GROUP DEVELOPMENT: A COMPLEX ADAPTIVE SYSTEMS PERSPECTIVE

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ABSTRACT

A substantial number of group development models have used sequential or phasic paradigms to create an understanding of group dynamics under normal conditions. Few GD models have used systemic perspectives to explore group dynamics in the face of adversity. This essay compared GD models with an ecological model of complex adaptive cycles to explore group resilience using the four principles of complex adaptive systems (CAS) – self-organization, hierarchy, emergence, and learning.

The comparison was based upon a historical literature review of several theories of GD, CAS, and group resilience. The rationale for this comparison was to bridge a gap in understanding between existing GD models and team resilience using lessons learned from CAS in ecology. The application of a model of complex adaptive cycles informed existing GD models through the four principles of CAS by revealing similarities, differences, and inflection points that provide potential to areas for further research.

Keywords: Group development, complex adaptive systems, adaptive cycle, self-organization, hierarchy, emergence, learning, feedback, creative destruction, resilience.

INTRODUCTION

Understanding how groups develop and evolve has been the subject of studies by organizational behaviorists and operations researchers since early in the 20^{th} century (Robbins & Judge, 2007). Group development research continues to inform organizational leaders as they acknowledge the potential that teams have in organizational learning and the achievement of objectives (Chan, Lim, & Keasberry, 2003). High performing teams are sources of intellectual capital (Ulrich, 1988). From early research, many models have been developed to explain what we can expect in typical group development (Hill & Gruner, 1973). However, what happens when a team encounters adversity? How is the group's development impacted? How does the group react and respond to adversity? What can we learn about group adaptation to adversity that will help our organizations become resilient?

This paper explores the gap in our understanding of typical group development (GD) under normal circumstances with that of GD under stress using a complex adaptive systems (CAS) perspective. I compare existing models of GD with a model of complex adaptive cycles to gain deeper understanding about the processes of organizational resilience. By examining GD through a lens of CAS, we delve deeper into existing theories grounded in organizational behavior, operations research, and organization development to further inform our understanding of groups and teams that experience adversity.

The application of CAS theory to GD is relatively new. In the last 10 years, CAS theory has been suggested as a constructive way to view groups by researchers (McGrath, Arrow, & Berdahl, 2000). Researchers in organizational behavior and development have come to understand that the scientific method, while valuable in many ways, has been limiting. McGrath et al. state,

> Much of that work, in line with a positivist epistemology that emphasizes control and precision and favors the laboratory experiment over other data collection strategies, has also tended to treat groups as though they were simple, isolated, static entities. Recent research trends that treat groups as complex, adaptive, dynamic systems open up new approaches to studying groups. (p. 95)

McGrath, Arrow, and Berdahl (2000) call on researchers to use CAS theory as a basis of conducting research about groups and teams. This essay responds to the call to use CAS theory as a framework for viewing GD, specifically using a model of complex adaptive cycles. Using CAS theory, which is grounded in ecology and used to explicate ecological resilience, may inform us about resilience in human organizational systems or complex adaptive social systems (CASS) (Miller & Page, 2007). At first glance, it may appear that theories used in ecological systems are disparate from theories applying to human systems. I will show how CAS theory is relevant and provides a useful conceptual framework upon which we can gain a deeper comprehension of teams' adaptability. By understanding the systemic processes that teams encounter during their evolution under stress, we may discover new approaches to building adaptive capacity to increase organizational resilience. In turn, the new approaches may also be valuable in organizational learning and resilience.

Definitions

Before introducing the GD and CAS models, it is important to define the terms and scope of this discussion. *Resilience* is "an ability to recover from or easily adjust from misfortune or change" (Merriam-Webster Online, 2009). Senior editor at the Harvard Business Review, Coutu (2003) says, "More than education, more than experience, more than training, a person's level of resilience will determine who succeeds and who fails" (p. 6). According to Engelhardt and Simmons (2002b),

> The need for organizational flexibility to accommodate a changing world is well understood. Today's high-velocity and competitive markets apply added pressure to adapt rapidly and perform at high levels. Technology is opening up new ways to compete while making old ways obsolete. These trends are recognized in strategic management theories that focus on constant change and speed. (p. 113)

Resilience in CASS may encompass engineering, ecological, and/or CAS adaptability. For example, human biological systems resemble engineering resilience in the feedback mechanisms that maintain homeostasis (Tortora & Grabowski, 2000). Human biological systems resemble ecological resilience through evolution and migration (Holland, 1992, 1999; Kauffman, 1993, 1996). In CASS, resilience comprises aspects of engineering and ecological resilience plus another layer of complexity. Human cognition and sensemaking (Weick, 1995) add complexity to the four factors that are characteristic of CAS – self-organization, hierarchy, emergence, and learning (Gunderson & Holling, 2002). As such, adaptive capacity in CASS is the ability to maintain function and integrity under new constraints while operating at a new level of conscious awareness.

This adaptive capacity allows for a higher tolerance for change (Bennett & Bennett, 2004). Organizational resilience is sometimes considered as the degree of flexibility or rigidity of an organization's culture in response to change (Schein, 2004). In other words, organizational resilience is a collective adaptive capacity for change. In the context of this discussion, resilience is the ability of a system (team, organization) to adapt its structure while maintaining its function, which often entails emergence of new processes (behaviors, norms, and hierarchical structures). In a nutshell, "form ever follows function," with the human experience and agency integral to the definition of the system's function (Sullivan, 1896, pp. 408-409).

Adversity is an antecedent to resilience. Adversity may occur as internal organizational disruptions, competitive markets, or environmental factors. Given the potential impact that adversity can have on the stability and sustainability of an organization, an understanding of how groups collectively rebound from adversity is essential to the ongoing success of the organization. As a result, it is important to understand the tension between adversity and resilience. Engelhardt and Simmons (2002b) observe that organizational resilience is an oxymoron,

> Organization is essentially a systemized whole consisting of interdependent and coordinated parts. Flexibility centers on modification or adaption. The more systemized and interdependent a group of humans is, the more difficult the change process. Thus, flexible organizations have typically have been thought of as having less top down control and more team and individual empowerment. (p. 113)

Two thoughts come to mind in this statement. First, organizational change is difficult and, second, if future change is to occur in organizations, it will likely come through resilient teams. The potential for organizational learning comes from teams in organizations that change and adapt by facing adversity (Chan, et al., 2003). As Farson (1996) puts it, "this presents us with the paralyzing absurdity that the situations we try hardest to avoid in our organizations would actually be the most beneficial for them" (p. 126). I take from these reflections that organizations have a lot to gain by understanding the dynamics of adversity and resilience in teams. Because preparation reduces uncertainty, leaders may be able to develop competencies of resilience in their teams and organizations, in a way of being prepared for the unexpected or *in omnia paratus*, prepared for all things. While teams may not be able to anticipate every adversity, teams can develop resilience to adapt and change to new conditions

Resilience has different meanings in different contexts. In this discussion, I focus on collective resilience in groups and teams, not individual resilience. In engineering, resilience is the efficiency of a system's return to stability (Walker & Salt, 2006). An engineering system's adaptive capacity is measured in terms of its distance from a set of thresholds. Ecological resilience is preservation of a system's identity, integrity, and function in the face of changes in its environment (Walker & Salt, 2006). In CAS, resilience comprises aspects of engineering and ecological resilience along with four other characteristics – that is (a) a system's propensity for self-organization, (b) building hierarchies and structures to conserve resources, (c) emergence of innovations to solve problems, and (d) learning in the face of environmental constraints (Gunderson & Holling, 2002). The CAS view of resilience will be the context of this discussion.

Level of Analysis and Scope

The review of the literature draws from ecology, CAS theory, organization development, and organizational behavior. These fields provide an appropriate basis for the analysis because they comprise research in GD, complexity, adaptability, organizational systems, and resilience. In this comparison, the level of analysis is limited to project teams in organizations and project teams are considered CASS. In the comparison of GD and complex adaptive cycles, a new conceptual model of GD and resilience is created in terms of CASS. In doing so, I acknowledge that resilience in teams may scale to organizational resilience. While the results of this analysis have implications for building competencies for organizational resilience, the focus of this essay is to discover how the relationship between these two models contributes to understanding resilience in project teams.

Project teams are the subject of this analysis because they typically have a longer life cycle (six months or more) than other types of groups such as committees, task forces, and work groups. A longer life cycle allows researchers to observe group behavior at multiple levels and with greater depth because there are more overt manifestations of group behaviors and norms over time. The intent of this comparison is to provide useful insights about resilience for a variety of organizations (e.g. non-profits and NGOs), and is not limited to commercial enterprises. While the examples provided for illustration in this discussion come from the author's experience in industry and education, the reflections are intended to be generally applicable to project teams in a wide variety of fields.

Assumptions and Limitations

Several explicit and implicit assumptions are made in this comparison and discussion. Based on a review of the literature, an assumption about the limited application of CAS theory in the field of GD is made. While this assumption may be true today, McGrath's (2000) call for more research in these fields using CAS is being answered by researchers. What has been published to date may quickly give way to new findings shared by researchers.

Further, I believe that a model of resilience used in ecological systems is relevant and applicable to human systems. While I make this assumption, I recognize that the comparison drawn in this essay is metaphorical, merely a comparison of mental models from a CAS perspective (Metcalf, 2008, 2009). The recognition of the limitations of comparing metaphors in the context of CAS was brought to my attention during a discussion with Dr. Juris Hartmanis, Professor Emeritus at Cornell University and member of the Science Board at the Santa Fe Institute. As such, this recognition lent credibility to my argument during our discussion. I conducted an extensive search of work done by anthropologists, primatologists, geneticists, ecologists, and other related systems scientists revealed that the CAS theory has not been widely adopted as the basis for research in their respective fields. As a result, it is difficult to make a cognitive leap directly from ecological systems to humans and the metaphorical use of mental models remains the basis of this comparison. Thus, this discussion uses Byrne's (1998) definition of isomorphism to bridge physical science with human science in a reflexive way.

Ahl and Allen (1996), de Waal (1989, 2006), Kauffman (1993, 1996), Metcalf (2008, 2009), and others have conducted significant work about the value of applying ecological models to human systems. In ecological hierarchy theory, ecological systems are linked to human systems (e.g. population or community) at the level of "primary production" because they share the same phenomena in common (Allen, Hoekstra, & O'Neill, 1984, p. 10). This linkage is important as a cognitive leap is made from ecological CAS to human CASS. The assumption that human resilience mimics ecological resilience is based upon the conclusions of their work; however, we must use care. There are limits to the application of this model of adaptation in the comparison. Direct correlations between the two models may contain inherent biases that lead to erroneous conclusions. Human cognition adds additional complexity that needs to be acknowledged and understood. The understanding of the scope and limitation of this study provides the basis for the introduction of the models.

