Adaptive Cycle

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A note from the authors: This version is static and as such has lost both formatting for viewing ease and important interactive elements like the ability to quiz oneself and click on key terms for hover-box definitions. We highly recommend using this module in it's interactive form by visiting the following link:
https://passel2.unl.edu/view/lesson/ab491bda9f88

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Overview and Objectives

Overview - What Will You Learn in This Lesson?

This lesson discusses was the adaptive cycle is and how it relates to understanding and interpreting natural phenomena.

Objectives

This lesson covers the concept of the adaptive cycle. At the completion of the lesson, you should be able to:

1. Outline the general definition and purpose of the adaptive cycle.
2. Define the four phases of the adaptive cycle.
3. Summarize how the phases of the adaptive cycle interact with each other.
4. Give an example of how the phases might appear in a system.
5. Illustrate how the adaptive cycle expands on the traditional model of ecological succession.

Correct answers to all questions are highlighted

Introduction - What Is the Adaptive Cycle?

The adaptive cycle is a conceptual model that helps us understand the structure and processes of complex system dynamics over time (Carpenter, Walker, Anderies, & Abel, 2001; Gunderson, Light, & Holling, 1995; Holling, 1992). It consists of four "phases" where the system acts in a distinct way to structure, collapse, or reorganize itself. Some helpful examples to illustrate this model include aquatic algal blooms, commodity crop markets, and cities such as ancient Rome, Jerusalem, or San Francisco that were repeatedly attacked or damaged, and then rebuilt. In this module, we mainly use the example of the Roman Empire to illustrate the four phases of the adaptive cycle.

