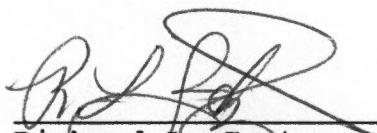


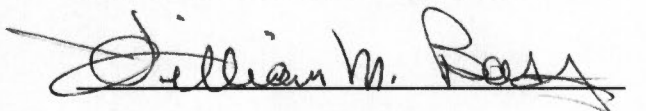
To the Graduate Council:

I am submitting herewith a thesis written by Richard P. Bigee entitled "Anthropometric Variation Among Cherokee, Choctaw, Kiowa, and Pawnee Amerindians." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.



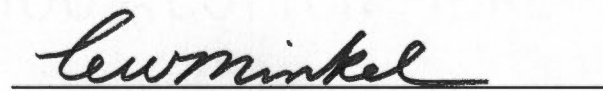
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We have read this thesis
and recommend its acceptance:





Accepted for the Council:



Associate Vice Chancellor
and Dean of the Graduate School

ANTHROPOMETRIC VARIATION
OF THE CHEROKEE, CHOCTAW, KIOWA,
AND PAWNEE AMERINDIANS

A Thesis
Presented for the
Master of Arts
Degree
The University of Tennessee, Knoxville

Richard Paul Bigbee

December 1992

A DEDICATION

For my mother, Ilalie "Tuck" Bigbee

12 August 1932 - 4 June 1989

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ABSTRACT

This thesis provides an overview of Anthropometric variation among six groups of American Indians: The Eastern Band of Cherokees, the Eastern Band of Choctaws, the Western Band of Cherokees, the Western Band of Choctaws, Kiowas, and Pawnees. Anthropometric variation among these groups is analyzed using a combination of historical and statistical information.

The history of the study groups was analyzed to determine the general level of health during the period leading up to the point when they were measured under the direction of Dr. Franz Boas. It is revealed that all the study groups experienced considerable stress, which effected anthropometric measurements such as stature.

The anthropometric data used in this study consisted of 12 measurements taken on 869 individuals belonging to the above mentioned tribes, under the direction of Dr. Boas in the late 1800's. This anthropometric data is analyzed using means, analysis of variance, and canonical variates. The means study reveals that there is notable morphological variation on both an inter- and intra- tribe and band level. These findings are supported by the analysis of variance study, which shows that two dependent variables, sitting height and face breadth are significant influences for variation among the study groups on a

tribe, sex, and tribe*sex type III sums of squares level.

A historical reveiw of the study groups relate considerable environmental stress acting on the study groups, while canonical variates study reveals that when the sexes are studied separately or together, there is substantial evidence for gene flow from among the groups and outside the groups as well.

TABLE OF CONTENTS

CHAPTER	PAGE
1. INTRODUCTION	1
Population Distance Studies	2
Stress Studies	5
Statement of Purpose	10
2. A HISTORICAL REVIEW	13
The Cherokee Indians	13
The Western Band of the Cherokees	21
The Eastern Band of the Cherokees	24
The Choctaw Indians	27
The Western Band of the Choctaws	31
The Eastern Band of the Choctaws	34
The Kiowa Indians	36
The Pawnee Indians	39
3. THE DATA BASE	45
Introduction	45
Anthropometric Data	47
Samples	50
Descriptive Statistics	51
4. ANALYTICAL METHODS	53
Introduction	53
Statistical Analysis Techniques	54
5. RESULTS	59
Means	59
Analysis of Variance	67
Canonical Variation Analysis	70
6. CONCLUSIONS	98
REFERENCES CITED	103
VITA	111

LIST OF TABLES

TABLE		PAGE
Table 3.1	The 12 Anthropometric Measurements and Their Definitions	49
Table 3.2	Sample Size Distribution by Tribe, Band, and Sex	52
Table 5.1	Definitions of Anthropometric Measurement Abbreviations	60
Table 5.2	Mean Scores from Anthropometric Measurements, for Western and Eastern Cherokee and Choctaw Males	61
Table 5.3	Mean Scores from Anthropometric Measurements for Western and Eastern Cherokee and Choctaw Females	63
Table 5.4	Mean Scores from Anthropometric Measurements for Kiowa and Pawnee Males and Females	64
Table 5.5	Male to Female Difference in Means from Anthropometric Measurements, by Band and Tribe	66
Table 5.6	F Values and P Values from Type III Sums of Squares for Analysis of Variance of Anthropometric Data from Cherokees, Choctaws, Kiowas, and Pawnees	68, 69
Table 5.7	Group Canonical Variate Results for Anthropometric Data versus Location for Males, Including Eigenvalues and % of Variation	71
Table 5.8	Canonical Structure Coefficients for Males	77
Table 5.9	Group Canonical Variate Results for Anthropometric Data versus Location for Females, Including Eigenvalues and % of Variation	79

Table 5.10	Canonical Structure Coefficients for Females	85
Table 5.11	Group Canonical Variate Results for Anthropometric Data Versus Location Both Sexes, Including Eigenvalues and % Variation	87,88
Table 5.12	Canonical Structure Coefficients for Both Sexes	96

LIST OF FIGURES

FIGURES	PAGE
Figure 1.1 Selyean Stress Model Showing the Relationship between Pyschosocial Stimuli, Stress, and Disease	7
Figure 1.2 The Goodman et al. Model Showing the Relationship between Environmental Conditions and Stress Response	9
Figure 2.1 Cherokee Lands Prior to 1800 (From Hudson, 1976)	14
Figure 2.2 Cherokee Lands, 1819 - 1838 (From Finger, 1984)	19
Figure 2.3 Western Band of the Cherokee Territory (From Carter, 1976)	22
Figure 2.4 Qualla Boundary (From Finger, 1984)...	25
Figure 2.5 Choctaw Nation East (shaded area) (From DeRosier, 1970)	28
Figure 2.6 Western Band of the Choctaw (After Blaine, 1990)	32
Figure 2.7 Eastern Band of the Choctaw (From Debo, 1961)	35
Figure 2.8 Kiowa Reservation (After Blaine, 1990)	38
Figure 2.9 Pawnee Indian Lands 1300 - 1725 (After Hyde, 1974)	40
Figure 2.10 Pawnee Reservation (shaded area) (After Blaine, 1990)	44
Figure 5.1 Study Group Males Vector 1 against Vector 2	72
Figure 5.2 Study Group Males Vector 1 against Vector 3	73
Figure 5.3 Study Group Males Vector 3 against Vector 4	74

Figure 5.4	Study Group Females Vector 1 against Vector 2	81
Figure 5.5	Study Group Females Vector 1 against Vector 3	82
Figure 5.6	Study Group Females Vector 3 against Vector 4	83
Figure 5.7	Study Group Both Sexes Vector 1 against Vector 2	90
Figure 5.8	Study Group Both Sexes Vector 1 against Vector 3	92
Figure 5.9	Study Group Both Sexes Vector 2 against Vector 3	93
Figure 5.10	Study Group Both Sexes Vector 3 against Vector 4	95

CHAPTER 1

INTRODUCTION

The purpose of this thesis is to ascertain causes for anthropometric variation witnessed between members of the Eastern and Western Bands of the Cherokee and Choctaw Indian tribes of North America. These data will be compared to data from two Plains Indians tribes, the Kiowa and the Pawnee. Previous researchers using similar data have shown relationships between physical attributes and aspects such as geographical location, linguistic affiliation, and climate (Hall and MacNair, 1972; Rudan et al., 1988; Falsetti, 1989; Jantz et al., 1992). Their results show how these factors influence population distance and variability. This thesis will differ somewhat from the above line of research in that it will focus more on the effects of gene flow, as well as that of environmental and nutritional stress, on the study populations.

