From Reactive to Proactive: Creating a Governance System for Negotiating Local and Regional Climate Change Mitigation Interventions

by

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ABSTRACT

Growing concerns over climate change and the lack of a federal climate policy have prompted many sub-national organizations to undertake greenhouse gas (GHG) mitigation actions on their own. However, the interventions associated with these efforts are typically selected in a top-down and *ad hoc* manner, and have not created the desired GHG emissions reductions. Accordingly, new approaches are needed to identify, select, develop, and coordinate effective climate change mitigation interventions in local and regional contexts. This thesis develops a process to create a governance system for negotiating local and regional climate interventions. The process consists of four phases: 1) mapping the overall transition, 2) reconstructing the current intervention selection system, 3) assessing the system against principles identified in the literature, and 4) creating an improved system based on the assessment. This process gives users a detailed understanding of how the overall transition has progressed, how and why interventions are currently selected, what changes are needed to improve the selection system, and how to re-structure the system to create more desirable outcomes. The process results in an improved system that relies on participation, coordination, and accountability to proactively select evidence-based interventions that incorporate the interests of stakeholders and achieve system-level goals. The process was applied to climate change mitigation efforts underway in Sonoma County, California to explore the implications of real-world application, and demonstrate its utility for current climate change mitigation efforts. Note that results and analysis from interviews with Sonoma County climate actors are included as a supplementary file.

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Climate change has emerged as one of the most pressing sustainability challenges of our time. The vast majority of scientific evidence indicates that anthropogenic climate change is occurring, and that we, as a global society, must work to mitigate its causes and effects if we hope to avoid severe consequences (Pachauri & Reisinger, 2007; Carnesale & Chameides, 2011). Furthermore, it is clear, due to the global nature of climate change and the widespread sources of greenhouse gas (GHG) emissions, that governments and other organizations must play a significant role in driving mitigation strategies. Governments have responded with a variety of efforts to combat the causes of climate change, from international agreements like the Kyoto Protocol to municipal programs like energy efficient building codes. In the United States (US), states, counties, municipalities, and private organizations have been at the forefront of climate change action. The US lacks a national-level climate policy, and many predict that due to other political concerns, uncertainty, and partisan divides, this arrangement is likely to persist (Rabe, 2007; Selin & VanDeveer, 2007).

This leaves the responsibility for addressing climate change in the US where it currently rests: at sub-national levels. And many states, counties, and municipalities have heeded the call to create a more sustainable climate system. The most popular course of action has been to inventory GHG emissions and then set reduction targets, with 26 percent of Americans represented under a city-level GHG emissions reduction target in 2007 (Lutsey & Sperling, 2008). At the state level, fully 96 percent were represented under at least a GHG emissions inventory, which amounted to 91 percent of total US GHG emissions (ibid.). Action plans usually accompany emissions targets, along with information

campaigns to increase visibility and support. However, these efforts have produced few actual GHG emissions reductions. Though sub-national organizations understand the need for climate action and have demonstrated the will to plan and develop mitigation programs, their actions are not producing the desired results. I hypothesize that the difficulty in reducing GHG emissions at local and regional levels thus far is in part due to the lack of effective governance systems for selecting interventions that move the system toward a sustainable state. If organizations lack the ability to select and coordinate effective interventions, i.e. actions intended to change the system, then no amount of planning will produced the desired outcomes. This research presents a process for creating a new type of governance system for negotiating local- and regional-level climate change mitigation interventions to help organizations achieve their goals.

The process is embedded in a sustainability transition framework (Wiek, 2010) and relies on a systematic, goal-oriented approach to identify and select effective interventions. It aims to address some of the shortcomings of traditional top-down climate change planning by incorporating new governance approaches that have emerged for engaging sustainability problems. For instance, many climate efforts create an action plan, but then reactively select interventions in an *ad hoc* manner when opportunities arise. Intervention (Fraser, Richman, Galinsky, & Day, 2009) and evaluation (Rossi, Lipsey, & Freeman, 2004) research take a different approach by creating a system-level action plan based on high-leverage intervention points, and then proactively seek interventions to affect them. However, intervention and evaluation research have traditionally been applied to problems in e.g. public health and social work, and not

specifically to sustainability challenges like climate change. Therefore, including sustainability planning research (Robért et al., 2002; Wiek, 2010), which provides guiding sustainability principles and an overall focus on achieving a sustainable system state, orients the process toward sustainability. Finally, many sustainability planning frameworks do not include a detailed processes for developing effective governance systems. However, fields like institutional analysis (Ostrom, 2005) have identified principles and configurations that can lead to successful, sustainable governance of resource systems in local and regional settings. Thus, combing institutional analysis, sustainability, and intervention and evaluation research can help fill gaps in current climate intervention selection systems in ways that increases both awareness *and* results. Though the process presented here is directed at climate mitigation interventions, it is a general approach focused on overall sustainability, and could therefore be adapted to create effective intervention selection systems for a variety of sustainability issues.

In addition to identifying and selecting effective interventions, the process will also allow users to compile evidence. The science of climate change (Solomon et al., 2007), as well as many sources of GHG emissions (Metz, Davidson, Bosch, Dave, & Myers, 2007), are well understood. However, far less evidence exists concerning the external validity, or effectiveness, of the policy and programs employed to address climate challenges (Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009). This lack is emphasized by significant evidence in other problem-driven fields like health care, social work, and psychology, which rely on evidence as a basis for practice (Fraser et al., 2009). The lack of evidence on climate interventions is likely due in part to the fact that climate problems are in

the “real world”, which makes testing and gathering data under controlled conditions difficult. However, efforts to collect rigorous evidence on *in situ* problems, such as institutional research using the Institutional Analysis and Design (Ostrom, 2005) and Social-Ecological Systems frameworks (Ostrom 2007, 2009, 2011) , and poverty research by the MIT Poverty Action Lab have been successful. An evidence base about what works and what does not in climate interventions will aide stakeholders in negotiating interventions to best suit their setting, needs, and resources.

Finally, the process presented here encourages collective learning and action. Participation and collaboration is widely regarded as a requirement for successfully engaging complex sustainability problems (Clark & Dickson, 2003; Kasemir, Jäger, Jaeger, & Gardern, 2003), and efforts to include stakeholder participation in sustainability research has been successful. However, as Talwar, Wiek, and Robinson (2011) point out, fully integrating participation in sustainability research has proven difficult, and the proper level of participation can also prove elusive (Bäckstrand; 2004). Furthermore Siebenhüner (2004) found that participation and the mechanisms that encourage it are often not maintained after sustainability research projects are completed. However, considering that a transition to sustainability requires shifts in several long term trends (Kates & Parris, 2003), and that climate change and other sustainability issues require collective learning and action (Ostrom, 2010) for change, it is vital that participation and collaboration are established as new governance norms, and not one-time events in research. Additionally, various stakeholder groups with different interests and positions of power will affect and be effected by interventions. Therefore, they should be included in intervention selection, and

participate in an effective negotiation process for creating consensus on the suite of actions that both move the system toward the desired state and meet current and future needs (van den Hove, 2006). By including participation and collaboration in activities that are *already* happening, i.e. climate change planning at local and regional levels, I believe the process presented here can significantly and durably increase the level of collective action in climate governance systems that choose to adopt it.

The main research question this thesis seeks to answer is: What is an effective governance system for negotiating local and regional climate change mitigation interventions? I chose to explore this question by contextualizing it within a climate change mitigation effort and answering the following three research sub-questions: 1) how do climate organizations currently select interventions; 2) how do these selection systems compare when assessed against the literature; and 3) how can these systems be improved? I addressed these questions by developing a process for understanding, assessing, and creating an improved governance system for negotiating interventions.

A governance system, as defined here, is a coordinated system of organizations and institutions with shared goals and agreed processes for achieving them (Rhodes, 1996; Heirlmeir, 2002). Governance systems traditionally do not rely on formal authority or police powers to enforce decisions, and instead use rules, norms, and trust and reciprocity to motivate action (Rosenau, 1992; Ostrom, 2005). A governance system for negotiating sustainability interventions, such as those directed toward mitigating climate change, is thus focused on creating cooperation around transitioning complex social-ecological systems (SESs) to more sustainable states. The process

presented here uses participatory structures that allow different stakeholders to negotiate the transition goals, determine which areas of the system need attention, and select interventions that serve their collective interests. It also relies on high levels of coordination, participation, and frequent monitoring and adaptation to drive the system transition.

The process builds off Wiek's (2010; Wiek, Withycombe, & Redman, 2011; Figure 1) transformative sustainability framework, which helps users plan and carry out sustainability transitions in complex SES. The framework first creates an understanding of the system by reconstructing the historical and current state; then builds a desired state based on sustainability that users wish to transition toward; assesses alternative non-intervention scenarios; and uses backcasting to create transition strategies to achieve the desired state. The process for creating an effective intervention negotiation system is situated in the transition strategy stage, and specifically focuses on how individual interventions are selected to fulfill the transition strategy given current system conditions.

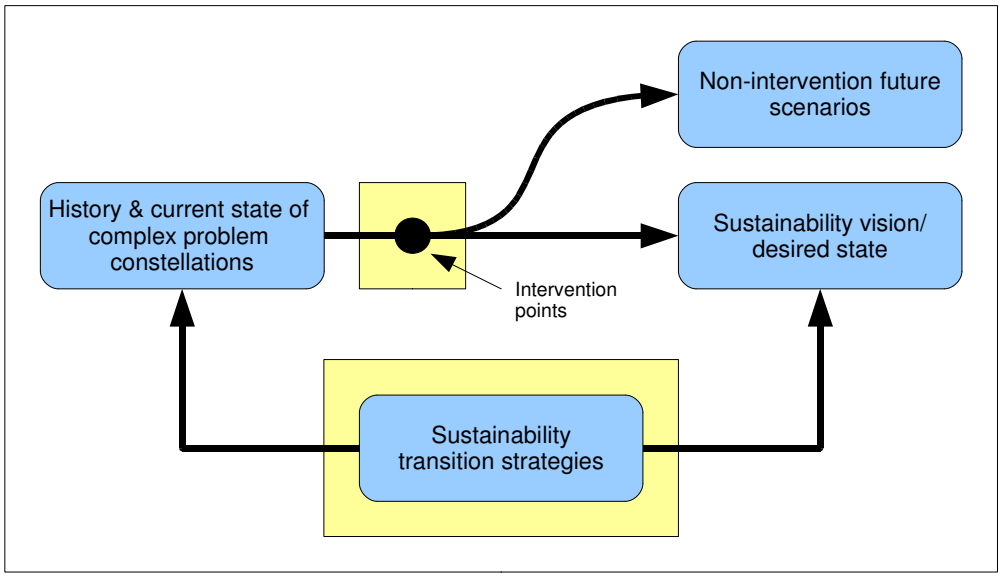

Figure 1. The transformative sustainability planning framework. The areas this study focuses on are highlighted. Adapted from Wiek (2010).

A significant body of work exists on visioning (Uyesugi & Shipley, 2005), scenario analysis (Loukopoulos & Sholz, 2004; Wiek et al., 2006), and backcasting methods (Robinson, 2003; Quist & Vergragt, 2006; Robinson, Burch, Talwar, O'Shea, & Walsh, 2011). However, less work has focused on methods to select interventions over time to fulfill the transition strategy. This is likely due to the context- and scale-specific nature of sustainable development, where the challenges and solutions are formed by a variety of environmental, cultural, political, economic, and social factors. However, by not providing tools to help create intervention strategies, we perpetuate the science-policy divide often cited as a major factor in slow or insufficient action on environmental challenges. After all, it is interventions that will eventually create sustainable outcomes, but if they are selected in an unsystematic or *ad hoc* manner, or are not aligned with overall system sustainability, they may never create system-level change (Robért et al., 2002). Other research in fields such as social work (Fraser et al., 2009) healthcare (Glasgow, McKay, Piette, & Reynolds, 2001), and public health (Kelly, 2005) provide means for selecting interventions that can be adapted for use in sustainability transitions. By combining these approaches with the sustainability transitions planning and governance principles from institutional analysis, I provided organizations with a tool to proactively select actions to fulfill their climate change and other sustainability goals.

The above lines of research provided the foundation for addressing the research questions and developing a process for improving intervention systems, but before further exploration, the research required further justification. I accomplished by investigating three questions:

1) Are local and regional contexts a worthwhile level for climate change mitigation interventions?
2) What type of governance systems are currently used to drive mitigation efforts, and what are their outcomes? and
3) What elements are required for sustainable governance of complex social-ecological systems (SESs)?

The next sections address these questions in order to assess the need for an improved system for selecting climate change interventions.

The effectiveness of local and regional mitigation.

Some argue that climate change mitigation is a global governance issue and thus must occur at international or national levels (Stavins, 1997), or that ground-up efforts, while useful for bringing early attention and action, do not create the necessary institutional leverage to affect large-scale change (Victor, House, & Joy, 2005). Others believe that local and regional GHG emissions reductions are too small to have significant impacts, and are of limited use (Wiener, 2007). Still others cite a several reasons that decentralized regulation for climate change could be ineffective in the US (Adler, 2005; Engel, 2006; Lutsey & Sperling,2008). For example, if regions lack a common set of regulations, they have less incentive to act since they may not get credit for their investment. Furthermore, the targets of regulation could simply move to another area where rules are more lax. Finally, enforcing many different regulations in different areas could prove difficult and resource intensive. As the arguments below will demonstrate, these lines of reasoning contain valid points, but are not sufficient to indicate that local or regional actions to mitigate climate change in the US are misguided or unable to produce significant emissions reductions.

Over the past decades an international approach has been the preferred strategy for attempting to govern action for climate change. World leaders have gathered at several well-publicized global conferences to try and create a consensus on the problem, its causes, and solution strategies for engaging climate change as a collective society. While these events have markedly increased visibility and awareness, they have produced few additional results. The most well known international outcome is likely the Kyoto Protocol, ratified in 1997 by members of the UN (excluding the US, and since denounced by Canada), which established target reduction levels for countries through 2012. The targets have no enforcement mechanism, and minimal progress has been made toward achieving them. Other conferences, such as recent UN summits in Copenhagen, Cancun, and South Africa have produced little in the way of augmenting the Kyoto Protocol or creating binding agreements, and at best resulted in unenforceable commitments or tenuous statements about what members should do in the future. From these examples it is obvious that the current methods for creating global action around climate change are ineffective for creating large-scale emissions reductions, and do not move at the speed necessary to curb combat climate change. Furthermore, postponing actions now while waiting for a global consensus on the levels that GHG emissions should be reduced to only serves to waste opportunities to address the problem (Ostrom, 2011). If effective action is to occur, it will have to include more nimble levels of governance.

Second, local and regional interventions could be highly effective in creating a sustainable climate system. Many US states have GHG emissions levels that outstrip developing and developed countries elsewhere in the world (Selin & VanDeveer, 2007), and direct household energy use accounted for 38 percent of

total US carbon dioxide emissions in 2005 (EIA, 2008; Garner & Stern, 2009), which equates to approximately 8 percent of global emissions (Dietz et al., 2009). These large GHG emission rates indicate the opportunity for significant and worthwhile reductions. Several studies have identified and prioritized a variety of individual and household solutions, many that are low-cost and easily accessible, which could curb household energy use by 20 percent or more over a decade or less (Vandenbergy, Barkenbus, & Gilligan, 2008; Garner & Stern, 2009; Dietz et al., 2009). Others have shown that policies and technologies that are currently available, if fully adopted, could be used to fulfill many local and state GHG emissions targets (Lutsey & Sperling, 2008; Kockelman, Thompson, & Whitehead-Frei, 2011). Additionally, Pacala and Socolow (2004) point out several currently available technologies that could be implemented over the next 50 years, primarily in local and regional contexts, to stabilize world-wide GHG emissions at less than double per-industrial levels, providing time for more revolutionary mitigation technologies to develop.

As a counter-point to the perspective that regional climate efforts are too limited in scale and scope to cohesively impact global climate challenges, Engel (2006) points out several reasons for states and other sub-national organizations to coordinate for climate mitigation. First, and most obvious, the larger the area under regulation, the more potential for GHG reductions. Second, as both Engel (ibid.) and Lutsey and Sperling (2008) state, a more uniform approach to climate action can increase the chances of compliance (participants are not forced to short though a patchwork of policies) and potentially ease political resistance to climate regulation. Coalitions of states may also be able to adapt more accurately to the environmental effects of climate change, which will not conform to political

boundaries. Finally, regions with a unified climate policy may also attract technological and efficiency firms through incentive programs and demonstrated commitment to supporting the industry. Toward this end, many governmental organizations have coordinated with others to leverage their resources and create larger GHG reductions. For example, the Regional Greenhouse Gas Initiative is a coalition of nine northeastern states that formed a cap-and-trade system for electricity generation. Four Florida counties have joined forces to create a regional action plan for climate change mitigation and adaptation. All nine municipalities in Sonoma County, California have committed to reducing GHG emissions across the county.

Furthermore, Ostrom (2011) highlights the importance of local contexts for effective climate governance and action, stating that though climate change is a global problem, GHG emissions are the result of the day-to-day activities of billions of actors around the world. These actors emit different levels of GHGs in different ways depending on where and how they live (Satterthwaite, 2009). Models and vulnerability assessments have also demonstrate that climate change will have varying effects in different locations (Parry, Canziani, Palutikof, van der Linden, & Hansen, 2007). Because the causes and effects of climate change differ so greatly from place to place, global or even national level plans may only be able to provide panacea, or one size-fits-all, interventions that are not sufficient for addressing complex sustainability issues (Ostrom, Janssen, & Anderies, 2007). Sub-national levels also provide a more adaptive space for testing interventions; programs are more easily changed or decommissioned in smaller contexts than they would be at a national scale (Lutsey & Sperling, 2008). Therefore, local and regional organizations, if guided by a common sustainability goal, may be *best*

equipped to create policies and interventions to alter GHG emissions in ways that fit local contexts. However, it should be noted that if a common sustainability goal is not the focus of all efforts, and if individual interventions do not conform to sustainability principles, local and regional efforts may more resemble a patchwork of disparate regulations than connected attempts to influence a larger problem (Robért et al., 2002). Finally, The US also has a history of adopting federal environmental policy and programs that have been proven at the state-, municipal-, and private-sector levels (Purvis, 2004; Engel, 2006; Selin & VanDeveer, 2007), essentially treating these smaller programs as pilot projects. This makes it worthwhile for sub-national government organizations, in partnership with non-profit and private sector actors, to develop and test climate change mitigation interventions which could one day represent portions of a national climate policy. As the above points indicate, local and regional mitigation efforts are worthwhile and potentially highly effective levels for climate change mitigation interventions.

Current mitigation outcomes. Determining the effectiveness of addressing climate change mitigation in local and regional contexts was the first step in establishing the need for a governance system for negotiating interventions. The second is answering the question: What type of governance systems are currently used to drive local and regional mitigation efforts, and what are their outcomes? By assessing whether current governance regimes have been effective, we determine whether an improved process for selecting mitigation interventions is even necessary.

As described previously, the US's climate change activity is concentrated at the sub-national level due to disagreement and partisan divides at both the

federal and international levels (Selin & VanDeveer, 2007). This lack of agreement has prevented the US from creating a federal climate policy, but it has also kept the spotlight at national level, allowing states, counties, and municipalities to quietly develop their own climate change strategies (Rabe, 2007). Several sources have taken stock of US sub-national climate change initiatives. Lutsey and Sperling (2008) survey climate action policies in the US, and found that 42 states and 684 cities have taken action toward addressing climate change. Engel (2006) looked at current sub-national climate mitigation interventions, focusing especially cooperation between organizations. Along with measuring emissions and setting targets, cooperation between state governments seems to be a vital component in emerging cap-and-trade emissions reduction networks. Ramseur (2007) took stock of state-level climate mitigation initiatives and found that while many early actions were little more than symbolic gestures, states have become more pragmatic in their approaches to addressing GHG emissions. The most aggressive state in the climate action arena is California, which has passed laws mandating heightened fuel efficiency for passenger vehicles and state-wide GHG emissions reductions. Rabe (2007) compared climate action in the US and Canada post Kyoto Protocol and found that while as a nation the US is viewed as doing little to combat climate change, in reality a plethora of sub-national level actions have occurred, indicating climate change action is a high priority for states, counties, and municipalities.

All these sources agree that local and regional organizations have taken a significant amount of action toward mitigating climate change, and that the most popular of these actions by far are GHG inventories, reduction targets, and action plans (Ramseur, 2007; Lutsey & Sperling, 2008). These measures cover a variety

of contexts, from emissions solely within organizations to efforts to reduce municipal or regional emissions across all sources and sectors. State-level climate action often begins from within government, but at city and regional levels action often starts with strong leaders or concerned citizen organizations (Selvin & VanDeever, 2007). Mitigation efforts usually begin with a GHG inventory, and organizations then set targets for emissions reductions and create action plans for achieving their goals. Action plans typically include a range of interventions for each emissions sector, essentially creating a menu of actions administrators can pick from as opportunities or resources allow. The interventions range in scope from voluntary to mandatory. Most mandatory programs occur at the state level, and many are attempting to develop a market-based cap-and-trade approach to curbing emissions in sectors such as power generation (Ramseur, 2007). However, cap-and-trade schemes are complex and have been slow to form, and in some formats may even challenge legal barriers related to trade and federal environmental regulation (Engel, 2006; Ramseur, 2007). Others have pointed out that due to economic inefficiencies and the price elasticity of energy products, cap-and-trade systems may not function as well as hoped, and may provide unbalanced benefits to some users (Engel, 2006; Kockelman et al., 2011). Other enforceable interventions rely on regulation, such as California's fuel efficiency standards for passenger vehicles and mandate for GHG emissions reductions to 1990 levels by 2020 (Doughman, 2007). Voluntary interventions rely on a variety of informational and incentive-based campaigns to spur behavior or structural changes like altering driving habits or increasing home energy efficiency.

There are several organizations that support local and regional climate efforts, the most popular of which is arguably ICLEI–Local Governments for Sustainability (ICLEI). ICLEI provides resources to local governments for setting reduction targets and building action plans to combat climate change, a method that has proven popular with over 550 participating organizations in the US. Other such as the Climate Registry have established themselves as trusted third-party verification organizations that confirm the results of emissions inventories and reductions. Still others help drive behavior or structural changes by providing information or incentives. And these examples are only a fraction of the resources available to cities and regions to help inventory emissions, set targets, and create strategies to reach their reduction goals.

However, while there is clear logic as to why local and regional climate efforts (i.e. sub-national) "make sense," their widespread efforts have not created systematic and significant GHG emissions reductions (Lutsey & Sperling, 2008). Because climate change mitigation efforts differ by location, it is difficult to identify overriding causes for these shortcomings. However, we can say that despite the popularity of the measure-target-plan method, it has not created the desired effects considering the number of sub-national organizations who use it and the continued rise in emissions. It also appears that some organizations may make climate commitments or collaborate with others without a clear action plan just to satisfy constituencies concerned with climate change (Engel, 2006). In other cases, the interventions outlined in action plans are not acted upon, or implemented slowly and *ad hoc*. Regardless of the causes, the above discussion indicates that it is not for lack of options that climate change mitigation efforts are failing, nor from lack of desire to combat climate change. This suggests that it

may be *how* these efforts' interventions are selected and coordinated that is causing them to not achieve their goals.

We have now established that regional and local contexts are a good level for addressing climate mitigation, but current approaches are not producing the desired results. This leads to the third foundational question. If the context is effective for mitigation but current efforts are failing, what elements *are* required for sustainable governance of local or regional SESs? That is, is it known which types of governance elements could produce the desired outcomes?

Characteristics of effective environmental governance systems. As noted above, creating effective sustainability governance systems has proven difficult, especially on the international scale. Usually a simple function of the sheer number of different contexts and actors involved, international environmental governance (and politics) can be difficult due to incongruencies between political, environmental, legal, and economic systems; differing economic, sustainability, cultural, and social concerns; time lags; and lack of expert capacity across scale levels, among others (Chasek, Downie, & Brown, 2010). However, addressing such governance challenges at local and regional levels could prove less difficult. Several fields of research study characteristics of governance systems for sustainably managing SESs at local and regional scales, including institutional analysis (Ostrom, 2005, 2009) and sustainability science (Kates et al., 2001). The field of institutional analysis has developed methods for understanding SES governance processes and determining which have the greatest effect on successful management. Institutional analysis focuses primarily on common pool resources, or resources that are open to a number of users where extraction may benefit the individual user, but hurt the overall system. The

classic example is Hardin's (1968) description of a grazing system where herders benefited from grazing their animals in open pastures, but eventually destroyed the pasture's productivity through overuse. Climate is another example of a common pool resource; individual users realize little to no impact from emitting GHGs, but the overall system suffers from the cumulative impact of emissions.

In the past decade the institutional analysis field has compiled principles from several meta-analyses on successful SES and common pool resource management. Dietz, Ostrom, and Stern (2003) determined five requirements for robust environmental governance, which include providing information about the system; providing effective mechanisms for conflict resolution; inducing compliance with rules; providing the necessary infrastructure for change; and encouraging adaptation and change. They also provide several strategies to do so (ibid.). Ostrom (2009) adds strong leadership, shared cooperation norms, ability to construct and enforce collective-choice rules, and the importance of resources to users, as characteristics that encourage effective governance of SESs. Ostrom (2011) further adds that shared system understanding, frequent communication, and a moderate-sized systems increase the chances of successful management. Finally, Ostrom's seminal work on institutional analysis, *Understanding Institutional Diversity* (2005), gives an in depth view of institutional configurations that have proven successful for sustainable common-pool resource management.

Sustainability science seeks to understand complex SESs and the sustainability challenges within them, and create strategies that address these challenges in ways that are systematic, equitable, durable, account for uncertainty, and minimize unintended consequences (Kates et al., 2001; Clark &

Dickson, 2003; Komiyama & Takeuchi, 2006; Clark, 2007). Sustainability challenges occur in complex SESs when human actions threaten to undermine system function. The complexity and inter-linkages of sustainability challenges makes them "wicked" problems, or problems that are constantly changing and have no "optimal" solution (Rittel & Webber, 1973). Thus, effectively intervening in SESs requires a dynamic, system-based understanding from a variety of perspectives that is adaptable, iterative, reflexive, and anchored by an overall sustainable system goal and adherence to sustainability principles (Robért et al., 2002; Grunwald, 2004; Blackstock & Carter, 2007). Such solutions rely heavily on participatory approaches to create ownership and context-specific action, and are forward-looking, using modeling and scenario-construction to assess potential outcomes before acting (Wiek, Binder, & Scholz, 2006; Videira, Antunes, Santos, & Lopez, 2010), as well as goal-focused, always guided by sustainability principles and the desired, sustainable system state (Robért et al., 2002; Gibson, 2006).

Sustainability science supports sustainable development, which is progress that meets the needs of society within the limits of natural systems, over the long term (Clark & Dickson, 2003; Kates, Paris, & Leiserowitz, 2005). For climate change specifically, a growing body of literature explores the linkages between climate change and sustainable development and the co-benefits they can create when addressed simultaneously. In addition to global implications (Sathaye et al., 2007) and potential in developed (Robinson et al., 2006) and developing countries (Beg et al., 2002), there are potential co-benefits of using sustainable development principles to guide climate change action at local levels (Bizikova, Robinson, Cohen, 2007; Bizikova, Neale, & Burton, 2008). Some

believe (e.g. Robinson et al., 2006) that sustainable development may be a prerequisite to a low-carbon society, and that ample opportunities exist for organizations to develop sustainable technologies that with low or no GHG emissions. Perhaps most important to today's decision-makers, growing evidence demonstrates the economic imperative of pursuing sustainable development strategies as we address climate change in the coming decades (Stern, 2007; Banuri & Opschoor, 2007).

