Panarchy

This material is based upon work supported by the National Science Foundation under Grant No. DGE-1735362 and 1920938. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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 introduces panarchy theory and how it relates to understanding and interpreting natural and social systems.

Objectives

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

1. Define a panarchy and related principles
2. Analyze how panarchy theory can be used to manage social or ecological systems
3. Apply panarchy theory to social and ecological systems
4. Explain two panarchy transition pathways
5. Understand how panarchy is useful in order to assess a system's ecological resilience

Correct answers to all questions are highlighted

Introduction - What is Panarchy (and the Adaptive Cycle)?

Panarchy theory was developed by Lance Gunderson and C.S. Holling in order to understand how systems function and interact across scales (Resilience Alliance 2018). Allen et al. (2014) defines panarchy as "a conceptual model that describes the ways in which complex systems of people and nature are dynamically organized and structured across scales of space and time". A panarchy is a set of nested adaptive cycles (see Fig. 1 for an image of an adaptive cycle) organized into a hierarchy (see Fig. 2), which connects adaptive cycles at small scales to adaptive cycles at large scales (Gunderson and Holling 2002, Allen et al. 2014). While "hierarchy" is generally used to describe a system in which power, influence, or authority originate at the top and travel down to the bottom, in panarchy theory "hierarchy" is defined more broadly as the overall structure of the scales where systems operate (Allen et al. 2014).

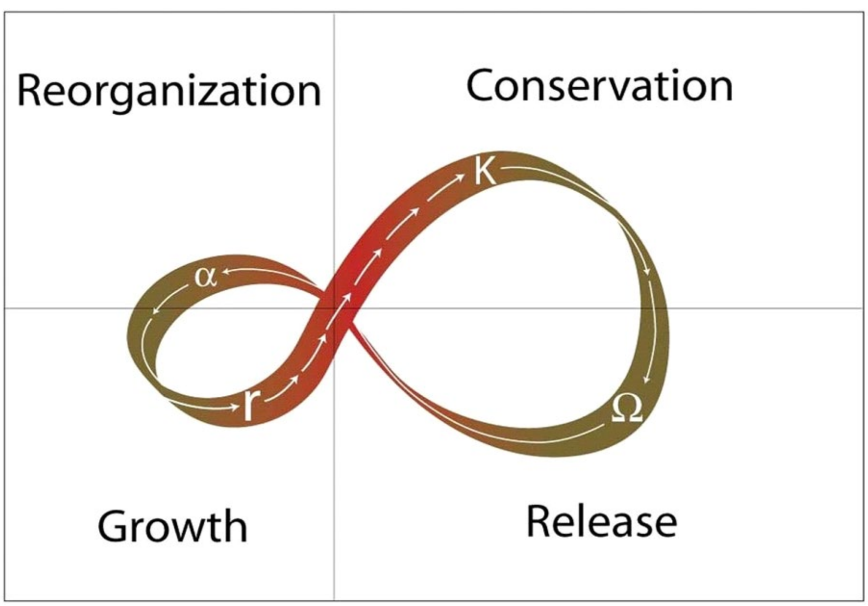

Figure 1. The adaptive cycle. Courtesy A. Garmestani, US EPA.

