ECOLOGY AND TAXONOMY OF WATER CANYON, CANADIAN COUNTY, OKLAHOMA

Master's Thesis, University of Oklahoma 1961
[Revised 2013]

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Keywords: disjunct species, erosion, microclimate, plant distribution, sediment, Caddo Canyons, Acer saccharum

[ABSTRACT]

Numerous canyons have been cut into the Rush Springs Sandstone of Permian age in West Central Oklahoma and subsequently refilled. Some of these canyons have been partly exposed by erosion of the sediment fill. Fossils collected indicate the canyon fill is sub-Pleistocene to geologically recent. The microclimate of these canyons is more mesic compared to the dryer prairie uplands. Sugar maple (*Acer saccharum*) persists there, far west of its other locations in very eastern Oklahoma. Beginning in 1932 several of these sediment-filled canyons began a process of rapid erosion, exposing the rock walls of the canyons. This study is a comparison of Water Canyon and two of its branches: Water Branch Canyon, a stable canyon wooded with mature vegetation including sugar maple and Activity Branch Canyon, a newly excavated canyon branch that began eroding after excessive rainfall in 1932. This study was completed in 1960. Six transects are used to show the distribution of the 233 plant species found in the Water Canyon complex. Herbaceous species generally were unique to each canyon type.

[2013 INTRODUCTION]

This 1959-60 study of the Water Canyon complex, a part of the Caddo Canyons, compares the vegetation of an actively eroding canyon branch to the vegetation of a more stable canyon branch. At the time of the study, there was little overlap of herbaceous species in the two branches. With over 50 years of succession, it would be most interesting to compare the current vegetation of the recently eroded Activity Branch of Water Canyon with that currently present in the more stable and mature Water Branch Canyon to see how many species of the more stable canyons have become established.

Scientific names have been updated according to USDA PLANTS Database, 2013. Common names have been added according to Taylor and Taylor (1994).

1961 INTRODUCTION

This morning we continued up the south side of the creek . . . at the point where the road strikes the crest of the ridge we found ourselves only one mile from the river, and continued . . . until we reached the head of Spring Creek, where we encamped, making our day's march sixteen miles. The valley of Spring Creek . . . is a mile in width, abundantly watered, arable soil,

https://doi.org/10.22488/okstate.17.100096

> *and timbered with black walnut, elm, hackberry and cottonwood. It is in the immediate vicinity of the Upper Cross Timbers, where postoak timber is abundant. It is also directly opposite the head of the Little Washita River, where there is said to be hickory and sugar-maple timber, within a distance of ten miles from this place.* (Foreman 1939)

On May 22, 1849, Captain R. B. Marcy made camp near the head of what is now Boggy Creek in Caddo County, Oklahoma. The next day, he and his company travelled the ridge dividing the South Canadian River and Sugar Creek (called by him, Little Washita) drainage basins. This prairie road passes through one of the most interesting and unique areas in Oklahoma. Within a half mile of both sides of the divide lie numerous steep walled canyons where water flows year round and eastern sugar maples (*Acer saccharum*) occur (Little 1939; Taylor 1960). The relic maples here are growing 160 to170 miles (258 to 273 km) west of their western most locations in eastern Oklahoma.

The Caddo Canyon area, as it is frequently called, lies principally in northeastern Caddo County and southwestern Canadian County. Steep box canyons have vertical rock walls at their upper end. Numerous canyons occur from Binger, Oklahoma to 8 miles (12.8 km) north of Hinton in Blaine County, and from 4 miles (6.4 km) west of Hinton, east along the South Canadian River into Canadian County to a point northeast of Cogar. To the west of the general area, the streams flow in shallow V-shaped valleys approximately 50 feet (15m) wide. North of Hinton, on the north side of the South Canadian River, a few shallower box canyons are found, but most streams there are in rounded valleys where erosion has not removed the sediment from the canyon walls.

The so-called Caddo Canyons are located in the South Canadian and Washita river basins which are separated by a relatively narrow ridge or divide. Marcy's route followed the ridge, which is now traversed by Oklahoma State Highway 37 between Cogar and Hinton, and by a section line road west of Hinton. The steep canyons have cut back into the ridge for distances of a mile or more. Downstream they gradually spread out into low rounded valleys. The South Canadian River is three to five miles (5-8 km) north of the ridge; whereas, the Washita River lies about 24 miles (38 km) south of the divide. The canyons of the Washita drainage flow first into Sugar Creek which flows to the southeast into the Washita River. The canyons on the north side drain directly into the South Canadian River.

THE STUDY AREA

Little (1939) studied the vegetation of four canyons: South, Devils, Kickapoo, and Water. Both Devils Canyon (site of the United Methodist Church Canyon Camp) and Kickapoo Canyon are located on many maps. South Canyon is now called Red Rock Canyon and is the location of a state park. The exact location of Water Canyon was not mentioned by Dr. Little. However, Smith (1930), in her study of the geography of Canadian County, includes a map of the county's water drainage and the location of this canyon.

The Water Canyon complex was chosen for detailed study because many disjunct species occur there and its branches are representative of the two major canyon types. It is located in the very southwestern corner of Canadian County. Hinton, Oklahoma is five miles (8 km) west; the small community of Niles is on the eastern edge. The main stream of the complex flows

directly 4.5 miles (7.2 km) from its head to the South Canadian River (Figure 1).

This study dealt with the vegetation in the canyon proper and its two large east-west branches. The northern boundary was placed at the Moss Grove School site's section line bridge which is about 1.5 miles (2.4 km) south of the South Canadian River. The vegetation here is similar to the floodplain, which has been greatly influenced by human activity. Oklahoma State Highway 37 defines the boundary of the canyon complex drainage on the south and west, while the north-south section line road which passes through Niles roughly defines the drainage boundary of the east side of the study area. The area studied is located in T11S, R10E in Sections 3, 4, 5, 8, 9, 16, and 17.

Creeks in the canyons on the south side of the South Canadian River flow northward, entering the river at more or less right angles. Therefore, that part of the Water Canyon complex, which was designated as the Main stream, flows from the very north central part of Section 16 north to the Moss Grove School bridge and on to the South Canadian River. There are four major branches in the complex.

There are two major types of canyons in the Caddo Canyons. Previously excavated, stabilized canyons with deep sheer walls, little erosion, and mature trees are the first type. Water Canyon Branch is an example of this type. Other examples are the Red Rock Canyon State Park and Devils Canyon. The other type of canyon is characterized by recent rapid erosion, having been excavated to depths of as much as 100 feet (30 m) starting in 1932. With slump, unstable slopes, and young trees, Activity Canyon Branch represents this type.

This research was done from September 1959 to September 1960. Specimens are deposited in the Bebb Herbarium at the University of Oklahoma, Norman, Oklahoma.

[Portions of Water Branch, as well as the main canyon, now have dams, including the northeast corner of Sec. 4. Google Maps (Niles Cemetery, Canadian, Oklahoma) shows the upland vegetation strongly contrasts with the mesic vegetation in the canyons which are dark green.]

GEOLOGY

Canyon Formation

The canyons are cut in the Whitehorse Formation of late Permian age (270-250 million years ago). The upper member, Rush Springs sandstone, is a poorly cemented and very friable rock with much cross-bedding. It varies from 160 to 300 feet (48 to 91 m) in thickness. The lower Marlow member in its upper part is composed of red brick shale with bands of white sand, sandy gypsum, and thin beds of dolomite. It is approximately 120 feet (36 m) thick. The box heads and upper canyons are cut in the Rush Springs sandstone; the lower parts farther downstream 1.5 to 3 miles (2.4 to 4.8 km) are cut in the Marlow member. The general widening into rounded valleys is due in part to the Marlow member being more easily eroded.

