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Applying Natural System Metaphors to the Force Modernization Process

K. Todd Chamberlain

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to the Force Modernization Process**

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K. Todd Chamberlain

The Institute of Land Warfare
ASSOCIATION OF THE UNITED STATES ARMY

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LAND WARFARE PAPER NO. 86, February 2012

Applying Natural System Metaphors to the Force Modernization Process

by K. Todd Chamberlain

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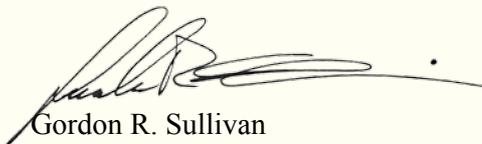
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Foreword

This paper advances previous efforts within the military to use concepts and principles from biological systems to better understand and solve military problems. In looking to the next ten years or so, the Army must be better prepared for an uncertain and unpredictable future—a goal that is possible through a force modernization process providing capabilities that support and enable Soldiers' adaptability. According to the author, the Army's activities already follow natural system principles; therefore, taking additional steps that imitate the natural systems process—including improving adaptability capabilities—would increase the Army's ability to evolve in any future world scenario.

The author relies on recent research and findings in the fields of species evolution, ecosystem transitions and ecosystem management to provide recommended actions for the Army to take within each phase of its force modernization process: 1) operational environment and concept development; 2) capabilities integration and development; and 3) force development. By applying metaphors from genetic variability, natural selection, evolutionary strategies and natural system management activities, the Army could develop operationally adaptable forces that can survive and rapidly evolve to operate successfully in the current environment as well as in any potential future world that emerges. In the author's view, this modified force modernization process would provide capabilities that support and enhance a Soldier's inherent adaptability, thus increasing the Soldier's ability to provide innovative and unexpected behaviors. Ultimately, adopting these techniques, as modeled by natural principles, would overwhelm an adversary's ability to cope.



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3 February 2012

Applying Natural System Metaphors to the Force Modernization Process

Introduction

Given the many changes that will occur in technology within the next ten to fifteen years, attempting to anticipate the types of capabilities the Army will need for the Army Future Force might be a fool's errand. However, a valid assumption can be made that these future capabilities will unfold as a modification of current capabilities. Rather than trying to predict the unpredictable, a better approach is to put into place the procedures that will allow current capabilities to evolve and rapidly adapt to future missions and conditions. The example the Army should follow is one that has been successful for over three billion years—nature.

Using examples from nature is not new to the military. In the 1960s and 1970s, Colonel John Boyd, U.S. Air Force, coupled lessons from tactical air-to-air experience in Korea with the recently developed principles of quantum physics and then applied the concepts of stimulus-response learning from biology. With this research, Boyd developed the circular Observe–Orient–Decide–Act (OODA) loop process with constant feedback. He sought to use tempo and rhythm, adjusting the rate at which one performs an OODA loop to manipulate the actions of an opponent, thus forcing that opponent into a reactive posture and preventing him from dictating the course of battle.¹ Since then, the military, in particular the Defense Advanced Research Projects Agency (DARPA), has pursued “biomimicry”—i.e., using inspiration from nature and its models, systems, processes and elements to solve human problems. Biomimicry has helped the military develop new capabilities, such as robotic “hummingbirds” and chemical sensors based on butterfly-wing design. These efforts are focused on applying lessons from nature at the tactical level. Significantly larger improvements could be realized by applying natural systems principles and metaphors at the operational and strategic levels and mimicking nature's learning and adaptation processes.

The U.S. Army Training and Doctrine Command's Army Capabilities Integration Center (ARCIC), which is responsible for the Army's capability development strategy, has already implemented some practices and procedures that, even if not modeled after natural systems processes and principles, are at least in line with them. The Army family of concepts, operations doctrine and strategies published within the past three years clearly recognizes the need for the Army of the future to be able to make sense of complex environments, rapidly adapt,

take action and gather feedback about the effectiveness of those actions. These concepts of applied learning to rapidly adapt can also be found in the Army's organizational structures. The use of modular designs provides the flexibility to tailor forces to the specific conditions they are expected to face. By designing all its forces to be full-spectrum capable and by adopting a compo-neutral approach—i.e., active (compo 1), National Guard (compo 2) and Reserve (compo 3) forces have the same capabilities and mix of forces—the Army is pursuing the development of forces and capabilities that are able to adapt to any situation. Similar themes can be found in the Army's materiel development and acquisition process: affordable force modernization and rapid fielding initiatives. Applying additional natural system evolution and management principles (such as genetic variability, natural selection, evolutionary strategies and an adaptive management process) will allow the Army to produce capabilities that enable an operationally adaptable future ground force.

The current Army force modernization process can be broken into three distinct phases of activities: 1) operational environment and concept development, 2) capabilities integration and development and 3) force development (see table 1). During the first phase, ARCIC envisions the type of future environment and describes in its concepts how Army forces will operate in order to be successful. In the capabilities development and integration phase, it describes the capabilities these forces will require and how these capabilities will be integrated across warfighting functions, formations and units. During force development, these capabilities are “packaged” into the most effective systems. The goal of this entire process is to develop operationally adaptable forces that can succeed in the current and future operating environments.

Similarly, the goal of systems in nature is to develop adaptable species and ecosystems that can survive in current and future operational environments. There are three aspects of natural systems that allow species and ecosystems to adapt: 1) genetic variability, 2) natural selection and fitness landscape and 3) evolutionary strategies (again, see table 1). Each of the cells in table 1 lists the natural system-based activities currently being undertaken by the Army; additional activities, shown in bold font, posit recommendations the Army could accept to improve its ability to produce operationally adaptable forces.

This paper will provide a brief description of each of these natural system principles and how it can be applied to each phase of the Army's force modernization process.

Over the past few years, the Army has begun a subtle but significant shift in its thinking regarding how it will fight in the future and how it must guide and manage the transformation of this vision. This shift reflects a similar one that is occurring across many other fields of human endeavor—a shift of the pendulum from the predominate use of reductive thinking in linear, sequential and mechanistic approaches—which have been the underlying paradigm of human endeavors since the mid-1700s—toward a more balanced focus that incorporates inductive thinking into a circular, iterative and organic approach.

In *The Scientific Way of Warfare: Order and Chaos on the Battlefields of Modernity*, Antoine Bousquet provides a detailed description of the military's application of scientific concepts and theoretical frameworks throughout history as metaphors for developing new warfighting capabilities, structuring its organizations (the Napoleonic staff) and military decisionmaking process (MDMP) and informing the principles for conducting warfare (from close-order drill during the 1800s to today's net-centric warfare). Metaphors can be a powerful means by which a simplified descriptive meaning or understanding of a more complicated matter from one domain can be transferred to create a better understanding of a complicated matter in another domain.²

Table 1 – Force Modernization Activities Based on Natural Systems Metaphors

Army Force Modernization Process

	Operational Environment and Concept Development	Capabilities Integration and Development	Force Development
Genetic Variability		<ul style="list-style-type: none"> Retain hidden and neutral capabilities <ul style="list-style-type: none"> Ensure backward compatibility and interoperability Cascade equipment to reserve component 	<ul style="list-style-type: none"> Maintain modularity Incorporate compo-informed
Natural Selection – Fitness Landscape	<ul style="list-style-type: none"> Adopt alternative futures Develop alternative operating concepts Use characteristics of alternative futures to develop a fitness landscape(s) 	<ul style="list-style-type: none"> Use a fitness landscape: <ul style="list-style-type: none"> To evaluate level 2 integration To push research, development, testing and evaluation 	<ul style="list-style-type: none"> Use a fitness landscape to evaluate level 3 integration Adopt ascendancy as a key performance parameter
Evolutionary Strategies	<ul style="list-style-type: none"> Incorporate adaptive cycle phase and panarchy considerations 	<ul style="list-style-type: none"> Incorporate adaptive cycle and Cynefin framework to determine appropriate action Develop key performance parameters tailored for each evolutionary strategy Adopt <i>r</i>-strategy practices <ul style="list-style-type: none"> Rapid acquisition (capabilities development for rapid transition) Affordable force modernization Multiple prototypes 	<ul style="list-style-type: none"> Incorporate adaptive cycle phase and panarchy considerations Develop force design/mix(es) tailored for each evolutionary strategy
Adaptive Management Process	<ul style="list-style-type: none"> Acknowledgment of uncertainty Extend manpower and personnel integration beyond the capability development phase Directly involve stakeholders (American public, Congress, etc.) Integrate levels 1, 2 and 3 Apply design to the force modernization process Expand two-year force modernization process (to iterative force modernization process) 		