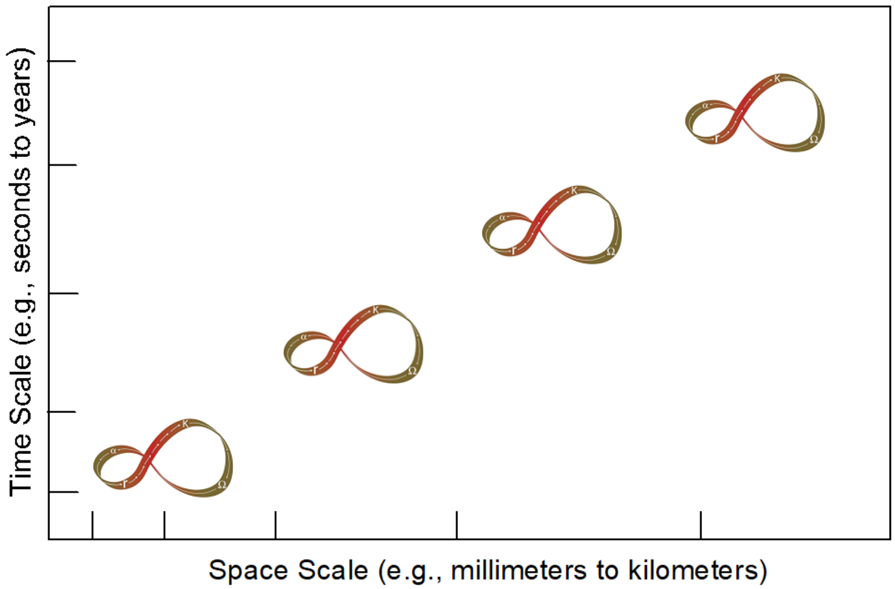

Figure 2. Nested adaptive cycles in a panarchy. Adapted from A. Garmestani. US EPA.

If two systems' structure and processes occur at the same temporal or spatial scale, then they are at the same scale of the panarchy (Holling et al. 2002). However, this does not mean system effects only travel one way (from large scales at the top to small scales at the bottom). Instead, influence can travel from top to bottom, or from bottom to top since self-organized, smaller scales also affect larger scales (Holling et al. 2002). Panarchy theory's ability to examine the interactions of adaptive cycles at multiple scales is what makes it so useful when assessing a system's ecological resilience. Recall that adaptive cycles in the late K stage may have little resilience (Allen et al. 2014). A system may experience a disturbance it cannot absorb, triggering an Ω-stage collapse. Panarchy theory allows us to assess how one system's collapse will influence – and be influenced by – other systems that the collapsed system interacts with.

You will notice that the concept of adaptive cycles is core to this module. They are covered in greater detail in their own module, which will be helpful reading prior to tackling the concept of panarchy. However, this module will also provide a brief recap of these ideas. Do not worry if the above description of panarchy is a bit confusing as the core components will be broken down in the description next.

Description - What are the Details?

A Brief Recap of the Adaptive Cycle (Taken From the "Adaptive Cycle" Module)

The adaptive cycle is a conceptual model that can help us understand the structure and processes of complex system dynamics over time (Holling 1992, Gunderson et al. 1995, Carpenter et al. 2001). It consists of four "phases" where the system acts in a distinct way to either structure, collapse, or reorganize itself. Some helpful examples to illustrate this 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.

The adaptive cycle illustrates how systems can, after collapse, reorganize into a system with either similar or different structures and processes. 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). Please see the "Adaptive Cycle" module for more in depth information on each of these phases and the application of the adaptive cycle itself in management.

Panarchy

However, the adaptive cycle does not stand alone in practice. Every adaptive cycle, and the system that it describes, is linked to cycles above and below the cycle in scale (Figure 3). These scales include both space and time. For example, an adaptive cycle that describes the cyclical nature of a forest that goes through periods of growth, prolonged stability, collapse through fire, and reorganization is then linked to the cycles above and below the forest scale in space. These include smaller patches of forest that may be of one particular species and the surrounding landscape beyond the forest that may include grasslands or even human habitations. Even the examples above, of the collapse of ancient cities, are linked to adaptive cycles in the scales above and below the cities including particular market sectors and the overall climatology of a region. This is panarchy.

