Tutorial 5: Understanding Socio-Environmental Systems- Adaptive Cycle

Learning Goals:

- Be able to explain the concept of **Adaptive Cycles** and explain how it can help to understand a socio-environmental system.
- Be able to describe the four phases of the adaptive cycle.

Tutorial 3 explored concepts of multiple states and thresholds and how S-E systems can shift from one state to another across a threshold. This is an important way to study an S-E system and to understand resilience in such systems. But there are other ways to think about the dynamics of S-E systems, including the concept of **Adaptive Cycles.** While the concepts of thresholds and adaptive cycles can be related, they are really two different models to understand different aspects of S-E systems, namely systems behavior over time and transitions between regimes.

The adaptive cycle is a metaphor that describes a pattern of how systems move through four characteristic phases, and helps us think about the behavior of socio-environmental systems across time. The idea of the adaptive cycle was developed by C.S. "Buzz" Holling from a comparative study of the dynamics of several ecosystems, and has been further developed by researchers in the Resilience Alliance (see www.realliance.org). Here is an explanation of adaptive cycles from Resilience Alliance researchers:

> "Most systems of nature usually proceed through recurring cycles consisting of four phases: rapid growth, conservation, release, and reorganization (Gunderson and Holling 2002). The manner in which the system behaves is different from one phase to the next with changes in the strength of the system's internal connections, its flexibility, and its resilience." (Walker & Salt, 2006)

While the adaptive cycle was developed from studies of ecosystems, this metaphor also has relevance for social systems and socio-environmental systems. In fact, the original idea originated from an economist, Joseph Schumpeter, who studied economic boom and bust cycles (Walker & Salt, 2006). The utility of understanding adaptive cycles is that it can provide insights into the behavior of a system and why a system changes; these insights can help inform decisions on management interventions.

This diagram, created by the Resilience Alliance, describes the four phases of the Adaptive Cycle:

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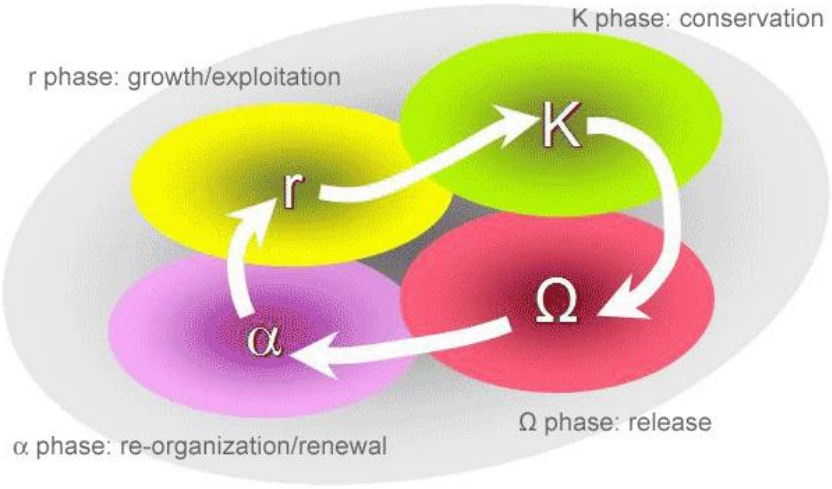

Figure by the Resilience Alliance: http://www.resalliance.org/index.php/adaptive_cycle
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Four phases of an adaptive cycle

Rapid Growth (r phase)
In the early phases of a system, individuals in the system are busy exploiting new opportunities and resources, which facilitates the overall growth of the system. At these early stages, the components of the system are not strongly connected, and regulation of the system is weak. The "r" refers to the biological concept of **r-strategists**. R-strategists are agents (individuals) characterized by traits promoting rapid growth in highly variable environments (i.e. in biological systems- quick reproduction, small body size, short life span, and high dispersal ability).