Gasparatos, El-Haram, & Horner (2008) synthesized input from over two decades for sustainability science and development research into a list of five guiding meta-principles. These state that sustainability efforts should seek to be integrated, combining elements of the environment, society, and economy into a single system; predictive, taking steps to assess the consequences of actions far into the future; precautionary, acknowledging uncertainty and imperfect information and encouraging precautionary bias; participatory, accessibly engaging all stakeholders including the public; and equitable, giving fair representation to the interests of all stakeholders including traditionally under-represented groups such as minorities and future generations (ibid.). Gibson (2006) created a similar synthesis, and adds the need for sustainability actions to maintain SES integrity and provide sufficient livelihood and opportunity to users. These and other principles have been built into a variety of frameworks for assessing, planning, and managing sustainability transitions (e.g. Rotmans, Kemp, & van Asselt, 2001; Robért et al., 2002; Kates & Paris, 2003; Wiek & Binder, 2005; Gibson, 2006; Bizikova et al., 2007; Ostrom, 2009; Loorbach, 2010; Wiek, 2010; Videira et al., 2010).

The above review indicates that there are several principles and methods

for sustainable SES governance. Institutional analysis touts a system-based approach that relies on a shared understanding, frequent communication and trust, rules that fit the context, and the ability to monitor and enforce rules. Sustainability science also presents several principles that focus on systems integration and integrity, participatory processes, and adaptive management, and orientation toward an overall sustainable system state. Combined, these principles provide a robust planning guideline for creating effective governance systems for managing climate change mitigation. These examples heavily emphasize the participation of all stakeholder groups and the integration of their interests when determining goals and interventions. This is why the term "negotiation" is apt when discussing intervention selection; the selection process relies on a negotiation between different stakeholder groups to determine actions that meet the needs of users and the system. However, very few climate change mitigation efforts use these principles in planning and intervention selection. This indicates that there is an opportunity to develop a process that incorporates such principles to create an effective intervention negotiation system.

Developing a Governance System for Negotiating Climate Change Mitigation Interventions

I established that local and regional climate change mitigation interventions are potentially worthwhile, and that many mitigation efforts exist in the US but have thus far been ineffective in reducing emissions. I also found that there are principles for effective SES governance that, if incorporated into a system, could create a platform for successfully negotiating interventions to drive sustainability transitions. With this understanding in place, I created a plan to address the research questions and establish an improved system for climate

intervention selection. The plan can be viewed as a process consisting of four phases that are ordered so that each builds off the previous and adds layers of detail while addressing the research questions. The process was designed to both create a system for negotiating interventions within organizations, and coordinate actions between organizations to create system-level change. The four phases are as follows:

1) Map the transition to determine progress along the transition curve.
2) Reconstruct past and current processes used to select interventions.
3) Assess the results to determine the 1) system's capacity for change, effectiveness of the overall transition strategy, 3) effectiveness of the current intervention selection system, and 4) effectiveness of interventions selected thus far.
4) Create an improved intervention negotiation process using the results from Phase 3 and principles from sustainability, institutions, and interventions literature.

The first two phases provide the necessary context to understand the system, transition, and past and current actions used to select interventions. These phases together answer the first research question, i.e. how organizations currently select interventions. Phase 1 gives a broad overview of the system, the goals of the transition, and determines to what extent the transition has developed. Understanding the progress of the transition is important for intervention selection as different parts of a transition require different types of interventions.

With this broad system understanding in place, the second phase uses institutional analysis (Ostrom 2005, 2009) to gather details on past and current

intervention selection processes. This phase is where specific details about points for improvement in the process begin to emerge. The analysis can be used as a design tool for building a new negotiation process, but it is geared toward transitions that are already underway. The data from this phase are used to build a rich understanding of the intervention selection system, and to populate the assessment in Phase 3.

Phase 3 presents an assessment that takes the information gathered in Phases 1 and 2 and determines areas for improvement. The assessment answers the second research question of how current selection processes compare to the literature. The three phases of the assessment build off one another, beginning with a determination of the system's capacity for change. Organizations in systems with low change capacity are less likely to align the support, resources, and participation necessary to create an effective intervention process, and should thus first work to increase their capacity for change. Once capacity is sufficient, prerequisites for planning, goal setting, and system construction are required before an intervention system can function effectively. Next, an effective process for negotiating interventions is required. If the process has major operational or governance shortcomings, it is unlikely to produce effective interventions. Finally, once an effective process is established it must target the right types of interventions. By assessing each area in turn, Phase 3 identifies strong points and areas for improvement, which are addressed in Phase 4.

Phase 4 develops an improved system for negotiating interventions. This also address the final research question of how to improve intervention selection systems. The improved process aims to address the shortcomings identified in Phase 3 given the context provided in Phases 1 and 2. It also incorporates

principles from intervention and evaluation research, the transformative sustainability framework, institutional analysis, and other research streams like multi-criteria decision analysis (MCDA; Belton & Stewart, 2002; Kiker, Bridges, Varghese, Seager, Linkov, 2005). The resulting process allows organizations to determine high-leverage intervention points and select interventions to effectively drive the system transition.

Case Study: Sonoma County, California

I applied this process to the climate change mitigation efforts currently underway in Sonoma County, California. Sonoma, in the north San Francisco Bay area, has been a leader in county-level climate change mitigation interventions since the early 2000's, as evidenced by its aggressive commitment to reducing GHG emissions to 25% below 1990 levels by 2015 (CPC, 2008). All nine Sonoma County municipalities and the county government adopted this commitment in 2005, and it continues to guide planning efforts. Since its adoption, several organizations devoted to meeting the target have formed, and their actions have produced a large local capacity and pool of expertise in intervention planning. Sonoma also enjoys widespread support for its goals, visible through continued commitment to climate change action by citizens and government officials. With these conditions Sonoma County has instituted over 15 climate programs to date, most of which have benefits in addition to GHG emissions reductions such as reduced energy costs, streamlined transportation, and new jobs.

However, Sonoma County's efforts have not created GHG emissions reductions. Emissions in the county have continued to rise, creating an ever-widening gap between present and desired emissions levels (Erikson & Hancock, 2010a). Preliminary research into Sonoma's climate activities revealed several

contributing factors in the failure to curb emissions, both within and outside the county's control (Wiek, Culotta, Denker, Krause, & Sharma, 2011). Those within the county's control included the lack of a comprehensive framework for coordinating climate activities between organizations; a GHG emission inventory model not geared towards actionable interventions; and the lack of a systematic process for selecting, testing, implementing, and implementing interventions.

The final finding provided an optimal point of departure for developing a process for effective intervention negotiation. From Sonoma's history of action it was obvious that organizations had a high capacity and desire for change. But, the intervention methods used thus far have not led to the desired outcomes. For Sonoma's transition process, I hypothesize that *how* county climate organizations select interventions, and subsequently the types of interventions that are implemented, have been a major factors in the lacking emissions reductions. By creating an improved intervention process, Sonoma climate organizations will be better equipped to meet their 2015 target.

Sonoma's current efforts have produced interventions that concentrate on only sections of the emissions system, and have not been sufficient to move the county toward its 2015 goal. For example, in Sonoma's widely supported Community Climate Action Plan (CPC, 2008), a GHG emissions analysis identified prominent emissions sectors and prescribed several strategies to reach the 2015 target. Despite this, the county's interventions have concentrated on the energy sector, with very few aimed at intervening in the transportation system– which comprised 64% of county GHG emissions in 2009 (Erikson & Hancock, 2010a). This thesis is timely because Sonoma has already implemented several programs, so data is available that can be used to analyze, assess, and improve

the selection processes. Furthermore, it is important to use this opportunity to learn and improve, as it is the likely outcomes of interventions selected in the near future that will determine whether Sonoma achieves their 2015 target. Finally, Sonoma has used a common approach for coordinating climate action, so this study's conclusions can be extrapolated to other climate change efforts.

When applied in Sonoma, the research questions become more specific:

1) How do Sonoma County climate organizations currently select programs;
2) Why have these processes not led to programs that significantly impacted GHG emissions; and
3) What improvements would optimize the selection process for Sonoma County?

Addressing the research questions and applying the process phases in Sonoma, provides county organizations with an improve system for negotiating the next generation of interventions for maximum emissions reductions and economic efficiency and effectiveness, as well as sustainable co-benefits.

As a final note, applying the process to Sonoma was not meant to identify things county is doing “wrong”. Quite to the contrary; Sonoma represents the leading edge of climate action, and as such improvements in its system can be adapted to other efforts to enhance results. However, this study also does not provide “silver bullets” that will instantly fix all of Sonoma's climate difficulties. Rather, by systematically analyzing, assessing, and recommending an improved construction of the intervention system, this thesis identifies new paths that Sonoma organizations can follow to further drive their system transition.

Research Outline

This study addresses the above points in five additional chapters. The following four chapters correspond to the four phases of the intervention system development process as applied in Sonoma County. The next (second) chapter reviews transition theory and maps Sonoma's climate transition to gain a better understanding of its historical context, goals, and recent development. The chapter also introduces the network of Sonoma County climate organizations and their associated interventions. The third chapter reviews institutional analysis theory, and then reconstructs the Sonoma County climate action system and intervention selection process using institutional analysis and interviews. The fourth chapter assesses the information from chapters two and three to determine points for improvement in Sonoma's overall capacity for change, their intervention system, and the types of interventions they have selected thus far. The fifth uses the results of the assessment to construct an improved system for Sonoma organizations to negotiate effective climate change mitigation interventions. The final chapter concludes the study and discusses possible implications from using the improved process.

Chapter 2 – Sonoma County Climate Transition

This chapter describes Sonoma County's transition to a low-carbon system. By gaining understanding of what actions have led the system to its current state, I was able to determine to what extent the system has transitioned, which parts were functioning sustainably, and which were in need of improvement. This knowledge also provided the broad context for Phase 2 of the process: analyzing the intervention selection system itself.

Scholars have studied transitions with great interest, especially intentional transitions that aim to move a complex system from one state to another. Transitions to sustainability are an example of such a configuration. By understanding transitions, scholars and practitioners hope to efficiently manage system change rather than leave it to the mercy of outcomes from a plethora of disconnected actions and interests (Rotmans et al., 2001). Though Sonoma organizations' main focus tends to be on reducing GHG emissions, in effect these interventions are driving a transition to a more sustainable, low-carbon system. By viewing Sonoma's actions as such, I was able to compare their progress to transition theory to see how their transition has progressed, what some of its main drivers are, and what areas may need attention.

Methods

The literature on transitions is wide ranging, encompassing a variety of social, technical, and ecological fields. I identified literature by following sources from prominent works in the transitions field (e.g. Rotmans et al., 2001), and through expert interviews. The literature were complied to form a comprehensive review of current transitions theory.

Prior to this work, a comprehensive description of the Sonoma climate organizations and interventions did not exist. However, it was crucial to understand the county's climate action system in order to further study the county-wide transition, and subsequently the intervention selection process. The results of the review are presented in a table listing Sonoma County climate programs to date; an organization map that shows the relationships between programs, organizations, and institutions; and a narrative that describes the history of climate action in Sonoma.

To inform the summary, I completed an extensive document and website review of the relevant literature on Sonoma County climate organizations and interventions. The literature review focused on identifying individuals and organizations involved in Sonoma County climate change activities, when they became involved, their type (e.g. governmental, NGO, private organizations, consultants), what their roles were, and what influenced their activities. This information was then combined with details about Sonoma's climate programs, and together they present a rich history of the county's climate action.

The CPC was the first organization formally involved with climate change in the county, and their website houses several documents, including summary reports (Erikson & Hancock, 2006, 2008, 2009, 2010a), methods descriptions (Erickson & Hancock, 2010b; ICLEI & SCWA, 2010), emissions inventories (CPC, 2003; Hancock & Sandler, 2005a), and strategy documents (Orrett, 2002; Hancock & Sandler, 2005b; CPC, 2008), that describe the evolution of Sonoma's climate activities. The Regional Climate Protection Authority (RCPA) website contained an annual report (RCPA, 2010a) and a mission, goal, and objectives statement (RCPA, 2010b) that described climate change mitigation activities. The

California Air Resources Board (CARB) website provided details on AB 32 and SB 375, and housed the AB 32 scoping plan document (CARB, 2008). Finally, several state and county organization websites, including Solar Sonoma County, the Leadership Institute for Ecology and the Economy, the Sonoma County Water Agency, Transportation Agency, Energy and Sustainability Division, and Open Space District, as well as the state Transportation, Energy, and Utilities commissions all provided information on the links between different organizations and climate change intervention programs.

Results

Transition theory. The concept of transitions has roots in population demographics and biology, but has since been adapted to several areas including governance transitions (Kemp & Loorbach, 2006), ecosystem transitions (Karunanithi, Cabezas, Frieden, & Pawlowski, 2008), socio-technical system transitions (Smith, Stirling, & Berkhout, 2005), socio-ecological system transitions (Krausmann, Schandl, & Sieferle, 2008), and resilience theory– specifically panarchy (Folke, 2006). These all subscribe to the same basic transition structure, although vary somewhat in how they describe the transition process (e.g. Smith, Stirling, & Berkhout, 2005; Geels & Schot, 2007; Makard & Truffer, 2008). Rotmans et al. define transitions as "a set of connected changes, which reinforce each other but take place in several different areas, such as technology, the economy, institutions, behavior, culture, ecology and belief systems" (2001: 16). This systematic understanding is essential to sustainability, which requires coordination between multiple components of the socio-ecological system. Transitions also fit well with regions such as Sonoma, which are complex with variables operating on several different scale levels.

Transitions are comprised of four stages and can be represented by an S-curve where the y-axis represents change indicators and the x-axis represents time (Figure 2; Rotmans et al., 2001; Martens & Rotmans, 2005). In pre-development, momentum for the transition may be mounting, but no noticeable change in the status quo is apparent. This phase can be long as the complexities involved in the transition coalesce in a common direction. The take-off phase is where specific events, a build-up of momentum, or a combination of both set the transition in motion. Acceleration occurs as the transition gains momentum and developments in different sectors combine to drive the transition. In this phase, changes become visible and the system becomes unstable. Stabilization occurs as changes mature and the system settles into its new mode of equilibrium.

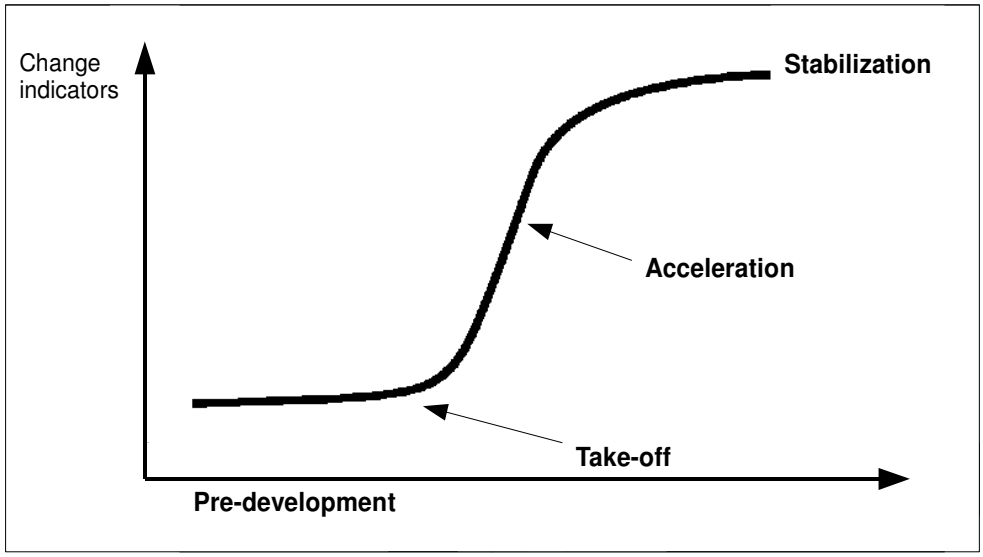

Figure 2. The transition curve. Adapted from Rotmans et al. (2001).

It is crucial to understand that complex system transitions, like those to sustainability, occur across several sectors, and are thus made up of many smaller transitions which enable or inhibit the desired outcome (Martens & Rotmans,

2005). For example, a transition that replaces fossil fuel-burning cars with electric powered vehicles may be accompanied by a transition to electricity generation methods that create more pollution, thus complicating a transition towards comprehensive sustainability. Multiple factors can contribute to each of these sub-transitions, making the larger transition extremely nuanced, unpredictable, and lengthy.

The transition management field seeks to guide transitions through governance mechanisms toward a desired outcome (Rotmans et al., 2001). This generally takes the form of encouraging and augmenting desirable sub-transitions, but as Shove and Walker point out, in extremely complex processes managers have only limited influence (Shove & Walker, 2007). In a study of examples of transition management, Voß, Smith, and Grin (2009) observed that transition management processes are often subject to power and political struggles, with actors concentrating on their personal concerns as much or more than the transition's. These critiques highlight the fact that transitions occur in dynamic social systems that are not easily managed and involve high levels of uncertainty. Transition management theory acknowledges this as well, stating that the process is meant to not determine the product of the transition, but structure the process in a way that encourages sustainable outcomes (Rotmans et al., 2001). Transition managers must strike a balance between guiding the process without taking over or becoming overly influential, and thus themselves entering into power struggles.

The transition environment. Sustainability transitions can play out at several different levels in the social system. These levels can broadly be broken down into micro, meso, and macro, where micro represents individuals or

organizations, meso represents networks and communities, and marco represents groups of high-level institutions and organizations, e.g. a nation (Rotmans et al., 2001). The meso level best represents entities such as counties, which are complex networks that are also changeable in a short- to mid-term time period of years to decades, unlike the macro level which generally realizes changes over decades or centuries.

Furthermore, transitions are often described using Rip and Kemp's (1998) multi-level model (MLM) of socio-technical system changes. The MLM is comprised of three levels: niche, regime, and landscape, that roughly correspond to the social levels described above. The niche level is made up of individual actors, technologies, or practices that can experiment and deviate for the status quo. Change most easily occurs at the niche level, where actors experience less pressure to maintain order. The regime level is the dominant practices, rules, structures, and assumptions that govern the system. This is the level that has the most impact in guiding day-to-day life. The landscape is comprised of the large, long-lasting institutions and structures that shape society, including world views, political structures, infrastructure, macroeconomics, and the natural environment.

Each level exerts forces on the others. As Geels and Schot (2007) point out, a common critique of the MLM is that it relies too heavily on the notion that change begins at the niche level. They and others (Smith, Stirling, & Berkhout, 2005) counter that forces from both above and below incite change, and that at the regime level, where transitions have the greatest effect, pressures from the landscape can be equally or more important than niche pressures. Niches often give rise to new innovations, but pressures from all the levels shape transitions.

A county like Sonoma can be viewed as a regime level entity, and also as a complex socio-technical-ecological systems. Studies of socio-technical regimes consider why and how people act with the tools and process they use to carry out those actions, as well as how these aspects influence each other (Fox, 1995). Sonoma County offers a somewhat bounded study area to analyze social and technical aspects and their tightly coupled interplay. Sustainability also involves a closely-tied system of social and technological process and their effects on the environment, and thus considering sustainability transitions as socio-technical-ecological transitions is appropriate.

Actions, both individual and collective, are what drive the transition process. Similar to societies and socio-technical systems, actions can also be separated into different levels. These levels–operational, tactical, and strategic–represent actions directed toward different outcomes (Ostrom, 2005). Operational activities are the day-to-day actions that carry out system functions. These are shaped by tactical and strategic activities at broader levels of the system. Tactical activities relate to the build-up, break-down, or maintenance of system structures, and can include actions related to institutions, infrastructure, laws, regulation, and standards. Tactical activities are shaped by strategic activities, which are large-scale actions like policy making that are related to broad objectives and social structures. All of these actions are present within each socio-technical-ecological system level, and create outcomes that either positively or negatively reinforce changes within the system.

It is important to note that all the transition attributes listed thus far are arranged in nested systems in which each level influences the others. The smallest of these nested systems (e.g., micro, niche, and operational activities)

change more rapidly and are more easily influenced than the levels above. These different levels also operate on different scales, with smaller levels changing more quickly than larger levels.

As the above sections demonstrate, sustainability transitions are complex systems comprised of multiple sub-transitions in different sectors operating on different time and spatial scale levels. Each transition is comprised of four phases that begins with pre-development, moves through take-off and acceleration, and eventually stabilizes at a new equilibrium. These stages are not inevitable, and a transition may stall at any stage if it encounters a barrier that it is unable to overcome. Local and regional sustainability transitions occur at the regime level, and are created and advanced by pressures exerted by both niches and the landscape. These pressures are the outcomes of actions that also occur at different levels, from day-to-day maintenance activities to strategic policy decisions. Transitions cause changes in strategic and tactical actions, which alter the form of operational activities. As these changes mount, they can create positive feedback loops that further advance the transition. Eventually, regime level transitions may aggregate to cause large changes at the landscape level.

This framework creates a space to analyze transitions with an understanding of why and how they progress. With this understanding, we now move to a description of the activities that comprised Sonoma's transition.

Sonoma County Transition. Sonoma County climate organizations operate in the governmental, NGO, non-profit, and private sectors, and are involved with other federal, state, county, municipality, and private level organizations through a variety of interventions. Though the focus of this study is county-level organizations and programs, examining the levels above and below

gives a clearer indication of how the target level functions, as well as some of its main drivers (Ostrom 2005). Table 1 lists Sonoma climate interventions, which sectors they target, and their associated organizations. Figure 3 arranges this information in an actor map that includes federal, state, county, and private organizations, their governing institutions, and the interventions they administer. Links are determined by tracing which organizations share interventions and institutions. When combined with the following narrative, the map and table represent the complex relationships between the climate organizations, institutions, and interventions in Sonoma.

Table 1

Sonoma County climate change interventions

Intervention	**Sector**	**Purpose**	**Organizations involved**
Emissions reductions commitment	All	Reduce county GHG emissions to 25% below 1990 levels by 2015	Climate Protection Campaign (CPC), County of Sonoma, Local governments
Community Climate Action Plan	All	Create strategy for reaching emissions reduction target	CPC, Sonoma County Water Agency (SCWA)
Emissions inventory	All	Establish total amount and source of county GHG emissions	CPC
Educating Leaders for a Sustainable Future	All	Educate county leaders on sustainability issues	The Leadership Institute
Sonoma County Energy Independence Program (SCEIP)	Energy	Provide financing mechanism to encourage energy efficiency retrofits	County of Sonoma Energy and Sustainability Department (ESD), RCPA, SCWA
Renewables and Retrofits Program	Energy	Provide information and support to encourage efficiency and	Regional Climate Protection Authority (RCPA)

		renewable energy retrofits	
Sonoma Clean Power (CCA)	Energy	Create governance and infrastructure for county to purchase energy from preferred source	SCWA, CPC
RESCO model	Energy	Create optimum renewable energy portfolio for county	CPC, SCWA, Los Alamos National Laboratory
Energy Upgrade California	Energy	Provide information and support to encourage efficiency and renewable energy retrofits	RCPA, CPC
Whole Neighborhood Approach	Energy	Enable neighborhood scale energy retrofits	RCPA
Farms to Fuels	Energy	Create energy from farm refuse	SCWA
Clean Energy Advocate	Energy	Assist homeowners in attaining solar	Solar Sonoma County
SMART Rail	Transportation	Provide alternative transportation option	Sonoma County Transportation Authority (SCTA)
Real-time Ride Share	Transportation	Connect commuters to reduce individual vehicle miles traveled	CPC, RCPA, SCTA
Electric Vehicles Program	Transportation	Provide infrastructure and information to encourage increased electric vehicle usage in county.	SCTA, RCPA, ESD, Sonoma County Agricultural Preservation and Open Space District

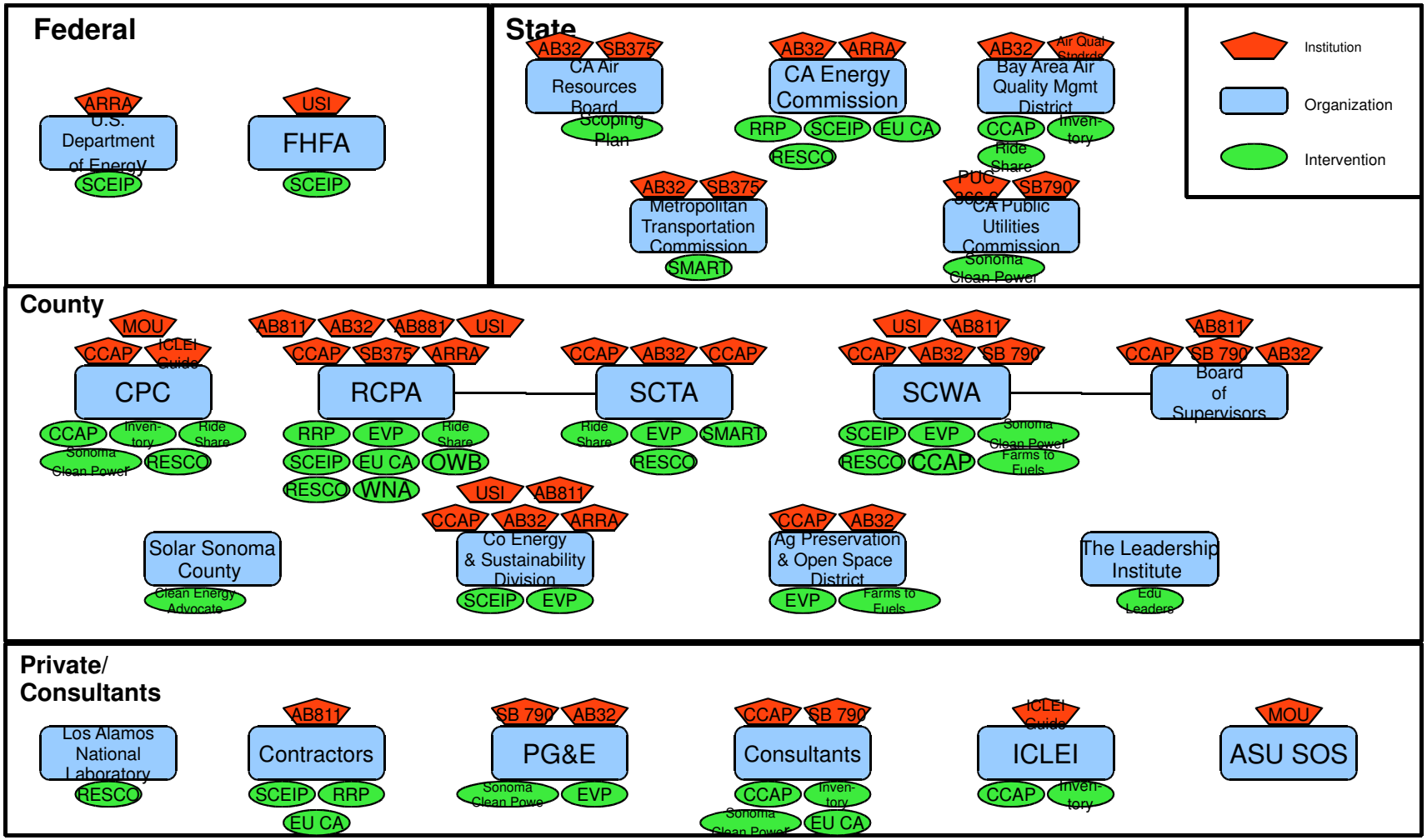

Figure 3. Sonoma climate organizations, institutions, and interventions.

