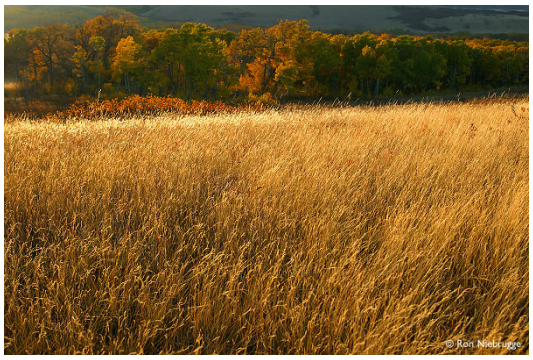
QUAPAW TRADITIONAL LIFEWAYS SCENARIO



"soul-melting scenery... the prairie at sunset, when the green hill-tops are turned into gold – and their long shadows of melancholy are thrown over the valleys – when all the breathing of the day are hushed and naught but the soft notes of the retiring dove can be heard, or the still softer and more plaintive notes of the wolf, who sneaks through these scenes of enchantment." (George Caitlin)

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EXECUTIVE SUMMARY

The purpose of this report is to describe Quapaw tribal traditional cultural uses of natural resources, and to present them in a format typically used by regulatory agencies during evaluation of baseline environmental risks.

This document is not a risk assessment. However, information presented in this scenario about environmental exposure pathways (inhalation, water and soil/sediment ingestion, and diet) may be combined with information about contaminants in air, water, soil/sediment, or natural resources used as food, medicine, or materials to answer specific questions about risk. This report describes traditional uses. The purpose of this report is not to describe contemporary uses that are suppressed or distorted by lack of access, resource degradation, or knowledge of contamination.

The basic process for developing the diet and direct exposure factors was to:

(a) Develop ecological descriptions of Ottawa County, OK and more locally for the Tar Creek Superfund Site;
(b) Conduct a literature search of credible historical records concerning the traditional lifeways and foods of Native Americans in Arkansas and Oklahoma, including a list of natural resources specific to the Tar Creek Site;
(c) Develop an understanding of the major categories of subsistence activities (such as hunting, fishing, gathering, basketmaking, and so on);
(d) Identify the major activities that contribute to exposure, and the major dietary staples;
(e) Evaluate the relative proportion of major food groups, and evaluate nutritional information, total calories and quantities of foods for a natural diet specific to eastern Ottawa County;
(f) Iteratively crosswalk between activities and conventional exposure factors to develop exposure factors for inhalation rates and soil and water ingestion

Because environmental degradation has been so extensive in the Tar Creek vicinity, this scenario relies on ecological descriptions of the relevant ecotypes, ecological information from reference sites, historical accounts of the local area and Quapaw activities before mining, and from contemporary interviews.

A nutritionally complete subsistence diet has been reconstructed from the ecological setting, natural resource uses documented for the Quapaw Indians, and the biomedical literature. Exposure factors for soil contact, water ingestion, and inhalation are also presented.

Table of Contents

1.0 INTRODUCTION

This document presents the subsistence exposure scenario for the Quapaw Tribe in Ottawa County, Oklahoma. The term 'subsistence' refers to the hunting, fishing, and gathering activities that are fundamental to the economy and way of life of many indigenous peoples. Subsistence farming is included in some areas, such as the middle Mississippi region where Oklahoma is located. Today's subsistence economies utilize both traditional and modern technologies for harvesting and preserving foods as well as for distributing the produce through communal networks based on respect, sharing, and bartering. "Subsistence also embodies cultural values that recognize both the social obligation to share as well as the special spiritual relationship to the land and resources. This relationship is portrayed in native art and in many ceremonies held throughout the year."[1]

This scenario identifies general exposure pathways specific to Quapaw lifestyle and key resources that the Quapaw people use. An exposure scenario is a narrative and numerical representation of the interactions between humans and their immediate environment. If contaminants are present, a contaminant dose to humans and the risk it poses can be estimated. Exposure scenarios include media-specific and pathway-specific exposure factors that are required to estimate a contaminant dose to the target receptor as they pursue a defined set of activities in particular locations.

Even though many Tribal lands have been lost and resources degraded, there are generally more traditional or subsistence practices followed by Tribal members than the general non-native population realizes. Further, the objective of many Tribes is to regain land, restore resources, and encourage more members to practice healthier (i.e., more traditional) lifestyles. Therefore, the objective of subsistence exposure scenarios is to describe the original lifestyles and resource uses for pre-release baseline (and/or restored) environmental conditions, not to present a current snapshot of restricted or suppressed uses of degraded resources. Reservations are set aside to be permanent homeland, providing all the necessary resources to sustain the Tribe in perpetuity.

The eastern Oklahoma culture area is located along the intersection of the oak-hickory savanna of the Ozark Highlands broadleaf woodland, and the tallgrass prairie of the eastern Great Plains. A reasonable approximation is presented of what natural resource conditions were like in Ottawa County at the time of the Treaty and the arrival of the Quapaw Tribe in eastern Oklahoma, through the advent of mining.

The process of developing an exposure scenario begins with a general description of baseline natural resources that should be present in Ottawa County and in the local Tar Creek vicinity. A subsistence diet of natural foods is presented. A general description is included of the activities that traditional people undertake to survive and thrive in the local ecosystem, including hunting, gathering foods and medicines, fishing, making material items, farming or gardening, raising livestock, irrigating, and various cultural, occupational, and domestic activities. Finally, exposure factors based on environmental contact (frequency, duration, and magnitude) are presented in a format that is used for risk assessments. This method has been developed over a decade of work, and is described in more detail in Harper et al. (2007).

[1] National Park Service: http://www.cr.nps.gov/aad/cg/fa_1999/Subsist.htm

2.0 General Approach to Scenario Development

Under the paradigm used by the federal government (NRC, 1983), risk derives from the combination of human contacts with natural resources, contamination data, and the toxicity of the contaminants (Figure 1). The basic tool used to evaluate contact rates with natural resources is the exposure scenario. An exposure scenario is a narrative and numerical representation of the interactions between humans and their immediate environment. Development of the scenario therefore starts with a general description of baseline natural resources that are or could be available to the Quapaw. It then describes the activities that Quapaw people undertake, including hunting, gathering foods and medicines, fishing, collecting firewood, making material items, and various other cultural and domestic activities.

Once the activities comprising a particular lifestyle are known, they are translated into a form that is used for risk assessment. Traditional activities and foods form the basis for "exposure factors" which describe the amount of contact with air, water, soil, and sediment (direct exposure pathways), as well as with native and/or cultivated plants and wild or domesticated animals for food or material items (indirect exposure pathways). This translation captures the degree of environmental contact (frequency, duration, and intensity) that occurs through activities and diet, expressed as numerical "exposure factors." Exposure factors for direct exposure pathways allow the estimation of exposure to any contaminants in abiotic media (air, water, soil, and sediment), via inhalation, soil ingestion, water ingestion, and/or dermal exposure. Indirect pathways refer to contaminants that are incorporated into biota and may subsequently reach people who ingest or use them.

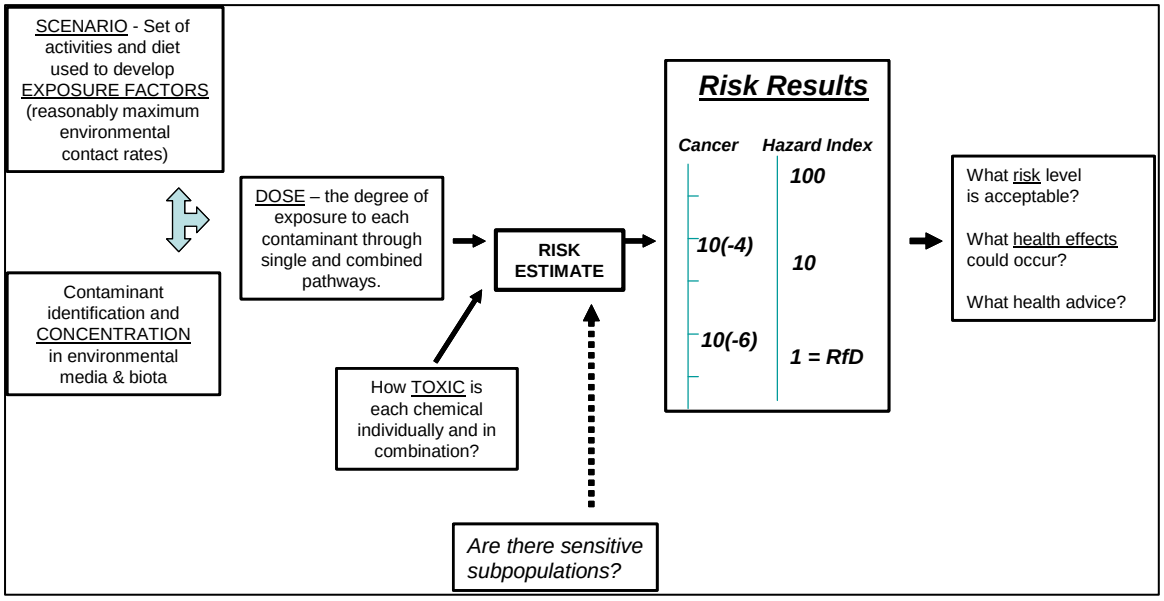

Figure 1. Risk assessment process

For the direct exposure factors, each of the major activity categories includes activities that result in exposure to each medium. For example, by estimating the relative amount of time spent in activities that result in high, medium, or low soil contact rates for each activity category, an overall soil ingestion rate was estimated. However, we did not attempt to be overly quantitative in enumerating the myriad of activities and resources in each category because this implies more precision than is warranted. Thus, each crosswalk is a systematic estimate rather than a statistical exercise.

When developing an exposure scenario for the general U.S. population, there are national databases available for exposure factors (e.g., contemporary diets and human activity data) that have been summarized in EPA guidance. For the general suburban population the exposure scenario used in risk assessments is well defined in EPA guidance (EPA, 1992, 1997)[2]. However, there are no tribal-specific databases of subsistence activities, resources, or diets as there are for the general U.S. population. Cross-sectional surveys of most contemporary tribal populations will not generate that data because much resource use is currently distorted due to loss of land and access, awareness of contamination, and other reasons. Further, tribal communities often include people who rely largely on the natural environment as well as people who partake in the western economic system to varying degrees (Figure 2).

The supporting information is obtained from the ethnohistorical literature as well as confirmatory interviews with Tribal members. The ethnohistorical literature is generally qualitative or semi-quantitative, yet risk assessments require deterministic numerical inputs in the form of exposure factors. This scenario provides a reasonable representation (central tendency) of the traditional cultural lifeways. Due to the semi-quantitative and professional judgment approach, ranges or distributions for the exposure factors were not developed. Unlike databases that are available for the general population (EPA, 1989), there are no such databases available for tribal cultural lifeways. Therefore, single best-professional-judgment estimates for direct exposure pathways (inhalation, soil ingestion, water ingestion) are presented along with the diet that reflects the local ecology.

[2] U.S. EPA. Exposure Factors Handbook (1997) http://www.epa.gov/ncea/efh/ *and*
Guidelines for Exposure Assessment. U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, DC, 600Z-92/001 (1992) http://cfpub.epa.gov/ncea/raf/recordisplay.cfm?deid=15263

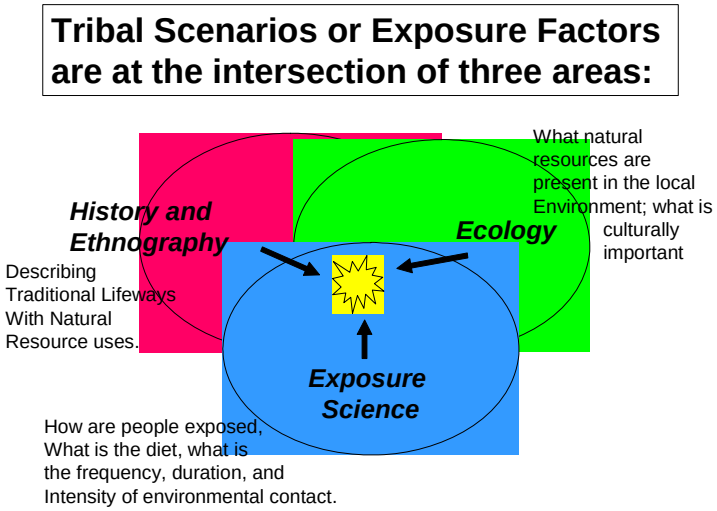

Figure 2. Multidisciplinary Information Base for Describing Traditional Lifeways

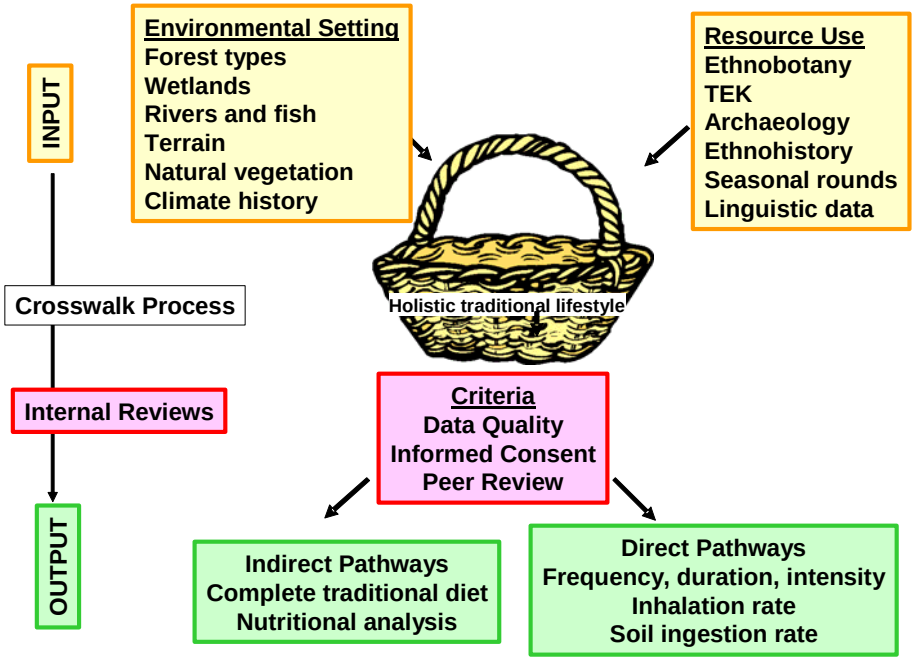

Figure 3. Input and output information

A variety of information is used to understand the degree of environmental contact and support the derivation of numerical exposure factors (Figure 3). The chapters in this report are organized around the input data and output requirements.

- Tribal history
    - The section on Tribal history describes factors such as whether Tribes have moved or have been consolidated on reservations, what happened as a result of contact with settlers and incoming governments, historical reports, and linguistic and oral history that describes how Tribes identify with and use natural resources.
    - This information is needed to understand lifeways as they existed prior to significant resource degradation.
    - Historical characterization is important (even if they lived elsewhere), because the Tribe transported traditional uses will them, changing if necessary to accommodate a different resource base.

- Environmental Setting.
    - The ecological description provides information about plants, animals, biodiversity, relative proportions of different habitat types, seasonality, and physiographic features of the environment.
    - This information is needed to support estimates of dietary staples (the resources that are most abundant and reliable), and environmental characteristics that affect contact rates with soil, sediment, and water (for example, proportion of wetlands versus dry upland habitats).

- Natural Resource Use
    - Ethnobotanical and ethnohistorical literature describes the general diversity of plants used for food, medicine, or materials in various regional ecotypes and helps derive dietary intake values. This section is both general to Ottawa County and specific to the Tar Creek site.
    - Traditional ecological knowledge (TEK) combines anthropological and environmental knowledge with tribal knowledge, teaching, and observation.

- Diet
    - In some cases, a complete diet may have been identified in the foraging theory literature, but more often the major dietary staples are identified but not fully quantified within a nutritionally complete diet.
    - Information about natural resources and their abundance and uses is used to estimate relative importance of the major food categories. This is combined with nutritional information to estimate a nutritionally complete subsistence diet (for as many major regional habitat types as are appropriate).

- Direct exposure factors (soil, sediment, water, and air pathways)
    - There is little data directly relevant to environmental contact rates with abiotic media for indigenous styles other than the foraging theory literature, which tends to be non-specific, and some individual studies.

- The crosswalk between major activities (hunting, fishing, gathering, and so on) and the abiotic exposure pathways (soil ingestion, sediment ingestion, water intake, and inhalation) is based on estimates of activity levels and the frequency, duration, and intensity of each activity category.
- Physiological information adds knowledge of activity levels, and the relation between inhalation rates and calorie needs to ensure a reasonable and physiologically coherent set of exposure parameters.

3.0 Middle Mississippi Anthropological History

This section describes general anthropological history and resource uses in the middle Mississippi region, including the general areas used by the Quapaws. Anthropologists have developed and termed sequential phases of habitation based on distinguishable by their implements, pottery, burial styles, and other material remains. The Middle Mississippi area has several phases, and the more recent phases (not specific to contemporary Tribal organization) are summarized below. The specific post-contact Tribes and their history relative to their environmental locations are presented at the end of this section.

3.1 Anthropological History

WOODLAND PERIOD (500 B.C. to AD 1000).

One of the earliest identifiable cultures in the Ohio Valley was the Indian Knoll people, who hunted and fished, especially for mussels and clams. The Woodland Period is marked by changes in material culture, subsistence base, and sociopolitical or ideological systems. During the Woodland Period, the hunter-gatherer adaptation continued to evolve with a greater emphasis on grindstone plant processing tools and with the addition of ceramics to the cultural repertoire.

The Early Plains Woodland period (500 BC to AD 1) culminated in the Adena-Hopewell mound builders, including the Great Serpent mound in Ohio. It is likely that the Quapaw are the descendants of the Adena-Hopewellian Moundbuilders (note: a different group later established the temple mounds at Cahokia). The Dhegihas had a similar religion to the earlier Moundbuilders, similar ceremonial life, and identical hair styles. Several species of native annual plants were cultivated and the first tropical cultigens may have been introduced at this time. New styles of stone tools suggest technological diversification as well as the importance of lithic resource procurement. Artifacts include specific styles of projectile points, stone axes, and ceramics. The characteristic thick walled vessels are tempered with clay, bone or grit and are undecorated. The construction of burial mounds and the presence of exotic materials interred with the cultural elite indicate a more complex social order than earlier cultures (Early and Limp, 1982). Sabo (1990) notes that sites at higher elevations above stream valleys include short-term hunting and collecting camps, quarries, and other special use sites. Late in the period, however, a pattern of small, dispersed farmsteads prevailed (Sabo, 1992).

The Middle Plains Woodland phase (AD 1 – 500) and Late Plains Woodland phase (AD 500-1000) supported subsistence economies based on hunting and gathering supplemented with native plant horticulture (Morse 1991). During the late phase corn, squash and domesticated marsh elder (*Iva annua*) appear along the eastern edge of the plains. The “eastern agricultural complex” domesticated many native plants, including sunflower, squash, sumpweed, chenopodium, marsh elder, goosefoot, other oil seeds, with corn eventually becoming the primary staple. Large burial mounds in eastern Oklahoma (e.g., the Spiro site) evidenced extensive trade networks, and were continued by the Caddo people. By the end of the Late phase, the settlement pattern includes stable villages of extensive temporal duration or seasonal reoccupation, and corn, beans and squash cultivation were widespread (Johnson 2001).

MISSISSIPPIAN PERIOD (AD 1000 to 1700).

Other technology, such as shell-tempered pottery, was developed, resulting in the Mississippian culture as the major cultural climax in the eastern US (Morse, 1991). Permanent settlements were growing maize, beans, squash, and other native plants, but gathering, hunting, and fishing remained important, occurring at hunting camps and fishing camps. The widespread appearance of political and religious hierarchies is a hallmark of this period. New forms of social integration emerged in cultures across most of the Southeast, continuing the social evolution sparked in the Late Woodland Period. Subsistence continued to be derived from a mixture of wild plant and animal foods, but with substantial reliance on Mesoamerican cultigens, particularly corn and beans. Platform mounds were used for special purpose buildings, functioned as repositories for burial of elite society members, served as the nucleus of society, and provided tangible evidence of the power of sociopolitical and religious leaders.