The origin of the canyons is not completely known. They are believed to have formed after the creation of the South Canadian River, which controls the water gradient of drainage in the area. In road cuts along State Highway 37, rounded quartzite pebbles form a layer at about the 1600 foot (480 m) contour level. This pebbly deposit is believed to have been laid down by the ancestral Canadian River during the early part of the Pleistocene. Since that time, the river has moved 4 miles (6.4 km) north of this locality and has cut down about 300 feet (480 km). The highest elevation in the study area is slightly over 1700 feet (510 m) and the lowest point is approximately 1380 feet (415 m) at the stream near Moss Grove School bridge 3 miles (4.8 km) away. Rough calculations from the topographic map

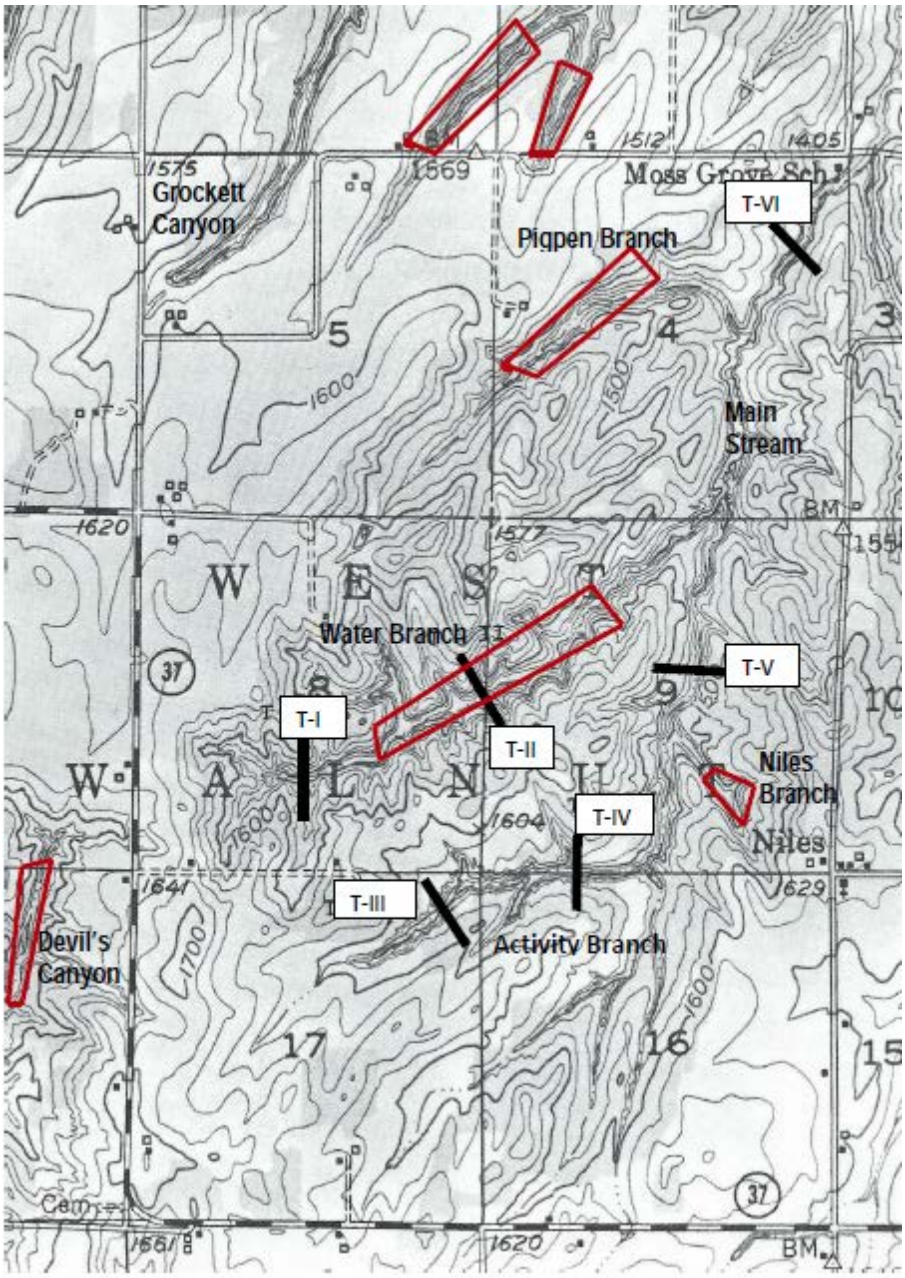

Figure 1 Canyon Transect Locations. Binger Quadrangle map, 1951. U.S. Geological Survey. Black lines indicate *Transects I* through *VI*. Red outlines indicate sugar maple habitats.

indicate the gradient of the stream bed from the head of Water Branch to Moss Grove is about 80 feet per mile (24 m per 1.6 km). It is thought that four cycles of cutting occurred in relation to the ice ages (one million to 12, 000 years ago).

Norris (1951) suggests that rounded valleys were cut during the Nebraskan glaciations, with the box heads appearing during the Kansan. During the Illinoian stage of glaciations, the old canyons were widened and cut deeper. [Suneson and Johnson (1996) suggest the colder wetter glaciation periods produced permanent streams with waterfalls cutting back the box heads, and interglacial periods were a time of filling with sediment.]

Norris reports finding a sediment filled canyon. Once one is familiar with the area, other non-eroded canyons can be identified. The forested slopes indicate that erosion in most exposed canyons is currently slow. Several exceptions occur, among which are Activity Branch and Grokett Canyon. Here, rapid re-excavation has occurred since 1932. Before this time, small ravines marked the drainage channel. Mr. Frank Hagen states he drove lumber wagons across Grokett Canyon on a road which followed the entire north side of Section 5 (see Figure 1) as late as 1925. There is no record of a bridge. This location is about one-third mile downstream from the present box head, and the sheer walls of the canyon are over 70 feet (21 m) in height.

Activity Branch began its extensive erosion May 31, 1932, when a reported 15 inches (38.1 cm) of rain fell in the area within 12 hours. This was followed by a week of extremely rainy weather. Here too, almost one-half mile of ravine was eroded and re-excavated back to bedrock canyon. The drainage area had been cleared, recently plowed, and planted to cotton just prior to the rainy period. This increased runoff of the drainage area and the increase in the amount of sediment carried by the stream has affected the topography of the main stream. At Moss Grove, a bridge 25 feet (7.5 m) in height is now necessary to cross the stream. Local inhabitants report that upstream a 6 foot (1.8 m) fence was buried under sediment in less than 5 years.

Sedimentation and Fossils

Norris (1951) reports that the sedimentary fill in the canyons is composed of rather uniform particles. Close examination of the sandstone bedrock shows it too is composed of similar particles. It can thus be concluded that the sandstone bedrock was formed from wind deposited material, and that the fill in the canyons resulted from water deposition of the weathered parent rock. Various means were employed to date the sediments in certain areas. Fragile snail specimens were collected from various locations in several canyons. Dr. Branley Branson (Kansas State College) was kind enough to identify all specimens collected. Two snail species dated as sub-recent to sub-Pleistocene were identified as *Mesodon* sp. and *Viviparus* sp. These forms are characteristic of the more mesic forests in the eastern United States. Other species dated this age were *Helisoma triavolvis*, *Lymnaea bulimoides*, *Gyralus parvus*, and *Succinea avara*. Dated as recent forms were *Zonotoides arboreus*, *Polygyra stenotrema*, *Monodon aliciae*, *Physa anatina*, *P. halei*, and *Helicodiscus parallelus*. [These investigations were later published by Branson, Taylor, and Taylor (1962, 1982).]

Soil samples taken near the box head of Niles Branch were analyzed for pollen. Each sample was collected 6 inches (15.24 cm) into the slope at 5 feet (1.5 m) intervals vertically. The first sample was taken about one foot above the stream bed; the last sample was taken about 2 feet (0.6m) below the rim. Care was taken to avoid contaminating samples with surrounding soil that might have been washed down from the top. All samples were found to contain fossil pine pollen, *Pinus* sp. The nearest stands of pine growing naturally in

Oklahoma are the shortleaf pine, *Pinus echinata* Mill., found near Coalgate, about 150 miles (240 km) southeast of the study site. Grass and oak pollen were also abundant. Dr. L. R. Wilson, Oklahoma Geological Survey, University of Oklahoma, made the analysis.

