8. Ecosystem Sustainability and Long-term Species Viability

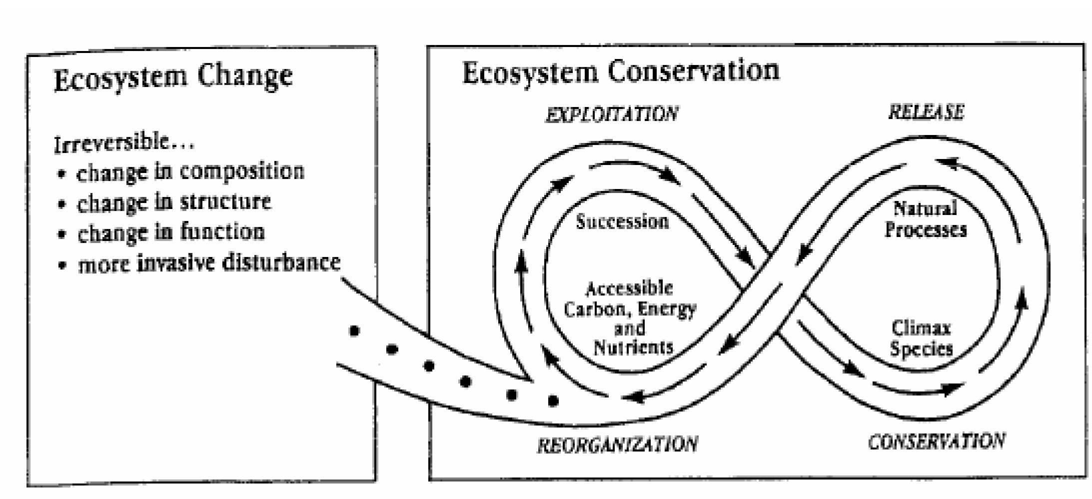
Ecosystem Sustainability

Holling (1992) describes four phases to an ecosystem: 1) reorganization where the amounts of nutrients, carbon, and minerals and the intensity and type of ecological process interact to shape the future (by succession) ecosystem; 2) exploitation where succession begins and accessible nutrients are adsorbed; 3) conservation where climax species store carbon and other important resources; and 4) release of energy, nutrients, carbon, and minerals due to fire, wind through, disease or other factor causing the death of vegetation (Samson and Knopf 1996) (Figure 1).

Understanding an ecosystem cycle is essential to understanding the systems ability to function and provide essential services and to conserve biodiversity element such as species that depend on a particular ecosystem (Allen and Holling 2002).

Altering one of the four stages can lead to a new ecosystem with self-reinforcing properties. An example is the invasion of native sagebrush systems of the Great Basin in the western United States by an exotic species—cheat grass (Anderson and Inouye 2001). Cheat grass out competes native species (reorganization), increases in abundance (exploitation), alters the release of energy (increasing the fire frequency) (conservation) and, rather than returning to the natural ecosystem, exists the ecosystem cycle.

Figure 1. Flow of events including exploitation, conservation, release, and reorganization that describe an ecosystem cycle (after Holling 1992), ecosystem conservation is a natural figure 8. Exit from the cycle at the left leads to ecosystem change and increases in costs to management (Samson and Knopf 1996).



This March 6 2006 version replaces all earlier versions.

Table 23. Representativeness, Redundancy and Resiliency as the evaluation criteria for long-term population viability (after Shaffer et al. 2002).

Principle	Effect	Advantage	Concerns
Representative	Ecological/evolutionary habitat for all native species and reduces factors related to human disturbance.	Promotes population stability and reduces or eliminates negative biotic interactions.	Costs to restore native landscapes are high and increases with time.
Redundancy	Provides multiple examples of native habitat ensuring opportunities for genetic variation and "backup" in terms of habitat in case of native predation or disease.	Promotes stability in populations that exists as subpopulations and ensures habitat is distributed across the landscape.	More homogeneous and well connected landscapes follow suppression of natural processes.
Resiliency	Ensure a full range of seral stages are present on a landscape where all natural processes—large and small—operate within their natural range.	Promotes habitat for all species native to a landscape in a pattern consistent with life history requirements for all native species.	Ecosystems are no longer resilient causing loss of ecosystem elements and more extensive and invasive ecological processes.

An exit from the ecosystem cycle is evident in changes, most often irreversible, in ecosystem composition, structure, function, and in patterns in ecological processes (Figure 1). Cheat grass in the Great Basin of the United States has created an annual-based ecosystem versus the historic and relatively long-lived shrub-based ecosystem (Anderson and Inouye 2001). Without very large investments to restore native species and ecological processes, cheat grass will become more extensive and will continue to further create a self-reinforcing ecosystem (or a new "figure 8"). This new ecosystem will have habitats unlike any suitable for species that evolved within the historic Great Basin.

