

Terrestrial Mammals of Virginia: Trends in Distribution and Diversity

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ABSTRACT

The present mammal fauna of Virginia dates from the late Pleistocene and early Holocene. Indians had little impact on the fauna, but European introduction of firearms led to terminal exploitation of bison and elk and to deliberate extirpation of large predators. Logging, clearing for agriculture, and urbanization had a negative impact on some forest species and brought gains for some open country species. The present era of conservation attempts to maintain diversity and to stabilize the fauna through protection, restoration, and management. Future challenges include: 1) Creating an informed and environmentally responsible citizenry by means of better education and public relations; 2) Maintaining diversity and ecological equilibrium by acquiring fundamental knowledge of natural history of all species as a primary management tool, managing for diversity of habitat and fauna, including both prey and predatory species, maintaining large roadless and relatively trailless wild areas connected by forest corridors, and establishing more and larger refuges to protect non-threatened as well as relict flora and fauna. Predictable future threats to mammals are from pressure of an expanding human population, global warming, and severe environmental perturbations such as acid rain and infestations of gypsy moths.

Key Words: mammals, Virginia, distribution, diversity, management, history, vagility

INTRODUCTION

In historic times 75 species of indigenous terrestrial mammals, including bats, have occurred in Virginia. Most of these (45 species) have boreal (northern or cold) affinities (Tables 2-6). Fewer (30 species) have austral (southern or warm) relationships (Tables 8-10). The boreal segment of the fauna is rich in long-tailed shrews, moles, squirrels, voles, jumping mice, and carnivores. The austral segment includes the only marsupial, is rich in short-tailed shrews (including the state's most ubiquitous wild mammal, the northern short-tailed shrew), and has more species of bats and mice than the boreal segment.

This mixed fauna of northern and southern taxa had its roots in the late Pleistocene Wisconsin glacial age, 23,000--12,500 years B. P. (= before present) when continental glaciers were not far to the north, in Ohio, Pennsylvania, and New Jersey. At that time the tops of the higher mountains in Virginia probably had a treeless, alpine aspect; open, taiga-like parkland characterized lower mountain slopes; and on the piedmont and coastal plain, which then extended to near the edge of the continental shelf, was an open parkland with spruce, jack pine, fir,

birch, alder, and grass (Delcourt and Delcourt, 1986). Today's Chesapeake Bay was then the valley of the great Susquehanna River. In the late Pleistocene the Susquehanna with its major tributaries, the James and Potomac, was the largest river between the Mississippi and the St. Lawrence on the Atlantic Coast.

THE LATE PLEISTOCENE (23,000 to 12,000 years B. P.)

The mammalian fauna of the Wisconsin age in Virginia was a curious melange of old and new species. Remnants of the old fauna that thrived earlier in the Pleistocene still roamed the forests and plains of Virginia (Tables 1 and 7). There were a ground sloth, giant beaver, dire wolf, large cats, mastodon, mammoth, horses, tapir, peccaries, giant moose, and muskox. These giants became extinct at the end of the Pleistocene, while other contemporary megamammals such as black bear, mountain lion, bobcat, white-tailed deer, elk, moose, caribou, and bison survived into the Holocene. With very few exceptions the microfauna of Wisconsin time was the microfauna of the Holocene---today. The exceptions, a Pleistocene armadillo resembling *Dasybus bellus* and a round-tailed muskrat, *Neofiber leonardi*, died out along with the old Pleistocene megafauna when the climate abruptly warmed at the end of the Pleistocene (Eshelman and Grady, 1986).

The rich bone deposits beneath the ledges outside Clark's Cave in Bath County, Virginia, give us a window through which we can look back to late glacial time, 23,000 to 11,000 years B. P. What we see is astonishing by today's perspective. The edge of the continental glacier is not far to the north. Winters are moderate and summers are cool. Sheltered by limestone ledges above the cave mouth we look out over the valley of the Cowpasture River to the slopes of Warm Springs Mountain beyond. The mountain tops are bare, alpine. The slopes and valleys have a park-like boreal appearance, with scattered patches of spruce and pine, meadow and muskeg---taiga. Around the bend of the river on warmer west and south facing slopes there is denser temperate forest, perhaps with closed canopy (Guilday, et al., 1977).