Sonoma County climate action narrative. Sonoma's climate change mitigation activities officially in 2001 with the formation of the CPC, whose mission was to reduce GHG emissions using practical and science-based solutions. The CPC's initial interventions concentrated on measuring GHG emissions and providing recommendations for reductions (e.g. Orett, 2002; CPC, 2003; Hancock & Sandler, 2005a). The CPC chose ICLEI's Milestones for Climate Action framework (ICLEI, n.d.) as a guide and lobbied for climate action, which in 2005 led to Sonoma's municipal and county governments committing to reduce county GHG emissions to 25% below 1990 levels by 2015. This formalized climate action in the county government, but the governing institutions, namely the commitment to emissions reductions, where not enforceable and thus constituted a shared norm (Ostrom, 2005). The county placed climate activities under the jurisdiction of the water agency (SCWA) and the newly formed Energy and Sustainability Division of the County of Sonoma General Services Department. The SCWA shares a board of directors with the Sonoma County Board of Supervisors, making this board ultimately responsible for approving most government-led climate activities. As county agencies and local governments began planning how to achieve their emissions target, the CPC continued to advance climate activity at the county and state levels, e.g. administering the Cool Schools program with the Bay Area Air Quality Management District and continuing research and education on climate change mitigation best practices.

In 2006 California's state government passed Assembly Bill (AB) 32, which committed to reducing state-level GHG emissions to 1990 levels by 2020. The AB 32 scoping plan, which was finalized in 2011, outlines the strategies to

reach this target (CARB, 2008). AB 32 carries penalties for non-compliance, which represents the first time a rule (Ostrom, 2005) was attached specifically to climate change mitigation in California, and subsequently Sonoma. After AB 32 was passed Sonoma had two major targets–the 2005 commitment by local governments and the less lofty but enforceable AB 32. In 2008 California adopted State Bill (SB) 375, which set targets for achieving GHG reductions tied to land use. SB 375 used a regional approach, with each regional organization (Sonoma falls under the Metropolitan Transportation Commission's jurisdiction) responsible for approving Sustainable Communities Plans. Sustainable Communities Plans require local governments to include climate change mitigation and sustainability features into their land use and transportation planning. In Sonoma, many local governments are created Sustainable Communities Plans, and the Energy and Sustainability Department manages the project at the county level. The Metropolitan Transportation Commission's boundaries are similar to the Bay Area Air Quality Management District's, which demonstrates California's commitment to the regional approach when addressing climate change.

In 2008, the CPC, in cooperation with city and county government organizations, ICLEI, and private consultants, created the Community Climate Action Plan, which updated Sonoma's GHG emissions profile and gave detailed strategies to reach the 2005 target (CPC, 2008). After the CPC issued the Plan the county moved into the implementation phase, and interventions were extended beyond measuring emissions to administering reduction programs.

In 2009, the county, with guidance from the CPC and SWCA, created the Regional Climate Protection Authority (RCPA) to have a central location to

coordinate the county's expanding climate activities (RCPA, 2010b). The RCPA, which was authorized by AB 881, was housed within the Sonoma County Transportation Authority (SCTA), and worked primarily with the CPC and several county organizations, including the SCWA, the SCTA, the Agricultural Preservation and Open Space District, and the County Energy and Sustainability Division, in implementing a variety of programs across several sectors (see Figure 3). Some of the most visible county programs involved energy conservation retrofits, such as Energy Upgrade California and the Retrofit and Renewables programs, which were created in 2010 through funding from the Energy Efficiency and Conservation Block Grant of the American Reinvestment and Recovery Act. Energy Upgrade California is administered by the California Energy Commission, and was designed to help building owners implement energy conservation upgrades (RCPA, 2010a). The RCPA worked with the Energy and Sustainability Division to administer the program, which in Sonoma mainly consisted of marketing and information sharing for property owners and contractors about energy efficiency opportunities. The SCWA and Energy and Sustainability Division, in conjunction with the Retrofit and Renewables program and Energy Upgrade California, administered the Sonoma County Energy Independence Program (SCEIP), which finances energy efficiency retrofits. SCEIP was authorized through AB 811, but the Property Assessed Clean Energy (PACE) structure on which SCEIP is based was recently challenged by the Federal Housing Finance Agency (FHFA), which claimed that PACE violated the lending safety measures set forth in their Uniform Security Instrument (FHFA, 2010). Several organizations, including SCEIP, responded to FHFA's challenge, and the SCEIP program continues to operate in Sonoma. The Retrofit and Renewables,

Energy Upgrade California, and SCEIP programs all worked with local contractors to install retrofits in homes.

From the CPC's initial efforts, the number of climate-focused organizations in Sonoma grew into a complex system of actors in a variety of sectors (see Figure 3). These organizations operate several intervention programs to achieve GHG reductions. Though the AB 32 goals apply to Sonoma, most county organizations still claim the 2005 commitment of 25% below 1990 levels by 2015 as their target. Some organizations created their own internal targets in addition to the county-wide goal, such as the SCWA's commitment to have zero emissions by 2015. The CPC continues to research, advise, provide annual emissions updates, and identify new opportunities for programs and funding. Other NGOs, like Solar Sonoma County and the Leadership Institute for Ecology and the Economy, administer education programs to teach citizens and leaders the importance of taking climate action, and ways to do so. The RCPA acts as the hub for administering county-level mitigation programs, and also focuses heavily on the Energy Upgrade California program, as well as pilot programs in the energy efficiency and retrofits sectors. The SWCA has a large capacity for program development and access to discretionary funds that can be used to develop interventions. This allows them to serve as a "catalyst" for getting many interventions off the ground in the form of feasibility studies, early resources investments, and pilot programs. Several pilots are currently underway, including the Real-time Ride Share, On Water Bill, and Whole Neighborhood Approach programs, which test solutions for the transportation, energy, and water sectors for rapid scaling. The RCPA, CPC, SCWA, and SCTA are working with Los Alamos National Laboratory through a California Energy Commission grant to create a

dynamic model of Sonoma's GHG emissions to be used for optimizing the county's renewable energy portfolio (RCPA, 2010a). This model goes beyond the typical targets for percentage of energy generated by renewable sources, and seeks the best configurations of renewables for a given context. Though the model is being constructed with Sonoma in mind, Sonoma organizations and Los Alamos plan to scale it to other locations.

Perhaps the largest program underway in the county is Sonoma Clean Power, a community choice aggregation program authorized by SB 790. Sonoma Clean Power will allow the county to directly purchase electricity from their choice of sources, and therefore control how much of the power is renewably generated. Previously all Sonoma's electricity was provided by the privately owned Pacific Gas & Electric (PG&E) utility. Under Sonoma Clean Power, PG&E would still deliver energy, but the county would have control over the sources. Several organizations are working to implement Sonoma Clean Power, including the SCWA, RCPA, CPC, and private consultants. The SCWA recently completed a feasibility study to determine if and how a community choice aggregation energy program can best serve Sonoma, the results of which were favorable.

Discussion

Sonoma's actions to reduce GHG emissions represent continued progress along the climate system transition curve. Climate actors proceeded through pre-development phase by creating broad political and social alignment for climate action, as well as new organizations devoted specifically to coordinating climate activities. The take-off phase began when all the county's governments agreed to reduce emissions to 25% below 1990 levels by 2015. This action took the transition from its formative phases into those where actual changes began to

occur. Currently, programs create changes in infrastructure and organizational operation, all with the intent of moving toward a sustainable climate system. These changes have grown in scope and number over the past years, placing the county in the acceleration phase. However, interventions have not led to the GHG emissions reductions that would signal that the system is near stabilization. Therefore, interventions are needed that create more tangible results, or the transition may be in danger of stalling.

Progress through the transition stages is not inevitable, and systems in the early acceleration phase are especially vulnerable since this is where changes begin to manifest in operational activities. In the acceleration phase actors can no longer simply proclaim support for a transition's goals and motives; they must begin making changes in day-to-day activities. Status quo conditions can be difficult to change, and actions must be well selected to motivate changes in high leverage intervention points to maintain transition momentum. If this does not occur, progress could slow, support could erode, and attention and resources may shift to other areas. It is therefore vital that interventions are well selected to continue acceleration.

Sonoma's progress along the curve has been driven by a number of factors. Leadership played a large role in the pre-development and take-off phases. Leadership, vision, and experience from motivated individuals often help drive the early phases of transitions (Ostrom, 2009). In Sonoma's case, vision and leadership helped to coalesce support to form the CPC and convince county decision makers that climate action, and specifically GHG emissions reductions, were good for the County's future. This leadership was augmented by a county-wide culture of support for action on environmental issues. County citizens were

receptive to the idea of action for climate change, as were elected officials and government organizations. Without this type of support and local capacity for change, motivated individuals may find it difficult to push transitions into the acceleration phase.

However, these factors mainly support transitions in their early phases. Landscape-level factors have been vital in driving Sonoma's transition beyond the pre-development and take-off phases. Hard work and expert input can carry transition efforts through planning phases, but it takes resources to fully design, implement, and monitor and adapt interventions. These resources are often not available at the local level, which means higher-level organizations' support for sustainability actions is crucial for launching and accelerating programs. Examples include the availability of American Reinvestment and Recovery Act funds, and state and federal organizations interested in taking action on climate change through partnerships with local and regional organizations.

There are also factors that have hindered the transition. The necessity of partnering with other organizations and funding sources has sometimes forced Sonoma organizations to wait to select interventions until resources allow. Though this has not been the case for every intervention, a reactive approach can slow transition progress and cause organizations to base intervention selection on e.g. funding availability rather than what is needed to move toward the goal. Additionally, the growing number organizations, interventions, institutions, and the relationships between them has significantly increased system complexity. Working with such complexity can increase organization, transaction, and information costs, and slow the transition due to the number of requirements and steps organizations must fulfill to take action (Ostrom, 2005).

Transitions literature also points out the importance of focusing on how transitions are managed, in addition to specific actions and outcomes (Rotmans et al., 2001). That is, the fundamental process of *how* actions are identified, selected, and carried out is as much or more important than *what* those specific actions are. The underpinning theory is that if the process is guided by a set of principles that encourage sustainable outcomes, i.e. those that comply with sustainability principles, are goal-focused, system-oriented, adaptive, and reflexive (Robért et al., 2002; Gibson, 2006; Wiek, 2010), then the interventions that process produces will be effective and sustainable. However, Sonoma organizations have have placed much more emphasis on what they do than how they do it. There is no shared system for evaluating system needs and selecting interventions that move the system toward the desired state, nor guidelines for what those interventions should entail. The Community Climate Action Plan is the best example of comprehensive climate intervention selection in the county, but it was only carried out once, and did not include a process for selecting actions in addition to the list of interventions it provided. Now that the transition is off the ground, it is critical that Sonoma organizations focus on how, in addition to which, interventions are selected as they continue through the acceleration phase.

Finally, the literature suggests that complex system transitions, like those to a low-carbon system, occur across several sectors, and are thus made up of many smaller transitions (Rotmans et al., 2001; Marten & Rotmans, 2005). This is well represented by the variety of areas Sonoma's programs affect, and by the different levels at which programs operate. However, from a broader perspective climate is but one component of a sustainable SES (Robért et al., 2002). This

narrow focus on climate highlights a major flaw in Sonoma's theory of change. Since climate is one part of a sustainable system, climate actions must be guided by and aligned within an overall sustainability transition. If interventions are not oriented within an overall sustainability transition, a climate transition never be completed since other parts of the SES linked to climate are not changing in parallel. Focusing on one part of the system can create situations where interventions to reduce GHG emissions produce unintended outcomes in other areas, or even inhibit overall sustainability. Organizations should reformulate their planning strategy to include backcasting from an overall sustainability goal that includes sustainable climate activities (Robinson, et al., 2011). Backcasting starts with the goal and then plans a strategy in reverse to the current state. By starting with the goal of sustainability and only considering the current state near the end of the process, organizations are not constrained by present system conditions in planning. By using sustainability as a guide and backcasting for planning, climate-focused actions will both contribute to the overall goal and not unintentionally impact other parts of the system (Robért et al., 2002).

Conclusion

This chapter fulfilled the first research phase: understanding the historical and current state, and also served to partially answer the first research question of how Sonoma organizations select climate interventions. It also established that Sonoma County's intention for undertaking climate action is to combat climate change and transition to a low-carbon system. This can be viewed as their goal, or desired, state, that they aim to move the system toward.

However, to fully answer the first research question I had to gain a more detailed understanding of the activities and institutions that specifically govern

intervention selection. The discussion above highlighted the importance of successful interventions at this stage of Sonoma's transition. Even with widespread support and buy-in for the transition, if the selected interventions cannot produce the desired changes, the transition will flounder. Additionally, if interventions are poorly designed and participation and outcomes are low, then progress toward the desired state may slow or halt altogether.

With the broad context in place, next chapter describes the processes Sonoma organizations use to select climate interventions. This more detailed look provides the information necessary to assesses the strengths and weaknesses of the intervention selection system, and subsequently to design an improved process for selecting interventions.

Chapter 3 – Sonoma County climate intervention system reconstruction

This chapter provides a detailed assessment of Sonoma County's current intervention processes, how they evolved, and why they operate the way they do. To do this, I used elements of institutional analysis, which identifies the formal (e.g. laws) and informal (e.g. organizational culture) institutions, or "rules in use", that govern actions in a given context (Ostrom, 2005). By understanding why and how institutions affect actors, enabling and constraining factors can be identified that help explain why actors take the actions that they do.

I gathered information about Sonoma climate organizations and their program selection processes by reviewing climate organization documents and conducting semi-structured interviews with county climate decision makers. Then, in the results section, I used the data in combination with institutional analysis to reconstruct the processes climate organizations used to select past and current interventions. A discussion section follows that looks at some of the process elements in greater detail.

Methods

To understand the processes used to select climate interventions, Sonoma's network of organizations, intervention programs, and institutions identified in Chapter 2 needed to be grounded in a conceptual framework. I chose the Social-Ecological System (SES) analysis framework (Ostrom 2007, 2009, 2011) for this purpose. The SES framework breaks the system into components and variables that combine to influence outcomes (Figure 4). This allows for careful study of the different parts of the system and the institutions that shape them, and how they interact and produce the outcomes. I defined

organizations as groups of actors engaged around a common mission; interventions as actions, such as programs or commitments, intended to change a system (Fraser et al., 2009); and institutions as the rules, both formal and informal, that govern human interactions (Ostrom, 2005).

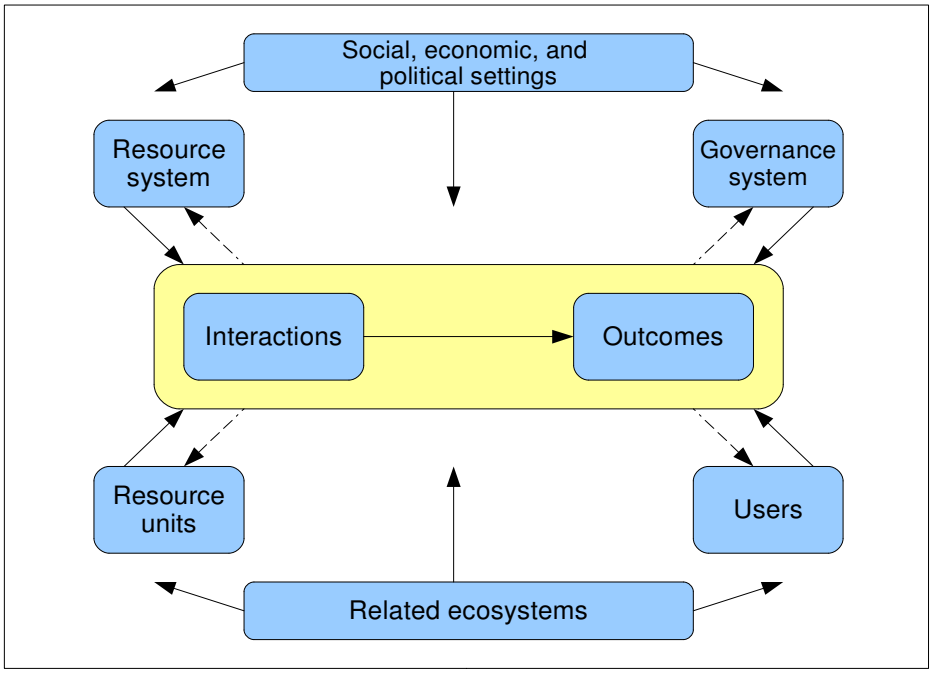

Figure 4. Social-ecological System Analysis Framework conceptual model. Adapted from Ostrom (2007).

Action situations are the spaces within the SES framework where actors with different positions, levels of control, and amounts of information interact to produce outcomes which have associated costs and benefits (Ostrom, 2005, 2011; Figure 5). Viewed through an institutional analysis lens, the processes used to select climate change mitigation interventions comprise the action situation of the Sonoma climate change mitigation system. As such, the current selection processes and the changes that have occurred in them over time represent an evolving action situation.

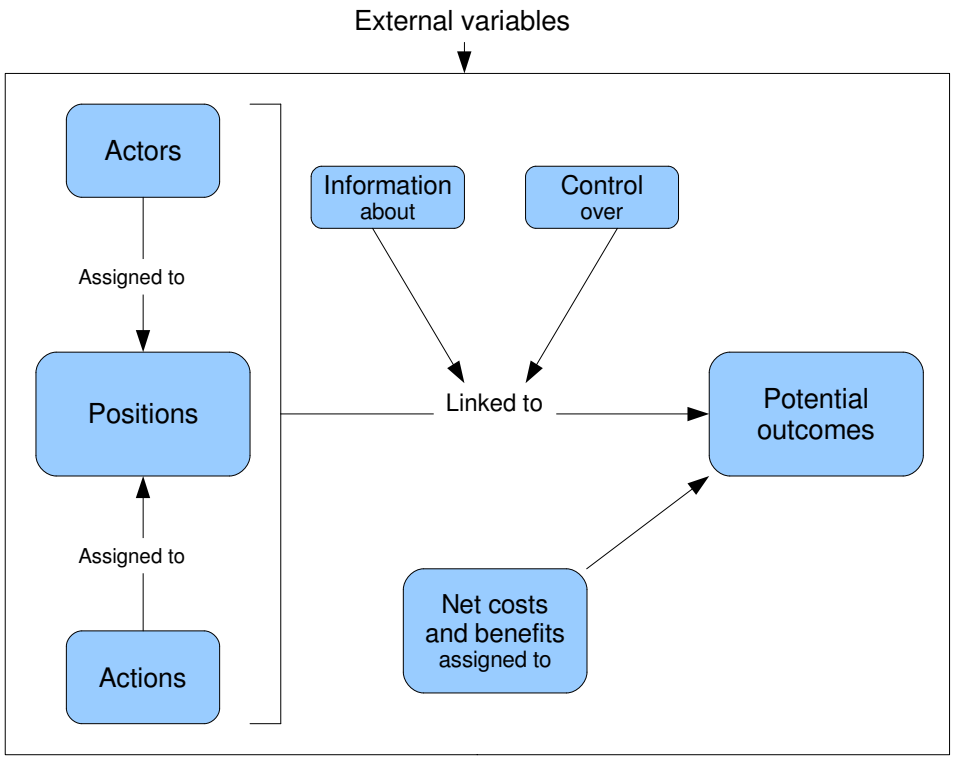

Figure 5. Internal structure of an action situation. Adapted from Ostrom (2005).

By organizing the organizations, institutions, and programs in the SES framework, I described Sonoma's intervention selection system in functional way that allowed for study of its constituent parts. This structure also made the relationships between the variables of the climate system more apparent, which helped highlight the most influential components. Most importantly, this method described the system's action situation, which results in intervention programs (i.e. outcomes) that affect GHG emissions.

I conducted eight semi-structured interviews to substantiate the theory-based SES system representation with empirical evidence. Those interviewed represented four county government organizations and two NGOs, and discussed 10 major county climate programs. The multiple perspectives provided by the diversity of interviewees helped avoid the inaccurate or unrefined understanding

that can result from only reviewing official documents and interviewing high level officials (Poteete, Janssen, & Ostrom, 2010). The primary criteria for interviewee selection was that they played an instrumental role in selecting climate mitigation interventions, and therefore are or were part of an influential climate organization. The other criteria the potential interviewees had to satisfy was a substantial history of involvement in Sonoma climate action, which was essential for capturing the effects of institutional changes on program selection processes over time. The interviews described the process representative organizations used to select and develop climate programs, what factors influenced the process, and how it evolved over time.

I selected the barriers and carriers method (Wiek & Larson, under review*)* to guide the interviews. The barriers and carriers method allows users to describe processes by mapping their various phases, who does what in each phase, and what acts as barriers (constraints) and carriers (enablers) during and between the phases (Figure 6). Barriers and carriers can be thought of as the institutions that shape the process, which makes the method a good fit with institutional analysis. Interviewees completed a barriers and carriers worksheet during the interview, which were conducted by phone and lasted approximately one hour. Interviews were conducted in two rounds, the first between November 23rd and December 2nd, 2011 and the second between February 10th and 27th, 2012. All ideas or direct quotes are identified with a code to protect the interviewee's anonymity. A copy of the interview questions and Barriers and Carriers worksheet can be found in Appendix A.

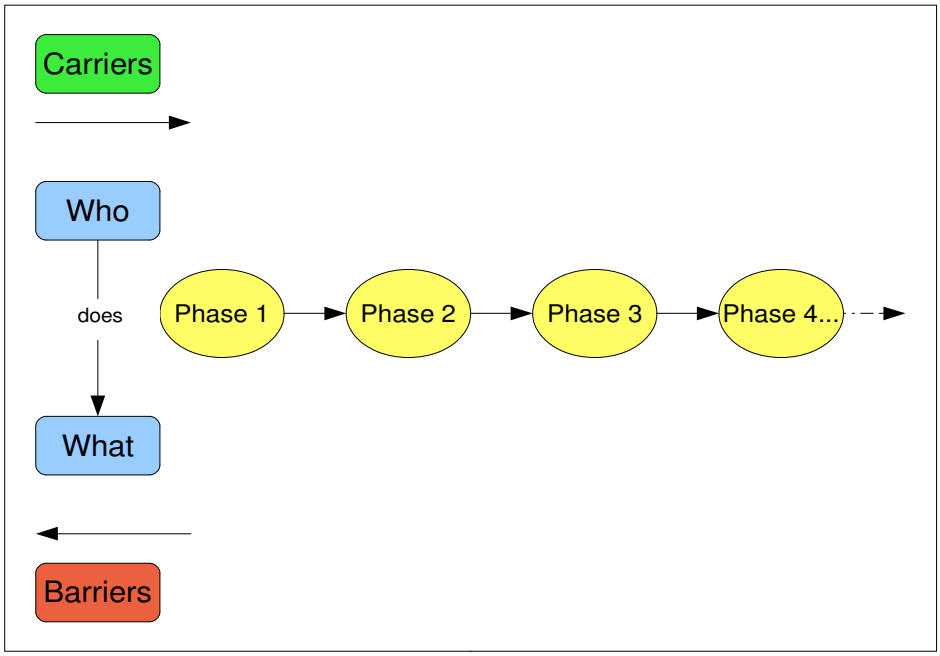

Figure 6. Barriers and Carriers conceptual model. Adapted from Wiek & Larson (under review).

For coding, I separated respondents' action, participant, barrier, and carrier statements for each phase. I then grouped the statements into categories. These categories were drawn from the interview results, not predetermined. By analyzing the interview data based on responses and not on predetermined categories, I was able to capture the selection processes from the respondents' viewpoints and not conform the data to preconceived notions of my own (Bringer, Johnston, & Brackenridge, 2006). That is not to say that my prior knowledge played no part in the interview and coding process; any researcher automatically bases their work on elements of prior knowledge and experience. However, I used prior knowledge highlight important aspects that respondents may have considered routine or taken for granted (Charmez, 1995), not to interpret the interview results in the way I believed they "should" go.

Results

Sonoma County and the SES framework. Figure 7 represents Sonoma County climate change mitigation activities through the SES framework. For Sonoma County climate programs, the most important variables were the governance system, interactions, outcomes, users, and the outside setting. Sonoma actors were organizations that were both influenced by and part of the governance system of laws, regulations, commitments, and organizational rules. The governance system and actors were further influenced by outside factors, such as federal agencies and regulations, economic conditions, ecological conditions, and political climate. Actors interacted to create outcomes, which were interventions intended to reduce GHG emissions. Many of these interventions, like the Community Climate Action Plan, were also influenced by user, or county citizen, input. The outputs of the system created effects in terms of resource units, or equivalent tons of carbon dioxide released into the environment, which affected the resource system. Users were also affected by the system's outcomes, both in terms of air quality, and through secondary effects like jobs created and county resources gained or lost.

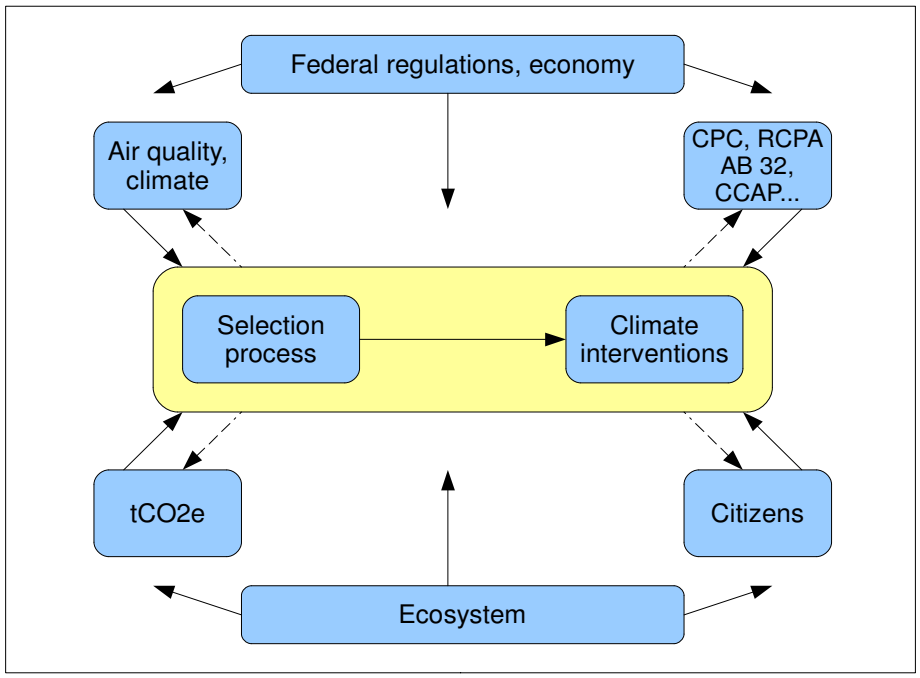

Figure 7. Sonoma County climate change action system represented in the SES framework.