During the 17th century, Western civilization began to move toward science-centric thinking. The beginning of modern science established the reductionist paradigm that has now been integrated into the fabric of Western thought. Reductionist thinking maintained that studying small, discrete parts in detail would lead to understanding the whole. In response to the challenge of intercepting German bombers during World War II, Britain established operations research (OR) groups, led by Patrick Maynard Stuart Blackett (winner of the 1948 Nobel Prize in Physics) and comprising members whose specialties included mathematics, science and the military. These techniques, which have come to be known as operations research and management science (OR/MS), were quickly adopted by the U.S. Navy and Air Force in the 1950s and 1960s.³

These early OR groups took a very holistic systems approach to developing effective solutions. At this same time, Jay Forrester, director of the Massachusetts Institute of Technology’s

Digital Computing Laboratory, coupled computers and cybernetics (the study of control and communication in animals and machines) to develop automatic devices that used error-sensing, negative feedback to correct the performance of the machine (a servomechanism). These devices, which stabilized radar platforms on ships, were followed by the SAGE (semi-automatic ground environment) system that would later defend the airspace over Canada and the United States from possible Soviet nuclear bombers. Also during this time, Ludwig von Bertalanffy used ideas from biology relating to “wholes” to craft the general systems theory (GST), which could explain features and governing principles of all complex systems. Insights from early OR efforts concerning system control and feedback and the fundamentals from systems theory led to the emergence of complexity science in the late 1960s. Complexity science involves a special class of systems that has since come to be called complex adaptive systems (CAS). Unfortunately, in the decades following the science’s emergence, OR/MS practitioners have tended to take a reductionist approach, focusing their efforts on the tools and techniques rather than on the larger problems, tackling only narrow aspects of a particular problem.⁴ Similarly, within the military, reductionism continues to be the predominate approach to solving complex problems; just a few individuals follow the successful approaches of the early military OR groups.

In the late 1970s, some unconventional military thinkers began exploring GST and CAS as a means to better understand and explain military systems. Colonel John Boyd may have been the first military thinker to couple ideas from mathematics and quantum mechanics with theories of evolution and natural selection to create his well-known OODA loops.⁵ His ideas were also part of the major rethinking of Army doctrine that led to the concept of AirLand Battle.⁶ In addition, General Donn A. Starry established “Task Force Delta” to increase the effectiveness of Army units. Colonel Dandridge M. “Mike” Malone led this task force, which sought to increase efficiency by examining programs needed to implement the concepts of James Grier Miller’s Living Systems Theory (LST), a biologically based type of von Bertalanffy’s GST.⁷

Since that time, additional military practitioners have advocated using natural systems as a metaphor for warfare. In the 1997 workshop “Warfare Analysis and the New Sciences,” sponsored by the Military Operations Research Society, Lieutenant General Paul K. Van Riper, U.S. Marine Corps (Retired), suggested that warfare be thought of in ecological rather than mechanistic terms. Another member of this symposium proposed that historical military conflicts be analyzed using both a mechanistic and an ecological response paradigm to see whether a difference exists.⁸ More recently the military has begun applying metaphors from nature, including biomimicry, to help address challenges. Most of these applications have been at the tactical, individual level—using nature’s “solutions” to craft human-built solutions to address a similar challenge. The progress that this approach has produced includes miniature flying “hummingbird” sensors,⁹ robots that mimic actual bird flight¹⁰ and solar cells that mimic photosynthesis.¹¹ However, these successes are relatively small when compared to the progress the military could make by applying nature’s learning and adaptation processes.

Natural Systems and Military Forces: Comparable Context?

Given the ease with which metaphors can be applied but the likelihood that the context in the two domains is often different, it is critical to reflect on the efficacy of applying an appropriate metaphor in the new domain.¹² Before applying natural systems principles and management techniques to the military, it is important to determine if the contexts of these two domains are adequately similar for the metaphors to be appropriate—that is, if natural systems and military

forces are similar complex, self-adaptive systems. CAS are characterized by three main features: 1) structural and dynamic complexity, 2) hierarchical structures and emergence and 3) applied learning. By examining each of these features within the contexts of natural systems and military forces, it can be determined whether they are similar types of CAS. If so, then it will be legitimate to apply natural system principles and management techniques to military forces and force modernization management.

Structural and Dynamic Complexity

Complex adaptive systems comprise many elements or parts (structural complexity) with many relationships among the elements that constantly change (dynamic complexity). Combining these two types of complexities makes the systems inherently unpredictable. All ecosystems in nature comprise many different species interacting with one another and the environment. Changes in the environment and competition internal to and between species cause these relationships to adapt over time. These changes are commonly called evolution and co-evolution.

Similarly, military forces comprise different capabilities that interact with one another to produce a synchronized, unified action. The interaction of these capabilities can lead to internal tensions and competition, requiring a resolution that projects an effective, unified action. As a military force engages with an adversarial force, each side will change its behavior and actions in response to the other's actions, reflecting the commonly used phrase "the enemy gets a vote." Force modernization efforts also face an environment of structural complexity, because of the many stakeholders involved and the different capabilities requiring interoperability and dynamic complexity that occur from the initial concept development through the employed capability. This similarity in complexity and capability demonstrates that both natural systems and military systems exhibit this first characteristic of CAS.

Hierarchical Structure and Emergence

Complex adaptive systems comprise nested subsystems within a hierarchical framework, which is sometimes referred to as a system-of-systems. It is important to understand that CAS hierarchies do not indicate a superior-subordinate relationship; they simply reflect a scale of organization on different levels. The properties and behavioral patterns exhibited at each level of hierarchy emerge as a result of the interactions between entities in the system and are different from the properties and behavioral patterns of the parts comprising that subsystem—i.e., the whole is greater than the parts (referred to as either emergence or holism).¹³

Natural systems comprise many levels of hierarchical structures. Levels of hierarchy in natural systems progress from the singular cells, which comprise organs, which comprise organisms, which comprise species, which comprise ecosystems, which comprise biomes. Each of the hierarchical structures in natural systems exhibits attributes, properties and behaviors that cannot be found in the parts of that hierarchy. The best example to illustrate the concept of emergence or holism is humans. The cells in the human body demonstrate properties, such as the ability to replicate, that the chemical reactions performed by the molecules that comprise the cell are not able to perform. At the next hierarchical level, human organs have properties—for example, the heart's ability to beat—that cells comprising the organ cannot perform themselves. Human beings have properties—for example, consciousness—that are not contained within the cells or organs of the body. Human beings also exhibit properties at the *Homo sapiens* species level, such as cultural and social structures, that cannot be found in individual human beings.

A military force can be viewed in a similar manner as seen in how levels of hierarchy are constructed: four to ten Soldiers comprise a squad; four squads comprise a platoon, three to five platoons and a headquarters section comprise a company, and so on, all the way up to a combined, joint task force level. Military doctrine establishes properties and behaviors (called tasks, functions and missions) for each level of hierarchy that produces synergistic results that are greater than simply the additive results of each of the lower levels of hierarchy. Both natural systems and military forces also exhibit this second characteristic of CAS.

Applied Learning

Applied learning is defined as an iterative process by which an entity observes changes in its environment, makes sense of those changes relative to itself, makes a decision, adapts to the changes in the environment and then receives feedback as to the effectiveness of the adaptation or its impact on the environment. This applied learning process is continual and cyclic, always returning to the first step of this process: observing the changes in the environment. Following that, adaptations are made, as appropriate.