There are two concepts involved in this study which should be reviewed. The primary concept is that of anthropometric variation and its application in the study of population distance, with a brief overview of related studies. This review will show how relevant a population distance approach is to this specific thesis and the unique

problems associated with it. The second concept is that of stress and how populations can reflect it anthropometrically.

Population Distance Studies

An often used approach in population distance research is that of skeletal anthropology. Measurements are taken to record specific skeletal features, for example, standing height. Utilizing this approach, Kurisu (1970) analyzes seven Malaysian tribes using 25 measurements and finds while some of the tribes' scores tended to cluster, others are quite different, supporting previous ethnographic research. Hall and MacNair (1972) use Boas' data for tribes in British Columbia to determine distances between the study groups. They find that the various tribes studied can be distinguished from each other. Spielman et al. (1972) analyze anthropometric data from 19 Yanomama tribes and present two arguments. First, the study showed the Yanomama Indians are a genetically distinct group from other South American Tribes; and second, interobserver error can substantially affect the outcome of one's study. Neves et al. (1985) have marginal success correlating anthropometric data and geographic distances from 12 Brazilian Indian groups. The strongest relationship appear in the Xingu area, with geographically close groups being quite similar. DaRocha and Salzano (1972) use data from three Brazilian Indian groups and find that variation among

the groups is not as large as they had expected when compared to demographic and geographic information. Rudan et al. (1986) find evidence that there are several genetically different groups inhabiting the Island of Hvar, based on morphological data derived from 24 body and 14 head measurements. While anthropometry alone suffices, many researchers use additional information.

A survey of the literature uncovers several examples of anthropometry used in conjunction with other methods for population distance studies. Johnston et al. (1971) report on Peruvian Cashinahua Indians, stating they are, based on skinfold measurements and measurements from wrist-hand radiographs, morphologically similar to other comparable groups. Pingle (1984) uses 16 anthropometric measurements with seven serogenetic markers to study the distance between five Gondi-speaking groups of India. The results show that the five groups did separate as a heterogeneous group, and within the study parameters they are different morphologically and genetically. Rudan et al. (1988) use anthropometric measurements, physiological traits, dermatoglyphic traits, and a kinship coefficient to determine population distances between rural groups on the Island of Korcula. Anthropometric differences are found between the eastern and western portions of the island, with some within-east variance occurring. Relethford (1988) uses anthropometric data, a binary English admixture score,

and surname frequencies to study population distance between seven Irish groups. The results show that English admixture had the greatest influence on anthropometric variation. Relethford states that his study shows the usefulness anthropometry has in population studies, and that "differential gene flow into populations can have a major impact on local genetic structure" (1988:111).

Having concluded this review, one can now see that it is possible to conduct, with reasonable success, population distance studies using skeletal anthropometry either by itself, or with other information.

Goodman (1973) examines some potential problems in using anthropometric data in population distance studies. This examination first recognizes the fact that morphological data could be inaccurate because of modification from the environment, while genetic markers are somewhat more stable. However, Goodman points out that shortcomings in anthropometrical data can be accounted for.

If the measurements can be taken in a manner which minimizes the effects of environments and genotype by environmental interactions, however, there is no a priori reason why one type of characteristic should be more informative than another (1973:10).

Goodman further argues that genetic markers such as serological information are used in intrapopulation studies with success, but when applied in interpopulation studies,

not much extra information is obtained. Morphological data, in contrast, provide considerable information about how much populations differ, partly because there is substantial information accumulated over "centuries of observation" (1973:10). The final point of Goodman's argument is that if genetic markers are no more successful in identifying distances than morphological (or anthropometric) data, then the use of morphological information is an acceptable approach to research, even if it is more affected by environmental modification.

Because of such arguments, it is important to understand the concept of stress and how it can potentially affect a population. The following review will help explain the concept of stress as it relates to this thesis.

Stress Studies

In order to discuss stress and its effect on individuals, it is important to define stress as the term will be used in this thesis. Goodman et al. (1988) review several studies that have attempted to define stress, and, they also offer their own model for the concept of stress.

The first model for stress they present is the Environmental Physiology model, where Stress (either a stressor or deforming forces) leads to Strain (a disturbance or a deviation from homeostasis), which is then manifested as Response (either restoration or failure, and adaptation or maladaptation) (Goodman et al., 1988:171).

This model is adapted somewhat to account for more variables. Environmental constraints (as stressors or limiting resources) lead to either a Cultural Buffering System or Culturally Induced Stressors. Regardless, the model then continues to the Host Resistance Factors. If the host is unable to cope, then there is a Physiological Disruption (or Stress). This disruption can also be reflected skeletally by one or more of the following: growth disruption, disease, or death. The main failing of these approaches is that they cannot take into consideration more than one specific stress at a time.

The Selyean Stress model provides room for several interacting variables that can be added anywhere along the model. This model also allows for feedback from any of the major steps back to the first two, Psychosocial Stimuli and Psychobiological Program, as seen in Figure 1.1. The authors state that while this model is acceptable for linking psychosocial factors to disease, it still has some drawbacks. One drawback is that it remains difficult to measure stress because large sample sizes are required. Chronic diseases (which occur infrequently) are usually the only ones that can clearly be linked to psychosocial factors, and these kinds of diseases usually require long periods of time to act on the host. Thus, the researcher is faced with the problem of needing large samples which have individuals that suffered the stress for a long time.

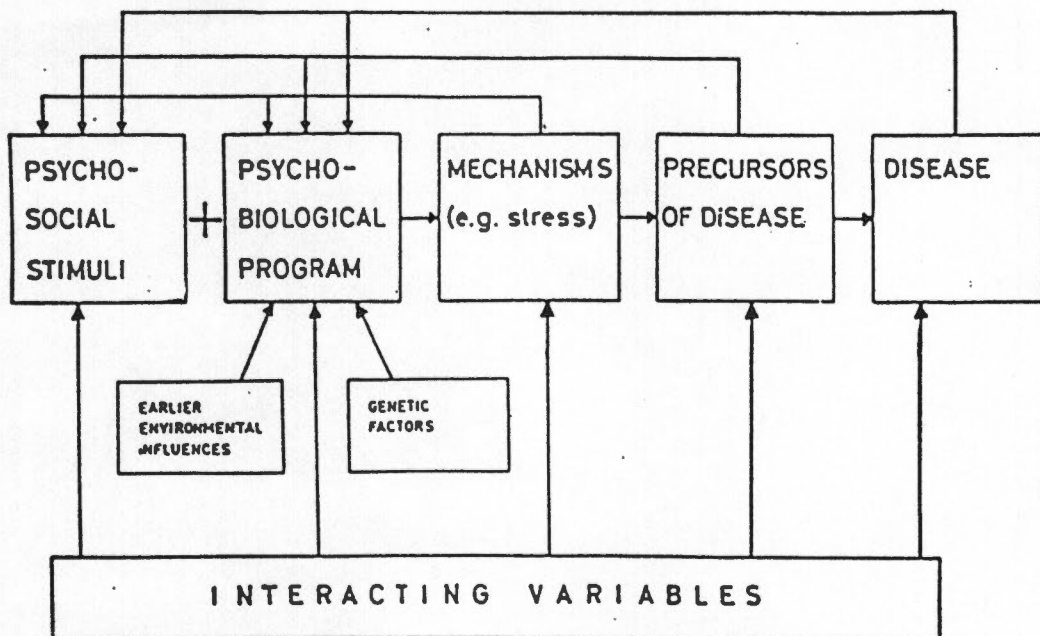


Figure 1.1. Selyean stress model showing the relationship between psychosocial stimuli, stress, and disease. After Goodman et al. (1988).

