

Using prescribed fire to restore evolutionary processes at Ozark National Scenic Riverways

The case of the collared lizard

By Angela R. Smith, summarizing the research of Alan R. Templeton

“Earth’s biodiversity is the product of past evolution, and is not, nor has it ever been, static. Hence, conservation programs should try to preserve processes (such as evolution) that affect living organisms and ecosystems rather than conserving the current status quo of the living world.”

—Alan Templeton

At its most basic level, the National Park Service (NPS) mission is to protect and preserve resources. Yet meaningful assessment of our success in this broad mandate can be difficult. In parks set aside to preserve exceptional natural resources, aspects such as water quality, species diversity, and natural processes will inevitably be part of the “protection and preservation” yardstick. But managers must also consider other issues when implementing the NPS mission. For example, on a global scale, human activities are causing massive impacts on biodiversity at the ecosystem, community, species, and genetic levels. Though impacts on species diversity are often more obvious and thus receive more human attention, impacts on *genetic* diversity affect the very foundation of all the other levels.



Gene flow—a natural process

The importance of genetic diversity cannot be overstated. Without it, a population cannot evolve and adapt to environmental change. Given the rate at which environmental change is occurring worldwide, the ability to adapt to new conditions has been and will become critical for many species. *Genetic drift* is the random loss of a population's genetic variation. Genetic drift is greatly accentuated when local populations are isolated from one another and are small in size: genetic variation decreases within each local population as individuals become more genetically similar to each other. In this instance, genetic *differentiation* increases between isolated populations; that is, Colony A will become genetically different from Colony

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B if the colonies do not have access to each other. Genetic drift and isolation can prevent the spread of adaptive characteristics outside of the population of origin, which disrupts the evolutionary and speciation process (Templeton et al. 2001).

Conversely, *gene flow* occurs when Colonies A, B, and C all have access to each other. In this case, genetic variation within a single population (Colony A, for example) will increase, but overall, all three colonies will become more genetically

Gene flow helps populations to evolve and adapt to changing conditions.

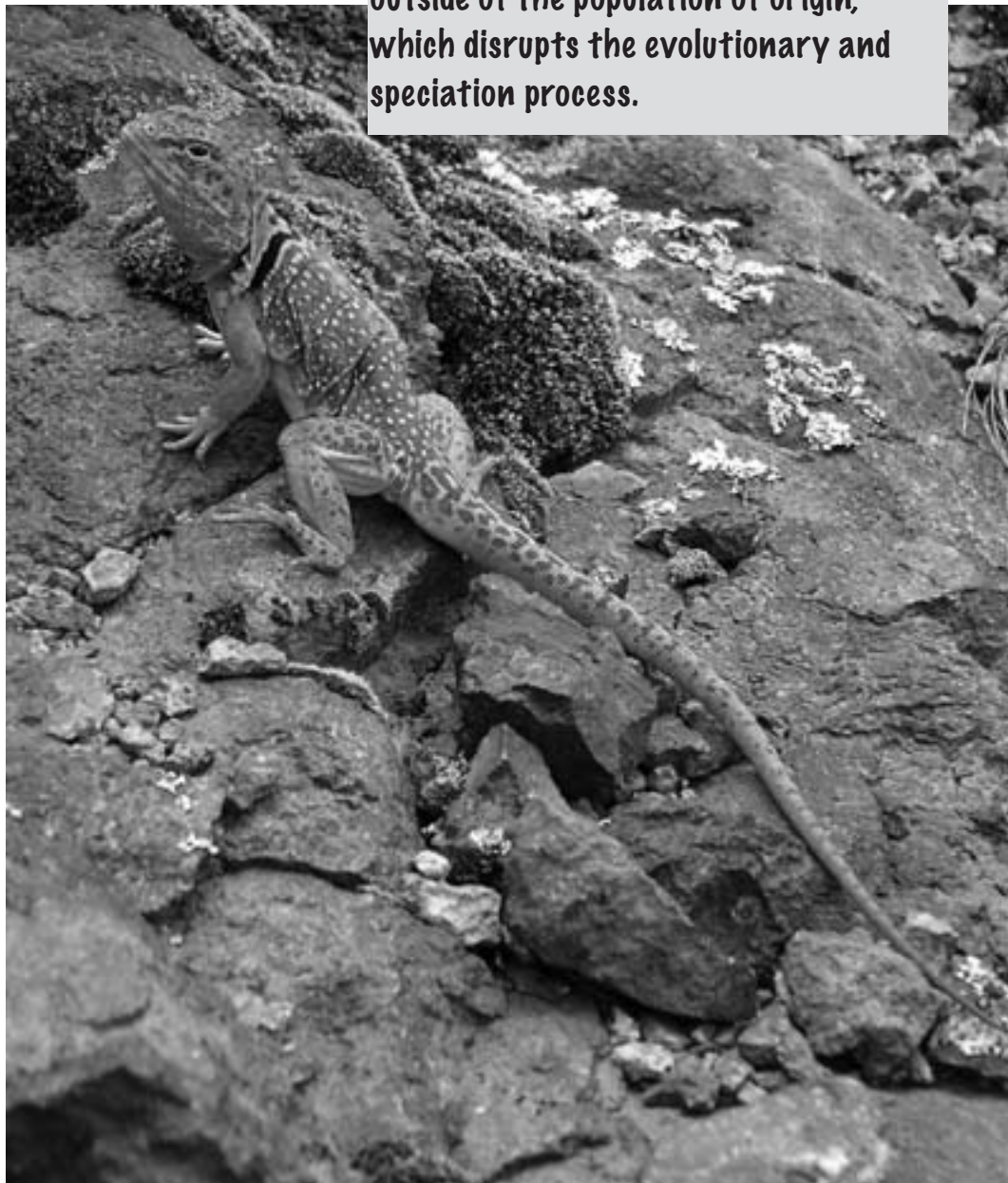
ly similar. Gene flow also allows new mutations (the source of genetic variation) to spread from their population of origin to other populations. By increasing local variation and allowing that variation to spread, gene flow helps populations to evolve and adapt to changing conditions.