In the following review of the literature, GD is introduced and explored as it relates to literature currently available in CAS theory and complex adaptive cycles. Beginning with a historical perspective of the evolution of GD models, an overarching framework of four principles of CAS theory (self-organization, hierarchy, emergence, and learning) is presented, followed by the model of complex adaptive cycles. Finally, the four principles of CAS theory interweave the comparison of both models to integrate the ecological model of adaptive cycles into GD. The CAS framework forms the basis for the discussion, conclusions, and recommendations.

REVIEW OF THE LITERATURE

Much of the research concerning GD focuses on understanding why and how groups change over time. Based on observations made by Engelhardt and Simmons (2002a) and the author's search, little research exists about the relationship between GD and CAS, much less team resilience in the face of adversity. And yet, organizational resilience is highly desirable from a strategic point of view (Coutu, 2003).

The purpose of this review of the literature is to develop a basis for comparison of a model of GD and a model of complex adaptive cycles. Since there are numerous GD models, a search of literature was conducted to find a definitive model or to develop a composite of the most reliable models. The rationale for the examination of various theories of GD is to create an understanding of how and why groups, specifically project or program teams, change, evolve, and become resilient. Through comparing and contrasting the theories of GD, one part of the foundation is established to build an integrated theoretical bridge. A second part of the foundation is created by the explanation of adaptive cycles. By understanding the strengths and limitations of the models that have been developed, CAS theory is introduced to bridge the two foundational models using the principles of self-organization, hierarchy, emergence, and learning. Bridging the gaps between models may yield new paths through adversity to resilience for project teams and organizations.

Group Development Models

There are numerous theories (over 100) and theoretical models of GD (Hill & Gruner, 1973). Based on different perspectives of typologies, they are classified as linear, phasic, teleological, life cycle, dialectical, and normative (Mennecke, Hoffer, & Wynee 1992; Smith, 2001; Van de Ven & Poole, 1996; Zachary & Kuzuhara, 2005). The models developed after linear and phasic models (stages) attempt to present group development as an integrated process.

Perhaps one of the most promulgated or dominant models of GD is Tuckman's Stages Model (1965). Tuckman's linear model is widely used in organizational behavior and is widely used in organizations (Robbins & Judge, 2007). Since it is a validated model and easily understood, Tuckman's model is used for this comparison. The four linear stages are forming, storming, norming, and performing. Later, Tuckman and Jensen (1977) added a fifth stage, adjourning, to describe disbanding of the group. It is summarized by Schuman (2001) in Table 1. Two aspects are involved in this model, based upon unitary sequences of decision-making – interpersonal relationships and task behaviors. While Tuckman and Jensen's model is the basis of many others that followed it, this model was based upon group research conducted at the Tavistock Clinic and Institute of Human Relations (Tavistock) by researchers, such as Herbert and Trist (1953) and Bennis and Shepard (1956) at MIT.

Critics of Tuckman's (1965) model point to its development based on research done with subjects who were students, patients undergoing group psychotherapy, or trainees. A question arises about whether or not the group behaviors of students and those in psychotherapy are truly reflective of normal GD (Herbert & Trist, 1953). A similar criticism is applied to the work done at Tavistock; however, these studies were later found to be comparable to training groups (T-groups), a group model pioneered by National Training Laboratories (NTL) (Weisbord, 2004). NTL's model evolved from Lewin's (1947a, 1947b) action research experiments.

The purpose of T-groups is to study "here and now" behavior (Weisbord, 2004, p. 104). According to Weisbord, "A T-group was (and is) an education in self-awareness" (p. 352). The self-awareness by group members and researchers helped render insights and did not harm the research group (Herbert & Trist, 1953). The researchers themselves understood the potential limitations and applicability of their work and were mindful not to overreach in making their conclusions. The concerns of critics appear to be unfounded because the researchers' conclusions have yet to be discounted. Subsequent studies in GD have validated their conclusions and built new insights upon them.

Tuckman's (1965) linear model served as the basis of Gersick's (1988, 1989) Punctuated Equilibrium Model. As opposed to linear models, Gersick's model is appropriate for temporary groups with specific deadlines (Robbins & Judge, 2007). Morgan, Salas, and Glickman (1994) used the GD models created by

Table 1. Stages of Group Development

Stage	Group Structure: The pattern of interpersonal relationships; the way members act and relate to one another.	Task Activity: The content of interaction as related to the task at hand.
Forming: Orientation, testing, and dependence	Testing and dependence	Orientation to the task
Storming: Resistance to group influence and task requirements	Intragroup conflict	Emotional response to task demands
Norming: Openness to other group members	Ingroup feeling and cohesiveness develop; new standards evolve and new roles are adopted	Open exchange of relevant interpretations; intimate, personal opinions are expressed.
Performing: Constructive action	Roles become flexible and functional; structural issues have been resolved; structure can support task performance	Interpersonal structure becomes the tool of task activities; group energy is channeled into the task; solutions can emerge
Adjourning: Disengagement	Anxiety about separation and termination; sadness; feelings toward leader and group members	Self-evaluation

Note. From "Editors note: Developmental sequence in small groups," by Schuman, 2001, p. 66 . Location: *Group Facilitation*

Tuckman (1965) and Gersick (1988, 1989), and integrated several other theories to develop their Team Evolution and Maturation (TEAM) model. This phasic model is comprised of nine developmental stages and is geared to task-oriented teams. Two other phasic models were developed, one by Fisher (1970) based on decision emergence and one by Tubbs based on a "systems" approach (1995). Wheelan (1990, 1994) incorporated Tuckman's (1965) model and Bion's (1961) work into her "integrated" model of GD.

Poole (1981, 1982, 1983), Poole and Roth (1989), Poole and Holmes (1995), and Poole and Van de Ven (2004) developed a multiple sequence model (teleological) based upon group decision-making as a function of several contingency variables (i.e., group composition, task structure, and conflict management strategies). In this model, three activity tracks are presented as task, relation, and topic. Breakpoints occur when interaction shifts between the three tracks. While Poole and his colleagues had created a descriptive system for studying sequences, Poole later rejected phasic models of GD and suggested a model of continuous threads of activity, for example life cycle models.

In a departure from phasic and sequential models, three studies revealed additional insights into GD. First, McGrath (1991) proposed that although teams follow different development paths, they usually reach the same outcome. In his activity and function-based (dialectical) model based on time, interaction, and performance (TIP), he observed four activity modes (inception, problem solving, conflict resolution, and execution) and three functions (production, well-being, and member support).

Second, Hackman's (1987) Normative Model of Group Effectiveness takes a design approach to GD in work teams, specifically focused, synergistic groups. This integrative model, which relies on organizational behavior research and environmental factors internal and external to the group, prescribes the characteristics necessary for effective team performance (Zachary & Kuzuhara, 2005).

Third, Wheelan, Davidson, and Tilin (2003) introduced an Integrated Model that discussed successful teams in terms of maturity. Typically, a team that is fully integrated meets their criteria for group maturity, shown in Table 2. This model explores the concepts of feedback, decision making, cohesion, and acceptance of minority views, and introduces some systemic perspective into the discussion.

Table 2. Ten Criteria for Measuring Maturity of a Group

Criteria	Immature Group	Mature Group
Feedback mechanisms	poor	excellent
Decision-making methods	dysfunctional	functional
Group loyalty/cohesion	low	high
Operating procedures	inflexible	flexible
Use of member resources	poor	excellent
Communications	unclear	clear
Goals	not accepted	accepted
Authority relations	independent	interdependent
Participation in leadership	low	high
Acceptance of minority views	low	high

Note. Adapted from Schermerhorn, Hunt, & Osborn, 2000, p.180, *Organizational Behavior*. New York: Wiley & Sons.

While these three studies (Hackman, 1987; McGrath, 1991; Wheelan et al., 2003) added to the understanding of GD, they remain partial perspectives of a dynamic, complex, and systemic process. Later models of GD attempted to account for the complexity of group dynamics; however, Tuckman and Jensen's (1977) group developmental sequence model remains rooted in the findings of foundational work done by Herbert and Trist (1953) as well as research done by Bennis and Shepard (1956). It has been validated by its continued use in research and practice. This model conveys significant meaning about GD in few words through its use of colloquial terms – forming, storming, norming, performing, and adjourning. As a result, this model provides a strong basis for the comparison in this review. CAS theory introduces complex ideas; yet, the brevity of Tuckman and Jensen's model clarifies the discussion. Because Tuckman's model is compelling, valid, and concise, it will be used as the GD model for this comparison.

Limitations of Existing Group Development Models

Existing GD models have limitations, as well as significant value. Given that groups are intricate human systems operating in multi-faceted organizational systems with multiple layers of hierarchy, the ability of current models to fully explain the complexity of groups is limited by the perspective used to develop them. Foremost, many models attempt to identify phases, stages, and functions of *normal* GD.

Normal Group Development and Why it is Important

Knowing what to expect in normal GD is useful because team leaders can anticipate their teams' evolution, plan for conflicts, and develop strategies to keep them focused on goal attainment. In the author's experience as a project manager, *normal* rarely occurs in project teams, yet it appears to be an implicit assumption of the models developed to date. During the lifecycle of many project and program teams in which she has been a member, some adversity or perturbation (systemic disturbance, disequilibrium, or imbalance) occurs. For example, the team's project loses funding, resources, or essential personnel; the customer makes significant design changes; the organization is sold and merged; the market fluctuates; or the economy changes.

It makes sense to plan for adversity and its impact on team development. By understanding adversity and developing ways to become resilient, teams may identify unrecognized leverage points for organizational learning and change. Understanding and insight can be gained when questions about GD in the context of adaptability and resilience are framed in response to uncertainty and adversity.

Group Development: A CAS Perspective

The significance of historical research in the creation of theories and models of *normal* GD during the 20th century is important (Bennis & Shepard, 1956; Gersick, 1988, 1989; Herbert & Trist, 1953; McGrath, 1991; and Tuckman, 1965). Existing theories and models provide mental models of what one could typically expect during GD. This body of knowledge has enabled us to ask new questions and pose them from different perspectives. A good understanding of a norm gives us a baseline for comparison and a foundation upon which to build new theories and models. Tuckman and Jensen's (1977) model of GD provides a solid foundation for this purpose.

Current Group Development Models are Incomplete

From a CAS perspective, Carpenter, Folke, Scheffer, and Westley (2009) caution us to limit our reliance on existing models because of two, biased filters. The first filter is a propensity "to focus on the computable, despite awareness of noncomputable aspects" (p. 2) that impact complex scenarios. I interpret this to mean that we shouldn't overlook implicit factors in favor of explicit factors because they are not easily comprehended. The second filter is an inclination "to believe in dominant models even though they are incomplete" (p. 2). They suggest that inclusion of multiple points of view is a way to balance the bias toward quantitative knowledge devoid of qualitative, contextual understanding.

