the Pacific Islanders change the way they viewed families, especially since family and the extent of kin relations are paramount to local social identity and notions of self-worth. *Who are they* to demand such things?

Well-meaning advocates may be tempted to do exactly the above—demand through various means for others to change norms, opinions, and preferences to be more in line with sustainable practices. These demands, at least in small-island states, fail in large part because of my immediate reaction—that *they* (the proposers) are not local or do not have a good reputation in local society, nor are they part of significant cultural interactions. That is, *who are they* (and *who are we*) to propose and expect coordination to happen?

Waring and Tremblay claim that CMLS theory can help explain and address this human side of the socio-ecological equation. They can make this claim because CMLS derives from modern cultural evolutionary theories that make explicit the transmission of information (or culture) of which much of human behavior is based (Boyd & Richerson, 1985; Cavalli-Sforza & Feldman, 1981). I believe they are on the right track, yet there is much empirical work to be done for their approach to become validated. Waring and Tremblay have scratched the

surface of a larger, long-term empirical agenda. To illustrate, I would like to highlight the particular issue of identity formation, which Waring and Tremblay explicitly mention.

Understanding the dynamics of identity formation is important because they present a solution and a challenge. By identifying with an ethnic, business, or other type of group, an individual adheres to group norms and expectations. As part of these group norms and expectations, sustainable practices may be a central characteristic or "core" of a cultural group, or may be a secondary trait riding on the group's success or growth. The issue then becomes how we promote sustainable practices to be a part of the relevant religious or secular groups. Figuring this out represents a solution.

The challenge, however, is noting that identity and thus group membership is dynamic. In small-scale groups, we see that ethnolinguistic membership may be flexible (Moya & Scelza, 2015), and so it is with modern groups of religious, political, and secular types. The crux of their analysis of the Bhutan, Fiji, and U.S. littering cases revolves around the strength of groups to solve cooperation problems. In essence, strong groups promoting cooperation are good for sustainability, weak groups yielding to individual-level competition are bad. So how do you get individuals to identify with strong groups who push the sustainability agendas? The anthropological problem hence becomes explaining and predicting the conditions by which individuals shift identities. Further, under what conditions are new identities created that may support institutions promoting a sustainability agenda? Much has been written about identity formation, yet strong empirical tests of evolutionary hypotheses are few. These are the types of empirical agendas CMLS theorists should promote.

A specific obstacle in much of the developing world is that the sustainability agenda is challenged by modern patterns of migration. Developing countries experience significant amounts of out-migration to urban centers or other nations (Castles & Miller, 2003). In the very areas where strong leadership and local connections to ecological contexts are needed, high emigration rates are stretching the effectiveness of the often ephemeral leadership of relevant groups. While a resulting remittance economy often results in development back "home," a culture of migration also shifts individual concern far beyond the local ecological context.

These "micro" types of concerns are eventually what Waring and Tremblay claim CMLS will address because current theories do "not consider or include endogenous cultural dynamics." Ambitious empirical vision is needed to validate CMLS in this way, including an agenda that tackles the many dimensions of cultural multi-level selection at both the scale of large institutions and the scale of individual-level patterns of identity formation and group membership. Heeding

such cultural dynamics would likely make working with small-scale ethnic groups more effective, at least softening the reactionary push-back from minority ethnic groups who view their culture as a ruler by which their behaviors are judged.

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Timothy M. Waring and Ethan Tremblay. *Response to commentaries on "An Evolutionary Approach to Sustainability Science"*

Our target article recapitulated and summarized "A multilevel evolutionary framework for sustainability analysis" by Waring et al. (2015). We argued that challenges of social and environmental sustainability may be usefully approached with an evolutionary understanding of human behavior, institutions, and culture. After considering the summary and the original article, our peer commentators have offered a number of useful critiques and provocative reflections on the idea of using cultural evolution to study social-ecological sustainability.