Decline of the collared lizard

One illustration of genetic isolation and possible management responses can be found in and around Missouri's Ozark National Scenic Riverways. Ongoing research is revealing a fascinating example of successful species protection and preservation through managed restoration of a natural process: fire. The story begins with habitat loss and the collared lizard.

The male collared lizard is spectacular to behold (fig. 1). At 8–14 inches (20–35 cm) in length, it is relatively large and brightly colored, and its turquoise or green legs and orange throat overshadow the female's brown and usually smaller body. Two brown or black lines across the necks of both female and male collared lizards (see fig. 1) gave rise to their popular and scientific names (*Crotaphytus collaris collaris*).

Figure 1. Collared lizards are recovering in the Ozark National Scenic Riverways area thanks to a prescribed burning program that reduces thick underbrush in the forest, allowing the reptiles to disperse and colonize new glades. Colonies are no longer as isolated from one another and gene flow among them is on the rise. ALAN R. TEMPLETON



Missouri is at the eastern edge of collared lizard range. These animals prefer desertlike habitat and are more commonly found in the Southwest and Great Basin. In Missouri, collared lizards occupy glades, which are open areas with thin, rocky soil, usually on south- or southwest-facing slopes (fig. 2). The hot and dry microclimates within glades provide habitat for an important diversity of desert-adapted plants and animals (Nelson and Ladd 1981).

Glades were once maintained by fire. Whether natural in origin or set by Native Americans, fire often swept through the Missouri Ozarks, keeping the woodlands open and grassy (Anderson and Bowles 1999). Tree-ring studies at Ozark National Scenic Riverways indicate that between 1640 and 1800 fire occurred approximately every five years (Guyette and McGinnes 1987). When European settlers arrived, they commonly harvested the woodlands and eventually implemented fire suppression measures. Deprived of fire, the once-abundant glades began to diminish in area and number and were replaced by forest that was much denser (fig. 3). Where collared lizards had formerly moved freely from one glade to another, they began to be limited to their original colonies



Figure 2. Ozark glades are typified by thin, rocky soil and are usually located on south- or southwest-facing slopes, resulting in hot, dry microclimates that suit collared lizards. Fire suppression on adjacent forest tracts had prevented the species from dispersing and colonizing glade habitat. A prescribed fire program has reversed the declining trend in collared lizard numbers. ALAN R. TEMPLETON

because they could not locate new habitat through the dense underbrush.

Eastern red cedar (*Juniperus virginiana*), which had been controlled by fire, began to invade the glades, and in

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turn allowed successional invasion by other woody species. With reduced habitat and isolated colonies, collared lizard populations declined. Without the ability to interact with other collared lizard groups, genetic diversity was diminished and long-term survival of the collared lizard was threatened.

A genetics study confirms this connection between habitat change

and genetic drift. Using molecular markers called microsatellite loci, researchers compared genetic variation among collared lizards in the vicinity of Ozark National Scenic Riverways and the Southwest. Their analysis revealed a very unusual pattern. In the past, collared lizards in the northeastern Ozarks shared the same genetic variants, a pattern indicating much gene flow, but in a matter of decades the populations became fragmented and gene flow halted (Hutchison and Templeton

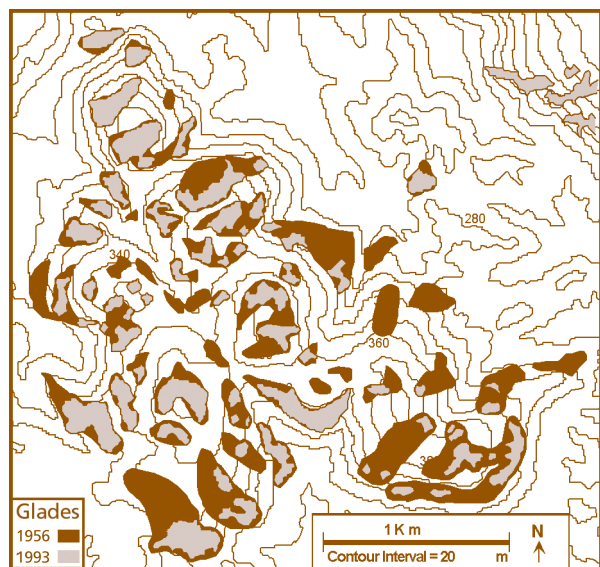


Figure 3. Decline in glade habitat in the Stegall Mountain Natural Area from 1956 to 1993. A prescribed fire program was implemented to manage natural communities and increase glade habitat. ALAN R. TEMPLETON

1999). Over this relatively short period most genetic variation among collared lizards living in any single glade was lost; genetic variation among all glades, however, was retained (a pattern typical of genetic drift). Hence, genetic variation in the Ozarks as a whole was high, but no single collared lizard population had access to it.

Prescribed fire

By the 1980s, no known populations of collared lizards existed within a 50-mile (80 km) radius of Ozark National Scenic Riverways or Stegall Mountain Natural Area, which is jointly owned and managed by the Missouri Department of Conservation, The Nature Conservancy, and the National Park Service. Between 1984 and 1989 Dr. Alan Templeton of Washington University in St. Louis and the Missouri Department of Conservation implemented a program to increase collared lizard numbers in the area. The initial effort involved translocating three populations of collared lizards that were living in threatened habitat. Twenty-eight adult lizards were translocated to three glades in three releases (one per glade) from 1984 to 1989: 10 on each of two glades and 8 on the third. All of the lizards survived but they did not colonize other available glades in the area, one of which was only approximately 200 feet (60 m) away. Monitoring by Templeton indicated that each of the translocated populations rapidly lost about half of its initial genetic variation—though a different, random subset—which mimicked the pattern discerned in the 1999 collared lizard genetics study. Land management of the Stegall Mountain Natural Area included a fire suppression policy, which remained in effect through 1993. Monitoring over this period revealed no dispersal or colonization of the nearby glades and, thus, no genetic exchange (Templeton et al. 2001).

In 1994, after a Biodiversity Task Force recommended the use of managed fire on a landscape level, the Missouri Department of Conservation and the National Park Service began a prescribed fire program at Stegall Mountain. The first unit planned for treatment was partially burned in 1994 and completely burned in 1996. In 1997, a second unit to the south of the first was also burned, and by 1999 about 5,000 acres (2,025 ha) of the Stegall Mountain area had been treated with prescribed fire.

Results

The effect was dramatic. Vegetation monitoring revealed significant thinning of the understory, despite little change in the canopy trees (fig. 4). Monitoring of vegetation transects revealed a reduction in sapling density from approximately 1,000 per acre (405/ha) prior to the burn to 600 per acre (243/ha) after the burn (Nigh 2004). For the collared lizards, interglade dispersal went from undetectable before 1994 to being common in the areas that were burned. Since burning, 35.6% of the juveniles (both sexes), 40.8% of adult males, and 8.1% of adult females have dispersed to nearby, uninhabited glades (Templeton 2001). Marked impacts on



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Figure 4. Comparison of a glade before (1994, top) and after (2004, bottom) prescribed burning. After fire was introduced, understory vegetation became thinner, allowing collared lizards to disperse and begin to colonize nearby glades.



colonization were also evident. For 10 years, no glades had been colonized by lizards in the study area until the prescribed fire of 1994. However, over the next three years 13 glades were colonized. Twelve of the colonized glades were in the burn area and one was unburned. Interestingly, the unburned glade had been part of a mechanical thinning project conducted by the Missouri Department of Conservation in anticipation of extending the burn area to include the glade. During the winter of 1996–1997, workers cut much of the woody vegetation that separated the two fragments of what was formerly a single glade. Although the collared lizard population on the original glade was very dense, the lizards had not colonized the nearby fragment between 1989 and 1996; however, they did so immediately after the mechanical thinning. (The mechanically thinned area was also burned making the effects of one treatment indistinguishable from the other.) Apparently, the ability of collared lizards to disperse among and colonize glades depends strongly on the intervening forest structure, particularly the understory. In the nine years prior to prescribed fire

restoration, no glades had been colonized naturally. Yet by 2003, nine years after prescribed fire, 51 new glades had been colonized with collared lizards (fig. 5) (Washington University, A. R. Templeton, professor of biology, personal communication, 13 September 2006).

There are at least two possible explanations for the apparent inability of collared lizards to disperse through thick underbrush. One is that as visual predators, the lizards were reluctant to move into territory that restricted their field of vision. Also, most long-distance dispersal takes place by hatchlings, which have low food reserves (fig. 6). A sampling of the insects on which they normally feed indicates an abundance of the food source in burned forest, while in unburned areas the insects were virtually absent. Hence they may avoid unburned areas because of the lack of significant food sources (Washington University, A. R. Templeton, professor of biology, personal communication, 8 January 2007).

Remarkable increases in population numbers also occurred following the prescribed fire treatments. The original translocation population had consisted of 28 animals in three releases, but by 2003, 276 collared lizards—nearly 10 times the original release—were documented through mark-recapture techniques on Stegall Mountain. Interestingly, lizards in the newer, mostly unoccupied habitats demonstrated a surprising colonizing ability by having two clutches in 2002 rather than the normal single clutch. Thus, each female in the newly colonized and low-population-density glades was able to have 12–16 offspring. Moreover, the growth rates of these offspring were 1.5 to 2 times the rates estimated from saturated habitats. As a result, many of the hatchlings were of adult size by the end of September of 2002, a phenomenon not observed before by the researchers (Templeton 2002).

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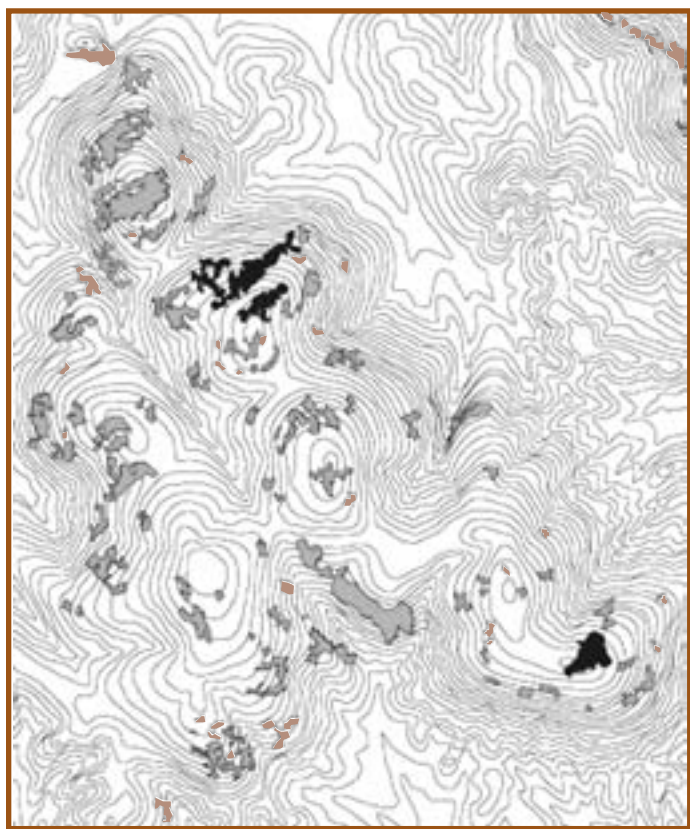


Figure 5. The map shows changes in the occupancy of glades by collared lizards in the Stegall Mountain Natural Area from 1984 to 2003. All glades were unoccupied before the 1984–1989 translocations of collared lizards (black). These three populations remained stable, though their numbers did not increase, and no new glades were colonized by the end of 1993. In the nine years following a series of landscape-scale prescribed burns (1994–2003) collared lizards increased nearly 10-fold, colonizing 51 new glades (gray). Glades still uncolonized in 2003 are shown in light brown. ALAN R. TEMPLETON



Figure 6. Dispersal by collared lizard hatchlings may be limited by food availability. Insect prey is abundant in areas treated by prescribed fire but lacking in unburned areas. ALAN R. TEMPLETON

Conclusion

Researchers believe that with appropriate management, a reversal of genetic isolation and population decline is possible with regard to collared lizards. (Ongoing research indicates plant diversity is increasing, and at least one other animal species—a glade grasshopper—is also increasing in number.) Preliminary conclusions note extensive gene flow among the glades and high levels of genetic diversity (Templeton et al. 2001).

Focusing management on a landscape scale and using natural ecological processes to maintain habitat may be a more successful strategy than pursuing individual species conservation. Fire management is an important part of this approach for this species, and with continued use, the collared lizard and other glade and savanna species can be expected to thrive in the Ozark National Scenic Riverways.

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