Many forests of the Rocky Mountains are either at the transition from ecosystem conservation to ecosystem change (Figure 1) or have shifted to a new and self-reinforcing pattern of ecological processes. As compared to historic, large fires lead to large patches of similarly aged trees, that

Table 24. Habitat conditions on the basis for long-term viability in the USDA Forest in the USDA Forest Service Northern Region for the goshawk, black-backed woodpecker, flammulated owl, and pileated woodpecker using the three R's.

Principle	Goshawk	Black-backed woodpecker	Flammulated owl	Pileated woodpecker
Representativeness	Low	Low	Low	Low
Redundancy	Low	Low	Low	Low
Resiliency	Low	Low	Low	Low

at some point, collectively are vulnerable to fire. Large insect outbreaks create stands similar in age, which in turn, reach a future point when stands due to age collectively will be vulnerable to another large insect outbreak, a self-reinforcing pattern.

Table 24 summarizes habitat conditions using the three R's (Table 23) as the basis for *long-term* viability for the goshawk, black-backed woodpecker, flammulated owl, and pileated woodpecker.

Restoring western forests to a pattern more characteristic of historic is expensive, as indicated by the Healthy Forest Initiative.

Long-term Viability

Long-term viability is closely associated with the habitat in which the species evolved (Hunter et al. 1988). Shaffer et al. (2002) describes this preferred habitat for long-term viability by three ecological and non-statistical concepts—the three R's (Table 23). The expectation is that each of the three R's would be rated as "high" in order to ensure long-term population viability.

For each species (Table 24), the three R's are low due to the following.

- A lack of Representativeness. Major changes since European settlement in grasslands (losses), shrublands (increases) and forest landscape structure (increases in mid-aged forests) and composition (increases in shade tolerant species). Today's landscape is no longer representative in virtually any way to that in which the species evolved.

- A lack of Redundancy. Few examples of the full natural landscape exist and increased areas of intermediate aged forest and increased connectivity of the landscape threatens key remaining elements of biodiversity such as areas of oldgrowth that no longer persist in fire-protected refugia but are embedded in a well-connected matrix of intermediate-aged forest that permits the rapid spread of fire and insect outbreaks with a spatial-temporal pattern unlike historic landscape.

• A lack or Resiliency. Massive landscape changes due to the irreversible historic loss of open grasslands because of the conversion of grasslands to croplands and and due to the increase in intermediate-aged forests because of prior fire suppression in forested systems is leading to further changes (larger and more intense) in ecological processes, which, in turn eliminates the Resiliency of a system operating within its natural range of variation.

Providing for ecosystem sustainability (Figure 1) and the long-term viability for the four species under consideration in this assessment requires a much larger, more widespread and active vegetation management program than evident today.

The need to manage the current (and soon to be irreversible if similar to other ecosystems) changes in the ecosystems of the Northern Rocky Mountains is urgent in that costs to do so will only increase. Environments in which at least 426 vertebrates and a very large number of lesser known taxa will continue to depart from that which influenced their evolution (see Arnaiz-Villena et al. 2001 for how evolution at the subspecific level is possible since the last glacial advance suggesting historic habitats although variable are important).

9. Summary[1]

• Ecosystems partially under the management of the Northern Region of the Forest Service have undergone profound changes since European settlement. Native prairies in North Dakota, South Dakota and Montana have declined in area (Samson and Knopf 1994, Samson and Knopf 1996) and are highly fragmented and exist in a matrix of agricultural and other lands (Samson et al. 2004). In sharp contrast, area of forest in North Dakota, South Dakota, Montana and Idaho has increased in area and connectivity is at an all-time high at least since 1800 (Hessburg and Agree 2003, Hessburg et al. 2004). The prairies and forests do share three characteristics: 1) a relative decline in relative extent of early and late stages of vegetation succession; 2) sharp increases in the mid successional stage vegetation (Knopf and Samson 1997, Hessburg and Agee 2003); and 3) increasing threats due to species not native to an ecosystem (Knopf and Samson 1997, Hanauska et al. 2003 and others).

• Viability is not yet a mature science (Samson 2002) and should be principle based (Beissinger and Westphal 1998, Beissinger 2002, Ralls et al. 2002, Shaffer 2002) until long-term demographic information is available permitting more quantitative approaches.

• The National Forest Management Act (1976) requires that a diversity of plant and animals be maintained. The four species considered in this conservation assessment are not at risk and habitat for each has increased since the arrival of Europeans—short-term viability is neither an issue or concern.

• The most urgent issue is to restore the sustainability of the grassland and forested ecosystems to a condition more like historic (Pre-European)—therefore provide for the long-term viability of the four species considered in this assessment as well as all 426 vertebrates. This will require a very aggressive program in vegetation management.

[1] A detailed assessment of short- and long-term viability for the Idaho Panhandle National Forests in included in Appendix 9.