This scene of diverse habitats can be reconstructed from the ecological preferences of the small mammals and birds represented in the Clark's Cave bone deposits. The Clark's Cave Fauna is a remarkably complete and varied assemblage (Tables 1 to 9). It cannot be said unequivocally that all of the species of the Clark's Cave Fauna coinhabited the area simultaneously, but it is possible that they did (Guilday, et al., 1977).

Today Clark's Cave also has a diverse flora and fauna. There are northern plants such as giant woodfern, *Dryopteris goldiana*; southern resurrection fern, *Polypodium polypodioides*, and Carolina rhododendron, *Rhododendron catawbiense*; and relict white cedar, *Thuja occidentalis*, and yew, *Taxus canadensis*. At 1500 feet elevation the cave is too low for a boreal montane fauna, yet at or near the cave are 3 or 4 species of long-tailed shrews, southern red-backed vole, southern lemming vole, and woodland jumping mouse, all at the lower margin of their ranges. Elsewhere in Bath County or in adjacent Highland County all of the boreal relicts of Table 3 (except the extirpated porcupine) still can be found. On the other hand, austral species such as Virginia opossum, least shrew, Eastern cottontail, fox squirrel, and eastern harvest mouse, not part of the Clark's Cave

Fauna of 23,000 to 12,500 years B. P., are now in fields and forest at or near the cave.

Some species of the Clark's Cave Fauna and others that undoubtedly occurred there were especially adapted to cold and did not remain in Virginia as the climate warmed (Table 2). They moved northward and westward, following the retreating glaciers and boreal flora. Today these species live in a variety of boreal habitats--the 13-lined ground squirrel in the northern plains, from the Great Lakes states to central Alberta; yellow-cheeked vole and caribou in the tundra and taiga north of the boreal forest belt; the caribou also within the forest, along with Arctic shrew, least chipmunk, heather vole, northern lemming vole, marten, ermine, and moose.

Because the remains of Clark's Cave mammals were mostly deposited by owls, there is a bias for smaller species. Larger species in the deposits, such as snowshoe hare, woodchuck, porcupine, raccoon, black bear, marten, elk, and white-tailed deer must have been dragged to the cave mouth by larger carnivores. The fauna of large mammals nevertheless is under-represented. Most large species which must have occurred at Clark's Cave have been found in fossil deposits of similar age elsewhere in Virginia. These include gray wolf, red fox, fisher, river otter, mountain lion, bobcat, moose, caribou, and bison, as well as the extinct Pleistocene megamammals.

It is plausible that the high boreal faunal element (Table 2) was compressed southward during the Wisconsin glaciation, finally occupying a narrow area of familiar habitat and superimposing on marginal habitats already occupied by a resident boreal fauna (Tables 3 to 5). A general shift of habitats to lower latitudes during the Pleistocene would have removed at least some of the low boreal species of Table 6 and high austral species of Tables 8 and 9 from the vicinity of Clark's Cave. Medium austral species (Table 10) likely disappeared from Virginia altogether.

At the end of the Pleistocene, as glaciers retreated northward, high boreal habitats expanded, and there was a general northward shift of low boreal and high austral habitats. High boreal species (Table 2), compressed during the glacial interval, recoiled northward, eventually disappearing entirely from Virginia. Probably the mammals of Table 3 properly belong with those of Table 2 and represent the last stages of the recoil of high boreal species from southern latitudes into higher latitudes in the United States and Canada---north and west of Virginia.

The point to be made here, with reference to the Clark's Cave Fauna, is that major changes in habitat in a relatively short period of time (Delcourt and Delcourt, 1986) apparently resulted in minor changes in faunal composition. There were relatively small losses and gains among peripheral species of the boreal and austral segments of the fauna. This is somewhat surprising in view of the vagility of mammals. Even shrews and moles are vagile.