The regional Mississippian manifestation is known as the Arkansas Valley Caddoan tradition (1,100-450 B.P.), which is subdivided into three sequential phases: Harlan, Spiro, and Fort Coffee. The characteristic Caddoan settlement pattern contains a large mound center surrounded by small, dispersed farming hamlets as well as temporary camps and special use areas along tributaries and in inter-riverine upland areas. Two such mound centers occur near Ouachita National Forest. Caddoan sites are characterized by diagnostic arrowpoints and other lithic artifacts, and shell tempered ceramics, often richly embellished with Caddoan iconography. New vessel forms occur including bottles, plates, and carinated jars, and human and animal effigies were also manufactured. Mississippian cultures continued to flourish in Arkansas and the southeastern United States until the arrival of European explorers in the sixteenth and seventeenth centuries. (Sabo, 1992).

Around 1350 the climate got drier, which caused social structure to be stressed and forced greater reliance on trade (corn-buffalo trading), but society remained semi-sedentary with corn in the river valleys and buffalo on the plains (Calloway, 2003).

Fritz (1979) studied the skeletal remains of bluff dwellers and found relatively scarcity of diseased or malformed bones. By the end of the lower Mississippi phase (e.g., the Parkin site), archaeological evidence indicates a maize dependent diet, with suggestions of protein deficiency, anemia, and arthritis as cultures were being disrupted by disease and destabilized by competing European traders – social stress and conflict. Unlike beans, maize does not provide niacin, but maize and beans together provide essential amino acids (Jeter et al., 1989). Because corn also provides little iron or calcium, extreme corn eaters could develop osteoporosis, which was rare among hunters and gatherers. There is evidence that maize consumption increased as more nutritious wild foods were less available , which suggests that people knew to balance their diet, but were less able to do so due to diminishing resources. The latest phases indicate a more diversified diet again, presumably due mostly to the addition of cultivated crops. “It is hypothesized that the nutritional quality of the contact period diets declined significantly and that carbohydrate consumption increased to replace a variety of nutritionally adequate foods which were no longer available.” (Fritz, 1979).

Contact with Europeans also triggered a requirement for an increase in storable food. In the early historic period, degenerative disease data (such as arthritis) suggests that the workload was comparatively high and strenuous, suggesting that the complex agricultural

system required an increase in the individual work load and increased physical stress (Rollings, 1995).

3.2 The Quapaw Nation

The Quapaw people belong to the Dhegiha subdivision of the Sioux, which includes the Osage, Omaha, Kansas, Quapaw, and Ponca Indians. The name "Quapaw" is a derivative of the term O-gah-pah (various spellings), meaning "downstream people." Quapaw origin stories tell of a 16th or 17th century migration down the Mississippi River from the Ohio Valley and Kentucky's Cumberland Valley. The reasons for this move are not clear, but may include increased conflicts with the Iroquois after the Dutch armed the Iroquois and Algonquians with rifles during that time frame. This time frame is also the era when epidemics were sweeping through indigenous communities (Baird, 1980; Morse, 1991; Arnold, 2000; Wright, 1951).

When the Dhegiha people left the Ohio River valley, a large group ascended the Missouri and Mississippi Rivers, and became the Omahas, Kansas, and Poncas (Omaha means upstream people). The remaining group descended the Mississippi to the confluence of the Arkansas and Mississippi Rivers and became the Quapaw, or downstream people. Hernando de Soto described large communities of people living in the middle Mississippi valley when he passed through the area in 1541. It is not clear if the Quapaw of 1673 (when first identified under that name by the French explorers Marquette and Joliet) were the direct descendants of the people de Soto described or were various indigenous communities who survived epidemics and consolidated and hybridized their pottery styles and other practices (McGimsey, 1989). In either case, one could expect the basic economic systems suitable to the area (a mixture of farming, hunting, gathering, and fishing) to be carried on by whatever people or peoples live there. As such, archaeological analyses of pre-contact settlement sites are useful for establishing an economic baseline in the Arkansas area where the Quapaw first settled, as well in the Oklahoma area where they now live.

3.2.1 Arkansas period

Hernando de Soto passed through the area where the Arkansas River joins the Mississippi River in 1541 and described larges villages with thousands of residents and large corn fields. The next contact was in the mid 1600s when the French explorers, Marquette and Joliet, traveled down the Mississippi and used the Illini Indians as their guides. The guides referred to the Quapaw tribe as "Arkansea" - People of the South Wind.[3] They were highly skilled farmers who hunted, gathered, and fished to fill out their diet, but by the 1600s their population had been reduced by perhaps as much as 90%.

As trading posts were established by the Spanish, French, and English, tribal communities invested more time in hunting for pelts, meat, and oil to trade. The European traders also deliberately fostered political instability for the purposes of gaining access to trade routes, and of gaining superiority over the indigenous allies of each other's European competitors.

[3] http://www.geocities.com/Athens/Aegean/1388/

When the United States purchased Louisiana in 1802, the Quapaw lived in three large villages on the south bank of the Arkansas River near its confluence with the Mississippi River. They farmed, hunted, and raised horses that they used and also sold in early colonial markets. Indian nations such as the Cherokee and Choctaw, after removal from their lands east of the Mississippi River, settled along the middle Arkansas River and its tributaries. All of these historic Indian groups were sedentary farmers living in comfortable residences with gardens, fields, and orchards, along with extensive forest areas maintained for hunting, and grasslands with bison and prairie plants. (Williams, Abbott, and Joseph 1992; Smith 1988.

3.2.2 Treaties and Forced Relocation to Indian Territory (Oklahoma)

By the early 19th century, the Quapaw had fallen on hard times—they were forced to sign a series of Treaties to cede their homelands and relocate on reservations first along the Red River in Arkansas, and subsequently in Indian Territory (now Oklahoma) (Hoxie, 1996, Baird 1980; Young and Hoffman, 2001; Waldman 2000).

In 1835, the United States government moved the Quapaw to the northwest corner of Oklahoma, under to the Treaty of 1833. The Quapaw planted fields, some of which the federal government promptly took back due to an error in surveying and moved them to a further restricted piece of Ottawa County. According to early Indian Agents, the first Quapaw residents in Oklahoma had fine hunting grounds. There were a great number of wild turkey, deer, antelope, wolves, ox, quail, and prairie chickens. They spent much of their time hunting and fishing (Thompson, 1955). The Quapaw also attempted to reconstruct their traditional economic system in the new environment and they resisted European-style farming. For a few years they maintained traditions of nucleated settlements, planting corn fields in common in 1834 and 1835. Indian agents, however, forbade the establishment of traditional villages specifically in order to disrupt social patterns and to force the Quapaw to become ‘farmers’ in the European style (Baird, 1980; Indian Agent reports (see below)). Nevertheless, the Quapaw planted corn and danced the annual Corn Dance as before. They also hunted and gathered in the adjacent woods, gathered fished in the surface waters, planted fruit trees, and grew other crops.

The narrative of this scenario reflects the era before mining affected the land and when the land was still able to support agriculture as well as hunting, gathering, and fishing.

4.0 Environmental Setting

This section is intended to provide a general introduction to habitats and plant communities that are present in Quapaw territory. Baseline environmental conditions in the Arkansas and Oklahoma habitats are approximated in this section. This baseline is not a fixed year, but rather a condition of natural resources generally in an era of early contact when relatively little environmental degradation has occurred. In the case of the Quapaw in Oklahoma, this is from the time of arrival in Oklahoma and before extensive mining and mass industrialized agriculture has commenced.

4.1 General Environmental Setting

The description of the environmental setting begins with the identification of natural ecological zones, or ecoregions. Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. They are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing the spatial differences in the capacities and potentials of ecosystems, ecoregions stratify the environment by its probable response to disturbance (Bryce, Omernik, and Larsen, 1999). Ecoregions are general purpose regions that are critical for structuring and implementing ecosystem management strategies across federal agencies, state agencies, and nongovernmental organizations that are responsible for different types of resources in the same geographical areas (Omernik et al., 2000).

In North America, seven broad climatic zones are recognized, roughly corresponding to temperature and moisture. North American vegetation types roughly track these same zones, such as the tall grasslands and the Oak-Hickory forest that are relevant to the Quapaw scenario. Because these zones are defined by dominant vegetation types, the composition of plant and animal species is fairly predictable for the dominant species. Local differences in geology (soils and deeper substrates), elevation, climate (light, temperature, precipitation and wind), and water (streams, wetlands) affect individual plant associations.

A hierarchical scheme has been adopted for different levels of ecological regions, and is being used by the US Environmental Protection Agency[4]. Level I is the coarsest level, dividing North America into 15 ecological regions. Level II divides the continent into 52 regions. At level III, the conterminous United States has 84 (U.S. Environmental Protection Agency, 2005). Level IV ecoregions are further subdivisions of level III ecoregions. Methods used by the U.S. Environmental Protection Agency (USEPA) to define the ecoregions are explained in Omernik (1995, 2004), Omernik et al. (2000), Gallant et al. (1989); and Bailey (US Forest Service)[5]. The approach used to compile these ecoregion maps is based on the premise that ecoregions can be identified through the analysis of the spatial patterns and the composition of biotic and abiotic characteristics that affect or reflect differences in ecosystem quality and integrity (Wiken, 1986; Omernik, 1987, 1995). These characteristics include physiography, geology, climate, soils, land use, wildlife, fish, hydrology, and

[4] http://www.epa.gov/wed/pages/ecoregions.htm and http://www.cec.org/files/PDF/BIODIVERSITY/eco-eng_EN.pdf

[5] USFS Bailey province ecology: http://www.fs.fed.us/land/pubs/ecoregions/intro.html

vegetation including "**potential natural vegetation,**" defined by Kuchler (1966)[6] as vegetation that would exist today if human influence ended and the natural vegetation were restored (including the earlier fire regime of mixed natural and indigenous origin, and natural flooding).

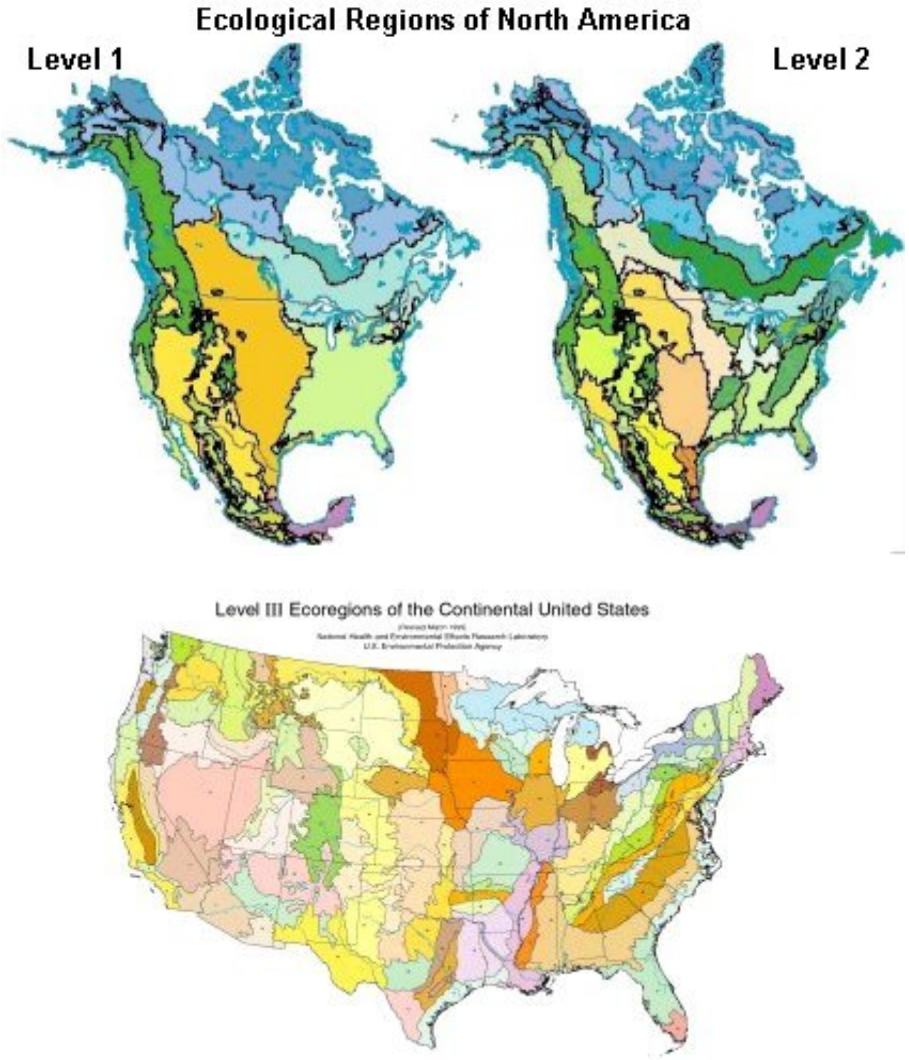

Figure 4. Level 1 and 2 Ecoregions of North America

from: http://www.epa.gov/bioindicators/html/usecoregions.html

[6] http://www.ngdc.noaa.gov/seg/cdroms/ged_iib/datasets/b13/ek.htm

Ecological diversity is strongly related to climate, terrain, geology, and soil. Oklahoma contains vast plains, elevated karst plateaus, hills, and folded, low mountains. Precipitation increases eastward, rainfall variability increases westward, and both mean annual temperature and the length of the growing season increase southward. Soils influence the effectiveness and availability of moisture for plant life. Forests cover most of the Ozark Plateau and the Ouachita Mountains; they become progressively more stunted and open westward. Southern pine forests, typical of the Gulf Coastal Plain, occur in the southeast. Tall grass prairie, mixed grass prairie, and short grass prairie are native across much of Oklahoma, with tallgrasses in the east transitioning to short grass in the west. Bison were numerous enough so as to be responsible for maintaining grasses by their physical impact, along with natural and indigenous fires. Tall grassland bounds the forest to the east and shortgrass to the west from Texas to Canada. The dominant plants are porcupine grass, prairie dropseed, little bluestem, side-oats grama, Junegrass, western wheatgrass, plains muhly, panic grass, and the sedge *Carex pensylvanica*. There are numerous species of forbs. The strong east-west zonation of vegetation and climate in Oklahoma significantly influences the distribution of fauna, including reptiles, mammals, and insects (Blair and Hubbell, 1938; Webb, 1970). The western boundary of deciduous forest limits the westward extension of many eastern species.

The following map is an example of the level of detail available on a state-wide basis, based on soils, game, and/or vegetation, depending on the agency's mandate.

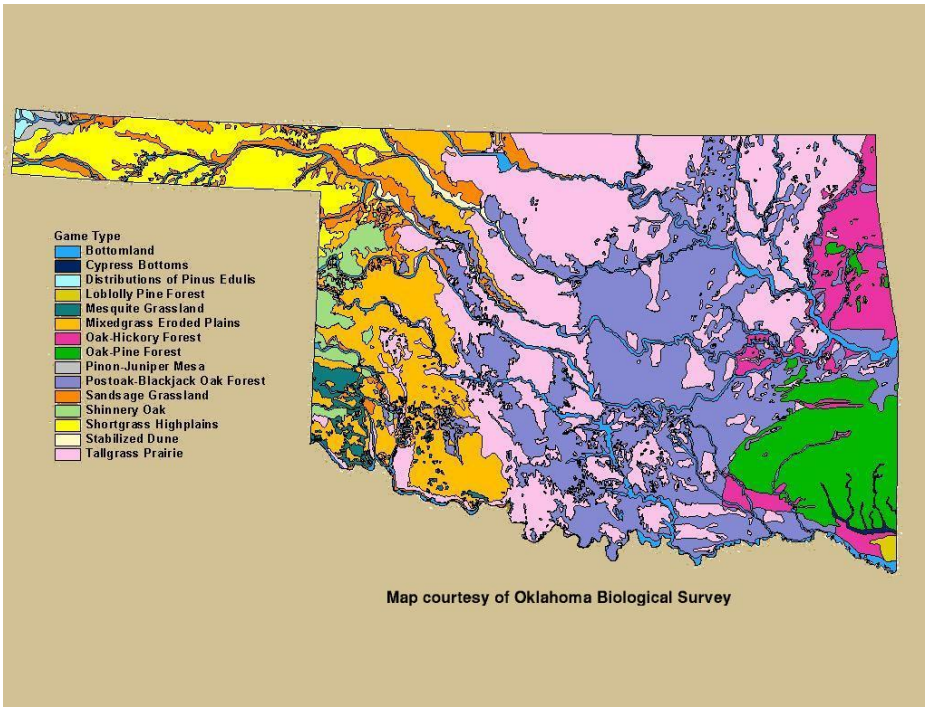

Figure 5. Oklahoma Biological Survey map

from: http://www.biosurvey.ou.edu/duckflt/dfhome.html[7]

[7] see also: http://www.dynamicsolutionsgroup.com/OK/; http://www.biosurvey.ou.edu/; http://maps.scigis.com/odwc/); http://www1.dasnr.okstate.edu/natResOklahoma.shtml; http://botany.okstate.edu/osu_herbarium.htm

4.2 Ottawa County

In Ottawa County, the primary ecotypes are Tallgrass Prairie and Ozark Highlands, along with aquatic and riparian zones. The demarcation between ecoregions is fairly clear, with the forest edge to the east and extending into drainages, and grasslands in the western half. The western half of Ottawa County includes the eastern edge of the Great Plains Grasslands (the Osage Plain) with mollisols (moist to wet warm soft grassland soils). The eastern part of Ottawa County includes the western boundary of the Ozark oak-hickory highlands (Springfield Plain) with utillisols (warm acidic soils with clay-rich subsoils) (Savage, 2004).

> "At the limits of the school ground we had to go down the hill, which was steep and rocky. At the foot, under solid rocks was a spring of the finest and clearest water [Rock Creek, which is more recently known as Beaver Creek]." *Neiberding 1953, quoting a visit to the town of Quapaw by a nun in 1903.*

Typical Ottawa County forested riparian areas include groves, shrub patches, forbs, and grasses in a progression that is quite consistent depending on the latitude, aspect and precipitation. This mix is known as savanna or parkland. Low trees tend to be hawthorn, wild crab, wild plum; the shrubs tend to be hazel, sumac, dogwood, wolfberry, coralberry, and persimmon, dwarf oaks, along with vines (e.g., grape, gooseberry, and raspberry). Hazel and sumac may form thickets. Sunflowers may be dominant forbs in some areas. Because the northernmost boundary of the dry southern vegetation, some yucca and prickly pear is also present. A floodplain forest may be comprised of cottonwood, willow, elm, and hackberry. Forest edge animals include black bear, turkey, white-tailed deer, gray fox, squirrel, raccoon, opossum, rabbit, and other fowl. Bison were present throughout the county. Elk divided their time between forest, bushland, and grassland. Numerous permanent or seasonal ponds occur, with wetland plants (sedge, moss, willow, and so on) and water-tolerant trees (Savage, 2004).