The Life Change model tries to link psychosocial stress to disease by assigning a weight to each life change during a given period. There has been success in this model according to Goodman et al. (1988), but the specific forces involved in the stress process are lost.

In an attempt to incorporate the positive aspects of all the above approaches, Goodman et al. (1988), developed the following model (Figure 1.2). In this model, critical stressors and their interactions should be identified. Once defined, the Processes of Impact, Response and Consequence can be easily identified, where Impact is the psychosocial stress enacted on an individual, and Response is the individual's attempt to cope with the stress. Consequences include the effects of both the Impact and the Response on the individual.

Goodman et al. (1988) finally point out that anthropometry is an acceptable and reliable method for finding indications of stress and that it can be an important indicator of the nutritional status of a population (1988:196). There are several studies which support this concept.

Studies show that nutritionally stressed children tend to be shorter in stature, even as adults (Boas, 1959; Garn, 1962; Damon, 1965; Eveleth et al., 1974; Johnston et al., 1976; Bielicki and Welton, 1982; Byard et al., 1984; Kimura, 1984; Malina et al., 1985; Cameron, 1991).

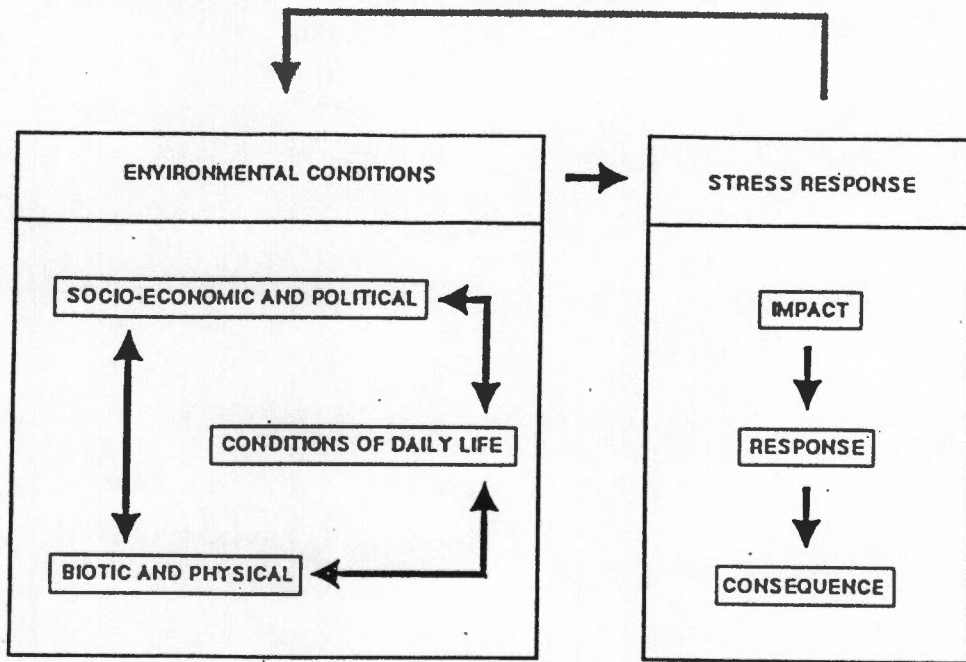


Figure 1.2. The Goodman et al. model showing the relationship between environmental conditions and stress response. After Goodman et al. (1988).

Individuals who are not nutritionally stressed as children tend to be taller than those that experienced nutritional stress, if the stress occurred over a long period. Gray and Wolfe (1980) address nutritional stress and sexual dimorphism. They conclude that while nutritional stress plays an important role in sexual dimorphism, there are several other factors that influence it. It is important to consider these consequences of malnutrition when conducting anthropometric research.

Statement of Purpose

The purpose of this thesis is to analyze and to offer an explanation for the anthropometric variability among four tribes of American Indians: the Eastern and Western Bands of the Cherokee and Choctaw, the Kiowa, and the Pawnee. Data collected under the direction of Franz Boas during the late 1880's form the data set. Six head measurements and six body measurements are analyzed in this project to determine group distance among the various bands and tribes studied.

In one of the few reports Boas produced from his data, he notes a stature difference between the Western and Eastern Cherokees (Boas, 1895). In a report written for a seminar on the Boas material, I note a stature difference between the Eastern and Western Bands of the Cherokees, as well as one between the Eastern and Western Choctaw (Bigbee, 1988). In both cases, the Western Bands of

Cherokee and Choctaw Indians are taller than their Eastern counterparts.

The stature differences between the Eastern and Western Bands of the Cherokee and Choctaw Indians has been attributed to several factors. We should consider the more important influences for the difference in stature. Three hypotheses for this difference are tested using statistical and historical data. The first hypothesis is that after separation the Western Bands of Cherokee and Choctaw had a better diet than that of their eastern counterparts. The second hypothesis concerns the concept of gene flow, where the Western Bands experienced admixture with various Plains Indians tribes. The third hypothesis is that the individuals removed from the eastern United States were taller than the Indians that avoided removal.

There are three primary goals for this thesis: 1) to test the three previously mentioned hypotheses to see if any or all are viable explanations for anthropometric variation between the Eastern and Western Bands of Cherokee and Choctaw, 2) to increase the amount of information derived from the Boas data set, in a group distance study context, and 3) to provide insight into the condition of the study groups during the middle of the 19th century.

Within the scope of this project, the history of the study groups, up to the point of Boas' work, will be examined. Anthropometric data from the Boas data set will

be analyzed, using means, general linear models and canonical variates to test the three hypotheses.

In order for the first hypothesis to be accepted, one would expect the results to reflect evidence for the presence or absence of environmental stress. If the Western Cherokees and Western Choctaws enjoyed a better diet and less environmental stress than the Eastern Cherokees and Choctaws, the results would show this. The Western Bands would be taller than their eastern counterparts, but would be similar to the Eastern Bands in other aspects such as cranial dimensions.

For the second hypothesis (that of gene flow among the Plains and Western Bands), to be accepted, we would expect to see in the Western Bands of Cherokee and Choctaw Indians to differentiate from the Eastern Bands to a greater degree. Plots from the data would show that the Western Bands are similar to the Plains groups in body and cranial dimensions.

Results for accepting the third hypothesis would be slightly different. If individuals who were to later make up the Western Bands were taller before removal due to gene flow from whites and blacks, we would expect to see them plot away from all other indian groups used in this study.

CHAPTER 2

A HISTORICAL REVIEW

This project involves anthropometric data derived from four North American Indian Tribes: the Cherokee, the Choctaw, the Kiowa, and the Pawnee. As mentioned earlier, the environment in which these tribes existed could have certainly affected their physical dimensions; specifically malnutrition could have lead to diminished stature. As Goodman (1973) warns, researchers should attempt to take into consideration effects of the environment on a study population, especially in the absence of genetic markers. Because of the nature of the data used in this research, it is relevant to review the history of the study tribes, up to the point of measuring by Frans Boaz.