Sonoma County action situation. Sonoma's action situation was mainly comprised of the governance system, interactions, and outcome variables from the Sonoma SES model above. Figure 8 depicts an action situation early in Sonoma's climate activities. The number of participants and positions were relatively few, as were the available actions. The direct potential costs of the available actions were also low, with a relatively small amount of lost time, resources, and public image at stake. The CPC acted as the lobbyist for change, and also provided much of the information concerning available actions. The city and county governments, after weighing the costs and benefits associated with the available actions, enacted resolutions that produced the outcome of adopting GHG mitigation commitments. It should also be noted that control over the potential outcomes differed depending on time scale. Control over proximal outcomes, e.g. the passage of resolutions and institutionalization within county

government organizations, was relatively high. However, control over distal outcomes, e.g. producing the actions, including changes in citizen behavior, necessary to reach the GHG emissions goal, were relatively low under the set of allowable actions. Control over the distal outcomes was also influenced by the focus on climate rather than overall sustainability, as discussed in the previous chapter.

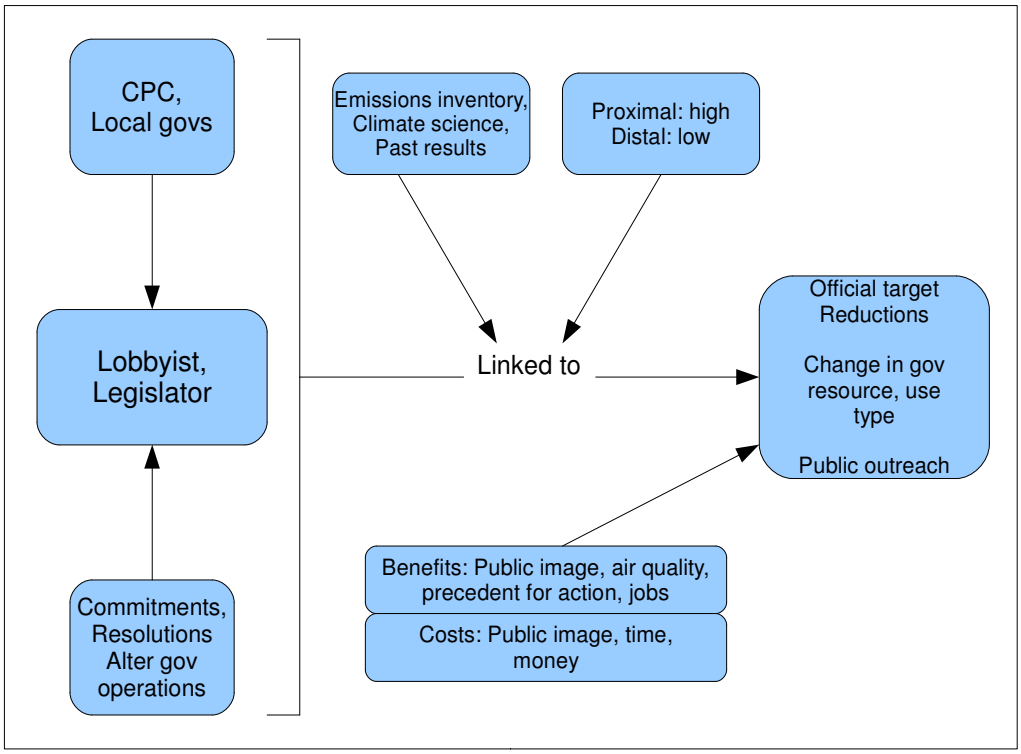

Figure 8. Example of an early Sonoma County climate intervention action situation.

The Sonoma climate action situation became more complex over time. This was a result of several new participants who brought with them new allowable actions, positions, information, and potential costs and benefits. Many of the new participants entered the action situation through programs and requirements associated with institutions at higher levels, such as AB 32. Others,

such as state and federal organizations, entered the situation through associations with resources or the administration of Sonoma interventions. While this increased the total number of allowable actions, the scope of those actions decreased. Allowable actions were now constrained by e.g. the AB 32 scoping plan, the Community Climate Action Plan, and the requirements associated with outside sources of funding and other resources. These actions allowed more pointed influence over sources of GHG emissions, and as such increased control over many of the potential programs' outcomes. But because some of the allowable actions, mainly those supported by outside funding organizations, carried the possibility of sanctions for not upholding their requirements, the potential costs also increased. Figure 9 depicts an example of a current Sonoma climate action situation.

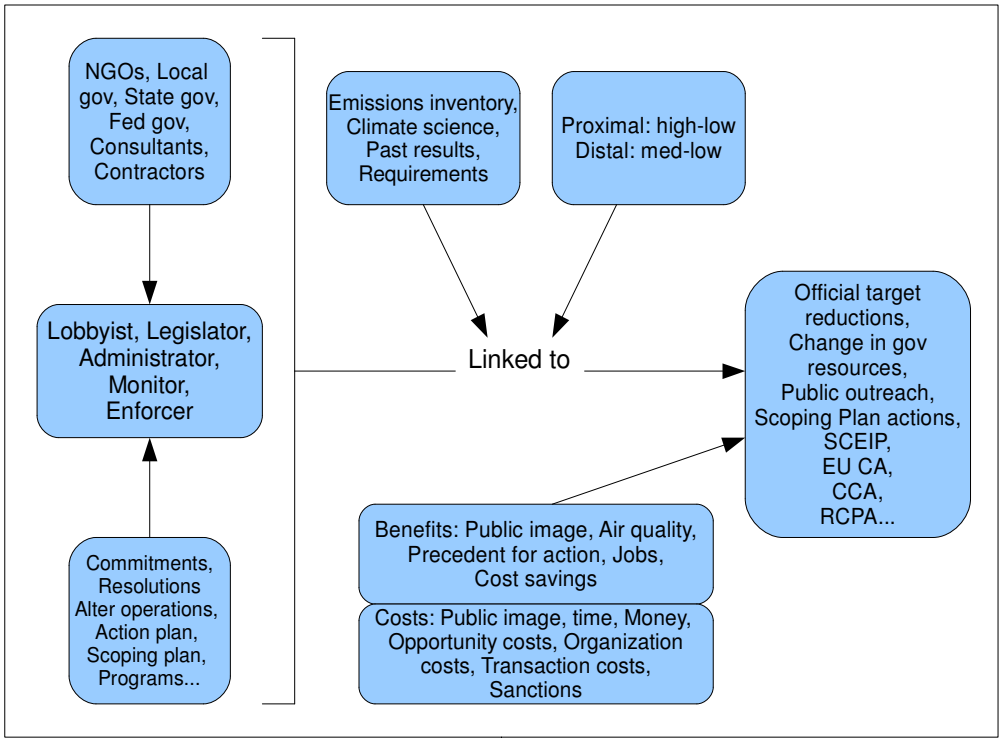

Figure 9. Example of a current Sonoma County climate intervention action situation.

Interview results. Interviews with Sonoma county climate actors largely supported the theoretical construction of the SES and action situation, but also yield additional insights. The compiled interview results are presented in Figure 10, which shows the different activities mentioned for each phase in the program selection process, the enablers and constraints, and who participated. The barriers and carriers results are also presented in greater detail in the supplementary file. When combined with the theoretical program selection process from above, the insights gained from the interviews paint a rich picture of how and why climate interventions are selected in Sonoma.

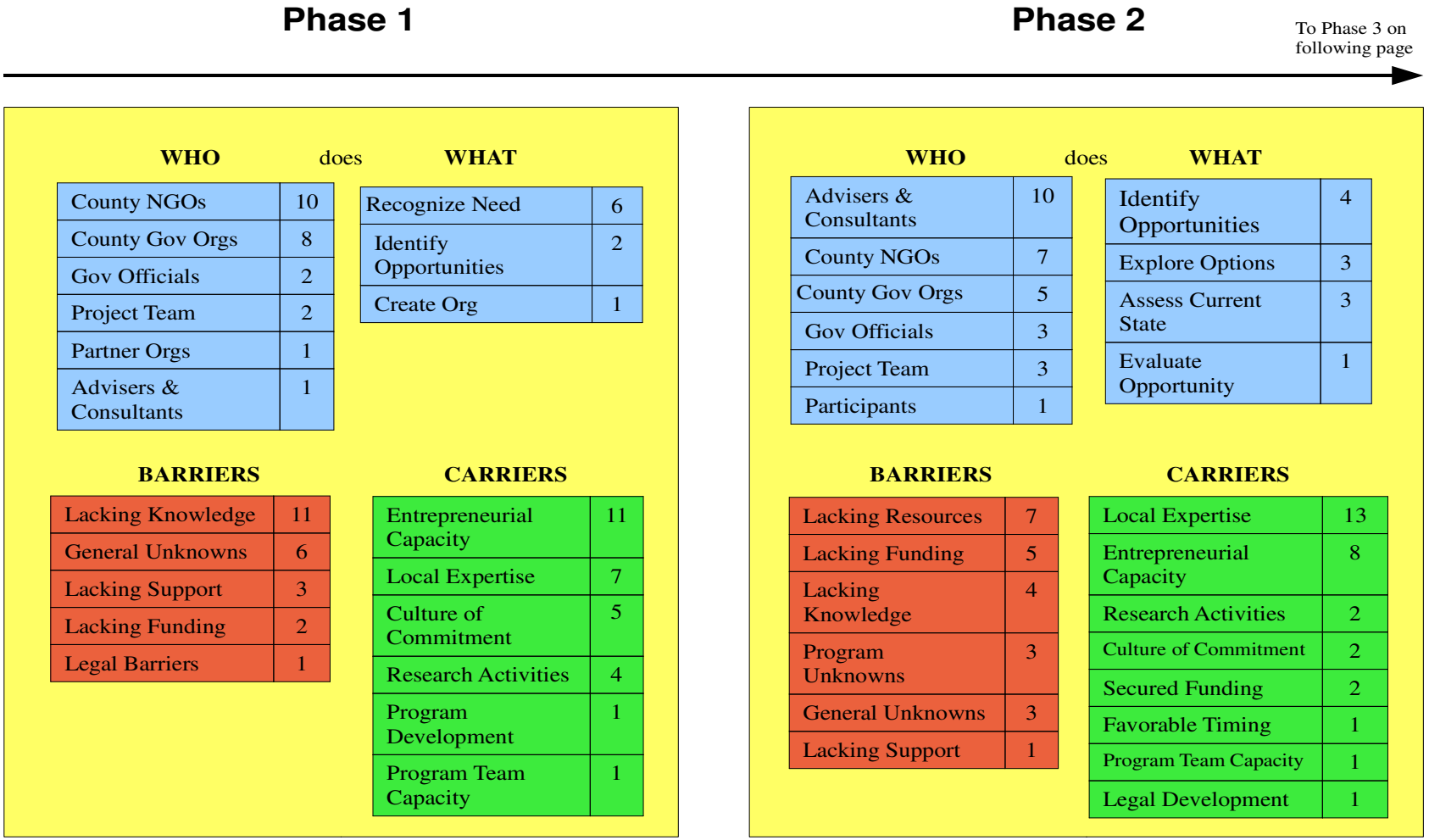

Figure 10. Barriers and Carriers interview results. Labels in tables indicate categories, numbers indicate number of mentions.

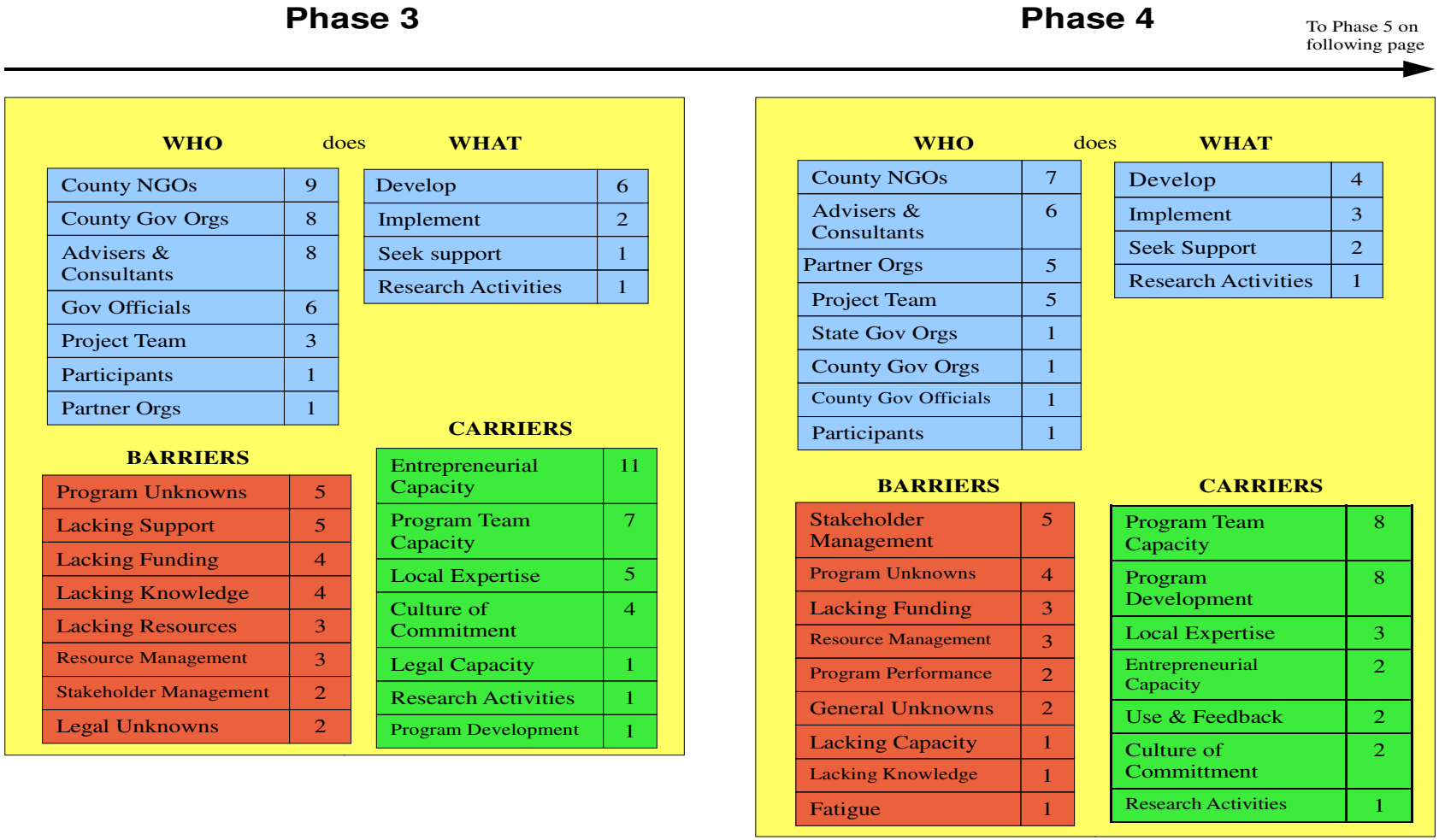

Figure 10. Barriers and Carriers interview results continued.

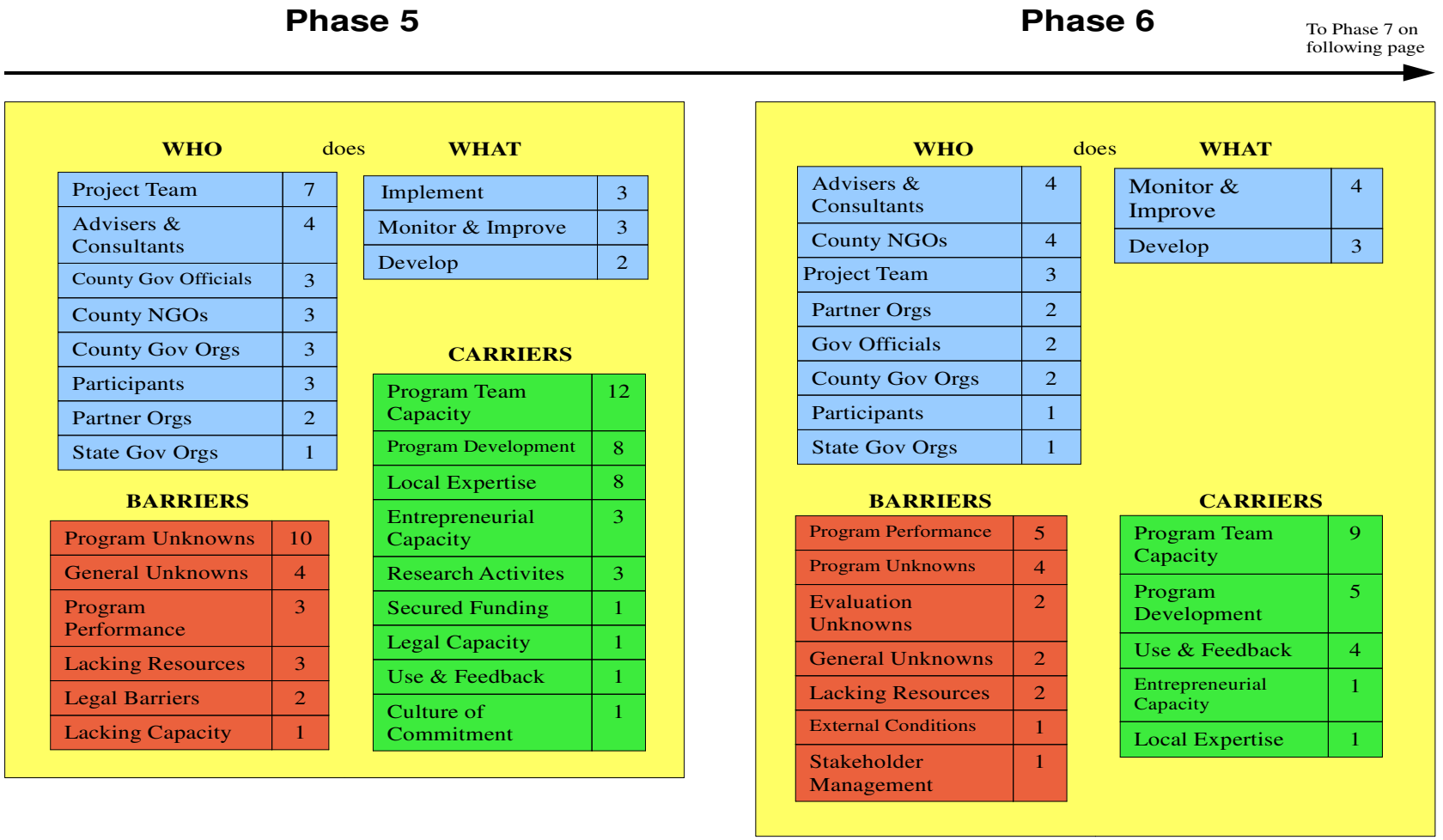

Figure 10. Barriers and Carriers interview results continued.

Figure 10. Barriers and Carriers interview results continued.

Discussion

The first point of note is that Sonoma organizations do not share a process to select interventions. The processes of several organizations have at times converged around one or two interventions, such as the Community Climate Action Plan, and at other times operate independently or in parallel with a few other organizations. Interviewees representing NGOs identified more steps in their selection processes than those representing government organizations. The additional NGO steps usually involved research and program design. This confirmed description of the NGO-government organization relationship described by many interviewees, where NGOs provided information on research and design for programs and government organizations aligned support and provided resources for implementation. NGO's processes were not necessarily more lengthy, they just involved more steps in the research and development phases. The relationship between NGOs and government organizations is discussed in greater detail below.

Combined, the various selection processes can be thought of as the intervention selection system, which align in different ways at different times to produce the interventions that affect GHG emissions in the county. However, there were no formal mechanisms in place for aligning the different processes, or ensuring they all contribute to the same goal. Despite their differences, most of the individual processes selected and developed interventions using a fairly typical development pathway. When viewed as an aggregate system, early activities focused on recognizing the need for action and identifying opportunities to fill those needs. Organizations then gathered knowledge and resources to assess intervention options, and once a path was selected they engaged with a

variety of partner organizations, consultants, and government officials to gain resources and support for development. Organizations leading development usually partnered with other actors for their expertise, to expand the reach of the intervention, or to aid in administration. Interventions programs were implemented by their developing organizations or in combination with partner organizations or consultants. The administering organizations then monitored interventions and gather feedback in order to assess performance and modify as needed.

In the early phases of the processes, participants were generally concentrated in the NGO, adviser, and government organization areas. Interviewees noted that this was due to these organizations' access to broad resources, as well as the local capacity and expertise they represent for dealing with issues involving high levels of uncertainty. As the process progressed, leading participants shifted to members of sponsoring organizations and the project team, which dealt with more specific development issues. Initial planning phases involved a collaboration between experts across several organizations, but as the intervention develops and plans become more concrete, operations were usually internalized between one or two organizations.

Barriers mentioned by interviewees generally began as broad and high-level unknowns, and then moved toward more specific program, resource, and performance issues. Resource concerns generally revolved around funding or personnel, but also included the need for experts in climate interventions and program management, and the need for legal advice for taking unprecedented actions. Barriers that consistently arose later in the process were more specific, and involved unknowns in program design, driving participation, and effective

monitoring and adaptation. This shift from broad to specific barriers in most of the processes was expected, as the uncertainty was steadily reduced by development and increased capacity.

The carriers mentioned highlighted the importance of entrepreneurial capacity, local capacity and expertise, and partnerships with other organizations when working in areas of high uncertainty or "breaking new ground" (SC3, personal communication, November 24, 2011). Interviewees noted that the a strong goal orientation, persistence, and dedication play important roles alongside expertise and resources. Advisers and consultants were noted as very important due to the complexity of the issues and the wide variety of expertise needed to address the numerous sectors affecting GHG emissions. Collaboration between organizations also proved vital for creating new and untested programs. Interviewees also noted that strong funding streams were one of, if not the most, important carrier for many interventions.

The results also highlighted several aspects of the process that cut across all phases. The first was the collaboration between NGOs and county government organizations. An interviewee noted that this was largely due to these organizations' different focuses (SC5, personal communication, February 10, 2012). NGOs have the ability to specifically focus on climate change or sustainable development related issues, while government organizations are concerned with climate change, but are primarily charged with other duties like providing services to citizens. This has led to mutually beneficial relationships where NGOs who may lack funding or support provide governmental organizations with the latest research, monitoring, and program funding searches. In turn, government organizations concerned with climate change but

focused on other duties provide the NGOs support, resources, and policy to enable interventions. One interviewee used the analogy that governments are like sailboats, and NGOs are the wind in their sails (SC3, personal communication, November 28, 2011).

For example, the CPC continually searched for interventions that have worked or showed promise in other locations, and conformed to the criteria of 1) significant potential for GHG reductions, 2) politically feasibly, 3) under local control, and 4) cost effective. If an option showed promise, the CPC partnered with government organizations to further develop and implement the intervention. Similarly, the Leadership Institute for Ecology and the Economy holds a yearly training course to educate elected officials and other leaders on the issues that affect sustainability in Sonoma. Course content focused on current, county-specific issues, which helps leaders select interventions that fit their context. Additionally, the county's contractor network carried out the operational activities needed to administer many climate programs, such as selling and installing efficiency retrofits. Contractor groups were also vital for stakeholder engagement, as relationships of trust often exist between contractors and property owners. Contractors also provided valuable feedback to program administrators about what is and is not working in an intervention. The relationships between NGO and county government groups are thus vital to driving climate action in Sonoma.

All interviewees noted the importance of external influences for successful climate actions. Political will and public support have been vital throughout Sonoma's climate efforts, and neither flagged in the progressively-minded county. However, these have been tempered by the poor national economic

conditions that have persisted since the late 2000s. While county government organizations still develop climate interventions, dwindling resources for local governments heavily influence which programs are promoted. Funding was one of the earliest identified barriers, and interventions that were not essentially cost neutral had little chance of success. Some Sonoma organizations, such as the Water Agency, have access to discretionary funding which allows them to investigate and play a foundational in selecting and developing many interventions. Other organizations addressed funding issues by partnering with state and national organizations to tap into larger resource pools. One interviewee noted that a strategy that worked well for Sonoma was a focus on procuring continuous streams of funding over one-time awards to sustain their programs (SC3, personal communication, November 24, 2011). However, access to funding came with its own costs. Many funding awards had specific performance requirements, which added additional, and at time overshadowing, focuses to the original goal of climate change mitigation. Another interviewee noted that funding barriers also influenced the type of programs that organizations promoted (SC5, personal communication, February 10, 2012). When selecting a new program, potential options were often narrowed down by the types of funding available and what type of programs those funds supported. While these conditions may simply be realities of operating local government programs, it was evident from the interviews that when selecting programs, early decisions had shifted from identifying what was needed to change the system to what was possible given present circumstances.

Most interviewees mentioned feedback, monitoring, and continuous improvement, but these aspects were emphasized to different degrees depending

on the program. Programs administrators relied on a variety of metrics for success, including structural (e.g. jobs performed) and behavioral (e.g. number or participants who adopted new behaviors). Programs were monitored using a variety of methods ranging from focus groups to practitioner response to consultant-led evaluations. Conspicuously absent from the performance metrics mentioned were GHG emissions reduced. Instead, most metrics revolve around more proximal outcomes, such as houses retrofitted, jobs created, or financial savings.

Interviewees still considered the county's 2005 goal of 25% below 1990 levels by 2015 their main driver despite the state-level mandate established by AB 32. This is likely because the county's goal is more aggressive both in target reductions and time scale, and therefore any actions aimed at achieving the county goal should also satisfy AB 32 requirements. Several interviewees reflected this by statements indicating that AB 32 supported Sonoma's activities, but the 2005 county-wide target is still their main goal. Interviewees also indicated the importance of the 2008 Community Climate Action Plan in identifying potential programs. Representatives of both NGO an government organizations noted that one of their earliest actions when selecting a program was to see if it conformed to the strategies outlined in the Plan.

Finally, all interviewees noted that Sonoma's early action in climate mitigation allowed them to weather many challenges that created significant barriers for other counties and municipalities. One example used by an interviewee involved the FHFA's challenge of SCEIP (SC1, personal communication, November 23, 2011). As previously noted, SCEIP is based on the PACE financing structure, which the FHFA determined did not conform to their

Universal Security Instrument. This challenge caused other organizations that were considering or had recently initiated PACE-based programs to suspend operations (Nix, 2010). However, because SCEIP was well established included much legal consideration during its planning, Sonoma was able to defend the program against the FHFA challenge and continue operation.

Legal and political issues can act as barriers or carriers, depending on the outcome. Take PG&E's challenge of Sonoma Clean Power. In order to try and block Sonoma Clean Power and protect their market share, PG&E sponsored Proposition 16, which called for a two-thirds electorate majority vote to approve programs where public agencies enter the energy business. The passage of Proposition 16 would have made it very difficult to establish any type of community choice aggregation or similar program, which represented a potentially huge barrier. The proposition was defeated in June 2010, allowing the intervention to go forward. But it also had unintended positive benefits. PG&E launched an aggressive informational campaign to make citizens aware of Sonoma Clean Power, and though this was meant to highlight the program's drawbacks, it actually exposed many more citizens to the program, building support and easing the promotional burden of sponsoring organizations.

Finally, interviewees also noted that Sonoma's early action many times acted as a barrier since there was no precedent to follow. Sonoma actors have done well thus far in dealing with this uncertainty, and share their insights with others interested in climate mitigation through documents, meetings, conferences, and web-based seminars.

Conclusion

This chapter described the processes Sonoma organizations use to select climate interventions, and discussed how the current institutional structure governing both enables and constrains actions. The results were presented using a theoretical institutional analysis framework, and through interviews with major climate actors in Sonoma. This combination of methods provided a rich picture of Sonoma's intervention system structure and operation.

