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Range Expansion of *Sigmodon hispidus* (Hispid Cotton Rat) into Reclaimed Coal Surface-mines in Southeastern Kentucky

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Abstract - *Sigmodon hispidus* (Hispid Cotton Rat) is the most wide-spread species of *Sigmodon* in North America. In recent years, this species has expanded northward and westward in the western part of its range due to changes in habitat and climate. Evidence suggests northward expansion is also occurring in Kentucky. Since the 1980s, extensive coal mining via surface mining and mountain-top removal has transformed more than 2300 km^2 of hardwood forests on the Cumberland Plateau of eastern Kentucky. Mining has transformed the landscape, once characterized by forests with deep valleys, steep slopes, and narrow, winding ridgetops into reclaimed sites with a relatively flat landscape dominated by grasses and forbs suitable for run-making rodents. Hispid Cotton Rat is thus poised to expand into the reclaimed mines of eastern Kentucky. We report the first record of Hispid Cotton Rat from a reclaimed-mine site and predict this species will expand its range north and east through this new habitat.

Evidence of range expansion—populations expanding into new geographic locations—is important because it indicates changes in the environment (Frey 2009). A number of American rodent species are exhibiting northward expansions. For example, 3 species of *Sigmodon* (cotton rats) are undergoing northward and westward expansions. *Sigmodon ochrognathus* Bailey (Yellow-nosed Cotton Rat) is expanding northward in New Mexico (K.N. Geluso, University of Nebraska, Omaha, NE, and K. Geluso, University of Nebraska, Kearney, NE, unpubl. data), whereas *S. fulviventer* J.A. Allen (Tawny-bellied Cotton Rat) is expanding westward in New Mexico (Geluso et al. 2005). *Sigmodon hispidus* Say and Ord (Hispid Cotton Rat) has the widest distribution of the genus throughout North America, ranging from Florida north to Virginia, west to Arizona, and from southern Nebraska to Texas and Mexico at the Lower Rio Grande Valley (Bradley et al. 2008). Field surveys demonstrate that this species has expanded its range northward in New Mexico (Geluso et al. 2005, Mohlhenrich 1961), northward and westward in Nebraska (Frisch et al. 2015, Wright et al. 2010), and northward in Missouri (Thompson and Finck 2013).

The history of the Hispid Cotton Rat in Kentucky is less well understood relative to its history in western parts of its range. Robinson and Quick (1965) claimed the first known record of the species in Kentucky from the western side of the Cumberland River, Lyon County, in what is now the Land Between the Lakes National Recreation Area (open star in Fig. 1). This specimen appears to have been lost. An earlier specimen was collected near Paducah, McCracken County, in the Jackson Purchase Region of western Kentucky on 2 November 1958 (skull deposited in Florida State Museum; FLMNH-5599; solid diamond in Fig. 1). By the 1970s, Barbour and Davis (1974) reported that Hispid Cotton Rat was established in 10 counties west of the Cumberland River (solid squares, solid diamond, and open star in Fig. 1). Those authors suspected this species only occurred in western Kentucky and questioned a specimen from the Cumberland Plateau in southeastern Kentucky (solid star in Fig. 1) collected by Thane Robinson in 1964 (Barbour and Davis 1974). This specimen was collected ~1.5 km east of Wilstacy, Breathitt County, along state highway 1111 that followed a stream. Barbour and Davis (1974) stated (p. 192) "[the] locality is well out of the

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known or expected range of the species, and we are at a loss to explain its presence there." This specimen also was not included in their state distribution map for Hispid Cotton Rat (Barbour and Davis 1974) and appears to no longer exist.

On 15 October 1977, Davis and Barbour (1979) trapped 7 Hispid Cotton Rats on the Cumberland Plateau at the visitor's center of the Cumberland Gap National Historical Park, Bell County, KY, (western pentagon symbol in Fig. 1; 2 specimens are deposited in the National Museum of Natural History; NMNH-559133, NMNH-559134). No additional specimens were trapped at this location a year later. Davis and Barbour (1979) suggested absence of Hispid Cotton Rats was the result of a die off from a cold winter in 1977–1978. Those researchers also trapped specimens in adjacent Lee County, VA, on 26 November 1977 (eastern pentagon symbol in Fig. 1). Davis and Barbour (1979) reported these as new records for southeastern Kentucky and southwestern Virginia. These captures in southeastern Kentucky strongly suggest that the Breathitt County specimen was valid and the northern most record of Hispid Cotton Rat in Kentucky.

Additional records of Hispid Cotton Rat have been reported for the Cumberland Plateau of southeastern Kentucky since 1977. A *Felis silvestris catus* (L.) (House Cat) captured a

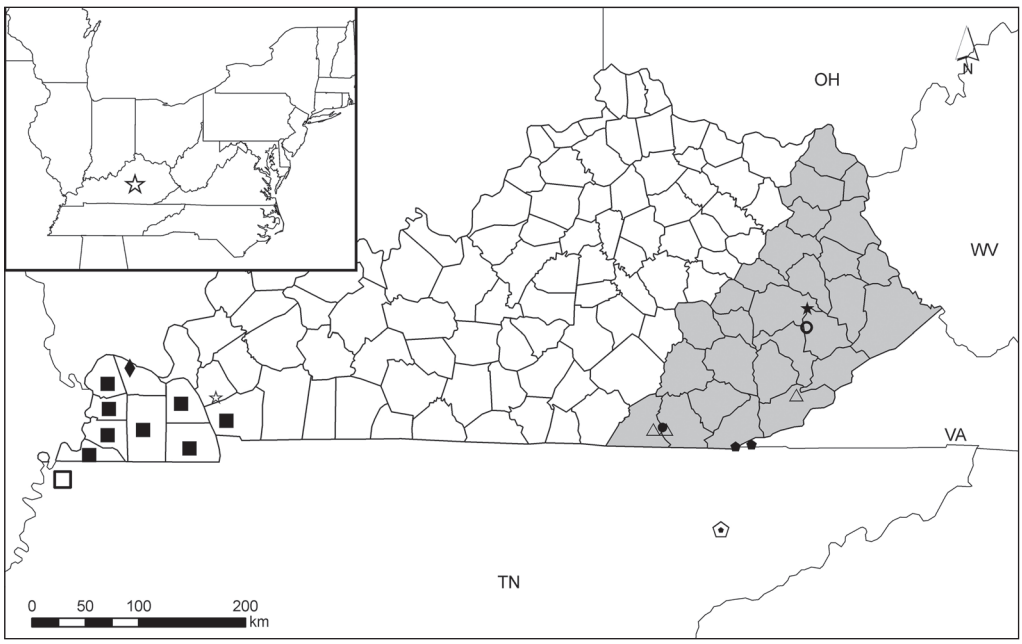

Figure 1. Locality records for *Sigmodon hispidus* (Hispid Cotton Rat) in Kentucky. The Cumberland Plateau portion of Kentucky is in grey. The presence of the Hispid Cotton Rat has been well documented in western Kentucky with the first published record collected in Lyon County (open star; Robinson and Quick 1965). However, the first known specimen from Kentucky was collected in 1958 from Paducah, McCracken County (solid diamond). Other western records for Kentucky (solid squares; Barbour and Davis 1974) and northern Tennessee (open square; Goodpaster and Hoffmeister 1952) are included. One specimen was collected from Breathitt County by T. Robinson in 1964 (solid star), with additional specimens collected in Bell County and adjacent Lee County, VA (solid pentagons; Davis and Barbour 1979). Records have also been collected from eastern Tennessee (open pentagon; Howell 1954), with more recent specimens from Harlan, McCreary, and Whitley counties (open triangles [specimens collected by J. MacGregor and J. Kiser]; solid circle [specimens collected by J.J. Krupa, present study]). The open circle represents a range expansion into reclaimed coal-mine habitat in Knott County based on the present study.

Hispid Cotton Rat at the Pine Mountain Settlement School in Harlan County on 13 July 1992 (easternmost triangle in Fig. 1); the voucher specimen was not kept (J. MacGregor, Kentucky Department of Fish and Wildlife Resources, Frankfort, KY, pers. com.). Forty pitfall traps were set out from 16 June to 20 July 1992 and 24 Sherman live traps were set from 15 to 17 October 1992 at that location where the House Cat was thought to have caught the cotton rat; no additional individuals were caught (J. Kiser, Stantec Consulting, Louisville, KY, pers. com.). In addition, Hispid Cotton Rats were captured frequently and repeatedly in snake traps in the early 2000s in open grass and forb-dominated habitat under Eastern Kentucky Power Company's power lines in McCreary and Whitley counties in southeastern Kentucky along the Tennessee border (westernmost triangles in Fig. 1); no voucher specimens were kept (J. MacGregor, pers. com.).

Although confirmed records of Hispid Cotton Rat exist from the Cumberland Plateau, no records were known from reclaimed surface-mines in the coalfields of the Cumberland Plateau, where suitable habitat exists and is increasing following extensive deforestation from mining. On 29 May 2015, we discovered a male *Crotalus horridus* L. (Timber Rattlesnake) that was road-killed between 0500 h to 0900 h on a gravel road 4.0 km north of Talcum, 4.0 km northeast of Ary, Knott County, KY (37°27'1.21"N, 83°7'15.71"W; open circle in Fig. 1). We removed from the stomach of the snake a recently swallowed *Peromyscus leucopus* (Rafinesque) (White-footed Deermouse) and a partially digested, adult female Hispid Cotton Rat. We recovered teeth, pieces of skull, and the posterior half of the carcass (including tail [= 96 mm] and hind feet [= 21 mm]). Ours is the first record of Hispid Cotton Rat from reclaimed surface-mines on the Cumberland Plateau; the study skin and bones were initially deposited in the University of Kentucky Vertebrate Collection (JJK-3601).

The collection location was on an area of active and reclaimed surface-mines covering 26 km^2. This disturbed area is surrounded by hardwood forests dominated by *Quercus* (oak), *Acer* (maple), and *Carya* (hickory). We found the snake ~2.8 km north, 3.4 km east, 1 km south, and 2.78 km west of forest edges. These reclaimed mines are planted with a combination of grasses, typically the 5 genera *Andropogon* (bluestem), *Argostis* (bentgrass), *Panicum* (panic grass), *Tridens* (fluffgrass), and *Festuca* (fescue) and legumes (mostly 5 species of *Lespedeza* [bush clover]; Krupa and Lacki 2002). Further, this location is 18.4 km south of the valley through which state highway 1111 passes and where the 1964 specimen was found. These 2 locations are separated by hardwood forest, and thus are isolated from each other, which suggests that the snake captured the Hispid Cotton Rat on a reclaimed mine.

We attempted to locate a Hispid Cotton Rat source population on reclaimed mines in Knott County. We set a total of 159 Sherman live traps during the day only at 3 locations for 7 h on 28 May 2016 and 12 November 2016. We also set a total of 414 trap nights at 9 sites (31 May–1 June 2016, 3–4 March 2017, 7–9 April 2017). We set an additional 39 rat traps overnight (24–25 December 2016) under Eastern Kentucky Power Company's power lines at state highway 478, 1.5 km south of state highway 679, Whitley County. This is the site where Hispid Cotton Rats were commonly caught in snake traps in the early 2000s (J. MacGregor, pers. com.). The purpose of trapping this site was to examine habitat where the Hispid Cotton Rat is established in southeastern Kentucky as a reference to search for similar habitat on reclaimed surface-mines. Our efforts to trap Hispid Cotton Rats in Knott County failed despite finding old runs large enough to have been made by this species. However, we trapped 8 Hispid Cotton Rats at the Whitley County site (solid circle in Fig. 1).

The Hispid Cotton Rat reported here represents the first record of this species on reclaimed mines in eastern Kentucky. We feel that this collection represents a range expansion

into relatively new human-created habitat now prevalent in eastern Kentucky. The Hispid Cotton Rat prefers open habitat dominated by grasses with mixed forbs (Cameron and Spencer 1981). Until the mid-1900s, 87% of eastern Kentucky was covered by hardwood forests dominated by oak, hickory, and maple (Plass 1967); non-forested areas were small, isolated agricultural plots. By the mid-1900s, paved roads, with *Lolium arundinaceum* (Schreb.) Darbysh. (Tall Fescue) planted along the shoulders, were being built along streams in the valleys of eastern Kentucky. These roadside plantings represented the first corridors for run-making rodents into the forests of eastern Kentucky. By the 1950s, bands of hardwood forests were being cleared for power lines in eastern Tennessee and Kentucky. The resulting clearings beneath the power lines are dominated by multiple species of grasses and forbs preferred by run-making mammals. This habitat represented the second type of corridor to penetrate the hardwood forests of eastern Kentucky. Surface mining for coal, including mountain-top removal, in the 1950s led to deforestation of eastern Kentucky which accelerated in the 1980s. Ridgetops were removed to expose seams of coal with the overburden dumped into the valleys. This practice eliminated the natural topography of deep valleys, steep slopes, and narrow, winding ridgetops natural to the Cumberland Plateau, leaving a relatively flat topography. The 1977 Federal Surface-Mine Control and Reclamation Act required that grasses and legumes be planted on former mining sites not used for growing crops (Plass 2000). Following the accelerated mining of the 1980s, over 2300 km^2 have been mined, all of which must be restored under federal law (Plass 2000). Thus, in the last 35 y, open habitat in eastern Kentucky has been formed, creating a great potential for expansion of the Hispid Cotton Rat into the Cumberland Plateau.

Published records suggest that the Hispid Cotton Rat has been expanding northward in Tennessee towards Kentucky and Virginia. Kellogg (1939) reported Hispid Cotton Rat from 4 counties in Tennessee along the southern border. In western Tennessee, Goodpaster and Hoffmeister (1952) discovered a population near Samburg, 14 km south of Fulton County, KY, in extreme western Tennessee (open square in Fig. 1). In eastern Tennessee, Howell (1954) discovered an established population near Knoxville (open pentagon symbol in Fig. 1). Davis and Barbour's (1979) records of 1977 for Bell County, KY, and Lee County, VA, were new. Rose et al.'s (1990) observations from the 1980s for the Great Dismal Swamp in eastern Virginia also were new records. Those studies suggest, but do not confirm, that the Hispid Cotton Rat is expanding northward in the eastern part of its range. We predict that this species will be released from the barrier presented by hardwood forests and expand into the extensive area of reclaimed mines on the Cumberland Plateau. As temperatures rise in the region (Powell and Keim 2015, Tebaldi et al. 2012), warmer temperatures and milder winters coupled with the corridors created by power lines cutting through existing hardwood forest from Tennessee northward should provide an environment for expansion.

Given that we were unable to trap Hispid Cotton Rats on the reclaimed mines, we believe this suggests expansion into this new habitat is in its early stages. In addition to our current trapping efforts, other recent trapping on reclaimed mines failed to catch Hispid Cotton Rats (Krupa and Haskins 1996, Larkin et al. 2008), which also suggests that currently Hispid Cotton Rat colonies are small and spotty on reclaimed mines. We did not trap until 12 months after the snake was found. In that time, the area underwent drastic changes as reclaimed-mine sites became active mines with destruction of all stands of grasses and forbs, and possibly destroying the source population. Further, Davis and Barbour (1979) provided evidence that a population of Hispid Cotton Rats died off after a cold winter. The same thing may have occurred in the area where the specimen was located.

The expansion of the species into new areas in the western parts of its range and possible expansion in Virginia (Davis and Barbour 1979, Linzey 1998, Rose et al. 1990), suggests

it is plausible that in the near future the Hispid Cotton Rat will become more common on reclaimed coalfields than present evidence indicates and will continue to spread north and east over the Cumberland Plateau where mining has occurred. Additional trapping is necessary to monitor this progression of expansion.

Specimens collected during this study were deposited in the Field Museum of Natural History, Chicago, IL, on 22 October 2018. Catalog numbers are as follows: Knott County specimen, FMNH-235729; Whitley County specimens, FMNH-235730–235733.

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