This last feature of CAS may pose a more difficult correlation between natural systems and military forces. At the individual organism level in natural systems, it is easy to envision how applied learning occurs (and that it does indeed occur). Individual organisms are constantly observing changes in their environment and making appropriate adjustments in their actions and behaviors, whether these adjustments can or cannot be attributed to a conscious decisionmaking process. If applied learning is simply adaptations in response to changes in the environment, then the changes a species undergoes in response to changes in the environment can be viewed as applied learning.

A similar construct of gradual changes to the environment can also be applied at the ecosystem hierarchical level. Eminent ecologists C. S. “Buzz” Holling and Lance Gunderson (and others) developed the Adaptive Cycle Model (see figure 1) to describe the phases in an ecosystem: the progression from a pioneering state (the *r* quadrant in figure 1) through exploitation to conservation in a mature state (the *K* quadrant in figure 1) and then cycling back to its original (pioneering) state after a release and reorganization (the *omega* and *alpha* quadrants, respectively, in figure 1).¹⁴ In the *r* phase of the adaptive cycle, potential (in the form of accumulated biomass) and connectedness (the tightness of coupling among the factors of the fitness landscape) are low, but the magnitude of disturbance that can be absorbed—called resilience—is high.

As an ecosystem progresses from the *r* phase through exploitation to conservation in the *K* phase, change is incremental, smooth and fairly predictable. Both potential and connectedness increase; resilience, however, decreases. The change as an ecosystem transitions from the *K* phase through the *omega* and *alpha* phases and then back to the *r* phase tends to be abrupt. The mature state undergoes a rapid release of accumulated biomass. This biomass, along with the consequential decrease in connectedness, leads the system to a pioneering state of reorganization and renewal. Once these critical thresholds are crossed, the system can reorganize the freed elements with the opportunity to evolve to a new, and potentially different, metastable regime. A forest wildfire that destroys the forest canopy (the large trees) and all the small growth but is then followed by the establishment of new grasses and forbs is an example of an *alpha* phase following an *omega* phase.¹⁵ This rapid transformation of a CAS from one stable state to a new stable state has commonly been termed “punctuated equilibrium.” With reorganization and transformation of CAS, the systems tend to be highly sensitive to initial

Figure 1 – Adaptive Cycle Model

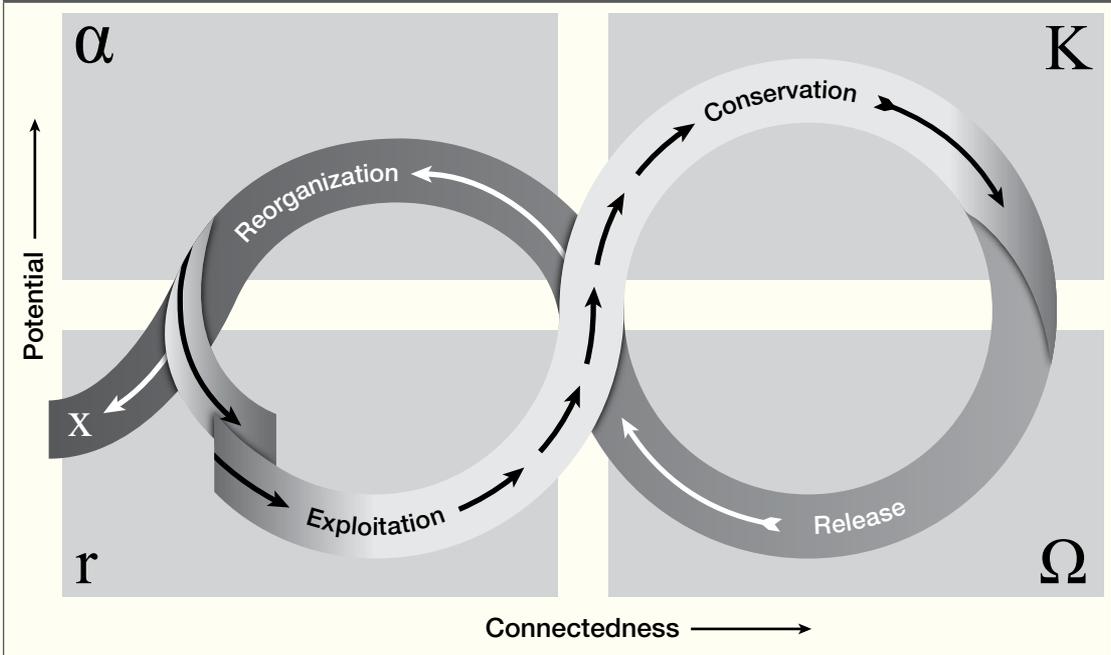
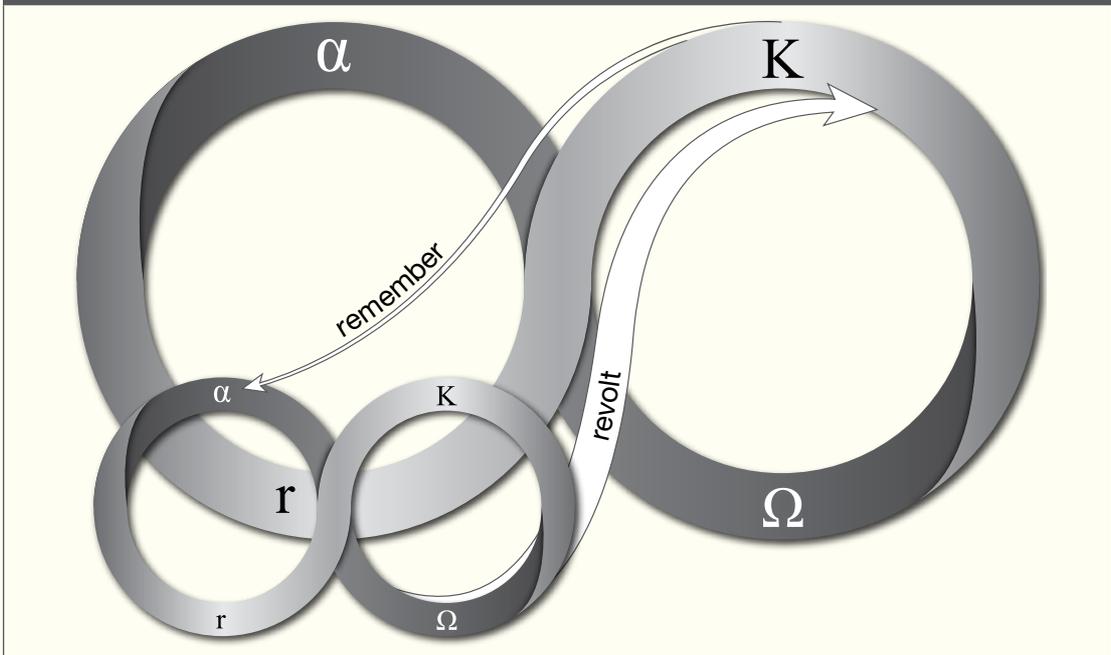


Figure 2 – Panarchy – Nested Adaptive Cycles

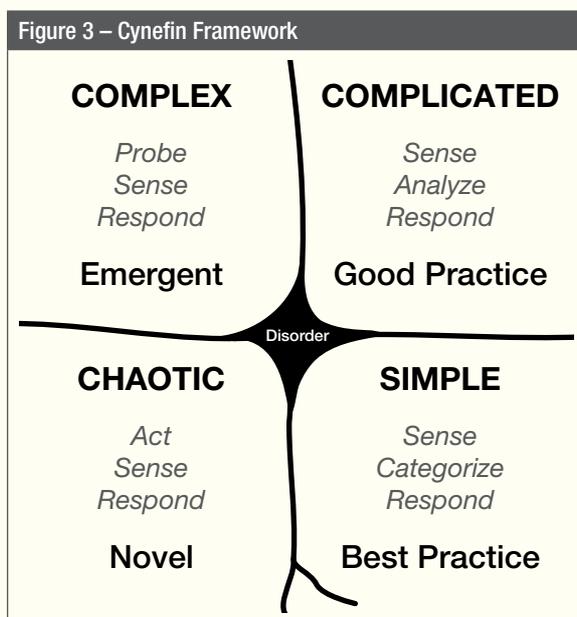


conditions. Small differences at this early stage, which are barely—if at all—noticeable, establish the structures, variables and relationships that lock in and eventually grow to become the dominant, stable regime.