The Cherokee Indians

The Cherokee Indians are a tribe that is historically located in the Southern Appalachian Mountains (Figure 2.1). They are Iroquoian speakers in the Macro-Siouan family (Voegelin and Voegelin, 1966), and migrated to the Appalachians from farther north (Finger, 1984; Swanton, 1987). As a group the Cherokees have been traditionally divided geographically into three subgroups, known as towns. The Upper (or Overhill) Cherokees were located in East Tennessee and Western North Carolina, on the lower

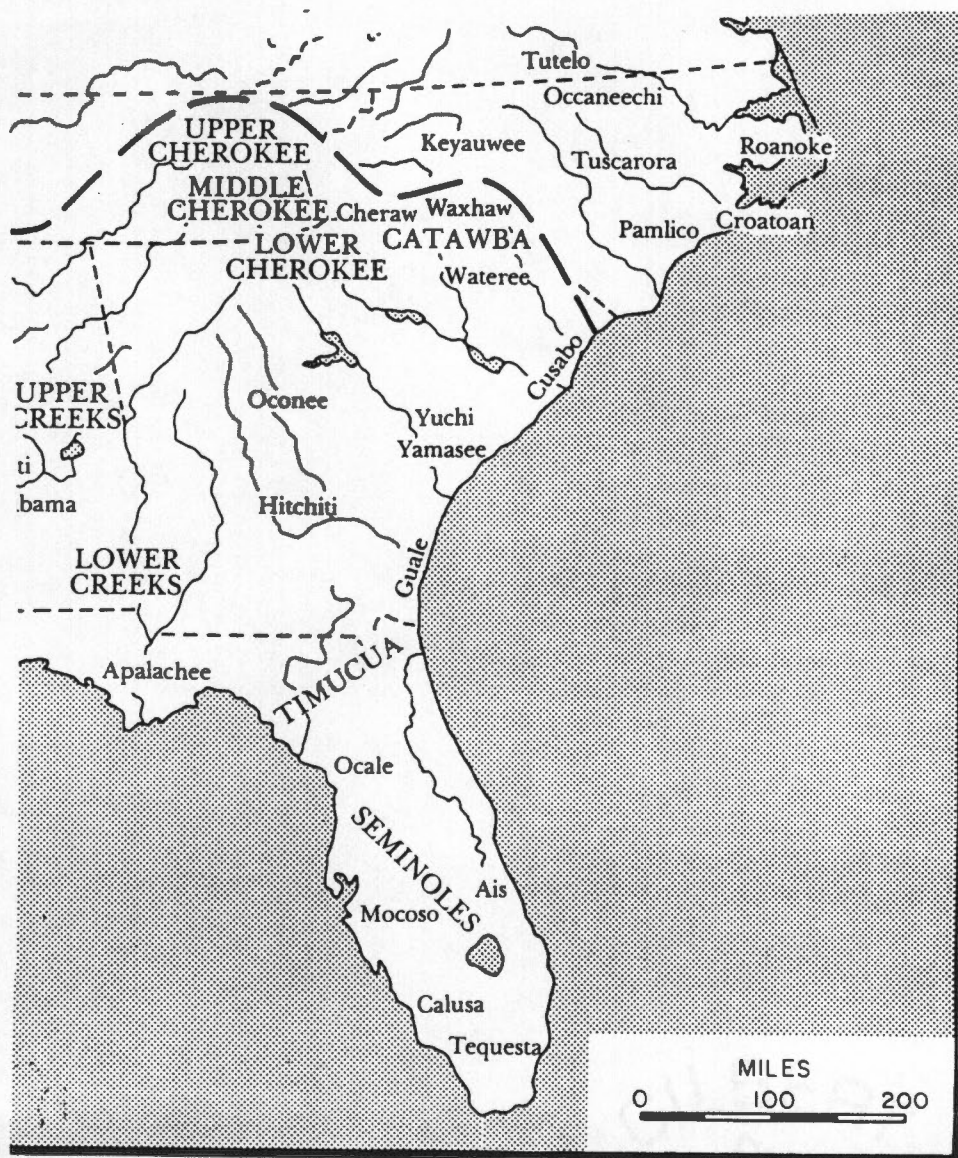


Figure 2.1 Cherokee Lands Prior to 1800
(From Hudson, 1976).

Little Tennessee River (Cockran, 1962). The Middle Towns were found around the upper Little Tennessee, the Tuskasegee, Cheoah, and Valley Rivers of North Carolina and Tennessee. The Lower Towns were along the upper Savannah River and on the upper Piedmont of South Carolina (Cockran, 1962; Hudson, 1976).

When the Spanish Explorer De Soto came to the area in 1540 (Hudson, 1976), the Cherokees were occupying bottom lands and subsisting predominately on agriculture during the spring and summer. As fall approached, the towns' population broke up, with family groups splintering off. Deer hunting typically took up a majority of their time during this part of the season (Cockran, 1962).

Between 1540 and 1673, the Cherokees had little contact with Europeans, but that changed. European demand for deer hide was considerable, and by 1750 the Cherokees began hunting deer year around, trading hides for European goods such as firearms, clothes, and iron farming implements.

The Cherokees vacillated in their support of Great Britain during the French and Indian War, actually aiding in the fall of British-held Fort Loudoun, located in the Overhill area. As tensions between the American colonies and Great Britain increased, the Cherokees, feeling the threat from colonists eager to possess tribal lands, aligned themselves with the Crown (Finger, 1984), with

disastrous results. During and after the Revolutionary War, members of the Lower Towns found themselves being pushed out of South Carolina and forced into Tennessee, Georgia, and Alabama.

Starting in 1785, those Cherokees who remained in South Carolina found their land holdings were smaller and smaller after each treaty they signed. Because the Cherokee land in Southern Appalachia was somewhat undesirable to the Europeans, the Middle and Overhill Cherokees managed to hold onto more of their land than their Lower Town counterparts.

Formal plans for Indian removal were drawn during Thomas Jefferson's term as President. While it was his desire to Christianize the Indians of the Southeast, Jefferson began to feel pressure from other whites to adopt a less tolerant policy. Finger (1984) contends that part of Jefferson's motivation for the Louisiana purchase was to find new lands for the Southeastern tribes.

Andrew Jackson was not nearly as sympathetic. Despite the fact that in 1814 Cherokee braves were instrumental in helping Jackson defeat Creek Indians at the Battle of Horseshoe Bend, he was still a strong advocate for Indian removal. He argued that if the Cherokees and other members of the "five civilized tribes" (Foreman, 1966) were to move to the territories in the west, they would then acculturate more smoothly under the

protection of the federal government. This argument would prove to be most effective in the 1830's, even if many Cherokee had already adopted a lifestyles similar to white farmers.

In July of 1827, the Cherokee elected delegates and wrote a constitution quite similar to that of the United States of America. The Cherokee constitution included a declaration of the boundaries of the Cherokee nation, policies for governing, and a list of citizens' rights (Starr, 1922). This act, of course upset many southern whites, who claimed this constitution was in direct violation of the State of Georgia's right to govern. Additionally, Finger (1984) mentions that while the Cherokees had adopted many aspects of white society, they still clung to their culture, upsetting whites even more.

The Treaties of 1817 and 1819 were the first to spell out the terms for removal, promising vast tracts of land in Arkansas and Oklahoma in return for Cherokee lands in the East. These treaties also made provisions for those who wished to remain in the East, making them state citizens. On May 6, 1828, the next major treaty involving Cherokee removal was signed. In this treaty, the boundary of lands to be held by the Western Cherokees was defined, and articles concerned with cost of removal (or emigration) were covered as well (Starr, 1922). More land in the East was sacrificed, along with Western Cherokee

holdings in Arkansas. Those lands around the Little Tennessee, Tuskasegee, and Oconaluftee (also called Quallatown) Rivers remained Cherokee (Figure 2.2), and many Eastern Cherokees who had lost land in the Treaty of 1819 relocated there.