Emphatic testimony to vagility in the past is the present occurrence of so many species of mammals north of the boundary of Wisconsin glaciation in the northern United States and Canada (Handley, 1971). Locally, the peculiar fragmented range of the southern short-tailed shrew and the continuous distribution of the northern short-tailed shrew in eastern Virginia and North Carolina show the influence of parapatry and the effects of episodic movements of these species in the past. Even now we are witnesses to measurable movement of several species

of mammals in the eastern United States. The southeastern shrew is following closely the retreat of the masked shrew to higher elevations in the mountains of Virginia (Pagels and Handley, 1989). The Virginia opossum, nine-banded armadillo, and hispid cotton rat are moving northward. The prairie deer mouse (*Peromyscus maniculatus bairdii*) and the coyote have moved eastward from the prairies and now are proceeding southward on the Atlantic Coast.

The obvious potential for vagility in mammals emphasizes the flexibility of a majority of the Clark's Cave Fauna in choice of habitat. When the habitat at Clark's Cave changed from open boreal to closed temperate forest the diverse Clark's Cave Fauna could have shifted latitudinally with the vegetation, but few species moved (Tables 2 and 9). The implication is that in the future much of the mammalian fauna of Virginia should successfully absorb the impact of deliberate habitat modification by human beings and the impact of other environmental perturbations, whether natural or induced by human beings.

THE INDIANS (12,000 to 400 years B. P.)

Near the end of the Pleistocene, human beings came upon the scene for the first time. Judging by the variety of projectile points and skin scrapers that have been recovered in Virginia, the early people (Clovis Culture, 12,000 to 10,000 years B. P.) must have been primarily hunters (McCary, 1986). Some have postulated that they contributed to the disappearance of the old Pleistocene megafauna---ground sloth, mastodon, mammoth, tapir, etc., but somehow they spared the contemporary modern megamammals such as moose, elk, bison, etc. Oddly, no bones of old Pleistocene megamammals have been found in eastern North American Paleo-Indian sites (Gramly, 1982; McCary, 1986). Perhaps the sites are too young.

From about 12,000 years B. P. to about 400 years B. P. Indians harvested the megafauna but apparently had very little impact on it or on the microfauna. Rose (1986) reviewed reports of mammalian remains found at archeological sites in Virginia dated back to 4000 years B. P., and he listed 22 species squirrel-size or larger for the sites. White-tailed deer was most abundant. Other species utilized by Indians nearly statewide (no sites in the north, southeast, or on the Eastern Shore) were eastern cottontail, gray squirrel, woodchuck, beaver, muskrat, gray fox, black bear, raccoon, mountain lion, and elk. A few species were geographically limited: Virginia opossum was mostly in the piedmont and coastal plain, fox squirrel and red fox were only in the piedmont and coastal plain, eastern wood rat was only in the mountains and piedmont, and Eastern chipmunk was only in the mountains.

Rose (1986) speculated that the absence of remains of bison at all sites might be due to location of sites where bison did not occur or the probability that such a large animal would be butchered at the kill site rather than at the camp. I believe that at least in late prehistory in the Central Appalachians the Shawnee Indians treated as hunting reserves the white oak-blue grass savannahs on limestone karst, where elk and bison were most likely to occur. The Indians did not live in or near the savannahs, so they must have transported dried meat and hides dozens if not hundreds of kilometers back to their villages, as far away as Ohio.

THE EUROPEANS (400 to 200 years B. P.)

The equilibrium that had existed for centuries between man and beast was shattered when the Europeans landed on the shores of Virginia. Whereas the impact of Indians on the mammals had been minimal, the impact of the European colonists was profound. In place of bows and arrows and spears, the colonists brought more lethal firearms. They also brought an exploitive philosophy, and in place of village, house, yard, and garden plot, they brought the concepts of fields, plantations, livestock, and cities.