For example, in industry, the drive toward "best practices" based upon efficiency, rationality, and standardization has prevailed in a tendency toward monoculture or dominance of the few (Frank & Cook, 1995). This phenomenon can easily be observed by the business population that can readily recite the elements of dominant models like SMART (specific, measurable, attainable, realistic and timely) goals (Drucker, 1954) and Tuckman's (1965) model of GD as forming, storming, norming, and performing. It is interesting that the final "adjourning" phase, which explicates additional subtleties of GD, is often forgotten (Tuckman & Jensen, 1977). While there is value in developing best practice methods, it is equally important to evaluate whether or not those methods remain valid within the increasingly complex and faster developing operating environments and contexts in which they are applied. When the dominant model becomes constricting, it is important to widen the scope of the lens, to introduce different perspectives, and to validate relevance of the model. This comparison seeks to widen the lens of understanding of GD through CAS theory and the model complex adaptive cycles.

An overview of GD has been presented. The value of understanding normal GD models and their limitations as the basis of an argument for applying CAS theory has been discussed. The rationale for choosing Tuckman and Jensen's 1977 model for this comparison was argued. Next, a model of systemic resilience is presented. First, the ecological model of complex adaptive cycles is introduced and explained. Second, the historical research and underlying theories for Tuckman and Jensen's (1977) are discussed in terms the foundational concepts of CAS (self-organization, hierarchy, emergence, and learning). Third, the four CAS characteristics are related to group governance, specifically decision-making norms used for information sharing and resource management (Doppelt, 2003).

Complex Adaptive Systems, Adaptive Cycles, and Panarchy

Why would we want to view project teams in terms of CAS and complex adaptive cycles? The value of this perspective lies in the additional insights that may be learned about team resilience from a comparison with standard GD theories and models. I propose the investigation of project teams with a life cycle of six months or more. In doing so, I accept two assumptions, which are: (a) teams are collectives of human agents working together in complex environments to achieve specific goals, and (b) the phases of team evolution follow normal GD models (i.e., Tuckman & Jensen, 1977).

As a result, I assume that the subject project teams for this analysis are complex, adaptive social systems (CASS), which means that the group's development manifests the four behaviors of CAS. In other words, project teams demonstrate self-organization, hierarchy building, emergence of decision-making norms and innovative approaches for problem solving, and potential for group learning for future adaptive capacity. If I accept this argument, then I need to examine more closely how these characteristics manifest when project teams face adversity. Ultimately, the purpose of this inquiry is to understand team resilience. An explication of resilience, panarchy, and CAS theory are explained in detail in the following sections.

Resilience and Panarchy

To explore resilience and panarchy, I begin by examining a project team's ability to adapt to adverse conditions in its environment with a systemic goal to maintain its functional integrity and to learn from its experience. According to the Resilience Alliance (2009) on their website, resilience is defined as follows:

Ecosystem resilience is the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes. A resilient ecosystem can withstand shocks and rebuild itself when necessary. Resilience in social systems has the added capacity of humans to anticipate and plan for the future. (www.resalliance.org)

The explanation continues,

Resilience, as applied to ecosystems, or to integrated systems of people and the natural environment, has three defining characteristics:

- The amount of change the system can undergo and still retain the same controls on function and structure,
- The degree to which the system is capable of self-organization
- The ability to build and increase the capacity for learning and adaptation.

The development of the Resilience Alliance's definition of resilience in ecological and social systems stems from Gunderson and Holling's (2002) development of panarchy theory. Paul Emile de Puydt (1860) coined the concept of *panarchy*, which describes governance that includes all other forms of governance. While the term, panarchy, is used in international relations to describe global governance, the Resilience Alliance uses the term to refer to non-linear organization. Linear organizations can be understood through their individual parts and putting them together. A non-linear organization cannot be understood as a sum of its parts; rather, the whole is greater than the sum (Mitchell, 2009). With respect to building sustainable organizations, Gunderson and Holling (2002) state that,

> Panarchy, a term devised to describe evolving hierarchical systems, offers an important new framework for integrating insights from ecology and the social sciences in this effort. Based on the concept of cycles of creative destruction and renewal, panarchy is a fundamental new development in a widely acclaimed line of inquiry. (Cover)

Essentially, the Resilience Alliance views panarchy as an interconnection of natural and human systems in recurrent adaptive cycles of exploitation, conservation, release, and reorganization that exhibit processes of self-organization, building hierarchies, emergence of innovation, and collective learning.

Principles of Complex Adaptive Systems

Panarchy theory is embedded in CAS theory. According to Holland (1992, 1999), CAS are dynamic networks that have several agents (e.g. cells, neurons, individuals) acting in coordination (e.g. neural networks, groups, and teams), continually acting in response to other agents and the environment. Control in a CAS is highly dispersed and decentralized. Coherent behavior amongst agents in a CAS arises from cooperation, collaboration, and/or competition. The overall behavior of the system is the result of a huge number of decisions made every moment by many individual agents (Waldrop, 1992).

In this section, I explore the four principles of CAS: self-organization, hierarchy, emergence, and learning. These four principles serve in the ebb and flow of CAS and GD. Self-organization supports the group's *function*. Hierarchy serves as the group's *structure*. In terms of Louis Sullivan's (1896) law, "form ever follows function," emergence serves as the group's dynamic *flow* between structure and function (pp. 408-409). Learning is the application of lessons from an adaptive experience of the flows between structure and function to future situations building adaptive capacity for resilience. Understanding these foundational principles is the basis of this discussion of GD and CAS theories and in comparing them to complex adaptive cycles.

Self-organization and emergence. According to Mitchell (2009), "Systems in which organized behavior arises without an internal or external controller or leader are sometimes called self-organizing" (p. 13). As one of the characteristics that distinguishes ecological from environmental engineering, self-organization is a natural process of life as opposed to a purpose-driven design (Allen, Giampetro, & Little, 2003). Self-organization, hierarchy, and emergence are intertwined with one another and their dynamics manifest more or less throughout the process of adaptation. Because self-organization and emergence provide creative tension throughout the process, they are discussed together. This is done so their relationship to one another can be more easily understood relative to hierarchy, which supports self-organization and sometimes impedes emergence, which will be revealed in the following explanation.

Emergence is a process of self-organizing (Lichtenstein, 2000). According to Bennett and Bennett (2004), self-organization entails complex systems "in which the agents have a high degree of freedom to organize themselves to better achieve their local objectives" (p. 290). In addition, they determine how objectives will be attained. In other words, the systems and project teams develop their own form of governance.

Emergence, or emergent properties, is the concept that the whole is not merely the sum of its parts. According to Checkland (1999), it is,

> The principle that whole entities exhibit properties which are meaningful only when attributed to the whole, not its parts – e.g. the smell of ammonia. Every model of a human activity system exhibits properties as a whole entity which derives from its component activities and their structure, but cannot be reduced to them." (p. 314)

Ashby noted (1962) that self-organization involves specific discernment about how organisms change their organization or their functional mapping. It is important to recognize that Ashby was not satisfied with the term, *self-organization*, from the start because he felt the term was "self-contradictory" (p. 269). For Ashby, self-organization is not about autonomous change. It entails influence from higher level sources of randomization and it rests on conditionality, "Thus, the theory of organization is partly co-extensive with the theory of functions of more than one variable" (p. 256). Ashby (1962) delineated two interpretations of self-organizing:

There is a first meaning that is simple and unobjectionable. This refers to the system that starts with its parts separate (so that the behavior of each is independent of the others' states) and whose parts then act so that they change towards forming connections of some type. Such a system is "self-organizing" in the sense that it changes from "parts separated" to "parts joined." (p. 266)

Ashby characterized this as "self-connecting" and made no value judgment on this type of self-organization, noting that it is neither "good" nor "bad;" however, he does recognize that "no machine can be self-organizing in this sense" (p. 267). A change in conditionality has occurred; however, a criterion for improvement has not been established. This is where Ashby derives his distinction for a second interpretation of self-organization.

In his second interpretation, Ashby (1962) accounted for the principles of competition and requisite variety, Shannon's Tenth Theorem, in his definition (Shannon & Weaver, 1949). In Ashby's view, these principles govern self-organization. Competition is important to recognize in CAS because, even if intelligence is developed by organisms, the adaptation will be specialized to a specific environment or context and it will be directed towards keeping their own essential variables within limits (i.e., "They will be fundamentally selfish," Ashby, p. 273). Requisite variety is a "reality check" for CAS theorists and prompts them to focus on realistic, solvable problems because it parallels the law of conservation of energy in engineering. Like the brain, the amount of regulatory or selective action that can be achieved is "absolutely bounded by its capacity as a channel" (p. 274). In the comparison with GD, I specifically look for dynamics of competition and requisite variety in the norming process of the sequence.

In ecology, most CAS are self-organizing (Bennett & Bennett, 2004); however, human systems intercede with variances of control. There is a spectrum of control from low (self-managing teams) to high (autocracy and bureaucracy) in human organizations. Bennett and Bennett state, "Self-organization provides the organization with robustness and resiliency" (p. 291) in the face of adversity. Based on Prigogine's (1997) view of dissipative structures, Wheatley (1994) observed that disequilibrium is necessary for a system's growth. Systems must give up their form to recreate themselves in new forms. This principle is important when teams are forming, as well as when they are reforming and reorganizing at the adjourning stage.

Wheatley (1994) also recognized that when systems are faced with increasing levels of turbulence, they demonstrate an inherent ability to reorganize themselves, given the new information. She states, "For this reason, they are called self-organizing systems. They are adaptive and resilient rather than rigid and stable" (pp. 79-80). Wheatley's use of terms like adaptive, resilient, rigid, and stable are also applicable at the team level as applied to group decision making norms. In sum, the dynamic between self-organization and emergence are like function and flow in CAS.

Hierarchy. CAS are simultaneously self-organizing (function), emergent (flow), and hierarchical (structural form). In broad terms, hierarchy refers to how things are arranged, ordered, or organized relative to each other – higher, lower, or at the same level. Hierarchy provides organizational structure to systems.

Different disciplines, for example religions (angels, church authority) and mathematics (ordered sets), make distinctions about the meaning of hierarchy (Ahl & Allen, 1996).

In organizational systems, hierarchy is often linked with command and control governance, as well as positional power (Gharajedaghi, 2006; Wiener, 1948, 1954). Hierarchy serves as systemic stabilizer to reduce uncertainty (Ahl & Allen, 1996). Hierarchy, such as designating leaders for specific decision-making tasks in governance or setting policies and procedures, frees resources to be used efficiently because they are not continually employed in repetitive decisions and work (Allen, 2009; Bennett & Bennett, 2004). The characteristics of hierarchy as stabilizing and resource liberating provide a secure foundation for groups to focus on solving problems.

Hierarchies exhibit differentiation (Allen, 2008). Horizontal differentiation (flat hierarchy) is the elaboration of structure that solves problems and moves onto the next problem, leaving the structure behind. The process makes a complicated structure that is difficult to control, predict, mend, or change. Decentralized, matrix-managed, virtual, and cross-functional task forces and project teams are examples of horizontal differentiation or flat hierarchies in organizations. It may be observed in group development as horizontal hierarchy is established through peer norming, based on conformity to standards of behavior acceptable across the group. Ahl and Allen (1996) distinguish the difference between "complicatedness" (horizontal, flat hierarchy) as simple and "complexity" (vertical) as deep. Vertical differentiation (deep hierarchy) is an elaboration of organization that creates dissipative energy, far from equilibrium. Centralized and departmental organizations are examples of vertical differentiation or deep hierarchies. Vertical hierarchies often result in "silo" thinking that is myopic in favor of a department or organizational function (e.g., accounting, finance, operations, sales, and marketing). It may be observed in group development as power norming, based on designated position or authority in the group.