By the 1820's many Cherokees had relocated in Oklahoma. Many of those who remained in the east were experiencing considerable pressure to give up their lands and to relocate also (Foreman, 1953). In 1830, President Jackson signed the Indian Removal Act, which stated that the Federal Government could no longer protect any Native Americans who remained in the East, as they were now citizens of the given state of occupation. In 1835 a minority of Cherokee leaders, under the persuasion of whites, signed the Treaty of New Echota, relinquishing all lands east of the Mississippi to the federal government, in return for \$5 million and a considerable amount of land in Oklahoma. Terms of the agreement stipulated that emigration would be within two years (Starr, 1922).

A majority of Cherokees protested this treaty, but in 1836 the treaty was ratified by the United States congress. One article of the treaty was that those Cherokees that remained would be citizens of the state of North Carolina, and would be subject to any laws that North Carolina imposed on them. The general assembly in North Carolina, though, refused to offer full protection

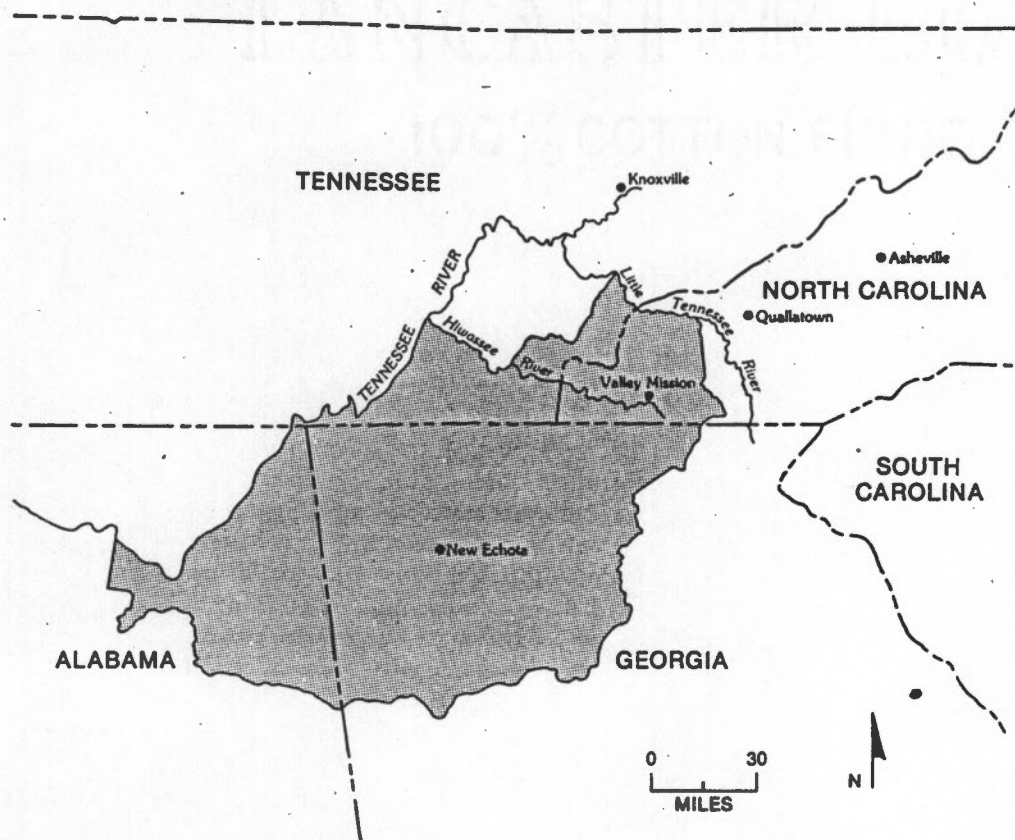


Figure 2.2 Cherokee Lands, 1819 - 1838
(From Finger, 1984).

until well after the majority of Cherokees elsewhere had been rounded up and removed.

In 1838, the removal began under the direction of Major General Winfield Scott (Carter, 1976). Between May 26th and June 20th, 1838, over sixteen thousand Cherokees were removed from their homes and forced into stockades for emigration to the Oklahoma territories. Quallatown Cherokees were protected from removal according to the treaties of 1817 and 1819, but they still had to assure the federal government that they would not harbor fugitives. Regardless, some Cherokees did manage to hide in the Great Smokey Mountains (Carter, 1976; Finger, 1984). Scott was under the impression that as few as two hundred remained in hiding. By the end of 1838, the War Department had decided that as long as it was acceptable to North Carolina, those that remained in hiding could stay in the East, if they abided by state laws. It has been estimated that by the end of 1835, the total number of Cherokees remaining in the Southeast was 1,400 (Finger 1984). Brett Riggs, a Ph.D. student in archaeology at the University of Tennessee, Knoxville, in an interview stated that a review of census records for North Carolina for this time period reflects that many of the Cherokees that remained consisted primarily of several interrelated families of pure-blood Cherokees. He also relates that many of those who were removed were mixed-blood Cherokee,

though they had claimed to be either full blood Cherokee or not Cherokee. The State of North Carolina had refused to recognize federal waivers for lands held in the East by Cherokees who had opted not relocate under the provisions of the Treaties of 1817 and 1819 (Riggs, personal communication, 1992).

The forced emigration to the West, now known as the Trail of Tears, was responsible for the deaths of an estimated four thousand Cherokees. Deaths occurred from a wide of range causes, including cholera and exposure (Foreman, 1953, 1966; Carter, 1976; Finger 1984). Upon arrival in Oklahoma (Figure 2.3), the emigrants were met by the Old Settlers and the Treaty Party (Finger, 1984:10), approximately two thousand Cherokees who had migrated there in the 1820's. The Cherokees now in the West made up what will be referred to as The Western Band of the Cherokees.

The Western Band of the Cherokees

The new arrivals came without the benefit of even the most basic essentials and were viewed by the Old Settlers with some degree of mistrust. Goods promised by the federal government under the Treaty of 1838 were either never delivered or sub-standard. John Ross, a Cherokee leader who emigrated from the East on the Trail of Tears, chastised the federal government for its unwillingness to assist. He transferred funds the government meant for