Near the junction of Niles Branch and the main stream several fossil seeds were dug out of a 50 foot (15 m) sediment wall. Specimens were removed about 20 feet (6 m) above the base. The seeds are probably those of *Celtis occidentalis*. In the same layer with the seeds were several fingernail clam shells in the Order Sphaeriidae. Species could not be determined.

A buffalo (*Bison bison)* molar was also found in this general area, and along the main stream a buffalo skull was dug out of a sediment wall. The specimen was located about 27 feet (8.1 m) from the base of a 40 foot (12 m) wall. Soil around the specimen was very firm, while the skull itself was extremely fragile. The probable age is late Wisconsin.

CLIMATE

Since the soils in the area are all derived from sandstone, the controlling factors for vegetation were topography and climate. The hot dry winds of summer are important in limiting the western extent of species. Maximum precipitation occurs during the spring and summer months. In this section, a large portion of the spring rains come during violent storms from the southwest. Much of the torrential rain water is lost in runoff despite the porous, sandy soil. Such rains are significant in erosion of the canyon sediments, particularly where vegetative cover is sparse.

Weather data since 1912 are available for Geary, Blaine County, Oklahoma which is about 14 miles (23.3 km) north. The table below gives the monthly average rainfall in inches and average temperature for the Geary Station. Averages are U.S. Weather Bureau data taken from 1931 to 1952.

The averages are given for a period of erratic rainfall that includes the drought period of the early thirties. The temperature during the summer frequently surpasses 100 degrees F (37.7 degrees C), though winter temperatures rarely go below zero degrees.

Rice (1960) studied the microclimate of a sugar maple stand in Devils Canyon located about one-half mile (0.8 km) west of the study area. This canyon drains into the Washita River. Data were collected from April to November of 1958. He compared the microclimate inside the canyon with that above the rim. Data were obtained during a relatively wet year, the precipitation being about twice the average during the summer months. Rice found that the average daily air temperature was consistently higher at stations located outside and just above the canyon as was the average daily air movement, which was from 3.5 to 15 times higher outside. After the first week in May, the average daily relative humidity was consistently higher at stations located within the canyon. The precipitation/evaporation ratio in the canyon was about 1:1; whereas, it was about 1:3 outside the canyon. Average soil temperature was also higher outside. These differences emphasize the more mesic environment in the bottom of the canyons as compared with the upland areas. Differences were greatest during hot, dry periods.

Sugar maple (*Acer saccharum)* has thus been able to retain numerous populations in the canyons as hot and dry conditions have eliminated this species from all but very eastern Oklahoma.

Table Average Monthly Rainfall (in.) and Average Temperature (°F)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	total
in.	1.23	1.17	1.63	2.87	4.14	3.89	2.14	2.66	3.03	1.91	1.50	1.34	27.51
°F	38.3	42.0	49.8	60.0	68.5	78.5	83.4	83.2	74.6	64.4	49.4	40.8	61.1

GENERAL VEGETATION OF THE AREA

According to the Duck and Fletcher Game Type Map of Oklahoma (1943), the two major vegetation types occurring in the area are the Tall Grass Prairie and Oak Woodlands. Due to the extensive cultivation of the upland area, its general appearance is that of Mixed Grasses. Among the more abundant species found here are western ragweed (*Ambrosia psilostachya*), little blue stem (*Schizachrium scoparium* var. *scoparium*), fall witch grass (*Digitaria cognata*), triple awn grass (*Aristida oligantha*), hairy grama (*Bouteloua hirsuta*), and Indian grass (*Sorghastrum nutans*).

On the more thinly soiled, steeper slopes not cleared for cultivation is found red cedar (*Juniperus virginiana),* blackjack oak (*Quercus marilandica*), and some post oak (*Q. stellata*). There, open savannahs become scrubby forests in places. The major grasses which grow in the savannah area are those listed above, particularly the triple awn grass and hairy grama. Prickly pear cactus (*Opuntia* sp.) is a prominent savannah species. The sheer walls of the canyon, especially on the north facing side, are frequently covered with mosses and lichens, depending on how long they have been exposed. The talus slopes of the stable canyons support a forest vegetation: sugar maple (*Acer saccharum*), hackberry (*Celtis* spp.), black walnut (*Juglans nigra*), chinkapin oak (*Quercus muehlenbergii*), bur oak (*Q. macrocarpa*), Shumard's oak (*Q. shumardii*), and American elm (*Ulmus americana*). An understory of redbud (*Cercis canadensis*), rough-leaved dogwood (*Cornus drummondii*), coralberry (*Symphoricarpos orbiculatus*), poison ivy (*Toxicodendron radicans* spp. *radicans*), and greenbriar (*Smilax* spp.) is to be found. The floor of the canyons have these same species, with slippery elm (*Ulmus rubra*) and blackhaw (*Viburnum rufidulum*) characteristically occurring. The stream is generally without vascular forms of aquatic vegetation.

Species occurring on the newly formed talus slopes were noted to come from two major sources. The first was the expansion of the clumps of vegetation which were not covered by soil when the slope or wall collapsed; these clumps usually occurred on the top of the slope. The second source of species was seed dispersal from plants growing in the area. The more stable and older slopes are covered by tall grass prairie species, the major species being little blue stem and Indian grass, with smooth sumac (*Rhus glabra*) and coralberry represented by scattered individuals. The bottoms of the actively eroding canyons, particularly in the upper end, are occupied by cottonwood (*Populus deltoids*) and black willow (*Salix nigra*), with some sandbar willow (*S. interior*). Downstream where less severe erosion has occurred, red cedar and chinkapin oak are predominant on the talus slopes and the floor, with Shumard's oak being common. The stream edges support stands of cattail (*Typha* sp.) and horsetail (*Equisetum* sp.).

The canyon complex, midway from its box canyon head to the floodplain, is characterized by much lower rims. The walls are soil and are rarely over 50 feet in height, being generally about 30 feet high, with severe erosion occurring. Deposition of

material in the stream is continuous. The trees on this flat floodplain are box elder (*Acer negundo* var. *texanum*), cottonwood, black willow, and American elm. Water speedwell (*Veronica anagallis-aquatica*) and members of the Cyperaceae are present along the stream edge and in other permanently moist areas.

DISJUNCT SPECIES

The accepted explanation for the presence of disjunct species in western Oklahoma is the relict vegetation theory. This theory proposes that at one time middle and western Oklahoma had a wetter climate, enabling the eastern maple forest to grow naturally throughout the state. As the climate became dryer and dryer, the western boundary of the distribution range of some species moved eastward.

In the Caddo Canyon area, the more mesic conditions of the canyons enabled the disjunct species to survive generation after generation. The presence of a number of disjunct herbaceous species seems to rule out chance seed dissemination to the area. The presence of pine pollen and fossil snails all tend to support the theory. Some of the canyons in the area would have to have been excavated at the time the more mesic vegetation receded or the habitat would not have been available for the survival of the disjunct species.

Sugar maple is the most obvious of the disjunct species. It has a rather large distribution—from Blaine County just north of Bridgeport to south of Binger in Caddo County, and from just west of Hinton to its eastward extension in Canadian County north of Cogar in the Cedar Lake Sportsman Club area. In only one location in the study area did maple become dominant, although it was a common tree in some areas. Figure 1 shows that the maples are found in three branches of Water Canyon, becoming dominant in Water Branch about halfway downstream from the head of the box canyon. In the head of the Niles Branch box canyon, sugar maple trees are distributed from the stream edge to the canyon rim. Trees at the latter location are small. No trees were of the large diameter reported by Little (1939). Several core samples were taken from sugar maple trees at a height of four feet. Many had rotten centers. Tentative identification of the disease is brown checked wood rot caused by *Polyporus sulphureus*. The year this study was done, no seeds were produced by the maple trees. An attempt was made to dig up several young trees, and it was found that they were attached by underground rootstock to the larger parent tree nearby.