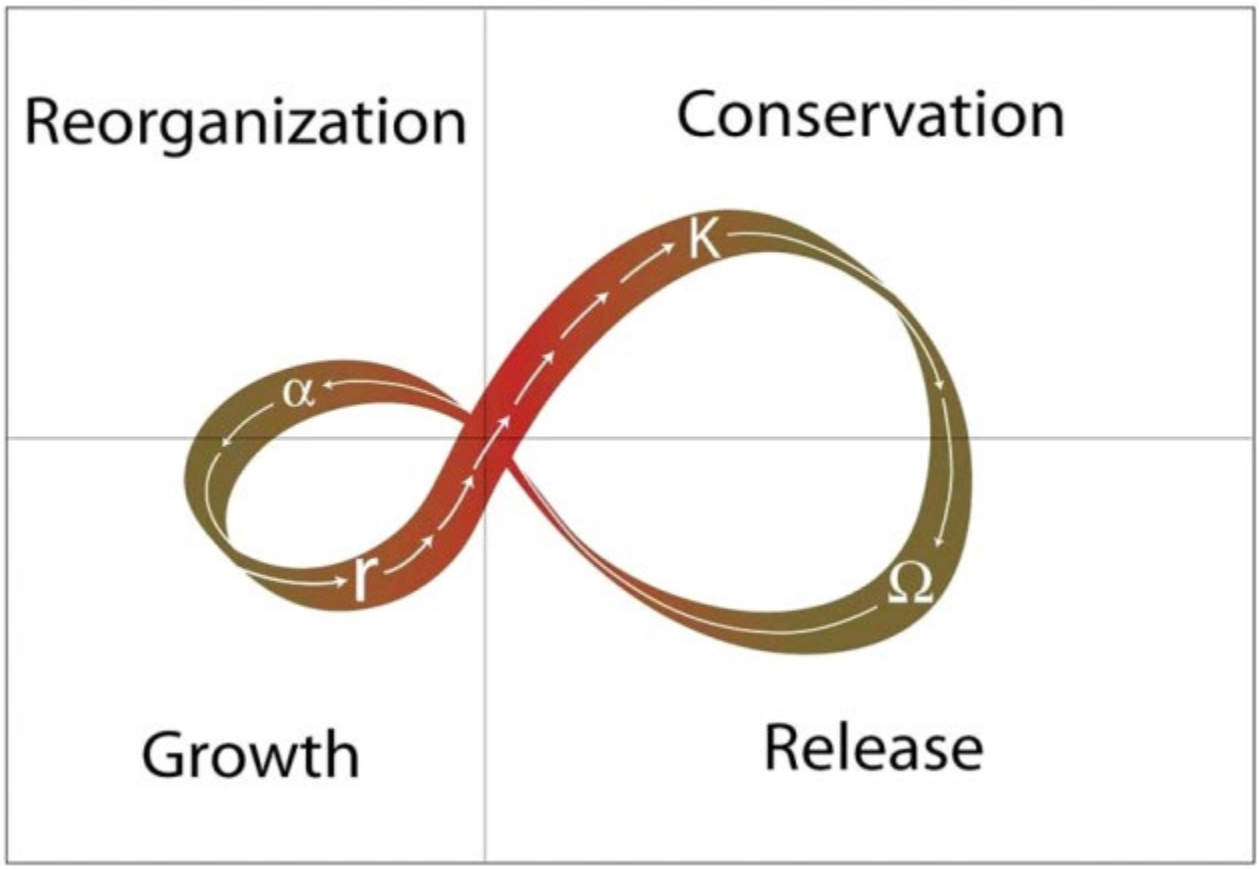

Figure 1. The Adaptive Cycle. Courtesy A. Garmestani, US EPA.

The adaptive cycle illustrates how, after collapse, systems reorganize into either similar or different structures and processes (see Alternative Stable States module). The four phases of the adaptive cycle are the "r" (exploitation or growth) phase, the "K" (energy conservation) phase, the "Ω" (release or collapse) phase, and the "α" (reorganization) phase. They are typically illustrated by a lazy-eight figure (Fig. 1). In the next section, we will walk through the adaptive cycle phases, using ancient Rome as an example.

Description - What Are the Details?

The "r" (exploitation or growth) phase is defined by rapid accumulation (or exploitation) of resources and new reorganization in a system. As the system grows and accumulates resources, its structure stabilizes and its processes form more connections between the parts of the system. To picture this phase, think of a town or city in early stages of growth, when effort is often concentrated in creative ways to accumulate and exploit key natural resources based on citizen needs, what resources are locally available, and what can be obtained by trade. For this example throughout the module, let's picture the first town that organized on the site of what would become ancient Rome in central Italy (ca. 8th century B.C.E.). This stage, with plentiful creative organization, increased structure complexity, and increased connections between the parts of the system leads to decreasing system flexibility, and moves into the "K" phase.

The "K" or conservation phase is defined by stable, rigid structures and processes that conserve energy. The system usually does not change much during this phase, because it is less flexible and adaptable than the other phases. We can visualize this by thinking of ancient Rome at the peak of its power and expanse (second century C.E.). Intensively managed systems are often held in this phase because the strong, consistent structure can be highly streamlined and productive. However, this makes the system more rigid and less likely to be adaptive to disturbances. Conservation of energy makes the system more likely to tip into the "Ω" or release phase.

The "Ω" or release phase, which follows some kind of disturbance to the system, is defined by a collapse of system structure and process. Collapse occurs when systems can't withstand a disturbance in their present form and collapse, releasing conserved energy accumulated during the "K" phase. The collapse of the Roman Empire in the 5th century C.E. in response to multiple disturbances (corruption, far-flung extension of its borders, and foreign invasions) illustrates this.

The "α" phase is an especially critical point in the adaptive cycle, because it is defined by system reorganization. This reorganization can look similar to how it did before collapse, but it can also look so drastically different from the previous system that it is unrecognizable. Following our example of ancient Rome, the transition of the age of the Roman Empire to what we now call the Middle Ages period after the 5th century C.E. illustrates a shift in the overall structures and processes of that part of the world. These new, unrecognizable systems are called "alternative states" and are covered in the "Alternative Stable States" module.

Concept Use in Management - How Is the Adaptive Cycle Relevant in the Real World?

The adaptive cycle model can be useful to managers and decision makers as a way to visualize and quantify the structural changes in systems being managed. To continue with the example of human society, governments can gain new perspective on political and social processes by viewing them as parts of a complex system that is constantly changing and sometimes significantly reorganizing itself. The adaptive cycle can be useful to natural resource and ecological managers as well. For example, phytoplankton communities in the Baltic Sea have been demonstrated to reliably follow patterns of growth, organization and conservation, and collapse over time (Angeler et al. 2015). These patterns are visible in the sudden algal blooms that can inhibit recreation and safe use of the water. Being able to better understand and predict these dynamics in large systems makes the adaptive cycle a powerful option in the toolbox of managers.