While hierarchy resolves complexity in some senses making things simpler, it also causes intricate structures with many levels with their own complexity in the use of resources. Allen (2008, 2009) distinguishes resource expenditures relative to the value (gain) returned. In other words, when resource expenditure is low and return is high, the activity is high gain. For example, exploitation of the earth's resources, such as oil and coal, has been high gain until late in the 20th century. Peak oil in the United States was reached in 1973 (Martenson, 2009). Now, oil and coal take much more effort and are much more costly to access and extract from the earth's surface. The quality may not be as high; therefore, their utility is lower. As a result, oil and coal are now low gain resource expenditures and conservation programs have begun to mitigate costs (Allen, 2009; Gunderson & Holling, 2002). The dynamic between exploitation and conservation is a preview of adaptive cycles, which will be discussed in detail.

Hierarchy increases with complexity and subsequently requires more resources to maintain (Allen, Hoekstra, Pires, & Tainter, 2001). The Roman Empire illustrates the tendency of advanced hierarchies to require more resources (Allen, Hoekstra, Little & Tainter, 2003; Gibbon, 1996; Tainter, 1988). Rome's governance and infrastructure were successful; yet, as the Romans conquered more geographically dispersed populations, the infrastructure became complicated and overextended. By 300 C.E., Rome's infrastructure required massive resources to maintain and it had become stretched thin, beyond its functional threshold. Its inability to adapt contributed to its disintegration (Tainter, 1988).

Hierarchies of organizational governance are low gain because they become dense in the middle (Allen et al., 2001). For example, mid-level managers in many companies are slow to respond and weighed down with policies and procedures. Like Rome's infrastructure, mid-level governance requires significant resources; however, maintaining it requires even more resources when it is stretched to serve a broader base. It requires reinvestment and becomes self-perpetuating. As demands increase, middle managers' responses slow the process down by creating more requirements, more policies, and more procedures. Eventually, it becomes a bureaucracy.

On the other hand, emergence of new phenomena, ideas, and concepts that are derived through the creative process and innovation require fewer resources. Self-organization is high gain and adds components to the top of the hierarchy (Allen et al., 2001). Groups and teams negotiate the CAS dynamics of self-organization, hierarchy, and emergence in their development. Organizations that learn to negotiate these dynamics effectively adapt, such as Semco (Semler, 2007) and Southwest Airlines (D'Aurizio, 2008). Organizations that do not learn to negotiate the dynamic effectively fail, such as Digital Equipment Corporation (Schein, 2004).

Learning. In CAS, resilience develops out of learning from adaptive experiences. Substantial organizational learning and subsequent organizational change is derived from emergent properties in team decision making (Senge, 1990; Mintzberg & Westley, 1992). As part of a decision system, organizational learning systems help to provide conceptual models for the process which results from being surprised. In other words, the feedback from adversity is incorporated into the decision system as a result of learning from experience. Learning systems identify the gaps between the expected and the actual occurrence, and assist in the development of adaptive responses (Argyris, 1999).

Ackoff (1981) designed a learning management system that functions as a feedback system. It calls for corrective action before a problem occurs. Organizational learning systems, like Ackoff's learning management system, support building capacities for resilience because. According to Gharajedaghi (2006), "such a system will continuously monitor the validity of the assumptions on which the decision was made, as well as the implementation process and intermediate results" (p. 77). It becomes an integral part of the feedback loop, serving as a balance to reinforcing trends in beliefs, assumptions, and norms in decision-making. Such learning systems render iterative learning that builds organizational decision-making competence (Mintzberg & Westley, 1992). High reliability organizations, such as the United States Naval Aircraft Carrier Fleet (Burke, Wilson, & Salas, 2005) rely on this kind of feedback mechanism to build team competencies of resilience.

The four principles of CAS have been reviewed, including self-organization, hierarchy, emergence and learning. In summary, these four principles serve in the ebb and flow of CAS and GD. Recall that self-organization serves as *function*, hierarchy serves as *structure*, and emergence serves as *flow* in CAS. Adaptation depends upon the organization's ability to flow with change and adapt its structure while maintaining its function. Understanding these foundational principles is the basis of the discussion of GD and CAS theories as I compare them to complex adaptive cycles. Next, I will introduce Gunderson and Holling's (2002) ecological model of adaptive cycles by discussing Holling's (2004) view of sustainability to build a bridge between ecological systems and social (human) systems.

Adaptive Cycles

A bridge between ecological and social systems' definitions of resilience may be made based upon Holling's (2004) interpretation of sustainability. According to Holling, the key to sustainable systems is a capacity to recover after a disturbance. In his view, ecosystems and social systems are considered as interacting with and impacting one another because they both share adaptive cycles in changing environments. Adaptive cycles occur in social systems such as businesses, governments, and communities, as well as in ecological systems. Using Holling's rationale, I examine the nature of adaptive cycles for application to project team development.

Adaptive cycles are characterized by connectedness and the following four phases: (a) rapid growth, (b) conservation, (c) release, and (d) reorganization. According to Gunderson and Holling (2002), adaptive cycles are "a way of describing the progression of socio-ecological systems through various phases of organization and function" (p. 163). The adaptive cycle model developed by Gunderson and Holling (2002) and graphically illustrated by Walker and Salt (2006) is shown in Figure 1.

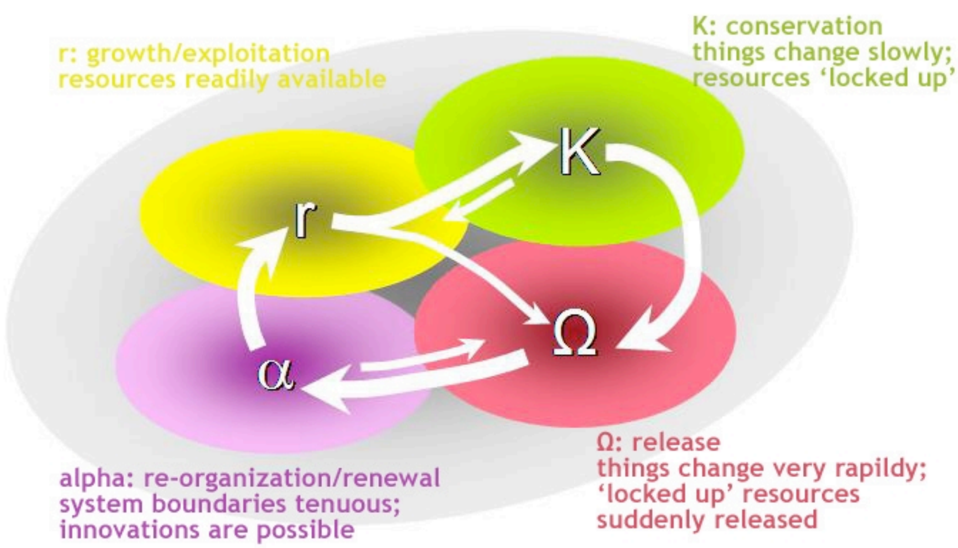

Figure 1. Adaptive Cycle. From "Resilience Thinking: Sustaining Ecosystems and People in a Changing World," by B. Walker & D. Salt, p. 81, Washington, DC: Island Press, 2006.

The adaptive cycle, when placed on an X-Y axis, reflects the relationship of the four phases to the *potential* inherent in accumulation of resources (X) with *connectedness* among controlling variables (Y). Use of Greek notation is indicative of the Gunderson and Holling's (2002) references to terminology used in ecology. In ecology, species in the exploitative phase are referred to as *r*-strategists, while those in the conservation stage are referred to as *K*-strategists. The symbol *r* represents the rate of growth of a population. The symbol *K* represents a plateau or that a maximum population has been reached (Pearl, 1927). Gunderson and Holling (2002) note that the two phases "could be seen as equivalent to the entrepreneurial market for the exploitation phase and the bureaucratic hierarchy for the conservation phase" (p. 34).

Gunderson and Holling (2002) use Greek notation for the remaining two phases as symbols to express the essence of a system's activity in that phase. Omega (Ω) represents endings (high connection with lower potential), and alpha (α) represents new beginnings (high potential with lower connection). The notation serves an additional purpose of clarity and ease in identifying phases of adaptive cycles, which I will use just as the terms forming, storming, norming, performing, and adjourning are used to identify the stages of Tuckman and Jensen's (1977) GD model.

The strength of a system's internal interconnections, flexibility, and resilience are reliant on the way the system behaves during the transitions from one phase to another. The first phase is rapid growth (*r*) in which "resources are rapidly available and entrepreneurial agents exploit niches and opportunities" (Gunderson & Holling, 2002, p. 163). The second phase is conservation (*K*) in which "resources become increasingly locked up and the system becomes progressively less flexible and responsive to disturbance" (p. 163). The third phase is release (Ω), in which "a disturbance causes chaotic unraveling and release of resources" (p. 163). The disturbance, or perturbation, is analogous to an adversity. The fourth phase is reorganization (α) "in which new actors (species, groups) and new ideas can take hold. It generally leads into another *r* phase" (p. 163). It is important to note that "the new *r* phase may be very similar to the previous *r* phase, or may be fundamentally different. The *r* to *K* transition is referred to as the fore loop, and the release and reorganization phases are referred to as the back loop" (p. 163). While most ecosystems typically go through the four-phase sequence, other transitions are possible.

The understanding of hierarchy theory helps us look for examples of these phases. For example, the concept of high-gain/low-gain shows us that demand for energy (coal and petroleum-based) in North America has created large infrastructures to deliver energy to us, such as the national power grid for electricity. Rich and readily accessible coal and oil deposits have been exploited (high gain), *r*-phase, and conservation (*K*-phase) programs have begun (Allen, 2009). The resources that remain are not as accessible and lower quality (low gain) (Allen, 2009).

Energy companies are searching for new resources and new technologies to use existing resources more effectively. Leaders of companies, communities, and governments are re-evaluating how resources are used while realizing old structures no longer work and will not serve future needs for energy. Hierarchies and structures that no longer serve our needs will cease (Ω). For example, the national power grid does not just deliver electricity to homes, but it accepts power generated by homes that have used alternative methods, such as solar power, to create and return it to the system. The impact of this realization has wide implications in economics, ecology, and equity (McDonough & Braungart, 2002). We, as a global society, are at a critical decision-making or inflection point that concerns the survival and sustainability of the human species, as well as others (Friedman, 2008). In other words, we are approaching a threshold or inflection point of existence on this planet (Land, 1986; Jarman & Land, 1992).