A specimen of sugar maple from Blaine County was not collected, as the tree was discovered during the winter. It is located just northeast of the center of Sec. 17, T13N, R11W. This tree is growing on the upper half of the talus slope in a rather rounded canyon. The presence of maples on the rim or near it might suggest that they are fairly drought resistant.

There is one strong piece of evidence that suggests that the Caddo Canyon sugar maple might possibly be a different biotype than the eastern maples. On Oct. 3, 1954, Dr. G.J. Goodman, University of Oklahoma, made a trip to the Noble Nursery at Noble, Cleveland County, Oklahoma, where he collected specimens from two rows of sugar maple trees. One of the rows had been grown from stock obtained from an eastern nursery, while the other row had been grown from seeds collected in the canyons. The sun-scorched and dried leaves of the eastern maple were quite striking in comparison with the Caddo sugar maple. Dr. Goodman states that the difference between the rows of trees was much more striking than is indicated by the specimens. The collections, Goodman 6012 and 6013, are deposited in the Bebb Herbarium, University of Oklahoma, Norman, Oklahoma. Survival of the sugar maples in the canyons may be due partially

to the fact that they are a more drought resistant biotype than those that grow in eastern Oklahoma.

The disjunct species of coralroot (*Corallorhiza wisteriana*) was collected for the second time. This saprophytic orchid is a member of the more mesic eastern Oklahoma forests.

One of the most interesting disjunct species collected was figwort (*Scrophularia lanceolata*). It is reported to be present also in the Wichita Mountains. Identification of a duplicate specimen (Stevens No. 923) was made by Pennell and was cited in his work (Pennell 1935) on the Scrophulariaceae of the eastern temperate section of North America.

Other disjunct species which occur in the Caddo Canyon area are deertongue panicum (*Dichanthelium clandestinum*), woodnettle (*Laportea canadensis*), bonewort (*Cryptotaenia canadensis*), aniseroot (*Osmorhiza longistylis* var. *villicaulis*), fragrant bedstraw (*Galium triflorum*), daisy fleabane (*Erigeron annuus*), enchanter's nightshade (*Circaea lutetiana* ssp. c*anadensis*), and purple-leaved willow weed (*Epilobium coloratum*). The only collections of *E. coloratum* from the state are from the canyon area. Hackberry (*Celtis occidentalis*) is also disjunct; however, specimens have been collected from Custer County, farther west. Many species reach their western limit in the canyon area, and these are usually found growing in the stable type canyons.

One specimen of dwarf prairie willow (*Salix humilis*) [later corrected to *Salix exigua*] was collected. Verification of the identification of this specimen, as well as that of a specimen tentatively identified as slender muhly (*Muhlenbergia tenuiflora*) [later corrected to *Muhlenbergia sobolifera*], will add two more species to the list of disjuncts.

Although eastern redcedar (*Juniperus virginiana*) is not disjunct, its distribution in the area has had an interesting history. The local inhabitants of the area remember few redcedar occurring when they first settled the land in 1902. At the present time [1960], it is one of the most abundant and widely distributed species, occurring in almost all habitats. There are a number of very old trees, but most trees are small, young individuals. [Continued expansion of populations is such that in 2013, redcedar is considered a nuisance tree by the State of Oklahoma.]

HABITATS

The habitats described below all have distinctive vegetation types or species which are characteristic. One may delineate the habitats vertically from rim of canyon to stream edge in the bottom and horizontally from the box head to the Canadian River floodplain. They may also be separated into two distinct types. Niles, Water, and Pigpen Branches represent the first type of canyon where very little erosion is taking place at the present time [1960]. They may be described as stable. Activity Branch is an example of the second type which is characterized by rapid erosion that has resulted in the recent excavation of the sediment in the upper end of a previously filled bedrock canyon.

The vegetation growing in the habitats along the main stream is similar to the second or recently excavated type. Habitat locations are discussed below with the use of six transects taken across the canyon branches at various positions from the box head to the floodplain. Transect locations are indicated on the study area topographic map (see Figure 1). Distribution of species within the habitats of the transects are found in the Appendix.

Water Branch illustrates the typical habitats of the stable type canyons. *Transect I* (Figure 2) is taken at the box head where two habitats may be distinguished: the canyon floor (a) and the plunge pool-seep area (b). *Transect II* (Figure 3) is taken about one-half mile from the box head and is typical of most of the branch. Sheer

bedrock walls typical of *Transect I* are also present as a result of the stream meandering from wall to wall eroding sediment away from the bedrock walls. Major habitats that were collected here are: the north and south facing slopes of sediment remnants (a), the floor of the canyon (b), and the stream edge (c).

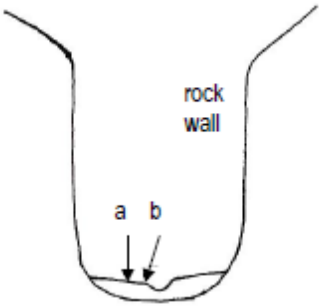

Figure 2 *Transect I* (T-I)
Water Branch's stable box head
a floor
b plunge pool-seep area

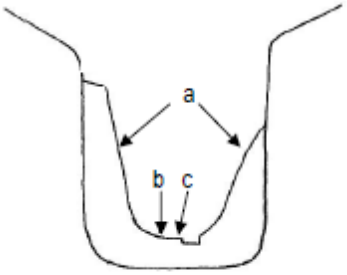

Figure 3 *Transect II* (T-II)
One-half mile downstream from Water Branch's stable box head
a talus slopes
b floor
c stream edge

Activity Branch represents the rapidly eroding type of canyon. The upper half of the canyon is more eroded than the lower end. *Transect III* (Figure 4), taken about one-fourth mile down from the box head, shows the following habitats: extensive north (a) and south (b) facing talus slopes, which are continuously changing; floor of the canyon (c,) where deposition of sediment is common; and the stream edge (d,) which is frequently inundated. The sheer bedrock walls were recently exposed by erosion. The curve of the canyon from a slight southwest-northeast direction to a west-east direction has caused the stream to flow on the north side of the floor. Thus, a large portion of the remnant fill has eroded away on this side, exposing more of the wall. The slopes themselves are continually slumping, the sediment sliding into the stream bed. This causes a frequent change in the stream course. These habitats, exclusive of the slopes, occupy the box head area.

Transect IV (Figure 5), taken about three-quarters of a mile from the box head of Activity Branch, has habitats in the lower part where less erosion has occurred. Habitats include the north and south facing talus slopes (a), the floor of the canyon (b), and the stream edge (c). The rim is not as high above the canyon floor, and the width is slightly greater.

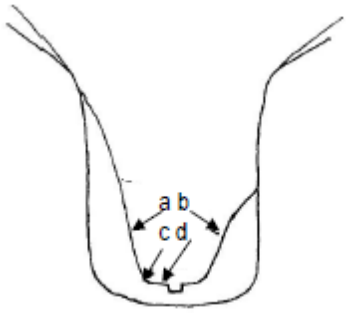

Figure 4 *Transect III* (T-III)
Upper half of Activity Branch's rapidly eroding canyon one-fourth mile downstream from its box head
a south facing talus slope
b north facing talus slope
c canyon floor
d stream edge

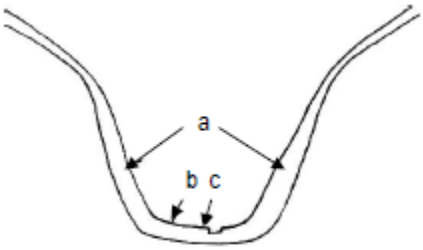

Figure 5 *Transect IV* (T-IV)
Lower half of Activity Branch canyon three-quarters mile from its box head
a talus slopes
b floor
c stream edge

Transect V (Figure 6) is taken along the main stream of the drainage between Niles Branch and Water Branch junction. The bedrock form in this area is probably of an older cutting cycle than that of Activity Branch, and the upper level habitat was probably at one time the bottom of the canyon. During the next cutting cycle, the channeling of water would have caused a new inner canyon to develop in the old canyon. As erosion developed this new inner canyon, the walls of the older canyon were rounded and the floor widened. Then the entire canyon complex was probably filled with sediment. The form of the topography at present is the result of geologically recent erosion. Habitats in this transect are: upper slopes (a), in which the sheer rock walls may reach a height of 50 feet (15 m); the slump slopes (b), resulting from the sediment not yet removed by erosion; the floor (c); and stream edge (d).