Holling and Gunderson also advocate using the term “panarchy” to describe the ability of adaptive cycles occurring at different hierarchy levels (e.g., the applied learning of the

organism, species evolution and ecosystem maturation cycles) to interact and exchange information with one another.¹⁶ Figure 2 shows these two interactions: *remember* and *revolt*. The *remember* connection constrains, to some degree, the amount of transformation—invention, experimentation and testing—that can occur lower on the hierarchy’s scale. This connection also allows a higher level of hierarchy to stabilize and conserve the accumulated memory of past successful (i.e., surviving) experiments from the hierarchy’s lower level. An example of this “memory” within natural systems resides in how the gene pool of a particular species represents the successful mutations—e.g., genetic variability—that occur within each organism of that species. This connection also functions as a memory of the past—a hierarchical level progresses from the *K* phase through to the *r* phase, providing the “seeds” that set the stage and conditions for the next start of the cycle. The *revolt* connection, on the other hand, allows a collapse at one hierarchy level to trigger a crisis (and potential collapse) at the next higher level of hierarchy. Whether the crisis and collapse occur is highly dependent on the degree of the ecosystem’s ascendancy—i.e., the ability of an ecosystem to prevail against disturbance by virtue of its combined organization and size.¹⁷

As an ecosystem transitions from a relatively simple system in the *r* phase to the more complex *K* phase of the adaptive cycle, the number of elements in the system increases (structural complexity) and the number of relationships between those elements increases (dynamic complexity). Dave Snowden, a Welsh consultant and researcher in the field of knowledge management, developed the Cynefin framework (see figure 3) using an ecological metaphor to provide business managers with recommended iterative actions based on a system’s complexity. A system with high structural complexity would most closely fit the complicated quadrant wherein the relationship between cause and effect can be understood through analysis. A system



with both high structural and high dynamic complexities most closely fits the complex quadrant wherein the relationship between cause and effect can only be perceived in hindsight. Applying the Cynefin framework to systems as they pass from the *omega* phase through the *alpha* phase, with the *remember* and *revolt* interactions establishing a new environment and where there is no relationship between cause and effect, fits the chaotic quadrant and would indicate that the appropriate approach would be to take action—any action.¹⁸ Taking an action in this situation, even if that action leads to failure, helps define the problem and establish the initial conditions for the emerging reorganization.

A much easier case can be made that military forces exhibit and utilize applied learning. The military devotes considerable effort to educating and training its Soldiers at the individual and the collective levels. Intricate processes and systems have been developed to support organizational learning and decisionmaking, including John Boyd’s OODA loops, the Army’s

Military Decision Making Process (MDMP), Commander's Critical Information Requirements (CCIR) and all the various command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) systems that have been fielded. Colonel Mike Malone even defined Edgar Schein's Adaptive-Coping cycle¹⁹ as the "depiction of how any sentient being, from living cell to living multinational organization, copes with threats and opportunities in its internal and external environment."²⁰ This description demonstrates that both natural systems and military forces share this third characteristic of CAS.

With the correlation established that natural systems and military forces share the same CAS context, appropriate metaphors from natural systems can be applied to military forces. A closer look at the principles of natural systems determines the attributes that can be embedded into the ground force of 2025. Subsequently, an examination of natural systems management techniques that have been successfully applied to ecosystems over the last two decades could be applied to techniques managing force development and modernization.

Natural System Principles

Before discussing these activities, one fundamental question needs to be considered: where in the adaptive cycle model is the current world geopolitical system? Even though many of the activities to be discussed will occur regardless of the answer to this question, the answer *will* change the content and the emphasis placed on a particular activity. If current release and reorganization activities occurring at the local and regional levels—demographic changes, globalization, the "Arab spring," technological advances and hybrid warfare—prove to be successful experiments, then the "survivors" will be incorporated into the future-world system as it continues to transition into its *K* phase of the adaptive cycle (i.e., the operating environment will follow the *remember* connection demonstrated in figure 2). In this situation, the Army can adopt an incremental, evolutionary approach to its force modernization. However, if these multiple "collapses" from the lower levels of the hierarchy trigger a collapse of the world system (i.e., the operating environment follows the *revolt* connection shown in figure 2), then a much more experimental, revolutionary approach to force modernization would be appropriate.

Examining how natural systems undergo change, how evolution occurs at the species level and how changes in the adaptive cycle take place at the ecosystem level, natural system principles can be arranged into three categories: 1) genetic variability, 2) natural selection using a fitness landscape and 3) evolutionary strategies. The following sections, based on these categories, provide a brief description of the natural systems characteristics. Each section includes a description of Army's activities, based on each one's respective natural system characteristic, that fall within each of the three phases of the Army force modernization process; these activities could improve the Army's ability to produce operationally adaptable forces.

Genetic Variability

One of the means by which a species can persevere in a rapidly changing environment is through genetic variability, i.e., individual organisms within a species having differing genotypes and differing morphological features. Genetic variability can be attributed to:

- hidden variation (i.e., variation in the form of recessive genes and traits that can be exploited by natural selection if environmental conditions change);²¹
- mutations (i.e., changes passed on by heredity; mutations provide a constant injection of new variations that are "tested" by natural selection);²² or

Table 1a – Genetic Variability Concepts Applied to Force Management Process

Army Force Modernization Process

	Operational Environment and Concept Development	Capabilities Integration and Development	Force Development
Genetic Variability		<ul style="list-style-type: none"> • Retain hidden and neutral capabilities <ul style="list-style-type: none"> ◦ Ensure backward compatibility and interoperability ◦ Cascade equipment to reserve component 	<ul style="list-style-type: none"> • Maintain modularity • Incorporate compo-informed

- neutral variation (in which mutations in the genetic variability are neither beneficial nor harmful to the organism but which can be exploited by natural selection if environmental conditions change).

This genetic variability, along with a certain level of physical and physiological tolerance, allows populations of species to survive and evolve through further adaptations; this condition is referred to as “preadaptability.”²³ A key point with preadaptability is that it does not imply advance preparation. Nature does not try to anticipate or predict future events.

Capabilities Integration and Development

The Army’s current approach to embedding adaptability into its military systems is to rely on the human component. However, by expanding the application of genetic variability and natural selection principles to the materiel domain, it may be possible to develop materiel solutions that enable the human component to be even more adaptable. The Army currently conducts two activities within the materiel domain that could be viewed as supporting hidden or neutral variation. Neither of these types of variations may necessarily contribute to future success or hinder future success. A key requirement for all materiel solutions that are developed is for them to be interoperable with one another and also to be backward compatible with earlier versions of the same capability. The other activity is the Army’s practice of cascading outmoded or obsolete equipment into its reserve component. Rather than viewing this practice from a cost-effective perspective or from a perspective that prioritizes modernizing the force most likely to be employed, the Army could view this practice as a means to retain sufficient variability to employ the force most able to adapt to the emergent future environment, which, in this case, could be the reserve component force.

Force Development

Modularity. Over the past ten years, the Army has converted its forces to a modular configuration, allowing forces to be task organized to meet specific operational missions and demands and to operate effectively given the specific operating environment. The ability to create differing configurations easily is similar to individuals, within a species, who have differing genotypes or morphological features. Applying lessons learned from the effectiveness of differing task force configurations is similar to nature’s passing beneficial traits via heredity.

Compo-informed. Historically, both active and reserve components have taken a compo-neutral approach to force development. All Army forces were designed to reflect the attributes of the active component. This approach produced readily employable reserve component forces that were trained and equipped to the same standards and interoperable with active component

forces. Recent Defense Department studies have indicated that the Army would benefit from adopting a “compo-informed” approach; in this approach, the Army would take into consideration the unique strengths and attributes of each component (active, National Guard and Reserve) when it conducted force modernization (see figure 4).²⁴ Force recommendations discussed in these studies include: 1) increased use of “blended units,” i.e., units that comprise members from all components; 2) leveraging the civilian-acquired and -maintained skill of reserve component members; and 3) flexible “contracts” with reserve component members that would allow them to serve for more than the traditional 39 days a year.

