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Information, networks, and the complexity of trust in commons governance

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Abstract: The publication of Elinor Ostrom's (1990) *Governing the Commons* fueled significant theoretical and empirical progress in the field of commons governance and collective action, most notably in the form of the Institutional Analysis and Development (IAD) framework. A central question within this literature is how trust is created, maintained, and potentially destroyed in the context of sustainability issues. While the commons literature has provided a deeper understanding of trust, most empirical work has been done in relatively simple settings that do not capture the complexity of many global, institutionally-complex dilemmas that we face today. This paper discusses how our understanding of trust in these more complex settings may be improved by considering how two broad categories of variables – belief systems and networks – influence trust.

Keywords: Advocacy coalition framework (ACF), belief systems, common pool resources, homophily, information, institutional analysis and development (IAD), networks, reputation, risk, sustainability, transitivity, trust

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I. Introduction: the importance of trust and the challenge of complexity

How can individuals learn to successfully manage common pool resources? Since the publication of *Governing the Commons*, the Institutional Analysis and Development (IAD) framework has addressed this issue. Merely posing this question was at odds with the prevalent assumption underlying the “tragedy of the commons,” elucidated most famously in Hardin’s (1968) paper: resources managed as commons are inevitably degraded and the only options to avoid degradation are either government control or privatization. In contrast, early empirical work in the IAD tradition demonstrated that individual decision makers can, under some circumstances, learn to successfully manage common pool resources and avert the tragedy assumed by Hardin (Ostrom 1990, 1998; Ostrom et al. 1994). As a theoretical framework, IAD has continued to provide us with a more nuanced understanding of the types of institutions – conceptualized as combinations of various types of rules – that are more likely or less likely to support cooperative behavior in the face of CPR dilemmas, conditional on contextual factors such as the resource system, the resource units, the governance system, and the users (Ostrom 2009).

Trust is a central theoretical variable within this tradition (Ostrom 1998), and thus it is no surprise that a great deal of research has focused on how trust amongst individuals is created, destroyed, and evolves over time. The most common approach to trust derives from Coleman (1990; see also Sztompka 1999). In this view trust is manifest as a behavior in which an individual puts herself at risk of an outcome dependent upon the actions of others. This is not the only form of trust that is relevant to sustainability challenges, but it is the one that has been most extensively examined in the literature on decision making. We label this *trust in actions* to differentiate this form of trust from another type of trust considered below. It is trust in actions that has been invoked to explain decision making at least since Arrow (1974) and to which Poteete et al. (2010:226–227) are referring when they discuss the “centrality of trust.”

Trust is an important determinant of sustainability outcomes because it influences strategic interaction between actors whose individual incentives are not necessarily in alignment with that of the collective (Olson 1965). Trust is crucial to collective action since cooperative behavior – acting outside of one’s narrow self-interest in order to advance the interests of the group – carries the risk that others will not cooperate, leaving cooperators paying all the costs of cooperation without receiving commensurate benefits. Thus, in order to make the prediction that an actor will behave cooperatively, one must also assume that they have some degree of trust that the others involved in their decision-making situation will also cooperate. Such situations are frequently analyzed using frames such as the Prisoner’s Dilemma (Nash 1950; Rasmusen 2001), the tragedy of the commons (Hardin 1968), or any of a variety of games where pure self-interest mixed with an inability to trust others leads to less than optimum outcomes. Such metaphors are

useful but not sufficient for understanding many wrenching conflicts surrounding the commons, ranging from local and regional planning efforts (Schneider et al. 2003; Feiock and Scholz 2010) to global environmental change (Ostrom et al. 2002; Dietz et al. 2003). Before offering the required extensions to our understanding of trust, it will be useful to briefly review the state of our current understanding. Note that our review remains focused on ideas about trust that are close to those used in the commons literature. Especially since trust is often viewed as a central feature of social capital, the idea of trust has been deployed in many literatures that we do not cover here, including literatures that consider trust as a society-wide or culture-wide phenomenon (e.g. Fukuyama 1995; Keele 2007; Rothstein and Stolle 2008).

Despite a great deal of theoretical development over the last several decades, the empirical settings in which trust has been studied have not fully kept pace with the growing complexity of many commons governance issues. In particular, IAD scholars have generally studied trust within relatively small and isolated institutional settings (Hahn et al. 2006; Ruttan 2006), controlled experimental settings (Ostrom et al. 1994; Ostrom and Walker 2003), or some combination of the two (Bouma et al. 2008; Vollan 2008). In contrast, many of the actual issues to which we wish to generalize our findings are global and institutionally complex, involving many hundreds or thousands of actors interacting over substantial geographic distances and across many different institutional settings (Sabatier 1999).

Efforts to understand these more complex commons are emerging (e.g. Young 2002). In particular, Ostrom's (2010 a,b) emphasis on polycentric governance systems for addressing global environmental change demonstrates the importance of the evolving linkages between actors and institutions – especially in situations where these actors were previously isolated or embedded in strict hierarchical relationships. Such polycentric systems, following the definition of Vincent Ostrom et al. (1961:831), are characterized by “many centers of decision making which are formally independent of each other.” There are multiple actors, each of whom has some autonomy, and who may or may not collaborate. In this essay, we argue that a more comprehensive theory of trust is needed to successfully apply IAD to these settings. Such a theory must build on research in less complex contexts, but must also give attention to the added effects of evolving networks and information-sharing amongst those making decisions relevant to sustainability and global environmental change.