Example - Ancient Roman Empire

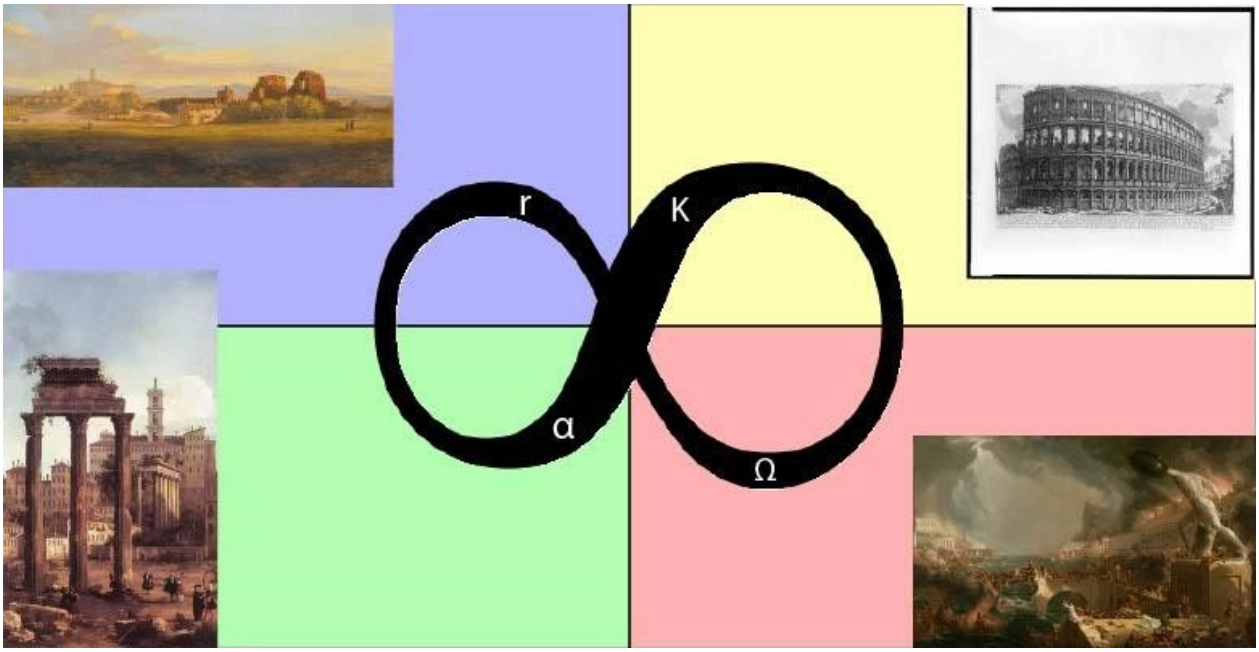

Figure 2. An example of the ancient Roman empire as a panarchy. Image created by Julie Fowler. Images within (clockwise from top-right): Roman Colosseum by Piranesi, Giovanni Battista, 1756. Obtained from Wikimedia Commons and in the public domain per PD-US-expired. Destruction from The Course of Empire by Thomas Cole, 1836. Obtained from Wikimedia Commons and in the public domain per PD-US-expired. Rome: Ruins of the Forum, Looking towards the Capitol by Canaletto, 1742. Obtained from Wikimedia Commons and in the public domain per PD-US-expired. A View of the Roman Campagna, a Villa and Aqueduct in the Distance by Edward Lear, 1841. Obtained from Wikimedia Commons and in the public domain per PD-US-expired.

We can use the rise and fall of the ancient Roman Empire as an example of a system moving through the phases of the adaptive cycle (Figure 2). The “adaptive cycle” of the Roman Empire

centers around the development of the first town that organized on the site of what would become ancient Rome, the center of the Roman Empire, in central Italy (ca. 8th century B.C.E.). This was a time when effort had to be concentrated in creative and innovative ways to accumulate key resources that fulfilled citizen needs, and set the town as a centerpoint for trade and urban development in the coming centuries. This illustrates the "r" (exploitation or growth) phase of the adaptive cycle.