Adopting these recommendations, along with the continued use of a compo-informed approach to force development, would increase the “genetic variability” of Army forces by taking advantage of the unique attributes of each Army component.

Natural Selection/Fitness Landscape

The phrase “survival of the fittest” has become common to describe natural selection. The phrase is commonly misunderstood as describing the “fitness” of an individual organism’s survival ability. Fitness, within the natural selection context, instead refers to the ability of an individual to pass on its genetic traits to the most offspring, thus having a higher relative contribution to the adaptability of its population’s gene pool.²⁵ There are many environmental factors that impact the ability of an organism to survive and pass its genes onto the next generation. The sum total of all these natural selection factors is typically referred to as “the fitness landscape.” A fitness landscape not only provides the natural selection of individual organisms, it can also be applied at higher levels of natural system hierarchies, such as the species or ecosystem levels.

Operational Environment and Concept Development

Adopt Alternative Futures. To describe the future operational environment, U.S. Army Training and Doctrine Command (TRADOC) uses important social, cultural, economic and

Figure 4 – Compo-informed Total Army Attributes



Table 1b – Natural Selection Concepts Applied to Force Management Process

Army Force Modernization Process

	Operational Environment and Concept Development	Capabilities Integration and Development	Force Development
Natural Selection – Fitness Landscape	<ul style="list-style-type: none"> • Adopt alternative futures • Develop alternative operating concepts • Use characteristics of alternative futures to develop a fitness landscape(s) 	<ul style="list-style-type: none"> • Use a fitness landscape: <ul style="list-style-type: none"> ◦ To evaluate level 2 integration ◦ To push research, development, testing and evaluation 	<ul style="list-style-type: none"> • Use a fitness landscape to evaluate level 3 integration • Adopt ascendancy as a key performance parameter

demographic trends. Scientific and technological advancements and the dynamics among all these factors help the Army plan for future threats, challenges and enemy capabilities. The Army Capstone Concept describes a future operational environment that is uncertain and complex, requiring balanced Army forces capable of responding to a broad range of threats and challenges; attaining this balance will require operational adaptability.²⁶ This future operating environment, with its fairly predictable transitions, is consistent with a system that is in the *r* or *K* phase of Holling and Gunderson's adaptive cycle.

To assist the force modernization process, TRADOC has developed a number of future scenarios wherein force developers identify gaps in existing capabilities and test proposed capability solutions. This process is comparable to a fitness landscape with one significant exception: even though all the documents acknowledge that the future is unpredictable and that the scenarios projected will be wrong, by specifying a most likely and a most dangerous alternative future,²⁷ TRADOC is indeed attempting to predict the future. Nature, as previously discussed in the genetic variability section, does not attempt to predict the future—nor should the military.

An alternative methodology for developing a description of the future that better supports possible predictable transitions of a natural system in the *r* or *K* phase of the adaptive cycle would be adopting an alternative futures approach.²⁸ By altering the direction and magnitude of the same trends, technological advances and dynamics currently being used, different futures could be crafted. These four to five fundamentally different futures would provide a requisite variety of potential future operating environments that truly challenge the effectiveness and survivability of our concepts, doctrine, organizational structures and capabilities.

Develop Alternative Operating Concepts. Each of these alternative futures could present fundamentally different threats and challenges. In assessing these differing operating environments, the Army could decide to create a single operating concept that would be applicable across any of those alternative futures, or it could decide to create an operating concept that meets the specific demands of each of these four to five alternative futures. As one of those alternative futures begins to emerge, its respective operating concept could be used to develop the rest of the family of concepts and modify its necessary doctrine. A more likely approach, given fiscal realities, is that TRADOC could apply these alternate futures as a single suite of futures. Such a situation would offer TRADOC the opportunity to test alternative operating concepts to determine which operating concept allows the most adaptability.

Fitness Landscape Development. By exploring the attributes required for success within each of these alternative futures, an overarching fitness landscape could be constructed that would select for capabilities that are the most adaptable across all different futures. Each of the factors needed for success could then be used as a natural selection criterion for updating the Army family of concepts and identifying key performance parameters (KPPs) for use in later phases of the force modernization process. At the same time, a specific fitness landscape for each alternative future could be constructed. This would allow the Army to develop specialized capabilities that are optimized for that respective alternative future.

Capabilities Integration and Development

Fitness Landscape. While a CAS is in the *r* and *K* phases, the biggest gains in achieving operational adaptability within the materiel domain could occur by applying the natural selection or fitness landscape concept in an incremental, evolutionary approach. Capability developers could use a fitness landscape to evaluate how well the capability solutions are integrated within their

warfighting function. ARCIC calls this evaluation “level 2” integration. (“Level 1” integration refers to consistency and integration within concepts; “level 3” integration refers to integration of capability solutions across the six current warfighting functions and across all Army organizations and forces). The set of alternative futures and this fitness landscape would also allow Army research, development, test and evaluation (RDT&E) to push the extremes in the operational environment rather than simply focusing on the most likely or most dangerous scenarios.

Force Development

Fitness Landscape. The fitness landscape described above could also be applied at the total force level (i.e., level 3 integration). In doing so, ARCIC would be consistent with the environmental conditions applied throughout all system hierarchies (capability development, warfighting function integration and total force integration). The Army’s current force modernization process, however, uses different fitness landscapes at each level of hierarchy. Each capability developer establishes its own KPPs by which a certain capability will be evaluated. Each Center of Excellence establishes its own criteria by which it conducts level 2 integration. During the Fiscal Year 2010 force design/force mix effort, ARCIC’s Task Force 13-1 essentially used the capabilities of “What an Army Must Do” as its fitness landscape, including the criteria by which certain capabilities or an aggregation of capabilities were evaluated. Using this “collective fitness” measure marked an attempt to optimize the ability of the force as a whole to function effectively rather than allowing the warfighting function “parts” to be optimized. Adopting a single fitness landscape that would be applied at all levels of force hierarchy would assist in producing “parts” that are optimized to contribute to the optimized whole.

Ascendancy. One of the overarching metrics or key performance parameters that could be used at the total force level as part of the fitness landscape would be ascendancy. This measure would allow the Army to evaluate how well different force design/force mixes would prevail against disturbances, either in other operating environments or in a variety of alternative futures.

Evolutionary Strategies

Ecologists have long categorized the reproductive strategies of species along a continuum that extends from an *r*- to a *K*-type strategy (an *r*-type strategy refers to reproductive rates; a *K*-type strategy refers to environmental carrying capacity). These two strategies and the associated types of species they produce align with the *r* and *K* phases of Holling and Gunderson’s adaptive cycle at the ecosystem level. The *r* phase reflects a pioneering state predominately populated with *r*-type strategists, colonizing species tolerant of environmental variation. The *K* phase reflects a mature state predominately populated with *K*-type species. Species categorized as *r* strategists have short-lived individual organisms who produce many young but few who will survive to maturity. The *r* strategists are generalists or opportunists whose behavior is conducive to responding to rapidly changing environmental conditions; therefore, they are good colonizers. On the other hand, species categorized as *K* strategists are characteristically long-lived individuals who produce few young but who are protected by a parent or community and who adopt complex but predictable behavior. *K* strategists are specialists and efficient users of their environments; however, they are also susceptible to disturbance or changes in their operating environment.²⁹

Operational Environment and Concept Development

Adaptive Cycle/Panarchy. If the exploration of future trends indicates that the geopolitical world is entering or will enter the *omega* phase in its adaptive cycle before 2025, then

Table 1c – Evolutionary Strategy Concepts Applied to Force Management Process

Army Force Modernization Process

	Operational Environment and Concept Development	Capabilities Integration and Development	Force Development
Evolutionary Strategies	<ul style="list-style-type: none"> • Incorporate adaptive cycle phase and panarchy considerations 	<ul style="list-style-type: none"> • Incorporate adaptive cycle and Cynefin framework to determine appropriate action • Develop key performance parameters tailored for each evolutionary strategy • Adopt <i>r</i>-strategy practices <ul style="list-style-type: none"> ◦ Rapid acquisition (capabilities development for rapid transition) ◦ Affordable force modernization ◦ Multiple prototypes 	<ul style="list-style-type: none"> • Incorporate adaptive cycle phase and panarchy considerations • Develop force design/mix(es) tailored for each evolutionary strategy

contrary to the earlier recommendation to build alternative futures, developing future scenarios is especially fruitless. (The operating environment follows the *revolt* panarchy connection and consequently falls in the chaotic quadrant of the Cynefin framework.) As stated previously, a CAS in this situation will be highly sensitive to initial conditions following the collapse, and it will be nearly impossible to predict toward which stable condition the CAS will evolve. Any “weak signals” that might be visible as a result of the small differences in structures, variables, relationships or trends will likely point in multiple directions, thus making it almost impossible to craft any single and most plausible future scenario. Concepts developed to meet a chaotic operating environment would advocate for doctrine, capabilities and forces that could rapidly act to establish favorable initial conditions, sense the changes created by their actions and adapt and respond to those changes.