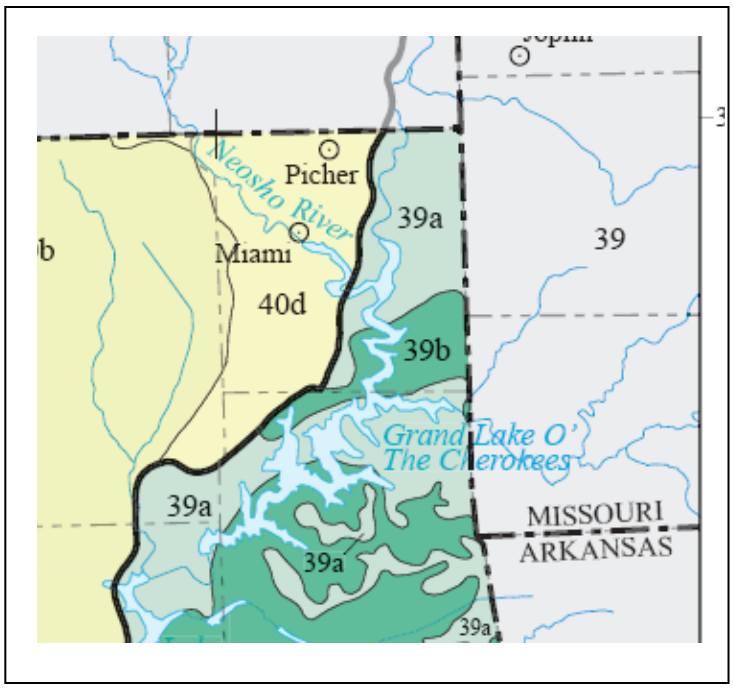

Figure 6. Level IV ecoregions in Ottawa County

(http://www.epa.gov/wed/pages/ecoregions/ok_eco.htm)
39 = Ozark Highlands; 40 = Tallgrass Prairie
The Tar Creek area is located near Picher and Miami.

4.3 Ozark Highlands

The Ozark Highlands ecoregion (Area 39 on Figure 6) has a more irregular physiography and is generally more forested than adjacent regions to the east, with the exception of the Boston Mountains to the south. The Ozarks are bordered on the southwest by the Neosho River, on the south by the Arkansas River, the Black River on the east, and the Osage and Missouri Rivers form the northern boundary. The Ozark region is characterized by thin, rocky soils; numerous caves and associated sink holes, springs, and underground rivers; clear, cool streams; and waterfalls.

The majority of this dissected limestone plateau is forested; oak forests are predominant. Karst features, including caves, springs, and spring-fed streams are found throughout the Ozark Highlands. The eastern part of Ottawa County is also designated the Springfield Plain subsection of Ozark Highlands[8] . The Springfield Plain lies in Missouri (3,136,051 ac) and Oklahoma (161,881 ac) and is a gently rolling land with karst features underlain by Mississippian limestone (sometimes very cherty) and cherty clay residuum. It is covered with southern tallgrass prairie and oak-hickory woodlands and forest. Kuchler vegetation types

[8]see: www.naturalheritage.com, ozark highlands.

are mapped as oak-hickory forest, oak-hickory-pine forest, a mosaic of bluestem prairie and oak-hickory forest, and cedar glades. Dry upland sites include post oak-blackjack oak-black hickory with lichen-moss ground cover, and shortleaf pine-oak in areas of sandstone bedrock. Mesic slopes sites have white oak, northern red oak, bitternut hickory and flowering dogwood. Riparian sites have river birch and silver maple. Glades have little bluestem and baldgrass; eastern red cedar has invaded these prairie sites as a result of fire suppression. The current trend is to characterize Ozark's landscapes as "woodland" or "savanna" rather than "forest," in recognition of the role of frequent, low-intensity fire and many meadow openings. Frequent, low intensity, widespread fire occurred prior to European settlement. Fire suppression led to changes in community type and species composition, resulting in closed-canopy forests that replaced many woodlands; pastures that replaced prairies, and an increase in glades and bottomland forests.

Clear, cold spring-fed streams characterize the Ozarks. Karst topography influences surface water, producing losing streams, springs (some large) and spring-fed streams, seeps, and fens. Small sinkhole ponds exist but few natural lakes; however, several large rivers have been dammed to create reservoirs. There is a moderate density of small intermittent drainages, and small to medium-sized perennial streams, most with low to moderate rates of flow. Climatic influences include occasional summer droughts, winter ice storms, and tornadoes.

Oak-Hickory Savanna/Forest.

Oak-hickory forest is one of the richer ecoregions in North America due to its size and its location as the ecozone between the Great Plains and the eastern deciduous forest. It shares a strong affinity with the adjacent grassland ecoregions in that many of the tallgrass prairie species can be found in the understory layer. It also shares much of the fauna of the adjacent grassland ecoregions; these species persist in the ecozones and openings within the ecoregion. Although other forests have oak and hickory, only this particular forest association has both species in abundance. The main vegetation type of the Ozarks is an upland oak-hickory forest, although shortleaf pine does occur on escarpments to the north and on the drier south slopes. Red cedar glades are located on xeric exposures and beech-maple forests are found in cool, moist north-facing ravines. Bottomland hardwoods are found in the floodplain of large rivers. This large expanse of timberland provides breeding habitat for numerous species of neotropical migratory birds. Remnants of the original tall grass prairie are scattered throughout the Springfield and Salem Plateaus[9] and many areas are more like savanna than dense forest.

Typical oaks are blackjack oak (*Q. marilandica*) and post oak (*Q. stellata*) in the southern part of this ecoregion. The oak-hickory forest becomes more savanna-like in its northern reaches, forming a mosaic with prairie. Bison were abundant in this ecoregion prior to Anglo settlement. Widespread dominant trees are white oak (*Q. alba*), red oak (*Q. rubra*), black oak (*Q. velutina*), bitternut hickory (*Carya cordiformis*), and shagbark hickory (*C. ovata*). Flowering dogwood (*Cornus florida*) often occurs in the understory with sassafras (*Sassafras spp*.) and hop hornbeam (*Carpinus spp.).* The shrub layer is distinct, often with

[9] ***http://www.fws.gov/midwest/ecosys/ozark.htm***

evergreens, and wildflowers are common. Intact wetter sites feature American elm (*Ulmus americana*), tulip tree (*Liriodendron tulipfera*) and sweet gum (*Liquidambar styraciflua*).[10]

Fauna.

Major ungulates are white-tailed deer, as well as bison before the bison were extirpated. The major predator is the coyote (the red wolf, timber wolf, and cougar were extirpated). The mink, otter, beaver, black bear, fox, and bobcat had declined but are recovering. There are over 140 bird species, including bald eagle and other raptors, turkey, various owls, wood duck, kingfisher, various woodpeckers, and various songbirds (many warblers). Habitat diversity (glades, sinkholes, and caves) contributes to rich herpetofauna, including rattlesnakes, copperheads, turtles, and many salamanders. The richness of fish species is great, including 18 endemics and some relic species. Trout and carp are introduced. Crustaceans (19 endemic crayfish) and mollusks (seven endemics) include some threatened and endangered species.

Table 1. Federal T&E species, Ottawa County

Common Name	Scientific Name	Status
American burying beetle[1,B]	*Nicrophorus americanus*	E
Gray bat	*Myotis grisescens*	E
Ozark big-eared bat	*Plecotus townsendii ingens*	E
Winged mapleleaf mussel	*Quadrula fragosa)*	E
Bald eagle	*Haliaeetus leucocephalus*	T, PD
Neosho madtom	*Noturus placidus*	T
Ozark cavefish	*Amblyopsis rosae*	T
Piping plover	*Charadrius melodus*	T
Arkansas darter	*Etheostoma cragini*	C
Neosho mucket mussel	*Lampsilis rafinesqueana*	C

Notes: E=Endangered, T=Threatened, PD=Proposed for Delisting, C=Candidate for Listing, D=Delisted,
[1] Historical Range – According to specimen records, the recovery plan and available life history information, this county is within the documented historic range of the American burying beetle.
[B] Unconfirmed – Surveys within the last 15 years are lacking or insufficient to determine presence of the American burying beetle. However, suitable habitat is present and this county is adjacent to at least one county with current positive findings. In some instances, occurrences of American burying beetles have been reported by reputable individuals, but identification has not been verified by a Service biologist or trained entomologist.
Source: USFWS 2006

Source: US Fish and Wildlife Service (2006). http://www.fws.gov/Endangered/wildlife.html; State species: http://www.wildlifedepartment.com/endanger.htm; http://www.wildlifedepartment.com/endanger2.htm

[10] The Audubon Society (1985) Eastern Forests. The Audubon Society Nature Guides. New York: Alfred A. Knopf , Inc.

4.4 Southern Tallgrass Prairie

The Southern Tallgrass Prairie is topographically more irregular than the Western Corn Belt Plains to the north. The region, however, is less irregular and less forest covered than the ecoregions to the south and east (Brown, 1989). The potential natural vegetation of this ecological region is a grassland/forest mosaic with wider forested strips along the streams. Kuchler vegetation types are mapped as dominantly mosaic of bluestem prairie and oak-hickory forest, with corridors of oak-hickory forest along drainage ways. This section was once 70 percent tall-grass prairie, little bluestem and associates, with groves of post and blackjack oaks. Upland prairie graded into wet bottomland prairie, with sloughs, marshes, and mixed bottomland forest. This forest included silver maple, green ash, cottonwood, pecan, pin oak, and bur oak. Habitat includes relatively large surviving prairie fragments, some over 1,000 acres. Cattle replaced elk and bison (the latter are being re-introduced under domestication). White-tailed deer are still abundant. Large predators were extirpated, except for coyote. Birds include hawks, turkey vulture, bobwhite quail, meadowlark, scissor-tailed flycatcher, dickcissel, and sparrows. This biome has a moderate density of small to medium size, highly meandering, perennial and intermittent streams with dendritic drainage pattern. Most streams have a low to moderate rate of flow and moderate velocity. Large seasonal fluctuations in discharge of streams; i.e., June's maximum may be six times greater than December's minimum. Waters may stand for three months or longer in wide, flat floodplains. There are a few oxbows.

The tallgrass prairie is rich in plant diversity and contains over 650 plant species. Tallgrass prairie is dominated by the grasses *Sorghastrum nutans*, *Panicum virgatum*, and *Andropogon gerardii,* which can reach over 5 feet tall by the end of a good growing season. A large portion of a grasses' biomass is underground. The roots can be twice as deep as the grass is tall, and half of the biomass of the prairie during the growing season is underground (Brown, 1989).

Tallgrass prairie is distinguished by its mix of savanna, prairie and woodlands. Tallgrass grades into mixed and then shortgrass along a moisture gradient. It is delineated from the tallgrass prairie and Central and Southern Mixed Grasslands to the west by the higher tree and shrub densities. Annual precipitation ranges from 600 to 1040 cm. The uniform soil type (mollisol) unites this wide-ranging ecoregion. A shift in soil type corresponds to the Ozark Highlands edge in central Ottawa County (Brown, 1989).

Table 2. Common Tallgrass prairie biota (Canada to Oklahoma, Brown, 1989)

REPTILES & AMPHIBIANS		
Great plains narrowmouth frog	Prairie skink	Western ribbon snake
Woodhouse's toad	Racerunner lizard	Northern water snake
Great plains toad	Slender glass lizard	Corn snake
Striped chorus frog	Great plains skink	Eastern hognose snake
Plains leopard frog	Tiger salamander	Racer
Western box turtle	Eastern fence lizard	Rat snake
Painted turtle	Common garter snake	Rattlesnakes
Snapping turtle	Plains garter snake	
BUTTERFLIES & MOTHS		
Acmon blue	Common sulphur	Pipevine swallowtail
Acraea moth	Eastern black swallowtail	Prairie ringles
American painted lady	Eastern tailed blue	Red-spotted purple
Artichoke plume moth	Gray hairstreak	Regal fritillary
Beard-grass skipper	Greenish blue	Silvery blue
Buckeye	Meadow fritillary	Sleepy orange
Cabbage white	Milkweed tiger moth	Sed webworm moth
Checkered white	Orange sulphur	Viceroy
Common checkered skipper	Painted lacy	Woolly bear caterpillar moth
	Pearly crescentspot	Yellow woolly bear moth
OTHER INSECTS		
American horse fly	Large bee flies	Robber flies
Digger bees	Metaphic jumping spider	Rose, Pea, and Potato aphids
Digger wasp	Nebraska conehead	Spur-throated grasshopper
Early tachnid fly	Nine-spotted ladybug beetle	Three-lined potato beetle
Golden northern bumble bee	Orb weavers	Toxomerus hover flies
Goldenrod spider	Paper wasps	Tumblebugs
Green midges	Pennsylvania firefly	Two-striped grasshopper
Honey bee	Pyralis firefly	Yellow-faced bees
House mosquito	Red-blue checkered beetle	Pennsylvania firefly
Jumping lynx spider		Pyralis firefly
GRASSES		
Big bluestem – *Andropogon gerardii*, chief tallgrass species	Little bluestem – *Andropogon scoparius*	Switch Grass – *Panicum*, a dominant species
Foxtail barley	Needlegrass	
Indian grass – *Sorghastrum nutans*	Prairie cordgrass	

TREES		
American plum	Common chokecherry	Paper birch
Apple	Common persimmon	Post oak
Bigtooth aspen	Common prickly-ash	Prairie crab apple
Biltmore hawthorn	Eastern cottonwood	Quaking aspen
Black cherry	Eastern redcedar	Russian olive

Black locust	European buckthorn	Shining sumac
Blackjack oak	Glossy buckthorn	Smooth sumac
Bur oak	Oneflower hawthorn	Siberian elm
	Osage orange	
MAMMALS		
Badger	Franklin's ground squirrel	Plains pocket mouse
Coyote	House mouse	Prairie vole
Deer mouse	Least shrew	Red fox
Eastern chipmunk	Least weasel	Striped skunk
Eastern cottontail	Long tailed weasel	Thirteen-lined ground squirrel
Eastern mole	Meadow jumping mouse	Western harvest mouse
Eastern spotted skunk	Meadow vole	White-tailed deer
Fox squirrel	Plains pocket gopher	White-tailed jack rabbit
Raccoon	Woodchuck	
BIRDS		
American goldfinch	Eastern meadowlark	Northern shrike
American kestrel	Field sparrow	Red-tailed hawk
Barn owl	Grasshopper sparrow	Red-winged blackbird
Barn swallow	Gray partridge	Ring-necked pheasant
Bobolink	Greater prairie chicken	Sharp-tailed grouse
Bobwhite	Horned lark	Short-eared owl
Brewer's blackbird	Killdeer	Tree sparrow
Clay colored sparrow	Lark sparrow	Turkey vulture
Cliff swallow	Loggerhead shrike	Upland sandpiper
Dickcissel	Long-billed curlew	Vesper sparrow
Eastern bluebird	Mourning dove	Western meadowlark
Eastern kingbird	Northern harrier	
FORBS		
Bird foot violet	Flowering spurge	Plains larkspur
Black eyed susan	Giant sunflower	Pointed blue-eyed grass
Bladder campion	Great lobelia	Prairie acacia
Blue salvia	Hairy golden aster	Prairie blazing star
Blue vervain	Hoary cress	Prairie false indigo
Boneset	Horse nettle (not a true nettle)	Prairie larkspur
Butterfly weed	Illinois tick trefoil	Prairie mimosa
Calico aster	Indian blanket	Prairie rose
Camphorweed	Indian paintbrush	Prairie smoke
Carolina anemone	Ivy-leaved morning glory	Purple prairie clover
Common barberry	Jerusalem artichoke	Queen-of-the-prairie
Common milkweed	Lance-leaved goldenrod	Ragged fringe orchid
Common strawberry	Leadplant	Rattlesnake master
Common sunflower	Locoweed	Rough blazing star
Bird foot violet	Maximilian's sunflower	Rough-fruited cinquefoil
Compass plant	Mouse-eared chickweed	Rough-stemmed goldenrod
Crazyweed	New England aster	Showy evening primrose
Death camas	New York ironweed	Shrubby cinquefoil
Dense blazing star	New York ironweed	Silverleaf scurf pea
Evening primrose	Panicled aster	
Fall goldenrod	Pasqueflower	

Prairies and Grasses[11]

The following discussion is excerpted from http://www.okprairie.com/Grasses.htm [OK Prairie page].

> *"The center of the United States has been blessed with a sea of grasslands. Prairie diversity is due to the number of forbs. The eastern section of Oklahoma is composed of tallgrass, the center section is mixed grass, and the western area is short grass prairie. The tallest of the grasses, especially when the summer season is blessed with adequate rainfall, is the Big Bluestem. The height of mature grasses depends upon the rainfall and when that rainfall occurs. If the conditions are less than ideal and the grasses only reach knee high, the prairie is still considered a tallgrass prairie. The dominant grass species are Big Bluestem, Little Bluestem, Indian Grass (the Oklahoma state grass), Switch Grass, and Prairie Cord Grass. In Oklahoma Tallgrass prairie vegetation is dominated by C4 grasses including big bluestem, switchgrass, Indian grass, and rough dropseed. C4 plants fix carbon into 4-carbon compounds. The C3 graminoid component includes panicum, grama, junegrass, Kentucky bluegrass and several sedges.*
>
> *Big Bluestem, Andropogon gerardii. The Big Bluestem is a majestic grass. The main stem is a definite blue-green color. The seed head branches into three segments, which prompted some people to call it turkey foot grass. The root system is very dense and may extend ten feet into the soil. It was the perfect material for making "bricks" for the building of sod houses. Big Bluestem is a very important nutritious forage crop. Cattle and bison relish the immature green leaves in spring and early summer. Just as with other grasses the Big Bluestem will slowly disappear from a prairie if the grass is repeatedly grazed to eight inches or less during a growing season. The Big Bluestem starts its growth in early April and matures by September. The leaves are up to two feet long and less than half an inch wide. The leaves begin their growth rolled into a tube and unroll as they grow. The flowers are at the end of tall stalks and form three clusters from a common point. The leaves turn a reddish color after frost.*
>
> *Little Bluestem, Andropogon scoporius. Little Bluestem is a warm season perennial grass that grows up to four feet tall. It grows in dense clusters with a root system that goes down 5 to 8 feet. The leaves, like the Big Bluestem, emerge from the stem folded and unfold as they grow to twelve inches in length and less than one-fourth inch wide. The main stems are hairy and flat near the base. The flowers of the Little Bluestem are scattered along the upper parts of the stems and have a feathery appearance. In the fall the plants turn a reddish color and sport white, feathery flowers. Little Bluestem is the most widely distributed grass. It is found in all but four states. It is considered the most important grass in Oklahoma and Kansas because of its nutritive value to cattle.*
>
> *Indian Grass, Sorghastrum nutans. Indian Grass is another important plant on the prairie. It is nutritious and is eaten by all types of livestock. It grows in clumps or as single stalks. Leaves are up to two feet in length and less than one half inch wide.*

[11] http://www.okprairie.com/Grasses.htm [OK Prairie page]

Indian Grass can be identified by a pair of tooth-like, pointed lobes where the leaf meets the stem. The seed heads form attractive plumes at the top of the stems.

Switchgrass, Panicum virgatum. Switchgrass is another warm-season grass with bluish- green leaves. It grows three to six feet tall. Propagation is by seed and by underground stems. Leaves are one-fourth to one-half inch wide and six to eight inches long. Identification can be made by observing a dense tuft of hairs at the upper surface of leaves where they join the stems. The seed head is made up of a large cluster of slender stems with the tiny flower buds on the ends. Switchgrass is a very nutritious forage crop and is eaten by all types of livestock.

Prairie Cordgrass, Spartina pectinata. Prairie Cordgrass is a tall grass growing up to ten feet tall. The leaves are twelve to thirty inches long and about one-half inch wide. The edges of the leaves have short sharp teeth. Each stem is topped by a cluster of up to 32 side branches, each of which is 1.5 to 6 inches long and covered with numerous straw-colored flowers. The grass propagates by seed and heavy, woody, creeping rhizomes. The grass is also known as Slough Grass or Ripgut."

Ottawa County.

Individual plant associations that occur in Ottawa County include[12] (from okvegclass).

Acer saccharum - Quercus alba - Carya cordiformis forest association (Sugar maple, white oak, bitternut hickory)
Distribution: eastern-most tier of Oklahoma counties (Adair, Cherokee, Delaware, LeFlore, Mayes, McCurtain, Muskogee, Ottawa, and Sequoyah counties). Habitat: floodplains and mesic slopes. Associates: *Arundinaria gigantea, Fraxinus americana, Ilex opaca, Liquidambar styraciflua, Ostrya virginiana, Quercus velutina, Ulmus americana*.

