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ECOLOGICAL SUCCESSION ON A NATURAL AREA IN NORTHEASTERN KANSAS FROM 1948 TO 2006

HENRY S. FITCH

Fitch Natural History Reservation
2060 East 1600 Road
Lawrence, KS 66044, USA

***Abstract.*—Long-term ecological studies provide important information applicable to the conservation, management and restoration of native ecosystems. These studies allow us to observe changes in habitat and the correlated changes in associated amphibian and reptile communities. Research over the last 58 years at the Fitch Natural History Reservation has indicated biotic responses that would likely have been imperceptible over the short-term. New investigators are encouraged to conduct long-term studies and institutions must devise ways to foster these activities.**

Key Words.—long-term research, ecological succession, herpetology

The University of Kansas Natural History Reservation, where I have spent the last 58 years of my life, exemplifies the benefits of long-term studies and the misconceptions that can result from relatively short-term efforts. The Reservation is a 239-hectare area in northeastern Kansas on the eastern edge of the Deciduous Forest Biome and its Oak-Hickory Association (Shelford 1963). Before my arrival in 1948, the tract had been used for grazing of livestock and cultivation of crops, and there were many fenced (barbed wire and rock wall) subdivisions. About half of the area had been devoted to the pasturing of cattle and horses (and sheep at an earlier stage) and consisted of a grass-weed mixture with little arborescent vegetation. After the area was designated as a Natural History Reservation in 1947, anthropogenic disturbance was largely limited to the lab buildings, residence and surrounding lawn, driveway, and scattered trails that were cleared with a machete (Fig. 1A). Domesticated animals, including grazing livestock, were prohibited. Fire was excluded.

The most obvious change on the Reservation since 1948 has been the widespread intrusion of dense woody vegetation (Fig. 1B; Fitch et al. 2001) a well-documented result of suppression of fire and grazing (Heisler et al. 2003; Knapp et al. 1998). My field work was mostly confined to the Reservation in the early years of sampling. Faunal composition changed as originally open areas acquired trees, and snakes became progressively scarcer. As catches dwindled, my responses typically included a shift to new areas for sampling and/or a change in collecting techniques. Diminishing returns, beginning in the late 1980's, encouraged me to shift my efforts to adjacent experimental areas of the University of Kansas (Fitch 2005, 2006), where grazing, burning, and mowing were regularly implemented. The experimental areas generally were in a stage of succession similar to that of the Reservation several decades earlier.

Most parts of the Reservation have undergone progressive change over the past 58 years, each of the areas expressing divergent rates of ecological succession. Least modified are the hilltops and slopes that already had the climax forest species, Chinquapin Oak (*Quercus muehlenbergii*), Black Oak *(Q. velutina*), Bur Oak (*Q. macrocarpa*), and Shagbark Hickory (*Carya ovata*). Also changing slowly, but less stable than the climax forest, was the mixed forest with some or all of the climax species growing in close association with Black Walnut (*Juglans nigra*), Common Hackberry (*Celtis occidentalis*) and American Elm (*Ulmus americana*). Early seral forest, which consisted mainly of Honey Locust (*Gleditsia triacanthos*) and Osage Orange (*Maclura pomifera*), was subject to relatively rapid change.

In the first year, grazed pastures reverted to a luxuriant grass-weed mixture. The grasses were composed primarily of two exotics, Smooth Brome (*Bromus inermis*) and Kentucky Blue-grass (*Poa pratensis*). Native species of the local tall-grass association, the bluestems, Indian Grass, and switchgrass were scarce. The most abundant weedy species were those that were noxious or otherwise resistant to the grazing of livestock. These included milkweeds (*Asclepias* sp.), Snow-on-the-mountain (*Euphorbia marginata*), Nettle Leaf Noseburn (*Tragia betonicifolia*), thistles (*Cirsium* sp.), Blackberry (*Rubus allegheniensis),* Carolina Horse Nettle (*Solanum carolinense),* Buffalo-bur Nightshade (*Solanum rostratum)*, Prickly Lettuce (*Lactuca serriola*), Cocklebur (*Xanthium strumarium*), and Hoary Vervain (*Verbena stricta*). The grass-weed association changed rapidly from year to year. Weedy species tolerant or resistant to grazing disappeared first, due to competition with grasses. After several years, there remained mainly a stand of Smooth Brome, which in turn was crowded out by thick stands of young trees (mostly elms).