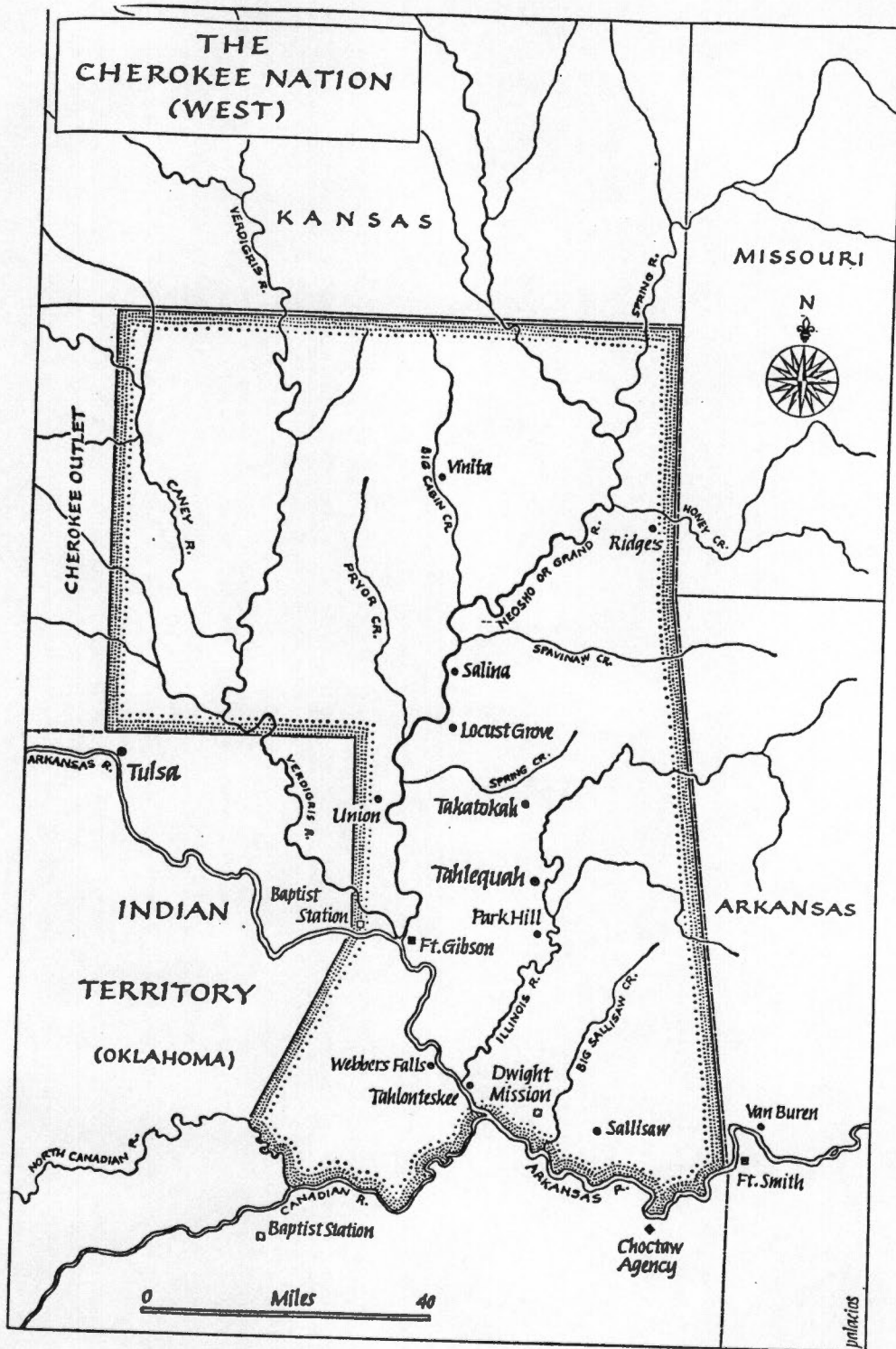


Figure 2.3 Western Band of the Cherokee Territory (From Carter, 1976).

emigration, and managed to obtain many of the essentials the recent emigrants required.

From their arrival in the West through the Civil War, the Late Emigrants had difficulties getting along with the Old Settlers and the Treaty Party. While John Ross argued that not to side with the Union would be disastrous, leaders from the other factions (many of whom owned slaves) felt that the Confederacy (which had considerable support from Kansas and Texas) would be less of a threat, therefore the Western Band allied itself with the Confederacy (Carter, 1976). In 1862, Ross was captured by invading Union forces and was sent to Philadelphia. Later he was pardoned, with assurances from President Lincoln that the Western Band's alliance with the Confederacy would not be held against it after the war. Despite Lincoln's promise, the Western Band did experience destitution after the war. In 1871, two hundred emigrants from the Eastern Band arrived only to have their crops devoured by locust, and they did not receive federal relief funds.

Eventually, the Western Band did begin to recover and experience stability. Schools that had been destroyed during the Civil War were rebuilt, and the Western Band was blessed with several years of successful crops.

The Eastern Band of the Cherokee

The period after the Trail of Tears was one quite difficult for the Eastern Band of the Cherokees as well. Only a few years after the removal of 1838, some members of the Eastern Band considered relocating to the West. A majority, though, focused their efforts on receiving recognition from state and federal agencies. The Eastern Band's legal counselor, William Thomas, had repeatedly supported the Cherokees of Quallatown since before the Trail of Tears. In 1840, he did manage to secure monies for the Cherokees, and bought Western North Carolina land, known as the Qualla Boundary, for the Eastern Band (Finger, 1984:44) (Figure 2.4).

Especially in Quallatown, Thomas's hard work paid off. Schools were erected, public roads were maintained, and white visitors, generally found the Cherokees to be "sober and orderly" (Finger, 1984:69). He had the respect of the Cherokees, and he continued representing them throughout his life. Unfortunately, this association was not to the Eastern Bands' advantage during the Civil War.

Thomas convinced the Eastern Band to support the Confederacy using the argument that the Cherokees were citizens of the State of North Carolina, and were thus obliged to help protect its borders. He convinced the Confederate congress to pay annuities to the North Carolinian Cherokees, as the federal government had

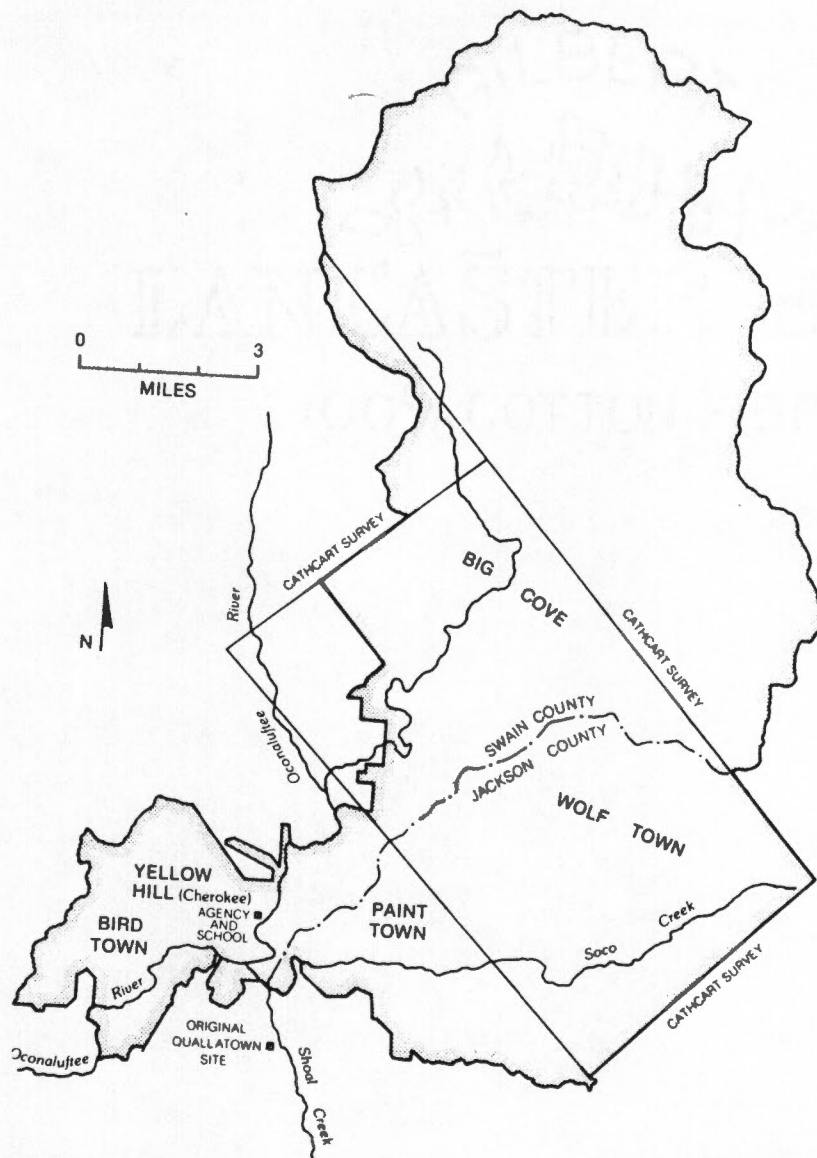


Figure 2.4 Qualla Boundary (From Finger, 1984).

discontinued payment to disloyal tribes. The Cherokees agreed to enlist, with Thomas as their commander.