The next phase for the Roman Empire adaptive cycle came gradually, culminating in ancient Rome (the city as the center of the Empire) at the peak of its power and expanse (second century C.E.). This illustrates the "K" or conservation phase, when the system is more stable and rigid and usually means the system is engineered towards maintaining the status quo in social, political, and cultural senses. However, as we see over the course of the rise and fall of the Roman Empire, this stability makes the system less adaptable to disturbances. It makes the system more likely to tip into the next phase, the "Ω" or release phase.

The "Ω" or release phase, which follows some disturbance to the system, is defined by a collapse of system structure and process. Collapse occurs when systems can't withstand a disturbance in their present form and collapse, releasing conserved energy accumulated during the "K" phase. The collapse of the Roman Empire in the 5th century C.E. in response to multiple disturbances (corruption, far-flung extension of its borders, and foreign invasions) illustrates this.

The "α" phase is an especially critical point in the adaptive cycle, because it is defined by system reorganization, which can only occur after a broad scale collapse or release of the structures and processes of a system. In sociopolitical examples (like ancient Rome's collapse), this is also commonly termed a "vacuum". When a major player falls or is removed, something else takes its place. This reorganization and rise of the next adaptive cycle can look similar to the pre-collapse adaptive cycle, but it can also look so different from the previous system as to be unrecognizable. The transition of the collapsed Roman Empire to what we now call the Middle Ages period in Europe after the 5th century C.E. illustrates a shift in the overall structures and processes of that part of the world. These new, unrecognizable systems are called "alternative states", and are covered elsewhere.

Summary - What Did We Learn?

An initial idea of the adaptive cycle was to expand on the theory in ecology that ecosystems progress relatively linearly through phases of exploitation (r) and conservation (K) over time. This is also known as the traditional ecological succession model (see Figure 2). The adaptive cycle expands this linear model into the more circular, lazy-eight model (Figure 1) by adding release (Ω) and reorganization (α) phases, and reflects more recent understanding of how complex, adaptive systems function.

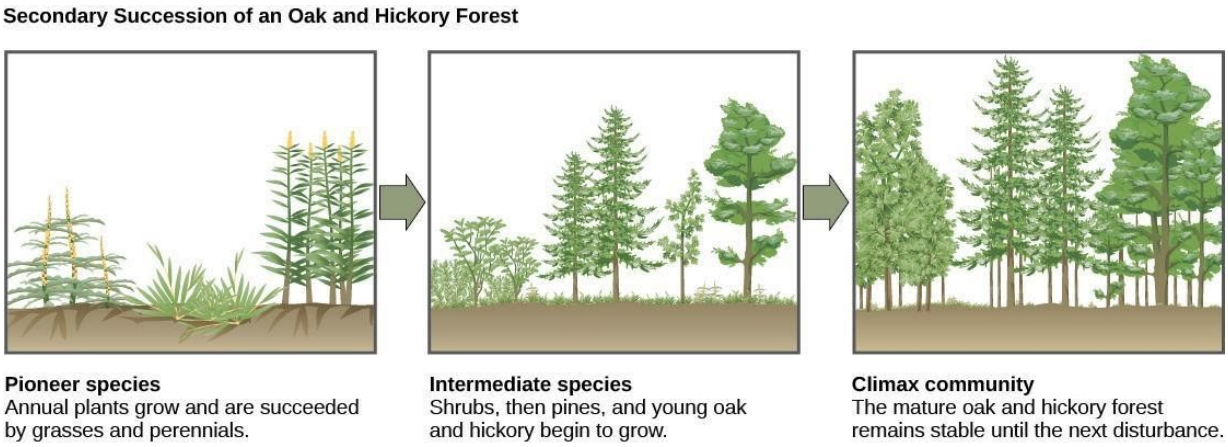

Figure 3. Ecological succession. Source: CNX OpenStax CC-BY-4.0.

Quiz Questions

Question

What is the definition of the adaptive cycle?