Transect VI (Figure 7), taken at the north end of the study area near the Moss Grove School site, shows later development of the previous profile. Here the canyon proper is wider than its approximately 35 foot (10.5 m) depth. The upper level has developed into an extensive flat area which is cultivated and grazed. For this reason it was not studied. From the rim there are stable slopes (a) into the canyon, and at one time the local inhabitants crossed without the need of a bridge. The meandering of the stream from one side of its bed to another has cut into these slopes and produced, in many places, sheer sediment walls which are continuously collapsing into slump slopes (b) above the floor (c) and stream edge (d). Not studied was one small area that was commonly covered with a few inches of standing water. It was the only marsh type habitat noted.

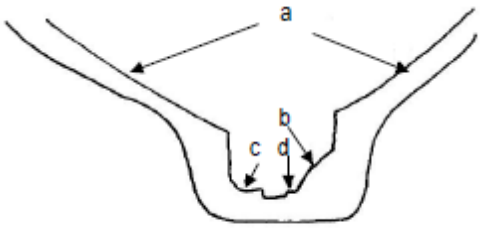

Figure 6 *Transect V* (T-V)
Main upper canyon between its Niles and Water Branch junctions
a upper slope
b slump slopes
c floor
d stream edge

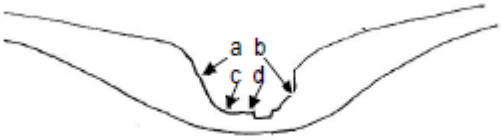

Figure 7 *Transect VI* (T-VI)
Main lower canyon downstream from its Water Branch junction
a stable slopes
b slump slope
c floor
d stream edge

VEGETATION OF HABITATS

***Transect I* – Across the box head of Water Branch** (See Figure 2)

The north and west facing sheer bedrock walls are almost continuously shaded and are covered with lichens and liverworts. Dry as this habitat may be, after rains, when the air is very humid, the walls take on a definite green hue. In some places, the wall has a narrow ledge where the most important species are grasses.

Virginia creeper (*Parthenocissus virginiana)* and poison ivy (*Toxicodendron radicans*) climb the walls to considerable heights. The ferns found in crevices and at the base of the wall are lady fern (*Asplenium* sp.), Eaton's lipfern (*Cheilanthes castanea*), purple cliff break (*Pellaea atropurpurea*), and blunt lobed cliff fern (*Woodsia obtuse*). Little (1939) states that *Reboulia hemisphaerica* is the common liverwort in the shaded moist areas. The south facing sheer bedrock walls receive considerable sun and vegetation is sparse. Near the base of the cliff where the walls are shaded by trees, the species are the same as those listed above.

The plunge pool-seep area has two major divisions. On the walls of the seep area, which are moist at all times, *Conocephalum conicum* is common. Ferns, such as common bladder fern (*Cystopteris fragilis)*, may be found. These areas are almost continually shaded, and where there is enough soil for herbaceous plants, the following species are found which are characteristic of the seep habitat (see Appendix). These are hairyseed paspalum (*Paspalum pubiflorum* var. *glabrum*), fragrant bedstraw (*Galium triflorum)*, small flower brookweed (*Samolus parviflorus)*, and water speedwell (*Veronica anagallis-aquatica)*, the latter not being restricted to the seep area. The plunge pool at the base of the cliffs where stream runoff comes over the rim does not have aquatic or wetland vegetation zonation, probably due to the fluctuation of the water level.

The floor at the base of the canyon extends to the base of the walls. Many of the species found on the slopes and in the more shaded parts of the canyon are present here. However, the trees are young without dense forest canopy, allowing denser growth of understory plants. Here, greenbriar (*Smilax* sp.) and poison ivy make passage very difficult. Chinkapin oak (*Quercus muhlenbergii*), American elm (*Ulmus americana),* and redcedar (*Juniperus virginiana*) are the common trees. The forenamed vines and grape (*Vitis* spp.), which climb the wall, are extensive. Species which grow here are not only those of the shaded slopes, but many upland grasses such as bluestem (*Schizachrium* sp.) and grama grass (*Bouteloua* spp.) are found less extensively.

***Transect II* – One-half mile down from Water Branch box head** (See Figure 3)

The walls in *Transect II* are similar to the walls at the box head. The talus slope generally slants up at an angle of over 60 degrees, but the dense vegetative cover is a great deterrent to erosion. In places where a path has been made up the slope, deep ruts are now present.

The vegetation of the slopes are variable, determined by degree of slope, age, and soil stabilization. The major woody plants are American elm, chinkapin oak, bur oak (*Quercus macrocarpa*), Shumard's oak (*Q. shumardii*), redcedar, netleaf hackberry (*Celtis reticulata*), sugar maple (*Acer saccharum*), and black walnut (*Juglans nigra*). Major understory species are redbud (*Cercis canadensis*), rough leaf dogwood (*Cornus drummondii*), elbowbush (*Forestiera pubescens*), and coralberry (*Symphoricarpos orbiculatus*). Virginia wild rye (*Elmus virginicus*) seemed to be the most common grass in the less densely shaded areas. Herbaceous species were limited in number, the most common being the sedge (*Carex artitecta*) and Missouri violet (*Viola missouriensis*). The ground had a very dense covering of mosses, the major species being *Mnium cuspidatum*. No attempt

was made to identify the bryophytes. Little (1935) gives a fairly comprehensive list of the species of this group and the Pteridophytes which occur in the Caddo Canyon area.

There are several differences in the north and south facing slopes. The species are the same, but the south facing side has a slightly thinner tree canopy, particularly near the rim, and the density of shrubs and herbs is slightly greater. The major difference was the number and abundance of upland species which could be found on the upper slopes of the canyons right below the rim. As is expected, both number and abundance were greater for the south facing side. I have included many of the upland species which grow in this area and have indicated them with a "u" (see Appendix). It was interesting to note that many of the upland species found here were not found in other places throughout the canyon complex. Many of these species were collected in the few areas along the slopes where there is slight erosion or in clearings.

The floors of the stable type canyons supported almost all species present in the slope habitats. They contained many species not found on the slopes, including hackberry (*Celtis occidentalis*), white mulberry (*Morus alba*), red mulberry (*M. rubra*), green ash (*Fraxinus pennsylvanica*), and slippery elm (*Ulmus rubra*). Shrubs such as blackhaw (*Viburnum rufidulum*) and wahoo (*Euonymus atropurpurea*) were mostly limited to this habitat, while both greenbriar and Virginia creeper were usually on the more level grounds. Grasses found only in this locality were stout woodreed (C*inna arundinacea*) and slender muhly (*Muhlenbergia tenuiflora*). When the upland species found on the slopes are not taken into consideration, the number of herbaceous species was greater for this habitat. Some of the more common herbs included green dragon (*Arisaema dracontium*), day-flower (*Commelina erecta*), and white avens (*Geum canadense*).

The stream itself was generally one to three feet below the general canyon floor. Among the characteristic species of the stream edge were coralroot orchid (*Corallorhiza wisteriana*), veiny pepperweed (*Lepidium oblongum*), bloodleaf (*Iresine rhizomatosa*), richweed (*Pilia pumila*), false nettle (*Boehmeria cylindrica*), elephant's foot (*Elephantopus carolinianus*), and inland sea oats (*Chasmanthium latifolium*) which reached its greatest development here.