International engagement with the problem of climate change serves as a useful example of such large-scale commons governance problems being addressed by a polycentric system (Ostrom 2010 a,b). If we view the system at a high level of aggregation to facilitate using it as an example, the actors include nation states, non-governmental environmental and development advocacy organizations, major corporations and the associations that represent them, scientific assessment bodies (and especially the Intergovernmental Panel on Climate Change, or IPCC)

as well as a diversity of formal international organizations. Of course, each of these aggregate actors has its own internal policy system composed of individual and organizational actors, and so this is clearly a multi-tiered system. Nor are the elements neatly nested – a scientist working for a government research unit may also be a lead on a chapter in the reports of the IPCC. So the system includes actors of very different characters, ranging from the most powerful states on the planet to small NGOs, each of which is ultimately comprised of individuals. Some actors are embedded neatly within others (e.g., a state or provincial government that may choose to take action on greenhouse gas emissions or a national research center embedded in a national government), while other actors are either autonomous (other nation states) or have complex governance linkages often through intermediary organization (e.g., the linkage between nation-states and the IPCC Working Groups via the United Nations and the IPCC Secretariat). In the discussion that follows, we use international actions on climate change to illustrate the issues that are highlighted when we move from more local to more global commons governance problems.

The purpose of our discussion is to 1) identify the limits to concepts of trust that were developed in the robust literature on local to regional commons, 2) to expand on the solid base of the existing literature by distinguishing between trust in information and trust in actions, and 3) show the importance of network effect on the evolution of trust, especially in larger-scale commons management systems. We assert that a more nuanced and complex approach to trust will be needed that is faithful to the existing literature while expanding on it. We offer some hypotheses in that direction.

1.1. Two limitations in our understanding of trust

The IAD framework has been an important platform for research on trust. As with all theoretical frameworks, however, there has been an inherent tension between the need to simplify a complex landscape, and to include sufficient detail to ensure explanatory power for real-world processes (Sabatier 1999). While IAD has made substantial empirical contributions in spite of this tension, we argue that two issues deserve attention in generalizing IAD's findings regarding trust to more complex governance settings. Moreover, each of these issues suggest the need to focus on new variables that are traditionally under-emphasized in the literature on trust:

Limitation #1: Most research on trust concerns trust in actions, whereas many sustainability challenges also involve trust in information.

Trust is a highly context-specific phenomenon, and depends in particular upon the object of trust. As noted above, most empirical studies focus on trust in actions, or trust objects that are concrete actions taken by another actor – examples include abiding by a resource extraction quota or supporting a particular government program. At the same time, most issues of sustainability involve large amounts of uncertain scientific information, and trust in this information is an important motivator for

the policy learning and change (Sabatier and Jenkins-Smith 1993, 1999; Mitchell et al. 2006; Henry 2009). We argue that *trust in information* is conceptually distinct from trust in actions, and understanding this type of trust requires that we consider how environmental cognitions (such as beliefs and values) influence trust and decision making in sustainability challenges. While Ostrom (2005) has addressed the issue of mental models, cognitive structure has not been a central feature of the approach and has not been central to the empirical work inspired by the IAD framework. This is an area where other theoretical frameworks – such as the Advocacy Coalition Framework (ACF: Sabatier and Jenkins-Smith 1993, 1999) – provide the theoretical tools necessary to model the role of cognitions in the development of trust in information as well as trust in actions that can complement the IAD framework.

We note that these two forms of trust are closely related, and it may be that they represent developmental stages towards a generalized trust of one another – one believes that another actor can be trusted both to provide accurate information and to act in a way that is predictable. But as we will emphasize as trust is discussed in more detail, the two forms of trust can be distinguished logically and the correlation between the two, as well as the temporal sequencing in their development, are both questions that require empirical evidence to answer. We will consider the relationship between these two forms of trust in more detail below.

Limitation #2: Most of the literature on trust has focused on institutionally simple or controlled experimental settings where one can assume that trust can be built on personal relationships or behaviors that are directly observed.

Issues of sustainability often involve large numbers of actors who seldom (if ever) interact face-to-face, and therefore are often unable to directly observe the actions of other actors in the system. This suggests the need to understand how trust is generated and maintained outside of repeated direct interactions that characterize more local commons, and leads us to a consideration of trust and networks. While some scholars have noted the importance of social and policy networks for understanding commons governance, and have developed both theory and empirical evidence about the effects of network structure (Sandström and Carlsson 2008; Bodin and Crona 2009; Booher and Innes 2010; Butler and Goldstein 2010; Sandström and Rova 2010), the relationship between network evolution and trust is in need of greater theoretical development.

Before developing these ideas more fully, we turn to a brief review of the current literature on trust, with a particular emphasis on what we have learned since Ostrom (1990) about the role of trust in actions in decision making.

1.2. Trust in actions: moving beyond the thin rational actor model

Recent work suggests that trust in actions is influenced by at least four factors, three of which are preferences or values that are relatively stable in an individual over time, and one of which is a belief that can readily be influenced, at least

in principle, by observation of others (Fehr 2009). First, and obviously, an individual's willingness to take trusting actions with uncertain outcome depends in part on their overall willingness to take risks. Second, most people also seem to have a strong aversion to being betrayed when trust is extended (Fehr 2009 provides a recent review). Third, when the action taken has the potential for benefiting others, as it does in actions to protect a common pool resource, then altruism (the degree to which an individual takes account of the well-being of others) also matters. Finally, an individual's assessment of the probability that the relevant others will act in a trustworthy fashion rather than betraying the trust plays a role in deciding whether or not to engage in an act of trust. This unpacking of the factors that underline trusting behavior is helpful in clarifying the dynamics of trust, especially in the complex situations that characterize many commons governance issues.