A. A conceptual model that allows managers to predict system behavior into the future
B. A decision making tool that focuses on how complex systems collapse
C. A conceptual model that helps humans understand the structure and processes of complex system dynamics over time
D. The concept behind public policy that systems are erratic and unpredictable
E. Burger King's constantly changing advertisements over time

Question

What are the key words that define the four phases of the adaptive cycle (in order: r, K, Ω, α)?

A. Growth, maturity, death, birth
B. Exploitation, conservation, collapse, reorganization
C. Eeney, meeney, miny, moe
D. Increase, stability, instability, redirection
E. Reorganization, exploitation, rigidity, collapse

Question

How do the phases of the adaptive cycle typically interact with each other?

A. They're all very introverted and prefer to unite separately, in their own homes.
B. "r" reorganizes into a new structure that more effectively uses resources in Omega, before Omega ends change and freezes the system in "K".

C. “r” accumulates resources and makes the system more rigid in “K”, which is more vulnerable to collapse during Omega, which then allows the reorganization of Omega to typically return to “r”.

Question

How might the “r” phase appear in a system in real life? Select the most appropriate example.

A. A small town that becomes a city over time
B. A business that changes its model and branding to appeal to a different customer base
C. A student who decides they can’t stand college and drops out to drive a rickety second-hand RV across the country
D. A political system that fails to implement adaptive policies and becomes less able to cope with climate change over time

Question

The adaptive cycle model expands on the traditional model of ecological succession.

A. True
B. False

References and Further Reading

References

Angeler, D. G., Allen, C. R., Garmestani, A. S., Gunderson, L. H., Hjerne, O., & Winder, M. (2015). Quantifying the Adaptive Cycle. PLoS ONE, 10(12), 1–17. https://doi.org/10.1371/journal.pone.0146053

Carpenter, S., Walker, B., Anderies, J. M., & Abel, N. (2001). From Metaphor to Measurement: Resilience of What to What? Ecosystems, 4(8), 765–781. https://doi.org/10.1007/s10021-001-0045-9

Gunderson, L. H., Light, S. S., & Holling, C. S. (1995). Lessons from the Everglades: Learning in a turbulent system. BioScience, 45 (Supplement: Science and Biodiversity Policy (1995)), S66–S73. https://doi.org/10.2307/1312447

Holling, C. S. (1992). Cross-Scale Morphology, Geometry, and Dynamics of Ecosystems.

Further Reading

Allen, C. R., Angeler, D. G., Garmestani, A. S., Gunderson, L. H., & Holling, C. S. (2014). Panarchy: Theory and Application. Ecosystems, 17(4), 578–589. https://doi.org/10.1007/s10021-013-9744-2

Angeler, D. G., Allen, C. R., Garmestani, A. S., Gunderson, L. H., Hjerne, O., & Winder, M. (2015). Quantifying the Adaptive Cycle. PLoS ONE, 10(12), 1–17. https://doi.org/10.1371/journal.pone.0146053

Burkhard, B., Fath, B. D., & Müller, F. (2011). Adapting the adaptive cycle: Hypotheses on the development of ecosystem properties and services. Ecological Modelling, 222(16), 2878–2890. https://doi.org/10.1016/j.ecolmodel.2011.05.016

Fath, B. D., Dean, C. A., & Katzmair, H. (2015). Navigating the adaptive cycle: an approach to managing the resilience of social systems. Ecology and Society, 20(2), 24. https://doi.org/10.5751/ES-07467-200224

Adaptive Cycle

The interactions among the biotic and abiotic elements of system within a single scale, including elements' organization, growth, and decay.

Conservation

A phase of the adaptive cycle characterized by stable, rigid structures and processes that conserve energy and often emphasize production ("K" phase).

Exploitation

A phase of the adaptive cycle characterized by rapid accumulation of resources and a new trajectory of a system ("r" phase).

Perturbation

Also known as disturbance. An event or input to a system that causes a loss of the system's capital. It may cause a regime shift. For example, wildfire in a forest, ocean acidification and coral reefs, woody encroachment in a grassland.

Release

A phase of the adaptive cycle which follows some kind of disturbance to the system, and is characterized by a collapse of system structure and process ("Ω" phase).

Reorganization

a phase of the adaptive cycle characterized by recombination of system components to create similar or novel structures and processes (“α” phase).

System

A whole made up of interacting components.