Example:
The for-hire transportation system, traditionally dominated by taxis, is currently experiencing a rapid growth phase thanks to the emergence of on-demand car services like Uber and Lyft. Uber is a startup company from San Francisco that launched in 2010 and is now in more than 60 cities internationally and worth more than $4 billion. Made possible by GPS and smart phone technology, Uber has created a new model within the for-hire transportation system and a competitive alternative to taxis; riders and drivers can now use a smartphone app to find each other, thereby increasing the convenience of using such services. With the dramatic increase in the use of smart phones, these companies are busy exploiting new opportunities and making aggressive grabs for resources (i.e. aggressive attempts to poach taxi drivers from competitors), which in turn is fueling their rapid growth and the growth of the overall system. They have effectively increased the supply, utility, and efficiency of using for-hire transportation

services resulting in increased use of for-hire transportation services and decreased incentive for private car ownership[1]. Furthermore, as characteristic of r-phase systems, the components of this system are not strongly connected, and regulation of the system is weak. Overall regulation of companies like Uber is weak, and this is reflected in the current controversies surrounding Uber regarding quality, regulation, and treatment[2] of Uber drivers, as well as pricing policies[3], aggressive recruiting tactics[4] and safety issues[5].

Conservation (K phase)

In this phase, connections between elements or agents in the system begin to strengthen, which in turn helps to regulate its internal state. There is a shift from rapid growth and exploitation of new opportunities and resources to a focus on specialization. This is the phase where stocks in the system accumulate, such as energy in a biological system or money in a financial system.

Like the "r-phase", the "K-phase" is based on ecological concept of K-strategists. K-strategists use resources more efficiently and tend to live longer.

As a system in this phase accumulates capital, develops connections, increases internal regulation, develops specializations and increases efficiency, the growth rate slows. The system here is more efficient, but as we saw earlier, efficiency often results in less resiliency: as systems increase efficiency, redundancy is often eliminated, and this makes the system less flexible and more vulnerable to a disturbance. Basically, a system in this phase does really well in current conditions- i.e. they will excel if things stay the same- but if conditions change a lot, the system may not have the flexibility to cope with the changes.

Example: The for-hire transportation industry might be considered as system in the K-phase prior to the emergence of startups like Uber. In that time period, the system was dominated by taxi companies, which are regulated by taxi commissions. A taxi commission has strong rules and regulations that govern the licensing of drivers and the functioning of the system. The system also has unions that work for fair wages and

[1] http://www.nytimes.com/2014/06/12/technology/personaltech/with-ubers-cars-maybe-we-dont-need-our-own.html?_r=0

[2] http://thinkprogress.org/economy/2014/11/06/3589715/uber-lending-investigation/

[3] http://www.pcworld.com/article/2824832/ubers-surge-pricing-earns-it-an-f-on-better-business-bureau-test.html

[4] http://www.salon.com/2014/08/31/why_uber_must_be_stopped/

[5] http://www.cleveland.com/business/index.ssf/2014/04/critics_of_uber_and_lyft_raise_questions_about_insurance_and_safety.h

working conditions for drivers, and builds a professional community of taxi drivers. Contrast this to Uber, where drivers have great flexibility but are not well supported: Uber is facing lawsuits from drivers alleging unfair practices such as stealing tips, and from customers who allege irresponsible practices in selecting and regulating drivers (e.g. lawsuit over Uber driver who hit and killed a 6 year old girl[6].)

The traditional for-hire transportation system as represented by taxi commissions is a system with high internal regulation, high efficiency, high connectedness, and relatively low resilience. In the face of the disturbance in the system caused by smartphone technologies and companies like Uber, many speculate that this system may be pushed beyond its resilience capacity.

Release (Omega Phase)

If a disturbance pushes a system beyond its resilience capacity, the system breaks down. All the interactions- the feedback loops and connections- break apart, and the system collapses. As a result of a system's collapse, the resources that were tied up in the system- the stocks that are part of the system- are released. Hence, the naming of this "release phase." As the connections in the system break apart, the system loses its structure and the stocks flow out of the system. It's a time of uncertainty and confusion. But it is also a time of creativity and new opportunity.