Three of these individual characteristics – risk aversion/acceptance, loss/betrayal aversion, and altruism – probably change slowly. Indeed, there is some evidence that performance in the trust game frequently used to study trust dynamics is influenced by genetically heritable factors (Cesarini et al. 2008). While we do not view them as immutable, it does seem likely that these three factors are relatively constant for an individual compared to the fourth factor that influences trusting behavior – assessments of the likely behavior of others. Thus, for example, Fehr (2009) classifies altruism, risk aversion and betrayal aversion as preferences while he considers assessments of the trustworthiness of others as a belief that can be modified quite readily by evidence. It still may be true that individuals differ substantially in their propensity to trust – but in this framework that propensity can be thought of as the influence of evidence about the behavior of others. In a sense, this propensity is a sort of weight given to a Bayesian prior about the probability of betrayal compared to the weight given observed evidence. Some people may have strong priors about how trustworthy others are and will adjust that view in a particular situation only with substantial evidence, while others may give little weight to their priors and rely almost exclusively on context-specific evidence. So trust may vary because of variance in both priors about behaviors, and in the weight given to observations; each of those factors may vary across individuals and, within an individual, across interactions and contexts.

While individuals may have different predispositions to trust or not to trust others, most theory assumes that trust is quite context-specific. When trust is defined as a generalized prediction about the behavior of others, it follows that the degree of trust depends on the object of trust. Some individuals or organizations are trusted and some are not. Much of the experimental literature on commons and on Prisoner's Dilemma is about how the structure of interactions can influence trust, and IAD also notes the importance of knowledge of others – it is, for example, one of the key elements in the micro-institutional context described by Poteete et al. (2010). So while individuals may have predispositions to be trusting or suspicious in the abstract, and many have varying degrees of altruism, risk aversion, and

betrayal aversion in experiments and in most commons management contexts, this disposition is instantiated in assessments of particular individuals, groups or organizations that in turn may be modified based on direct observation of their behavior.

2. Trust in information

We now consider a different set of objects in which trust is potentially created or destroyed: scientific (factual) information used to inform policy choices. We begin with the observation that information is an important motivator for decision making within commons governance systems, and trust in information is at least as important as trust in actions in supporting successful governance. We also argue that trust in information is related to trust in actions but these concepts are best decoupled into distinct concepts, which in turn allows for greater flexibility in theoretical development and modeling. This brings us to a consideration of how belief systems may influence trust in information and, by proxy, may influence trust in actions as well. In doing so we draw on the ACF literature (Sabatier and Jenkins-Smith 1993, 1999), which has developed what amounts to a theory of trust in information rather independently from the literature on trust in actions that we have just reviewed. Our argument is that both forms of trust are critical for commons management, and the dynamics of the two, especially in governing large-scale commons such as the global climate, may be sufficiently different to warrant careful attention.

2.1. The importance of trust in information

Information is an important commodity in most sustainability debates and especially in commons governance. As noted above, the literature on trust has focused primarily on actions, one classic example being an actor's actual commitment to agreed-upon quotas for commons harvesting. Less attention has been paid to the determinants of trust in the information that informs these actions – for example, an actor's trust in the science that led to the established quota, or the perceived need for a quota in the first place. Many sustainability issues are mired in conflicts over scientific information that informs the presence (or absence) of a problem, the likely causes and severity of problems, and appropriate solutions (Lackey 2006). This information must be obtained and processed by an actor to formulate strategies for action, and so trust or mistrust in this information is also an important driver of conflict and consensus in commons governance arenas (Sabatier and Jenkins-Smith 1993, 1999). In this type of decision-making landscape, trust in information can be at least as important as trust in actions.

Since we are dealing with rather abstract concepts, a few definitions are useful to support further theoretical development and modeling. In particular, let us focus our attention on three objects: 1) a focal actor, named *Ego*, who is in the position of making a determination of trust in a particular piece of information or the

actions of another individual; 2) a second actor, named *Alter*, in whom Ego makes a decision to trust or not trust; 3) a particular bit of policy-relevant *information*, communicated by the Alter to Ego, that is meant to inform Ego's decision or otherwise influence Ego's beliefs. Actors are also referred to as "agents," and may be individual people or aggregated policy actors, such as organizations or governments. The simplest example would be to consider individuals who are part of a group that makes use of and mutually governs a commons, such as two fishers, two harvesters of forest resources, or two nations engaged in addressing the problem of climate change.¹

Consider an example. As a policy actor, the United Nations (Ego) receives information from a variety of sources to inform appropriate responses to climate change. One of these sources is the IPCC (Alter), which offers numerous bits of information including, for example, the likely impacts of climate change. While the United Nations in the aggregate may have some degree of trust towards the IPCC, this trust is distinct from the trust that is generated in the bits of information flowing from specific reports. Thus, we must consider Ego's trust in the persuading agent separately from Ego's trust in the information received from Alter, for example, the estimates of likely temperature increases, the contribution of various nations to these increases, and recommended responses to these threats.

Scale is of tremendous importance in the evolution of trust. At smaller scales, such as in the management of a localized resource, both the state of the resource and the actions of others may be relatively easy to observe directly. But when one moves to a larger scale, and particularly to global commons such as the climate, neither the actions of others nor the state of the system are easily observable by most actors. Thus, the ability to assess the trustworthiness of others and the ability to assess the state of the resource depend much more critically on network ties rather than direct information. Some of the debate about climate change pivots around whether or not the community of climate scientists that collect and integrate the data on climate change and the IPCC (which assimilates and interprets that data for the international community) are trustworthy. Most participants in the international discussions about policy to limit greenhouse gas emissions are not in a position to directly evaluate the data and the assessment, although they may call on actors they do trust to advise them. For example, the U.S. Congress recently asked the U.S. National Academy of Sciences to assess the science of climate change (U.S. National Research Council 2010).