The comments were overwhelmingly positive and constructive. All commentators offered useful suggestions about how to improve upon the proposed research agenda, and none found it untenable or unneeded. Virtually every commentator discussed the need for improved methodology, better integration with empirical data, more nuanced understanding of relevant factors, and an appreciation of the pitfalls of application, interventions, and policy. We interpret this thread in a positive light. There are many unanswered questions about the most appropriate and useful way to apply evolutionary thinking to the field of sustainability, and there are complications to doing so effectively, consistently, and ethically. Our commentators appear to agree, however, that

despite these complications the central concepts and intent break new ground for sustainability science. Taken as a whole, these critiques are a call for better and broader use of an evolutionary approach in general, and for cultural multilevel selection (CMLS) in particular. Here we highlight some important and recurring themes in these commentaries.

Placing Cultural Multilevel Selection

Several commentaries (**Wilson, Brewer, Lipo, Safarzynska, Bell**) seek to place the CMLS framework in relation to disciplinary approaches and alternative methods for applying evolutionary theory to sustainability. **Wilson** discusses the promise evolutionary thinking holds for advancing sustainability science, which he characterizes as "strong on ecological dynamics and complex systems thinking but light on cultural dynamics and evolutionary thinking." He claims that most sustainability scientists don't appreciate that genetic evolution happens at ecological time scales, which implies that ecological parameters shouldn't be assumed to be constant. He similarly notes that a sophisticated understanding of evolution is critical for understanding mismatches between rapid environmental change and adaptations that take place more slowly.

Safarzynska makes the point that the CMLS framework is but one way to apply evolutionary theories to behavior, institutions, and environmental policies. Safarzynska herself is a leader in this realm (Safarzynska 2013; Safarzynska et al. 2012). While we agree with her suggestion that there is no need for a unifying theory, we do hope that evolutionary thinking will contribute to the ongoing process of intellectual unification underway in sustainability science (Bettencourt & Kaur 2011). The complementarities between an evolutionary approach and other approaches are numerous. Taking this critique further, nothing is truly new about the CMLS framework, so much as the restating and reframing of well known patterns and dynamics in a new way. However, the response to this reframing from the sustainability community has been dramatic and telling. We believe that the evolutionary framing can help to expose important areas of human social dynamics to more causal thinking. For example, we see large complementarities between the evolutionary approach we describe for social dilemmas and strategic niche management (SNM) (Kemp et al. 1998; Schot & Geels 2008), as well as Norgaard's coevolutionary model of society-nature interaction (Kallis & Norgaard 2010; Norgaard 1984), **Brewer**'s culture design approach and many others. We cannot hope to explicitly identify every logical connection to prior work, but recommend the original (Waring et al. 2015) for connections to more related literature.

Lipo wonders whether the CMLS approach we outline is inherently better than traditional theories such as political economy. To the contrary, we see the

value of our young framework in its complementarity and possibilities for collaboration with well-established theories and disciplinary approaches. Political economy is one of those approaches with which a very pleasant combination might be effected. One aspect that does make the CMLS framework uniquely useful in the world of sustainability science, however, is that it includes a general mechanism of social causation. For instance, although our commentators did not address it directly, the original article makes an explicit, causal and testable hypothesis about the evolution of sustainable practices. The hypothesis suggests that when the strength of selection on groups for resource conservation outweighs the strength of selection on individuals for greater consumption, conservation practices can emerge even when individually costly. We feel this hypothesis is of very high value in a field where testable hypotheses are scant, and generalization is dearly sought (Levin & Clark 2010).

Our original article emphasized that selection on individual behavior or the balance of selection pressures impinging from multiple organizational levels may influence institutional practices. While this is globally true, there is no reason to assume it is globally useful. Multilevel dynamics are but one issue to consider in using evolutionary tools to understand social-ecological systems change — and of course evolutionary tools themselves do not apply to all sustainability relevant phenomena. Indeed, CMLS is not of use in every situation because human groups do not always matter or even exist (as **Lipo** emphasizes). Still, we suggest that CMLS will remain a very useful tool for two reasons. First, many of the hardest sustainability challenges are intransigent social dilemmas over environmental use. Second, humanity appears well adapted to group life, with adaptations that serve collective functions and that facilitate solving common challenges. If these are true, then the CMLS framework will be a useful tool in the sustainability toolbox.