In ecosystems, disturbances like floods or fires may break down an existing system. After a forest fire, the rich biological interactions that formed the forest ecosystem are broken. Trees no longer provide habitat for forest dwelling animals, or shade for shade-tolerant plants. But in the destruction of this ecosystem, nutrients and biomass are released. These resources are then used by pioneering plant species that colonize the area. These pioneers are usually r-specialists that grow rapidly in the face of new opportunities and resources provided by the release of nutrients and biomass caused by the fire. Over time, a new ecosystem emerges as species respond to the new conditions and opportunities.

Going back to our for-hire transportation system example, many have speculated that the appearance of Uber and other companies may force the end of the taxi industry[7]. If this happens, we may see a time of uncertainty and chaos in this system, with the basic structures of the system, such as the rules regulating the taxi industry, breaking down.

Reorganization (Alpha Phase)

[6] http://www.sfgate.com/bayarea/article/Uber-denies-fault-in-S-F-crash-that-killed-girl-5458290.php
[7] http://time.com/money/3397919/uber-taxis-san-francisco/

The release phase is quickly followed by a phase of reorganization. Here, there is room for new possibilities. In the forest ecosystem example we just discussed, pioneer plants take advantage of the new landscape and the newly released resources- nutrients and biomass- to grow and thrive. They create new possibilities and shape the communities of organisms that begin to grow in the new ecosystem.

The reorganization phase is where new dynamics of a system begin to develop and new connections are made. It leads back to the start of the adaptive cycle- to the r phase of rapid growth. In this phase of renewal, a new identity is being forged in the system.

We may be seeing this reorganization phase in the for-hire transportation system as taxis are adopting the use of mobile apps like mytaxi and companies like Uber revise their policies in response to criticism[8].

Moving through the adaptive cycle

Generally, systems are thought to proceed through the four stages of the adaptive cycle in the order just described. But not always. The only order that is not possible is release back to conservation without first passing through rapid growth. In the transportation example discussed, we still do not know how the system will move through the cycle after the r phase.

This diagram, created by the Resilience Alliance, describes the four phases of the Adaptive Cycle (note: some readers may be more familiar with the Figure 8 diagram of the Adaptive Cycle. They are the same figure drawn from different perspectives).

[8] http://sanfrancisco.cbslocal.com/2014/03/14/uber-lyft-announce-insurance-policy-changes-following-fatal-crash-involving-rideshare-driver/

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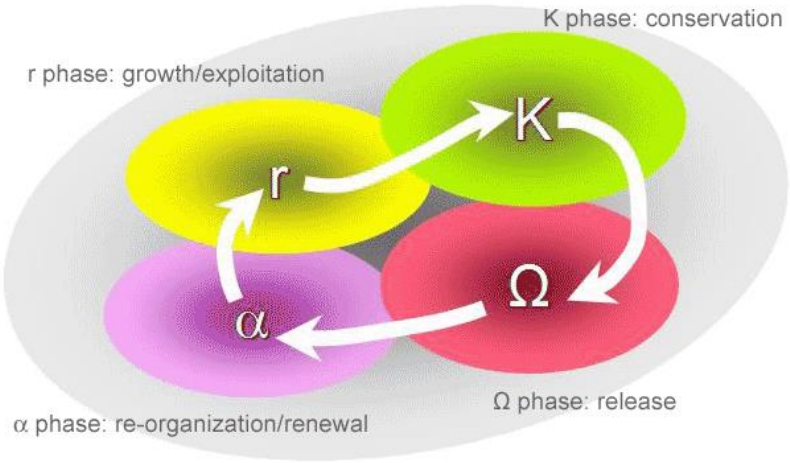

Figure by the Resilience Alliance: http://www.resalliance.org/index.php/adaptive_cycle
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The r and K phases are often referred to as the **"fore loop**", and the Omega and Alpha phases are the "**back loop**". These terms are not unlike the more familiar concept of "boom" and "bust" cycles. While boom and bust cycles do not describe all systems, it conveys the general idea of at least one form of the adaptive cycle. In the "fore loop", capital is accumulating and the system is growing and fairly stable. In the "back loop", capital is released and the system is chaotic. It's a time of uncertainty but also opportunity. This part of the adaptive cycle is the least well studied and understood, and is a strong focus of researchers interested in systems resilience.