2.2. Relationship between trust in information and trust in actions

Trust in information amounts to trust in the beliefs offered by others. In many cases, actors must acquire information not from primary sources (e.g. the scientific literature, formal policy analyses, or detailed analyses of the likely actions of

¹ We note that the actions of nations are shaped by multiple actors within nations, and that nations are not the only actors in the global policy system. We simplify for ease of exposition.

other actors) but from other members of the action arena. With many individuals and organizations potentially providing information, and given the risks inherent in adopting misinformation, an actor has to assess how much to trust each source. While this trust may be correlated with trust about actions, it is distinct from it. One may trust how another may act, but feel that actor is not well informed. Conversely, one may consider a particular individual's statement of fact to be accurate, even if their actions are not trusted. For example, you may know that another fisher violates mutually agreed upon quotas, but still trust the information she provides about the actions of others. Or you may feel she adheres strictly to the quotas but is either too trusting or too cynical in reporting the behavior of others. But generally the two will be related. While the size of the correlation between trust in actions and trust in information will vary across contexts and even across individuals assessing their trust in others, we suspect the correlation will nearly always be positive and often quite strong. In most circumstances it will be much easier to observe the information an actor provides than to observe the actions they take. This yields a testable proposition:

H_1 : *Trust in information is proportional to trust in Alter's actions.*

We conjecture that in contexts where actions are hard to observe, as they are in many policy networks, trust in information may serve as a proxy for trust in actions. In localized commons, the link between trust in actions and trust in information may be very strong and the distinction we are making here of minor consequence. But for polycentric systems engaging many different kinds of actors working at different scales, and for regional and especially global commons, we believe the distinction becomes much more important and the degree to which trust in actions and trust in information are correlated must be assessed with context specific empirical examination. For example, it is at the national and global scales that arrangements emerge that are specifically intended to provide trustworthy information – prominent examples include the Millennium Ecosystem Assessment, the IPCC, and the U.S. National Research Council.

2.3. The role of belief systems

A key problem with social learning around sustainability is that individuals are subject to a confirmatory bias in the way they interpret information; that is, people tend to believe information that supports their prior beliefs and mistrust information that disconfirms what they already believe to be true. This phenomenon has been labeled “biased assimilation” (Innes 1978; Lord et al. 1979; Munro and Ditto 1997; Munro et al. 2002), and is an important motivator for considering the role that individuals' belief and value systems play in motivating political behavior and conflicts over policy-relevant information (Sabatier and Jenkins-Smith 1993, 1999).

The interaction of biased assimilation with differences in the trust an actor ascribes to various other members of a policy system may lead to complex

dynamics that in many cases will be antithetical to social learning for sustainability and adaptive management. For example, the scientific norm that underpins most discussions of adaptive management is that new information should be assessed based almost entirely on the quality of the evidence. But in most policy systems, the methodological quality of emerging information is hard for most actors to assess. As a result, they are likely to evaluate new information based on how congruent this information is with prior beliefs, and to form decisions about trust accordingly. It is plausible that such dynamics will be chaotic in the sense that small difference in the initial distribution of even weakly held beliefs could lead to widely divergent outcomes.

The intersection of biased assimilation and differential trust could easily lead to substantial differences in beliefs across groups of actors and make those differences become hard to resolve even in the face of strong empirical evidence. This seems to be the case for U.S. public opinion on climate change, where views of conservatives and liberals have become increasingly divergent over time even as the scientific consensus has converged (McCright and Dunlap 2011). Recent calls for adaptive co-management of ecosystems are in part based on the need to build trust in emerging information across multiple types of decision makers (Armitage et al. 2007, 2009) and thus can be seen as a response to the need to build trust in information in the face of bias and differential trust. Similar approaches are being proposed for climate change (U.S. National Research Council 2011).

To summarize these arguments in a testable hypothesis, we argue that trust in a particular piece of information is positively related to the degree with which the information confirms an actor's priors:

H₂: Trust in information is proportional to the degree to which information is congruent with Ego's prior beliefs.

This proposition is not new to the policy literature. The ACF has long argued that biased assimilation causes policy actors to filter evidence through their existing beliefs, and in particular those beliefs labeled the "policy core" that relate to actors' understandings of system-wide problems, as well as the causes, severity, and likely solutions to perceived problems (Sabatier and Jenkins-Smith 1999). These arguments help to explain why supposedly objective analyses are so often misused or altogether neglected in the policy process. While these theoretical arguments originate from a look at the relationship between Ego and a particular bit of information, the logic may be extended to infer that two actors with conflicting systems of beliefs will also tend to mistrust one another. This is because they are likely to ascribe different meanings to the same piece of information (Leach and Sabatier 2005), and therefore come to doubt one another's good intentions in what Sabatier et al. (1987) label the "devil shift" phenomenon. Thus, trust in information is not merely a function of the degree to which the information confirms Ego's beliefs, but is also a function of the degree to which Alter's beliefs conform to Ego's beliefs – if they hold widely divergent viewpoints, then Ego

may doubt Alter's intentions in providing a particular piece of information. If you feel most of the members of your community are fairly honest in adhering to quotas, you may discount the report of someone who says otherwise and come to question their motive for doing so.

H₃: Ego's trust in information is proportional to congruence between the beliefs of Ego and Alter.