The results indicated that as Sonoma's climate actions progressed from the planning to the implementation stages, the processes used to select programs became more complex through the addition of actors, available actions, information, costs, and benefits. Organizations choose programs primarily based on available funding and opportunities that correspond to the strategies outlined in the Community Climate Action Plan. Some of those programs had measures of success that differed from the county's GHG emissions target. Because this target was not enforceable, organizations chose programs with more tangible pay-off structures to incentive participation.

Sonoma organizations implemented several programs that successfully motivated actions that reduced GHG emissions, such as increasing residential energy efficiency, expanding sustainable transportation options, and increasing the amount of renewably-generated power in the county's energy portfolio. However, organizations' program selections were often biased by the organization's purpose (e.g. transportation organizations selected transportation programs), and not by a systematic focus on countywide GHG emissions or sustainability. Most interventions focused mainly on behavioral and structural changes that reduced emissions as a by-product.

The system reconstruction will be used in the next chapter to assess Sonoma's intervention selection system against “best practice” principles presented in institutional analysis, transition, sustainability science, and intervention, an evaluation research literature. These principles also form an assessment tool that can be applied to other sustainability transition efforts to evaluate capacity for change, the intervention selection process, and individual interventions.

Chapter 4 – Sonoma County climate intervention system assessment

While the description in the previous chapter shows *how* Sonoma's climate intervention system works, it does little to illuminate *why* it produces the outcomes that it does. Without knowledge of what is working and what is not, we essentially have an example of the black box effect where outcomes are known, but why they happen and how to improve them is a mystery. To avoid this, the intervention process must be assessed against criteria to determine specific points that are functioning well, and those which could be improved.

An assessment tool for evaluating sustainability interventions did not exist, so I created one by compiling principles from the literature from successful SES management and intervention selection strategies. The principles come from a variety of sources, including sustainability assessment and planning (Robért et al., 2002; Wiek & Binder, 2005; Gibson, 2006; Gasparatos et al., 2008; Wiek, 2010), intervention and evaluation research (Glasgow et al., 2001; Rossi et al., 2004; Fraser et al., 2009; Brennan, Castro, Brownson, Claus, & Orleans, 2011), and institutional analysis (Dietz et al., 2003; Ostrom, 2005, 2009). Each field has principles or procedures for influencing complex problems, and when compiled create a robust assessment tool for evaluating the processes used to select climate interventions.

The assessment principles are divided into four groups. The first contains principles that affect the capacity of users to self-organize and sustainably manage SESs. The second group looks at prerequisites required for an effective sustainability planning and governance system. The third group specifically assesses attributes of the intervention process. With the capacity, foundation, and process established, the fourth part of the assessment focuses on the

interventions themselves. These four assessment levels provide a comprehensive appraisal of Sonoma's intervention system, identifying both strong points and areas for improvement.

Methods

For each section, principles were derived from a variety of literature cited in the results section. The literature was compiled by consulting classic works in each area and following sources cited therein, and through expert interviews. The principles are described in aggregate at the beginning of the results section and then in greater detail in each part of the assessment. Sonoma County's climate action system is then assessed against them.

For each criterion, Sonoma's process is given a rating of fulfilled, mostly fulfilled, partially fulfilled, or not fulfilled, and an explanation of the rating and areas for improvement follows. A fulfilled rating means Sonoma organizations completely conform to the principle. Mostly fulfilled means they have made significant progress toward the principle, but still have room for improvement. Partially fulfilled means that they have made some progress, but can improve on the principle significantly. Not fulfilled means organizations have made no progress toward or have not considered the principle. Ratings were determined subjectively considering the data compiled in the previous two chapters. Rating using evidence and personal judgment replicates the way a practitioner in the field would preform the assessment, and is appropriate considering the context-specific nature of sustainability transition processes.

Results

Assessment structure. The literature provided several principles for each part of the assessment. These are listed below by title, description in the

form of an ideal example, and the principle's literature sources (Table 2) . A justification of why the principles were included, and which part of the system they aim to evaluate follows. The justification is divided into four parts which correspond to the assessment sections. These parts build sequentially (i.e. strong capacity for change allows for the creation of a transition system, which houses the intervention selection process, which in turn allows for effective transitions) and thus should be addressed in the order presented.

Table 2

Principles for assessing capacity for change, intervention selection processes, and interventions

Principles	**Ideal configuration**	**Source**
Part 1. Capacity to affect system change	**The system has…**	
Leadership	Strong leaders with entrepreneurial skills and prior management experience, which increases capacity for self-organization and management.	Ostrom, 2009
Norms/social capital	Groups who trust each other and agree on how to interact, which lowers transaction costs making it easier to organize and manage change.	Dietz et al., 2003; Ostrom, 2009
Knowledge of SES	Users who share knowledge and understanding of local SES function, impacts of actions, and purpose of system rules which increases capacity to affect system change.	Dietz et al., 2003; Ostrom, 2009
Importance of resource to users	Users who depend on or attach high value to the resource system, which highlights the need for sustainable management.	Ostrom, 2009
Control over collective choice rules	User autonomy in crafting and enforcing SES management rules, which lowers transaction costs, and increases chances of enforcing rules.	Dietz et al., 2003; Ostrom, 2009
Number of users	A moderate number of users, which allows for effective participation, integration of various stakeholder interests, and actionable intervention strategies.	Ostrom, 2009
Part 2. Prerequisites	**The overall transition strategy…**	

System-based	Uses a cross-sectoral, system-oriented approach to establish a comprehensive, shared understanding of the problem and its drivers and outcomes.	Ostrom 2005, 2007; Gibson, 2006; Ostrom et al., 2007; Fraser et al., 2009; Wiek, 2010
Creates a system-level sustainability goal	Creates, at the outset, a system-level, sustainability-focused goal that the entire process is planned from and strives for and a strategy for achieving it.	Robért et al., 2002; Gibson, 2006; Wiek, 2010
Reflexive, precautionary, and anticipatory	Establishes possible future scenarios in addition to the desired state to assess the outcomes of different types of action. Also acknowledges uncertainty and imperfect information, and assesses long-term and non-linear effects in addition to short term or immediate pay-offs.	Gibson, 2006; Lee, 2006; Gasparatos et al., 2008 Wiek, 2010
Part 3. Process & governance	**The process…**	
Establishes a shared intervention process	Establishes a goal-oriented, shared process for planning, identifying, assessing, selecting, monitoring, and adapting interventions to transition from the current to desired state.	Wiek & Walter, 2009; Fraser et al., 2009; Wiek, 2010
Participatory	Acknowledges and incorporates multiple understandings and perspectives into problem construction, priority-setting, and solution strategies to create ownership and reinforcing gains.	Kasemir et al., 2003; Bäckstrand; 2004; Lee, 2006; Gasparatos et al., 2008; Fraser et al., 2009; Wiek, 2010
Establishes accountability	Establishes accountability for planning, actions, outcomes, and enforcement at outset, and has mechanisms to enforce accountability for these positions.	Dietz et al., 2003; Ostrom, 2005; Gibson, 2006
Transparent	Is transparent about who's involvement, values, perspectives, and goals are represented in all phases.	Bäckstrand; 2004; Gibson, 2006; Wiek, 2010
Establishes trade-off rules	Uses agreed-upon, shared rules or processes for addressing trade-off decisions.	Gibson, 2006
3. Effective interventions	**The intervention…**	

Prioritizes the goal	Establishes the system-level goal as the primary focus.	Robért et al., 2002; Gibson, 2006; Wiek, 2010
Context specific	Includes context-specific variables and broader principles to guide development.	Ostrom, 2007; Ostrom et al., 2007
Targets upstream intervention points	Targets key upstream intervention points and mutually- reinforcing outcomes, rather than sector-specific actions.	Glasgow et al., 2006; Gibson, 2006; Wiek, 2010
Seeks synergistic solutions	Seeks mutually reinforcing, synergistic solutions that affect multiple sectors and are viable both short- and long-term.	Gibson, 2006
Adheres to sustainability principles	Adheres to sustainability principles in all planning and implementation phases.	Robért et al., 2002; Gibson, 2006; Gasparatos et al., 2008
Evidence based	Relies on evidence as a basis for selection and development, and are designed to produce evidence when implemented.	Glasgow et al., 2001; Fraser et al., 2009; Brennan et al., 2011
Adaptive, reflexive, and iterative	Incorporates a continuous learning and improvement approach that monitors and assesses progress and new information often, and allows for modifications as knowledge and conditions change.	Fraser et al., 2009; Wiek, 2010

Capacity for change forms the first part of the assessment because these conditions are necessary before an effective intervention selection process can be created. If capacity for system management is low, the infrastructure for negotiating and supporting interventions will likely be insufficient to drive a transition. However, if the system has sufficient capacity for change, efforts can be put toward developing an effective transition and intervention selection process.

Institutional analysis provides a way to "unpack" system variables to better understand which enhance the capacity of users to sustainably manage the system, and which hinder it. Dietz et al. (2003) and Ostrom (2009) synthesized a number of studies on common pool resource management, and identified ten variables that play important roles in creating capacity for self-organizing and sustainably managing SESs. Six of these variables are under the control of system users, and are thus can be changed if performance is found unsatisfactory. The remaining variables (size of the resource system; productivity of the system; predictability of resource dynamics; and resource unit mobility) involve latent attributes of the system. Though these do influence users' capacity for self-organization and management, they are difficult or impossible to influence and thus not included in this assessment tool. Note that predictability of system dynamics refers to the fundamental knowledge pool on resource systems. For climate change, this would include the comprehensive understanding of climate science and how GHG emissions impact climate systems over time. This mainly scientific knowledge may be difficult for users to change, and therefore was not included in the assessment.

The second group of principles determines whether prerequisites for successful sustainability planning and governance are fulfilled. An effective intervention system is brought to bear only after other planning and strategy activities are put in place. Therefore, organizations must fulfill the prerequisite principles to form the foundation for a successful interventions system. Wiek (2010; Wiek et al., 2011) constructed the transformative sustainability planning framework for creating sustainability transition strategies. The framework contains several steps that form the basis of the intervention strategy phase,

including system construction that concentrates on upstream drivers, visioning of a desired state, and anticipatory scenario analysis. Robért et al. (2002) present a system-based, hierarchical sustainability planning structure that uses principles to plan a system-wide sustainability goal and backcast a flexible strategy for achieving it before moving to actions (interventions) that advance the strategy. Gibson (2006) also compiled principles from sustainability literature into a practical approach for sustainability assessments and planning. This approach relies on a system-understanding, adherence to sustainability and governance principles, and goal setting to create the necessary infrastructure for planning interventions.

After establishing the transition system prerequisites, the third part of the assessment zooms in on the processes organizations within the system use to select interventions. As mentioned above, there are several sustainability planning frameworks that, after creating foundational prerequisites, move on to outline principles that guide intervention selection. Gibson (2006) compiled a comprehensive sets of criteria for planning sustainability actions, and Wiek has developed a body of work (Wiek & Binder, 2005; Wiek & Walter, 2009; Wiek et al., 2011; Wiek, 2010) that builds similar principles into a process for designing sustainability interventions. Robért et al.'s (2002) work also creates a process for contextualizing, planning, selecting, and monitoring interventions. In addition, several of Ostrom's works (2005, 2007; Ostrom et al., 2007) contain principles that SES users have used to successfully identify, select, and design interventions for sustainable governance. Finally, intervention research presents a system-based process approach for developing (Fraser et al., 2009) and evaluating (Glasgow et al., 2001, Rossi et al., 2004) interventions to effectively change

problems in complex systems. These sources give principles and guidance for intervention selection, but unfortunately none (aside from intervention research and some of Wiek's most recent work (e.g. Wiek & Childers, 2010; Wiek, working paper)) go into great detail or construct an actual an intervention selection process. However, when combined, the principles drawn from these various works form the components of an intervention selection system for sustainability challenges.

The primary characteristics of such a process are an orientation toward a shared, system-level sustainability goal that serves to drive action and coordinate the transition process; transparency and inclusiveness, as an effective transition requires buy-in, input, and action from all stakeholder groups; a reflexive, adaptive approach that allows for new information and systems conditions to be incorporated and assessed often (Voß & Kemp, 2006); and effective rules that fit the resources system, which formalize and guide user actions (Ostrom, 2005). An effective process and governance structure for engaging sustainability challenges allows for organizations to move to the final phase: selecting effective interventions.

Effective interventions are needed to drive transitions. As such, principles of well-designed interventions make up the fourth group of the assessment. Intervention research provides several attributes of effective interventions (Fraser et al., 2009) which can be used for evaluating potential options. Despite this knowledge and the obvious need for effective action, a refined method for generating and selecting interventions has so far been absent from most sustainability transitions. Most current efforts simply rely on interventions that are popular, available, or proven effective in theory or other applications.

However, these may not be the interventions needed to affect the SES in the ways required to drive the local transition. This assessment section helps to change this condition by providing principles that organizations can use to help identify and select interventions, and evaluate and improve those already in place. The principles were derived primarily from intervention research literature (Glasgow et al., 2001; Kelly, 2005; Fraser et al., 2009), but also incorporate sustainability principles (Robért et al., 2002; Gibson, 2006; Gasparatos et al., 2008; Wiek, 2010) to ensure that interventions are specific to sustainability transitions.

Fulfilling the four principle groups will give organizations increased ability to drive sustainability transitions. Below is the assessment as applied in Sonoma.

Part 1: Capacity for change. While no SES with multiple user groups and complex system dynamics is easy to manage sustainably, there are many examples of success (e.g. McCay & Acheson, 1987; Baland & Platteau, 1996; Dietz et al., 2003; Ostrom, 2005). In the Sonoma case, users have made major efforts to enhance their capacity self-organize to sustainably managing GHG emissions (Table 3). This is a step in the right direction, as self-organized management has often proven more successful than top-down change strategies which may prescribe solutions at odds with local needs (Ostrom et al., 2007). In Sonoma, performance on the majority of the variables is satisfactory or improving, and the system capacity for change is high.

Table 3

Sonoma's performance on capacity principles

Capacity principle	**Sonoma fulfillment level**
Leadership	Fulfilled
Norms/social capital	Fulfilled
Knowledge of SES	Mostly
Importance of resource to users	Not
Collective choice rules	Partially
Number of users	Fulfilled

Leadership – Fulfilled

Description. Leaders with strong network connections and desire to affect the system increases capacity for self-organization and management. Entrepreneurial skills and prior management experience also aid organizations' ability to change the system. Systems without strong leaders may find it difficult to gain momentum and support for change. Additionally, leadership and capacity should be cultivated throughout the system as transitions that rely on a single or small group of leaders are vulnerable to stalling if leadership changes.

Sonoma assessment. Strong leadership has undoubtedly played a large role in Sonoma's current capacity for changing. Strong, capable individuals brought to fruition the county-wide commitment to reduce GHG emissions, the Community Climate Action Plan, and the focus on climate change in county and local politics. Strong leadership has also played a crucial role in administering and maintaining Sonoma's current set of climate interventions.

Recommendation. Sonoma should maintain and continue to widely cultivate its high leadership capacity as it will play a continued role in promoting self-organization and sustainable management of the transition.

Norms/social capital – Fulfilled

Description. Systems with user groups who trust each other and agree on interaction rules enjoy lowers transaction costs, making it easier to organize and manage change. Users who share the view that action is necessary, and generally agree on effective paths for change also have high capacity for managing the system. Systems with users who do not agree on the need for action, the types of actions, or rules of engagement between groups may have difficulty in gaining support and coordinating interventions.

Sonoma assessment. As indicated in the interview results, the positive effects of Sonoma's strong leadership have been closely tied with the norms and social capital that exist within and between user groups. County climate organizations often collaborate on designing and administering interventions, and rely on relationships of trust and reciprocity to obtain information and resources to organize their actions. Additionally, many interviewees noted that the county culture and local capacity for supporting sustainability action has allowed for extensive organization and interventions.

Recommendation. This local capacity and norm of engaging sustainability issues is vital in the county's ability to manage the climate SES and should be maintained and promoted in addition to intervention planning.

Knowledge of SES – Mostly fulfilled

Description. Systems with users who share knowledge and understanding of local SES function, impacts of actions, and purpose of system rules have increased capacity for change. This shared understanding is closely tied to the social capital principle, but deals more specifically with how users understand the effects of actions on the system. If users share an understanding of how their

individual management actions affect system function, then organization costs will be lower and groups can more effectively craft management rules. However, if users disagree or do not know how their actions affect the systems, information and transaction costs will be much higher.

Sonoma assessment. As noted in the previous section, the predictability of the global climate system is not easily influenced by Sonoma users, but it is closely linked with the knowledge of the local SES and warrants discussion. In recent years climate scientists have rapidly advanced our understanding of climate system dynamics (Solomon, Qin, & Manning, 2007). However, due to extreme complexity there is no shared model nor way to reliably predict effects, both positive and negative, of management actions (e.g. Araújo & Rahbek, 2006; Stern, 2006). There is also considerable disagreement in current political discourse around the existence and effects of climate change (Selin & VanDeveer, 2007).

However, Sonoma organizations are attempting to improve their knowledge of (and ability to predict) the climate system through iterative emissions assessments, development of the RESCO model, and improved accounting methodologies. Information is shared with users via public reports and engagement events, which helps create a shared understanding of how the system functions, what the impacts of actions may be, and why rules are needed to manage the system. Shared knowledge of the system both adds to individuals' knowledge, and engenders the positive sustainability norms and social capital mentioned above–all of which enhance the capacity for sustainable management.

Recommendation. Efforts to better understand the system should continue, and organizations should also keep abreast of the latest climate

research both to understand global climate dynamics and discover potentially scalable interventions for use at the local level.

Importance of resource system to users – Not fulfilled

Description. Systems with users who depend on the SES for their livelihood, or attach high value to the system, have an increased capacity for change and management. Users who find the system important are more likely to understand need for sustainable management, and recognize the need for change when undesirable effects are present. However, if users are not closely tied to the system, they may not notice the negative outcomes of unsustainable action, or may not give high priority to taking action to change the system.

Sonoma assessment. The importance of the resource system to users plays the largest role in hindering Sonoma's capacity to change and manage the climate SES. Sonoma users, like most others, do not place the climate system at the forefront of their concerns, especially considering other pressing issues like poor economic conditions. However, if climate change continues unabated, Sonoma users may attach greater importance to the system as a significant portion of the county's economic identity is based on wine-making, which can be highly climate-dependent (Nicholas & Durham, in press). This is not to suggest that conditions must worsen before users will organize for action. Other studies have demonstrated success in spurring sustainability actions through the compounding effects of publicly-visible altruistic behavior (Milinski, Semmann, Krambeck, & Marotzke, 2006) and barrier-targeted social marketing (McKenzie-Mohr, 2011).

Recommendation. Climate organizations must determine ways to increase the importance of the climate SES and convey the costs of inaction to users. Even

with well-designed programs in place, if users do not see the need to take climate action they are unlikely to participate. Sonoma organizations have made efforts to increase the importance of taking action mainly through economic arguments (e.g. climate change mitigation also reduces energy costs), or presenting actions as an "add-on" (e.g. programs allow users to complete already planned renovations in a "green" way). However, neither of these approaches has produced the desired levels of participation. Sonoma organizations should continue to seek novel ways to increase the importance of the system in order to broaden the base of support and action for GHG reductions.

Control over collective choice rules – Partially fulfilled

Description. Users who can autonomously make and enforce management rules have a higher capacity for system change. The ability to craft rules lowers transaction costs between SES users and higher level organizations, and allows users to create rules that fit the local context. Rules that fit the system are vital for support and participation, since users who do not agree with rules in their local context are less likely to abide by them (Ostrom, 2005). Additionally, if users are given autonomy in enforcing their rules, they are better able to coordinate actions internally and defend against mismanagement of the SES for outside groups.

Sonoma assessment. Sonoma organizations have been able to create many collective-choice level rules that encourage sustainable change. The ability to create these rules itself enhances change capacity, and the rules have allowed users to initiate interventions such as the emissions reduction commitment, the formation of the RCPA, and the ability to carry out the SCEIP and CCA programs. However, many of Sonoma's rules lack enforceability–an aspect that hinders the capacity to change the SES (Dietz et al., 2003; Ostrom, 2009). If users see no way

to enforce management rules, they may be less likely to take action. Even when they do take action, the inability to sanction those who do not conform to the rules makes sustainability more difficult to achieve.

Number of users - Fulfilled

Description. The number of users can have significant effects on capacity for self-organization an change. As Ostrom (2009) demonstrates, large numbers of users can greatly increase organization and transaction costs, and make it difficult to incorporate all the various stakeholder interests and meet different groups' needs. A large user base can also make monitoring difficult. Conversely, a small number of users may find it difficult to create rules that effectively govern the wider system, and the costs of monitoring and enforcement can be much higher as they are split between fewer users. Therefore, moderate sized systems seem to work best for sustainable management. However, number of users can have varying effects depending on the specific system under review (Ostrom, 2009). Though number of users may seem difficult to influence from a structural standpoint, from a management and governance perspective it can be accomplished by changing the boundaries of the system. For example, if Sonoma County had a larger citizen base that made county-scale interventions difficult, it could reformulate its intervention strategy to take place at the city-level. As long as the same set of guiding principles are used, interventions created in subdivisions of the system will contribute to the overall transition goal.

Sonoma assessment. Sonoma has an advantageous arrangement as it is a moderate sized county, and many of its citizens are interested in sustainably managing the climate system. The county's moderate size makes it easier to engage citizens groups compared to an area with a higher population. However,

as indicated by the evolving action situation in Chapter 3, the increasing number of users and governance structures has led to higher organization and transaction costs.

Additionally, Sonoma's modest population growth (U.S. Census Bureau, 2012) has mixed effects. Though more people equal greater GHG emissions, Fragkias and Lobo (2010) found that in US counties every one percent of population growth brings with it 0.87 percent increase in carbon emissions. Essentially, as population grows, the counties become more emissions efficient. The effect is even more pronounced for percentage economic growth (0.81 percent emissions increase per one percent GDP increase). While population growth does increase GHG emissions, it does so in a non-linear fashion, again supporting the position that number of resource users has variable effects on the ability to self-organize and sustainably manage the SES.

Recommendation. Sonoma's moderate number of users enhances the capacity for organization and change. However, if the county continues to grow, it may need to switch actions to the city- or another smaller level.

Part 2: Prerequisites

Selecting interventions is but one phase in a larger process for planning and executing sustainability transitions. As such, organizations must establish a broader process for planning sustainability transitions before creating an interventions system. The prerequisite principles represent aspects of the process identified in sustainability literature as necessary for sustainability transitions. The principles were derived primarily from Wiek (2010), who presented a comprehensive process for planning and driving sustainability transitions; Gibson (2006), who identified the principles necessary for planning

sustainability actions, and Robért et al. (2002) who created a hierarchical system for planning sustainability transitions.

Table 4

Sonoma's performance on prerequisite principles

Prerequisite principle	**Sonoma fulfillment level**
System-based	Partial
Creates a system-level sustainability goal	Partial
Reflexive, precautionary, and anticipatory	Partial

System-based – Partially fulfilled

Description. Literature on intervention and planning frameworks that aim to sustainably affect change, regardless of the subject or field, all call for a system-based understanding of the problem context. The system construction of the problem should include all contributing factors and how they interact. More specifically, the transformative sustainability planning framework (Wiek, 2010) recommends a system construction that focuses on upstream drivers that produce "downstream" effects. By focusing on upstream drivers, solutions are created by intervening in the underlying structures that lead to negative outcomes. If interventions occur downstream, improvements will be incremental and may never create the inertia needed to transform the system. Interventions that change the system far upstream also help avoid situations where actions focused on in one sector create negative or unintended outcomes in another.

Sonoma assessment. Sonoma organizations established a system-level understanding by inventorying (Orrett, 2005) and updating (Erikson & Hancock 2006, 2008, 2009, 2010a; CPC, 2008) their overall GHG emissions. However,

the inventory focuses attention primarily on the total GHG emissions, and does not include the upstream drivers that eventually cause the downstream emissions outcomes. Without upstream drivers, it will difficult for organizations to identify high-leverage intervention points to meet the 2015 target.

Recommendation. Sonoma should augmenting its current GHG emissions system construction with upstream drivers. Though details were unavailable, the RESCO model that is currently in development may help to fill this need. Improving the system construction will also allow for improvements in many other parts of the process, as noted below.

Creates a system-level sustainability goal – Partially fulfilled

Description. A desired sustainable vision state should be the main motivator for all interventions (Gibson, 2006), and the goal should be established early in the planning process (Robért et al. 2002; Wiek & Binder, 2005; Wiek, 2010). A strategy based on an overall sustainability goal serves to coordinate and guide action over the long-term, and ensures that actions in different sectors still contribute to the sustainability of the system. Furthermore, a broad goal such as sustainability is necessary to guide transitions in complex systems. For example, if GHG reductions are the primary goal, interventions that do reduce GHG emissions could also create configurations of infrastructure, technology, or behavior that are unsustainable in the long run, simply leading to new problems. However, if the transitions is based on sustainability, which includes a sustainable climate system, then interventions that adhere to the guiding sustainability principles will also reduce GHG emissions (Robért et al., 2002).

Sonoma assessment. Sonoma County has long recognized the imperative to combat climate change (Orrett, 2002). For example, the Community Climate

Action Plan explains the global need for climate change action, as well as the economic imperatives and potential benefits for local economic, social, and environmental systems. However, the goal of moving to a low carbon system was left implicit, while the focus of climate action was explicitly placed on reducing GHG emissions to a specified level. Without a shared, high-level goal to prioritize and work toward, it is difficult to coordinate actions between organizations over time (Gibson, 2006). However, if organizations create an overall sustainability vision that includes *but is not limited to* climate change, and then backcast a strategy for reaching it, interventions that adhere to the strategy and sustainability principles will help move toward the vision while simultaneously curbing emissions (Robért et al., 2002). Though Sonoma's 2005 commitment and subsequent GHG reduction target are strong motivators for action, they may not carry with them the longevity and high-level aspirations that can create long-term and trans-sectoral change.

Recommendation. Sonoma organizations should create and prioritize a sustainable system state. This desired state will form the focal point for planning intervention strategies, and the 2015 target can still act as a milestone in the overall transition process. Placing focus on achieving the desired state rather than meeting the target will give organizations the ability to plan and coordinate for long-term, sustainable actions that fuel the transition to a sustainable and low-carbon system.

Reflexive, precautionary, and anticipatory – Partially fulfilled

Description. The SES framework, intervention research, and the transformative sustainability planning framework all acknowledge the complexity

and uncertainty associated with sustainability solutions, and work to harness complexity to identify high-leverage intervention points. It is important to acknowledge that information in such complex systems will never be complete, and therefore action cannot be based on such requirements. To address complexity and uncertainty, sustainability and transition strategies use an iterative and reflexive approach, which allows new information to be incorporated frequently and interventions to be adapted accordingly. Thus, rather than be stifled by lacking information, a functional intervention process allows for information to be incorporated as it becomes available. The precautionary principle also plays heavily into sustainability decisions (Gibson, 2006) so that unintended negative outcomes do not result from actions that were taken without the requisite research into long-term effects.