Transect III **– Upper end of Activity Branch** (See Figure 4)

The box head of Activity Branch does not contain any distinct vegetation types. The recent exposure of the canyon bedrock walls is the reason for the limited development of the liverwort population. The talus slopes here have only been recently formed, and many are not stabilized. Some are presently being held by a rather dense grassland cover, as trees are absent or rare on the slopes. The north facing slope supports more mesic vegetation than the south facing slope. Major grasses are little bluestem (*Schizachrium scoparium*), Indian grass (*Sorghastrum nutans*), knotroot bristlegrass (*Setaria parviflora*), little barley (*Hordeum pusillum*), and others. The major grasses of the south facing talus slopes are bluestems in lesser quantity with purpletop (*Tridens flavus*) dominant in some localities. Species composition depends on the age of the slope.

The floor of the area near the box head is dominated by cottonwoods (*Populus deltoids*) about 25 years of age and by both sandbar and black willows (*Salix exigua* and *S. nigra*). It was noted that the sandbar willow was more abundant on the lower part of the talus slope than in the level bottom. In this canyon as well as in the others, the vegetation of the floor tends to extend up the bottom of the talus slope until the incline becomes steeper than 45 degrees. The extensive erosion of sediment from the drainage area above the canyon

and from the slopes has resulted in the deposition of sediment in the stream, burying the bases of the cottonwoods and willows. Here, during the spring, large portions of the canyon bottom are inundated. Farther downstream, Indian cigar tree (*Catalpa speciosa*) is abundant with a few elm trees. Many cedar trees only 4 feet (1.3 m) in height or less are dead, probably from inundation. Both poison ivy and greenbriar are present, but not to great extent. Barnyard grass (*Echinochloa crus-galli*) and water speedwell are present, but cattail (*Typha latifolia*) and horsetail (*Equisetum hyemale*) are the more abundant species of the stream edge.

***Transect IV*– Lower part of Activity Branch** (See Figure 5)

In this area of less erosion, the talus slopes are forested. The major woody species include red cedar and chinkapin oak, with Shumard's oak occurring frequently. Blackjack oak (*Quercus marilandica*) is also present. Coralberry is the common shrub, and bluestem and grama grasses are present in sunny spots. These slopes support a forest which is transitional between the upland forests and the more mesic forests of the box head area of the stable type canyons. The floor is not densely wooded, and greenbriar and bluestem cover most parts. The increased amount of water flowing through the stream, as well as the effect of deposition, cause the stream edge to closely resemble that of the upper end of the branch. Species which are most common along the stream edge are cattail and horsetail.

***Transect V*– Across the main stream and canyon** (See Figure 6)

The main stream has forest occurring on the upper level. Species here are generally the same as those of the slopes of Water Branch, but sugar maple is absent, and Shumard's oak is the predominant species along with chinkapin oak and American elm. The canopy is such that most of the shrubs are on the slope. Common are rough leaf dogwood, elbowbush, some blackhaw (*Viburnum rufidulum*), and coralberry. The moss ground cover is not as thick as that of the slopes of Water Branch. Herbaceous species are the same, but are few in number in comparison to the other habitats.

Along the main stream, the upper level begins to slope upward to the upland, and the more mesic oak forest gradually grades into the redcedar – blackjack oak shrub savannah characteristic of the less protected areas. In some places, the upper level slopes downward to the stream, but this is infrequent, as the sediment-carrying stream has caused extensive cutting, which in turn has produced sheer walls. The stream meanders from side to side and cuts under the walls, causing frequent collapsing with production of slump slopes. The common species of these recently produced slopes depend in part on the composition of species growing on the top before it collapsed. Other species include sandbur (*Cenchrus spinifex*), hairy grama (*Bouteloua hirsuta*), Canada wild rye (*Elmus canadensis*), sixweeks fescue grass (*Vulpia octoflora*), and little barley (*Hordeum pusillum*). Also, little bluestem is frequently found here. Woody species, such as smooth sumac (*Rhus glabra*) and coralberry, are present on the older slopes. Herbs include *Croton* spp., Wild buckwheat (*Eriogonum annuum*), white sweetclover (*Melilotus alba*), and yellow sweetclover (*M. officinalis*). It is felt that the list of species occurring in this habitat is not complete.

Woody species on the floor include hackberry, *Celtis* spp., green ash, Kentucky coffeebean (*Gymnocladus dioica*), chinkapin oak, Shumard's oak, and Indian cigar tree. These trees are widely scattered, and the floor habitat itself is quite narrow due to the wide stream edge where black willow is abundant. Occurring along the stream edge

with black willow is water speedwell, cattail, and horsetail.

***Transect VI* – near the Moss Grove School site** (See Figure 7)

Here, stable slopes around 35 feet (10.7 m) in height are common. Woody species are box elder (*Acer negundo*), redbud, redcedar, American elm with rough leaf dogwood, smooth sumac, and coralberry. Trees are widely spaced, and in the sunny areas one finds rescue grass (*Bromus catharticus*), Japanese brome (*B. arvensis*), Canada brome (*B. pubescens*), sixweeks fescue, and little barley (*Hordeum pusillum*), with various species of corydalis, croton, wild buckwheat, and sweet clover.

On the slump slopes, species present are characteristic of newly formed surfaces. These include water hemp (*Amaranthus tamariscinus*), toothcup (*Ammannia coccinea*), goosefoot (*Chenopodium hybridum*), carpetweed (*Mollugo verticillata*), and sandbur. The canyon floor is wider than the walls are high, and the meandering of the stream from side to side forms isolated spots of habitat. The trees occurring here are the same as those on the slopes, but box elder is more abundant. Cottonwood and black willow are common. Herbaceous species characteristic of this area are the grasses mentioned above for the stable slope plus Scribner's panic grass (*Dichanthelium oligosanthes* var. *scribnerianum*), meadow dropseed (*Sporobolus asper*), Venus looking glass (*Specularia holzingeri*), spurge (*Euphorbia heterophylla*), three-seed mercury (*Acalypha ostryaefolia*), salt marsh aster (*Aster exilis*), western ragweed (*Ambrosia psilostachya*), toothed spurge (*Euphorbia dentata*), and sweetclovers.

The stream edge is also wide at this location. Here also, frequent inundation and deposition of sediment occur. Horsetail and cattail are infrequent, with water speedwell being the more abundant species. In one isolated spot in the Moss Grove area there was a depression which was usually covered with water. Here several species occurred which were found nowhere else. They were fescue sedge (*Carex brevior*), slimpod rush (*Juncus diffusissimus*), one-flowered flatsedge (*Cyperus uniflorus*), dark green bulrush (*Scirpus pallidus*), swordgrass (*Scirpus americanus*), water speedwell, and barnyard grass which grew at the stream edge.

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation for the time and aid given by Dr. George J. Goodman, University of Oklahoma, in the identification of species found in the study area. Thanks also to Dr. William T. Penfound for his advice and guidance in the ecological aspect of the study. Dr. R. L. Wilson and Dr. D. B. Kitts, both of the University of Oklahoma, and Dr. Branley Branson, of Kansas State Teachers College, were most helpful in providing information about the classification of fossil forms found in the area.

Thanks is given to Mr. Frank Hagen, Mr. Ed Major, and Mr. F. Hienchel, all residents of the Hinton, Oklahoma area since 1902. They supplied much helpful information about the study area in the early nineteen hundreds.

My most sincere gratitude is expressed for the encouragement and moral support of my husband, John Taylor.