While these arguments are not new to the policy literature, they have not been much emphasized in the boundedly-rational model of the individual upon which the IAD framework is built. According to this view, actors are not subject to systematic biases in the way they perceive information and, moreover, actors' limited ability to process information implies that they must rely on other sources of information to learn how to deal with complex and uncertain problems. The most effective way to accomplish this is to populate one's network with diverse perspectives and worldviews (Hong and Page 2004), and thus there is no *a priori* motivation for an actor to mistrust information or actors based on divergent viewpoints.

The strength of these differing theoretical perspectives are likely to depend greatly upon the context in which commons dilemmas unfold (Dietz and Henry 2008), and further empirical work is needed in this area. In the meantime, it is useful to explicitly state alternatives to the above hypotheses, under the theory that actors are not subject to systematic cognitive biases:

H_{2a}: Trust in information is independent of the degree to which information is congruent with Ego's prior beliefs.

H_{3a}: Trust in information is independent of the degree to which Ego's beliefs are congruent with Alter's beliefs.

These hypotheses of trust in information collectively lead us to a broad consideration of how beliefs, values, and other cognitions influence trust. Ultimately, a closer examination of cognitive structures are likely to reveal more nuanced insights into the types of trust that influence commons governance as well as the determinants of trust. And of course there are almost certainly cross-cultural differences in these cognitive structures. This is a place where the macro-comparative literature on trust might inform work on trust in commons governance, but we will not explore those possibilities here. We turn now to a second category of variables that have received relatively little attention in the trust literature: the role of social and policy networks.

3. Trust and networks

Much of what we know about trust derives from either controlled lab or field experiments, or case studies within relatively isolated, small communities facing collective action problems. This is perhaps one reason why much of the

literature focuses on the importance of face-to-face communication and repeated interactions in supporting trust; in small settings where most participants may be assumed to know one another and have many opportunities for repeated interaction these are natural factors to emphasize. For many commons governance issues, however, the population we wish to generalize to is far more “messy” in the sense that actors represent a diverse range of interests, drawn from many different institutional contexts and geographic regions. Climate change is a prototypical example.

The importance of trust in settings such as these has become a major theme in the risk literature (Siegrist et al. 2007; Renn 2008:222–230), where it has been found that individual perceptions of environmental and technological risk are strongly influenced by trust in the institutions and organizations that manage risk. For example, in the U.S. one of the strongest predictors of support for, or opposition to, nuclear power is the degree of trust in the nuclear industry and the government agencies that regulate it (Whitfield et al. 2009). In small to moderate scale commons management, direct interaction with others can be commonplace and is central to successful commons management. But most citizens have little direct interactions with organizations charged with managing societal risk. As a result, they must establish their level of trust based on other cues and indirect sources of information such as the media where the troubled dynamics of trust in information comes into play.

This makes trust in abstract groups something that can be manipulated in political and social movement campaigns. A major tactic of those who are opposed to putting a price on greenhouse gas emissions or in other ways reducing them is to raise questions about the trustworthiness of climate science. McCright and Dunlap have labeled this strategy “anti-reflexivity” (2010). It is not new. The same strategy, sometimes deployed by the same organizations and individuals, was used to resist regulation of DDT, smoking, the air emissions that cause acid rain, and ozone depleting substances (Oreskes and Conway 2011).

3.1. The importance of networks

There is an influential group of actors where trust about actions falls somewhere between the very abstract and generalized views of the public about institutions and large organizations, and the experience-based and particularistic views of those actively managing commons – whether in the real world or in an experiment. These are the professionals and activists whose work constitutes policy networks. Members of policy networks certainly have some opportunity to directly observe and learn from the behaviors of others. But many policy networks are sufficiently large and complex that actors will have no direct experience with most other actors. Further, many important policy decisions are made, if not in secret, at least in processes that are not transparent to those not present during the decision-making process. Anyone who has served on a committee or other decision-making body will know that the minutes of a meeting, even if accurate, seldom

capture the nuance of the process that led to a decision. And some actions, such as conversations between lobbyists and legislators, are usually done behind closed doors.

Thus, it would seem that the study of trust in policy networks would follow one of Ostrom's suggestions regarding directions for future research:

"We need to develop an underlying theory of human behavior in diverse settings so that we can begin to predict how individuals who interact in one type of setting will or will not gain trust and reciprocity compared to another type of setting..." (Ostrom 2010 a:19).

We submit that national and global policy networks are one such setting, and one of great importance as they are the arena in which rules for commons governance are often developed. The networks literature provides some insight into how trust may be modeled in more complex action arenas such as policy networks. Within a policy network, trust is potentially built not only as a result of dyadic, interpersonal interactions, but also through the use of heuristics that actors may use to attribute trustworthiness to others based on their network position or shared attributes. Discussion of these heuristic factors emerge primarily from the literature on social and policy networks, but are also compatible with mainstream theoretical perspectives on trust. From these literatures we can develop hypotheses regarding the role of three key network effects on trust: *reputation*, *transitivity*, and *homophily*. We posit that these factors will have a direct and substantial influence on an actor's assessment of the probability that particular others will act in a trustworthy way. They may also, in the longer term, influence an actor's degree of altruism, preferences with regard to risk and betrayal aversion, and priors about the trustworthiness of strangers. But whether or not this is true, it is very likely that networks will be important in shaping beliefs about the trustworthiness of specific other actors in the network.

Much of what we know about the relationship between network structures and trust is tied to the literature on social capital, which emphasizes the mutually-reinforcing "virtuous triad" of trust, social networks, and norms of reciprocity (Coleman 1990; Putnam 2000). While this literature began with a more qualitative treatment of the relationship between networks and trust, more recent research has begun to specify more concrete ways in which social capital is reflected in the structure of actual policy or social networks (Lin 1999; Burt 2000; Henry et al. 2011a). As we move from the policy network of those actively engaged in shaping decisions about policy and regulation to the polity as a whole, we move from trust of the sort we are considering, ultimately grounded in dyadic relationships, to social capital. At that larger scale, for many people trust is not based on direct observation, or even indirect observation via traceable network ties. Trust is rather assigned to institutions, organizations, roles and public figures, and might be thought of as the average value across a very large and only loosely connected network.