The adaptive cycle diagram might make one might wonder if all systems are bound to collapse at some point, release, and then reorganize. Will all systems eventually move through the K phase and be pushed to the release phase by some disturbance to the system?

The answer to the first part of the question is Yes: Systems cannot stay in the K phase forever. In this period of conservation, systems become more efficient by removing redundancies, and therefore less resilient. It is also a period of decreasing flexibility. As the connectedness of the system increases, there is a great degree of control in the system, but at the cost of flexibility. Consider a bureaucracy; typically, there are many rules and regulations in such a system because of the need for a high degree of control in the system. However, as the definition of bureaucracy suggests, "an administration characterized by red tape and routine", and as anyone who has had to deal with bureaucracies knows, the cost of such control is a lack of flexibility.
By the "**late K phase**", the emphasis is on keeping things as is because the release phase can be painful as valuable capital is lost. The longer the system stays in this phase, the

more it costs to keep the status quo. Eventually, the costs will outweigh the benefits of maintaining the system. Eventually, the system will move out of the K phase.

While the concepts of threholds, regimes, and adaptive cycles are all important for understanding resilience, these concepts are not necessarily directly transferable. For example, when parts of a system cross threshold into another regime, this does not mean that the system is collapsing (or entering the release phase, as described below). The Everglades, for example, are still functioning as a system despite the regime shift from sawgrass to cattails in the northern Everglades. However, as more shifts occur, the risk of the whole system collapsing becomes greater.

Limitations

The metaphor (or mental model) of the adaptive cycle is widely used, but it is important to note that it is not the only model for understanding the dynamic nature of systems, and not all systems, such as those that lose their continuous identity in space or time, fit the adaptive cycle. (Cumming & Collier, 2005).

Panarchy

In previous tutorials, the concept that systems are often composed of interconnected subsystems was introduced, as was the importance of hierarchies and scale. Adaptive cycles- and hence the systems that they operate in- can also be structured in nested hierarchies across space and time. Such hierarchies are called **a panarchy**. In a panarchy, changes in adaptive cycles at one level can have impacts at another level, and thus cross-scale, dynamic linkages exist across adaptive cycles. Panarchy is an integrative theory developed by researchers at the Resilience Alliance to help understand the dynamics and cross-scale linkages of complex S-E systems, and is illustrated in the figure below:

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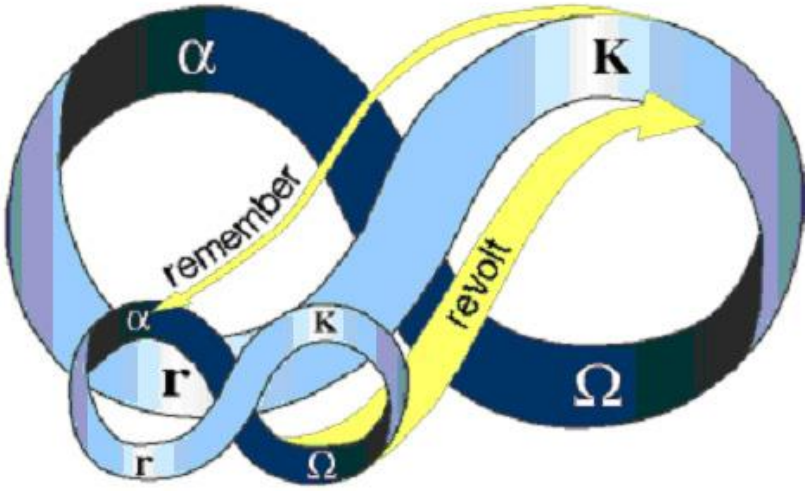

Figure by the Resilience Alliance: http://www.resalliance.org/index.php/panarchy
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