Capabilities Integration and Development

Adaptive Cycle Model/Cynefin Framework. The location of a system within the adaptive cycle provides significantly different levels of structural and dynamic complexity with correspondingly different iterative actions that should be taken, based on the Cynefin framework quadrants. If the future portends an operating environment that is in the *r* or *K* phase with fairly predictable transitions, then an incremental, evolutionary approach to capabilities integration and development would be appropriate and would align with the recommended actions in the simple, complicated and complex quadrants of the Cynefin framework. If, on the other hand, the future operating environment is projected to be one that is progressing through its *omega* phase and beginning to enter the *alpha* phase, which produces a chaotic operating environment, then a more experimental, revolutionary approach to capabilities integration and development would be appropriate. In this type of environment, the initial conditions of the reorganized structures, variables and relationships will not yet be established, causing confusion and extreme competition. In this phase, having or being able to develop the appropriate capabilities may not be important. Having or developing a capability—any adaptable capability—quickly and doing it often will help transform the chaotic environment into a complex environment, setting a stable trajectory for the future.

Tailored Key Performance Parameters. Depending on the decision made during the operating environment and concept development phase regarding the application of alternative futures, the fitness landscape could be used to develop KPPs that are tailored to a *K* strategy. In this way, the fitness landscape could develop efficient, specialized capabilities. Alternatively, the fitness landscape developed from the suite of alternate futures could be used to identify KPPs most likely to produce operationally adaptable forces, an approach more in line with an *r* strategy. Agility—the ability to cope successfully with changes in the environment by maintaining acceptable levels of performance, effectiveness and efficiency—could become the predominate KPP for all materiel capabilities. Additional KPPs that would measure a capability’s ability to “survive” in an uncertain environment include resilience (the magnitude of disturbance that can be absorbed) and versatility (the ability to perform many things competently).

***r*-Strategy Practices.** Recently, the Army has adopted or is proposing to adopt practices that support an *r* strategy. Since the advent of the long war, the Army has implemented an accelerated capabilities process. In this process, capability developments for rapid transition allow the rapid fielding of new capabilities, essentially increasing the “weapon system ‘genotypes’” within the ecosystem. ARCIC’s recent pursuit of “Operational Adaptability through Affordable Force Modernization,” wherein the intent is to “buy fewer, more often,” could be viewed as a strategy following this approach. By allowing a weapon system to be modified using innovation when opportunities meet needs, ARCIC’s concept would encourage different versions (e.g., different “genotypes”) of the same weapon system. An additional measure for following an *r*-strategist approach would be to develop many prototype solutions to identify capability gaps across all the alternative futures without necessarily bringing any to full production and fielding. Such an approach would allow rapid development of a required capability when one of the differing alternative futures actually emerges.

Force Development

Adaptive Cycle. Determining the operating environment’s location on the adaptive cycle is also important for force development. As was the case with capabilities integration and development, if the future operating environment will be chaotic, then taking action—any action—will help establish the initial system conditions and subsequent future state of the system. The chaotic conditions and extreme competition in this phase will require rapid development and the generation forces that are sufficiently resilient and adaptable to be able to survive into the *r* phase of the adaptive cycle.

Since the last *omega* and *alpha* transformation of militaries, military structures incrementally evolved into the current Line-and-Staff model. Such an organization is planned, rational and hierarchical, with an even distribution of leaders and followers. Leaders are the linchpin of the staff (or group). In this model, advancement is “up” the organization, and it is visually apparent that there are more requirements as one moves up in the organizational structure. Line-and-Staff organizations can easily be split into recognizable levels.³⁰ These organizations were developed to handle environmental conditions—including specialization of labor and tasks, stability, predictability and centralized decisionmaking—prevalent during the Industrial Age. Line-and-Staff models follow the basic organizational model of mechanistic organizations, which are highly specialized, centralized, standardized and relatively closed. Their emphasis is on objectivity, rationality, stability and certainty.³¹ Information collection, processing and transmission in this type of organization have been adequate and efficient but can also be slow and redundant.³²

In developing an alternative organization to the current Line-and-Staff model, the Army could use an alternate basic organizational model—the organic organization. Organic organizations have low degrees of specification, formalization, centralization and routines. These types of organizations best function at the problem-solving transformation process and with dynamic, uncertain environments that emphasize openness, exchange, change, interrelatedness and uncertainty.³³ The Army’s recently completed modularity conversion is a clear implementation of such a structure and harkens back to some of the early AirLand Battle proposals for force configuration.³⁴ This force structure is able to respond to rapidly developing situations on the battlefield and could be tailored to meet specific missions. It may also be adaptable to nonconventional warfare scenarios.

Tailored Force Design/Force Mix. In applying metaphors from evolutionary strategies, ARCIC could explore the benefits of having a force design/force mix that supports both the forces best suited to operate in stable environments (*K* strategists) and the forces best suited to operate in unstable environments (*r* strategists). Based on the current Army operating concept—which states that “to succeed in the future operational environment, Army forces must be able to conduct full-spectrum operations, rapidly transition between types of operations and conduct operations decentralized”—the force design should follow an *r* strategy. The attributes that nature uses for this strategy could help inform the best force design strategy. For example, a force design for an *r* strategy would have many small units (i.e., individual organisms) with short-lived organizational designs that are tough and adaptable to rapid changes in the environment. Given the possibility that the environment of 2025 could be more stable (remote though that possibility may be), there may be value in considering force designs that would be more effective following the attributes of a *K* strategy, as seen in highly specialized, large, long-lived organizations.

Adaptive Management Process

Five management techniques found in natural systems have been successfully applied to ecosystems over the past two decades: 1) an acknowledgment of uncertainty; 2) human integration; 3) an ability to simultaneously understand the parts and the holism of a CAS; 4) an ability to integrate the “art” and “science” of management; and 5) the implementation of an adaptive management process.