While some scientists are still trying to determine our distance from the threshold of human survival, others are working on innovations that increase our distance from it using an engineering approach to sustainability. For example, the United States Department of Energy (DOE) sponsors a Solar Decathlon biennially. The Solar Decathlon is a competition between 20 student project teams to design, engineer, and build homes that use net zero power. The project teams work together for two years to compete for three weeks on the National Mall in Washington, DC. They are judged on their use of solar, renewable, and energy-efficient technologies using 10 criteria including architecture, market viability, engineering, lighting design, communications, comfort zone, hot water, appliances, home entertainment, and net metering (U.S. Department of Energy [DOE], 2009). Most of the criteria focus on energy efficiency and conservation, and engineering approaches to resilience; however, the project team from Cornell University (CUSD) returned to campus with plans to reorganize (α) the team for sustainable design in a multi-disciplinary (architecture, engineering, landscape design, and communications) collaboration. CUSD is illustrative of both models (GD and adaptive cycles). I will revisit and discuss CUSD in the comparison of models.

COMPARING MODELS – GROUP DEVELOPMENT AND ADAPTIVE CYCLES

Using the theories of CAS and GD, I compare Gunderson and Holling's (2002) model of adaptive cycles (Figure 1) with Tuckman and Jensen's (1977) model of GD (Table 1). In this section, I will elaborate on each step of the comparison of each phase of the models, as summarized in Table 3. This conceptual model will guide the comparison of the two models and the discussion about how they can inform each other when applied to project teams. The comparison uses historical and current research, as well as practical examples to support this new conceptual framework. It is important to recognize that, like GD itself, research has not evolved in a linear way because humans are dynamic beings. An analysis of historical research found this to be true, as early research established observational foundations and later research clarified, validated, or discounted some earlier findings.

The dynamism can also be found in the stages or phases of GD. Group behaviors and processes are dynamic and flow between the stages as groups mature. For ease, forming and storming have been combined into one phase because of this dynamic. Stages are defined by inflection points in which group momentum shifts indicating that significant change has occurred. For example, the inflection point between forming and storming phase with norming phase is marked by a shift from individual perspectives to a group perspective. This type of dynamic is characteristic of complexity, which is another reason that CAS may inform our understanding of GD.

Table 3. Comparison of Complex Adaptive Cycles and Group Development

CAS Process	*Complex Adaptive Cycle*	*GD Model*
Self-Organization	Exploitation (*r*)	Forming, Storming
Hierarchy	Conservation (*K*)	Norming
Emergence	Release (Ω)	Performing
Learning – Group & Organization	Reorganization (α)	Adjourning

Note. Based on Gunderson and Holling (2002), and Tucker and Jensen (1977).

Forming and Storming: Exploitation and Self-Organization

In this comparison, the exploitation (*r*) phase of the adaptive cycle model (Gunderson & Holling, 2002) is comparable to the forming and storming stage of Tuckman's (1965) GD model. In Tuckman's model, the processes of forming and storming serve to build a foundation for team cohesion (Schermerhorn, Hunt, & Osborn, 2000). Herbert and Trist (1953) refer to this period as *discovery*. Bennis and Shepard (1956) refer to this period as *dependence*. These theorists explore the ambivalence of the group members during this period. The issues of individual volition, submission, rebellion, and authority are manifested in member behaviors (Herbert & Trist, 1953; Bennis & Shepard, 1956). Researchers observe tension in team members' behaviors indicating conflict between either retaining members' individual beliefs or ceding to the group's views.

During the forming and storming phases, team members are enrolled and resources allocated to the mission of the group (Tuckman & Jensen, 1977). Team members search for commonality of beliefs and values, a dynamic between dependence, counter-dependence and resolution (Bennis & Shepard, 1956). They seek a shared vision and compelling reasons to commit to the group's mission. They are discovering each other's talents and potential for contributing to the group's goals. Like ecosystems, during this phase the team is self-organizing in an attempt to leverage strengths and identify weaknesses. A change in conditionality has occurred;

however, a criterion for improvement has not been established. This is one of Ashby's distinctions of self-organization. In forming and storming, competition and requisite variety can be observed in the vetting process of diverse points of view. In Ashby's view, these principles govern self-organization. In the author's experience, some teams formalize self-organization by performing an evaluative SWOT (strengths, weaknesses, opportunities, and threats) analysis periodically.

The team also reaches outside the group for support for the project's vision and to leverage and exploit resources – a high gain phase. If external support is not developed during this phase of GD, alternative support is sought. Team members either develop self-organization through self-direction and management or individual members retreat into their domains of origin. The latter may be interpreted as team members maintaining departmental or compartmentalized perspectives (or 'silo') and priorities, despite different needs of the project or program team. Bennis and Shepard (1956) recognize the group's fragility at this point as catharsis. Resolution is necessary for group cohesion (Schermerhorn et al., 2000).

Underlying the forming and storming stage is the development of respect and trust among team members. Respect and trust are critical elements in the development of group cohesion (Costa, 2003) and researchers have recognized them as essential in GD. Wheelan (1990, 1994) incorporated these elements into her model starting at the first phase. Interviews conducted in a pilot study in preparation for this essay revealed that respect and trust can make or break a team. The importance of trust and respect in project team development and cohesion were mentioned in every interview.

For example, in an interview with an executive who led a team that was performing due diligence for an acquisition, she reflected on the fact that the team never achieved cohesion due to a lack of trust and respect. The members retained their departments' agenda or silo thinking. She said, "The distrust and lack of respect for other points of view was corrosive." The lack of trust and respect was so harmful that the team did not perform as a cohesive group; instead, an external consulting company was retained to lead the team through the project. Trust and respect are critical in the formation of group norms, or *norming*, which is the focus of the next section.

Norming: Conservation of Resources through Hierarchy

In this comparison, the conservation phase (*K*) of the adaptive cycle model (Gunderson & Holling, 2002) is comparable to the norming stage of Tuckman's (1965) GD model. The second phase of GD is important because the norming process has broad and deep implications for project team equilibrium – stability and adaptability. In fact, this stage is characterized by the creation of stability through development of group norms and hierarchies of decision-making. Group cohesion is solidified in this stage (Schermerhorn et al., 2000).

In Tuckman's model, this stage is characterized by in-group feeling, group cohesion, trust, and respect. In Herbert and Trist's (1953) research, the group moved into an *execution* phase in which there was less conflict with the team leader, decreased intragroup conflict, and a shift in the group's focus "to an examination of a single basic problem" (p. 221). Bennis and Shepard (1956) describe this phase enchantment, disenchantment, and consensual validation. They discuss the solidarity and fusion of the group in terms of its suggestibility and Le Bon's (1895) "group mind," akin to "groupthink."

Groupthink is a plateau in which the group or team has reached a level of comfort internally with the establishment group norms and externally with the resources available. The group has assigned roles and responsibilities to its members in hierarchical structures to conserve resources by implementing implicit and explicit rules of how work will be done and decisions are made (*K* phase – a low gain phase). Hierarchy and norms influence how groups make decisions and the quality of those decisions, indicative of group cohesion and its propensity for groupthink (Postmes, Spears, & Cihangir, 2001). Group norms serve as feedback and moderators of thresholds for group cohesion through the process of how decisions are agreed upon, whether critical or consensus (Postmes et al., 2001).

Group norms as feedback mechanisms for group decision making. Group norms influence decision making, which is one of the major activities occurring within the boundaries of teams (Bettenhausen & Murnighan, 1985; Schermerhorn et al., 2000). According to Bettenhausen and Murnighan, "Social norms are among the least visible and most powerful forms of social control over human action" (p. 350). In their study, they examined the development of norms in 19 decision-making groups. Bettenhausen and Murnighan found that norms developed to counteract uncertainty over appropriate behavior. Members use their previous experiences as scripts and apply them in the current situation. They state,

> Depending on the similarity of the members' scripts, a common basis for action is either taken for granted or negotiated within the group. As the members interact they either tacitly revise their beliefs about appropriate action, implicitly agreeing with the direction being taken by the group, or overtly attempt to pull the group toward their own interpretation through challenges to the implied norm. (p. 350)

In systemic terms, project teams gather data and resources (inputs), perform decision-making by synthesizing information (processes), and provide results through reporting decisions, sharing knowledge, and delivering work products (outputs) to meet organizational objectives (purpose). Norms can act as slow-acting (implicit) and fast-acting (explicit) variables in human systems by serving as mechanisms of feedback in relation to behavioral boundaries (i.e. what is acceptable or tolerated and what is not acceptable or not tolerated in groups) (Colman, 1995; Conforti, 1999).

The concept of norms as decision-making feedback is not new. Forrester (1961, 1992) viewed decision making as a process in which decisions result from the application of rules (implicit and explicit) or policy to information about the world as it is perceived. Learning is a process in which feedback, in the forms of quantitative and qualitative information, from the real work flows to decision-makers. According to Sternman (2000), "The policies are themselves conditioned by institutional structures, organizational strategies, and cultural norms. These, in turn, are governed by our mental models" (p. 16). When mental models remain unchanged by feedback, then single loop learning (Argyris, 1985) has occurred; however, if a paradigm shift occurs and our mental models are altered, double-loop learning has occurred (Sternman, 2000).

In other words, group norms are mental models of standards of behavior that function as thresholds subject to feedback. If feedback does not change the normative threshold, then behavior remains unchanged. If feedback does change the underlying beliefs and assumptions of a normative threshold, the normative threshold may change and subsequently the behavior may change. Effective group decision making is dependent on whether teams change their norms in response to feedback (e.g. critical thinking) to support paradigm shifts and double-loop learning (Postmes et al., 2001).

While group cohesion is a critical goal during this stage, conformity is not. Groupthink is a norm for consensus that leads to poor decision making because group members do not want to risk alienation by the group to voice critical opinion (Robbins & Judge, 2007). Groupthink is rooted in the relative rigidity or flexibility of the group or organization's culture. For example, Schein (2004) describes the fall of the Digital Equipment Corporation, which was known for its strongly competitive organizational culture. Team members were required to prove the value of their ideas to their colleagues during rigorous team meetings. The norm was that only the best ideas would be pursued because they had been scrutinized. While this approach initially supported the Digital Electronics Corporation's success in the market for mainframes, the rapid market shift toward PCs caught the Digital Equipment Corporation by surprise. Team members chose not to voice their concerns about market changes for fear of losing their jobs by contradicting the Digital Equipment Corporation's norm of proving the value of their ideas.

"Groupshift" is related to groupthink, and it is a shift in group decision making toward greater risk or conservatism based upon the dominant decision making norm (Wallach, Kogan, & Bem, 1962). Postmes et al. (2001) found group cohesion to be constructive; however, groupthink and groupshift led to ineffective group decision-making. They found that groups made better decisions when they used critical thinking when new information was introduced into the process. This finding is important in this comparison of models because it highlights the need for groups to be open to new resources and information in the decision making process. While it makes sense to conserve resources through maintaining hierarchies of norms, continual evaluation of the relevance and effectiveness of those structures reduces the propensity for mediocrity in team performance. The relative rigidity or flexibility of these group structures sets the stage for the next phase.