3.2. Conceptualizing trust as a network

In thinking about the processes that generate trust within a network, it is useful to introduce the concept of a *trust network*, or a network where individual policy actors are possibly linked via the existence of dyadic trust relations (Josang et al. 2006). Such a network might represent trusting relations about actions or information, and somewhat different structures will be obtained for different forms of trust within a given community. For purposes of explication we will consider only one type of trust, but the approach we outline can be generalized to consider trust in actions and trust in information simultaneously. While the kinds of networks structures and properties that are likely to be important for trust are well known in the network research community, they may be less familiar to the commons research community, so we provide a simple illustration.

Figure 1 displays a hypothetical trust network with three agents labeled A, B and C (these agents may be interchangeably referred to as “vertices” or “nodes”). Trust is represented as the linkages between two agents in a dyad. In the simplest conception of trust (e.g. ignoring different types and intensities of trust, and ignoring the possible differences between a lack of trust and outright mistrust), we may think of each pair of individuals as having two possible direct links. A may or may not trust B, and B may or may not trust A. This is called a “directed dyad” in which each link from an actor to each other actor takes on one of two values: either trust (a link exists) or non-trust (a link does not exist). So in Figure 1 we have that agents A and B trust each other, C trusts B but not A, and neither A nor B trust C.

In thinking of trust as a network of interactions amongst policy participants, it is crucial to recognize that trust networks, like many other types of socially- or politically-relevant relationships, evolve over time – new actors may enter or exit the system, and trust linkages may be dynamically created or destroyed. In other words, trust networks are evolving, stochastic objects. Given this, one useful way to approach the network mechanisms that influence trust is to think in terms of the

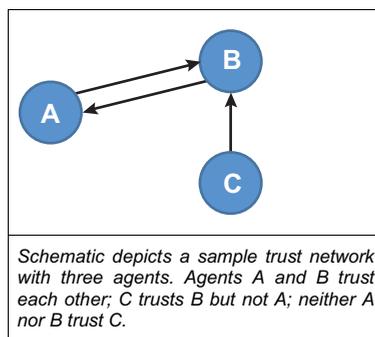


Figure 1: Trust as a network.

conditional formation of linkages. Individual agents make decisions to form or not form a trust linkage with a specific actor, taking the rest of the network structure as given for a point in time. In this paper we illustrate the possible network effects by focusing on Ego's decision to trust Alter (the potential trust linkage is drawn as a dashed line), given the larger network topology, which is fixed from the perspective of Ego and represented by black links. In a fishery, this might be Ego's decision to take seriously Alter's reports about the behavior of others or to accept that Alter is following the quota system rules. In a climate policy network it might be Ego's decision to accept estimates of the economic impacts of a policy developed by Alter, or it might be a decision to believe Alter when they say they will publicly support a compromise measure.

3.3. The role of homophily

One of the major factors that are thought to influence the structure of networks is homophily, or the tendency of network actors to form ties with others who are similar to themselves (McPherson et al. 2001). Homophily may be based on any set of actor attributes, and is often considered to be an important explanation for the types of segregated network structures that are often observed in social and policy networks (Girvan and Newman 2002; Henry 2007, 2011; Henry et al. 2011b).

The commons literature has long recognized the importance of heterogeneity in shaping collective action (Agrawal and Gibson 2001; Poteete et al. 2010: 54–57). It has been noted that differences in interests and values, power, control of resources, and concern with protecting the common resource, and that these differences often align with dimensions of social stratification such as gender, class and ethnicity. Ostrom (2005) notes the importance of alignments of like actors, as does the literature on size or group and commons governance (Yang et al. 2011). Carlsson and Sandström (2008) do note the importance of the tradeoff between diversity and heterogeneity in successful commons governance. However, the idea of homophily deserves more extensive exploration. Trust networks provide one mechanism for integrating homophily into our thinking about commons.

Homophily may be explained in the context of trust networks by the tendency of individuals to believe that similarity in terms of certain easily observed attributes, such as educational background, policy preferences, or institutional affiliation signals similarity in terms of other difficult-to-observe attributes that are critical for the formation of a trust relationship. For example, if an individual is both altruistic (i.e. predisposed to cooperation) and also an environmentalist, then he or she may believe that other environmentalists are also predisposed to cooperation and therefore trustworthy. This may be at least a partial explanation for why political activists tend to trust like-minded activists, and mistrust institutions or individuals with values that they believe to be contrary to their own. Thus similarity on a variety of attributes may lead to an assessment that an individual

can be trusted in the actions they will take, in, for example, forming political coalitions or making compromises.

Homophily may take on two forms with regard to its effect on trust about beliefs: actors may be *more* likely to trust information produced by those who are similar to themselves, or actors may be *less likely* to trust information produced by those who are dissimilar to themselves. These aversion and attraction aspects of homophily may work independently or in tandem. It is useful to note, however, that despite the attention paid to homophily as an attraction mechanism (see McPherson et al. 2001 for a review), it can be shown that one need not assume that actors have a strong preference for trusting, or working with, others who share their underlying attributes in order to produce clustering within a network. This is illustrated perhaps most convincingly in Thomas Schelling's classic model of segregation within societies (Schelling 1969, 1971; see also Henry et al. 2011b for an application to evolving networks), where slight preferences for homophily lead to substantial segregation. We might conjecture that the current polarization in U.S. discussions about climate change is a result of such segregation mechanisms.