Formerly cultivated fields developed a mixed stand of Giant Ragweed (*Ambrosia trifida*) and Sunflower (*Helianthus annuus*). Over a period of several years, a mixed weed association dominated by Goldenrod (*Solidago* sp.) flourished in these areas. As in the former pastures, this weed association was gradually replaced by young trees (*Ulmus* etc.).

All vertebrate species were drastically affected by these successional changes. In the first season after removal of grazing livestock, a population explosion occurred in the Prairie Vole (*Microtus ochrogaster*), which attained a density of hundreds per hectare. Its bird, mammal, and reptile predators thrived and increased. Reptiles were especially monitored to clarify their relationship to the changes that occurred. Live-traps were constructed of 6 mm wire “hardware cloth” shaped into cylinders 15.2 cm in diameter with an entrance funnel at one or both ends. Later, 1.2 x 0.6 m shelters of metal (corrugated roofing “tins”) or wood were used. These shelters were advantageous over the wire traps in that mortality of reptiles was never a factor. Also, reptiles using them for hiding places were much more likely to have food in their stomachs than their trap-caught counterparts.

Collecting effort for animals varied somewhat from year to

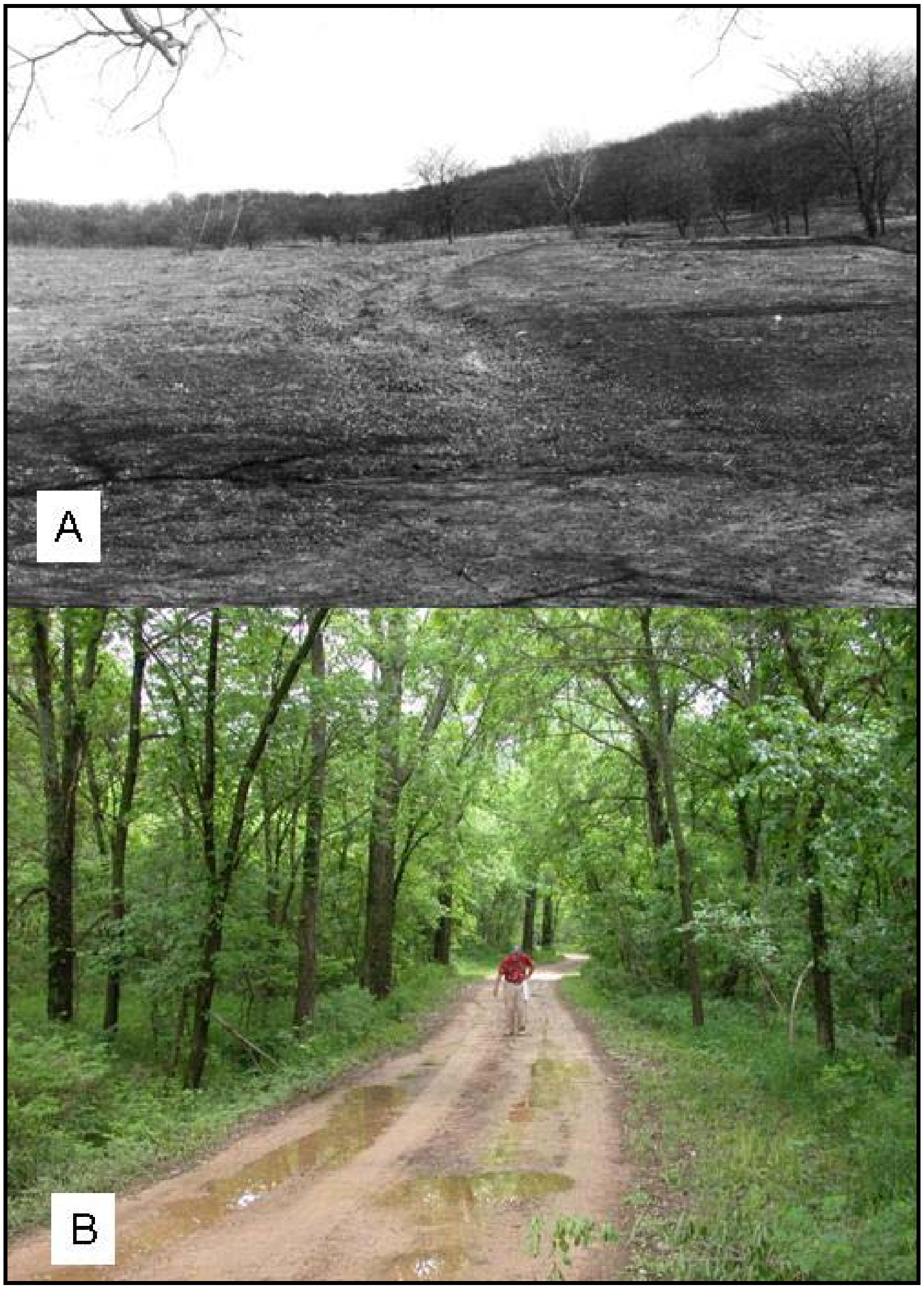

FIGURE 1. Entrance to Fitch Natural History Reservation in 1948 (A, photographed by W. Dean Kettle) and 2004 (B, photographed by Alice Echelle). The striking successional changes in vegetation were accompanied by equally remarkable modifications in the composition of the herpetofauna.

year and from decade to decade. During the first few years, the catch generally increased as more traps became available and as snake abundances increased under favorable conditions of food and cover. In the 1957 season, funnel traps with drift fences were added to the open areas comprising the snakes' summer habitat; whereas, in earlier years trapping had been limited to hilltop outcrops where the snakes came to hibernate in the fall months (Fitch 1965).

Every species of the local herpetofauna was drastically affected, with each species changing according to its own pattern (Fitch 2005). Table 1 shows species-specific catches of snakes (excluding recaptures) on the Reservation. It does not include those taken on the adjacent experimental areas. The table is included only to convey a rough approximation of general trends because the numbers are affected by unavoidable variables. Partial decades of collecting should not be considered as comparable to full decades. My efforts became more focused on the experimental areas as the herpetofauna declined on the Reservation, perhaps accentuating the impression of decreasing numbers on the Reservation. Also, numbers were affected by the previously mentioned shifts in trapping methods. In the 2001-2006 intervals, inevitable effects of aging curtailed my collecting intensity.

Responses of the various species to ecological succession can be broadly classified into several groups. Some of the species were early seral, and required bare soil, sand, rock or short grass.

TABLE 1. Numbers of snakes of each of 12 species processed per decade, from the 1940s into the 21st century on the Fitch Natural History Reservation. Recaptures are not included.

Species	1948-1949	1950s	1960s	1970s	1980s	1990s	2001-2006	Totals
Agkistrodon contortrix	44	773	436	455	534	37	6	2285
Carphophis vermis	7	169	161	33	9	23	0	402
Coluber constrictor	52	635	212	235	284	21	10	1449
Crotalus horridus	2	62	16	2	3	4	0	89
Diadophis punctatus	11	1430	1735	4090	4260	2195	193	13914
Lampropeltis calligaster	1	37	55	36	30	6	2	167
Lampropeltis triangulum	0	13	22	15	24	11	0	85
Nerodia sipedon	2	30	92	46	26	52	6	254
Pantherophis obsoletus	15	231	85	65	108	38	8	550
Pituophis catenifer	10	76	25	1	8	0	0	120
Storeria dekayi	0	23	164	32	23	15	0	257
Thamnophis sirtalis	25	313	788	359	447	448	98	2478
Totals	169	3792	3791	5369	5756	2850	323	22050

Among the first to disappear, members of this group were less useful in tracking succession than those that persisted longer. Most of the lizard species and also several amphibians were in this group, thus they are not represented in Table 1. This general category includes the Great Plains Skink (*Plestiodon obsoletus*), Five-lined Skink (*Plestiodon fasciatus*; still persists in 2006 around the residence and lab buildings), Six-lined Racerunner (*Aspidoscelis sexlineatus*), Ornate Box Turtle (*Terrapene ornata*), Woodhouse's Toad (*Bufo woodhousii*), Great Plains Narrowmouth Toad (*Gastrohryne olivacea*), Plains Spadefoot (*Spea bombifrons*), Prairie Skink (*Plestiodon septentrionalis*), and Flat-headed Snake (*Tantilla gracilis*). The last three species, never common and never occupying more than a small part of the area, were among the first to disappear. The other species of this group were initially at least moderately abundant, but most dwindled rapidly after cattle were removed.

The largest group comprised species that declined after livestock removal but then persisted for many years. Some of these are apparently no longer present on the area (Fitch 2006), including the Western Chorus Frog (*Pseudacris triseriata*), the Timber Rattlesnake (*Crotalus horridus*), and the Bullsnake (*Pituophis catenifer*). The two latter species were both fairly common in the beginning, but dwindled during the 1960s, and the few individuals found in later years were most likely vagrant. The last resident Timber Rattlesnakes were found in the 1960s at prominent limestone outcrops; the spread of deciduous trees in thick stands apparently eliminated critical basking places along the ledges.

Species that declined markedly but that still occur on the area include the Prairie Kingsnake (*Lampropeltis calligaster*), Little Brown Skink (*Scincella lateralis*), Slender Glass Lizard (*Ophisaurus attenuatus*), Prairie Ring-necked Snake (*Diadophis punctatus*), Eastern Yellow-bellied Racer (*Coluber constrictor*), and Osage Copperhead (*Agkistrodon contortrix*). The Prairie Kingsnake grew progressively scarcer, but is probably still present. *Scincella* occupied the grass-weed pastures on the Reservation rather than its usual leaf litter woodland habitat. It dwindled slowly but was still present in 2006. Although *Ophisaurus* was rare when the Reservation was created, it thrived after grazing livestock were removed, increasing from an initial nucleus of a few individuals to high abundance in the former pastures where tall grass had come to predominate. In the 17th year, it was so common that more than 70 were taken in a single day. By then, tree saplings had become established and were beginning to shade out the grasses. From the early 1960s, this species steadily lost ground, and by 2006, it was scarce although still present. *Diadophis punctatus*, at peak abundance, outnumbered all other reptile species combined. It has dwindled gradually but is still present in 2006 (Fitch and Echelle 2006). The Yellow-bellied Racer is a good example of a generalized snake. Unlike some of the other species, it is not dependent on one kind of prey; first-year young take orthopteran insects, and adults take mouse-sized rodents, common lizards or small snakes. However, *Coluber constrictor* dwindled gradually, and those found in recent years have been hatchlings, perhaps wanderers from other habitats. The copperhead increased for several years in response to increased cover and the abundance of the prairie vole, its favorite prey, but from the early 1950s, as voles began to decline, it underwent a downward trend that has lasted more than 50 years. Without the vole as food, snake litters are smaller and non-breeding is more common.

Several species are not easily classified in any of the above groups. One of these is the Red-sided Garter Snake (*Thamnophis sirtalis*). It increased rapidly and became abundant in the early years and is still thriving in 2006. The Northern Watersnake (*Nerodia sipedon*) was present at the pond throughout the years and seemed to be little affected by the changes in terrestrial habitats. The abrupt reduction in number of Black Ratsnakes (*Pantherophis obsoletus*) from the 1950s to the 1960s is due largely to the fact that, by the 1960s, a substantial proportion of those on the Reservation had been caught and marked; reduced captures in the 1990s can probably be explained by the shift of trapping effort to nearby experimental areas. The Brown Snake (*Storeria dekayi*) was most common during the 1960s and dwindled in later decades.

Superimposed on the changes precipitated by ecological succession, every species responded differently to environmental factors confronting it, and every year was unique in weather sequence. For example, environmental moisture was a critical factor for first-year young of the Red-sided Garter Snake. These depend almost entirely on earthworms for food. In drought years the availability of the worms is much reduced, depending on the severity of drought, and survival of young snakes is drastically affected. In a "bad year" only a small percentage may survive, and in these, sexual maturity may be postponed beyond the normal age.

As mentioned in Fitch (2006), it is ironic that on this area dedicated to preserving native flora and fauna and protected from anthropogenic disturbance for more than half a century, a large portion of the herpetofauna has been reduced by natural succession. However, perhaps it should not be surprising. The Reservation occupies the ecotone between eastern deciduous forest and tall-grass prairie. In this area, prairie is maintained as a fire or fire and grazing subclimax, and the balance can easily swing toward brush and forest when fire is suppressed. When the Reservation was created in 1947, it possessed a spectrum of habitat subdivisions and each was near, or adjoined, others of contrasting communities. Reptile/amphibian species thus had a choice of many habitats, all of them changing at different rates. Now, after 58 years of succession, the area as a whole is much different from what it was at the outset. The prospect is that over a sufficiently long time the fauna will become less diverse, different subdivisions will become more similar, and a climax community will eventually prevail. Some species, e.g., *Coluber constrictor*, which had shown marked decline on the Reservation, remained abundant on the experimental areas (Fitch et al. 2003). These areas thus provided perspective to the successional changes on the Reservation and demonstrated responses of the local ecosystem to management regimes such as mowing, fire, and grazing. To date, there are few published studies that have directly addressed the effects of brush management on native herpetofauna in the central United States (but see Jones et al. 2000). Effects of brush management have been more thoroughly studied for avian communities (e.g., Reinking 2005), and in some of these studies, reptilian responses are mentioned more or less incidentally (Shocat et al. 2005; Misenhelter and Rotenberry 2000).

In summary, observations of long-term changes in habitat and herpetofauna provide important information applicable to the conservation, management and restoration of native ecosystems. Without such observations, it would be difficult to surmise how these communities have changed or might change in the future. I have been fortunate to have the opportunity to conduct such studies. However, in the current atmosphere that fosters fast-return research supported by large grant money, long-term, detailed studies of natural history are generally not encouraged by academic institutions. This type of information is no longer solely pedagogical. Now, more than ever, we need a solid database to deal with the effects of human population growth and attendant problems of environmental alteration. Institutions need to promote detailed natural history research if only because the data can ultimately contribute to the management and conservation of biodiversity.

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Henry Sheldon Fitch was born 25 December 1909 in Utica, New York. Within a year after his birth, his family moved to the Rogue River Valley of southwestern Oregon where his parents had purchased a pear/apple orchard in the foothills of the Siskiyou Mountains. He received his B.A. from University of Oregon in 1930, and both the M.A. and Ph.D. degrees from University of California, Berkeley, in 1933 and 1937, respectively. He worked as a biologist for the U.S. Bureau of Biological Survey (U.S. Fish and Wildlife Service) at the San Joaquin Experimental Range in central California from 1938-1941 until he was drafted by the U.S. Army. After his release from the Army in 1945, he returned to his former job at the San Joaquin Range, but was transferred from California to Leesville, Louisiana in 1947. In 1948, the University of Kansas offered him a professorship position. His duties also included being resident naturalist and steward of the newly created University of Kansas Natural History Reservation, a 239-acre tract of land about seven miles northeast of Lawrence, Kansas. He still resides in this place that has been his home and living laboratory for the last 58 years. (Photographed by Vada Snider).