The early colonists were impressed with the variety and abundance of game animals and large predators wherever they landed or settled. Late comers also reported the abundance of large mammals, not that they saw themselves, but that they heard of, on the frontiers to the west. Hunters became explorers as they ventured beyond the frontiers to find meat animals they could barter or sell back at the settlements. Predators were extirpated to protect livestock. Furbearers were trapped until there were too few for trapping to be worthwhile. The black rat (*Rattus rattus*) was inadvertently introduced; then later Norway rat (*Rattus norvegicus*) and house mouse (*Mus musculus*). They became feral, often the dominant mammals, in fields, marshes, ditch banks, sewers, thickets, and buildings (Handley, 1980).

The colonial era, 400 to 200 years B. P., ended with no more frontiers in Virginia. Settlement had reached every boundary. Two hundred years of unrestrained exploitation primarily affected the larger mammals. The bison was gone; elk, white-tailed deer, wolf, mountain lion, and beaver were reduced to small fractions of their precolonial numbers. Presumably the smaller mammals scarcely noticed the European presence, nor did the Europeans notice the smaller mammals enough to write anything significant about them.

HABITAT DESTRUCTION (200 to 75 years B. P.)

The 19th century and the first quarter of the 20th century was the era of most severe habitat destruction in Virginia. Deforestation reached its maximum, with clearing for agriculture and clear-cutting for pulp and lumber; wetlands were drained for agriculture; streams were polluted with sewage, mine, and industrial wastes; and extirpation of fauna was commonplace.

The last of the original forest was clear-cut and the debris usually was burned. Forest fires were frequent and widespread. Growing on sterile ground, without benefit of long accumulated humus and soil nutrients, successional forests were inferior to the old growth they replaced. Trees we see today are comparatively low and scrawny, with no chance of ever attaining the status of forest giants, commonplace in the past.

Most tragic for mammals was the cutting and burning of the islands of spruce and fir on the higher mountains. This hastened the demise of the boreal relicts---the water shrew, snowshoe hare, northern flying squirrel, rock vole, and fisher. Most of these cling today to small fragments of only marginally suitable habitat, in numbers so small that their ultimate disappearance from Virginia is inevitable. When the European colonists replaced the parklike old growth forest of the coastal plain with a mosaic of agricultural fields, the fox squirrel survived in small numbers

in the most favorable habitat. However, in this century when the old fields were abandoned and grew up to scrub pine the fox squirrel disappeared.

Extirpation of mammals in Virginia peaked during this period: the last bison was killed in 1797; porcupine, about 1837; elk, 1855; mountain lion, 1882; fisher, 1890; the fox squirrel of the Eastern Shore, 1895; gray wolf, 1910; beaver, 1911; and the white-tailed deer and river otter were extirpated from most of western Virginia early in this century (Handley, 1980). Changing land use patterns led directly to extirpation of the fox squirrel, indirectly to extirpation of the others, making it easier in the shrinking forest to hunt or trap dwindling populations of mammals.

This era ended with an environmental disaster. The introduced chestnut blight reached northern Virginia about 1920 and had spread to the southwestern corner of the state by 1930. Quickly the oak-hickory-chestnut forest became an oak-hickory forest. The gray-white trunks of dead chestnuts became the dominant feature of mountain forests for the next quarter century. Ecological consequences were mixed. Disappearance of the chestnut was a serious sudden loss to mast foragers such as bear, deer, and turkey; but the standing dead trees provided optimal habitat for beetles and other burrowing arthropods, woodpeckers, and hole nesting birds and mammals; and later when the dead trees fell the prostrate trunks became habitat not only for invertebrates, but also for salamanders, snakes, shrews, chipmunk, mice, voles, and weasels.