It is vital to include procedures for anticipating and assessing the potential effects of actions before they are implemented (Lee, 2006). Though long-term prediction is impossible for complex systems that house wicked problems, anticipation can be help decision makers avoid decisions that create unintended negative outcomes or unwanted path dependencies. Scenario construction and analysis can be a useful method for assessing potential system-wide effects of interventions (Wiek, Binder, & Scholz, 2006; Wiek & Walter, 2009). The transformative sustainability framework points out the importance of creating anticipatory scenarios to refine action plans by creating rich "pictures" of possible future states, including the goal state and business-as-usual (Wiek, 2010; Wiek et al., 2011).

Sonoma assessment. The Community Climate Action Plan presents several scenarios outlining the potential effects of different suites of

interventions, as well as continuing on a business-as-usual emissions trajectory (CPC, 2008). However, it was unclear from the Chapter 3 results whether other organizations carry out anticipatory scenario analysis, or if the scenarios in the Plan have been updated to reflect current conditions. The updates administered by the CPC did incorporate new information on a somewhat regular basis, but it seemed to mainly be used to assess the (in)effectiveness of current interventions, rather than as the basis for identifying new actions. Additionally, for the areas where progress has been slow, such as accurate data sources and emissions accounting methods, complexity and uncertainty have been difficult to overcome, and at times have been posited as an excuse for lacking progress. Most interviewees did note that their selection processes included an assessment phase where the potential short- and long-term outcomes of programs are explored. Interventions thus far have also adhered to the precautionary principle by not taking drastic or path dependent actions without due investigation and focus on potential long term effects.

Recommendation. In the future Sonoma organizations should adopt anticipatory methods that create rich pictures of the potential outcomes of climate interventions. Such pictures should go beyond quantified emissions reductions and include descriptions of effects across the system, as well as qualitative aspects such as descriptions of quality of life for citizens. Anticipatory tools should also include a way to update scenarios as conditions change so decision makers can have the most relevant information at their disposal when selecting interventions. Organizations should continue and more explicitly adhere to the precautionary principle when selecting interventions, especially if future intervention strategies are targeted at upstream drivers that have profound

implications for system function. Additionally, organizations should address complexity and uncertainty as inherent parts of the climate SES, and work to rectify or circumvent shortcomings such as lacking data or insufficient accounting methods.

Part 3: Process and Governance

Once the prerequisites are fulfilled, a strong intervention system is necessary for selecting effective actions. Such a system relies on sound governance principles to create an inclusive, system-focused process to implement interventions that drive the transition and address stakeholder needs. The principles come from literature on selecting interventions for governing sustainability transitions listed in Table 2. These studies indicate that processes that strongly incorporate the following governance principles will have a high likelihood of selecting successful sustainability interventions. Thus far, Sonoma organizations have had only moderate success in fulfilling many of the principles (Table 4). However, they are not alone in this struggle. These principles are not the norm, and are thus difficult to incorporate into deeply entrenched governance regimes. Sonoma's high capacity for change provides an advantageous platform for organizations to continue to integrate and improve on the principles below.

Table 5

Sonoma's performance on process and governance principles

Process principle	**Sonoma fulfillment level**
Establishes a shared process	Partial
Participatory	Not
Establishes accountability	Not
Transparent	Partial
Establishes trade-off rules	Not

Establishes a shared process – Partially fulfilled

Description. Sustainability transitions literature points out the importance of constructing a shared, reflexive process for identifying and selecting interventions to change the system (Wiek & Walter, 2009; Loorbach, 2009; Wiek, 2010). Intervention research also promotes a systematic process for selecting interventions to address undesired outcomes (Fraser et al., 2009). Without a coordinated selection process, it is difficult to identify system-level intervention points, monitor performance, or understand why interventions create the system-level outcomes that they do. A shared transition process also ensures continued progress toward the goal. Without a transition process, interventions may be selected *ad hoc* and not drive transition or target system-level needs.

Sonoma assessment. The CPC and collaborators detailed a system-wide transition process in the 2008 Community Climate Action Plan. The Plan presented options for reducing GHG emissions across all sectors and showed several avenues for reaching the 2015 target. It called for coordinating emissions reductions across organizations, as well as widespread participation from cities and citizens. During interviews, respondents all indicated that they supported the action plan and try to adhere to it whenever possible.

However, this has not translated to a coordinated transition process that moves the system toward the target. Sonoma's various organizations do not employ a standard or shared process for selecting interventions, and focus mainly on their separate sectors. This is supported by the interview results which show that while many organizations' intervention selection processes are similar, they can differ greatly as far as which actions take place, and when. Several

interviewees noted that their organization follows no selection process, pursuing whichever programs become available. Furthermore, there is little coordination between organizations to determine what the needs are for the climate system at large, and how they can collaborate to fill those needs.

These *ad hoc* actions are largely due to the fact that while most organizations are concerned with climate change, their primary focus lies within a specific sector of the GHG emissions system. This is especially true for governmental organizations. Organizations pursuing their own climate agendas take viable opportunities to implement programs that could reduce GHG emissions in their sector, but these may not be the best interventions to meet system-level needs. Even Sonoma's climate-focused organizations do not share a selection process to systematically identify interventions across the GHG emissions system, instead relying primarily on strategies presented in the 2008 Plan and reacting to current opportunities. These opportunities may indeed reduce GHG emissions, but they may not create the changes in the system that current conditions require. Without a shared process or coordinating body it will be difficult to align various organizations' actions in a way that creates synergistic gains in GHG reductions to efficiently moves toward the 2015 target.

Recommendation. Considering Sonoma's various climate-focused organizations, a multi-level intervention selection process consisting of a system-wide coordination and individual sector levels could be a successful orientation for local climate-change mitigation(Ostrom, 2010). This process would be nested within larger regional, state, and national levels of climate action. Nesting levels of climate action would help drive the overall transition (Rotmans et al., 2002; Dietz et al., 2003), and avoid panacea recommendations that can result from

high level, top-down actions (Ostrom, 2007). At the system level, one or several climate-focused organizations would be responsible for identifying system needs and effective intervention points, and monitoring progress. The RCPA would be an excellent candidate for this coordinating position as it is a government organization involved in county operations that is specifically focused on climate change, making it less likely that competing interest could deter its focus. A climate-focused NGO, such as the CPC would form a good match for this position by continuing their research focus and providing support for the RCPA's action and recommendations.

Participatory – Not fulfilled

Description. Highly complex sustainability problems that include aspects of environmental, social, cultural, and economic systems, as well as high levels of uncertainty, require new types of knowledge production that includes participants alongside experts in all phases of research (Nowotny, Scott, & Gibbons, 2001). Thus, including all relevant stakeholder groups throughout the process for selecting sustainability interventions is crucial (Kasemir et al., 2003), but also sometimes difficult (Talwar et al., 2011). Stakeholders have a greater sense of context-specific requirements for changing the system (Potvin, Cargo, McComber, Delormier, & Macaulay, 2003), and interventions that incorporate their needs can be more successful since users are likely to take action on things they find important (Gibson, 2006; Fraser et al., 2009; Wiek, 2010). However, as Bäckstrand (2004) points out, there also must be balance of traditional "expert driven" knowledge production and participatory methods, depending on the context. Regardless of this balance, participation is vital for sustainability transitions, as it is ultimately changing peoples' attitudes and actions that will

create more sustainable SESs. Participation in administering and monitoring interventions ensures that target populations' input is received, which can highlight more effective areas for improvement than traditional monitoring metrics. Finally, as sustainability solutions aim to positively affect all parts of the system for both the short- and long-term, it is vital that the viewpoints of traditionally under-represented groups, such as low-income citizens, minorities, and future generations, are included.

Sonoma assessment. In Sonoma, most climate interventions are planned by government organizations or NGOs and then released to the public. There is some input from focus groups and survey feedback, as well as engagement events to publicize programs and educate citizens. However, there are little to no opportunities for citizens to participate in selecting and designing programs that fit their needs.

Recommendation. Sonoma should adopt mechanisms to incorporate and manage large-scale public input in its intervention planning and selection processes. Public input will not only highlight system needs that may be missed by climate organizations, it will also likely lead to greater participation in interventions, and as a result greater emissions reductions. Public participation is crucial in Sonoma, because a successful county-wide transition will depend heavily on the collective action of citizens. Additionally, climate organizations should continue to encourage participation from diverse range of organizations, but should also work to coordinate these activities to lower costs and leverage overlaps in focus between organizations and sectors.

Establishes accountability – Not fulfilled

Description. Multiple SES and institutional studies confirm that

accountability for monitoring and performance are vital for collective action and governing SESs (Dietz et al., 2003; Ostrom, 2005). However, top-down enforceability is not necessary for effective governance. Ostrom, Walker, and Gardner (1992) found that actors who are able to freely communicate, construct a shared goal, and have options for internal sanctioning can effectively self-govern complex systems. If organizations know that they are accountable for their performance, and that sanctions exist for non-compliance, they will be motivated to select interventions that meet system-level needs. Additionally, if rules are enforceable, users have the ability to protect their system from outside threats.

Sonoma assessment. Though almost all Sonoma organizations have committed to meeting the 2015 target, accountability for reaching the target and ensuring program performance was not established. In this respect, Sonoma is representative of all climate efforts since none contain enforceable rules and lack mechanisms for accountability. Even the state-level AB 32, which is enforceable by law, is very ambiguous as to who is responsible for imposing sanctions if performance benchmarks are not met. Enforceable rules like legal rulings have allowed Sonoma organizations to take actions that were previously restricted, like SCEIP, and defend their right to pursue interventions like CCA. However, there is little to no evidence of accountability positions for monitoring and driving performance toward the 2015 target. Additionally, since the 2015 target is not enforceable, it may be more difficult to spur continued system-wide action.

Recommendation. Sonoma organizations both freely communicate and share the 2015 target, and this has been large factor in why they were able to self-organize to the level they have. However, adding sanctioning mechanisms and assigning accountability for monitoring and performance will likely engender

more effective interventions and coordination between organizations. Sanctions do not have to impose fines or other "hard" penalties. Normative methods, such as pointing out under- and high-performers, can be effective to correct or encourage action. Accountability positions should be directly tied to intervention performance and progress toward the system-level goal, and should include options such as normative sanctions for when targets are not met.

Transparent – Partially fulfilled

Description. All the literature used to compile the process and governance assessment principles note the importance of transparency for creating trust and encouraging participation in interventions. As sustainability is inherently a user based and normative pursuit, transparency about who's values are represented and why, and what the goals of the intervention and transition are, is vital and highly tied to inclusiveness and participation (Wiek, 2010). Transparency allows users to understand and engage in the process, and thus encourages participation and input which, as discussed previously, helps create a rich understanding of the system and identify effective intervention points (Gibson, 2006). Finally transparency is important for gaining and maintaining trust and support–a important component for maintaining the social capacity that contributes to capacity for change.

Sonoma assessment. Many Sonoma climate interventions have included public information sharing, and some have included transparency around their methods and motives. This is especially evident in the Community Climate Action Plan, which details its reasons for taking climate action, who is involved, what they hope to accomplish, and the criteria for selecting action. Such examples of transparency were likely a major factor in the early support climate action from

organizations and elected individuals in the county. However, the specific details on why and how the 2015 target was established (e.g. why 1990 was selected as a baseline for sustainability) are not transparent. In addition, subsequent interventions have not been as clear about how they were selected and why, which organizations play which role, or who the intervention targets and what it hopes to accomplish. This is not to imply that organizations are intentionally masking details of the interventions or selection process. Many have just not taken direct actions to improve transparency, which is vital for maintaining buy-in and support from other organizations and citizens.

Recommendation. Sonoma organizations should be highly transparent in future climate actions. Thus far, transparency has played a central role in the development of the CCA program, but others programs under development lack this level of visibility. Increasing transparency will maintain the relationships of trust and support currently enjoyed between organizations and users, and may help point out opportunities in interventions not realized by their developing organizations.

Establishes trade-off rules – Not fulfilled

Description. Gibson (2006) notes the importance of establishing and following trade-off rules, and presents several methods for doing so. Trade-off rules help ensure that short-term pay-offs do not override the long term goals of the transition. They also work to make sure that the overall system goal is maintained as the prime motivator of action, and that sectoral needs to not dominate intervention selection. Shared trade-off rules also help build an understanding of how organizations should engage each other, which enhances the foundational capacity for change.

Sonoma assessment. The results of the document review and interviews did not reveal any efforts by Sonoma organizations to establish trade-off rules. Trade-off rules were likely not intentionally left out of the intervention selection processes; they are simply not a common feature of planning action systems.

Recommendation. Sonoma should adopt trade-off rules to ensure continued progress toward the goal and avoid negative outcomes from conceding to the demands of short-term needs.

Part 4: Interventions

Though a robust process for selecting interventions can aid greatly in changing the system, it is the interventions themselves that ultimately drive the transition. When coupled with a large capacity for change, strong transition process, and sound selection system, interventions that adhere to the principles listed below will have great potential to drive system transitions. Selecting effective interventions is very important in "real world" contexts, where programs gather inertia that prevents resources from being used for other actions. For example, many programs are funded by long-term grants and are designed to work over a long period of time, or indefinitely. Therefore, it is vital to ensure from the outset that the programs supported are the best for system given current conditions and information. Sonoma organizations have selected interventions that somewhat fulfill the principles (Table 6), which highlights areas for improvement that can be used to select a highly effective "next generation" of climate interventions in the county.

Table 6

Sonoma's performance on intervention principles

Intervention principle	**Sonoma fulfillment level**
Prioritizes the goal	Partial
Context specific	Mostly
Targets upstream intervention points	Not
Seeks synergistic solutions	Partial
Adheres to sustainability principles	Partial
Evidence-based	Mostly
Adaptive, reflexive, and iterative	Partial

Prioritizes the goal – Partially fulfilled

Description. It is important for interventions that create system-level change to focus on the system-level goal. Though this may seem obvious, the goal-orientation that drives the selection process can be circumvented at the intervention level by sectoral or short-term needs (Gibson, 2006). Aspects that take attention away from the goal may be context-specific, or pressures from the landscape level like changes in economic or political configurations. If interventions are selected primarily for their ability to fill system-level needs and move toward the overall goal, they will drive the transition process much more effectively than those which are selected based on short-term or narrow pressures.

Sonoma assessment. Though most organizations stated that the 2015 target was their top priority, other factors often out-competed it in terms of focus and resources. Specifically, the reality of limited funding heavily influenced the types of interventions considered, often acting as the primary criteria in program

selection. This condition is not unique to Sonoma; government-backed interventions often have to rely on outside funding or be cost neutral due to economic conditions. In Sonoma, funds to support climate interventions were usually not available from city or county sources, causing organizations join state or national partners to gain access to resources. Though this allowed organizations to take action, it also changed the focus and priority of the intervention. Additionally, when organizations aligned with others to secure resources and funding for programs, they sometimes shifted their focus and measures of success from GHG emissions to other metrics. Outside funding sources often came with their own performance requirements, and when Sonoma organizations aligned with such partners, they shifted their focus as well.

Recommendation. Low funding levels and shifting program requirements are realities of "on the ground" action, but if they are allowed to overshadow the broader goal, change, if it happens at all, can be slow and difficult. Sonoma organizations should follow the example of interventions like the Community Climate Action Plan and Real-time Rideshare, which were identified and selected based on their ability to meet system-level needs. Moving the toward the goal should form the primary criteria for intervention selection. The CPC adheres to selection criteria which place GHG reductions as the major priority, and other organizations should follow their example. Once interventions are selected in this manner, organizations should seek support and resources to carry them out.

Context-specific – Mostly fulfilled

Description. Nearly all literature on climate action (e.g. Sathaye, 2007; Ostrom, 2010) and sustainability transitions in general (Rotmans et al., 2001, Ostrom, 2007, 2009; Wiek & Binder, 2003; Wiek, 2010) note the importance of

context specific interventions to affect local SESs. This is why creating a detailed systems construction is necessary. Understanding the system allows users to identify context-specific interventions that can create the greatest local effects (Fraser et al., 2009; Wiek & Childers, working paper). This is akin to a doctor understanding the needs of an individual patient before prescribing a treatment plan. General interventions born from high-level top-down recommendations have less chance of creating the desired effects (Ostrom, 2007).

Sonoma assessment. Most Sonoma climate interventions were based on examples and precedents from other climate efforts. However, Sonoma organizations then took measures ensure that interventions had the potential to preform well within the local context. The actions used to understand, re-construct, and intervene in the climate system thus far have been tailored well to address conditions specific to Sonoma.

Recommendation. As discussed previously, a major shortfall is how interventions are coordinated. Current interventions are often selected by sector in an *ad hoc* manner, which may not create the desired results at the system level. Sonoma interventions should also be selected for their ability to serve the needs of users within the system context. Glasgow et al. (2001) presents a method for evaluating interventions based on their ability to effectively influence the local problem context, and this method has shown promise in translating research into effective intervention strategies in healthcare and behavioral medicine (Dzewaltowski, Glasgow, Klesges, Estabrooks, & Brock, 2004). Sonoma organizations should consider adopting a similar methodology for adapting interventions identified from research and other applications to the local context, and should work to coordinate interventions to better fulfill system needs.

Adheres to sustainability principles – Partially fulfilled

Description. Another basic criteria that sustainability interventions must satisfy is the fulfillment of sustainability principles. Gibson (2006), Gasparatos et al. (2008), and Robért et al. (2002) all provide lists of sustainability principles that interventions should fulfill, and these along with other foundational sustainability literature stresses the interconnections between principles. Thus, focus must be centered on sustainability at large; concentrating on only certain principles or narrow areas of the system may not effectively drive transitions and can create unintended consequences in other areas (Robért et al., 2002). Interventions that satisfy sustainability principles are more likely to contribute to the overall transition and not create unintended consequences in other parts of the system.

Sonoma assessment. In Sonoma, focus on overall sustainability seems to vary in importance by organization. For example, the County of Sonoma has an Energy and Sustainability Division (though this organization is primarily focused on energy), and the Community Climate Action Plan alludes to several sustainability principles. However, sustainability should play an important role in all climate actions because, as discussed in Chapter 1, climate change is inherently a sustainability challenge and must be addressed in the context of overall sustainability.

An overt focus on sustainability is not apparent in Sonoma climate interventions. As discussed previously, most interventions are focused on GHG emissions, and even then other factors such as funding or outside requirements can gain top priority. Sustainability principles addressed by Sonoma interventions seem to have been done so by association while focusing on more

specific GHG reduction criteria. However, fulfilling sustainability criteria should be a deliberate and fundamental requirement for any intervention aiming to support Sonoma's transition to a sustainable, low carbon system.

Recommendation. Sonoma organizations should include sustainability criteria early in their intervention system. Focus on overall sustainability should be a greater priority than even emissions reductions, as actions that reduce GHGs but fail to adhere to sustainability principles are not likely to create positive outcomes over the long-term.

Targets upstream interventions points – Partially fulfilled

Definition. Interventions should be selected that specifically target high-leverage upstream intervention points. This principle is closely tied with a functional, system-based understanding of the problem and creating an overarching system goal. Even if an understanding of upstream drivers exists, if organizations do not use this to select their interventions creating a system transition will be difficult. Organizations should identify interventions that first and foremost affect the upstream drivers that eventually cause negative outcomes within the SES, and then secondarily focus on other co-benefits or requirements.

Sonoma assessment. Most Sonoma organizations select interventions based on opportunities in their specific sectors rather than on their ability to affect upstream drivers. When viewed from a system-perspective, such interventions appear piecemeal and do not create the required impacts to fuel the transition. This is a condition not unique to Sonoma, as many other climate action initiatives focus on aspects under their direct control, which usually correspond to governmental sectors like transportation, energy, and water. However, most other climate initiatives focus on controlling emissions within

their organization; Sonoma differs in that it has made a commitment to lower emissions across the entire county. Therefore, interventions must focus on the drivers that cause emissions in the county-wide system, not just the aspects under the organization's control.

This is not to say that Sonoma's interventions have completely missed the mark; quite the contrary. The CCA intervention does have the potential to intervene at the driver-level by influencing the generation source of all electricity delivered to the county. CCA fundamentally changes a major upstream component in the system, and thus all downstream activities involving electricity should realize a reduction in GHG emissions. However, the current system-level understanding and emissions reduction target do not allow for driver-level interventions to be consistently identified and selected.

Recommendation. As noted previously, restructuring the system-based understanding to include upstream drivers will allow organizations to select interventions that target upstream drivers. These actions can be further augmented by tools that Sonoma already possesses, namely the RCPA. Regional coordination and governing bodies have been highly effective for managing other types of complex systems, like economies in metropolitan areas (e.g. the Greater Phoenix Economic Council). Developing regional coordinating bodies can be difficult, but Sonoma has already overcome significant logistical, regulatory, and normative hurdles to create the RCPA. The RCPA should be further positioned to take a coordinating role by identifying upstream intervention points across the system and coordinating interventions in different sectors to drive the transition.

Seeks synergistic solutions – Partially fulfilled

Description. Interventions should be selected that create mutually

reinforcing, synergistic solutions that affect multiple sectors and are viable both short- and long-term (Gibson, 2006). Such interventions are generally targeted at upstream system drivers (Fraser et al., 2009) and can affect multiple downstream outcomes (Wiek & Childers, working paper), efficiently driving the transition.

Sonoma assessment. According to the document and website review, several Sonoma organizations were connected with each intervention, and usually these organizations represented various sectors in the GHG emissions system. Additionally, several interviewee's noted that their organizations worked closely with others during the selection process. However, many of these relationships occurred during the early phases of the selection, and one organization, often representing one sector, administered and maintained the intervention. Furthermore, most interventions specifically targeted one sector of the emissions system without much or any crossover to others.

Recommendation. As stated previously, many of the interventions in Sonoma, and in most government led-sustainability efforts, are supported by organizations whose primary focus is in a specific sector, like energy or water, and not on climate change or GHG reductions. This makes it difficult to identify synergistic solutions across sectors, especially if organizations lack strong relationships of communication and trust. This is another example where a climate focused organization such as the RCPA or CPC could play a strong role, in this case taking responsibility for identifying such synergistic solutions.

Evidence-based – Mostly fulfilled

Description. Selecting interventions based on evidence, known as evidence-based practice (EBP), is a fundamental in other fields (e.g. Glasgow et al., 2001; Fraser et al., 2009; Brennan et al.; 2011). EBP relies on context to

identify intervention points, and then uses evidence provided by efficacy and effectiveness testing, expert and user input, pilot testing, and analysis of previous interventions to select actions. In addition, new interventions are designed using research and testing to collect evidence for future applications, and to ensure that the intervention can create the desired effects when implemented. Interventions selected for sustainability challenges should also rely on evidence to ensure that the desired outcomes can be achieved, and to support selection and adaptation in a variety of contexts.

Sonoma assessment. Sonoma organizations used evidence to the greatest extent possible. In the Community Climate Action Plan and current intervention selection processes, organizations gathered all available evidence on potential interventions, including technical specifications and experience from prior examples. A shortcoming of the Sonoma's process was that this evidence was often applied to the sector, rather than system, context. This led organizations to seek interventions that show evidence of effectively influencing problems in their specific sector, but that may not create the desired system-level outcomes.

However, most climate change interventions, and sustainability interventions in general, are not designed or selected on an evidence basis (Dietz et al., 2009). Selection instead is based on anecdotes of success, or extrapolated from scientific principles that indicate an intervention design should work. This often results in the panacea-like intervention strategies that sustainability planning frameworks intend to avoid (Ostrom et al., 2007). As more organizations, governmental and non-, begin to create strategies for sustainability transitions in different contexts, it is vital that interventions be created and selected with a evidence basis.

Recommendation. Sonoma organizations have done well to select interventions based on the limited evidence available. However, they should adopt more rigorous evidence criteria for identifying and selecting interventions in the future. By simply using well-designed, evidence-focused criteria in their selection system, Sonoma organizations can increase the evidence around interventions. Additionally, Sonoma organizations should take a more systematic approach for developing interventions for their local context. Context based evidence can be gathered in a variety of ways (Fraser et al., 2009; Brennan et al., 2011), including rigorous experimental testing, pilot studies, meta-analysis, and evaluations and summary measures (Glasgow et al., 2001; Rossi et al., 2004; Glasgow, Klesges, Dzewaltowski, Estabrooks, & Vogt, 2006).

Adaptive, reflexive, and iterative – Mostly fulfilled

Description. Since sustainability challenges are "wicked" (Rittel & Webber, 1973), there is no one optimal strategy to solve them. Therefore, interventions that aim to influence such problems must incorporate a continuous learning and improvement approach that monitors and assesses progress often, and allows for modifications as knowledge and conditions change (Fraser et al., 2009; Wiek, 2010). However, it is not enough to monitor progress along general performance metrics; interventions must be designed to frequently measure progress in advancing the system transition. Frequent monitoring, reflection, and the ability to adapt to new conditions allows interventions to change with system needs.

Sonoma assessment. Most interview respondents noted that their interventions used some type of monitoring to assess performance. Often these performance metrics were intervention-specific, and no interviewees stated that

they monitored GHG emissions reduced, nor broader variables that tracked contributions to the overall transition. Without such measures, it is difficult to determine which interventions successfully influenced the system, and which did not creating sufficient results, and why. However, it was clear that Sonoma organizations attempted to continually improve their interventions when new information indicated it was necessary to do so.

Recommendation. Organizations should select and design interventions for frequent monitoring of at least GHG emissions reduced, and preferably use metrics that determine the impacts on upstream system drivers. From a system perspective, yearly emissions updates may not be frequent enough to identify shortcomings and opportunities in the highly dynamic climate SES, nor allow monitors to determine which programs are preforming well or poorly. Sonoma climate organizations must increase their capacity to monitor GHG emissions sources more frequently and at a more granular level. Frequent and specific monitoring will provide more incentive for emitters and program administrators to organize for sustainable management.

Discussion

Table 7 below presents a summary of Sonoma's assessment against the principles compiled in this chapter.

Table 7

Sonoma's performance on all assessment principles

Principle	**Fulfillment Level**
Change Capacity	
Leadership	Fulfilled
Norms/social capital	Fulfilled
Knowledge of SES	Mostly
Importance of resource to users	Not
Collective choice rules	Partially
Number of users	Fulfilled
Prerequisites	
System-based	Partial
Creates a system-level sustainability goal	Partial
Reflexive, precautionary, and anticipatory	Partial
Process and governance	
Establishes a shared process	Partial
Participatory	Not
Establishes accountability	Not
Transparent	Partial
Establishes trade-off rules	Not
Interventions	
Prioritizes the goal	Partial
Context specific	Mostly
Targets upstream intervention points	Not
Seeks synergistic solutions	Partial
Adheres to sustainability principles	Partial
Evidence-based	Mostly
Adaptive, reflexive, and iterative	Partial

In the future, Sonoma organizations should consider adopting a shared, multilevel process for selecting interventions that addresses the entire system, not just individual sectors. The process should use a system-based understanding

to focus on upstream drivers that influence GHG emissions. Interventions should be coordinated across the system by climate focused organizations, and organizations in specific sectors should also work to identify high-impact interventions in their respective areas. Organizations should first identify the types of interventions required to create the desired system outcomes, and then seek funding sources to support them. Potential interventions should primarily focus on GHG emissions reductions, and additional requirements after. Co-benefits should be accounted for when selecting interventions, but the primary criteria should be advancing toward an overall sustainable system state, and influencing the major upstream points that create the unsustainable climate system. Potential interventions should include strong monitoring and assessment mechanisms to ensure that the programs can be adapted and new needs can be identified as conditions change. Finally, potential interventions should be measured against a variety of evidence-based criteria that measure efficacy and effectiveness, as well as how potential interventions will affect the overall local emissions system given current conditions.