We summarize these arguments in the following general proposition:

H_4 : *Ego's trust in Alter is proportional to the similarity between Ego and Alter.*

It is important to note that this hypothesis is meant to make explicit the general phenomenon of homophily, however future empirical work will need to further disaggregate this hypothesis to account for the roles of specific types of attributes in driving trust (or mistrust). For example, if one focuses on belief-system homophily, then H_4 is a subtle restatement of H_3 . But other attributes are also likely to matter. For example, we can extrapolate from the IAD framework that shared organizational or institutional affiliations might be an important driver of homophily, since such similarities are likely the basis for common interests in a policy network, just as common position in the social structure can produce common interests in the larger world. But as noted above, other theoretical traditions (such as the ACF) emphasize the importance of shared belief- or value-systems in the formation of trust relationships. In the case of U.S. climate policy debates, it may be that party or ideological identification has become the basis of strong homophily, or it could be that such homophily is structured based on the dependence of constituents on fossil fuels industries. While affiliation and interests are often correlated with beliefs and values, the degree of correlation will vary across contexts and may not always be very high. As yet, empirical evidence is not adequate to allow us to assess the importance of each factor (organizational affiliation versus beliefs and values) in national or global policy networks. For example Laumann and Knoke (1987), in a study of U.S. national policy systems, assume that organizational affiliation alone shapes networks, while Dietz and Rycroft (1987) working in one of the same policy systems at the same

time conclude that institutional affiliation, values and beliefs, and professional socialization all have influences on network structure.

3.4. The role of transitivity and reputation effects

Reciprocity and transitivity are additional network effects on trust that potentially operate at the level of three or more actors. Reciprocity effects capture the idea that, if one network actor trusts another, then this trust is likely to be returned (or “reciprocated”) later by another actor in the network. This is most commonly thought of in terms of specific reciprocity, where a repeated history of cooperation between pairs of agents builds a mutual reputation for being trustworthy, which in turn supports future cooperative behavior (Ostrom et al. 1994; Fehr and Gächter 2000; Rasmusen 2001). On the other hand, this effect may also be thought of in terms of generalized reciprocity, where this reputation is spread through multiple trusted partners before it is ultimately returned to a given network actor.

Figure 2 illustrates how these effects may relate to the structure and evolution of networks, in terms of Ego’s choice to form a “trust linkage” with Alter, given the conditional structure of the overall trust network (as noted above, we will speak simply of trust or a lack of trust for ease of explication, but network models can incorporate degrees of trust rather than a simple dichotomy). Should Ego choose to trust Alter (dashed links) in any of the cases depicted in Figure 1, then a cycle will be created within the network. These cycles may be short (in the simplest case, they may be a reciprocated trust configuration between Ego and Alter represented by a two-cycle) or long (including any k actors within the network to form a k -cycle). In these cycles, Alter’s trustworthy reputation spreads to actor A_1 , then to actor A_2 , and so on until an actor further down the cycle (Ego in this case) is able to make a judgment about Alter based on the reputation that has propagated throughout the network. Longer cycles are likely to yield smaller reputation effects, so Ego’s propensity to trust Alter on the basis of reciprocity is most likely a decreasing function of cycle length. If the density of cycles is high enough, an individual embedded in the network may have a relatively high level of trust for all others in the network, or at least in their region of it. These arguments may be summarized as follows:

H_5 : *Due to reputation effects, Ego is more likely to trust Alter if that decision creates a cycle in a trust network.*

H_6 : *The probability that Ego will trust Alter due to reputation effects is inversely proportional to the length of the cycle within the trust network that would be created by that decision.*

Transitivity is another important network effect that may work to build trust among groups of actors. Through transitivity, Ego is likely to adopt the trust judgments made by her trusted partners. This phenomenon is commonly known as “the

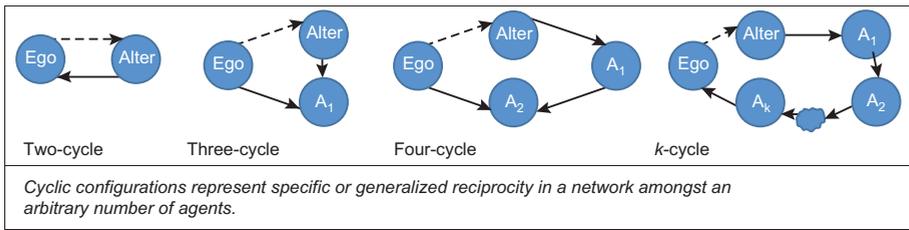


Figure 2: Cyclic configurations of trust.

friend of my friend is my friend,” and in this case implies that, if a particular actor is trustworthy, then whomever they trust must also be trustworthy.