Acer saccharum - Quercus rubra - Carya cordiformis forest association (Sugar maple, red oak, bitternut hickory).
Distribution: eastern tier counties of Oklahoma (Adair, Cherokee, Delaware, LeFlore, Mayes, McCurtain, Muskogee, Ottawa, and Sequoyah counties). Habitat: floodplains and mesic slopes. Associates: *Asimina triloba, Celtis laevigata, Elymus virginicus, Euonymus atropurpurea, Ilex decidua, Staphylea trifoliata*.

Quercus muehlenbergii - Acer saccharum forest association (Chinkapin oak, sugar maple)
Distribution: eastern tier of Oklahoma counties (Adair, Cherokee, Delaware, LeFlore, Mayes, McCurtain, Muskogee, Ottawa, and Sequoyah counties). Habitat: floodplains, ravines, and mesic slopes. Associates: *Carya cordiformis, Celtis laevigata, Fraxinus pensylvanica, Lindera benzoin, Parietaria pensyl*

[12] Bruce Hoagland, The Vegetation Of Oklahoma: A Classification For Landscape Mapping And Conservation Planning. Oklahoma Natural Heritage Inventory and Department Of Geography, University Of Oklahoma Norman, Ok 73019. December 2000. A publication of the Oklahoma Biological Survey.

Quercus rubra - Quercus shumardii forest association (Red oak, Shumard oak)
Distribution: Eastern Oklahoma (Adair, Cherokee, Craig, Delaware, Haskell, Latimer, LeFlore, Mayes, McCurtain, Muskogee, Ottawa, Pushmataha, and Sequoyah counties). Habitat: lowlands and mesic slopes. Associates: *Acer saccharum, Carya alba, C. tomentosa, Crataegus viridis, Elymus pilosa, Parietaria pensylvanica, Quercus velutina*.

Betula nigra - Platanus occidentalis/Alnus serrulata forest association (River birch, sycamore, Hazel alder)
Distribution: eastern Oklahoma (Adair, Atoka, Cherokee, Choctaw, Delaware, Haskell, Kay, Latimer, Leflore, Mayes, McCurtain [excluding the coastal plain], McIntosh, Muskogee, Osage, Ottawa, Pittsburg, Pushmataha, Sequoyah, Tulsa, and Wagoner counties). Habitat: riparian corridors. Associates: *Acer negundo, Arundinaria gigantea, Berchemia scandens, Carpinus caroliniana, Chasmanthium latifolium, Fraxinus pennsylvanica, Lindera benzoin, Salix nigra*.

Quercus palustris - Carya illinoensis/Ilex decidua forest association (Pin oak, pecan, possumhaw or deciduous ivy)
Distribution: Most common along the Deep Fork, Verdigris, and Neosho Rivers in northeastern Oklahoma (Cherokee, Craig, Haskell, McIntosh, Muskogee, Nowata, Okmulgee, Ottawa, Rogers, Sequoyah, and Tulsa counties). Habitat: moist to wet soils of bottomlands and floodplains.

Forestiera acuminata - Cephalanthus occidentalis shrubland association (swamp privet, buttonbush)
Distribution: This association occurs along the Deep Fork, Verdigris, and Neosho Rivers (Cherokee, Creek, Delaware, Lincoln, Muskogee, Okmulgee, Ottawa, Rogers, Tulsa, and Wagoner counties). Habitat: backswamp, sloughs and flooded habitats. Associates: *Amorpha fruticosa, Cyperus* sp., *Hibiscus laevis, Nelumbo lutea, Polygonum hydropiperoides, Zizaniopsis milacea*

Wetlands in Ottawa County (Abell et al, 2000)

Freshwater ecoregions, in most cases, comprise aggregations of catchments, also known as watersheds or drainage basins. A catchment includes all of the land draining into a particular river or lake. Tar Creek is in the Central Prairie drainage system. The major habitat type is temperate headwaters and lakes. It is defined by the watersheds of several rivers, including the middle portion of the Arkansas River and its tributary the Neosho River, and the lower Missouri River to Kansas City and its tributary the Osage River.

The Central Prairie drainage system contains 8 endemic fish species, including the threatened Niangua Darter (*Etheostoma nianguate*), bluestripe darter (*Parcina cymatotaenia*) and Missouri saddled darter (*Etheostoma tetraxonium*), all endemic to the Osage and Gasconade watersheds. Also endemic are the Neosho madtom (*Noturus placidus*) and orangethroat darter (*Espectabile squamosum*) in the middle Arkansas River. This ecoregion also includes an endemic mussel (known as the Neosho mucket, an elktoe mussel, *Alasmidonta marginata*), one endemic salamander (*Eurycea tynerensis*), 13 endemic crayfish species including the prairie crayfish (*Procambarus gracilis*), often found considerable distances from surface waters in the grasslands.

Table 3. Wetland plants in Ottawa County

Wetland plants in this table are known to be in Ottawa Co or the two adjacent counties.[13] The cultural information is taken from Moerman (1998).

Plant	***Traditional Uses***
Whiteroot rush (*Juncus brachycarpus* Engelm.) Needlepod rush (*Juncus scirpoides* Lam.) Torrey's rush (*Juncus torreyi* Coville) Tapertip rush (*Juncus acuminatus* Michx.) Slimpod rush (*Juncus diffusissimus* Buckl.) Common rush (*Juncus effusus* L.) Grassleaf rush (*Juncus marginatus* Rostk.)	Rushes were used for a variety of baskets, bedding, mats, fiber, cordage. Some rushes were used as root and shoot foods, and there are some reports of emetic properties of some rushes.
Cattails (Typhaceae) Broadleaf cattail (*Typha latifolia* L.); Narrowleaf cattail (*Typha angustifolia* L.); Southern cattail (*Typha domingensis* Pers.)	Humans have made extensive use of cattails. The rhizome and center of the stem can be eaten raw or roasted. The rhizome can be ground into flour after drying. The rhizome was also believed to have medicinal properties. The Cheyenne used cattail root extracts in the treatment of abdominal cramps. The Delaware used cattail roots to treat kidney stones. The Potawatomi treat inflammation. The Pawnee and Ponca used the down to treat burns. Many tribes used the down to prevent infant chafing. Leaves and stems were used in weaving and construction. The down was used to stuff mattresses, and is absorbent.
American water-willow (***Justicia americana*** (L.) Vahl)	Nectar is sweet.
Red maple (***Acer rubrum*** L.)	Bark is analgesic, emetic, many other uses as beverage or poultice. Sap is sweet. Wood was carved into many objects.
Box elder (***Acer negundo*** L.)	
Broadfruit bur-reed (*Sparganium eurycarpum* Engelm. ex Gray)	An important cover-forming plant for wildlife species in marshes. The achenes, or seeds, are eaten by waterfowl and shorebirds. The base of the plant provide fleshy food for beavers and muskrats.
American bur-reed (*Sparganium americanum* Nutt.)	
Branched bur-reed (*Sparganium androcladum* (Engelm.) Morong)	
Water plantain (*Alisma subcordatum* Raf.)	Unlike other species in this family, water-plantain has a profuse number of small flowers in wispy panicles. The seeds

[13] http://www.biosurvey.ou.edu/wetland/emergent_grasslike_junc.html and http://www.biosurvey.ou.edu/wetland/index.html

	(achenes) and roots are eaten by numerous bird species. The Cherokee prepared a poultice to treat sores, wounds and bruises.
Duck potatoes or arrowheads (*Sagittaria* spp.) Shortbeak arrowhead (*Sagittaria brevirostra* Mackenzie & Bush) Duck potato (*Sagittaria latifolia* Willd.) Kansas arrowhead (*Sagittaria ambigua* J.G. Sm.)	The seeds (achenes) of these species are eaten by numerous bird species. One quarter of North American arrowheads produce a starchy tuber which is eaten by waterfowl, muskrats, and beaver will eat the tubers. Native Americans and white settlers also ate the tuber. However, the milky sap of the tuber is bitter, but can be neutralized by boiling. All species are native perennials.

4.5 Riparian Forest or Bottomland

Bottomland hardwood forest is located along waterways across Oklahoma (Figure 7). The Oklahoma vegetation survey (Hoagland et al., 1996) developed a quantitative vegetation classification and analyzing patterns of species diversity in bottomland forest. The dominant bottomland trees vary across Oklahoma. In far southeastern Oklahoma bald cypress and willow oaks predominate; in northeastern areas are pin oaks and cove-type hardwoods; in central Oklahoma there are elms, pecan and a wide variety of oaks; in the western part of the state the majority of trees are cottonwood, elm and ash.

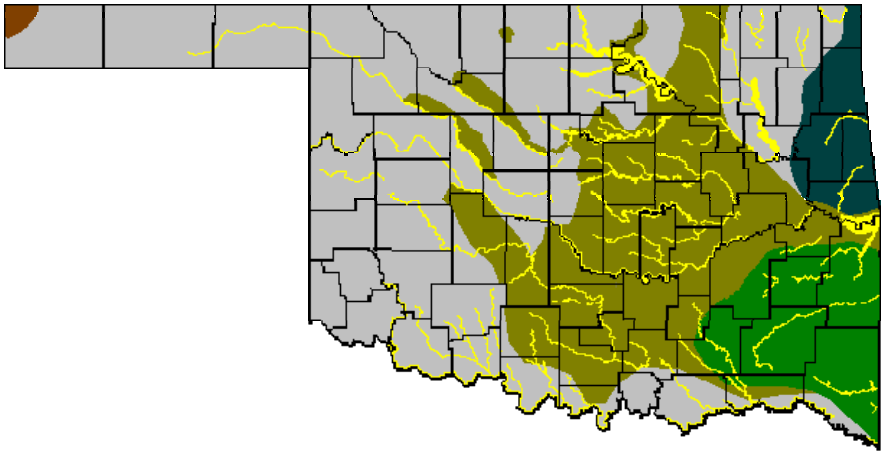

Figure 7. Oklahoma bottomland hardwood locations

From: http://www.forestry.ok.gov/oklahomas-diverse-forest. The yellow indicates bottomland or riparian forest.

4.6 Contemporary Tar Creek Resources

The original habitat type in northwestern Ottawa County where the Tar Creek is located was in the transition zone between Ozark Highlands and tall grass prairie, so both ecotypes were present along with wetlands and forested zones occurring along water courses (bottomlands, riparian forest, or gallery forest) (Groeneveld, 2006; Kindscher, 2007; Tar Creek Superfund Task Force report of the Natural Resources Subommittee, 2000).

Groeneveld (2006) surveyed contemporary conditions in riparian corridors inside and outside the visibly mined areas (VMA) in order to compare contemporary mined and unmined areas. Examples of culturally important species from the Tar Creek riparian areas include fish, crawfish, mussels, turtles, berries and fruit (persimmons, cherries, gooseberry, mulberry), herbs (snakeroot, redroot, dogroot, sage), foods (onion, garlic, water cress, mushrooms, asparagus, nettles) and nuts (acorns, hickory, walnut) (Tar Creek Superfund Task Force report of the Natural Resources Subcommittee, 2000).

The following tables show the species that Groeneveld identified, with information added about the cultural uses. Contemporary land coverage (Table 1) indicates that forested riparian areas could have accounted for one-fifth of the acreage in the general Tar Creek area. The rest of the tables in this section pertain only to the forested riparian bottomland areas.

Table 4. Land Cover Percentages (Groeneveld, 2006)

Land Cover Class	*Outside Visibly Mined Area (%)*	*Inside Visibly Mined Area (%)*	*VMA Acres Represented*
Forested	15%	22%	2224
Cultivated	58%	9%	910
Water/Marsh	2%	7%	707
Grassland	24%	17%	1718
Urban/Suburban	1%	4%	404
Mine Waste	0%	41%	4144
Totals	100%	100%	10,107

Table 5. Woody overstory (Groeneveld, 2006, Table 6)

Basal area reflects trunk diameter at breast height, summed for each species.

Species	***Basal Area (ft^2/acre)***		***Cultural Use***
	Outside VMA	***Inside VMA***	
Hackberry	31.5	6.9	Edible, medicinal
American elm	31.0	21.9	Medicinal, fiber, wood
Osage orange	15.0	3.8	Bow making
Pecan	13.0	0.0	Edible
Persimmon	10.0	1.3	Edible
Black walnut	8.5	0.0	Edible
Red oak	8.0	0.6	Edible
Green ash	4.5	0.0	Medicinal, fiber, splints, arrows, bows
Honey locust	4.5	0.6	Medicinal, edible pods, posts
Eastern red cedar	4.5	4.4	Medicinal, fragrance
Silver maple	4.0	0.0	Medicinal, fiber, sweet sap
Cottonwood	2.5	29.4	Absorbent fiber, fruit used as chewing gum, building materials, dye
Wild cherry	2.5	0.6	Edible
Pin oak	2.5	0.6	Edible
Mulberry	1.5	0.0	Edible
Black willow	1.0	2.5	Medicinal, building and basket materials
River birch	0.5	0.6	Medicinal
Catalpa	0.5	20.6	Carving
Sycamore	0.5	0.0	Wood
Wild Plum	0.5	0.6	Edible

Table 6. Woody understory (Groeneveld, 2006, Table 7)

Importance value is a combination of relative frequency and relative density. The understory includes young trees of overstory species.

Species	*Importance Value of Woody Understory*		*Cultural use*
	Outside VMA	*Inside VMA*	
Hackberry	37.2	5.2	Edible, medicinal
American elm	35.9	54.9	Medicinal, fiber, wood
Wild cherry	28.6	15.9	Edible
Roughleaf dogwood	17.9	5.9	
Sumac	15.5	68.2	Medicinal, edible
Green ash	14.6	0	Medicinal, fiber, splints, arrows, bows
Eastern red cedar	13.5	29.4	Medicinal, fragrance
Red oak	11.1	0	Edible
Pecan	9.1	0	Edible
Pin oak	7.4	5.2	Edible
Buckthorn	6.1	0	Medicinal
Catalpa	5.2	0	Carving
Pignut hickory	3	0	Edible
River birch	0	10.8	Medicinal

Table 7. Groundcover (Groeneveld, 2006, Tables 8 and 9)

Abundance index is (frequency of observation/median rank).

Species	*Abundance Index*		*Cultural use*
	Outside VMA	*Inside VMA*	
Buckbrush	62.5	2	Baskets
Honeysuckle	53.9	17.5	Baskets
Bermuda grass	42.8	26.6	
Aster	34.3	41.5	
Wild rye	24.1	1.9	Edible seeds
Big bluestem	11.9	0.3	Hay
Blackberry	11.5	8.2	Edible
Ironweed	11.1	4.7	Fiber, dye
Prairie brome	11.1	5.5	Fodder
Fescue	10.8	8.8	
Greenbrier	10	14.8	Medicinal, edible root
Sideoats grama	8.5	0	
Multiflora rose	8.2	0	Rosehips
Broom sedge	6	23.1	
Poison ivy	3.9	4.8	
Pokeweed	3.3	0	Edible
Yarrow	1.5	0.8	Medicinal
Roughleaf dogweed	1	0	Medicinal
Wild grape	1	0	Edible
Henbit	0.8	2	

Plantain	0.5	0	Medicinal
Yucca	0.5	6	Fiber, Edible root
Mulberry	0.3	0	Edible
Prairie dropseed	0.2	1	Edible seed
Pasture thistle	0.2	0.4	
Johnson grass	0	51.5	
Goldenrod	0	8.8	Medicinal
Black-eyed Susan	0	5.2	Edible
Wild asparagus	0	2	Edible
Sumac	0	0.5	Medicinal
Yellow clover	0	0.3	
Vetch	0	0.3	

5.0 Regional Annual Resource Cycles

This section describes the ecologically-based lifeways and traditional resource uses that comprises the traditional Quapaw subsistence lifestyle. When used in a narrow sense to describe only the environmental context of the eco-cultural lifestyle, the term "subsistence" refers to the economic activities of environmental management, hunting, fishing, gathering and trading activities that are fundamental to the way of life of many indigenous peoples. In economic terms, a subsistence economy is one in which western or European-style currency is limited because many goods and services are self-produced and consumed. Subsistence activities include traditional and modern technologies for managing the environment, harvesting and preserving foods as well as for distributing the produce and benefit (cash or goods) through communal networks of sharing and bartering. Examples of professions (specifically apprenticed and trained, with accoutrements, special knowledge and songs) included hunter, fisherman, doctor, and basket maker.

This section describes the history and resource uses of the Quapaw in Arkansas and then in Oklahoma.

5.1 Quapaw and other peoples in Arkansas

Many archaeological studies of sites in Arkansas have appeared in the literature, although there is a scarcity of data specifically about Quapaw phases and Quapaw ethnography (just before the early historic period). The major known Quapaw sites have extensive evidence of domestic structures in the form of midden deposits and house mounds retained from their origin in the upper Mississippi region. Later sites often had no central temple mound. Some sites were inhabited during good times, and some during times of migration epidemics. For example, the Parkin Site in Arkansas was occupied from approximately 1350 to 1650 under crowded conditions, showed a high rate of childhood stress and a maize diet with high sugar-carbohydrate (evidenced by dental caries), but also with high iron game meat (lack of osteoporosis) (Murray, 1989).

A village typically was a cluster of permanent beehive-shaped houses dispersed along rivers surrounded by corn fields and woodlots (Nieberding 1976; Key, 1991). Quapaw sites are generally located on natural levees or other relatively high land in river bottomlands, or are located on former river channels or bayous. One Quapaw town (Capaha) near the Mississippi River had a lake or moat around the village, with a great weir or channel from the MIssissippi through which fish came into the moat. Several other towns also had moats, generally thought to be for fish rather than defense (Hodges, 1910; Hoffman, 1975).

The typical Quapaw house was a long (quonset-shaped) house with rectangular bases of 15 x18 or 20 x 30 feet or larger, with several fireplaces, and covered either by bark or wattle and daub. Major stored foods include 10 varieties of corn, 8 types of beans, and seven kinds of squash and pumpkin (squash rounds were dried and strung), dried meat and fish, a variety of seeds and nuts. Tobacco was also cultivated and dried.

5.1.1 Direct observation by early explorers, traders, naturalists, and missionaries.

In 1537 de Soto and other early explorers noted populous agricultural districts in the main Mississippi river valleys (Key, 1991; Sabo in McEwan). These explorers were amazed at the abundance and fertility of the land. The Quapaw had long been master farmers when they settled in the rich alluvial soil of the Arkansas riverbottoms. The focus of Quapaw life was the permanent village with adjacent fields. The early explorers described fields of four or five miles long from which the Quapaw harvested corn, pumpkins, squash, gourds, sunflowers, beans, tobacco, and other crops, as well as nuts, seeds, persimmons and other fruit, grapes, and berries from trees and vines along the field margins (Key, 1991; Sabo in McEwan). Turkeys were domesticated and ducks and geese were kept in pens. A variety of forest and forest-edge species was hunted – bear, deer, small mammals, and birds, as well as fish and waterfowl (Key, 1991; Sabo, 2000).

During the 1670s to the early 1700s several French expeditions (e.g., Marquette, La Salle, Joutel, and Tonti) returned to the area. They encountered Quapaw villages near the junction of the Arkansas and Mississippi Rivers, but populations had already been greatly reduced and simplified, probably due to epidemics. Shea (1852, 1861) published several letters from other early French explorers in the early 1700s. Large villages had recently been devastated by epidemics and hunting was somewhat repressed due to population decrease and threats from other tribes. Still, at that time there were large fields of corn, beans, and squash. .

In 1721, Bernard de la Harpe traveled up the Arkansas River, and met several Quapaw bands with canoes loaded with buffalo and bear. Along his travels, he noted sandy banks with great quantities of grapes and plums, and many red and white morrels, so plentiful that they formed part of their subsistence. He saw large cane brakes and buffalo, turkeys, and fine lands with reeds, canes, and clear woods. Buffalo and turkeys were the main food they hunted on the trip. He noted some places suitable for marble and slate. Further upriver deer, bear, and turkeys were more common. The rivers abounded with fish and prodigious numbers of turtles.