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APPENDIX

Species-Habitat List, Water Canyon, Canadian County, OK

In the following table the species are listed alphabetically within groups: Trees, Shrubs, Woody Vines, Grasses. Herbaceous species have been separated into groups: those found in the stable canyons and those characteristic of newly eroded canyons. Habitats are arranged by transects. The list may be considered the beginning of a complete species-habitat list for the canyon area and serve as an aid to others who wish to study the canyons.

x – present frequently, either evenly distributed as individuals or in occasional clumps.
s – species abundant in that habitat.
i – infrequent or rare. Used when only a few plants were found in several places or many individuals occurring in only one limited area.
u – indicates the species is normally a member of the upland communities but is occurring in the mesic woods of the stable type canyon.

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
TREES																				
Acer negundo L. var. *texanum* Pax				i	x			x							x		s		s	x
Acer saccharum Marshall			x	x	i															
Catalpa speciosa (Warder) Warder ex Engelm.					x			x	x		x	x			x	x			x	x
Celtis laevigata Willd. var. *texana* Sarg.			x										x		x					
Celtis occidentalis L.				x																
Celtis reticulata Torr.			x					x												
Cercis canadensis L.	x		x	x						x	x		x				x		x	
Fraxinus pennsylvanica Marshall				x	x			x				x			x				x	
Gymnocladus dioicus (L.) K. Koch			x	x											x					
Juglans nigra L.			x	x																
Juniperus virginiana L.	x		x	x				x		s	x		x		x		x		x	
Maclura pomifera (Raf.) C.K. Schneid.																				
Morus alba L.				x																
Morus rubra L.				x																
Populus deltoids Marshall								s							i				s	
Prunus mexicana Watson																	x			
Quercus macrocarpa Michx.			x	x						x			x							
Quercus marilandica Münchh.			u							u			u							

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Quercus muehlenbergii Engelm.	s		x	x						s	u		x		x					
Quercus shumardii Buckley			x	x						x			s		x					
Quercus stellata Wangenh.			u							u			u							
Robinia pseudoacacia L.								x												
Salix humilis Marshall															i					
Salix interior Rowlee								s	s						s	s			x	x
Salix nigra Marshall	i							s	s						s	s			x	x
Sapindus saponaria L. var. *drummondii* (Hook & Arn.) L.D. Benson			i																	
Sideroxylon lanuginosum Michx.			x	x						x			x							
Ulmus americana L.	x		s		x			i		x			x				x		x	
Ulmus rubra Muhl.				x																
SHRUBS																				
Aesculus glabra Willd. var. *glabra*			u	u									u							
Cephalanthus occidentalis L.																			i	
Cornus drummondii C.A. Mey.	x		s	s							x		x				x			
Celastrus scandens L.			x																	
Euonymus atropurpureus Jacq.				x	x					x							x			
Forestiera pubescens Nutt.	x		s	s				i		x			x							
Rhus glabra L.						i	i			x	x		x	x	x		x	x	x	
Ribes aureum Pursh var. *villosum* DC.			x	x	x															
Sambucus nigra L. ssp. *canadensis* (L.) R. Bolli			x	x									x				x			
Symphoricarpos orbiculatus Moench	x		x	x		i	i	x		x	x		x	i	x		x		x	
Tamarix gallica L.								x							x				x	
Viburnum rufidulum Raf.			i	s						x	x		x							
VINES																				
Campsis radicans (L.) Seem. ex Bureau															i				i	
Cissus trifoliata (L.) L.																				
Cocculus carolinus (L.) DC.			x	x	x								x							
Melothria pendula L.																	i			
Menispermum canadense L.			x	x																
Parthenocissus quinquefolia (L.) Planch.	x		x	x							x		x				x		x	

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Passiflora lutea L. var. *glabrifolia* Fernald			i																	
Smilax bona-nox L.	s		x	s				i			x		x		i					
Smilax tamnoides L.			x	x																
Toxicodendron radicans (L.) Kuntze	s		s	s				i			i						i			
Vitis acerifolia Raf.																			i	
Vitis vulpina L.	x		x																x	
GRASSES																				
Aristida oligantha Michx.							i	i						i			i	i		
Bothriochloa saccharoides (Sw.) Rydb.						x														
Bouteloua curtipendula (Michx.) Torr.						i	i							i			i	i		
Bouteloua gracilis (Willd.) ex Kunth						i	i							i			i	i		
Bouteloua hirsuta Lag.						x	x							x			x	x		
Bromus arvensis L.				u		x	x							x			x	x		
Bromus catharticus Vahl			u											x			x	x		
Bromus pubescens Muhl. ex Willd.			x	x		x	x							x			s	x	x	
Bromus tectorum L.			u														s			
Cenchrus spinifex Cav.						x	x							x	x		i	x	x	
Chasmanthium latifolium (Michx.) Yates			x	x	s															
Cinna arundinacea L.				i																
Cynodon dactylon (L.) Pers.								x							x				x	
Dichanthelium clandestinum (L.) Gould	x																			
Dichanthelium oligosanthes (Schult.) Gould var. *scribnerianum* (Nash) Gould			u			x	x	x						x	x		x	x	x	
Digitaria sanguinalis (L.) Scop.																	x			
Echinochloa crus-galli (L.) Beauv.				i					x			x				x				x
Elymus canadensis L.						x	x							x			x	x	x	
Elymus virginicus L.	x		x	x																
Eragrostis capillaris (L.) Nees			u														x			
Eragrostis curvula (Schrad.) Nees														x			x	x		
Eragrostis secundiflora J. Presl ssp. *oxylepis* (Torr.) S.D. Koch			i														x			
Eragrostis sessilispica Buckley			u																	
Eragrostis trichodes (Nutt.) Alph. Wood														x						

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Hordeum pusillum Nutt.			u			x	x							x			s	x		
Leersia virginica Willd.		x																		
Melica nitens (Scribn.) Nutt. ex Piper																	i			
Muhlenbergia racemosa (Michx.) Britton			i	i			x										i	i		
Muhlenbergia tenuiflora (Willd.) Britton				i																
Panicum capillare L.															i					
Paspalum setaceum Michx.																			x	
Paspalum pubiflorum Rupr. ex Fourn.		x																		
Phalaris caroliniana Walter																	x			
Schizachrium scoparium (Michx.) Nash	i		i	i		s	i			i	x			x	x		x	x	x	
Setaria parviflora (Poir.) Kerguélen			x	x		x	x							x			x		x	
Sporobolus clandestinus (Biehler) Hitchc.															x					
Sporobolus cryptandrus (Torr.) A. Gray														x						
Tridens flavus (L.) Hitchc.						s	x							x	x					
Vulpia octoflora (Walter) Rydb. var. *octoflora*			u											x			x			
HERBS –- STABLE CANYONS																				
Acalypha virginica L.					i												i			
Antennaria plantaginifolia (L.) Richardson			x	x																
Arisaema dracontium (L.) Schott				x																
Boehmeria cylindrica (L.) Sw.				x	x											x				
Carex albicans Willd. ex Spreng var. *albicans*			s	s																
Carex blanda Dewey			x	x																
Carex brevior (Dewey) Mack.			x	x																
Commelina erecta L.				x																
Corallorhiza wisteriana Conrad					i															
Desmodium canadense (L.) DC.				x	x															
Desmodium glutinosum (Muhl. ex Willd.) Alph. Wood				x																
Desmodium perplexum B.G. Schub.			u																	
Draba brachycarpa Nutt. ex Torr. & A. Gray					i															
Elephantopus carolinianus Raeusch.				x	x															
Erigeron philadelphicus L.					x											i				