CONSERVATION (75 years B. P. to present)

Actually conceived in the previous era, the conservation movement has developed in the 20th century. Virginia's mammals have prospered. The U. S. Forest Service, national and state forests and parks, forest management, soil conservation, wetland preservation, federal and state game management agencies, the non-game conservation program, the Natural Heritage movement, private conservation organizations, and the introduction of natural resources curricula to universities, all have had a profound effect on the mammalian fauna of Virginia. This has been an age of discovery, enlightenment, and recovery. The fauna has been inventoried and mapped and much has been learned about natural history and population dynamics. The Virginia Department of Game and Inland Fisheries now sees its role as steward of the whole fauna, not just of the game and fur species.

Attempts to restore lost species have had mixed success. Restoration of elk and snowshoe hare failed. Lack of suitable habitat in Virginia now compromises reestablishment of the fisher and limits the lowland fox squirrels. Reduction of pollution and trapping, and return of natural dispersal aided by transplants, probably will restore the river otter to western Virginia. Return of the mountain lion by informal transplants is likely to fail. Restoration of the white-tailed deer to western Virginia and the beaver to all of Virginia have been outstandingly successful.

Introduction of exotic taxa as a rule is undesirable. That certainly is true of the black and Norway rats and house mouse introduced unintentionally by the European colonists. The South American nutria (*Myocastor coypus*) has invaded salt marshes of Virginia from points of introduction in the southern United States. It may prove to be a valuable fur bearer or a pest. The black-tailed jackrabbit

(*Lepus californicus*) of the western United States, established on several islands of the Eastern Shore, in time probably will be considered a pest. The Japanese sika deer (*Cervus nippon*) flourishes on Assateague Island, where it is a tourist attraction and a game mammal. The Assateague pony (*Equus caballus*), touted as wild, actually is a managed domestic animal.

The 400 year saga of deforestation has ended. The acreage in forest in Virginia now is greater than it was 75 years ago and continues to grow as unprofitable farms are abandoned. Species which have benefited from deforestation---white-tailed deer, red fox, coyote, meadow vole, prairie deer mouse, harvest mouse, woodchuck, chipmunk, and cottontail---probably are more widespread and abundant now than they have been since the Pleistocene. Reforestation is not likely to proceed to the point of seriously diminishing populations of these mammals. In fact, some reduction in their numbers is desirable. For example, the deer population has increased too much to be controlled by hunter harvest in some areas and consequent over-browsing is damaging habitat. Increasing acreage of forest and wilderness will benefit bear, mountain lion, bobcat, gray fox, and forest rodents and shrews.

ENVIRONMENTAL AWARENESS (The future)

THE PUBLIC

Education is the key to the future well-being of the flora and fauna. Increasingly sophisticated environmental education, public relations, advertising, and lobbying will create a majority constituency of voters actively concerned with environmental issues. They will not be satisfied with lip-service to conservation, promises of incremental future action on urgent issues, or reaction to crises based on economics. Atmospheric, freshwater, oceanic, and terrestrial pollution will be addressed properly and controlled. There will be greater resistance to the inclination of urban and highway planners and politicians to consider wilderness and wetlands as waste space, ideal for road corridors, land fills, and recreational parks.

NATURAL HISTORY

The greatest obstacle to effective management is ignorance of the basic natural history of most species. Only mammals of economic importance (mostly game, fur-bearing, or predatory species) are relatively well known. In the future, highest priority should be given to definitive studies of the natural history of those species that are threatened or endangered. Ultimately the biology of all species should be examined and habitat management decisions should be based on a firm knowledge of their natural history.

HABITAT MANAGEMENT

Much more attention must be given to *active* management of entire habitats. No longer should it be acceptable to just "let it grow." Had there been even a small amount of habitat management, the snowshoe hare might not be now on the verge of extirpation in Virginia. With prompt habitat management it may be still possible to create habitat suitable for fox squirrels on the Eastern Shore and in the southern coastal plain and piedmont of Virginia (Handley, 1991).

Breaking up even-age forest with small clear-cuts (Kirkland, 1990), prescribed burning, selective tree planting, and preservation of patches of surviving old growth

to create diversity and an artificial forest mosaic are forest management concepts that benefit mammals as well as many other animals. With a mosaic forest it is feasible to let forest fires burn, also a benefit for mammals.