DuPratz (1763) translated journals from French explorers. The explorers made soup from bison marrow and maize (sagamite) which “surpassed the best dishes in France.” Both sides of the rivers were dry after the annual flooding, as far as half a league inland. Buckwheat was sown in great quantity in good soil, with shoots over three feet high, compared to 1-2 feet in French fields. North of the Arkansas River fowl were in such great numbers that “those who are most fond of this game might easily satisfy their longing, as also every other species of game.” Small birds “are still vastly more numerous.”

Before and during early contact there was also a sophisticated technology with stone, bone, weed, shell, fibers, and basket materials and other media. Quapaw made beautiful ceramic wares from the locally abundant clays. There were many elaborate grave goods made from local and far distant resources, indicating an active trade network. Some of the local materials they traded included bison hides and salt, to obtain raw copper, stone and marine shell. Early explorers noted cotton and turquoise from the southwest. Trading records show that enormous numbers of deer hides were brought to the trading posts, and traders noted their beliefs that there were hundreds of thousands or millions of white-tailed deer. Deerskin trade as a bulk currency continued into colonial days, and early settlers pursued subsistence

as well as farming and livestock. Settlers were also reliant on trade with Indians for survival for many decades (Key, 1991).

Bear. Bears were hunted for meat but mostly for oil. The bear oil, up to 160 liters per bear, was used in cooking stews and fried foods, and when frozen was used to spread as butter on bread. The oil was stored in a seamless fawn skin (a "fawn of oil"). Bear oil could be further processed by adding laurel leaves and salt to draw out any odor from melted oil, then let to settle. An oil rose to the top, and a soft white lard layer formed below the oil layer. The Quapaw of that area usually traded 2500 to 3000 pots of bear oil per year (Young and Hoffman, 2001; Baird, 1980).

Buffalo. When the French came to Arkansas in the seventeenth century, bison were very plentiful in the meadows and forests and in the numerous huge canebreaks along the rivers. After the traders came, the buffalo diminished, although they were still plentiful in the upland, and game was also plentiful. The Quapaw hunted buffalo cows for meat and old bulls for tallow. Buffalo tallow was used for candles, soap and caulking boats, which were sold by Quapaw women. The old bulls had the thickest coat, the meat was fatter and juicer, and the animal would produce more tallow. Glue was made from tallow and a little ash. Summer hides did not require as much processing and were sought if they were to provide spring or summer clothing. Robes with paintings were use to separate different areas of the houses. (Arnold, 2000; Young and Hoffman, 2001; Baird, 1980). There were still an estimated 75 million bison in the mid-1800s. There were also so many buffalo and deer that they were regarded as endlessly renewable until their habitat was destroyed (LaVere 1998) Within 25 years they were almost exterminated in a government-sponsored effort to starve the plains Tribes (Waldman, 2000).

Deer. The forests, because they were managed to support browse, were home to hundreds of thousands of white-tailed deer and black bears that provided food, clothing, materials, and trade goods (Walsman, 2000; Arnold 2000).Deer were obtained in great number and boiled or roasted. They were often hunted by women because they were so easy to get and process. Painted deerskins were used as bedspreads, tablecloths, and other items. These painted skins were "very highly prized among the other nations" (Arnold, 2000).

Corn. Early visitors reported that the Quapaw harvested three different corn crops a year of many varieties, indicating a considerable amount of experimentation and selection on their part to develop strains selected for their differing characteristics. Corn was stored in baskets and gourds as large as half-barrels. Early explorers describe maize, with a grain the size of a pea, on stalks 8 feet high with seven hundred grains per husk. The husks were about two inches thick by seven or eight inches and upwards in length (Waldman, 2000; Arnold, 2000).

Native plants were also managed as part of the overall forest and land management to encourage persimmons, paw paw, haws, hackberries, several varieties of plums, mulberries, hickory nuts, walnuts, pecans, and acorns, grapes and raisins, dried fruits. Many other species are mentioned by various authors (Key 1991; Arnold, 2000).

Wetlands. Observers noted southern wild rice (*Zizaniopsis miliacea*), which need the sediment deposited annually by floods; it makes a flour that has more lysine than corn. Water chinquapin, or American lotus, has edible seeds and roots and was widely eaten. Seasonal flooding also created habitats for fish in the oxbows and sloughs, and were caught

with spear, hooks, nets, or weirs. They "did not want for fish of all sorts." Waterfowl were present in great numbers in the autumn along the Mississippi flyway (Key, 1991).

5.1.2. Colonial Era in Arkansas

Naturalists, surveyors, and early settlers came to Arkansas and recorded their observations. For example, Nuttall visited Pine Bluff in 1821. "The younger Indians... are so partial to cleanliness of the skin that they practice bathing both winter and summer. As to maize, it is a luxuriant as possible. But what most recommended this settlement, in my estimation, was the unequivocal appearance of health and plenty." The woods, which had been overrun by fire in autumn, were strewed in almost exclusive profusion with *Rananculus*. The first terrace by rivers is subject to inundation; the second terrace is free from water and is where the large cane brakes commence.

The Arkansas Post was 7 miles southwest of Gillett, Arkansas, at the southernmost tip of the Grand Prairie. Early observers describe the prairie as well covered with grass and herbaceous plants. Among other plants already in flower in early February were carpets of *Allium*, *Housatonia serphyllifolia* and *Claytonia caroliniana* (edible bulbs). Shallow waters covered the prairie after spring rains, with *Eryngium aquaticom* springing up. The alluvial forest contained oak, hickory, box, elder, and elm with cottonwood nearer the waters (Martin, 1977).

Sabo (2000) describes the Quapaw of 1673-1803 engaging in spring planting ceremonies and the summer Green Corn ceremony. "Despite their friendly disposition toward missionaries, the Quapaw were notoriously poor converts. When the American colonial era commenced at the beginning of the nineteenth century, traditional religious beliefs and practices remained intact." This reflects the strong adherence to traditional ways.

5.2 Traditional Resource Management (Middle Mississippi Region)

This section describes traditional resource management practices.

Fire.

Native people understood the relation of plant and fire cycles and employed fire to maintain browse, reduce overall fire hazard, and encourage germination of native plants and growth of native forbs. Undergrowth was controlled so forests were open, meadows were kept clear, and marshes were deliberately fired to clear out dead plants, control disease and insects, and increase breeding areas and diversity. Until suppression policies around 1900, late summer and early fall fires were an expected natural event, with a natural fire interval of 10-50 years (in addition to more frequent fire regimes employed by the native peoples for particular resources). Up to half of prairie and savanna fires were set by indigenous environmental managers (Anderson, 1997; Lewis, 1993; Key 1991). Thus, intense destructive fires were rare. Some plants not only evolved with fire, but some require fire. Without fire, brush can become dominant. With fire, grasses and young shoots provide deer browse. Certain species were known to better with annual burning, others did better with burning every several years. Canebreaks were maintained by less frequent burning every

7-10 years. Along the western banks of the Mississippi and parts of the Arkansas, the cane was so large and thick that animals, including bison, could not get though.

Annual flooding.

The primary staple food of the Quapaw, corn, and indeed the entire riverine ecosystem, depended on the annual flooding of the rivers. Since the Ice Age, the meandering Mississippi, Red, Yazoo, Arkansas, Black and other rivers have been part of dynamic interconnected ecosystems. Large annual floods enhanced the biological productivity of the river and its flood plain. The annual flood waters added dissolved and particulate organic matter and mineral nutrients on the surrounding flood plains, creating rich, arable soil and providing nourishment for insects and food for fish as well as rich soil for the annual corn fields.[14] Floods nourished the canebreaks as they did farm fields (Key 1991).

Over thousands of years the vegetation and animal life living in this ecosystem adapted to the frequency and amount of flooding, and came to rely on it. Flooding left natural levees, which attracted waterfowl - the Mississippi River forms the most important bird and waterfowl migration corridor on the continent. More than 20% of the nation's duck population migrates along the river and one-third of the freshwater fish species in North America live in the river (Key, 1991). Many floodplain plants species rely upon inundation for rapid growth and reproduction. In addition, many animals are adapted to the flood cycle and depend upon the high plant and microbial activity associated with annual floods. Floods also provide reproductive cues for many fish species, and make inundated floodplain vegetation available as a food source for fish and invertebrates.[15]

Settlements were located on the alluvial lands along rivers, fed by springs, creeks, and streams. This formed sloughs, lakes, marshes, and wide expanses of grassy wetlands, which formed excellent habitat for large populations of game (Rollings, 1995).

Farming.

Seasonal flooding of lowlands covered the field with fresh topsoil and also reduced weeds. Debris was burned each fall or spring to reduce disease and return nutrients to the soil. Ashes were worked back into the soil, and beans were planted to replenish nitrogen. Eventually productivity of a field would decline, and the field was allowed to lie fallow while nearby fields were farmed. After a grain field is abandoned (or meadow burning is discontinued), grasses and forbs first reappear for 4 years or so, and then woody shrubs such as sumac and tree seedlings begin to appear. By the 6th year post oak and shagbark hickory invade, followed by black oak and white oak in 10-15 years. In 30-40 years a climax community is established.

Smith (1992) described early agriculture with native plants. Of the fall-maturing crops, two (erect knotweed and chenopodium) have high carbohydrate content, while cucurbita, marshelder, and sunflower are high in oil or fat. Two spring-maturing crops (little barley and maygrass) are high in carbohydrate. In the central portion of the continent, maize remained a minor cultigen until around 800 AD. Between 200 and 800 AD the premaize agricultural zone was gradually expanding. Between 800 and 1200 AD maize farming rapidly expanded

[14] http://www.jracademy.com/~mlechner/archive1999/Ecological.html and http://www.cr.nps.gov/delta/volume2/natural.htm

[15] http://www.environmentaldefense.org/documents/2072_ImpactsCorpsProjects.pdf

(evidence includes the change in 12C/13C ratios in human bone). This shift was coincident with a new 8-row variety of maize adapted to the shorter growing periods of more northerly climes. The addition of dry shelling beans (*Phaseolous vulgaris)* completed the corn-squash-bean triad. Over time, more 10, 12, and 14-16 row varieties of maize appeared. Eventually, corn perhaps contributed more than half of the population's annual caloric intake, judging from the stable carbon isotope studies to date, but a wide range other plants were cultivated such as a number of varieties of beans, *Cucurbita pepo*, and the green-striped cushaw (*Cucurbita mixta*) as far north as Arkansas. Also grown were domesticated varieties of pale-seeded amaranth (*Amaranthus hypochondriacus*) and Jerusalem artichoke (*Helianthus tuberosus*), maypops (*Passiflora incarnata*), purslane, pokeweed, ragweed, chenopod, and carpetweed. Underlying this seasonal round of plant husbandry is an even older pattern of dependence upon the rich and diverse wild plant and animal resources of the eastern forests. Because of the steep ecological gradient separating the river valleys from the intervening upland areas, the resource-rich river floodplain corridors had attracted hunter-gatherers long before plant husbandry played even a minor role in subsistence economies.

One of the most important attractions was the localized and dependable aquatic protein sources of both main channel shoal areas and slackwater channel remnant oxbow lakes and backswamps. As much as half of the protein of at least some agriculturists came from fish and waterfowl. These main channel and backswamp aquatic resource zones were separated and paralleled by linear bands of natural levee soils, coalescing to form broad meander belts in the larger river valleys. Annually replenished by floodwaters and easily tilled, these sandy well-drained levee soils were highly prized by prehistoric farmers, and villages almost always were situated on these natural levees with maize fields beside them (Smith 1992).

Extensive cultivated areas were not isolated from the surrounding areas, but blended into them. Corn fields were miles long, with several varieties of corn in each. Field margins were kept in shrubs and berries; while forest margins encouraged nut-bearing trees – e.g., hickory trees on forest margins yield 8 times more nuts than under closed canopies. Peaches thrived in the edges of clearings, brought to Florida in the 1500s by Spanish or French Huguenots, and quickly spread. By the time of Marquette, there were more varieties of peaches in North America than in Europe (Usner 1992).

5.3 Oklahoma Resources and Tribal Uses (Caddo, Osage, Quapaw)

"Their fields are beautiful. They fish and hunt. There is plenty of game" (Toni, 1690).

Early hunter-scouts were amazed by the huge herds of pronghorn and bison, and the vast expanses of tall timber, seas of grass, clear brooks, and abundant wildlife. There were elk in the forested areas, whitetail deer in the river bottoms, raptors including the golden eagles, many bears, many small animals, and abundant food for early explorers. (Mails,1996).

In all indigenous communities the year was structured around major resources. The energy system flowed from mountains, woodlands, prairies and wetlands through native villages into a single larger ecosystem (Nieberding, 1976). Resource uses in Eastern Oklahoma are described for the original inhabitants (Caddo and Osage) and for the Quapaw after removal to Oklahoma. This section describes both pre-settlement and post-settlement conditions.

5.3.1 Caddo (southeastern Oklahoma)

The Caddo lived in southwest Arkansas and nearby areas of Texas, Louisiana, and Oklahoma from AD 1000 to about AD 1800, or just to the south of the major Quapaw areas in Arkansas and Oklahoma. The Caddo had many small settlements scattered in particular resource areas, and a reliance on horticulture as one of the primary means of subsistence. Communities were composed of isolated homesteads and or farmsteads, small hamlets, a few larger towns, and civic-ceremonial centers with mounds. Structures were grass and cane covered, associated with grass-covered arbors and ramadas. None were fortified, indicating a generally peaceful existence.

Schambach (1999) on the Spiro site on the Arkansas River in NE Texas at the Arkansas border, Some of the Caddo trading centers were located at the nexus of 3 major commodity regions – osage orange bows (a prized commodity), bison products, and eastern trade goods. Early European settlements relied on local natives for perishable items, including salt, bison, venison, vegetables, cultivated crops, and bear oil (Pertula, 1992). People who lived near saline marshes or salt springs made salt by boiling brine in large shallow pans.

The Caddo grew corn, beans, pumpkins, squashes, watermelons, sunflowers, and tobacco. Hunting for bear, deer small mammals, and birds was important, as were fishing and gathering shellfish, nuts, berries, seeds, and roots. Stable carbon isotope ratios indicate that by 1100 most of the Caddoan groups consumed large amounts of maize. When the first Spanish explorers encountered the Caddo in 1542 they were maize farmers and deer and bison hunters.

Caddo diets were basically the same as other tribes in the middle Mississippi valley – maize, cucurbits, beans, and other domesticated plants. Their diet included many wild plant and animal resources. Each farmstead or cluster of houses was situated apart from its neighbors, presumably by stretches of prairie and forest, so a single community could extend for several miles along a stream valley. The Caddo had a horticultural economy based on maize, 5 or 6 kinds of beans, and squash, as well as native cultigens such as maygrass, amaranth, tobacco, chenopodium, and sunflowers. Corn was the most important crop and was at the center of major ceremonies. The annual cycle was based on the importance of farming, hunting, fishing, and gathering. Early French explorers describe communal field preparation and planting. Enough seed was saved for 2 years in case one year did not produce good yield.

The Caddo also managed semi-wild orchards of peach, plum, persimmon, fig, peaches, apricots, hazel nuts, chestnuts, other nuts, grapes, strawberries, and mulberries. Nuts were ground for porridge and nut bread. There were many kinds of herbs, and edible bulbs and roots such sweet potatoes. The forests and rivers provided variety of small to large game animals and fish and shellfish. Deer, rabbits, raccoon, fish, turkey, squirrel, turtles, bison and bear supplied meat, furs, tools, and equipment. The Caddo worked the deep slow-moving rivers for fish. Deer was the main game animal, and after the horse was introduced communal winter bison hunts (when hides were thicker) on the plains to the west were more common (Pertula, 1992; Swanton, 1996).

5.3.2 Osage (northeastern Oklahoma)

The Osage lived along the Osage and Missouri rivers in what is now western Missouri when the French explorers visited in 1673, before they were removed to Indian Territory (Oklahoma).

Culturally and linguistically the Osage are closely related to the Quapaw, Kansa, Omaha, and Ponca, the Dhegiha branch of the Siouan language family. At the time of French explorer contact, the Osage were a typical prairie tribe with an economy that combined hunting, gathering, trading, and horticulture. They lived in permanent villages of mat or bark-covered wigwams. They went on three annual hunts for bison, deer, elk, bear, and smaller game. Hunting for bison, deer, and elk was by far their most important economic activity, since game provided the major source of subsistence as well as trade items. Bears were hunted mainly for their skins and oil, although the meat was also eaten. Otters, beavers, skunks, rabbits, raccoons, and opossums were hunted for their pelts and provided variety in the diet (Bailey, 2001).

Women gathered wild plant foods, and tended gardens of corn, beans, squash, and pumpkins. Although horticulture was of secondary importance, it did play a critical role in the economy. The Osage year began in April or May when they cleared fields and planted crops along the river and creek bottoms. Corn, beans and squash, dried and stored, served as the major food source during the late winter and early spring when hunting was poor. Among the wild foods, prairie turnips (*Psoralen esculenta*), persimmons, and water chinquapins (water lily roots), cherries, plums, paw paws, blackberries, hackberries, dewberries, and pecans were particularly important. Large quantities of the roots and fruits of these plants were gathered and dried for winter use (Bailey, 1995, 2001).

Immediately upon their forced resettlement in Oklahoma in the 1870s, the Osage established productive farms of corn, wheat, vegetables, orchards, and a variety of enterprises - sawmill, smithy, harness shops, and so on (Wilson 1985).

5.3.3 Quapaw in Oklahoma from early 1800s and forward.

After the Louisiana purchase, Thomas Jefferson quickly launched expeditions (Lewis and Clark, Dunbar and Hunter, Freeman and Sparks, and many subsequent expeditions). The objectives were to map and survey, build roads, establish boundaries, learn about the native inhabitants, and observe and gather specimens of animals, plants, and minerals.

Naturalists and geologists were sent on these trips. Samuel Woodhouse was one of these naturalists. He was a medical doctor in the Army Medical Corps as well as an ornithologist. He recorded observations in his journals while on the Creek Boundary Expedition of 1849-1850. Being an ornithologist, however, Woodhouse paid more attention to birds and plants, and less attention to mammals, reptiles, amphibians, or insects (Tomer and Brodhead 1992).

The Creek Boundary Expedition was sent to Indian Territory to mark the boundaries of Creek Indian Lands to comply with the requirements of the Creek Treaty of 1845. When the expedition arrived, the Creeks had been moved there, and had built homes and planted peach orchards. The Indians had fine fields of corn, beans, pumpkins, watermelon, and peach orchards. Along the Verdigris, Arkansas, and Cimarron Rivers in Oklahoma

Woodhouse noted numerous large flocks of Carolina parakeets, water fowl and passenger pigeons (*Ectopistes migratorious*). He saw great numbers of passenger pigeons; in some places "the trees were almost breaking down with them." There were greater prairie chickens in great flocks, abundant throughout Indian Territory.

Wild animals included turkeys, buffalo, elk, foxes, squirrels, raccoons, skunk, and other animals. Fresh fish and wild turkeys were brought into camp every day when near rivers. Woodhouse described a large canebreak two miles wide, which were numerous in delta areas until converted to grazing areas. Some creeks were full of soft shell turtles, red eared slider turtles, catfish and sunfish. In some areas jackrabbits were so numerous that farmers held drives to kill thousands at one time to protect their crops. He mentions a salt works with a salt well, long used by the Indians, in a slaty sandstone area. (Tomer and Brodhead 1992).

By the mid-1800s there were also grains and domesticated animals such as cattle, chickens and pigs. At settlements the expeditions were served pies, cakes, wheat and corn bread, rice pudding, coffee, and other foods. One meal they ate with an Indian family was corn bread, sweet potatoes, stewed peaches, tomatoes, salt pork, and a hominy drink (sofki or sofkey, a popular dish of the Creeks and Cherokees, a thin sour gruel made from corn, water, and lye.). One fancier meal at a fort near the Verdigris River was of venison, crayfish (called lobster) and mussels (*Cyprogenia aberti*, western fanshell; called oysters) (Tomer and Brodhead 1992).