Performing: Releasing Creative Potential and Emergence of Innovation

In this comparison, the release (Ω) phase of the adaptive cycle model (Gunderson & Holling, 2002) is comparable to the performing stage of Tuckman's (1965) GD model. The release phase is the turning point, which occurs when the group or team moves from maximum connectedness and potential to releasing its potential in creative and resourceful ways. This phase is known in Tuckman's model as the performing phase. It is important to note that this is the halfway point in the project, as noted in Gersick's (1988) punctuated equilibrium model. During this phase, the team recognizes that it has spent enormous time, yet produced few results, and the deadline is looming. It is a cathartic realization in which innovative problem-solving emerges and the team suddenly becomes productive.

Punctuated equilibrium is a theory in evolutionary biology developed by paleontologists Eldredge and Gould (1972) based on Mayr's (1954) theory of geographic speciation (evolve in isolation). Basically, punctuated equilibrium is an alternative to Darwin's (1859, 1871) theory of gradualism in evolution (Mitchell, 2009). Eldredge and Gould proposed that long periods of stasis (morphology over time) are cleaved by rapid events of branching speciation or cladogenesis (splitting). In CAS, punctuated equilibrium is a method of understanding social change, specifically how policy changes and emerging conflicts during extended periods of equilibrium are interrupted by precipitous shifts of radical change. In the adaptive cycle it is the impetus of release or "creative destruction" (Schumpeter, as cited in Elliott, 1980).

During this stage, project teams may encounter adversity that determines whether or not they will attain their goals. Unlike the previous stages, when the risk of team fracture would be generated from conflicts within the group, adversity during the performing stage typically comes from an external source (e.g. the market shifts, the economy declines, the customer changes the project specifications, or resources are withdrawn). Under normal circumstances, the project team is motivated to develop efficient means to meet its goals. For example, a project team may substitute one resource for another, sacrificing the end product quality, yet meeting the budget. Under adverse conditions, the project team is pushed to develop creative and innovative solutions. For example, the CUSD 2009 project team faced a $60,000 shortfall in January that would have prevented the team's participation in the DOE's Solar Decathlon, yet they found alternative lodgings with alumni for their stay in Washington, DC, and did additional fund-raising to eliminate the shortfall.

One of the author's pilot study interviewees, a project manager, provides another example of emergence of innovation and release of potential during the performing stage. The project manager discussed her project team's reaction to a customer's withdrawal of a request for proposal (RFP) for a product development. The team was close to delivering a response to the RFP that would meet its original requirements. The withdrawal of the RFP caused the team to lose funding and disband for three months until a revised proposal was issued. The team reorganized and faced new specifications with a shorter deadline. The project manager discovered that her teammates had to develop creative solutions by finding new subcontractors, sources of materials, and innovative designs for the project. The project manager said,

It really forced us to 'think out of the box.' We couldn't rely on how we did things in the past. We had to find new ways to get things done and very quickly, which is not one of our organization's strengths. As an organization, we are notoriously process-oriented, so the team had to find ways to negotiate those processes and enlist support by management.

The project manager's reflection on her team experience points to the value of resilience. It also highlights how teams can learn from adversity. To achieve these insights, the team needs to be flexible enough to evaluate its hierarchical structures and renegotiate its norms in light of new constraints. The process of team self-evaluation remains important in the next phase, adjourning.

Adjourning: Reorganization and Learning from Adversity

In this comparison, the reorganization (α) phase of the adaptive cycle model (Gunderson & Holling, 2002) is comparable to the adjourning stage of Tuckman and Jensen's (1977) GD model. Tuckman and Jensen describe this stage as group anxiety about separation and termination, including feelings of sadness, and mourning the impending loss of bonds with the leader and group members. Herbert and Trist (1953) recognized the need for an evaluation phase. Tuckman and Jensen mention self-evaluation as a task activity; however, they do not develop this idea in their article. The lack of development of self-evaluation by Tuckman and Jensen does not diminish its potential value to project teams in the pursuit of organizational learning and resilience.

Team debriefing is an often overlooked opportunity for group learning, as the project manager reflected. She mentioned that her group had not been debriefed after the second submission of her team's response to an RFP, yet she felt that our interview had helped her gain perspective and acknowledge the lessons she learned through her team experience, individually and collectively. She mentioned her plans to apply them in future team projects and implement debriefing sessions as standard operating procedure.

From a systems perspective, debriefing sessions help team members evaluate their performance, understand feedback, and acknowledge their achievements. If debriefings are done using the principles of Appreciative Inquiry (Cooperrider & Whitney, 2005) there is potential for organizational learning. High reliability organizations, such as the United States Naval Aircraft Carrier Fleet, a hyper-complex organization, make use of debriefings as well as other methods of rapid feedback, to continually improve team performance and increase resilience (Burke et al., 2005). High reliability organizations rely on swift feedback to anticipate and predict events; however, they promote resilience because "it is concerned with containing or managing those unexpected events that have already happened" (p. 513). As stated in the introduction of this essay, the principle of being prepared for all things (or *in omnia paratus*) is operative in high reliability organizations.

According to Gunderson and Holling (2002), this is "essentially equivalent to one of innovation and restructuring in an industry or society – the kinds of economic processes and policies that come to practical attention at times of economic recession or social transformation" (p. 35). In teams or groups, it may be evaluating its role and recasting its mission. If this phase includes a reflective team debriefing, this phase has significant potential for organizational learning (Chan et al., 2003).

Summary of the Comparison of Models

In summary, the comparison between Gunderson and Holling's (2002) model of complex adaptive cycles and Tuckman (1965) and Tuckman and Jensen's (1977) model of GD is illustrated as shown in Table 3. Project teams in the forming and storming stage display self-organizing behavior that exploits (r) the strengths and minimizes the weaknesses of the team members, while leveraging resources. In the norming stage, project team conserve (K) resources (human and material) by building hierarchical structures through norms.

The team is now at a critical juncture in its GD and the attainment of its goals – an inflection point. If the team's norming process builds a cohesive yet flexible team, then the team has a foundation for performing (under normal circumstances) or adapting (under adverse conditions). In this case, the team maintains its function by renegotiating norms and hierarchies. The team releases (Ω) old structures that not longer suit the team's needs to enable the emergence of new norms and hierarchies that operate within a new context or under new environmental constraints. Either the team has created distance from the threshold (performing) or it has successfully modified the threshold (resilience). If not, the team typically underperforms. Most organizations will not tolerate team underperformance and the team will be dissolved or the organization will implement a team intervention, as the executive noted in her experience with the due-diligence team.

Once the team has successfully performed or adapted, the team faces new beginnings (α) in the form of opportunities and challenges. It may be disbanded (adjourned) or reorganized. This stage has high potential for group learning for the purposes of reorganization and organizational learning, especially if a reflective team debriefing is done using Appreciative Inquiry.

CUSD is a good example of a project team that experienced the CASS model of group evolution and resilience. Despite CUSD's seventh place finish at the DOE's 2009 Solar Decathlon, which was a significant improvement over the team's 19th place finish in 2007, the team returned to campus to reflect in a debriefing session and reorganize as a collaborative, multi-disciplinary team focused on sustainable design.

THE VALUE OF A CAS PERSPECTIVE TO GD THEORY

The CUSD 2009 team's experience illustrates the potential value of applying a CAS perspective to consciously evaluate team progress for learning through adversity. It is important to note that CUSD 2009 was a student led project, not led by faculty or other decision-makers. The acknowledgement of this fact and that the team was a multi-disciplinary collaboration was appreciated in the team's final debriefing by many team members. The students mentioned that many of their greatest strengths and adaptability came from the diversity of viewpoints and inputs into the project. Had faculty members driven the project, team members may have lost valuable opportunities learn from their failures. They learned profound, lifelong lessons to the extent that they did because they had more latitude to take risks and experiment.

In the case of project teams viewed through the lens of CAS, diverse points of view can be expressed from competent sources (individuals and teams), rather than the best problem solvers (Page, 2007). The CAS perspective is inclusive rather than exclusive. The diversity of perspectives will reflect the scenario for what is, rather than what a select few see (Jehn, Northcraft, & Neale, 1999).

The implications of the CAS perspective mean that previously excluded questions are included. This approach has implications at multiple levels. First, it addresses developing a CAS model of GD for the purposes of building resilient teams. Second, it serves to support the development of resilience when the model is implemented, specifically at the forming stage when team members are selected. According to Carpenter et al. (2009),

> If we succeed, we will ask the excluded questions that must be asked to build resilience to unfolding environmental problems and a capacity to transform social-ecological systems as circumstances change. In this new approach to science, teams approaching complex scientific problems would from the beginning comprise diverse perspectives, including various experts, practitioners, and citizens, all equipped with the

> skills needed and an understanding of how to work together as a team. The process is one of uncovering, not masking, the heightened uncertainty created by engaging multiple perspectives to interpret and act in a complex world. The outcome is the resilience needed for the future. (http://www.ecologyandsociety.org/vol14/iss1/art13)

While Tuckman and Jensen's model (1977) is useful from a sequential perspective, it may have more utility when viewed from a CAS perspective. By reframing the GD phases in terms of CAS and human agency in responding to adversity, the processes and competencies of resilient teams may be revealed.

In addition to the value that CAS brings to GD, it is important to acknowledge the values that underpin this proposition. This comparison is grounded in humanistic values of organization development, including honoring human dignity in the creation of meaning in communities (Weisbord, 2004). The comparison and discussion are meant for researchers and practitioners in the fields of GD and CAS, as well as social systems scientists, who are interested in understanding how project teams adapt. Once we understand how teams adapt, the lessons learned may be useful in the identification of leverage points for change and development of competencies of resilience. These competencies may be used to build adaptive capacity at the organizational level. In other words, some of the competencies of resilience developed by teams may scale to the organizational system, thus creating organizational resilience.

DISCUSSION

The relationship between the theories of GD, CAS, and adaptive cycles has been explored to create a conceptual model that integrates them for application in CASS, such as project teams. While I discussed the dimensions of CAS in a dynamic way, the "spaces between" stages and phases or transition points need to be explored because they hold potential for deeper understanding of the dynamic processes of GD.

These spaces are the transitions between stages and phases, such as the norming stage (K – conservation phase) of hierarchy building and the performing stage (Ω – release phase) of emergence of innovation. In Western cultures, this is a point that is often associated in dualistic terms of preserving the old ways or progressing with new ways. In Eastern cultures, this point is viewed as more fluid, not necessarily good or bad. It is seen as creative tension with potential for liberation. This concept has existed for centuries. For example, in the 5000 year old Vedic philosophy, this cathartic point is considered "creative destruction" embodied by the relationship between Brahman (Creator), Vishnu (Preserver), and Shiva (Destroyer).