Warnings

Three commentators raised warnings about the theory and its application. **Bell** opens with an anecdote illustrating how unethical certain cultural sustainability interventions can be when foreign powers seek to change local reproductive norms to achieve sustainable population goals. It is fair to go further and say directly that the idea of governments influencing social norms (or "designing culture" as **Brewer** suggests) to achieve social goals is one that strikes a chord of unease amongst many political observers concerned with the overreach of the state. We acknowledge this issue, and believe there is no substitute for ethical science and humane policy, both of which, to borrow from Justice Potter Stewart, are hard to define but easy to recognize.

Gowdy points out that human ultrasociality, the ability to cooperate with huge

numbers of genetically unrelated individuals, can cause conditions in which the good of the group may not be good for some or most individuals in the group. He applies this idea to the global market economy, arguing that—like ultrasocial insects—the global economy places higher priority on economic growth than individual wellbeing. We agree. The same can be said for warfare (Turchin et al. 2013).

Wilson says he is skeptical that "usually bad ideas don't catch on." In retrospect, we see that phrasing was unhelpful. Environmentally bad ideas often catch on, he says, and cultural evolutionary theory can help explain why. As **Lipo** describes, strong selection for profit-generating practices that emerge through competition among private corporations has caused many of the environmental side effects (externalities) we are scrambling to solve today. We agree with **Lipo** that "establishing an environment that selects for corporate entities that exhibit socially and environmentally-beneficial behavior … will go a long way towards achieving a sustainable future."

Methodology

A number of commentators focus on the need for empirical application and raise issues concerning methodology that have yet to be addressed. For instance, **Brooks** reminds us that CMLS is data hungry, a fact that poses a challenge for empirical testing and application, and that group structure is complex and incompletely described in evolutionary terms. **Lipo** raises the difficulty of defining groups as a unit of analysis. He cautions against assuming some type of group or level of social organization is operant in any particular context and encourages researchers to carefully define groups of relevance for the purpose of analysis. This is excellent advice; human groups are often very fluid over short time spans. Of course the point of the CMLS framework is to provide scholars with tools for considering which 'groups' are more relevant, if any. So, ideally the groups could be identified directly from the data (as can sometimes be done in social network analysis), or groups should be included based on other empirical signals of their relevance to the phenomenon in question. The Ecology and Society article devotes some space to considerations of the methodological challenge of determining the relevant groups, but many unanswered questions remain. The larger point is for sustainability researchers to take groups, the units that compose them, and the interaction between the two more seriously.

Hillis and Burnside suggest that what sustainability science currently needs is better integration of culture and environment, rather than more emphasis on either. Of course the CMLS framework is designed to endogenize an important and understudied portion of both social dynamics. The two authors suggest that promise of CMLS is in both bridging environmental and social systems and scales,

the latter of which is something many other approaches lack.

Next Frontiers

Excitingly, many commenters (**Brewer, Eirdosh, Biglan, Gowdy, Bell**) utilize a portion of their commentary to apply the CMLS sustainability framework to a particular dilemma. For example, **Brooks** notes that the Bhutanese national identity example is far from complete, and includes some unfortunate ethnocentric divisions and conflict. However, **Brooks** also questions whether the GNH project in Bhutan can withstand the expansion of consumerism that comes with that country's development—a prediction rendered using CMLS. **Biglan** also uses the framework to describe the asymmetry between well-organized fossil fuel interests and less effective environmental groups. He traces the emergence of conservative organizations tied to fossil fuel interests using multi-level selection, compares it to the 20th century tobacco industry, and then discusses selection among corporate practices in general. Furthermore, **Bell** hints at the possibility of an evolutionary analysis of human migration as it relates to environmental outcomes. We think that the intuitive ease with which the framework can be applied is one of its best features, and we look forward to more applications with greater depth.

Interestingly, **Eirdosh** argues that the CMLS framework can be gainfully applied not only to natural resource dilemmas but also to project management. Using his experience as a part of a 50-member NGO research team in Madagascar, he explores how concepts such as the dominant levels of selection can help understand and better manage groups.

The most ambitious challenge was one offered by **Wilson**, who suggested constructing a cultural evolution research and application machine that accounts for our genetically evolved psychological mechanisms—a project upon which we have not yet embarked.

Conclusion

We are grateful for a wide range of commentaries, and have found each to be useful in the ways they select from the threads we have tried to lay down. The strongest shared sentiment among them is a sense that there is something new and valuable to the idea that evolutionary theories and models can truly help the quest for environmental sustainability.

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