The annual reports from Indian agents to the Commissioner of Indian Affairs provide accounts of Quapaw subsistence after removal to Indian Territory (later Ottawa County, Oklahoma).

Individual agent reports are summarized in the following section.

> Settlement patterns. The Quapaw attempted to reconstruct their traditional economic system in the new environment of the northeast Indian Territory. For example, for a few years, they maintained traditions of nucleated settlement, planting corn fields in common, in 1834 and 1835. Reservation agents, however, almost immediately attempted to remodel the Quapaw as farmers in the European style under instruction of the agency farmer, and they resettled Quapaw families in scattered hamlets and farmsteads, most located along the Spring (Pomme de Terre) River in the eastern part of the reservation (see Annual reports; Avery, 1940).
>
> Farming. Annual reports record Quapaw engagement in agriculture. Other observers note that Quapaw men mostly hunted, while women farmed small patches behind farmsteads (Thompson, 1955). The Quapaw retained their traditional gender division of labor in which men cleared the fields and hunted while women farmed and also prepared the hides. Jones (1997) suggests that Quapaw engagement in hunting for the colonial market may have altered this division of labor, or at least increased women's hide preparation labor. Corn remained a major part of the Quapaw diet; one report notes difficulties caused when the State of Arkansas provided wheat flour instead of corn meal as emergency rations for dislocated Quapaw (the recipes they used could not simply substitute wheat for corn).
>
> Animal husbandry. The Annual reports also note Quapaw animal husbandry (horses, cattle, chickens, pigs). Horses, in particular, would have been of major

importance as they were throughout the 19th century America. The Quapaw also leased out land to white cattle ranchers, receiving either cash or cattle in payment, and they or their lessees harvested tallgrass pastures to sell hay.

Hunting/fishing/gathering. Hunting for deer and turkey, if not bison and bear, remained important judging by references to the use of deer hide moccasins and footballs. Fishing and use of aquatic species would also have provided some portion of the diet although the historical record here is sparse. Prewitt (1981) provides an extensive list of plant species gathered and used by the Delaware (Lenape) who, like the Quapaw, had been removed to Indian Territory (three counties to the west).

Orchards, pecans, and nut oils. There is evidence that the Quapaw ate nuts and more general evidence for the importance of nut oils. In the main, however, hickory and black walnuts were the species commonly used for oil, although pecans were used whole or as nut paste. They planted or encouraged nut trees close to settlements, and also grew peach orchards.

Ethnomedicines. Scattered comment in the archives indicates that the Quapaw continued to make medicinal use of plant species, and also sumac, cedar, and sage (horse mint) for religious purposes.

Basket making. Quapaw continued to make and sell baskets made with the inner bark of ash, as well as cane, buckbrush, honeysuckle, and other materials.

Pottery and use of clay and mineral deposits. There is no direct evidence that pottery manufacture survived the move from Arkansas to Oklahoma, especially since iron kettles were available. Use of wooden platters may have been carried into Oklahoma; face paints of clays and minerals such as vermillion continued. People probably discontinued local salt production when commercial salt appeared in the marketplace. The Quapaw did exploit coal deposits.

Notes from Indian Agent reports are included below, in chronological order. Several Tribes were serviced by this agency, including the Quapaw.

Report of Commissioner of Indian Affairs, 1834.

Daily provisions given to Indians during the removal process were

- Bread: one pound wheat flour, Indian corn meal, or hard bread, or ¾ of a quart of corn, and
- Meat: one pound fresh meat (with 2 quarts of salt per 100 pounds of meat), or ¾ pound of salt meat or bacon.

This is the year the Quapaw arrived at the Neosho sub-Agency. When they first arrived, the lands designated for them were not properly surveyed. They immediately formed towns, built cabins, and planted crops, but were subsequently moved to other lands.

> *"The Quapaw lands are inferior in point of soil to either of the tribes they adjoin; there is too great a proportion of prairie; sufficient table land for the support of the tribe is, however, within their bounds. It is well watered and very healthy: they own horses, hogs, and cattle; have a blacksmith's shop,*

striker, iron and steel furnished them, with a farmer to instruct them in cultivating their lands."

Report of Commissioner of Indian Affairs; Report of Commissary General of Subsistence No. 11: 1835.

The same daily ration was provided as above, but salt was reduced to 2 quarts per 100 pounds of meat.

"The land is fertile, the water good, the wood sufficient on and near all the streams, and the game is undiminished in abundance."

Report of Commissioner of Indian Affairs, 1836. same wording as 1834

Report of Commissioner of Indian Affairs, 1839. same wording as 1834

Report of Commissioner of Indian Affairs, 1842.

In 1841 or 1842 they made hay for the first time, and enlarged their fields for corn and 'pumpkins'. The lands in general is

"high, rolling, healthy, and finely watered; springs in every direction of the best water, sometimes gushing out of the solid rock in streams large enough to turn a mill. Where it is fit for cultivation at all, the land is fertile; much of it is hilly and barren, worthless except for timber. The lands on the water course are of the best quality; well suited to the cultivation of tobacco, hemp, corn, the small grains, etc. The upland prairies are scarcely inferior. There is in fact a much greater quantity of good land than the recent occupants will ever use. The heavily-timbered bottoms on the Pomme de Terre and the Neosho afford not only good winter range for cattle, but an abundance of marsh for hogs."

Report of Commissioner of Indian Affairs, 1843.

The Quapaw had raised no wheat or oats yet, but they raised a great quantity of beans and some garden vegetables.

Report of Commissioner of Indian Affairs, 1844.

"The Quapaw possess a most beautiful country, about one-half of which is prairie, and nearly all in a body; the remainder is generally good land, and well-timbered, with very pure water."

"The present position of [the Quapaw manual labor school] is, in my judgment, the best that could have been selected, being situated in a beautiful forest on the east bank of the Pomme de Terre river – high, dry, and healthy, embracing, in one body, prairie and timbered land of good quality, with water, rock, and other conveniences."

"I am of the opinion that the lands owned by these three tribes (Quapaw, Seneca, Shawnees) are as valuable as any, in their original state, I have ever

met with. The climate is good and healthy, the water is superior, the lands are as rich as then can well be, with an ample supply of timber for building, fencing, and fire wood, and at the same time high and rolling, affording grazing grounds for immense herds of cattle."

"There are also three fine large rivers – the Cowskin, the Neosho, and the Pomme de Terre. The rivers can be navigated the greater part of the year by flat-bottomed boats. The Indians of all those tribes are healthy, well-satisfied with their country, and seem to be fast approaching to contentment and happiness; and would, if left alone by unprincipled white men, who are incessantly intriguing with them and frequently against the agent, ... would advance in the blessings of civilization much more rapidly." [Pomme de Terre is the Spring River]

Report of Commissioner of Indian Affairs: Neosho Agency, 1845.

Reporting on Seneca and Shawnee, the Commissioner noted cornfields, cattle, horses, hogs, potatoes, melons, beans, and cabbages. Some Indian groups sowed small grains, and some did not.

Report of Commissioner of Indian Affairs: Neosho Agency, 1846.

"The Quapaw are improving in many respects." He reported larger farms, repaired fencing, and the first wheat crop.

Report of Commissioner of Indian Affairs: Neosho Agency, 1849.

"The Seneca, Shawnee and Quapaw are all possessed of good health and busily engaged. They have raised sufficient quantity of grain, vegetables, swine, and cattle, to last through the winter."

Report of Commissioner of Indian Affairs: Neosho Agency, 1851.

"Their country is well-adapted to the growing of stock. The summer range is almost inexhaustible, and in winter the creek and river bottoms afford grass and pea vine sufficient to winter their out-houses and cattle. Many of them cut and cure a large amount of prairie grass, which makes good hay, and assists them greatly in wintering their stock."

Report of Commissioner of Indian Affairs: Neosho Agency, 1853.

"The lands of the Senecas. Seneca-Shawnees, and Quapaw are very similar, composed of woodland and prairie, about one-third prairie, and the remainder woodland. The prairie land will produce well for a few years, but it is not generally as good soil as the bottom lands along the streams. Their country is well watered with fine, clear running streams, and good springs of pure, limpid water. Much of their upland is poor and rocky, timbered mostly with black oak, very scrubby. The land along the streams is a rich black loam, timbered with black and white oak, hickory, ash, etc. The principle productions are wheat,

corn, oats, sweet and Irish potatoes, peas, beans, watermelons and muck-melons, all of which grow to great perfection."

Report of Commissioner of Indian Affairs: Fort Smith Agency, Arkansas, 1867.

"The Osage still chase the buffalo, without whose food and tallow they cannot subsist. They go on the hunt twice a year, in June and Sept-Oct (although they have to go further now than they used to). Whites generally steal their horses." At this time the Osage, to the northwest of the Quapaw, went on bison hunts twice a year on extended trips, but the buffalo were being driven north by the great emigration of white people crossing the plains. Some of the Quapaw did not cultivate land, but made an annual hunt to the plains and returned with peltries, and also owned horses, cows, and hogs.

Report of Commissioner of Indian Affairs: Quapaw Agency, 1869.

This report tells what the families were growing, in order: corn, oats, wheat, potatoes, and beans, along with horses, cattle, sheep, and hogs. They had several apple and peach orchards.

Report of Commissioner of Indian Affairs: Quapaw Agency, 1887.

"The Peorias, Miamis, Wyandottes, and Ottawas are practically white people, a part of these having farm-houses and barns that will compare very favorably with their white neighbors over the border in the states of Kansas and Missouri. They nearly all have good farms and are good average farmers...However, the Quapaws are content to live the life into which they were born."

Report of Commissioner of Indian Affairs: Quapaw Agency, 1920.

This agency includes all of Ottawa County lying east of the Neosho River and a strip of Delaware County to the south.

"The country is hilly, being an extension of the Ozark Mountains of Missouri. There are numerous streams flowing through the rather deeply cut valleys, the northern portion is perhaps not so rugged as that farther south. The river bottoms are rich alluvial soil, while some of the rolling uplands are also quite fertile. Some timber of considerable size still stands on the hillsides. The northern portion is included in the important lead and zinc mining field, known as the Joplin district, and there are many extremely valuable mines. The Quapaw reservation established by the Treaty of 1893 comprised 56,265 acres, all allotted. ... Everywhere the landscape is variegated by the ugly, gaunt mine buildings, whilst enormous piles of "chat," as the finely crushed refuse rock is called, are growing by leaps and bounds day by day. ... The present leasing system would appear to me to be adequate to the situation. There will also be more serious complications in providing for the discharge of mine water and the refuse chat than there are at present."

6.0 Diet

The approach used in describing an overall diet is to use the information about major resources present in the study area, foraging theory information, and information from the existing ethnographic literature. An overall food basket is derived for total caloric intake, with the proportions of the food groups based on information about the resource utilization patterns. This food basket is reconstructed from information about what the traditional diet actually was, rather than what it might be today if USDA recommendations about daily intakes were followed substituting wild for domesticated foods.

For the Quapaw, the baseline is the original subsistence with horticulture, as was practiced in Arkansas and practiced in Oklahoma before mining. It should be noted that wild foods have never been totally discontinued; traditional uses of native plants have continued (e.g., Prewitt, 1991).

The steps for reconstructing the Quapaw diet are as follows (Harper et al., 2007):

1. Review ecological information for a rough estimate of resource abundance and diversity of natural resources under baseline conditions;

2. Review foraging theory information presented above specific to the Tribe and the local ecosystems and habitats to establish the approximate rank order of natural foods;

3. Review ethnographic sources for methods of obtaining, preparing and using resources;

4. Develop overall percentages of major food categories and major staples within the total diet; and

5. Estimate calories and macronutrients provided by each food category, and develop estimated daily intakes for each food category as an average daily diet.

Staple foods are those that are abundant, reliable, and/or storable. In general, the foods that meet those requirements are nuts, fresh and dried meat from large game mammals, roots, seeds & grain, fresh and dried fish, dried fruits and vegetables, and dried leaves (spice, tea, medicine). Mixes, such as pemmican, were also commonly stored.

6.1 Ecological Information

6.1.1 Diversity of the Wild Portion of the Diet

As mentioned above, the Ozark highlands with its oak-hickory savannah, the tallgrass prairie with its diverse forbs, riparian forests and wetlands yield a wide range of edible and useful plant and animal products. This is reflected in eastern plains archaeological sites that yield 45 species of animals, and 40 flora taxa (Johnson 2001). There were abundant wild plants in the eastern plains – grasses and forbs, seeds, spring shoots, leaves, tubers, and

other parts. Of primary interest was the Indian breadroot or prairie turnip (*Psoralea esculenta*), which grows on well-drained hillsides and produces nutritious starchy tubers. They were collected in considerable quantity, peeled to be eaten fresh, dried, or boiled with vegetables, or strung in braids and hung in lodges (Wedel 1978, Reid 1977, Kindscher 1987). In the streamside bottoms were groundnut (*Apios americana*), a twining vine with long stringy roots on which tubers grow like beads on a string. The hog-peanut (*Amphicarpaea bracteata*) grows in the same habitat, a vine that produces small aerial beans and large underground seeds (Wedel and Frison, 2001).

Other plant foods in the general Plains/Highlands area that were entirely wild, encouraged through the use of fire and field margins, or actively cultivated include sunflower (*Helianthus annus*) for seeds; Jerusalem artichoke (*Helianthus tuberosus*), purple poppy mallow (*Callirhoe involucrata*) for their roots; the bush morning glory (*Ipomoea leptophylla*) for its huge but not very palatable root used mainly when other roots were not available); the American lotus (*Nelumbo lutea*), cattail (*Typha* spp.), and arrowroot (*Sagittaria* spp.) grow in ponds and slow streams provide tubers, shoots, and seeds. Some plants have heavy seed drops in the fall – sand dropseed (*Sporobolus cryptandrus*), vine mesquite (*Panicum obtusun*), barnyard grass (*Echinocloa muricata*) and pignut (*Hoffmannseggia glauca*). Prickly pear cactus grew widely. Pigweed (*Amaranthus* spp) and giant ragweed (*Ambrosia trifida*) provided seeds, spring shoots, and tubers. Ground plum (*Astragalus* spp), wild onion (*Allium* spp), lamb's quarters (*Chenopodium album*), ground cherry (*Physalis heterophylla*), purslane (*Portulaca* spp), curly dock (*Rumex crispus*), and prairie spiderwort (*Tradescantia occidentalis*) were eaten. Sago lilies (*Chalochortus nuttalli*) grow profusely in the foothills and on the open plains. Wild plums (*Prunus* spp), chokecherries (*P. virginia*), silver buffalo berries (*Shepherdia argentea*) and other fruits were gathered in season. The hackberry (*Celtis occidentalis*) is widespread and its seeds are usually abundant enough at archaeological sites to suggest use of its sugary fruits as foods, eaten fresh or mixed with meat as pemmican. Black walnut, pecan, and shagbark hickory nuts provided fats. Cottonwoods and willow grow in almost every riparian zone, providing fuel and low-grade building material. Oaks, elms and hackberry were used for wood, as were cedar and juniper (*Juniperus*) which was more durable than hardwoods (Wedel and Frison, 2001; Prewitt, 1981; Nieberding, 1976).

Delaware Indians during the time of settlement in Oklahoma (Copan Lake, 1867-1924) used wild plants. most significantly wild onions (Allium), water lily (*Nymphaea*) roots and pod nuts, Indian potato (*Apios americana*), lambsquarters (*Chenopodium*), milkweed (*Asclepius syriacea*), paw paw fruit (*Asimina triloba*) and black haw nuts (*Carya illinoensis*), persimmon (*Diospyro virginiana*) and black walnut (*Juglans nigra*), wild strawberry (*Fragaria virginiana*), raspberry, blackberry, dewberry (*Rubas occidentalis, R. allegheniensis, R. flagellaris*) and wild grape (*Vitis* sp.). Extensive lists of plant medicines are also available, and some individuals invest a considerable portion of their time gathering medicinal plants

6.1.2. Overview and Staples of the Baseline Traditional Diet

Staples of the diet tend to be those that are common, reliable, and storable. For the Quapaw, "by far the most significant plants from the perspective of subsistence were the products of agriculture, and of these corn was the paramount crop" (Rollings, 1995). Villages with intermittent fields stretched for miles along all rivers that annually flooded and enriched the soil annually with sediment and nutrients. Deer, small game, turkey, ducks and geese

were plentiful through the 1800s. The predominant trade goods (i.e., produced in surplus) were corn, beans, squash, deer meat, bear oil, and skins (Rollings, 1995; Prewitt, 1981). Several of the most important staples are examined in more detail below.

Corn

By the time that Europeans penetrated North America, maize had displaced sumpweed as a crop and had spread to its climate limits (Calloway 2003). Corn remains indicate gradual increases in numbers of rows per cob over 1400-1600, with smaller ears in the northeast US (Jeter et al., 1989; see also Nabhan, Enduring Seeds). One or two acres supplied enough corn per person for a year. The best fields were inundated annually be river floods, but when fertility of a field was eventually reduced, new fields were cleared while the older fields recovered and reverted. Native plants were allowed to remain in the cleared fields, so old fields were gradually colonized by fruit-bearing vegetation, and later by other shrubs and trees (Key, 1991).

By the colonial era, maize had evolved and become dependent on human planting (separating the seeds and planting them individually). Kernels were steeped for a day in water, and then planted 5 or 6 grains to a hill, 4 feet apart. Planting maize in hills encourages the growth of bracer roots. The stalks also hold beans up, which fix nitrogen. Squash shades the soil, to retain moisture and reduce weeds. Tobacco, beans, bottle gourds, pumpkins and sumpweed were grown, and sunflowers grown on the edges of fields have a high percentage of linoleic acid. The river bottom soil (with annual flood deposition) was rich enough that fertilizer was not needed, unlike the northeast of the continent. Fields were burned to allow the ash to replace some of the nitrogen. Fields were burned in spring, and then replanted, or fresh cane brakes were burned and planted in corn (Key 1991).

Corn recipes

After harvest, women prepared and stored food. Corn was kept in large cane baskets and gourds as large as half-barrels. Corn could be made into hominy or ground into meal. Mortars were made from logs hollowed into troughs with fire. Grinding was “very laborious” pounded with pestles in cadence, then sifted.One way of storing corn was to boil green corn (when corn is in milk) and dry it; it could then be boiled or cooked with fat. Ripe ears were boiled or roasted, dried in the sun and stored.

Sagamite or salamagundi was a very common corn recipe, a kind of gruel or thick broth. Sagamite was made of green corn boiled or pounded into meal and cooked with water and sometimes with tallow or three parts corn meal, one part sweetener[16] (Key, 1991).

In addition to baking and roasting whole ears, a great deal of creativity went into dressing up the ubiquitous corn dishes. Hominy is the basic corn dish of all midwest to southeastern tribes. Dry kernels are soaked in water and wood ash (lye), then pounded to break open the kernels using mortar, pestle, and a set of 3 baskets for

[16] Three parts corn meal to one part sweetener - http://www.harvestfields.ca/CookBooks/001/09bkc/0/020.htm; Boiled corn meal seasoned with fat - http://www.wisconsinhistory.org/odd/archives/001583.asp

sifting and sieving (these baskets were still in use in the 1950s in traditional homes) (Wright, 1958)

Several kinds of corn bread were also served with smoked meat and fruit. Corn meal was kneaded and cooked into corn bread cakes. Other breads were made by mixing maize with beans which was left whole and wrapped in corn shucks and then boiled.

Sometimes ground corn was seasoned with dried peaches, turkey, or squashes. Pecan butter was a mixture of corn meal and pecan paste (Key, 1991). 'Gru' was most often eaten by travelers - corn is pounded in order to remove the outer skin, then boiled for a long time in water; the gru replaces bread, a spoonful of gru and a mouthful of meat go together).