These critical junctures are also referred to as inflection points (Land, 1986; Jarman & Land, 1992), which signal potential for transformation. In CASS, inflection points are characterized by reflective questions such as, "What do we need to change in order to progress?" Typically, in CASS change requires renegotiation of norms, hierarchies, and structures in order to release potential and make advancements.

In the CASS model, there are four, significant inflection points with corresponding questions. First, the point between exploitation and conservation prompts the question, "Will the norming (self-organizing) function happen, that is individuals give up their individual positions and silo thinking to create a unified team through trust and respect?" Second, the point between conservation and release (emergence) prompts the question, "Will norming result in conformity and groupthink rather than quality performing and innovation, for example, renegotiate irrelevant norms and hierarchies to enable critical thinking and creativity. This is the critical inflection point of creative destruction (Schumpeter, 1942), in which the team releases old norms to create new ways of working together and solving problems.

Third, the point between release and reorganization prompts the questions, "Will the adjourning phase be just mourning the loss of team relationships or will the team take the opportunity to develop a legacy of learning? Will the team acknowledge its resilience?" Fourth, the point between reorganization and exploitation prompts the questions, "Will the team's learning scale to the organizational level? Will that knowledge bank be tapped in the next cycle so that the next *r*-phase is not a mere repetition of the last cycle, but lessons learned will be applied? Will the organization become resilient?"

The four inflection points hold potential for further research and investigation, especially with respect to nested adaptive cycles. There subtleties of norms within each phase of the adaptive cycle may be revealing and useful in understanding which norms support adaptation and resilience. The implication for future research is the application of the CASS model as the basis of design for further studies in GD.

CONCLUSION AND RECOMMENDATIONS

The paper explored, compared, and discussed the relationships between GD and complex adaptive cycles in order to understand team resilience using a theoretical framework of CAS. The compelling reasons for this comparison include the insights that can be gained from comparing models from different disciplines; in this case, CAS from ecology and GD from organizational behavior. While the comparison revealed convincing correspondence between the two models, intriguing prospects for further study were revealed as the inflection points between stages or phases and the dynamic of group norms as feedback mechanisms and behavioral thresholds.

CAS theory is being recognized as a valid approach to studying groups and teams (Schneider & Somers, 2006). McGrath et al. (2000) recognize that groups are dynamic, complex, adaptive systems. Conceptual and methodological approaches to studying groups and teams undergoing change are needed. While some work has begun in this area, much of it is focused on virtual teams (Curşeu, 2006; Yoon & Johnson, 2007. Researchers need to continue to hone our fundamental understanding groups and teams as they currently operate (in-person teams, virtual teams, and hybrids) using CAS theory.

I agree with McGrath et al. (2000) in their call to study GD using CAS theory; however, I recommend taking it to another level by introducing concepts from panarchy theory and adaptive cycles. I recommend that project teams can be empirically examined during each of the four stages of the adaptive cycle in four separate studies. These studies could be conducted to explore normal adaptation and adverse adaptation (nested cycles). Further, researchers should take notice of the four major inflection points between the stages for potential insights into GD.

The implications for future practice and theory include understanding project team evolution for the purposes of team and organizational learning. If, through the recommended research studies, researchers discover specific competencies that can be formulated into educational programs, then the results may contribute to building adaptive capacity and organizational resilience.

REFERENCES

Ackoff, R. L. (1981). *Creating the corporate future: Plan or be planned for*. New York: John Wiley and Sons.

Ahl, V., & Allen, T. F. H. (1996). *Hierarchy theory: A vision, vocabulary and epistemology*. New York: Columbia University Press.

Allen, T. (2008). *A summary of hierarchy theory*. Retrieved September 11, 2009, from the International Society for the Systems Sciences Web site: http://www.isss.org/hierarchy.htm

Allen, T. F. H. (2009). *Keeping ecology straight in a complex world: Narrative and levels of analysis*. Unpublished manuscript, University of Wisconsin at Madison.

Allen, T., Giampetro, M., & Little, A. (2003). Distinguishing ecological engineering from environmental engineering. *Ecological Engineering 20*, 389-407.

Allen, T. F. H., Hoekstra, T.W., Little, A., & Tainter, J. A. (2003). Resource transitions and energy gain: Contexts of organization. *Conservation Ecology, 7*(3), 4. Retrieved July 16, 2009, from http:/www.consecol.org/vol7/iss3/art4

Allen, T.F.H., Hoekstra, T.W., & O'Neill, R.V. (1984, July). Interlevel relations in ecological research and management: Some working principles from hierarchy theory. *United States Department of Agriculture Forest Service Technical Bulletin RM-110*, 1-11. Washington, DC: United States Government Printing Office.

Allen, T. F. H., Hoekstra, T. W., Pires, J. C., & Tainter, J. A. (2001). Dragnet ecology – "Just the facts, Ma'am": The privilege of science in a postmodern world. *Bioscience, 51*(6), 475-485.

Argyris, C. (1985). *Strategy, change, and defensive routines*. Boston: Pitman.

Argyris, C. (1999). *On Organizational Learning* (2nd ed.). Malden, MA: Blackwell.

Ashby, W. R. (1962). Principles of the self-organizing system. In H. Von Foerster & G. W. Zopf, Jr. (Eds.), *Principles of self-organization: Transactions of the University of Illinois Symposium* (pp. 255-278). London: Pergamon Press. Retrieved December 1, 2008, from Google Scholar database.

Bennett, A., & Bennett, D. (2004). *Organizational survival in the new world: The intelligent complex adaptive system*. London: Elsevier.

Bennis, W. G., & Shepard, H. A. (1956). A theory of GD. *Human Relations, 9*, 415-437.

Bettenhausen, K., & Murnighan, J. K. (1985). The emergence of norms in competitive decision-making groups. *Administrative Science Quarterly, 30*(3), 350-372. Retrieved September 15, 2009, from ProQuest Global database.

Bion, W. R. (1961). *Experiences in groups and other papers*. New York: Basic Books.

Burke, C. S., Wilson, K.A. & Salas, E. (2005). The use of team-based strategy for organizational transformation: Guidance for moving toward a high reliability organization. Theoretical Issues in Ergonomics Science, 6, 6, 509-530. Retrieved May 13 from ABI/Inform Global database.

Carpenter, S. R., Folke, C., Scheffer, M., & Westley, F. R. (2009). Resilience: Accounting for the noncomputable. *Ecology and Society, 14*(1), 13. Retrieved August 13, 2009, from http://www.ecologyandsociety.org/vol14/iss1/art13

Chan, C. C. A., Lim, L., & Keasberry, S. K. (2003). Examining the linkages between team learning behaviors and team performance. *The Learning Organization, 10*(4), 228-236. Retrieved September 15, 2009, from Emerald Insight database.

Checkland, P. (1999). *Systems thinking, systems practice*. New York: John Wiley & Sons.

Colman, A. D. (1995). *Up from scapegoating: Awakening consciousness in groups*. Wilmette, IL: Chiron.

Conforti, M. (1999). *Field, form, and fate: Patterns in mind, nature, and psyche*. New Orleans, LA: Spring Journal.

Cooperrider, D.L. & Whitney, D. (2005). *Appreciative inquiry: A positive revolution for change*. San Francisco: Berrett-Koehler.

Costa, A. C. (2003). Work team trust and effectiveness. *Personnel Review, 32*(5), 605-622. Retrieved September 15, 2009, from Emerald Insight database.

Coutu, D. L. (2003). *How resilience works*. In Harvard business review: Building personal and organizational resilience (pp. 1-18). Boston: Harvard Business School Press.

Curşeu, P. L. (2006). Emergent states in virtual teams: A complex adaptive systems perspective. *Journal of Information Technology, 21*, 249-261. Retrieved August 5, 2009, from ABI/Inform Global database.

Darwin, C. (1859). *The origin of the species*. London: John Murray.

Darwin, C. (1871). *The origin of the species*. London: John Murray.

D'Aurizio, P. (2008). Southwest Airlines: Lessons in loyalty. *Nursing Economics, 26*(6), 389-392. Retrieved June 25, 2009, from ABI/Inform Global database.

de Waal, F. (1989). *Peacemaking among primates*. Cambridge, MA: Harvard University Press.

de Waal, F. (2006). *Our inner ape: A leading primatologist explains why we are who we are*. New York: Riverhead Trade.

Doppelt, B. (2003). *Leading change toward sustainability: A change-management guide for business, government, and civil society*. Sheffield, UK: Greenleaf.

Drucker, P. F. (1954). *The practice of management*. New York: Harper & Row.

Eldredge, N., & Gould, S. J. (1972). Punctuated equilibria: An alternative to phyletic gradualism. In T. J. M. Schopf (Ed.), *Models in Paleobiology* (pp. 81-115). San Francisco: Freeman Cooper.

Elliott, J. E. (1980). Marx and Schumpeter on capitalism's creative destruction: A comparative restatement. *Quarterly Journal of Economics, 95*, 46-58.

Engelhardt, C.S., & Simmons, P. R. (2002a). Creating an organizational space for learning. *The Learning Organization, 9*(1), 39-47. Retrieved August 6, 2009, from Emerald Full Text database.

Engelhardt, C. S., & Simmons, P. R. (2002b). Organizational flexibility for a changing world. *Leadership and Organization Development Journal, 23*(3), 113-121. Retrieved August 6, 2009, from Emerald Full Text database.

Farson, R. (1996). *Management of the absurd: Paradoxes in leadership*. New York: Simon and Schuster.

Fisher, B. A. (1970). Decision emergence: Phases in group decision making. *Speech monographs, 37*, 53-66.

Forrester, J. (1961). *Industrial dynamics*. Cambridge: MIT Press.

Forrester, J. (1992). Policies, decisions, and information sources for modeling. *European Journal of Operational Research, 59*(1), 42-63.

Frank, R.H. & Cook, P.J. (1995). *The winner takes all society*. New York: Free Press.

Friedman, T. L. (2008). *Hot, flat, and crowded: Why we need a green revolution and how it can renew America*. New York: Farrar, Straus and Giroux.

Gersick, C. J. G. (1988). Time and transition in work teams: Toward a new model of group development. *The Academy of Management Journal, 31*(1), 9-41. Retrieved August 4, 2009, from ABI/Inform Global.

Gersick, C. J. G. (1989). Marking time: Predictable transitions in task groups. *The Academy of Management Journal, 32*(2), 274-309. Retrieved August 4, 2009, from ABI/Inform Global.