Many Cherokees died during the war, and Thomas was left physically diminished and slightly feebleminded. While Thomas was still respected, the Cherokees had lost faith in him. To add to the troubles, immediately following the war a smallpox epidemic swept through the Band, killing many leaders. And the already weakened indians were susceptible to three additional problems: alcohol abuse, a crop failure, and political division.

One of the political issues was that of removal. As many as two hundred Cherokees had emigrated to the Western Band between 1848 and 1869. The Western Cherokees extended an invitation to any Eastern Band member to join them. This increased political disagreements even more.

As time progressed, the Eastern Band did begin to resolve many of its internal problems, although there still was considerable confusion concerning federal and state protection and aid. Teachers, many being missionaries, were sent. This presence improved conditions, but the Eastern Band still had some major difficulties. The winter of 1871 was harsh, and tuberculosis was beginning to become a problem. While missionaries continued their efforts, it would not be until the 1900's for the Eastern Band to return to the stability they had known before the Civil War.

The Choctaw Indians

The Choctaw Indians are Muskogean speakers, a family in Macro-Algonquian (Voeglin and Voeglin, 1966), along with the Chickasaw and Creek Indians (Swanton, 1987; Hudson, 1976). They inhabited what is now central and southern Mississippi as well as southwestern Alabama (Figure 2.5), subsisting primarily on agriculture and supplementing their diet with hunting and fishing. The first European contact was with De Soto in 1540. De Soto had bullied other tribes in the Southeast, but it was a different case with the Choctaw. De Soto's demand for treasure was soundly denied by the Choctaw, resulting in armed conflict. Twenty-two Spanish soldiers were killed, along with more than 1,000 Choctaw men (Debo, 1961; DeRosier, 1970).

The next European contact with the Choctaw would not occur until approximately another one hundred, fifty years. By the 1700's, French traders were peacefully interacting with the Choctaw. By then the Choctaw had access to European grains, vegetables, and livestock (Debo, 1961). The French remained the predominant European influence on the Choctaw until England gained control over much of the area. After the Revolutionary War and the Louisiana purchase, the United States began to exert control over the area.

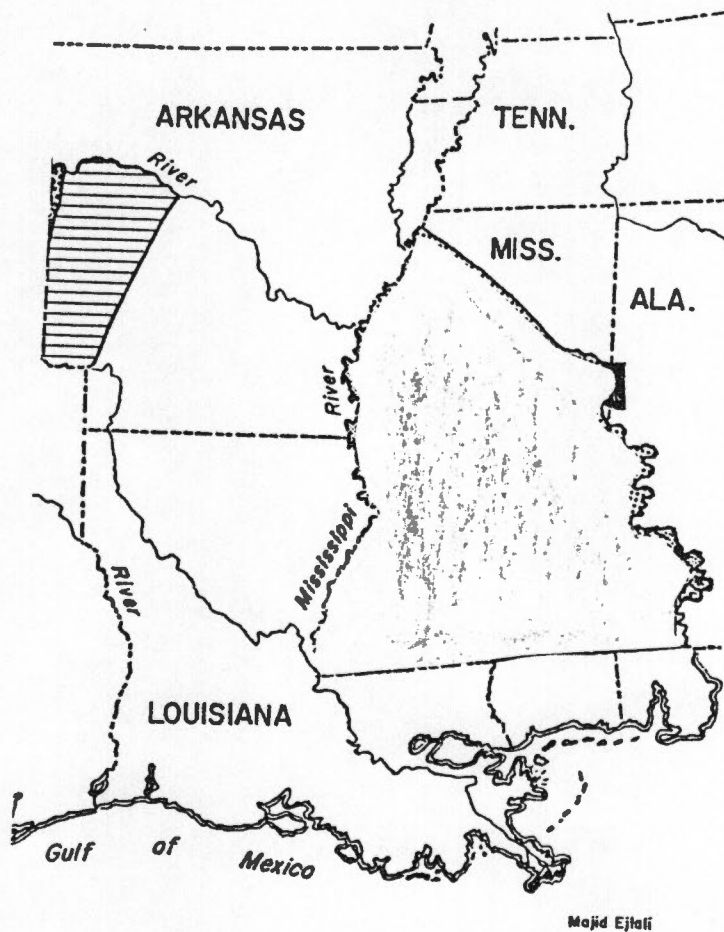


Figure 2.5 Choctaw Nation East (shaded area)
(From DeRosier, 1970).

In 1801, one of the first treaties between the Choctaw Nation and the United States was written. This treaty and those which followed reduced Choctaw lands considerably. In the early 1800's, plans were being drawn up in the United States Congress for Indian Removal: under the direction of John C. Calhoun. Calhoun and Thomas Jefferson had similar feelings about Indian Removal, that it was a necessary evil which could save the Indian from annihilation by land-hungry whites. Under their program, any indians willing to relocate would receive fair compensation for their lands, and those not wishing to move should be allowed to stay, accepting the consequences of the land hungry whites. Calhoun also provided much needed funds for missionary schools and churches within the Choctaw nation.

Three commissioners from Washington were sent to the Choctaw Nation in 1818 to suggest removal and were met with opposition. The following year, Andrew Jackson himself talked to the Choctaws ,who, like the Cherokees, had assisted him in military endeavors. Chief Pushmataha apologized to Jackson and stated that it was the Choctaws' desire to stay where they were.

Two years later, the Treaty of Doak's Stand was signed. Jackson, again, was in Mississippi to talk the Choctaw into relocating. He ultimately had to rely on threats to convince the Choctaw to sign the treaty,

forcing them to relinquish one third of their land in exchange for land in southern Oklahoma and Arkansas, guns, food, and annuities (DeRosier, 1970). White settlers in Arkansas complained bitterly, so in 1825 a new treaty was signed, offering more money to the Choctaws, and reclaiming most of the Choctaw lands in Arkansas given to them previously (Debo, 1961). For the next five years the Choctaws refused to sign treaties forcing removal, but in 1830, the Treaty of Dancing Rabbit Creek was signed. All remaining Choctaw land in Mississippi was ceded in return for goods and less land in Oklahoma than was promised in the Treaty of Doak's Stand; and removal had to occur within three years. Indians staying in the East had to register with the Indian agent with six months of treaty ratification.

It is estimated that about four hundred emigrants voluntarily left Mississippi in December of 1830. The following year, many Choctaw did not plant their crops in anticipation of removal. Alcohol abuse became a problem as well. In October of that year about 4,000 Choctaws prepared to leave. Agents in charge of removal divided the emigrants into smaller groups to avoid food shortages, which occurred. There was considerable suffering during this first removal because of a harsh winter and poor planning by the removal agents (Foreman, 1953). In March, the first major group of Choctaws arrived in Indian

Territory (Figure 2.6) Of the four thousand that started, two hundred perished along the way.

Two more official removals took place in as many years. Because the removal in 1830 had cost the federal government three times the estimated cost, the military was in charge of the next two. These later removals were considered to be as much failures as the first because of deaths due to exposure and a cholera outbreak. The survivors of these removals will now be referred to as the Western Band of the Choctaw.