Buffalo

Buffalo remained important throughout the colonial period until the wholesale slaughter by the US government in the late 19th century (Rollings 1995). Quapaw, like other Plains tribes, made extensive use of the bison. Bedding, moccasins and winter clothing were made from the hides. Wool was spun into thread used to make men's breechcloths and woven bags. Horns were made into spoons and used for powder horns. Bones were used for punches and awls, and sinews for sewing and bowstrings. A 900 pound animal yields 400 pounds of meat. It was important as a complement to protein-deficient corn. Pemmican as a storage form – dried meat was ground, mixed with fat and sometimes berries, and packed into casing made from hide or gut. Meat was smoked, suet was melted to form tallow cakes (Calloway, 2003).

Oil.

Battle (1922) explained how oils were obtained and used. Oils are the combination of glycerin and fatty acids (oleic, palmitic, stearic, and others). If oleic acid predominates it is liquid; if palmitic or stearic predominate it is fat. Animal or vegetable oils decompose when heated, whereas mineral oils simply distill. Some oils absorb oxygen from the air, which cause hardening, such as linseed (a drying oil). Caustic soda or potash causes the glycerin to separate from the oil and fatty acid; tribes and early settlers made ash water (lye) to add to form soap. The principal oil was bear oil; extensive bear ranges were left by several adjacent tribes where bears could propagate and no towns were allowed and everyone hunted in common. Vegetable oils were primarily black walnut (*Juglans nigra*, most preferred) and hickory, mocker nut hickory or live oak acorns. Before extensive clearing and settlement the black walnut was found everywhere and Indians grew these trees near their towns by transplanting them or raising them from seed; this was almost universally practiced and even now trees are found growing on these sites.

Animal fat (bear or buffalo) was rendered (to render is to separate by boiling or steaming, which melts out the fatty materials which float on the surface). Nuts or seeds were processed by cracking the nuts, boiling the cracked nuts without picking out the meat; and skimming the oil. The oil was highly esteemed in the preparation of corn cakes. The walnut was so important to natives of Louisiana and the southern coastal states that the thirteenth moon was called the walnut moon. Battle (1922) saw a hundred bushels of these nuts stored by one family; they pound them to pieces then cast them into boiling water, which after passing through fine strainers preserved the most oily part of the liquid, this is called by

a name which signifies hickory milk. It is “as sweet and rich as fresh cream, and in an ingredient in most of their cookery, especially hominy and corn cakes.”

Oil was used as food, paints, leather making or treatment of skins, bodily health, dressing hair, rubbing and polishing of ornaments and implements. In trading, one bottle of oil was equivalent to 19 pounds of pork, according to early general store records (Battle (1922).

6.2 Foraging Studies

The supporting information for the Quapaw diet includes literature on foraging theory. In some cases, a complete diet may have been identified in the foraging theory literature, but more often the major dietary staples are identified but not fully quantified within a nutritionally complete diet. Therefore, information about natural resources and their uses is used to estimate relative importance of the major food categories.

Foraging theory includes several methods for estimating the efficiency of obtaining specific resources in specific habitats. Foraging information is typically presented as return rates, or net calories obtained per hour of effort. It is estimated by evaluating the amount of calories expended in getting food (search costs) relative to time spent or calories obtained. Additional ecological factors such as biodiversity, abundance, and patchiness or continuity of resources result in time allocation decisions that are intentionally or unintentionally made by foraging societies, and expressed as optimal diet breadth, optimal foraging area, and/or optimal foraging group size for a particular ecosystem (Winterhalder, 1981). Depending on the evaluation methods used in a study, this return rate data may include (1) time and calories spent in preparing to hunt, fish, or gather (e.g., making nets or arrowheads), (2) time and/or calories spent in the actual activity, and (3) time spent in the processing of the resource after obtaining it. The drawback of oversimplifying foraging solely to caloric efficiency is that micronutrients (vitamins, minerals, specific amino acids, and fatty acids), medicinal or pharmacologically active compounds, other nutritional requirements, and non-nutritional utility such as aroma or dye are often not considered. Similarly, many plants and animals have multiple uses or are co-located with other resources; therefore, caloric calculations must not ignore the way that people actually make decisions about where to go or what to gather, or the reasons they seek to obtain particular resources. Additionally, information about paleonutrition, paleomedicine, and other lines of evidence on the health of the people while they were consuming different diets during different eras provides information as to nutritionally adequacy.

Species element counts sometimes allow general conclusions to be drawn concerning the relative importance of different species and species group, but sampling problems such as non-uniform preservation and recovery are rarely discussed, which makes even basic conclusions rather difficult. The concept of determining the minimum number of individuals of each animal species represented at archaeological sites was first suggested in 1953. A hundred species of vertebrates are found at various sites; a few dozen species contributed most to the protein requirements (Smith, 1975). Researchers may ask questions such as:

- What is the relation between seasonality and the particular species found at a site?
- Was human predation a rate limiting factor on animal populations?
- Can human be assumed to harvest the maximum carrying capacity?
- How did animal populations vary from year to year?

- How was species harvest governed by preference (or other uses), especially small animals?

Foraging studies relevant to the Quapaw or the general area are summarized below.

6.2.1 Smith (1975)

Smith evaluated the time from A.D. 700 to contact. The species by count and yield per animal for seven middle Mississippi sites were ranked in order of total meat yield values:

1. White tail deer (91% of total meat yield);
2. Beaver (2% percent of total meat yield),
3. Opossum, rabbits, turtles, dog, squirrel species, bear, elk (<1% of total meat yield each.
4. Raccoon, fish, migratory waterfowl, and turkey (3% of total meat yield combined),

Smith tested the hypothesis that the abundance of bones in sites is correlated with ecological abundance, and found no correlation. Smith concluded that calories alone do not drive species exploitation, or the overall abundance of bones would be approximately the same as ecological abundance of each species. It was apparent that deer were sought more than their abundance would warrant, and some of the small mammals were taken far less than their abundance, even accounting for seasonal abundance.

6.2.2 Smith and Wetterstrom (1978)

Smith and Wetterstrom (1978) evaluated the Gypsy Joint site in an oak-hickory forest. Animal remains (by percent of total projected meat yield based on the number of bones recovered and average amount of meat per animal) were: deer (92%), beaver (4%), turkey (2%), raccoon (1%), box turtle, cottontail rabbit, fox squirrel (<1% each).

Smith noted that no fish, bear, other small mammals, or waterfowl bones were recovered from that site, perhaps due to poor preservation, lack of those species being hunted nearby during the season of occupation of the site, or other reasons.

Smith and Wetterstrom also evaluated plant remains. Most were hickory nuts, but a variety of other species were present in small amounts: acorn, black walnut, corn, marsh elder (*Iva annua,* seeds), sunflower (seeds), knotweed (*Polygonum,* seeds), wild bean (*Strophostyles helvola)*, grape, crab apple, plum/cherry, morning glory (seeds), other seeds. This was not representative of the overall diet, but possibly representative of corn patches in an oak-hickory forest.

6.2.3 Klinger 1982

Klinger (1982) evaluated the Mangrum site in eastern Arkansas, which was occupied around AD 1000. It is widely assumed to have been built on intensive horticulture supplemented by gathering, fishing, and hunting, but archaeological remains of large boned fauna and hickory nuts preserve the best and may bias dietary estimates. At the Mangrum site, soil types that supported corn were limited. Hickory was the most important nut at this site, and is a key species in the oak-hickory forest; both the meat and oil were used. The acorn was probably the second ranked for oil; black walnut was used but not very commonly. Persimmon (pulp

is used for bread) is found in several forest types, as is hackberry. Grape, crab apple, cherry, and other forest fruits were used in the prehistoric and historic times. The wild vegetables include sweet potato, mushroom, and wild rice, American lotus nut (mixed with corn flour), wapato, nut sedge, bulrush, others. White tailed deer was the most common and important animal in this region, and the hide was probably the single most important article in native dress. Deer tend to congregate on the bottomland ridges because of the availability of acorns in the fall, a prime food resource. Next to deer, black bear was the next most useful animal, primarily for its fat which produced an oil. Rabbit meat and skin were plentiful in fields. Squirrels were also used for meat and skin. Fish were plentiful in brackish waters (much higher productivity than in rivers). Turkey was the most important game bird, and was semi-domesticated, followed by the passenger pigeon. Cultigens included maize, sunflowers, and chenopodium, and sumpweed (the latter two in flooding areas). Secondary hunting and gathering resources at this site were persimmon, pecan, hackberry, bear, birds, deer. Aquatic resources included waterfowl, fish, persimmon, birds, and raccoon.

Klinger suggests that optimal foraging occurs within 4 km of a foraging camp, assuming that the camp is situated to minimize pursuit time for the most critical resources that require the most pursuit time. He notes that the production cost of salt is a key factor in locating camps, especially if it is produced from plant leaves. The most abundant food plants from this site were hickory; six hickory species grew here, including water hickory (in low delta overflow areas), pecan (on higher first bottom areas) and bitternut, shagbark, big shellbark, and mocker nut hickories (grow on terraces). Black walnut grows on higher loamy ridges with the terrace hickories. Eighteen species of oak grow in the Mississippi deltas. Persimmons grow on low wet flats in disturbed areas. Hackberry and honey locust are most common on the first bottoms and clay ridges. This particular site did not have plants typical of the period such as lamb's quarters (*Chenopodium*), pigweed (*Amaranthus*), knotweed (*Polygonum*), Maygrass (*Pharlaris caroliniana*), or giant ragweed (*Ambrosia trifida*).

6.2.4 Cleland (1965).

Cleland (1965) evaluated faunal remains at 57 northwest Arkansas bluff shelters in the Ozark Mountains, which were occupied year-round from 500 to 1400. The Ozark Mountains extend down to the Arkansas River, with valleys and rivers, and relatively poor soil, interspersed with prairie meadows. Forest resources included bear, turkeys, raccoons; grasslands resources included bison, jackrabbits, and prairie chickens. Earlier bluff dweller levels had sand and grit-tempered pottery, twilled, coiled and wicker basketry, woven materials, and other characteristic items. Newer layers contained shell-tempered pottery, catlinite pipes, and newer tools.

Species and percent of total numbers that were recovered were deer (63%), turkey (13%), raccoon (3%), common box turtle (3%), woodchuck (2%), bison (2%), box turtle (2%), black bear (1%), and two dozen other animal, fish, and bird species at <1% each. Species were evaluated by the habitat they live in (he did not evaluate wetland or aquatic species):

> (a) deciduous forest [black bear, gray squirrel, raccoon, woodchuck, gray fox, turkey and eggs];
>
> (b) open prairie [coyote, bison, ornate box turtle, jackrabbit, prairie dog, badger, spotted skunk, prairie chicken];

(c) brushy park-like savannah where there are trees and grassland or edge communities [deer, elk, cottontail rabbit, striped skunk, fox squirrel, pine vole, bobcat, common box turtle]; and

(d) all three habitats equally [wood rat, beaver, muskrat, others].

The overall diet must consider evidence from archaeological sites, and the seasonality of foods taken in specific camps (fish camp, bison hunts, deer camps, hickory camps). It must consider the diversity of species known to have been used as well as the major staples identified by many authors. For example, fish were often harvested during the spring spawning run and the dry summer months when water in pools is lowest (fish and snapping turtles). Rabbits and bison are the other main summer hunting species, although the summer hunt was typically short. Migratory waterfowls were present in the largest numbers in the late fall and winter. The other 9 major species of animals were probably hunted during winter (deer, elk, bear, opossum, beaver, deer, wild turkey, and raccoon) (Smith, 1975).

The studies described above examined animal remains at a large number of sites from time periods shortly before contact. As the authors discuss, each study has a narrow applicability; for instance plant remains are not well described and corn is not seen although we know that corn was the major staple, which suggests that these are not year-round permanent villages which are usually located on levees near rivers where the cultivated field were located. Also, some species (such as fish) do not preserve well, and the use of these sites might be year round or seasonal.

6.3 Dietary Estimates

Our estimate of a natural subsistence diet in the Quapaw ecoregion is presented in this section.

The basis for the Quapaw diets is an assumption of 2000 kcal/day. This is based on a wide range of anthropological literature as well as on contemporary data. Today, the total quantity of food across all adult age groups in the United States is about 2000 grams per day[17]; the total calories averages 2195 kcal/d across the US in 2003-2004 (Egan et al., 2007). This amount of energy intake is much less than athletes in training require, but is adequate for a mix of 2 hours of high activity, 6 hours of moderate activity, 8 hours of low and sedentary activity and 8 hours of rest (the same activity used for estimation of inhalation rate). Basic nutritional and energy requirements (Stipanuk, 2000) were compared to information on resource abundance to evaluate overall adequacy of the initial diets. The initial estimates were then refined based on information on paleonutrition (Wing and Brown, 1979; Sobolik, 1994) and exercise physiology (McArdle et al., 1996; 1999). Additionally, methods from other authors was also evaluated for relevance and compared to the results reported in this report (Delorimer and Kuhnlein, 1999; Egeland, 2004; Kuhnlein et al., 1996; Kuhnlein et al., 2006; White, 1999).

[17] http://www.ars.usda.gov/Services/docs.htm?docid=14958

The combined consideration of raw food groups, habitats, plant families, lists of utilized species, and caloric similarities led to draw conclusions about major food categories as rough percentages. These percentages were converted to kilocalories by applying the same percentages to an assumed 2000 kcal daily intake. Table 8 shows information from the USDA database for 100 gram portions of representative foods, as close to the actual species as possible, and as close to the form eaten as possible.

Table 8. USDA Nutritional Data for Representative Native Species

Food Category	*Kcal per 100g (Representative species)**	Food Category	*Kcal per 100g (Representative species)**
Resident fish and other aquatic resources	Mixed trout, cooked – 190 Crayfish, wild cooked - 82 Turtle, raw - 89 Catfish - 100 Mussels - 182	***Bulbs***	Leek, onions and other bulbs (bulb & leaf) – 31
Game, large and small	Deer, roasted – 158 Bison - 143 Rabbit, wild, roasted – 173 Beaver, roasted – 212 Muskrat, roasted - 236	***Berries, fruits***	Raw elderberries – 73 Raw strawberries – 70 Raw blackberries - 55 Persimmon – 125
		Legumes	Beans, cooked pinto, kidney or white – 143 Peas, boiled pigeon or split - 120
Fowl and Eggs	Quail, cooked – 234 Duck, cooked - 200 Duck eggs – 185 Pheasant (for wild turkey) - 247	***Honey, Maple syrup, other***	Honey – 304 Maple syrup – 261
		Greens, Tea (includes leaves, stems, medicinal plants, flavorings)	Raw dandelion greens – 45 Raw watercress – 11 Fiddleheads, raw - 34
Roots, Bulbs, Tubers	Raw chicory root – 73 Boiled burdock root – 88 Potato, baked tuber – 93 Parsnip – 70 Lotus root (for cattail root), boiled - 66	***Other vegetables (above-ground)***	Squash, cooked winter – 37 Squash, cooked Navajo – 16 Pumpkin – 20 Asparagus, boiled – 22 Cattail shoots, raw - 25
Corn	Corn, Navajo strain steamed – 386 Corn meal – 384 Corn on cob – 365 Corn gruel or mush – 54 Corn bread – 180 Corn hominy grits – 60	***Seeds, Nuts, Grain other than corn***	Raw dried sunflower seeds – 570 Chia seeds – 490 Hazelnut, dry roast – 646 Pecan, raw – 691 Hickory - 650 Walnut - 618

Based on the literature and the other information presented above, the baseline average Quapaw diet in Oklahoma is estimated as roughly:

1/3 of calories from corn;
1/3 from meat, fowl, and fish.
1/3 from all other plants (nuts, roots, beans, squash, other seeds, fruits, leaves and greens), and sweeteners

	Percent of 2000 kcal	***Daily kcal***	***Kcal per 100g***	***Daily gpd***
Corn	30	600	225	267
Large game	20	400	150	267
Small game	6	120	175	69
Fowl & eggs	6	120	225	53
Aquatic & Fish	6	120	100	120
Legumes	6	120	130	92
Squash, other veg	5	100	75	133
Nuts, grains, seeds	6	120	500	24
Roots & Bulbs	5	100	75	133
Fruits & berries	5	100	60	167
Greens & sweets	5	100	50	200
Totals	***100***	***2000***		***1525***

Table 9. Summary of estimated relative proportions of dietary foods.

Calorie estimates are from the USDA nutrient database (http://www.nal.usda.gov/fnic/foodcomp/search/). One pound = 454 grams.

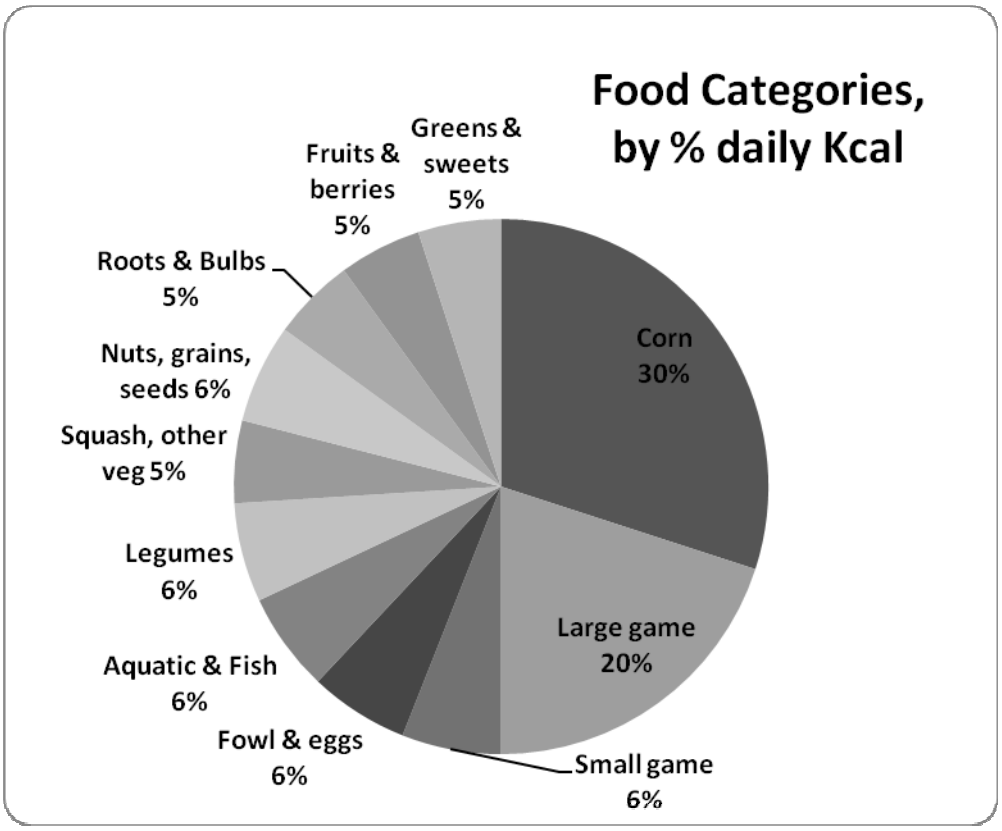

Figure 8. Food categories by percent of daily Kcal.