Historically, ecosystem management took a reductionist approach by compartmentalizing various environmental disciplines into specialized areas of research and management, such as forestry, wildlife management and recreation management.³⁵ Early natural systems management practices focused on understanding and managing a particular species of animal or plant. Failures in the 1970s and early 1980s with this traditional approach caused a shift toward a more holistic ecosystem management approach that had been previously promoted by earlier ecosystem management advocates, including Aldo Leopold. Leopold posited that a more comprehensive understanding and approach was needed, noting that ecosystem management

deals only incidentally with the identity of plants and animals and only incidentally with their habits and behaviors. It deals principally with their relations to each other, their relation to the soil and water in which they grew.³⁶

This more holistic approach focuses on retaining sufficient genetic diversity, thereby assuring that ecosystems continuously produce the same quality and quantity of benefits in perpetuity.³⁷

Table 1d – Adaptive Management Concepts Applied to the Force Modernization Process

Army Force Modernization Process

	Operational Environment and Concept Development	Capabilities Integration and Development	Force Development
Adaptive Management Process	<ul style="list-style-type: none"> • Acknowledgment of uncertainty • Extend manpower and personnel integration beyond the capability development phase • Directly involve stakeholders (American public, Congress, etc.) • Integrate levels 1, 2 and 3 • Apply design to the force modernization process • Expand two-year force modernization process (to iterative force modernization process) 		

An Acknowledgment of Uncertainty

An underlying premise of ecosystem management reflects the high degree of ignorance and uncertainty concerning the outcomes of these activities. Given the highly complex nature of ecosystems, management requires a philosophy that accepts a limited ability to predict outcomes. Therefore this philosophy requires a management strategy that embraces uncertainty rather than one which attempts to eliminate uncertainty. To be sustainable, all management decisions and actions must seek to retain as much flexibility and robustness as is feasible in order to include a margin of safety for this uncertainty. This decisionmaking process allows the requisite adaptability to be in place when things do not go as planned.³⁸

The current TRADOC Operating Environment (OE) and the Army Capstone and Operating Concepts acknowledge uncertainty as a characteristic of a future environment that is also complex and filled with persistent conflict. Many of today’s military capabilities are significantly complex systems whose future performance is uncertain. In ecosystems, it is extremely difficult to engineer and manage interactions in a complex system with any degree of certainty. By recognizing the inability to attain such concrete knowledge during capability development, force design/force mix and force modernization, community members would begin to design military systems capable of accommodating changes and unexpected outcomes. Such a system would be more robust, have a longer shelf life and more accurately reflect the needs of stakeholders.

Human Integration

Perhaps one of the most significant aspects of ecosystem management is the acknowledgment that humans, with their social, political and economic systems, are an integral part of the ecosystem.³⁹ Despite the fact that humans present some of the most significant challenges to managing ecosystems, the interdependence between humans and the natural world requires that the impact of humans be integrated into the design and management of the ecosystem. The various human stakeholders’ needs define the management requirements—the desired ecological states and the means to achieve them.⁴⁰ This interdependency requires as much an understanding of political and social factors as it does an understanding of biological processes and information.

MANPRINT Expansion

The current capability development process has a very specific component that focuses on the human integration aspect called MANPRINT.⁴¹ The focus on this aspect is a clear indication that the Army recognizes the importance of human considerations throughout the force modernization process. Currently, however, this activity is usually performed only during the

materiel acquisition stage of capability development. Expanding the use of MANPRINT concepts both earlier and later in the force modernization process would better reflect how human considerations are handled within natural systems management. Human integration should also include the consideration of all stakeholder needs (e.g., those of the American public and future military members), as well as political and economic issues from the standpoint of how they exist today and how they will likely be in the future. Examining needs based on social, cultural, technological, economic and cognitive trends will better inform the force design/force mix of what is the most “survivable” in the future. Recent recruiting and fitness challenges, along with some studies on generational changes,⁴² might indicate the need for differing force designs/force mixes in the future.

Stakeholder Involvement

The Army could also adopt ecosystem adaptive management by directly involving stakeholders in the force modernization process, similar to TRADOC’s development of its operational environment. TRADOC could seek their input about what they would like the military to do in the future and what they want in return for the gift of their sons and daughters. The answers could help us develop appropriate concepts and sustainable force design/force mix solutions.

An Ability to Simultaneously Understand the Parts and the Holism of a Complex Adaptive System

Another management technique used in current-day ecosystem management is the simultaneous consideration of the critical components, functions and structures—the ecosystem’s parts and the system as a whole.⁴³ Ecosystem management strives to maintain a balance between focusing efforts on the micro-environment and on the macro-environment. The micro-environment entails managing the viability of individual species with their functional role and intensively manipulating small areas of their landscape. The macro-environment considers the ecological consequences of the activities conducted at the micro-environment level from a comprehensive, long-term view. Ecosystem management requires development of an understanding about the biotic and abiotic processes and constraints so as to provide the proper mix of goods and services on a sustainable basis.⁴⁴ This understanding also requires an explicit examination of the relationship between humans and nature, regarding patterns of politics and methods of scientific inquiry.

Ecosystems will display emergence or holism, as previously discussed. At times, system behaviors will be surprising and counterintuitive. Certain actions can produce an abrupt shift in a trend or previously stable state, or they can produce an effect that is greater than would be expected from the effects of each action separately. This feature of CAS makes using historical-trend analysis especially problematic, since many of these trends depend on the behavior of the entire system.⁴⁵

Levels 1, 2 and 3 Integration

ARCIC’s current capability integration process, which uses three levels of integration, is a valid attempt to simultaneously understand each of the critical capabilities being developed and how these capabilities will function and interact with the other critical ones to produce successful behaviors of the force as a whole.

An Ability to Integrate the “Art” and “Science” of Management

One of the predominate techniques that is taught at many forestry and wildlife management colleges is based on the idea that managing natural systems requires integrating scientific

principles and “facts” with other aspects of management that cannot be explained solely using scientific principles. As is the case with many art forms, this aspect of management can be learned only through practice.

Determining which trees to cut in a timber sale requires that the trees be selected based on scientific principles but, at the same time, within a context of other factors that are not as easily explained using those same scientific principles. These factors include the direction the trees are pulled out of the woods, the number of other trees marked in the same area, the kinds of trees, the landowner goals, the economic value of trees in a particular area and the location of the closest logging road. Being able to combine the scientific aspects of management with the art of management makes ecosystem management successful.

Design Application

In the recently published Field Manual 5-0, *The Operations Process*, the Army introduced the concept of design as “a methodology for applying critical and creative thinking to understand, visualize and describe complex, ill-structured problems and develop approaches to solve them.”⁴⁶ This field manual provides an extensive description on how to apply this methodology, providing some techniques for implementation. Force modernization is arguably a means by which solutions to complex problems are sought. Many of the activities that are part of the current force modernization process use concepts and techniques similar to those described in FM 5-0. However, specifically adopting the design methodology and techniques from FM 5-0 within the force modernization process would better support the “art” of capability integration with the “science” of capability development.

Implementation of an Adaptive Management Process

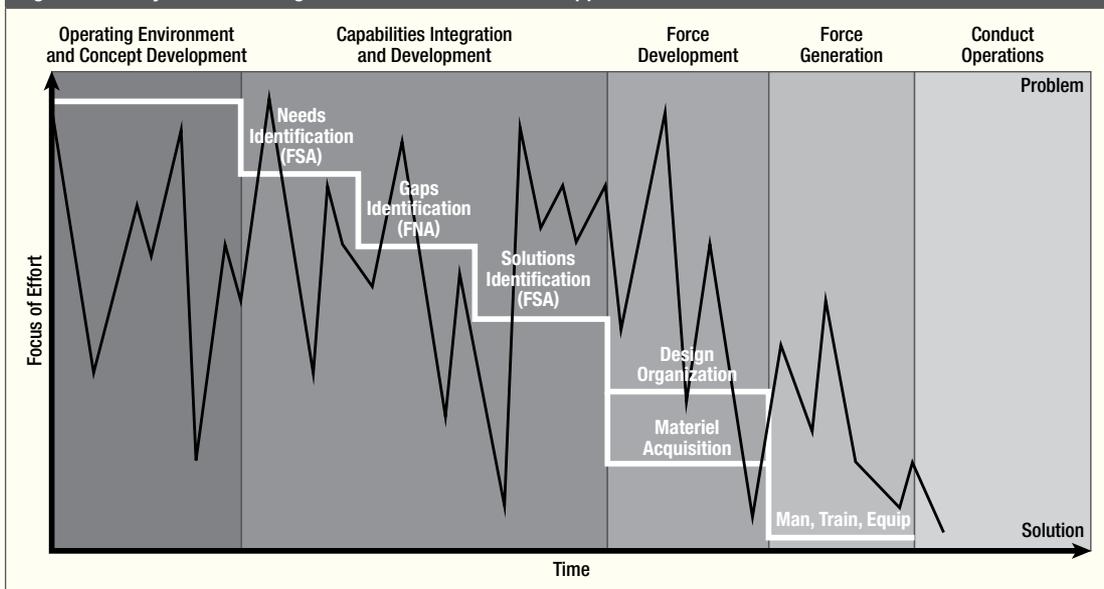
Success in managing ecosystems requires adaptive management—an iterative implementation that supports taking a particular approach, monitoring and analyzing the resulting ecological conditions and then applying lessons learned in the crafting of new approaches aimed at hastening progress toward management objectives.⁴⁷ Ecosystem management requires open communication and a continuous, collaborative effort between the stakeholders who determine the goals of resource management and those who are responsible for implementation.⁴⁸ To support a learning process, these management goals must explicitly state desired future conditions and system behavior and must be able to be measured directly and monitored continually. Ecosystem managers must then treat each management prescription as a working hypothesis, requiring on-the-ground experimentation followed by the measurement of progress and quality. Ecosystem managers must use a learning process to fully understand the problems and implement solutions.⁴⁹

Iterative Force Modernization Process

The Army’s current force modernization process was developed with a reductionist paradigm similar to that of 1950s–1970s ecosystem management. The process is broken into discrete phases that are implemented in sequential fashion, with each phase inching closer to a solution. This approach, commonly referred to as “the waterfall method,” is illustrated by the white, stepped line in figure 5.