Preservation of large roadless and relatively trailless blocks of forest, a challenging task in the face of burgeoning populations of human beings, is essential for perpetuation of large carnivores such as bear, bobcat, mountain lion, and fisher. Linking these blocks with forest corridors is a necessary component of the block scheme. In agricultural lands, farmers can create diversity simply by leaving fence rows weedy or shrubby and corners and damp ground wild. These practices benefit the farmer by providing habitat for small carnivores such as shrews, long-tailed and least weasels, and red foxes (Handley, 1991).

Virginia is fortunate in having most of its ocean fronting coastline and contiguous marshlands intact and protected. Wetlands of all types must be protected from filling, draining, flooding, polluting, and trampling. Small bogs and marshes in western Virginia are unprotected, unappreciated, and especially vulnerable. They provide habitat diversity that benefits many parts of the fauna, particularly birds, amphibians, and reptiles, as well as shrews, star-nosed mole, muskrat, lemming vole, harvest mouse, meadow jumping mouse, and mink.

Caves will come under increasing pressure for recreational spelunking. Management will be challenged to protect caves critical for bats, endangered or not, and yet to provide open or seasonal access for spelunkers to as many caves as possible.

GLOBAL WARMING

Natural ecological catastrophes such as hurricanes, tidal surges, tornados, ice storms, floods, droughts, and forest fires make short term drastic alterations of habitats on a local scale. Often they improve habitats for mammals by increasing plant diversity. Regional disasters on the scale of the chestnut blight, acid rain, and the invasion of gypsy moths, precipitated by human beings, have long lasting, perhaps permanent, impacts on the environment. New habitats may develop and parts of the flora and fauna may be lost. However, in scale these events are small in comparison with the global impact of the Pleistocene cooling or the global warming that may be in store for the world.

With substantial global warming we can expect large changes in the environment. Sea level will rise, inundating low-lying parts, perhaps large areas, of the coastal plain. There will be a latitudinal shift of floras. In Virginia, many species including spruce, fir, hemlock, clubmosses, and boreal ferns may disappear from the mountains; austral pines, gums, magnolias, pitcher plants, jasmine, and other southern plants may colonize the lowlands. Much of the mammal fauna will remain the same, but the high boreal species (Table 3) and some medium boreal species (Table 4) may be extirpated. Other medium boreal species (Table 4) could become mountaintop relicts, while others (Table 5) may become restricted to the mountains. The species of the other tables might move similarly, until eventually some or all of the low austral/tropical species (Table 11) would make their appearance in Virginia.

Lessons of the past, examined in this paper, assure us that if we protect and manage the flora and fauna intelligently we can maintain an optimum level of diversity. Climatic events beyond our control may force variation in composition of the flora and fauna but should not affect species richness.

TABLE 1. EXTINCT BOREAL SPECIES. Extinct by early Holocene; no survivors anywhere.

* Occurred in Clark's Cave Fauna.

<i>Castoroides ohioensis</i>	giant beaver
* <i>Canis cf. C. dirus</i>	dire wolf
<i>Panthera</i> sp. or <i>Felis atrox</i> ?	"large cat"
<i>Mammut americanum</i>	American mastodon
<i>Mammuthus primigenius</i>	woolly mammoth
<i>Equus complicatus</i>	horse
<i>Equus cf. E. fraternus</i>	horse
? <i>Sangamona</i> sp.	deer
? <i>Cervalces</i> sp.	giant moose
<i>Bootherium bombifrons</i>	woodland muskox

TABLE 2. HIGH BOREAL SPECIES. Extirpated prehistorically from Virginia; still occurring north and/or west of Virginia. * Occurred in Clark's Cave Fauna.