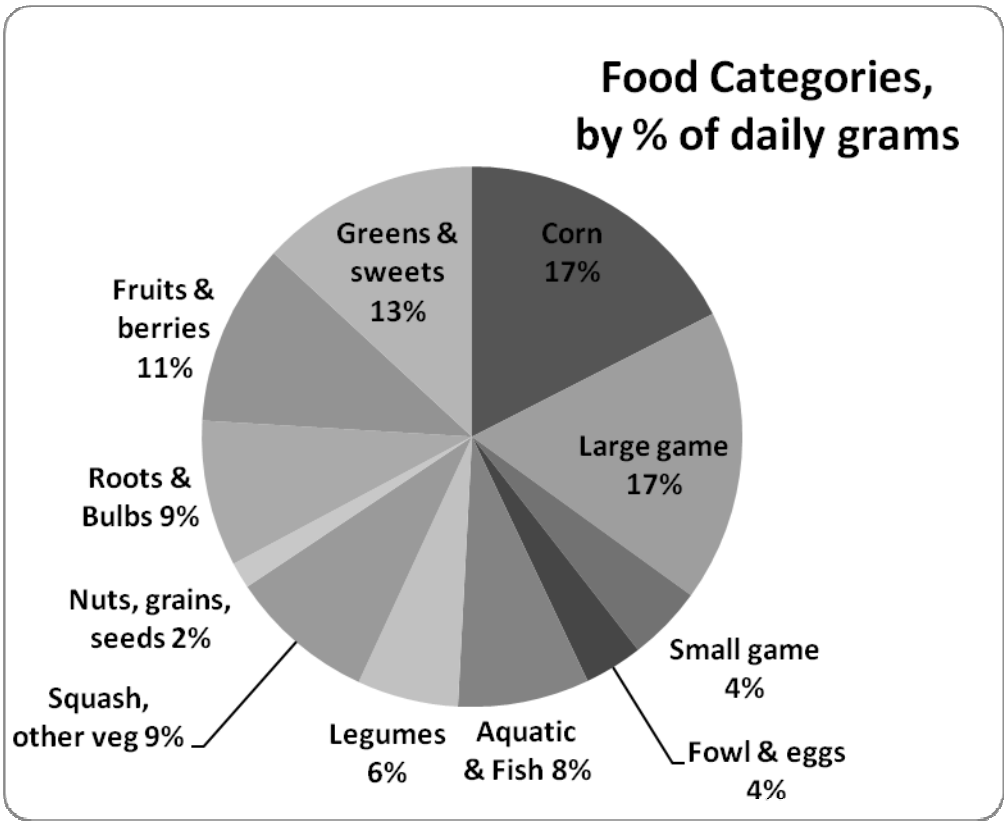

Figure 9. Food categories by percent of daily grams

7.0 Direct Exposure Factors

7.1 Approach

This section focuses on direct pathways: ingestion of water, sediment, and soil (including residual soil on the outside of food) and inhalation.

Default exposure factors have been developed for conventional suburban, urban, occupational, and recreational scenarios based on national statistics and assumptions about the activity patterns that comprise those situations. The approach for developing a tribal scenario is similar, except that large statistical databases are not available. Therefore, we rely on existing literature and professional judgment.

7.2 Major Activities

Quapaw indigenous subsistence foragers (both genders) perform a combination of aerobic (high pulse and ventilation rates), strength, endurance, and stretching-flexibility daily activities, as well as more sedentary work and resting. Table 5 and Figure 10 show the thought process for considering the wide range and numerous activities associated with the major activity categories (hunting, fishing, plant gathering, wood gathering, and sweatlodge purification). In actuality, many activities are sequential – for example, a resource might be gathered in one location, used in a second location to make an implement or basket, and taken to a third location for use in hunting or fishing[18]. The activities shown in Figure 10 are so interconnected that it is virtually impossible to separate a lifestyle into distinct categories, but they are presented as separate for illustration purposes. Figure 10 presents examples of the wide variety of tasks that occur within major activity headings. There are many educational and preparatory tasks, as well as many post-activity tasks that must be considered with respect to environmental contact. In reality, these activities tend to blend together, but they are presented as somewhat separate for informational purposes.

The activities shown below reflect original activities, whereas most are now modulated by modern conveniences. The direct exposure factors have taken this into consideration.

[18] This is similar to the Cultural Ecosystem Stories concept developed Terry Williams (Tulalip Tribes) with the associated software, ICONS (see, for example, http://www.epa.gov/owow/watershed/wacademy/wam/comresource.html).

Table 10. Descriptions of Major Activities

Activity Type	*General Description*
Hunting	Hunting includes a variety of preparation activities of low to moderate intensity. Hunting occurs in terrain ranging from flat and open to steep and rugged. It may also include setting traplines, waiting in blinds, climbing, etc. After the capture or kill, field dressing, packing or hauling, and other very strenuous activities occur, depending on the species. Subsequent activities include cutting, storing (e.g., smoking or drying), returning the remains to the ecosystem, and so on.
Fishing	Fishing includes building weirs, hauling in lines and nets, gaffing or gigging, wading (for shellfish), followed by cleaning the fish and carrying them to the place of use. Activities associated with smoking and constructing drying racks may be involved. Remains are returned to aquatic ecosystems.
Plant Gathering	Women gather plants, bark, and kindling up to a day or two distant from the camp or village using a variety of tools such as digging stick, knife, and basket or other means for carrying resources back to camp. A variety of activities is involved, such as hiking, bending, stooping, wading (marsh and water plants), digging, bundling, carrying, and climbing over a wide variety of terrains. This category also includes tending farm fields.
Wood Gathering	Gathering wood for firewood (domestic and sweatlodge) is a frequent and vigorous activity. Activities include felling, skidding, bucking, splitting, and stacking. Ash splints require lengthy pounding to loosen the bark from the core.
Ritual Purification (Sweatlodge)	Sweatlodge building and repairing is intermittent.
Materials Use and Food Preparation	Many activities of low to high intensity are involved in preparing materials for use or food storage. This category includes basketmaking, which is an example of a very important activity with its own set of prescribed activities, meanings, and cultural ethics.

Sweatlodge. The frequency of sweatlodge use has not been fully researched. There is sparse mention of middle Mississippi sweatlodge use. Some early structures that are small, semi-subterranean with central fire pits may have been sweatlodges even through the relation of the sweatlodge to Mound religions is not clear.[19] More recently, the Nez Perce Tribe brought sweatlodge use with them during their brief stay with the Quapaw Indians after the 1877 Nez Perce War.[20] The present Quapaw Tribe encourages sweatlodge use as part of an alcohol and substance program.[21] It is part of the Peyote religion.[22]

Each use of the sweatlodge requires the ingestion of a liter of water for rehydration (see drinking water section below).

[1919] http://www.nps.gov/archive/ocmu/Elsewhere.htm
[20] http://www.fs.fed.us/npnht/quapaw/exile
[21] http://deptets.fvtc.edu/BJAInitiatives/Frame%20IASA/INFO/2002%20IASAP%20Grantees.pdf
[22] http://www.accessgenealogy.com/native/caddo/page33.htm

Figure 10. Examples of Indigenous Subsistence Activities

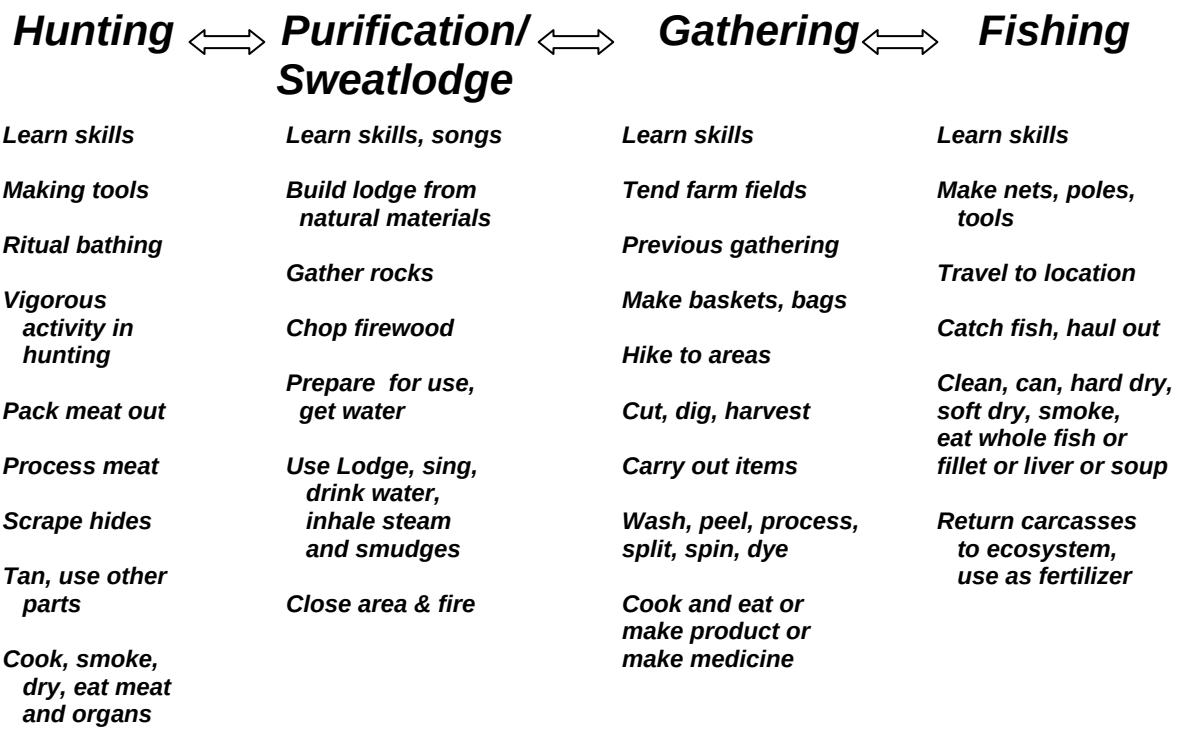

Table 11 shows the cross-walk between tribal activity categories and exposure pathways, showing how exposure factors are derived from knowledge about activities, and interlinked resources and ecosystem stories, and the technical literature. This is an iterative process that relies on multiple lines of evidence. This is not intended to be a complete listing of activities; for example, details related to wood gathering are spread among several categories although it could warrant its own category. It shows an example of the thought process used to iteratively cross-walk exposure pathways and categories of subsistence activities. The last column ("totals") shows how exposure pathways (such as soil ingestion) are evaluated by estimating across activity categories. This is not a statistical summation but rather a judgment based on multiple lines of evidence such as ethnohistorical, archaeological, nutritional, and experimental information.

Table 11. Integration of Activity Categories with Exposure Factors

	Hunting and associated activities	***Fishing and associated activities***	***Gathering and associated activities***	***Ritual purification and associated activities***	***Material and food use and processing***	***Totals for major exposure factor categories***
Food, Medicine, Tea, other biota ingestion (diet)	*n* deer /yr diet; Total large-small game, fowl. Organs eaten	*n fish* /yr diet; Total pounds or meals/day-wk-yr; Organs eaten.	Includes foods, medicines, teas, etc.	No food, but herbal particulates are inhaled.	Both as-gathered and as-eaten forms; cleaning and cooking methods.	Must account for all calories, breadth of plant species; parts eaten
Soil, sediment, dust, and mud ingestion	Terrain types such as marsh with more mud contact.	Sediment contact, dust and smoke if drying; weir construction.	External soil on plants; cooking method. Farming is included.	Includes building the sweat lodge and getting materials.	Includes incidental soil remaining on foods.	Must consider living area, unpaved roads, regional dust and mud.
Inhalation rates	Days per terrain type; Exertion level; hide scraping; load & grade.	Exertion level – nets and gaffing methods; cleaning effort.	Exertion level for load and grade; or gardening. Include making items.	Includes building the lodge, chopping firewood, singing.	Exertion level for pounding, grinding, smoke from fires.	Must account for exertion levels; smokes and smudges.
Groundwater and Surface water pathways	Ritual bathing, Drinking water; wash water; water-to-game and plants pathways.	Drinking water; incidental ingestion, washing and cooking.	Drinking water, cooking water, soaking in mud or water.	Steam in lodge; drinking water during sweat.	Soaking, washing, leaching tannins, other uses.	Must account for climate, sweat lodge, ritual bathing.
Dermal pathways	Soil, air and water pathways, plus pigments etc.	Immersion considerations.	Same as hunting.	Immersion with open skin pores.	Includes basketmaking, wounds.	Must consider skin loading and habitat types.

Seasonality. The changes in activity patterns over the annual seasonal cycle has been modified in modern times, but the ecological cycle has not, so people must still gather plants according to when they are ripe, hunt according to game and fowl patterns, and fish when the spawning runs occur. Many items are gathered during one season for year-round use. While specific activities change from season to season, they are replaced by other activities with a similar environmental contact rate. For instance, a particular plant may be gathered during one month, while another month may be spent hunting, and a winter month may include cleaning and using the items obtained previously.

For the purposes of this study, we are assuming that all activities throughout the seasons are roughly equal in terms of energy expenditure, and that there is no decrease in environmental contact rates during winter months. In reality, winter is a less active season, which might reduce caloric intake and inhalation rate, so the diet and inhalation rate are moderate and are intended to be central tendency rather than upper bounds. The report recognizes that late winter or early spring could be times of hardship when supplies were exhausted and the spring resources were not ready.

The main winter foods were dried corn, fresh, dried and frozen meats and fish, dried berries, seeds, dried root and seed cakes, and teas and medicines. Modern methods of storage (canning, pickling, salting, and so on) extend the availability of preserved foods throughout the year. Gathering firewood was required year-round. There was also winter fishing and hunting, as well as an emphasis on making tools, baskets, and other material items. Food and material preparation were constantly required regardless of the season. Similarly, Quapaw Indigenous people were always scouting, tracking game, monitoring areas to determine what resources were ready for harvest, or looking for good stands.

7.3 Exposure Factors for Direct Exposure Pathways

For the purposes of developing these exposure factors, the description of tribal activities focused on:

- Frequency of activity (daily, weekly, monthly)
- Duration of activity (total years)
- Hours at a time
- Intensity of environmental contact and intensity of activity

7.3.1 Drinking Water

For the Oklahoma climate, the drinking water ingestion rate is assumed to be the conventional 2 liters per day as recommended by the Exposure Factors Handbook.

7.3.2 Soil and Sediment Ingestion

Soil ingestion includes consideration of direct ingestion of dirt, mud, sediment, or dust, swallowing inhaled dust, mouthing of objects, ingestion of dirt or dust on food, and hand-to-mouth contact. Generally soil ingestion rates are poorly quantified, so a qualitative estimate

based on the literature and the environmental conditions and environmental activities has been made. Higher or lower rates could also be supported, so a moderate value was selected as generally representative.

The recommended Quapaw soil ingestion rate of 400 mg/day is the same as the author of this report recommend for all indigenous communities. It is based on a review of EPA guidance, soil ingestion studies in suburban and indigenous settings, and dermal adherence studies. It is also based on knowledge about tribal subsistence lifestyles with their higher environmental contact rates and local climatic and geologic conditions. It reflects a variety of soil exposure pathways activates such as cooking, wild foods harvesting and/or gathering (or gardening), residual soil or dust on foods and medicine, holding natural materials in the mouth while processing or using the materials, driving on unpaved roads, and other activities. It also considers the frequency of higher contact events such as sports, pow-wows, days in wetlands or forests, and similar activities. There are also likely to be many intermediate-contact days, depending on the occupation (e.g., wildlife field work, construction or road work, cultural resource field work).

The soil ingestion rate of 400 mg/d for all ages is also the published upper bound for suburban children (EPA, 1997), and is within the range of outdoor activity rates for adults but lower than the typical 480 mg/d applied to intermittent outdoor occupations such as construction, utility worker or military soil contact levels. The US military assumes 480 mg per exposure event[23] or per field day. The UN Balkans Task Force assumes that 1 gram of soil can be ingested per military field day[24]. Anecdotally, US forces deployed in Iraq report frequent grittiness in the mouth and food, reflective of soil grain size of 50-75 microns, the size threshold between sand and silt or clay in various soil texture classification scales. Haywood and Smith (1990) also considered sensory reports of grittiness in their qualitative estimate of a soil intake rate of 1-10 g/d in aboriginal Australians.

Simon (1998) reviewed soil ingestion studies from a perspective of risk and dose assessment. Because of their high dependence on the land, Simon recognized that indigenous peoples are at highest risk for inadvertent ingestion, along with professions that may bring workers into close and continual contact with the soil. Based on his qualitative judgment, Simon recommended using a soil ingestion rate for indigenous people in hunters/food gathering/nomadic societies of 1g/d in wet climates and 2 g/d in dry climates. He recommended using 3 g/d for all indigenous children.

For the Quapaw climate and lifestyle, the soil ingestion rate for all ages is assumed to be 400 mg/day for 365 days/year. This is higher than the prior EPA default value of 200 mg/day (USEPA, 1989). This rate reflects both indoor dust and continuous outdoor activities analogous to gardening or camping (Van Wijnen, 1990), but it is less than a single-incident sports or construction ingestion rate (Boyd, 1999).

Application of a soil ingestion exposure factor should consider whether the ingestion rate of 400 mg/d should be applied to each location and soil or sediment type separately, or

[23] http://www.gulflink.osd.mil/pesto/pest_s22.htm, citing US Environmental Protection Agency, Office of Research and Development, Exposure Factors Handbook, Volume I, EPA/600/P-95/002a, August 1997 as the basis for the 480 mg/d.

[24] UNEP/UNCHS Balkans Task Force (BTF) (1999). The potential effects on human health and the environment arising from possible use of depleted uranium during the 1999 Kosovo conflict. http://www.grid.unep.ch/btf/missions/september/dufinal.pdf

whether the soil ingestion rate should be apportioned among all locations within an assessment area.

7.3.3 Inhalation Rate

The inhalation rate in the Quapaw scenario reflects the active, outdoor lifestyle of traditional tribal members. Traditional tribal communities had no sedentary members except the frail elderly, whereas one-quarter of modern American adults of all ages report no leisure time physical activity at all.[25] This report recognizes that contemporary tribal communities are striving to regain this level of activity,

The activity levels associated with the traditional lifestyle and diet based on published anthropological studies, ethnographic literature on foraging theory, hunting-gathering lifestyles. Using EPA guidance on hourly inhalation rates for different activity levels, a reasonable inhalation rate for an average tribal member's active lifestyle is a median rate of 26.2 m^3/d, based on 8 hours sleeping at 0.4 m^3/hr, 2 hours sedentary at 0.5 m^3/hr, 6 hours light activity at 1 m^3/hr, 6 hours moderate activity at 1.6 m^3/hr, and 2 hours heavy activity at 3.2 m^3/hr. Unlike most other exposure factors, which are upper bounds, the inhalation rate is a median rate. This is rounded down to 25 m^3/day based on the relation of oxygen utilization to caloric intake. More detail is presented in Appendix 2.

7.3.4 Dermal Exposures

The dermal pathway has not been fully researched for this scenario, but EPA methods[26] for dermal exposure can be used. Two relevant papers are summarized here. Kissel, et al. (1996) included reed gatherers in tide flats in a study of dermal adherence. "Kids in mud" at a lakeshore had by far the highest skin loadings, with an average of 35 mg/cm^2 for 6 children and an average of 58 mg/cm^2 for another 6 children. Reed gatherers were next highest at 0.66 mg/cm^2 and an upper bound for reed gatherers of >1 mg/cm^2. This was followed by farmers and rugby players (approximately 0.4mg/cm^2) and irrigation installers (0.2mg/cm^2). Holmes, et al. (1999) studied 99 individuals in a variety of occupations. Farmers, reed gatherers and kids in mud had the highest overall skin loadings. The next highest skin loadings on the hands were for equipment operators, gardeners, construction, and utility workers (0.3 mg/cm^2), followed by archaeologists, and several other occupations (0.15 – 0.1 mg/cm^2). The Quapaw scenario recommends that a rate of 0.1 mg/cm^2 be used to account for averaging among outdoor activities with moderate to high dermal adherence and indoor activities with a lower adherence rate.

[25] http://www.cdc.gov/brfss/pdf/ 2001prvrpt.pdf and http://www.cdc.gov/brfss/pubrfdat.htm.
[26] http://www.epa.gov/superfund/programs/risk/ragse/

7.4 Summary Exposure Factors

As discussed in the beginning, the purpose of this document was to develop exposure factors that reflect the frequency, intensity, and duration of environmental contact. This includes a nutritionally complete diet, as shown in Table 12.

Table 12. Summary Exposure Factors

Exposure Factor	***Daily Rate***
Soil ingestion	400 mg/d
Water ingestion	2L/d
Inhalation	25 m^3/d
Corn	267 gpd
Large game	267 gpd
Small game	69 gpd
Fowl & eggs	53 gpd
Aquatic & Fish	120 gpd
Legumes	92 gpd
Squash, other veg	133 gpd
Nuts, grains, seeds	24 gpd
Roots & Bulbs	133 gpd
Fruits & berries	167 gpd
Greens & sweets	200 gpd

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