Implementing such improvements could help Sonoma overcome current difficulties like participation in interventions. For example, programs that target residential energy efficiency have recently suffered from low use. A stronger emphasis on participatory monitoring and evaluation–i.e. increasing citizen involvement in feedback and program changes-could help identify barriers to participation that were previously unseen, and may not be related to commonly-cited obstacles like low economic incentive or lacking information (McKenzie-Mohr, 2011). Such participation could have even more profound effects if citizens were more involved in program design.

These improvements could also help affect emissions transportation, one of Sonoma's most pressing climate difficulties. Currently, emissions from passenger vehicles account for a large portion of transportation emissions, which make up over 60 percent of total emissions. Transportation emissions are problematic because affecting driving habits has proven complex and difficult, especially considering the distances between Sonoma's towns and work commutes to larger Bay Area cities. However, by focusing on sustainability as a goal, organizations could coordinate interventions across several sectors that target upstream drivers and create synergistic outcomes, including GHG emissions reductions. Such interventions would seek to answer the question of, "what conditions are required to create healthy, sustainable cities (which include a reduced need for driving fossil-fuel powered passenger vehicles)," instead of "how do we get people to drive their cars less under the current conditions?" Upstream interventions like these may be more difficult to design and coordinate, but could lead to much greater sustainability outcomes in the long-run.

Conclusion

The chapter presented several principles for assessing sustainability intervention selection processes. The principles were divided into four parts which assess the overall capacity for system change, prerequisites required for an effective selection process, the intervention process itself, and individual interventions. To demonstrate the tool's utility, Sonoma's selection process was assessed against the principles and several points for improvement were identified. These points were detailed in the results section, and recommendations for future actions were provided alongside the assessment.

The next chapter uses the results of the assessment to create an improved process for selecting climate interventions. This improved process will allow for the systematic identification, negotiation, and selection of climate programs that create significant emissions reductions across Sonoma's climate SES. Not only will the improved process benefit Sonoma's future intervention selection efforts, but it also provides an example for other organizations planning to select interventions in their own local contexts.

Chapter 5 – Constructing an Improved Governance Process for Negotiating Local and Regional Climate Change Interventions

This chapter takes the assessment principles and structures them into an improved governance system for negotiating climate interventions. Creating this system answered the final research question process, which sought to discover how local and regional mitigation interventions systems could be improved. For the Sonoma case, organizations can use the process to select context-appropriate interventions in a participatory, evidence-based manner that strategically drives the desired system transition.

Since a process did not exist for selecting and coordinating interventions across the climate SES, I integrated the principles and results of the assessment were integrated into the system below (Figure 11). This system combines the principles from sections two, three, and four of the assessment with process elements from participatory intervention and evaluation research (Potvin et al., 2003; Rossi et al., 2004; Fraser et al., 2009) and sustainability science (Robért et al., 2002; Wiek, 2009, 2010). The result is an evidence-based approach that uses stakeholder input, current system conditions, and an overall orientation toward sustainability to identify intervention points and select, implement, monitor, and adapt actions that drive the transition. While the recommended process was built in part from the results of Sonoma's intervention system assessment, it may be used as a design guide to augment or create an intervention system in other contexts. By adopting such a process, Sonoma and other regions attempting to create a sustainable climate system can rectify shortcomings identified in the assessment and select more efficient and effective interventions.

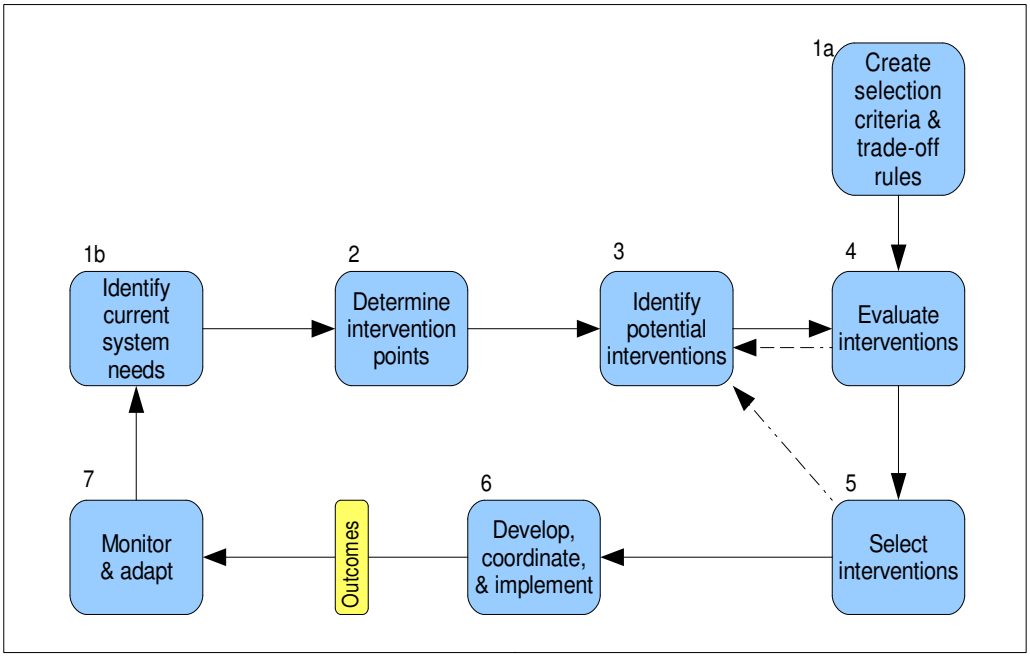

Figure 11. A governance system for negotiating local climate change mitigation interventions.

Guiding principles. The system uses several principles from the assessment as guiding elements throughout each phase. The first is a goal-orientation. Interventions selected for evaluation and potential use should primarily focus on the transition goals. For local and regional climate change mitigation efforts, this should be creating sustainable constellations of technology and behavior that result in a sustainable, low carbon system. Interventions may also use bench marks, such as reducing GHG emissions to a target level in a given time frame, as intermediate goals and to monitor progress.

In Sonoma, the stated goal for climate-change interventions is the 2015 target. However, as noted in the assessment many organizations are focused in specific sectors, such as energy, water, and transportation. Therefore, their efforts go toward creating sector-specific outcomes, of which GHG emissions mitigation

is often a co-benefit. This is a reality of trying to drive a transition with organizations who focus in areas outside or only partially related to the transition's goals; they must devote time and resources toward a variety of obligations of which climate change mitigation is only one. However, Sonoma actors recognized this and created several climate-specific organizations such as the CPC and RCPA. These organizations represent a major asset in Sonoma's transition, and should be used less for program administration and more to identify, select, coordinate, and monitor interventions across the system (Figure 12). This will help maintain a goal-orientation when selecting interventions, and create a more unified system-level transition.

More fundamentally, when viewed from a sustainability standpoint focusing on climate represents a similar situation as the one described above. As discussed previously, a sustainable climate is but on part of a sustainable SES. Therefore, by creating only climate goals, outcomes may not drive the overall transition to sustainability, much like the narrow actions of sectoral organizations may not achieve a system-wide GHG reduction target (Robért et al., 2002). Therefore, Sonoma organizations should reformulate their goal to create a sustainable SES, which *includes* a low-carbon climate system. This will be fundamental in driving a long-term and durable transition that does not solve one problem while creating others.

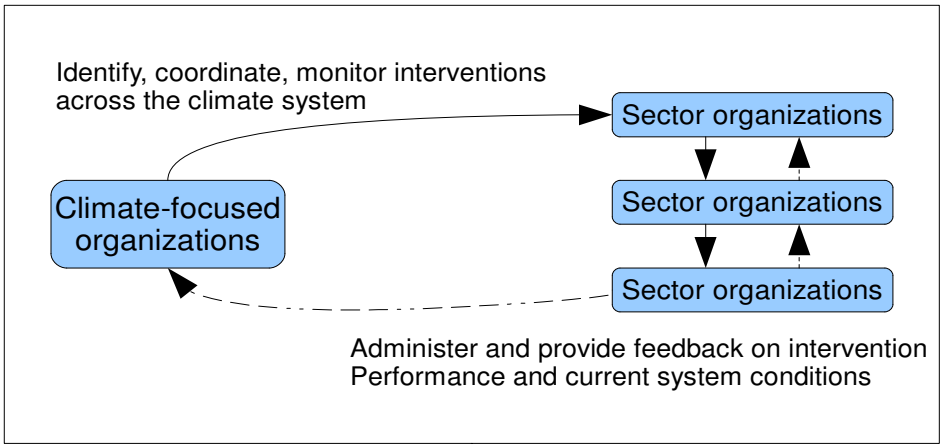

Figure 12. Climate and sector organization alignment in the intervention system.

A second guiding element is that the process should always target upstream system drivers. Interventions that affect upstream drivers produce greater impacts on downstream outcomes, since targeting upstream drivers essentially attacks the "root" of the problem. Along with an focus on overall system sustainability, targeting upstream drivers helps ensure that problems are not simply shuffled to other parts of the system, or that the results of interventions are only short- or medium-term in duration (Wiek, 2009). The assessment showed that Sonoma's interventions target a mix of upstream drivers and downstream outcomes. This is likely due to the 2015 target being focused on a downstream outcome–total GHG emissions. However, interventions such as CCA successfully target upstream drivers in the energy sector, and similar actions in other sectors should be identified and negotiated.

The system proposed here also uses a participatory approach throughout all phases. Mitigation interventions are typically expert driven and "top-down" since they require management of numerous users and emissions sources, many of which may be under governmental jurisdiction. However, this can create

misalignment as administrators try to create a programs general enough to reach broad populations, but more tailored actions may be necessary for the many different groups who must buy-in to the intervention and change their behavior. Therefore, interventions should represent the interests of all affected stakeholder groups, and thus be negotiated, to successfully drive participation and real-world change (Potvin et al., 2003; van den Hove, 2006). Participation in the process of defining the problems, solutions, and monitoring and evaluation mechanisms ensures that both stakeholder and system interests are incorporated into the intervention system, and can increase the rates of participation and positive outcomes (Kelly, 2005). Participatory approaches may require more resources during the negotiation and design phases, but this is offset by resources saved from not having to frequently adapt the intervention after launch to incentivize participation and reactively meet user needs. Changing the number of users by redefining system boundaries or target populations may also make the number and scope of stakeholder interests more manageable. Additionally, organizations now have access to online collaboration tools that can enable wider participation, especially in small to mid-sized local and regional settings.

For the Sonoma case, the main stakeholder groups to be included throughout the process are users (citizens, both present and future), climate-focused organizations (e.g. RCPA, CPC), county organizations (governmental and NGO concerned with climate mitigation), experts to help with technical aspects, partner organizations from other locations or levels, and the project team who develops and administers the intervention.

The process also encourages interventions that are highly adaptive depending on current system conditions. Potvin et al. (2003) point out the

importance of keeping interventions and strategies flexible in real-world settings, where conditions can rapidly change and problems may quickly evolve. This is especially important for "wicked" sustainability challenges where the problem structure is highly variable. One of the major shortcomings of current climate change mitigation efforts is that they establish an action plan early on, but then rarely update it to reflect progress or system changes. Monitoring activities usually include a yearly GHG emissions update, but this is often not accompanied by a reassessment of system needs and identification of new interventions to fit them. In the Sonoma, interventions were selected essentially by the availability of resources and opportunities, and not proactively aligned to address system-level needs. The intervention strategies in the 2008 Community Climate Action Plan, though well researched and constructed at the time, have not been updated. The intervention governance system presented here should be used to frequently monitor progress toward the goal and changing system conditions, and adapt or initiate new interventions as needed.

Prerequisites. It is assumed that at this point decision-makers have completed the previous three phases in the overall process for constructing an improved intervention system. However, the prerequisites from the assessment portion are vital for a successful system, and are revisited briefly here. The first is sufficient capacity for change across the system. If the system does not have sufficient capacity for creating changes for sustainability, then creating an effective intervention system will be difficult. Thus, users interested in creating an intervention negotiation system should first ensure that they fulfill the capacity for change principles to the greatest extent possible. Sonoma has a relatively high capacity for change except for one area: importance of the

resource system to users. This condition is common for climate change challenges in general, as evidenced by disagreement over the consequences (and existence) of climate change in the highest levels of US government (Selin & VanDeveer, 2007). Awareness of climate issues has increased in recent decades, but until users personally view the climate system as important they will be less motivated to take actions to sustain it. Thus, climate organizations must develop novel approaches to create a shared norm around the importance of the climate SES and the best ways to manage it.

After foundational capacity for change is established, organizations must create a systematic understanding of the climate SES, with an emphasis on upstream drivers. Creating a systematic understanding is the first step in the transformative sustainability planning framework (Wiek, 2010), and is the basis for all subsequent activities. Climate mitigation efforts usually construct a system model that illustrates the sources and amounts of GHG emissions. However, these models rarely include upstream drivers of emissions, especially the cultural and behavioral norms that support activities that emit GHGs. Figure 13 shows a model of a transportation system in a format adapted from Wiek (2009) which includes upstream drivers, current activities, and positive and negative outcomes. A similar model for each emissions sector and their interconnections would provide a systematic understanding of the climate SES and the activities that drive emissions. Organizations should construct or augment their current models in a similar manner before moving forward.

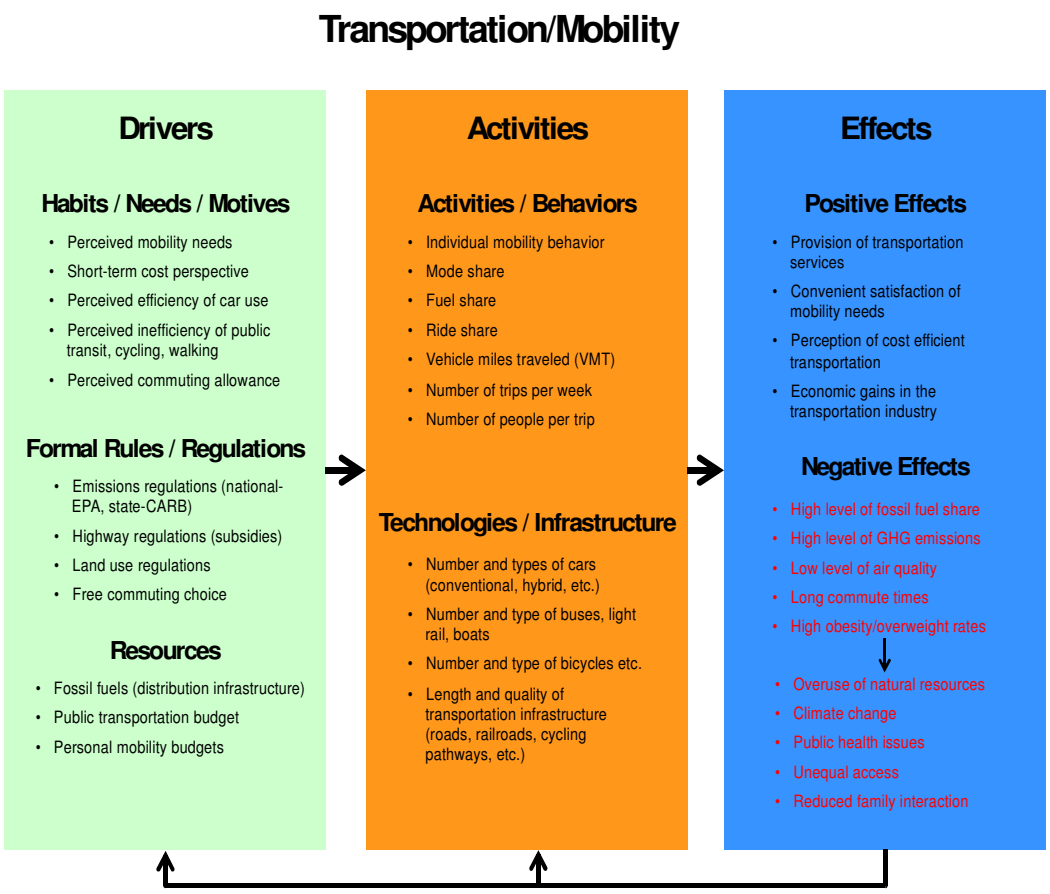

Figure 13. Example of a system-map of the transportation sector of a climate SES. Note the inclusion of upstream drivers in the left portion of the figure. Format adapted from Wiek (2009).

The final prerequisite for an improved intervention system is a shared goal or vision for the overall transition. As discussed in the guiding principles section, the system relies on a goal-orientation to identify and select interventions to effectively drive the system transition. Thus, organizations must understand and agree on what the transition goals are. The goal of the transition should be oriented toward an overall sustainable state, and include all sectors of the system (Robért et al., 2002; Wiek, 2010). This goal may include milestones and indicators to monitor progress, but these benchmarks should not be construed as the final outcome of the transition. This is another area where many

climate mitigation efforts fall short; though the impetus for action stems from creating a sustainable SES, the focus is shifted almost completely toward meeting target GHG emissions levels and not an overall sustainable system state (Ostrom, 2010). Not maintaining a focus on the long-term outcomes can result in trade-offs that are unsustainable over the long-term, or unintended consequences in different areas of the system (Robért et al., 2002; Gibson, 2006). Climate organizations should create an explicit, shared, and system-wide sustainability goal that is *supported* by performance milestones before improving their intervention selection system.

Steps in the improved system. After organizations fulfill the prerequisites, they can create an intervention system with the following steps. The steps refer to the process presented in Figure 10. The guiding elements discussed above should always be kept in mind when developing the process.

1a. Create intervention selection criteria and trade-off rules. Organizations should first create a shared set of criteria for selecting interventions that contribute to the system transition and meet the needs of stakeholders. These criteria should be negotiated between climate organizations, experts, county organizations, and citizens in a transparent, inclusive process that includes the interests of all groups. Some criteria will be specific to the location and transition, and others will be general, such as meeting sustainability principles. Organizations should construct the initial criteria set from the principles from section 4 of the assessment, and then augment this list with context-specific criteria. The stage of the transition (established in Chapter 2) should also be taken into account when constructing criteria. For example, interventions in the pre-development phase should focus on building awareness

and support, while those in the acceleration phase should make significant changes in high-leverage intervention points. During the process reconstitution in Chapter 3 the CPC indicated that they apply selection criteria when evaluating potential interventions, but most other Sonoma organizations did not. A shared set of criteria will ensure that organizations, regardless of their sector, select interventions that drive the system-level goals.

The criteria set will form the basis for the evaluation in step four. When properly constructed, a criteria set can greatly ease selection by culling the pool of potential interventions to only those that meet the system's needs. Criteria can also be incorporated into decision support tools, such as MCDA, which help determine which interventions represent the best options given current conditions (Belton & Stewart, 2002). Finally, by using rigorous criteria construction and evaluation techniques (Rossi et al., 2004), Sonoma organizations will begin to build an evidence base that is sorely lacking for climate change interventions. The criteria should be revisited often to ensure that they stay in alignment with system conditions as the transition progresses.

1b. Identify current system needs. After intervention selection criteria are determined, stakeholder groups should identify which parts of the transition are progressing sufficiently and which require interventions. This step should be carried out using the system model and input from climate organizations, citizens, experts, and county organizations. At the highest level this can be tied to the emissions inventory, but should also include feedback from current interventions and input from stakeholder groups not captured in emissions models and program evaluations. Identifying needs is a complex endeavor with many questions that must be addressed, like contributing factors,

scope, scale, the population effected, and what type of interventions may create the desired results (Rossi et al., 2004). A thorough and detailed system construction will help to answer these questions, and fields such as evaluation (ibid.) and intervention research (Fraser et al., 2009) provide guidance in identifying and defining needs, as well as developing interventions to solve them. System needs should be based on system-level conditions and thus may require a system model that is updated more frequently than once per year. Additionally, information about system needs can be gathered from county organizations, users, and project teams that have on-the-ground knowledge of current conditions and intervention performance.

A monitoring and feedback system for identifying system needs would again rely on strong coordination and leadership provided by climate-focused organizations. Climate organizations are also better suited than county organizations to monitor system-level performance and determine cross-sectoral needs. Finally, system needs should be assessed often and in a participatory manner, and should have mechanisms to gather input from all stakeholder groups.

2. Determine intervention points. Once stakeholders identify which parts of the system require interventions, the next step is to determine the best intervention points to address those needs. Intervention points should focus on upstream drivers in order to have the greatest effect on downstream outcomes, and have the potential to affect needs in several sectors of the system. Organizations should rely heavily on the upstream drivers identified in the system model, as well as feedback from previous interventions. For example, using the example transportation system construction from Figure 13, effective

upstream intervention points could be to change the perceived inefficiency of public transportation, or the fossil fuel distribution infrastructure by increasing access to low- or no-carbon fuel options. It is important to base intervention points on input from stakeholders, including citizens, experts, climate organizations, and county organizations. Multiple perspectives can help highlight intervention points not currently recognized by conventional planning methods, and help build consensus among various stakeholder groups about what is required to positively affect the system and meet their needs (Potvin et al., 2003). As mentioned in section one of the assessment, building consensus on what is required to change the system encourages ownership and buy-in for interventions, increasing the chance for success.

Sonoma climate organizations typically an expert-driven approach to determine interventions points that target a mix of upstream drivers and downstream outcomes (e.g. CPC, 2008). Because the GHG emissions target is focused on downstream outcomes, actions used to achieve it also often focus on downstream, or "end of pipe", intervention points. A more proactive approach of identifying current system needs to move toward the goal state, and then determining intervention points to affect them will help organizations select more impactful interventions.

3. Identify potential interventions. Organizations should next identify potential interventions for all the intervention points. Interventions should be identified that have the potential to 1) impact the desired intervention points and 2) fulfill the selection criteria. Organizations should gather all available evidence on promising interventions to inform the following steps. Sonoma organizations have done well in gathering evidence on potential

interventions during their selection processes. However, this evidence has largely spoken to the feasibility of successfully implementing the intervention, and less on effects on key intervention points or creating significant GHG reductions. As Dietz et al. (2009) point out, rigorous evidence on the effectiveness of climate change mitigation interventions is generally lacking, and organizations should develop promising interventions in ways that allow an evidence base to build on their efficiency and effectiveness (Fraser et al., 2009; Brennan et al., 2011).

In the improved system, climate organizations should take the lead in identifying the pool of potential interventions since they are closely connected with climate change research and action. However, county organizations, climate experts, and partner organizations may have additional perspectives and intervention sources, and should be included in the process. Additionally, when engaged, citizens can identify and develop interventions that are highly effective in the specific context (Corbie-Smith et al., 2010). Organizations should always take an anticipatory and precautionary stance when identifying interventions. Potential future, unintended, and cross sector outcomes should be assessed for all potential actions to ensure that interventions do not create negative outcomes or path dependencies in the future.

Potential sources for climate change interventions include examples from academic literature, such as large agency reports (Metz et al., 2007; Sathaye et al., 2007; Fri & Brown, 2010); articles on local and regional mitigation options (Pacala & Socolow, 2004; Byrne, Hughes, Rickerson, & Kurdgelashvili, 2007; Lutsey & Sperling, 2008; Vandenbergy et al., 2008; Dietz et al., 2009; Garner & Stern, 2009; Kockelman et al., 2011); interventions in specific sectors (e.g. Gallivan, Ang-olson, & Schroeer 2008; TRB, 2011); and case studies from other

climate change mitigation planning efforts (Bizikova et al., 2008). Organizations such as ICLEI, the Pew Center for Climate and Energy Solutions, and the National Academy of Sciences Climate Change Committee all produce reports on mitigation best practices and policy options. Interventions can also be identified from examples in other locations. Sonoma organizations have used this strategy to identify and evaluate many of their current interventions, such as CCA and the Community Climate Action Plan.

4. Evaluate interventions. Once a pool of potential interventions has been identified, organizations should describe and evaluate them against the selection criteria. The interventions determined to meet or exceed the criteria will form the pool from which stakeholder groups will select their final choices. Evaluations should be carried out by climate organizations, experts, and representatives from county organizations that may help administer the selected interventions. Rigorous evaluations, though often overlooked, are vital, as they allow organizations to not only determine if interventions meet the selection criteria, but also the differential effects of different types of interventions within the local context (Rossi et al., 2004). Besides fundamental approaches for determining the need for, potential effects of, and monitoring outcomes from programs (ibid.), there are several approaches to evaluation which could be useful for climate interventions. Czaja, Schulz, Lee, and Belle (2003) present a method for describing and "decomposing" complex interventions into standardized and comparable components. This allows decision-makers and researchers to compare interventions as well as better understand which parts contribute to which outcomes. Another method is Glasgow et al.'s (2001) RE-AIM framework, which describes and assesses intervention performance across

five criteria–reach, efficacy, adoption, implementation, and maintenance–that when combined indicate effectiveness in real-world settings. Focus on real world settings and participation makes the RE-AIM framework especially applicable for describing, evaluating, and comparing sustainability interventions. Glasgow et al. (2006) go further to present summary measures, which combine and weight the five criteria to give more refined scores that better capture details of complex interventions. Interventions can be evaluated while still in the planning stages, during implementation, or after completion depending on the intervention in question and context requirements (Rossi et al., 2004).

Once several interventions have been described and evaluated, a decision aid like MCDA gives users an additional step in creating an effective pool for final selection. MCDA methods allow stakeholder groups, which sometimes have conflicting interests, to select between several interventions measured against complex sets of criteria (Belton & Stewart, 2002). With MCDA, users score interventions for each criterion, and can ascribe weight to different criteria to signify priority. This allows stakeholders to customize the criteria set to their interests, goals, and context. When described, evaluated, and assessed against weighted criteria, the set of interventions that best fulfills the goals of the transition and stakeholder groups begins to emerge.

Regardless of the method(s) used, it is vital that the evaluation process be highly transparent, with administrators detailing which methods were used and why in addition to the results of the process. The interventions that the evaluation determines meet the selection criteria, can drive the system transition, affect the identified intervention points, and meet the goals of stakeholders form the final pool for selection. Note that organizations should identify and evaluate

potential interventions often outside of the standard process cycle. Carrying out these two steps in a more rapid progression will allow organizations to build a pool of pre-evaluated interventions that will help speed future iterations of the selection process, and contribute to the climate intervention evidence base.

5. Select interventions. The next step is to select interventions for implementation. Interventions should be selected from the final pool using a negotiation process between stakeholder groups to ensure that all interests are represented in the final suite of actions. It is likely that several interventions will be available for each intervention point, and each of these will have different outcomes for different groups, as well as on the system overall. Thus, groups must balance both personal costs and benefits with those of others and of the system. A negotiation process ensures that the final suite of interventions is equitable and accepted by all users. This step marks a departure from typical mitigation planning, which is often a top-down, expert driven affair with little citizen input. The negotiation phase will likely have to be iterated in order reach consensus on a suite of interventions that both affect the selected intervention points and are agreed upon by stakeholders. The step may also have to be repeated in order to provide sufficient access for all stakeholder groups to provide input.

Again, negotiating and reaching consensus on the best course of action is vital for producing system-wide outcomes. When stakeholders are included in the selection process, they develop ownership of the resulting interventions and are more likely to actively participate after implementation. Additionally, stakeholders are more likely to support climate action if they are able to assert their interests in the selection process and negotiate outcomes rather than have

per-determined interventions presented to them without input. Several studies outline methods for deliberation and negotiation between stakeholder groups… At the end of the negotiation process, users should have a suite of interventions that can both drive the system transition and create acceptable outcomes for all parties.