However, research has shown that the actual cognitive process individuals use to solve problems follows a much less linear approach (the black line in figure 5). In trying to understand the problem, individuals jump back and forth between formulating potential solutions and

Figure 5 – Army's Force Management Process: An Iterative Approach



refining their understanding of the problem.⁵⁰ These research findings would seem to support the observations made by Horst Rittel and Melvin Webber in their article “Dilemmas in a General Theory of Planning,”⁵¹ which discusses problem solving for social problems and the lessons learned from the ecosystem management field. The Army’s current two-year Concept-to-Capability process is a step toward quickening a sequential process, making it more adaptive. However, an iterative approach may produce better results and would better support the actual problem-solving process people use. That said, the 2009–2010 family of concepts development and follow-on force design/force mix work were actually more like an iterative approach than a linear one, and this concept caused huge challenges.

Still, this iterative approach would allow the early consideration of a capability-solutions role and the effectiveness and contribution to the whole system. As with ecosystem management, this approach would allow all members of the force modernization process to simultaneously understand the specific capabilities and the system as a whole.

Conclusion

People accomplish the mission. It is this human dimension with moral, cognitive and physical components that enables land forces to deal with the situational complexity of tactical actions with strategic impacts and adapt to rapidly changing conditions.

General George W. Casey, Jr., *ARMY*, October 2008⁵²

The strength of the Army has been and will continue to be its Soldiers. The Army focuses on equipping the Soldier. The Army has long relied on Soldiers and their inherent adaptability to provide the innovation and unexpected behaviors that overwhelm an adversary’s ability to cope. The Army needs a force modernization process that can provide capabilities that support and enhance its Soldiers’ adaptability. Despite recent improvements made by ARCIC to the Army’s force modernization process, the current process remains too structured and too

mechanistic to deal with a rapidly changing, uncertain and unpredictable future. As the Army has leveraged one product of natural systems (the Soldier) to achieve agility, it must now apply natural system metaphors to its force modernization process to increase efficiency and improve adaptability capabilities within the system.

Drawing on natural systems as a metaphor to design capabilities, organizations and doctrine is not new to the military. The Army should recall the lessons learned in the 1970s and 1980s through the use of some of the ideas and concepts from the Living Systems Theory to create AirLand Battle with its associated capabilities; today, the Army continues (with a few exceptions) to use these same systems: the Abrams tank, the Bradley fighting vehicle, the Apache attack helicopter and the Paladin howitzer, supported by the Air Force's A-10 Thunderbolt (also known as the "Warthog").

By specifically acknowledging the connection between natural systems and force management, the Army can recognize that its current activities follow natural system principles. Therefore, adopting the additional natural system principles and management techniques recommended here would ensure the Army produces ground capabilities that can rapidly evolve to operate and "survive" successfully in any potential future world that emerges.

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- ²⁴ There are three studies of note: “The Final Report of the Commission on the National Guard and Reserves,” 31 January 2008; “The Independent Panel Review of Reserve Component Employment in an Era of Persistent Conflict,” 2 November 2010, http://www.roa.org/site/DocServer/GEN_Reimer_Panel_Report_RC_Employment_in_the_Era_of_Pers.pdf?docID=30102; and the 2010 Quadrennial Defense Review-directed “Comprehensive Review of the Future Role of the Reserve Component.” 5 April 2011, [http://ra.defense.gov/documents/publications/Comprehensive%20Reserve%20Review%20\(5Apr11\)%20Ver26h%20-%20Final.pdf](http://ra.defense.gov/documents/publications/Comprehensive%20Reserve%20Review%20(5Apr11)%20Ver26h%20-%20Final.pdf).
- ²⁵ Smith, *Elements of Ecology and Field Biology*, pp. 26–27.
- ²⁶ U.S. Army, TRADOC Pamphlet 525-3-0, *The Army Capstone Concept: Operational Adaptability: Operating under Conditions of Uncertainty and Complexity in an Era of Persistent Conflict*, 21 December 2009, pp. 9–16.
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- ²⁸ The type of alternative futures recommended here is the methodology initially applied by Royal Dutch Shell (and subsequently Global Business Network) and described by Peter Schwartz in *Art of the Long View* (New York: Currency Doubleday, 1996), pp. 100–117, 241–248; and by Kees van der Heijden in *Scenarios: The Art of Strategic Conversation* (Chichester, England: John Wiley & Sons, 1996), pp. 183–224. An Army methodology can be found in Charles W. Taylor,

- Alternative World Scenarios for a New Order of Nations* (Carlisle, Pa.: U.S. Army War College Strategic Studies Institute, 1993), pp. 1–18.
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- ³¹ Carlton Whitehead and J. D. Blair, “Designing and Leading the Army of the Future,” in Hunt and Blair, *Leadership on the Future Battlefield*, pp. 136–138.
- ³² T. Owen Jacobs, “The AirLand Battle and Leadership Requirements,” in Hunt and Blair, *Leadership on the Future Battlefield*, p. 26.
- ³³ Whitehead and Blair, “Designing and Leading the Army of the Future,” pp. 136–138.
- ³⁴ Jacobs, “The AirLand Battle and Leadership Requirements,” p. 25.
- ³⁵ Mary G. Wallace, Hanna J. Cortner, Margaret A. Moote and Sabrina Burke, “Moving Toward Ecosystem Management: Examining a Change in Philosophy for Resource Management,” *Journal of Political Ecology*, vol. 3, 1996, pp. 16–22.
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- ³⁷ Mark S. Boyce and Alan Haney, eds., *Ecosystem Management: Applications for Forest and Wildlife Resources* (New Haven, Conn.: Yale University Press, 1997), p. 27.
- ³⁸ *Ibid.*, pp. 331–333.
- ³⁹ *Ibid.*, pp. 336–337.
- ⁴⁰ Wallace et al., “Moving Toward Ecosystem Management,” pp. 17–23.
- ⁴¹ Manpower and Personnel Integration, part of the Army force development process, is the comprehensive technical effort to identify and integrate all relevant information and considerations regarding the full range of manpower, personnel, training, human engineering, system safety, health hazards and Soldier survivability into the system development and acquisition process to improve individual and total system performance and reduce the cost of ownership throughout the entire life cycle of the system. Department of the Army, Army Regulation 602-2, *Manpower and Personnel Integration (MANPRINT) in the System Acquisition Process*, 6 June 2001, http://www.apd.army.mil/pdffiles/r602_2.pdf.
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- ⁴³ Wallace et al., “Moving Toward Ecosystem Management,” p. 17.
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- ⁴⁵ Chris Bright, “Anticipating Environmental ‘Surprise,’” *State of the World 2000* (W.W. Norton, 2000), pp. 23–24.
- ⁴⁶ U.S. Army, Army Field Manual 5-0, *The Operations Process*, March 2010, p. 3-1.

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- ⁴⁸ Wallace et al., "Moving Toward Ecosystem Management," pp. 17–20, 24.
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