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Eupatorium coelestinum (L.) DC.				x																
Euphorbia glyptosperma (Engelm.) Small			u																	
Euphorbia heterophylla L.			x	x															x	
Galium aparine L.			x	x	x									x			x	x		
Galium triflorum Michx.		x			x															
Geum canadense Jacq. var. *canadense*				x					x		x									
Hackelia virginiana (L.) I.M.Johnst.			x	x																
Houstonia pusilla Schoepf			u																	
Iresine rhizomatosa Standl.					x															
Lepidium oblongum Small var. *oblongum*					x															
Lobelia cardinalis L.					x															
Monarda clinopodioides A. Gray			u																	
Myosotis verna Nutt.			u																	
Oxalis dillenii Jacq.			u																	
Palafoxia texana DC.				u																
Pediomelum digitatum (Nutt. ex Torr. & A. Gray) Isely			u																	
Penstemon laxiflorus Pennell			i																	
Phemeranthus parviflorum (Nutt.) Kiger			u																	
Pilea pumila (L.) A. Gray					x															
Plantago patagonica Jacq.			u																	
Polygonum virginianum L.				x																
Polygonatum biflorum (Walter) Elliott				x																
Portulaca oleracea L.			u																	
Pseudognaphalium obtusifolium (L.) Hilliard & B.L. Burtt spp. *obtusifolium*			i																	
Samolus valerandi L. ssp. *parviflorus* (Raf.) Hulten		x																		
Sanicula canadensis L. var. *canadensis*				x																
Scrophularia lanceolata Pursh				x																
Spermolepis echinata (Nutt. ex DC.) A. Heller			u																	
Stillingia sylvatica L.			u																	
Tradescantia occidentalis (Britt.) Smyth			i	i	i								i							

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Verbena urticifolia L.				x				x												
Viola missouriensis Greene			x	x	x															
HERBS – RECENT TYPE CANYON																				
Acalypha ostryifolia Riddell																			x	
Acalypha virginica L.					i														i	
Amaranthus tamariscinus (Moq.) Sauer																		x	x	
Ambrosia psilostachya DC.						x	x							x	x		x	x		
Ambrosia trifida L.						x	x	x						x	x		x	x	x	
Ammannia coccinea Rottb.																		x		
Androsace occidentalis Pursh			u										x				i			
Aphanostephus skirrobasis (DC.) Trel.						x	x							x	x		x	x	x	
Apios americana Medik.														i						
Apocynum cannabinum L.														x			x	x	x	x
Argemone polyanthemos (Fredde) G.B. Ownbey						x	x							x			x	x		
Asclepias verticillata L.			i				x								x					
Asparagus officinalis L.								i												
Bidens cernua L.																		x		
Carex emoryi Dewey															x					x
Cassia fasciculata (Michx.) Greene var. *fasciculata*						i	i										i			
Chamaesyce maculata (L.) Small														x			x			
Chenopodium album L.						x	x							x			x	x	x	
Chenopodium simplex (Torr.) Raf.																			x	
Chenopodium leptophyllum (Moq.) Nutt. ex S. Watson			u																	
Cirsium undulatum (Nutt.) Spreng. var. *undulatum*																		x		
Conyza canadensis (L.) Cronquist			u	i		x	x	x			x			x	x		x	x	x	
Corydalis curvisiliqua Engelm. ssp. *occidentalis* (Engelm. ex A. Gray) W.A. Weber						x	x										x			
Corydalis micrantha (Engel. Ex A. Gray) A. Gray																	x			x
Croton glandulosus L. var. *septentrionalis* Müll. Arg.														x	x		x		x	

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Croton lindheimerianus Scheele var. *lindheimerianus*			u			x	x							x			x			
Cucurbita foetidissima Kunth																	x			
Cyperus echinatus (L.) Alph. Wood			u																	x
Cyperus retroflexus Buckley																				x
Descurainia pinnata (Walter) Britton			u		x									x			x			
Desmodium paniculatum (L.) DC. var. *paniculatum*						x	x													
Draba reptans (Lam.) Fernald													x							
Eleocharis montevidensis Kunth									x							x				x
Equisetum x ferrissii Clute (pro sp.) [*hyemale* x *laevigatum]*									x			x				x				x
Equisetum variegatum Schleich. ex F. Weber & D. Mohr									x											
Eriogonum annuum Nutt.			u			x	x							x			x			
Euphorbia dentata Michx.																			x	
Froelichia floridana (Nutt.) Maq.						i														
Gaillardia pulchella Foug. var. *pulchella*			u			x	x										x			
Geranium carolinianum L.			u														x		x	
Grindelia papposa G.L. Nesom & Suh			x	x										x			x	x		
Helianthus petiolaris Nutt.			x	x										x	x				x	
Heterotheca subaxillaris (Lam.) Britton & Rusby			u			x	x							x				x	x	
Hymenopappus scabiosaeus L'Hér. var *corymbosus* (Torr. & A. Gray) B.L. Turner						i	i	i						i	i		i	i	i	
Juncus brachyphyllus Wiegand																				x
Juncus diffusissimus Buckley																				x
Lactuca canadensis L.				x					x						x					
Lactuca ludoviciana (Nutt.) Riddell								x											x	
Lactuca serriola L.																			x	
Lepidium virginicum L.			u			x	x							x			x			
Lespedeza frutescens (L.) Hornem.			u				x													
Lycopus americanus Muhl. ex W.P.C. Barton														x						
Marrubium vulgare L.																	i			
Melilotus officinalis (L.) Lam.						s	s							x			x	x	x	

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Mirabilis nyctaginea (Michx.) MacMill.			x											x			x	x	x	
Mollugo verticillata L.							x							x				x		
Monarda punctata L. ssp. *punctata* var. *occidentalis* (Epling) Pollmer & Steyerm.			u					x					x							
Nemophila phacelioides Nutt.														x			x	x	x	
Nuttallanthus texanus (Scheele) D.A. Sutton																			x	
Oenothera laciniata Hill.			u			x	x							x			x	x	x	
Oenothera rhombipetala Nutt. ex Torr. & A. Gray						x											x	x		
Opuntia Mill.			u														x		x	
Packera plattensis (Nutt.) W.A. Weber & Á. Löve			u																	x
Parietaria pennsylvanica Muhl. ex Willd.									x											
Penthorum sedoides L.																x				
Phacelia strictiflora (Engelm. & A. Gray var. *lundelliana* Constance														x						
Phytolacca americana L. var. *americana*			u			i	i	x										x		
Plantago virginica L.			u		i															
Pluchea odorata (L.)Cass. var. *odorata*																i				
Polygonum lapathifolium L.																x				x
Pyrrhopappus grandiflorus (Nutt.) Nutt.			u													x				
Ratibida columnifera (Nutt.) Woot. & Standl.						i	i													
Rubus (L.)								x				x								
Rumex hastatulus Baldw.																			x	
Schoenoplectus pungens (Vahl) Palla var. *pungens*																				x
Scirpus pallidus (Britton) Fernald																				x
Solanum americanum Mill									x							x				
Solanum rostratum Dunal						x	x													
Solanum dimidiatum Raf.						x	x							x			x			
Solidago gigantea Aiton															x				x	
Sonchus asper (L.) Hill									x							x				x
Sphenopholis obtusata (Michx.) Scribn.						x											x			
Strophostyles helvola (L.) Elliott															x					
Symphyctrichum divaricatum (Nutt.) G.L. Nesom								x							x				x	

	stable canyon					eroding canyon							main canyon							
	head		lower			head				lower			upper				lower			
	T-I		T-II			T-III				T-IV			T-V				T-VI			
SPECIES	a	b	a	b	c	a	b	c	d	a	b	c	a	b	c	d	a	b	c	d
Taraxacum laevigatum (Willd.) DC.															x					
Teucrium canadense L. var. *canadense*															x					
Thelesperma filifolium (Hook.) A. Gray var. *intermedium (*Rydb.) Shinners			u			x											x			
Triodanis holzingeri McVaugh				x		x											x		x	
Typha latifolia L.									x			x				x				x
Verbesina encelioides (Cav.) Benth. & Hook. f. ex A. Gray ssp. *encelioides*																		x	x	
Vernonia baldwini Torr.			u																	
Veronica anagallus-aquatica L.		i			i				s			s				s				s
Viola bicolor Pursh			x	x	x								x	x			x	x	x	
Xanthium strumarium L.								x						x					x	
Yucca glauca Nutt.						x														