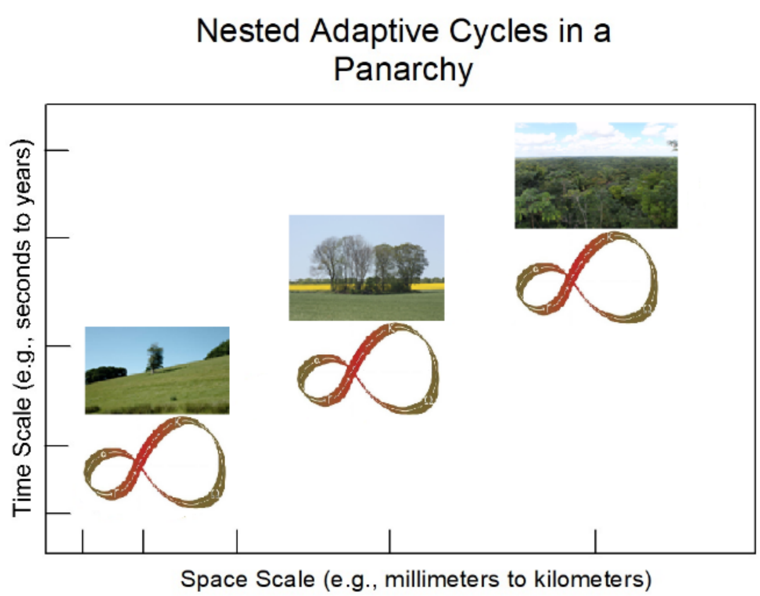

Figure 3. Individual trees, tree patches, and wide forests operate at different spatial and temporal scales. Images courtesy Wikimedia.org.

Federal governments also illustrate panarchy theory. In a country with a federal system, the national government does not hold all of the power, but instead shares it with regional and/or local governments. As a result, small-scale local governments such as counties and cities may make decisions which aggregate to influence nationwide policy. The large-scale national government also makes decisions which in turn may affect local governments. In the middle may be a regional scale such as states and provinces, whose decisions travel down to affect local scales or travel up to affect national ones.

Panarchy Transitions

Panarchy theory has important implications for ecological resilience, because it shows the adaptive cycle does not occur in isolation. The connections among different systems undergoing the adaptive cycle means the resilience of one system is influenced by the systems it is connected to. Panarchies themselves, featuring multiple systems, are not static but instead change as system processes and structures at different scales in the panarchy move through the adaptive cycle (Holling et al. 2002). This change can come about through two pathways. The first is when one scale enters the omega ("Ω", release or collapse) phase and collapses. In essence, the system components can no longer interact with each other the way they did before. The collapse causes the larger, slower scale or scales above it to experience a crisis. The second pathway is when a system undergoes a collapse and larger and slower scales above it influence how that system reorganizes

Pathway 1: Revolt

Revolt is the first pathway for change as fast and small events accumulate and overwhelm large and slow ones (Holling et al. 2002). Essentially, processes and structures at lower scales overthrow those at higher scales, which may lead to new processes and structures at those higher scales. Higher scales are particularly vulnerable if they are at the "K" (energy conservation) phase, which is more rigid, less adaptable, and less resilient than other phases. An example of revolt is a social revolution, when groups of individuals organizing at smaller scales overwhelm and change a larger scale, such as a national policy or even the governance system of an entire country. An ecology example would be the introduction of one or more invasive species that may live out their lives on a smaller scale, but the disruption to established processes may affect the functioning of an entire ecosystem.

Pathway 2: Remember

Remember is the second potential pathway within a panarchy. When a scale enters the omega phase and collapses, instead of a revolt, the renewal phase of the scale organizes according to the structure and processes of the larger and slower scale above it (Holling et al. 2002). The higher scale retains institutional memory of the previous structures and processes, and the lower scale uses that memory to create a similar system to what existed at that same scale in the past. An example for remember is a patch in a large forest that has recently burned. The surrounding unburned forest exhibits pressure on the burned patch to return to the prior state as forest species re-enter and re-organize the patch. In practice, this "pressure" that the unburned forest is exhibiting can be as simple as the presence of seeds of the same species of tree that lead the newly burned patch to "reorganize" or regrow as a forest similar in species composition to the surrounding larger scale forest. Both revolt and remember can be seen in Figure 4 as the arrows that connect adaptive cycles at different scales within the panarchy.

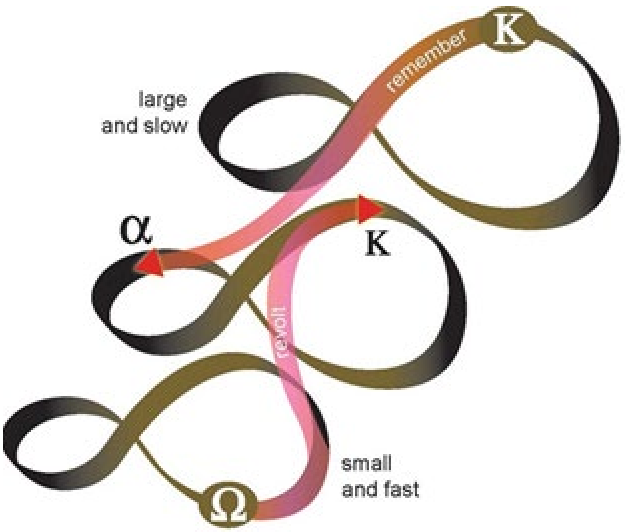

Figure 4. Adaptive Cycle Relationships in a Panarchy. Courtesy A. Garmestani, US EPA.

Panarchy in Management - How Can You Utilize This Concept?

Panarchy theory can provide a method for understanding how complex systems organize and interact with each other (Allen et al. 2014). For example, in ecology panarchy theory has been used to examine regime shifts (see the "Alternative State Theory & Regime Shifts" module) (Angeler et al. 2011) and to determine components of systems necessary for ecological resilience (Gunderson 2010). Panarchy has also been used to examine economic and governance systems (Garmestani et al. 2009), such as by assessing patterns in the size of companies (Garmestani et al. 2006). Ultimately, panarchy provides a way to conceptualize the interaction of complex systems at multiple scales and apply it to a wide variety of fields.

Example - Federal Systems

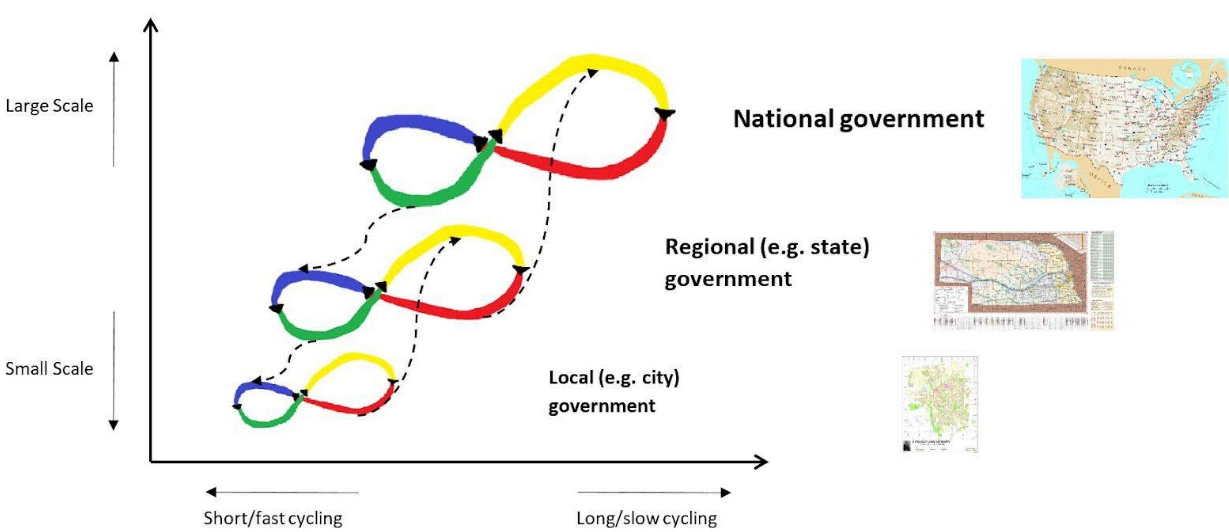

Figure 5. An illustration of the federal systems panarchy. Image created by members of the Council For Resilience Education. "Map of Lincoln, Nebraska streets and features" by the Government of Lincoln, Nebraska is in the public domain. “Official Map - Nebraska State Highway System (2011 - front).” by the State of Nebraska Department of Roads is in the public domain. "US map - geographic" by the US Department of the Interior in the public domain.

While much of the work surrounding panarchy and the adaptive cycle has focused on ecology and natural systems, these concepts are just as applicable to social systems (Figure 5). Take governments as an example. A federal government system is one that divides power among institutions at different scales, unlike a unitary system, which concentrates power in one central government. In North America alone, Canada, Mexico, and the United States are all examples of federal systems. Each of these countries has a national government with a regular election cycle that makes decisions affecting the country as a whole. National governments allow the country to address issues with broad spatial and temporal scales, from acid rain to cross-country transportation. Each country also has regional governments in the form of provinces or states. These regional governments operate quasi-independently of the national government, as they have their own separately elected representatives who pass laws reflecting regional issues and citizen concerns. Finally, at small scales there are local governments such as cities, counties, towns, and villages. These local governments are elected from the surrounding community and are focused on the small-scale issues of the immediate area.

Critical to panarchy theory is the idea that nested adaptive cycles can exert influence on each other. Like any panarchy, in federal systems the fast-and-small governments at the local scale can exert pressure at the regional or even national scale if the changing needs of their citizens demands it. Similarly, policies set at the national scale will influence decisions at the regional and local scale, and regional policies will influence decisions at the local scale. These are examples of both bottom-up and top-down control, concepts that are explored in the panarchy module.

As we have just mentioned, panarchy is a series of nested adaptive cycles. National, regional, and local governments conform to these cyclic patterns in many ways, including through their elections. Government systems may also collapse, or proceed through the the “Ω” (release or collapse) phase due to a variety of perturbations, including protests and other forms of civil unrest. Depending at what scale at which these perturbations occur, bottom-up or top-down ripple effects may occur. In this way, small forms of civil unrest at the scale of a local government may have the potential to influence the stability of a national government. This is one application of panarchy theory in real life, influencing everything from national policies on conservation or trade all the way to coup d'etats.

Quiz Questions

Question

Panarchy theory was developed to explain:

A. how systems function and interact across scales
B. the ability of a system to absorb disturbance without shifting to an alternate state
C. non-uniformity at a particular scale
D. undesirable change at a particular scale

Question

"Remember" is the panarchy transition pathway where the lower scale uses the higher scale's memory of prior structure and processes to create a similar system to what existed at the lower scale in the past.

A. True
B. False

Question

Which of the following is an example of the "remember" panarchy transition pathway?

A. Like-minded local community leaders get the national government to agree to a change in policy
B. A combination of fire suppression and tree planting flips a grassland ecosystem to a forest
C. After a tornado, species from unaffected surrounding wetlands move into a devastated wetland area
D. A national government is replaced by a new national government formed by an opposing party

Question

While useful for assessing ecosystems and governance structures, the complexities inherent in fields like economics prevent panarchy theory from being used effectively.

A. True
B. False

References and Further Readings

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Further Reading

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Glossary

Adaptive Cycle

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

Ecological Resilience

The capacity of a system to withstand disturbances without altering established processes, functions, and structures. This concept can be applied to other systems such as economies, governments, or companies, despite the term “ecological”.

Hierarchy

Method of structural organization where influence only travels from the top scale through middle scales (if any) to the bottom scale.

Panarchy

A nested set of adaptive cycles. Unlike in a hierarchy, influence comes not just from the top down but also from the bottom up.

Remember

Pathway in a panarchy that occurs when the renewal phase of the scale organizes according to the structure and processes of the larger and slower scale above it.

Revolt

Pathway in a panarchy that occurs when events at fast and small scales accumulate and overwhelm structures at large and slow scales.

System

A whole made up of interacting components.