Figure 3 depicts several ways in which transitivity may be reflected in the structure of an evolving network. In the schematics, Ego’s choice to trust Alter is supported by at least one indirect path from Ego to Alter – by following these indirect paths beginning at Ego, we begin to discover the other agents whom Ego is also likely to trust by proxy. The simplest instantiation of transitivity is depicted in the left panel of Figure 3; in this case, Ego may choose to close the indirect path mediated by actor A_1 by forming a direct trust relationship with Alter. Other, more complex network configurations may also serve to strengthen this effect. For example, if Ego shares not just one but multiple indirect paths of trust to Alter (as depicted in the middle panel of Figure 3) then Ego has further social evidence that Alter is trustworthy. In this case, the formation of a trust linkage between Ego and Alter would create what is known as a directed k -triangle (Snijders et al. 2006). It is likely that Ego’s propensity to trust Alter is an increasing function of k , or proportional to the number of indirect paths of trust between Ego and Alter:

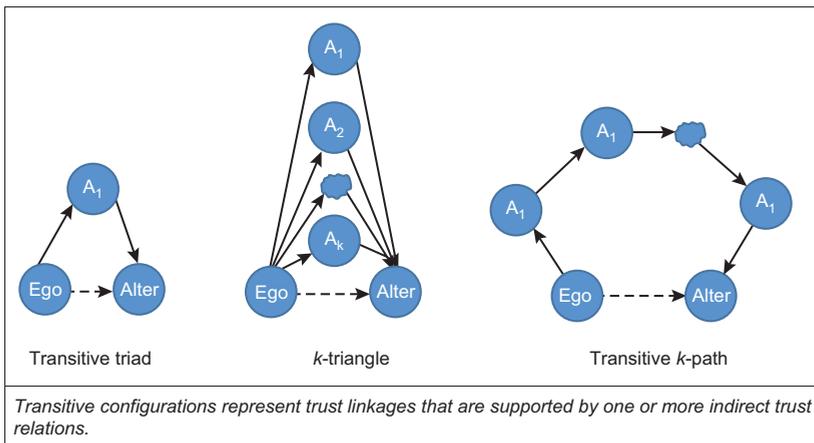


Figure 3: Transitive configurations of trust.

H_7 : *Due to transitivity effects, Ego is more likely to trust Alter if Ego trusts at least one other actor who also trusts Alter.*

H_8 : *The probability that Ego will trust Alter due to transitivity effects is proportional to the number of actors that trust Alter and are trusted by Ego.*

Social evidence that Alter is trustworthy may also come from the existence of a longer path of trust between Ego and Alter, as depicted in the right panel of Figure 3. Through the same logic, transitive effects may lead in this case to Ego's decision to trust Alter, however these effects (as with reputation effects) are likely to be a decreasing function of Ego's "distance" from Alter within the network.

4. Conclusion

In recent work, Ostrom has emphasized the value of polycentric arrangements for governing commons, and especially global commons. The theme of polycentric governance runs back to her earliest work (see Chapter 4 in *Governing the Commons*, based on her 1965 dissertation) as well as early work by Vincent Ostrom (1953 a,b). Polycentric governance is a logical extension of the path opened by *Governing the Commons*. However, polycentric governance will often engage actors whose relationships to one another will be somewhat different than those found in the typical commons management situation. These differences are matters of degree, and certainly have precedent in the literature on more localized commons. But as polycentric governance systems emerge to address global and regional environmental change, and as we begin to address more directly the effects of global teleconnections on even local resource management, we will have to continue down paths that were initiated in Ostrom's opus but not fully explored there.

Here we have focused on two characteristic features of polycentric governance systems – the importance of information and the existence of complex patterns of network connections among actors – and examined their implications for trust. Trust has long been acknowledged as central to commons governance and risk management. But that literature emphasizes trust about actions, while in many policy systems trust in the information that can be obtained from other actors is also vitally important, and perhaps more so in large polycentric systems than in more local commons governance situations. As governance systems embrace adaptive risk management as a way to deal with uncertainty around problems like climate change (U.S. National Research Council 2010), trust becomes even more important.

If we return to the climate change example, much attention has been given to trust in actions within this system, and indeed many would argue that concerns with free-rider problems is the reason that international action on climate change is largely stalled. This, in turn, is related to trust in information – will it be possible to develop accurate assessments of how

others are acting when many critical actions depend on information that must be obtained indirectly? For example, most mechanisms for giving credits for carbon sequestration rely on some mixture of national reporting and third party verification. In both cases, assessing trust will come, in great part, from indirect connections, such as between a nation and third party certifiers or international scientific assessment bodies rather than from direct observations of one nation by another.

The need to learn how to adaptively manage climate change risks as we proceed is widely acknowledged (U.S. National Research Council 2011), and here again both forms of trust matter. If we think of nations as a key set of actors in the social learning process, and viewing policies as social experiments, each nation must trust that others will implement actions mutually agreed upon. When the actions are those of reducing emissions, this is just the critical free-rider problem. But in the case of social learning, some actions may involve adhering to agreements about how to implement actions. This may include, for example, the ways in which carbon prices might be implemented, or the ways in which leakage of emissions across borders via carbon embedded in trade goods are handled. And of course the need for trust in information provided is paramount. Deceptive or even just inaccurate information could actively degrade the global capacity for social learning.

We emphasize the way in which network structures influence the evolution of trust by focusing on three factors (transitivity, reputation and homophily) that have been considered in many past studies of social and policy networks. These concepts can potentially enrich our understanding of the candidate drivers of trust, especially in extra-local or global research settings. In particular, the hypotheses that we propose illustrate how local dynamics of network formation may unfold within larger, more complex networks of trust, and are testable using emerging methodologies for the modeling of observed network structures, such as exponential random graph models (ERGM; see for example Snijders et al. 2006). Future research in this area needs to carefully consider the theoretical significance of network parameters such as k-triangles or k-cycles, and we have offered one set of possible interpretations in the context of evolving trust networks.

Networks can facilitate information sharing and will be critical for the social learning needed to move towards sustainability (Henry 2009). But network processes such as homophily and transitivity can also move actors away from a widely shared understanding of a problem and towards segmented and polarized understandings that retard effective commons management. We acknowledge that we have done little more here than indicate one direction further inquiry might take in exploring these areas. However, we believe progress can be rapid because the foundation laid by *Governing the Commons* and the work it has inspired is sufficiently solid to readily support such extensions and elaborations.

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