* <i>Sorex arcticus</i>	Arctic shrew
* <i>Tamias minimus</i>	least chipmunk
* <i>Spermophilus tridecemlineatus</i>	13-lined ground squirrel
* <i>Phenacomys intermedius</i>	heather vole
* <i>Microtus xanthognathus</i>	yellow-cheeked vole
* <i>Synaptomys borealis</i>	northern lemming vole
* <i>Martes americana</i>	marten
* <i>Mustela erminea</i>	ermine
cf. <i>Alces alces</i>	moose
<i>Rangifer tarandus</i>	caribou

TABLE 3. HIGH/MEDIUM BOREAL SPECIES. Relicts in mountains of Virginia; small isolated populations, all in danger of extirpation in Virginia. * Occurred in Clark's Cave Fauna.

* <i>Sorex palustris</i>	water shrew
* <i>Plecotus townsendii</i>	western big-eared bat
* <i>Lepus americanus</i>	snowshoe hare
* <i>Glaucomys sabrinus</i>	northern flying squirrel
* <i>Microtus chrotorrhinus</i>	rock vole
* <i>Erethizon dorsatum</i>	porcupine, EXTIRPATED
<i>Martes pennanti</i>	fisher, EXTIRPATED, restoration attempted

TABLE 4. MEDIUM BOREAL SPECIES. Restricted in Virginia to mountains; populations continuously distributed. * Occurred in Clark's Cave Fauna.

* <i>Sorex cinereus</i>	masked shrew (mountains and Eastern Shore)
* <i>Sorex dispar</i>	big-tailed shrew
* <i>Sorex fumeus</i>	smoky shrew
* <i>Parascalops breweri</i>	hairy-tailed mole
* <i>Sylvilagus transitionalis</i>	New England cottontail
* <i>Peromyscus maniculatus</i>	deer mouse
* <i>Clethrionomys gapperi</i>	southern red-backed vole
* <i>Synaptomys cooperi</i>	southern lemming vole
* <i>Napaeozapus insignis</i>	woodland jumping mouse
<i>Canis latrans</i>	coyote (recent immigrant)

TABLE 5. MEDIUM BOREAL SPECIES. Statewide in distribution, except absent from coast or Southeast. * Occurred in Clark's Cave Fauna.

* <i>Sorex hoyi</i>	pygmy shrew
* <i>Myotis leibii</i>	little-footed myotis
* <i>Myotis septentrionalis</i>	northern myotis
* <i>Tamias striatus</i>	eastern chipmunk
* <i>Marmota monax</i>	woodchuck
* <i>Tamiasciurus hudsonicus</i>	red squirrel
* <i>Zapus hudsonius</i>	meadow jumping mouse
* <i>Mustela nivalis</i>	least weasel
* <i>Mephitis mephitis</i>	striped skunk
* <i>Cervus elephas</i>	elk, EXTIRPATED, restoration failed
<i>Bison bison</i>	bison, EXTIRPATED

TABLE 6. LOW BOREAL SPECIES. Statewide in distribution. * Occurred in Clark's Cave Fauna.

* <i>Scalopus aquaticus</i>	eastern mole
* <i>Condylura cristata</i>	star-nosed mole
* <i>Myotis lucifugus</i>	little brown myotis
<i>Lasionycteris noctivagans</i>	silver-haired bat
* <i>Eptesicus fuscus</i>	big-brown bat
* <i>Sciurus carolinensis</i>	gray squirrel
<i>Castor canadensis</i>	beaver, EXTIRPATED, restored
* <i>Peromyscus leucopus</i>	white-footed mouse
* <i>Microtus pennsylvanicus</i>	meadow vole
* <i>Ondatra zibethicus</i>	muskrat
<i>Canis lupus</i>	gray wolf, EXTIRPATED
<i>Vulpes vulpes</i>	red fox
* <i>Ursus americanus</i>	black bear
* <i>Mustela vison</i>	mink
<i>Lutra canadensis</i>	river otter
<i>Felis concolor</i>	mountain lion, EXTIRPATED?
<i>Felis rufus</i>	bobcat

TABLE 7. EXTINCT AUSTRAL SPECIES. Extinct by early Holocene; no survivors anywhere. Not found in the Clark's Cave fauna.