6. Develop, coordinate, and implement. Once the final set of interventions is selected, county organizations, climate organizations, experts, and participating stakeholder groups should work together to develop implementation strategies. Interventions should be developed systematically to create evidence on the efficacy and effectiveness of the design, meet county-specific needs, address the interests of stakeholders, and successfully affect intervention points. Sonoma organizations have thus far been rigorous in their program development in ensuring that interventions can be effective in the county, and meet operational requirements such as funding and capable personnel. However, to date many interventions have been developed or adapted based on efficacy, or data and theory showing that the intervention works in experimental or controlled settings. However, much less evidence has been developed on the effectiveness of interventions, i.e. what outcomes they create when actually implemented. Intervention research is chiefly concerned with creating an evidence basis for developing or adapting interventions, and suggests several ways to do so (Fraser et al., 2009). For climate organizations, pilot testing may be the best option for developing interventions that show promise from an efficacy standpoint. Pilot studies allow administrators to test interventions with small segments of the target population early in the development phase to see what developments are necessary to transfer efficacy results into real-world

outcomes (ibid.). Though pilot studies are sometimes viewed as less rigorous than efficacy and effectiveness trials, they allow organizations to quickly develop context specific interventions and gather participant feedback before widespread implementation (Brennan et al., 2011). Sonoma organizations have instituted several pilot studies, including the current On Water Bill and Whole Neighborhood Approach programs, indicating that a more systematic approach for developing interventions is emerging in the county. Interventions designed for development using evidence-based methods, and that address the principles from section four of the assessment should prove highly effective in creating the desired changes. It is also vital to assign accountability and enforcement mechanisms for the intervention's operation, monitoring, and performance. Finally, details like funding and personnel alignment, support infrastructure, and monitoring mechanisms should all be developed during this phase.

Once implementation strategies are formulated, climate organizations should coordinate interventions by determining when, how, and who should carry them out to drive the system-level transition. These decisions should be made with county and partner organizations, and may also benefit from expert input. Interventions should be coordinated to leverage resources and create synergistic outcomes whenever possible. Climate organizations should also always coordinate interventions based primarily on the needs and conditions presented by the system, not by the availability of funding and other outside influences. Frequent communication between climate and administering organizations will ensure that both individual interventions and system-level strategies develop at the required pace.

After development and coordination, the programs are implemented and begin producing outcomes that change the SES. During this phase, administrators should keep in mind the processes organizations and individuals use to incorporate new activities. Fixsen, Naoom, Blasé, Friedman, and Wallace (2005) suggest that there are five phases from initial exploration of a new activity to adoption and maintenance: 1) exploration and adoption, 2) installation, 3) initial implementation, 4) full operation, and 5) sustainability. More fundamentally, Rogers (1995) found that there are five criteria a new intervention must meet to be considered for adoption: 1) superior to services as usual, 2) compatible with user practices, 3) no more complex than existing services, 4) easy to try and reject if it fails, and 5) likely to produce tangible results widely recognized as important. The fifth principle is yet another example of why it is important to negotiate and achieve broad consensus on the transition's problems, solutions, and goals. Organizations should consider these principles when developing interventions and implantation plans, and acknowledge the phases of implementation and aid users through them after interventions are launched.

7. Monitor and adapt. A successful intervention system will rely on a strong set of information rules that determine what, when, and to who performance is reported. Monitoring should relate directly to the selection criteria and different components of the intervention in addition to the outcomes. For example, if monitoring shows that an intervention has spurred moderate levels of participation, but users are not fully following through with the intervention and one user group is not responding at all, the administering organization can make specific adaptations to improve performance. If, in contrast, the same intervention was only monitored for overall outcomes,

administrators may be content with moderate performance assuming it will increase as the intervention spreads. They may never learn that there are specific areas that needed attention, without which the desired outcomes may never be achieved.

In addition to what is monitored, it is crucial to establish who is accountable for monitoring and reporting. Traditionally, organizations that administer interventions have been responsible for monitoring performance. Sonoma organizations used this configuration, but in a complex SES performance must be reported to coordinating organizations so they can determine system-wide performance. In Sonoma, county organizations should report intervention performance and results to climate organizations who aggregate the information to form an overall picture of the transition. This overview can in turn be used to identify system needs and start the process anew. Frequent monitoring and updates allows organizations to rapidly adapt interventions and create a more refined picture of overall progress.

How interventions are monitored is also important (Rossi et al., 2004). Large portions of feedback should come in the form of qualitative reports from citizens, the project team, and partner organizations. This should be coupled with quantitative measurements such as the number of participants, effects on resource consumption, and the amount of GHG emissions mitigated to provide a rich picture of the intervention's effects. Sonoma's SCEIP used citizen feedback in addition to meetings with the contractor network. This allowed SCEIP administrators to better understand the strengths and weaknesses of the program in practice, and change it as necessary. Organizations should build mechanisms for frequent, user-based feedback, as well as ways to incorporate this feedback

into adaptations. They should also designate who is responsible for gathering and incorporating feedback, and reporting performance to climate organizations. Interventions should be adapted accordingly, and new system needs should be identified according to the outcomes of all interventions across the system and new opportunities at the landscape and niche levels. From here, the process is repeated.

Discussion

The above is an example of and effective governance system for negotiating climate interventions. It incorporates the principles outlined in the assessment section and takes into account the overall transition's progress and goals. It also relies an evidence basis and principles that have proven effective in other fields for engaging collective action challenges in complex systems. Because the process uses the assessment principles, it fills shortcomings identified in Sonoma's current selection process. The participatory elements give users greater access, understanding, and control over climate action, which among other benefits could increase the importance of the system. Trade-off rules are established early to avoid unintended consequences and divergence from the transition goals. Accountability also plays a large role, with specific rules and roles assigned in all phases. Finally, including upstream drivers allows organizations to identify high-leverage intervention points that can create positive and durable outcomes across multiple sectors. If Sonoma organizations adopted the process described above, the assessment principles that they were rated not, partial, or mostly fulfilled on would be fully satisfied.

If Sonoma organizations elect to implement the above syste, they should consider the following actions for first steps. Initially, organizations should

address any of the prerequisite principles that remain unfulfilled, such as adding upstream drivers to the climate SES construction or reformulating the goal. Organizations should also realign their network to make climate-specific organizations directly responsible for system level coordination and monitoring. Sector-specific county networks should be assigned accountability for interventions and performance, and information rules for reporting feedback and results between county and climate organizations should be established. Organizations should also add mechanisms to increase participation, focusing on ways to make the process more widely accessible to stakeholder groups, including citizens. Once these steps are underway, Sonoma can begin the first steps of the process by creating selection criteria and trade-off rules, and identifying current system needs.

There are several barriers that Sonoma organizations may face when improving their selection process. First, it may be difficult to create a more system-oriented effort since thus far most of Sonoma's interventions have focused on outcomes in specific sectors. It may also be difficult to assign accountability for intervention performance and adaptation since climate change mitigation is not technically a requirement for county organizations. However, Sonoma has a unique capacity to overcome these organizational barriers through its climate-focused organizations, especially the RCPA. The RCPA, in collaboration with the CPC and other climate organizations, represents a governmental organization that can take responsibility for coordinating different sectors and identifying and monitoring action areas. Thus, organizations in other sectors do not have to manage (or ultimately be responsible for) climate change action, which may be viewed as “out of their jurisdiction”.

It may also be difficult to change the focus of intervention selection from operational requirements, such as funding or personnel, to transition-level needs. On-the-ground efforts are certainly subject to operational pressures, and considering the difficult economic climate many local and regional government actions must be highly fiscally efficient to have any chance of survival. By all means, criteria that address the cost and financing structure of interventions should be included in the selection set. The point is that these cannot become the determining criteria for intervention adoption. Organizations must always select interventions based on the needs of the system and stakeholders, and not the presence of financial or support opportunities, if they hope to advance their transition into the stabilization phase. This is why trade-off rules and strong selection criteria are vital to the intervention process; they ensure that short term pressures do not override long-term goals. Establishing criteria and trade off rules and creating consensus around the need for action will help Sonoma organizations re-align to focus on the system.

Finally, integrating a flexibility into intervention design may be difficult for organizations accustomed to more rigid, long-term project planning. First, high levels of participation are typically not the norm in environmental and sustainability planning for a number of reasons, not limited to the time and resources required, difficulty in managing stakeholder relations, lacking funding, and misaligned expectations (Talwar et al., 2011). Also, intervention selection will involve both consensus and compromise, again creating possibly a more difficult, and, if nothing else, lengthy, process (van den Hove, 2006). Thus, integrating participatory approaches into decision making will take additional time and resources, and will likely involve learning experiences on the path to an efficient

and effective configuration. This may be difficult to introduce when many decisions in local government are based on efficiency and effectiveness. Second, because sustainability challenges are highly dynamic, interventions need to be able to quickly adapt or be decommissioned to accurately address shifting needs. It may be difficult for organizations who have been trusted with resources and are expected to produce results to acknowledge that an intervention is under-preforming or requires adaptation. Furthermore, many interventions require significant time, infrastructure, and financial commitments that, once implemented, are not easily reversed. This is especially true for Sonoma, as they have already addressed many of the "low hanging fruit" options. As one interviewee put it, "We've changed all the light bulbs" (SC4, personal communication, December 2, 2011). This need for significant interventions underscores the requirement for an effective negotiation process that includes adaptability and a system-focus from the start. With such a process, Sonoma organizations could develop effective interventions from the outset, and adapt them as system needs dictate. Changing the system will take a commitment from all stakeholders, and could be met with resistance to maintain the status quo. Support from political leaders or other prominent actors in advocating such an approach may ease the transition (Chasek et al., 2010). Sonoma's high capacity for change may also make it easier for organizations to adopt new intervention selection and adaptation techniques.

Above all else, it is clear that despite many barriers, Sonoma County has made impressive advances in their sustainable climate transition. Groups have taken innovative actions like creating the CPC and RCPA, and instituted novel interventions to curb GHG emissions. Though there will be barriers to further

improving the intervention system, the results could be great. Improved interventions could speed progress toward the 2015 target, as well as create widespread co-benefits across Sonoma's environmental, economic, and social sectors. Improving the process would also further cement Sonoma as a national climate leader, and serve as an example for effective local and regional governance and stakeholder engagement. This case study has shown that Sonoma County has the will, capacity, support, and expertise to continuously improve their sustainability efforts. Applying the improvements identified here would mark another significant step in doing so.

Chapter 6 – Conclusion

This study developed an effective governance system for negotiating climate change mitigation interventions at local and regional scales. It established the need for such a system by showing that climate action at local and regional levels can be effective, that local and regional climate efforts are underway in the US (but produce lackluster results), and that there are principles, identified from the literature, for effective, sustainable governance of complex SESs. Reviewing these points showed that an effective intervention system was both worthwhile and needed, and that the knowledge and tools existed to build one.

With the justification in place, I formulated three research questions to explore in an effort to better understand and improve interventions selection. They were: 1) how do organizations currently select programs; 2) why has this not led to significant emissions reductions; and 3) what improvements would enhance the process and outcomes? I explored these questions in four additional using a case study of the climate efforts underway in Sonoma County, California.

The first research question was addressed in Chapters 2 and 3. Chapter 2 mapped Sonoma's climate change transition and assessed their progress along the transition curve. The chapter showed that Sonoma organizations have made significant progress in driving the transition into the acceleration phase. It also highlighted enabling factors, such as strong community support, expert capacity, and political will and leadership, as well as barriers like a poor economic climate and uncertainty, that have made change difficult. Chapter 2 also introduced the climate-focused organizations, institutions, and interventions at work in the county. Chapter 3 focused on the processes Sonoma organizations use to select

interventions. The process was reconstructed using concepts from institutional analysis–specifically the SES framework and action situation–and semi-structured interviews that followed the Barriers and Carriers method for process reconstruction. The results shows that Sonoma organizations follow a fairly typical development pathway for identifying, selecting, and implementing interventions, but that processes between organizations are disjointed with no overarching, system level coordination. The results also showed the evolution of barriers and carriers throughout the process, as well as the types of participants. The results also highlighted the importance of collaboration between NGO and government organizations, as well as some of the nuances of developing support and interventions for sustainability issues in local and regional contexts. Together, Chapters 2 and 3 answered the first research question by providing a rich picture of the overall transition, its participants and development, and how interventions were selected within it.

Chapter 4 aimed to answer the second research question by assessing the intervention system to identify strong and weak areas and recommend improvements. The assessment was constructed of principles derived from sustainability science, institutional analysis, intervention research, and evaluation research literature pertaining to sustainable SES management, sustainability planning, and effective intervention selection. It was divided into four sections which assessed the systems foundational capacity for change, prerequisites for effective sustainability planning, process characteristics of effective planning and governance, and elements of effective interventions. Sonoma's assessment highlighted several strong points as well as areas where the intervention system did not preform as recommended in the literature.

Chapter 5 answered the third research question by restructuring the assessment principles into an improved intervention negotiation system. The process specifically addressed the shortcomings identified in the assessment, as well as incorporated mechanisms for participation, coordination, accountability, and maintaining focus on the transition's goals. The chapter satisfied the third research question by providing an avenue for organizations to more effectively negotiate and select interventions to drive the overall transition.

The four chapters fulfilled the primary aim of the study, which was to develop steps organizations and researchers could take to understand, evaluate, and improve the systems organizations use to select interventions in a way that produces more effective drives sustainability transitions. These steps represented a new approach for understanding, assessing, and improving intervention selection in complex systems, which provides a pathway for taking principles and methods from research and adapting them to practice in real-world conditions.

General Discussion

After completing the study, several overarching points about climate change mitigation efforts in general stood out for further discussion. The first is the need to switch the focus of interventions from downstream outcomes to upstream drivers. Climate initiatives often place great weight on meeting GHG emissions targets and by doing so miss opportunities to create greater impacts by focusing upstream. This is likely in large part due to the type of intervention options that have been developed and promoted thus far. Many focus on “end of pipe” technologies, like efficient lighting or pollution scrubbers for power plants, that, while reducing GHG emissions, do not address the root causes of the actions that create emissions in the first place. These type of interventions add up to

incremental changes that ultimately do little to advance system-level sustainability transitions. Upstream interventions, such as changing the source of energy from non-renewable to renewable, reducing dependence on fossil-fuel powered transportation, and requiring development that both emits and encourages activities that emit fewer GHGs, are necessary to create the types of changes needed to create a sustainable system. This is consistent with literature that links sustainable development and climate change, which places the focus on improving sustainability across the system (Beg et al., 2002; Robért et al., 2002; Robinson et al., 2006; Bizikova et al., 2007). By focusing on sustainable development, GHG reductions are inherently part of all actions, and improvements are made in several sectors at once with multiple co-benefits. This allows for more parts of the system to be addressed simultaneously, and can create more synergistic actions than focusing on e.g. climate change mitigation alone. Upstream interventions may require more upfront resources, but the payoffs will also be much greater, and sustainable, over the long-term. In other cases upstream interventions will focus on behavioral changes and may be much less resource intense than changing infrastructure.

Second, climate change mitigation efforts, especially those housed in government, have taken a very sectoral approach to mitigating emissions. Interventions are focused in areas like transportation, energy, or water, and the results are expected to add up to comprehensive emissions reductions. However, many of these efforts lack coordinating bodies to monitor, direct, and enforce progress across the entire system. This is akin to a corporation using teams to work on challenges in different sectors with no management oversight, relying instead on yearly, company-level progress reports to infer success. Such is the

case when governments decide to tackle climate change, but create no organization or position to coordinate a coherent, system-wide effort. Organizations like the RCPA are gravely needed in local and regional sustainability efforts, and they must also be given the support and authority to manage interventions within and across sectors. Otherwise, progress will remain piecemeal and disjointed, creating slow or stalled transitions and few meaningful GHG emissions reductions or progress toward sustainability.

Following this line of inquiry further leads to an examination of emissions targets themselves. A hallmark of climate efforts thus far has been the formation and focus on achieving a GHG emissions target (C2ES, 2008; Kockelman et al., 2011). Sonoma's decision to adopt the ICLEI framework required a GHG reduction target, and most organizations' stated goal was achieving the target level. As discussed by Ostrom (2005) and highlighted in several meta-analyses on common pool resource management (e.g. Schlager, 1994; Berkes, Mahon, McConney, Pollnac, & Pomeroy, 2001), quota rules have been conspicuously absent from successful, self organized resource management strategies. This is usually because when users have a detailed understanding of the system, they are able to regulate choices on *how* resources are harvested (or emitted), e.g. time, locations, or types of technology permitted. Targets simply regulate *how much* can be emitted, regardless of when, how, or who is responsible for emissions produced.

Targets are often set by high-level organizations which may not be aware of the nuances of the local SES, or they may be based on arbitrary baseline values that have no correlation to the long-term sustainability of the system. Because targets involve more variability, they are much more difficult to monitor and

require significant information sharing and reporting for successful management. Targets may also be difficult to uphold because some emissions sources may be outside the jurisdiction of the regulating body, and thus impossible to influence despite their impact on the target. While an organization with broad jurisdiction may be able to monitor and enforce a target, smaller jurisdictions like counties may lack control over too many emissions sources. This is likely one of the major reasons Sonoma organizations have found it difficult to reduce GHG emissions, as discussed in Sonoma's most recent GHG emissions inventory and status update (Erikson & Hancock, 2010a). Finally, targets are another example of a "downstream" focus discussed above, and thus make it difficult to identify system intervention points, and select the best programs to address them.

Institutional analysis has shown that SES management is more difficult when users cannot enforce rules that protect system sustainability (Dietz et al., 2003). Because targets can cover such broad areas of action, the they are especially difficult to enforce and may be easier to circumvent (Ostrom, 2005). Rules for governing climate change, like emissions targets, are not enforceable for a variety of reasons, not the least of which is legality. Engel (2006) points out that states and local governments that intend to combat climate change using enforceable rules, and especially when working together, may challenge the power of the federal government and require congressional approval under the Compact Clause or other statutes. Though a precedent exists in AB 32, challenging the federal government could be costly endeavor, which is likely why few organizations have done so.

As demonstrated by in Sonoma, accountability and enforceability can have effects on the other principles for effective intervention selection, and on

overall progress toward the goal. Because the 2015 target is not enforceable, Sonoma interventions tend to rely on normative appeals and more tangible or near-term pay-offs to drive participation. This creates a mismatch between program level focuses and system goals, and can focus the selection process on interventions with the most public appeal. This is not a Sonoma specific issue, as many climate change efforts promote the co-benefits of GHG reduction strategies, sometimes far more than the GHG reductions themselves. This occurs because it is difficult for users to relate to and observe the effects GHG emissions reductions create, so programs rely on measures such as cost savings to motivate actions. For example, one interviewee noted that contractors, who are the primary promoters of one of the county's residential energy efficiency programs, sold the program by framing it as an easy way to "go green" and save money for home repairs that were already planned. GHG emissions savings were mentioned later in the conversation, and sometimes not at all.

The need for accountability is not only a condition for climate-focused organizations. Creating accountability for interventions and emissions across all sectors and organizations is vital for driving change. Lacking accountability makes if far too easy to shift focus when more pressing issues arise. This is not to suggest that organizations should myopically focus on climate change mitigation at the peril of ignoring other pressing issues. They should, however, address such issues within the context of the overall sustainability transition. Maintaining sustainability transitions as the primary driver of action is not the status quo, but assigning accountability and enforcing rules and actions would encourage such a change. In the future, organizations who develop or improve their intervention processes should ensure that accountability is assigned for monitoring and

performance, and that normative sanctioning measures are in place to encourage compliance with interventions and collective choice rules.

Another matter of great importance involves strategies for achieving funding for the type of intervention systems required for effective sustainable SES governance (Chasek et al., 2010). The current importance of funding for nearly all types of local government actions, including climate change mitigation, has shifted the focus of many climate efforts. Sonoma organizations are a strong example of this. Typically, once Sonoma organizations determined the actions needed to affect their emissions system, they began scanning for resource opportunities to support interventions. However, this strategy requires organizations to wait for and react to funding opportunities instead of proactively developing interventions. There have been exceptions to this arrangement, such as the Community Climate Action Plan where the proposal was created and then presented to gather support, and the Real Time Ride-Share pilot, which was developed as part of a suite of potential programs before funding was sought. But for interventions like Energy Upgrade California, the need was identified long before funding was procured and the program developed. This delay associated with waiting for resource opportunities can create overall timing issues, like slow progress toward the 2015 goal, and a misalignment of needs, where a part of the system may require quick action but none are considered because of lacking funding opportunities.

When Sonoma organizations aligned with funding or resource partners, they often shifted their focus as well. For example, programs focused on retrofitting homes for energy efficiency may base success on metrics like number of energy audits completed or upgrades financed. Because funding or support

may be contingent on meeting such targets, the best actions for overall GHG reductions may not be prioritized above actions that affect the success metrics. Several interviewees noted that this has been the case with ARRA-backed programs. State level organizations that oversee ARRA programs are so concerned with meeting the performance requirements (one interviewee even termed it "paranoia") that they pass this emphasis on to county and local organizations, making it difficult to take any actions that diverge from the metrics attached to the funding. This put organizations in a position where the focus of their individual programs, e.g. performing energy audits, do not align with their higher-level requirements, e.g. meeting emissions targets.

This is not to discount the co-benefits of GHG reducing actions. All the outcomes of an intervention, both positive and negative, should be described and understood when addressing complex sustainability problems. But when the overall goal of the transition is given a lower priority than other benefits, it is difficult for organizations to identify and select interventions that significantly contribute to the desired system-level outcomes. Literature on environmental governance regimes suggests that strong political will and leadership may be the key to increasing the importance of and focus on sustainability issues (Chasek et al., 2010). But in local government settings where officials often answer directly to constituents, sustainability issues must be framed in ways that resonate with the electorate. Additionally, changing the types of interventions funding-providers support may be another strategy for renewing the focus on sustainability. Sonoma organizations work closely with higher level funding agencies, and should make the case that changing types of interventions funded (i.e. to those that focus more on sustainability and upstream drivers) could create

huge impacts and greatly enhance outcomes. This would help align the interests of county and higher level actors, reducing the tensions that arise when groups must work together but have different measures of success.

The above points highlight the importance of landscape-level pressures. As discussed in Chapter 2, such pressures can significantly effect organizations' ability to select and maintain interventions. Unfortunately, landscape level actions are also slow and difficult to change, but if they are identified, measures can be taken to mitigate, circumvent, or use them to the transition's advantage. The above discussion also points out the need to critically assess common methods for engaging complex sustainability issues. Though these methods may be popular and easy to follow, they also may not create the conditions required to drive system transitions. Frequently assessing the system, process, and interventions using tools such as the ones presented here can help identify shortcomings, or alert practitioners when system conditions have changed and new methods may be necessary.

Finally, even the most well designed intervention systems cannot create the desired outcomes without participation. And as Ostrom (2009) points out, participation partly relies on making the system important to users. If users do not attach value to the climate SES, there is very little impetus to take action to sustain it. Organizations must find novel ways to engage users in climate action, and create shared norms around the importance of creating a sustainable, low carbon climate SES. The participatory elements in the improved system engage stakeholders and create ownership and importance in the interventions they help negotiate. Climate organizations should use such a participatory approach in all phases of planning, including formulating the problem and the desired outcomes

in addition to the intervention strategy. It will be the actions of citizens and stakeholders that ultimately reduce GHG emissions and move toward overall sustainability, and thus they must be engaged in the process from the outset.

Areas for future research

The process was constructed to determine where crucial elements are missing in an intervention system, and how to incorporate them. However, there are several areas for future research which could strengthen it in both research and practice. First, the process is applied to Sonoma's climate transition to serve as an example scenario of the possible outcomes of application. The results were based on extensive interviews with Sonoma climate actors, as well as in-depth research into their climate initiatives. However, though stakeholders have shown interest, at the time of writing the process was not adopted in Sonoma. Future studies could extend the study to include implementation and subsequent outcomes. Then researchers could gather evidence on whether the process does indeed produce more effective interventions by comparing the outcomes pre- and post-intervention system improvement. Such a study should be designed with an evidence basis, and should follow similar intervention development steps as discussed in Fraser et al. (2009) and Rossi et al. (2004), and other sources on participatory intervention development (e.g. Potvin, 2003; Corbie-Smith, 2010). The more applications and subsequent evaluations, the further the process can be developed and adapted to produce effective, participatory interventions across a variety of settings.

Additionally, researchers could enhance specific phases of the process by refining or augmenting the methods presented here. For example, in the improved process steps presented in the previous chapter, future work could

focus on creating an effective system for identifying potential interventions similar to that proposed by Brennan et al. (2011), or refining the application of MCDA. Further work on assessment section, or developing the process reconstruction from Chapter 3 to a greater degree would also improve the overall process.

Broader significance

Climate change mitigation interventions are both necessary and desired, and the principles to create effective interventions have been well developed in academic settings. Furthermore, society possesses the tools to create emissions reductions; effective governance seems to be the largest barrier in doing so. The process presented here identified effective gonvernance principles, created an assessment tool for establishing which are needed and where, and structured the principles into an improved process for intervention negotiation. A major goal of the project was translating research into practice so that on-the-ground efforts can benefit from, and add to, the knowledge produced in academia. Hopefully this or a similar process is applied and Sonoma and beyond to help create effective interventions and drive sustainable climate transitions. Not only could the process help Sonoma organizations achieve the 2015 target, but it could also help other California organizations achieve the statewide goals outlined in AB 32. Effective, well designed interventions stemming from the process could even one day contribute to a national climate policy. Furthermore, since the process is anchored by sustainable management and governance in general, it could be applied to variety of sustainability efforts. With improved intervention processes come improved actions, and improved actions are the most important step in creating a desirable, sustainable SES now and in the future.

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APPENDIX A

INTERVIEW MATERIALS

IRB Approval Form

To:	Arnim Wiek GIOS Build
From:	Mark Roosa, Chair Soc Beh IRB
Date:	11/04/2011
Committee Action:	**Exemption Granted**
IRB Action Date:	11/04/2011
IRB Protocol #:	1111007056
Study Title:	Creating and testing a process for describing and evaluating climate change mitigation interventions in Sonoma County, California

The above-referenced protocol is considered exempt after review by the Institutional Review Board pursuant to Federal regulations, 45 CFR Part 46.101(b)(2) .

This part of the federal regulations requires that the information be recorded by investigators in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects. It is necessary that the information obtained not be such that if disclosed outside the research, it could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

You should retain a copy of this letter for your records.

Interview questions for Sonoma County climate program selection process

1. Please describe your involvement in climate change action in Sonoma. What organization(s) have you been part of, and what programs have you helped develop? What are you currently working on?

2. How does your organization interact with others working on climate action in Sonoma?

3. Please use the barriers and carriers worksheet to describe the process your organization uses to select climate change programs. Describe each phase that makes up the process, who did what, and also what enabled (carriers) and hindered (barriers) each phase.

4. Is this typically how all climate programs are selected by your organization?

5. Once a program is selected and implemented, how is its progress typically monitored? Do the results of that program ever feed back into the selection process?

6. Are there any other feed-backs from one phase to another?

7. What would you say are the most important barriers and carriers in the selection process, and why?

8. Before the current barriers and carriers existed, what were the most important barriers and carriers, and how did they influence the selection process? How did the programs selected using this process differ from the ones selected today?

9. Who are the most important actors in selecting climate change action programs in Sonoma today?

Barriers and Carriers Process Mapping Worksheet

Date: