1 Resilience

Resilience theory provides a framework to better understand the complex and unpredictable nature of environmental and socio-economic systems.

Stabilising forces inherent within natural systems allow them to react and recover a state of equilibrium in the face of external shocks and stressors. In resilient systems, these stabilising forces maintain system productivity through feedback cycles, resulting in self-organising, self-managing environments that are able to effectively absorb and recover from shocks and stressors.

Conversely, destabilising forces (known as shock and stressors) are important in maintaining diversity, resilience and opportunity within natural systems. The interplay between stabilising and destabilising forces within a system lies not only at the heart of its resilience but also its productive capacity. Maintaining system resilience is therefore essential for maintaining the health and longevity of ecological and socio-economic systems.

Previous philosophies applied to NRM in Western Australia tended to view natural resources as fixed assets contained within predictable and manageable systems. This led to the development of fixed targets and the application of predetermined actions, resulting in an inflexible management response generally inconsistent with the unpredictable, complex self-organising nature of the systems being managed.

1.1 Definition

Although resilience is rapidly becoming a popularised and politicised term used to describe a desirable but non-specific goal or system outcome, resilience actually has a very specific meaning. As described by Walker et al. (2004), resilience is:

> *…. the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks mechanisms.*

An alternate definition is:

> *A measure of the inertia, resistance, flexibility and capacity for self-repair of a system in maintaining its essential structure and function, when faced with stressors and/or external shocks.*

In the context of a social community, resilience is (Longstaff et al. 2010):

> *The ability of the community facing adversity or external shocks and pressures to establish, maintain or regain an expected (satisfactory) structure and range of functions, when compared to the pre-stressor function.*

1.2 Properties of Resilience

Resilience theory can only be sensibly considered in relation to a stressor or shock; in other words, what is the system resilient to? In reality a system will be more or less resilient to some stressors than others, depending on its composition, history and current state of organisation.

Systems may rely entirely upon shocks or stressors for regeneration. An example of this is the scrubland heath within the Avon River Basin: this complex and diverse ecosystem can only regenerate in the presence of fire, as a result of an evolutionary history of frequent wildfire.

Natural systems are comprised of two core attributes or processes, which interact to determine the relative resilience of that system. They are:

- ***Resistance:*** *the magnitude of the force (disturbance) required to causes a change in structure and function, or alternatively the capacity of the system to absorb or resist the force of change*
- ***Capacity to recover*** *(flexibility and ability to self-repair): the capacity to return to the original state of operation and/or structure* (Stone 1996).

Natural systems utilise these attributes in different ways to maintain resilience, depending on the nature of the system and shocks and stressors encountered. Some systems are very robust, displaying a high degree of resistance to change, whilst other systems are more flexible and dynamic and rely on their capacity to recover from external stocks and stressors.

The extent of *resistance* (resource robustness) and *capacity to recover* (adaptive capacity) of a system is further defined by a series of underlying attributes (Longstaff et al. 2010) (refer Figure 1).

Resistance (Resource Robustness)

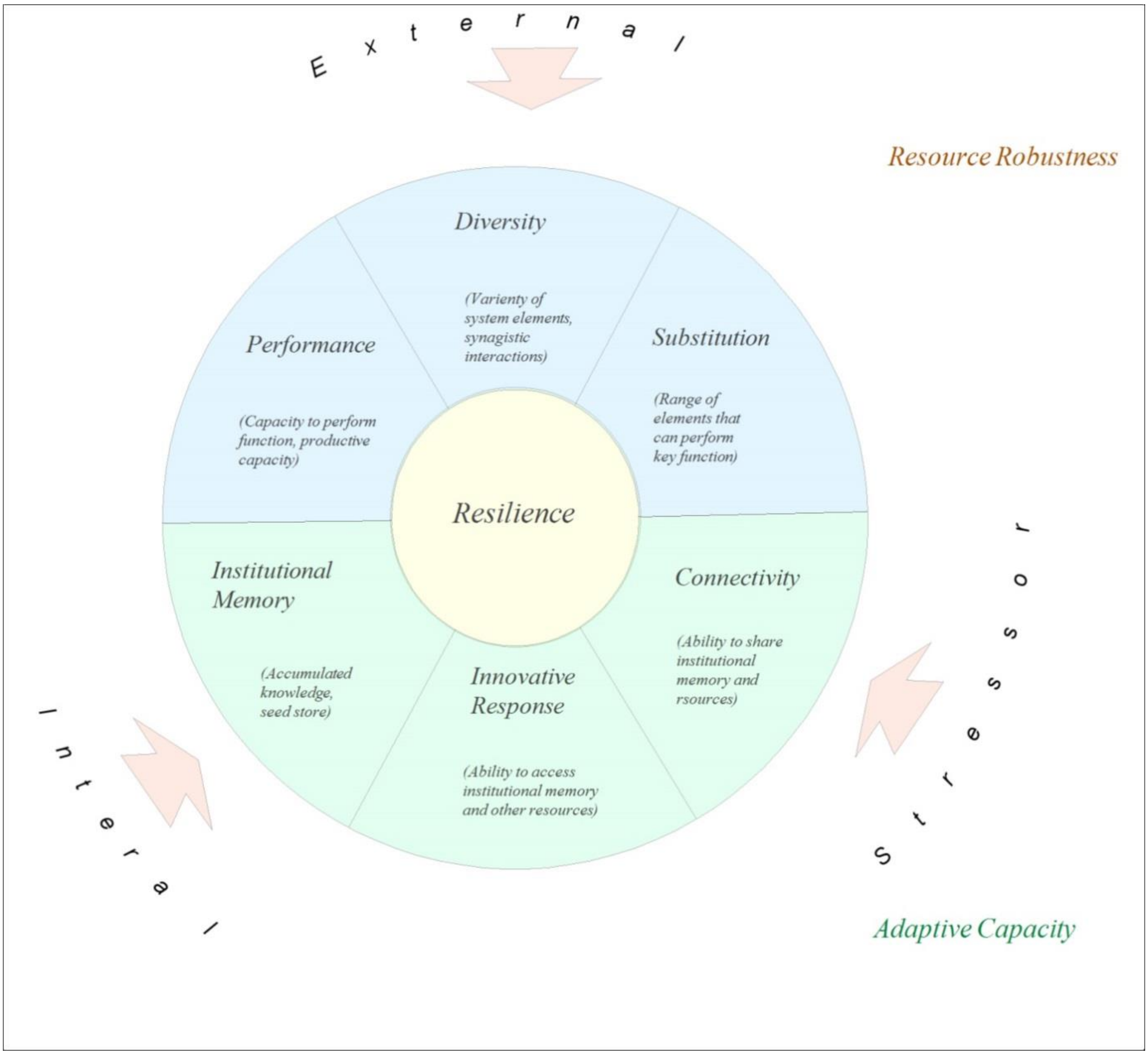
- ***Performance:*** *the capacity and quality of components or elements of a system in performing their role. Stressors impacting a system may result in individual elements of the system becoming more or less capable of fulfilling their function or role. Stressors may present strong selective pressures, causing individuals with particular traits to outperform and displace less fit individuals through the process of natural selection.*
- ***Diversity:*** *different types of available resources that perform various functions, underlying the extent of synergistic interactions between elements within the system. Systems subject to a variety of natural stressors may display a high degree of diversity. Conversely, an overriding primary stressor may result in less diversity, reducing system resilience to new or emerging stressors and shocks.*
- ***Redundancy:*** *the range or extent of resource elements that can perform key functions. The fail-safe capacity of a system to cover for losses of individual components within the system. Reduced redundancy may occur within a system subjected to severe, emerging or ongoing stressors, potentially reducing its capacity to absorb further stressors.*

Recovery (Adaptive Capacity)

- ***Institutional Memory:*** *the accumulated knowledge or experience of the community, the knowledge and/or genetic material contained within the system. Alternatively, institutional memory may consist of the reserves held within the system. Increased frequency or severity of stressors may erode reserves and institutional memory, impacting the capacity of the system to recover from stressors and shocks*
- ***Innovative Capacity:*** *the capacity of the system or community to use the institutional memory, genetic capacity or other system components to adapt to the altered environment. Acute or cumulative stressors may restrict the capacity of the system to effectively self-organise by reducing innovative capacity*

- ***Connectedness:** the ability of the system to share and transfer resources and institutional memory. The ability of impacted cells within the system to access knowledge and resources from adjacent cells. High levels of fragmentation or poor connectedness can lead to local extinction of knowledge or resources.*

Figure 1. Attributes of Resilience (Adapted from Longstaff et.al. 2010)



(Adapted from Longstaff et.al. 2010)

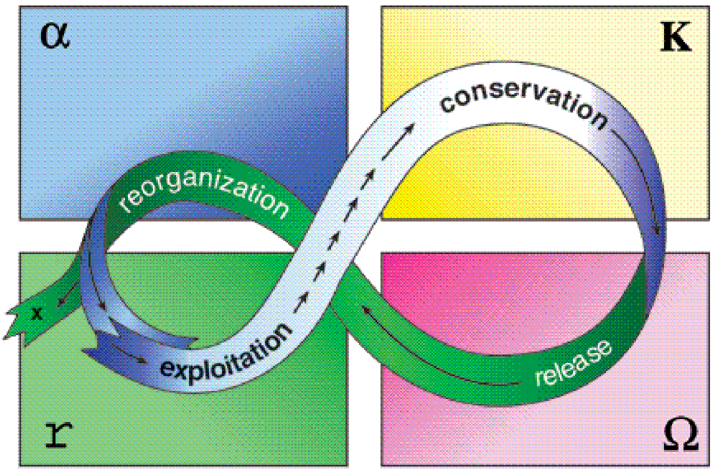
Understanding how cumulative external pressures and stressors influence the underlying attributes of resilience provides insight into appropriate management responses, which generally should be aimed at improving system resilience to key shocks and stressors.

1.3 The Resilience Cycle

The “adaptive cycle” that governs many natural systems consists of four interlinked phases (refer Figure 2).

- ***Growth / exploitation phase.*** This follows a period of reorganisation and is typified by opportunities to exploit vacant niches and unused resources, with much of the potential energy of the system available for exploitation. As the name suggests, this phase is associated with an increase in energy within the system and can be unpredictable in nature
- ***Conservation phase.*** Once niches have been filled and resources largely utilised, the system becomes relatively stable and more predictable with most of the available energy contained within the system itself. During this phase the system generally becomes less flexible and responsive to external shocks
- ***Release phase.*** Characterised by a chaotic release or collapse, the system eventually succumbs to internal and/or external influences in the form of cumulative stressors or specific shocks. This phase is characterised be a sudden release of energy, entering a phase of chaos and unpredictability
- ***Reorganisation***. The release phase rapidly gives way to a period of reorganisation (which may be rapid or slow depending on the nature of the system) during which innovation and new opportunities exist. This phase is unpredictable and the outcome of reorganisation depends on the underlying resilience of the system and the nature of stressors and/or shocks. The system may flip over into an alternate operating state if the limits of resilience are exceeded (Walker et al. 2004).

Figure 2. Resilience Cycle



(Walker et. al. 2004)

Depending on the robustness of the resources within the system and its adaptive capacity, and the nature of the cumulative stressors and shocks, the system may reorganise into a structure and function different from that which previously existed. In other words, the system may transition to a new or different state of operation if the resilience of the system is exceeded. Typically, it is during the reorganisation phases, and to a lesser extent the growth phase, that the most significant influences over the fate of a system occur (Walker et. al. 2004).

Understanding where the system is in the cycle, the nature and extent of stressors and shocks, and the likelihood of release and reorganisation are critical in understanding how to positively influence the system. For instance, applying remedies or pressures during the conservation phase may have very little influence on the overall resilience of the system, unless designed to specifically relieve impacts of identified critical stressors or to arm the system against specific impending shocks.

Application of multiple stressors may result in complex and unpredictable system responses, as the system will respond to new and emerging stressors differently at different stages of the resilience cycle. For instance, a period of drought or unexpectedly high grazing pressure during the recovery phase following bush fire may result in an ecosystem being dominated by a few particularly resilient individual species. It may also result in an empty niche awaiting colonisation by volunteer species.

1.4 Summary

Resilience recognises the importance of self-regulation and the inherent unpredictability of natural systems. Resilience analysis is intended to lead to strategies designed to prepare or arm natural systems to be better able to self-organise in the face of mounting shocks and stressors and recognises the natural cycles inherent within natural systems.

Resilience should be considered within the context of particular stressors or external shocks, and a process for understanding the interaction between multiple or cumulative shocks and stressors is essential. Cumulative stressors may feed off one another, resulting in impacts greater than the sum of the individual stressors, and there are often significant lag times between when stressors are introduced and when the impacts become apparent.

Resilience assessment must consider several questions:

- *What particular attributes of the system are advantageous or essential to its structure and function?*
- *What are the key aspects of the socio-economic and natural resource systems that are central to the well-being and quality of life of the communities which inhabit them?*
- *What shocks or stressors are we testing the system against?*
- *What are the specific system components that we are testing resilience to?*

Understanding the underlying attribute of resilience and the cyclical nature of natural systems is essential in determining where and when effective action can be taken to achieve desired outcomes.

1.5 References

Longstaff PH, Armstrong NJ, Perrin KA, Parker WM, Hidek M 2010 *Community Resilience: A function of resources and adaptability.* White Paper. Institute for National Security and Counterterrorism, Syracuse University, New York.

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