<i>Megalonyx jeffersonii</i>	Jefferson's ground sloth
<i>Dasypus</i> cf. <i>D. bellus</i>	armadillo
<i>Neofiber leonardi</i>	round-tailed water rat
<i>Tapirus</i> cf. <i>T. veroensis</i>	Vero tapir
<i>Mylohyus nasutus</i>	long-nosed peccary
<i>Platygonus compressus</i>	flat-headed peccary

TABLE 8. HIGH AUSTRAL SPECIES. Restricted in Virginia to mountains; mostly relicts. * Occurred in Clark's Cave Fauna.

* <i>Myotis grisescens</i>	gray myotis
<i>Myotis sodalis</i>	social myotis (not distinguished from <i>M. lucifugus</i> in Clark's Cave material)
* <i>Pipistrellus subflavus</i>	eastern pipistrelle
* <i>Neotoma floridana</i>	eastern wood rat
<i>Spilogale putorius</i>	eastern spotted skunk

TABLE 9. HIGH AUSTRAL SPECIES. Statewide in distribution. * Occurred in Clark's Cave Fauna.

<i>Didelphis virginiana</i>	Virginia opossum
<i>Sorex longirostris</i>	southeastern shrew (marginal in mountains, not on Eastern Shore)
* <i>Blarina brevicauda</i>	northern short-tailed shrew
<i>Cryptotis parvus</i> ,	least shrew
* <i>Lasiurus borealis</i>	northern red bat
<i>Lasiurus cinereus</i>	hoary bat
<i>Sylvilagus foridanus</i>	eastern cottontail
<i>Sciurus niger</i>	fox squirrel
* <i>Glaucomys volans</i>	southern flying squirrel
<i>Reithrodontomys humulis</i>	eastern harvest mouse (not on Eastern Shore)
* <i>Microtus pinetorum</i>	pine vole
<i>Urocyon cinereoargenteus</i>	gray fox
* <i>Procyon lotor</i>	raccoon
<i>Mustela frenata</i>	long-tailed weasel
* <i>Odocoileus virginianus</i>	white-tailed deer

TABLE 10. MEDIUM AUSTRAL SPECIES. Restricted in Virginia to the eastern, southeastern, or southern portions of the state. None of these species were found in the Clark's Cave Fauna.

<i>Blarina carolinensis</i>	southern short-tailed shrew
<i>Lasiurus intermedius</i>	greater yellow bat
<i>Lasiurus seminolus</i>	Seminole bat
<i>Nycticeius humeralis</i>	evening bat
<i>Plecotus rafinesquii</i>	eastern big-eared bat
<i>Sylvilagus palustris</i>	marsh rabbit
<i>Oryzomys palustris</i>	northern rice rat
<i>Peromyscus gossypinus</i>	cotton mouse
<i>Ochrotomys nuttalli</i>	golden mouse
<i>Sigmodon hispidus</i>	hispid cotton rat

TABLE 11. LOW AUSTRAL/TROPICAL SPECIES. Entire range south of Virginia. None of these species were found in the Clark's Cave Fauna.

<i>Myotis austroriparius</i>	southeastern myotis
<i>Tadarida brasiliensis</i>	Brazilian free-tailed bat
<i>Eumops glaucinus</i>	glaucous mastiff bat
<i>Dasybus novemcinctus</i>	nine-banded armadillo
<i>Sylvilagus aquaticus</i>	swamp rabbit
<i>Geomys pinetis</i>	southeastern pocket gopher
<i>Peromyscus polionotus</i>	old field mouse
<i>Podomys floridanus</i>	Florida mouse
<i>Baiomys taylori</i>	dwarf mouse
<i>Neofiber alleni</i>	round-tailed muskrat
<i>Nasua narica</i>	coati
<i>Felis pardalis</i>	ocelot
<i>Tayassu tajacu</i>	collared peccary

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