Gharajedaghi, J. (2006). Systems thinking: Managing chaos and complexity: A platform for designing business architecture (2nd ed.). London: Elsevier.
Gibbon, E. (1996). *The history of the decline and fall of the Roman Empire* (Vol. 1-6). New York: Penguin Classics.
Gunderson, L. H., & Holling, C. S. (Eds.) (2002). *Panarchy: Understanding transformations in human and natural systems*. Washington, DC: Island Press.
Hackman, J. R. (1987). The design of work teams. In J. W. Lorsch (Ed.), *Handbook of organizational behavior* (pp.315-342). Englewood Cliffs: Prentiss-Hall. Retrieved November 24, 2009 from Sage Journals database.
Herbert, E. L., & Trist, E. L. (1953). The institution of an absent leader by a student's discussion group. *Human Relations, 6*, 215-248.
Hill, W. F., & Gruner, L. (1973). A study of development in open and closed groups. *Small Group Behavior, 4*(3), 355-381.
Holland, J. H. (1992). *Adaptation in natural and artificial systems: an introductory analysis with applications to biology, control, and artificial intelligence*. Cambridge, Mass: MIT Press.
Holland, J. H. (1999). *Emergence: From chaos to order*. New York: Basic Books.
Holling, C.S. (2004). From complex regions to complex worlds. *Ecology and Society, 9*(1), 11. Retrieved January 20, 2009, from http://www.ecologyandsociety.org/ vol9/iss1/art11
Jarman, B. & Land, G. (1992). Break-point and beyond: Mastering the future today. New York: HarperCollins.
Jehn, K. A., Northcraft, G. B., & Neale, M. A. (1999). Why differences make a difference: A field study of diversity, conflict, and performance in workgroups. *Administrative Science Quarterly, 44*(4), 741-763.
Kauffman, S. A. (1993). *The origins of order: Self-organization and selection in evolution*. New York: Oxford University Press.
Kauffman, S. (1996). *At home in the universe: The search for laws of self-organization and complexity*. New York: Oxford University Press.
Land, G. T. (1986). *Grow or die: The unifying principle of transformation*. New York: John Wiley and Sons.
Le Bon, G. (1895) *The crowd: A study of the popular mind*. New York: Dover.
Lewin, K. (1947a). Frontiers in group dynamics, part 1: Concept, method and reality in social science: Social equilibria and social change. *Human Relations, 1*, 5-41.
Lewin, K. (1947b). Frontiers in group dynamics, part 2: Channels of group life: Social planning and action research. *Human Relations, 1*, 143-153.
Lichtenstein, B. M. B. (2000). Emergence as a process of self-organizing: New assumptions and insights from the study of non-linear dynamic systems. *Journal of Organizational Change Management, 13*(6), 526-544. Retrieved August 4, 2009, from ABI/Global Inform.
Martenson, C. (2009). *The crash course*. Retrieved September 15, 2009, from http://www.chrismartenson.com
Mayr, E. (1954). Change of genetic environment and evolution. In J. Huxley, A. C. Hardy, & E. B. Ford (Eds.), *Evolution as a Process* (pp. 157-180). London: Allen and Unwin.
McDonough, W., & Braungart, M. (2002). Design for the triple top line: New tools for sustainable commerce. *Corporate Environmental Strategy: International Journal of Corporate Sustainability, 9*(3), 251-258. Retrieved October 22, 2009, from http://mcdonough.com/writings/design_for_triple.htm
McGrath, J. E. (1991). Time, interaction, and performance (TIP): A theory of groups. *Small Group Research, 22*(2), 147-174.
McGrath, J. E., Arrow, H., & Berdahl, J. L. (2000). The study of groups: Past, present, and future. *Personality and Social Psychology Review, 4*, 95-105. Retrieved August 6, 2009, from Sage Journals database.
Mennecke, B. E., Hoffer, J. A., & Wynee, B. E. (1992). The implications of GD and history for group support system theory and practice. *Small Group Research, 23*(4), 524-572.
Metcalf, G. S. (2009a). A case for system-specific modeling. In *Making livable, sustainable systems unremarkable*. *Proceeding of the 53rd Annual Conference of the International Society for the Systems Sciences* (p. 88). Brisbane, Australia, Pocklington, United Kingdom: International Society for the Systems Sciences.
Metcalf, G. S. (2009b).Dialogue and ecological engineering in social systems design. In *Systems that make a difference*: *Proceedings of the 52nd Annual Conference of the International Society for the Systems Sciences* (p. 77). Madison, WI: International Society for the Systems Sciences.
Miller, J. H. & Page, S. E. (2007). *Complex adaptive systems: An introduction to computational models of social life*. Princeton, NJ: Princeton University Press.
Mintzberg, H., & Westley, F. (1992). Cycles of organizational change [Special issue]. *Strategic Management Journal, 13*, 39-59. Retrieved August 13, 2009, from ABI/Inform Global.

Mitchell, M. (2009). *Complexity: A guided tour*. New York: Oxford University Press.
Morgan, B. B., Salas, E., & Glickman, A. S. (1994). An analysis of team evolution and maturation. *The Journal of General Psychology, 120*(3), 277-291.
Page, S. E. (2007). *The difference: How the power of diversity creates better groups, firms, schools, and societies*. Princeton, NJ: Princeton University Press.
Pearl, R. (1927). The growth of populations. *Quarterly Review of Biology, 2*, 532-548.
Poole, M. S. (1981). Decision development in small groups: A comparison of two models. *Communication Monographs, 48*, 1-24;
Poole, M. S. (1982). Decision development in small groups II: A study of multiple sequences in decision making. *Communication Monographs, 50*, 206-232.
Poole, M. S. (1983). Decision development in small groups III: A multiple sequence model of group decision development. *Communication Monographs, 50*, 321-341.
Poole, M. S., & Holmes, M. E. (1995) Decision development in computer-assisted group decision making. *Human Communication Research; 22*(1), 90-127.
Poole, M. S., & Roth, J. (1989). Decision development in small groups V: Test of a contingency model. *Human Communication Research, 15*, 549-589.
Poole, M. S., & Van de Ven, A. H. (2004). Central issues in the study of change and innovation. In M. S. Poole & A. H. Van de Ven (Eds.), *Handbook of organizational change and innovation* (pp. 3–31). Oxford, UK: Oxford University Press.
Postmes, T., Spears, R., & Cihangir, S. (2001). Quality of decision making and group norms. *Journal of Personality and Social Psychology, 80*(6), 918-930. Retrieved September 15, 2009, from Google Scholar.
Prigogine, I. (1997). *The end of certainty: Chaos and the new laws of nature*. New York: The Free Press.
Puydt, P. E. de (1860, July). Panarchy. *Revue Trimestrielle* (pp. 222-245). Brussels. Retrieved November 24, 2009 from http://www.panarchy.org/depuydt/ 1860.eng.html
Resilience. (2009). *Merriam Webster Online*. Retrieved September 11, 2009, from http://www.merriam-webster.com/dictionary/resilience
Resilience Alliance. (2009). *Resilience*. Retrieved September 11, 2009 from http://www.resalliance.org/
Robbins, S. P., & Judge, T. A. (2007). *Organizational behavior* (12th ed.). Upper Saddle River, NJ: Pearson Education.
Schein, E. H. (2004). *DEC is dead, long live DEC: Lessons on innovation, technology, and the business gene*. San Francisco: Berrett-Koehler.
Schermerhorn, J.R., Jr., Hunt, J. G., & Osborn, R. N. (2000). *Organizational behavior* (7th ed.). New York: John Wiley & Sons.
Schneider, M., & Somers, M. (2006). Organizations as complex adaptive systems: Implications of complexity theory for leadership research. *The Leadership Quarterly, 17*, 351-365.
Schuman, S. P. (2001). Editors note: Developmental sequence in small groups. *Group Facilitation, 3*, 66. Retrieved August 4, 2009 from ABI/Inform Global database.
Schumpeter, J. A. (1942). Capitalism, socialism and democracy. New York: Harper.
Semler, R. (2007). Out of this world: Doing things the Semco way. *Global Business and Organizational Excellence, 26*(5), 13-21. doi:10.1002/joe.20161
Senge, P. M. (1990). *The fifth discipline: The art and practice of the learning organization*. New York: Doubleday.
Shannon, C.E. & Weaver, W. (1949). *The mathematical theory of communication*. Urbana, IL: University of Illinois Press.
Smith, G. (2001) GD: A review of the literature and a commentary on future research directions. *Group Facilitation, 3*, 14-45.
Sternman, J. D. (2000). *Business dynamics: Systems thinking and modeling for a complex world*. New York: McGraw-Hill Higher Education.
Sullivan, L. (1896). The tall office building artistically considered. *Lippincott's Magazine, 57*, 403-409.
Tainter, J. A. (1988). *The collapse of complex societies*. Cambridge, MA: Cambridge University Press.
Tortora, G. J., & Grabowski, S. R. (2000). *Principles of anatomy and physiology* (9th ed.). New York: John Wiley & Sons.
Tubbs, S. (1995). *A systems approach to small group interaction*. New York: McGraw-Hill.
Tuckman, B. W. (1965). Developmental sequence in small groups. *Psychological Bulletin, 63*, 384-399. Retrieved August 4, 2009, from ABI/Inform Global database.

Tuckman, B. W. & Jensen, M. C. (1977). Stages of small-GD revisited. Group and Organization Studies 2, 419-427. Retrieved August 4, 2009 from ABI/Inform Global database.
Ulrich, D. (1998). Intellectual capital = competence x commitment. *MIT Sloan Management Review, 4*, 15-26.
United States Department of Energy (2009). *Solar decathlon*. Washington, DC: U.S. Department of Energy. Retrieved October 3, 2009, from http://www.solardecathlon.org/
Van de Ven, A., & Poole, M.S. (1996). Explaining development and change in organizations. *The Academy of Management Review, 20*(3), 510–540.
Waldrop, M. M. (1992). *Complexity: The emerging science at the edge of order and chaos*. New York: Simon and Schuster.
Walker, B., & Salt, D. (2006). *Resilience thinking: Sustaining ecosystems and people in a changing world*. Washington, DC: Island Press.
Wallach, M. A., Kogan, N., & Bem, D. J. (1962). Group influence on individual risk taking. *Journal of Abnormal and Social Psychology, 65*, 75-86.
Weick, K. (1995). *Sensemaking in organizations*. Thousand Oaks, CA: Sage.
Weisbord, M. R. (2004). *Productive workplaces revised: Dignity, meaning, and community in the 21st century*. San Francisco: Jossey-Bass.
Wheatley, M. J. (1994). *Leadership and the new science: Learning about organization from an orderly universe*. San Francisco: Berrett-Koehler.
Wheelan, S. A. (1990). *Facilitating training groups: A guide to leadership and verbal intervention skills*. New York: Praeger.
Wheelan, S. A. (1994). *Group processes: A developmental perspective*. Boston: Allyn & Bacon.
Wheelan, S., Davidson, B., & Tilin, F. (2003). GD across time: Reality or illusion? *Small Group Research, 34*(2), 223-245.
Wiener, N. (1948). *Cybernetics or control and communication in the animal and the machine*. Cambridge, MA: The MIT Press.
Wiener, N. (1954). *The human use of human beings: Cybernetics and society*. New York: Doubleday Anchor.
Yoon, S. W., & Johnson, S. D. (2007). Phases and patterns of GD in virtual learning teams. *Education Technical Research Development, 56*, 595-618.
Zachary, W. B., & Kuzuhara, L. W. (2005). *Organizational behavior: Integrated models and applications*. Mason, OH: Thomson Corporation.