The Western Band of the Choctaws

As with the Cherokees, many of the goods promised to the emigrants were simply not forthcoming (Foreman, 1953). Some Choctaws became dejected and made little effort to establish themselves in the West (Benson, 1970), opting to squander the one year annuity the government was providing (Derosier, 1970). Many did attempt to start again but met mixed results. They had no sooner gotten settled, when the Arkansas River flooded, washing away crops, stored food, and homes. As many as one fifth of the Western Band perished following flood, because of sickness and starvation. In addition to these problems, more emigrants, in poor health, arrived during the winter months of 1833 and 1834. More emigrants arrived in 1838, 1845, 1846, 1847, and 1849. Each emigration was usually followed by a period of cholera and hardship.

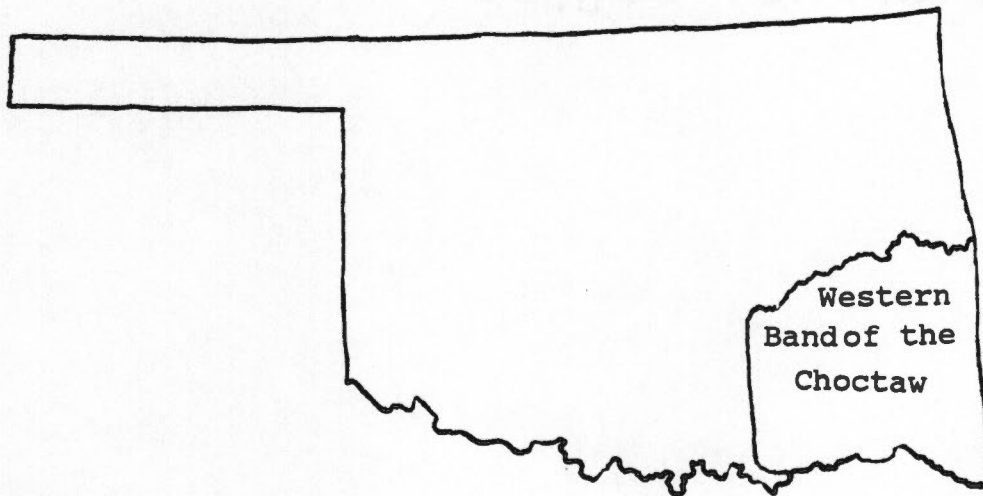


Figure 2.6 Western Band of the Choctaw
(After Blaine, 1990).

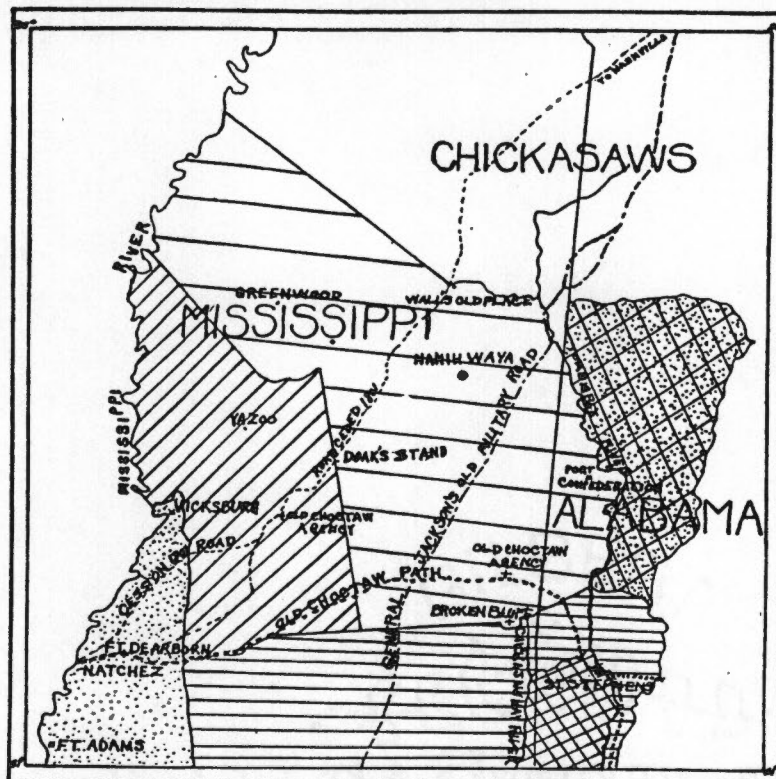
The Civil War led to more hardship for the Western Choctaw. Many Choctaw owned slaves, and thus they gave their support to the Confederacy. The Band also experienced problems of Cherokee and Creek refugees fleeing Union forces that had come into their territories. When it became apparent that the South was not going to win, many Choctaws petitioned the federal government for formal recognition again, and after a series of negotiations the Treaty of 1866 was signed. The Western Choctaws managed to hold on to a majority of their land. While refugees from the war tried to stay within the confines of the Western Band's boundary, they were eventually persuaded to return to their original tribes.

One stipulation the federal government made was that the Choctaw were to allow freed slaves to live within the Western Choctaw Nation. By 1880, freedmen who were already in Western Band land were allowed to remain, but it was a felony under Choctaw law to intermarry, and any immigration of blacks into Western Choctaw lands was forbidden under the Treaty of 1866.

As the nineteenth century came to a close, the Western Band grew both in population and economically. The increasing stability that the Western Band of Cherokees was felt by the Western Choctaws as well.

The Eastern Band of the Choctaw

No sooner had the Treaty of Dancing Rabbit Creek been signed then intertribal factionalism occurred. Many of the tribe members who wanted to stay in the East were full-blooded and spoke little if any English. As specified by the Treaty, any Choctaws wishing to remain in Mississippi had to register with the appropriate indian agents in order to keep any of their lands (Figure 2.7). William Ward was in charge of most of the Mississippi Choctaws and managed to register only a few families, of which consisted primarily of either mixed-bloods or white males with Choctaw wives (Satz, 1986). Despite Ward's efforts to discourage the Choctaws from remaining in Mississippi, an estimated six thousand stayed. As more and more white settlers arrived, the Eastern Choctaws were forced into the less fertile areas, living in destitution (Satz, 1986). The United States Congress analyzed Ward's treatment of the Choctaw, and in 1847, the Eastern Band was offered scrips for western lands. There was increased pressure from white settlers, so some Choctaw did relocate. As many as a third of the Choctaws in Mississippi remained loyal to the Union during the Civil War, causing them to lose much property to confederate loyalist. Almost two hundred Choctaws who were conscripted by the Confederacy were captured by the Union



COMPILED FROM ROYCE, Indian Land Cessions

CHOCTAW LANDS IN THE EAST SHOWING CESSIONS TO UNITED STATES

 TREATY OF 1801	 TREATY OF 1816
 TREATY OF 1802	 TREATY OF 1820
 TREATY OF 1805	 TREATY OF 1830

SCALE OF MILES



Figure 2.7 Eastern Band of the Choctaw
(After Debo, 1961).

during the Vicksburg campaign of 1863, and presumably were sent to the West (Satz, 1986). The Eastern Choctaws did not receive any specific punishments from the federal government after the war, though relocation efforts continued with marginal success.

As the political and economic systems in Mississippi changed, so did the Eastern Choctaw. In the 1880's, sharecropping replaced simple squatting as a means of subsistence for the Choctaws. While the sharecrop system kept the Choctaws in indentured service, they received food for their labor. Schools and churches were built in these communities, so the general condition of the Eastern Choctaws improved.

The Kiowa Indians

The Kiowa Indians were originally a Plains Indian tribe that is classified as belonging to the Aztec-Tanoan linguistic group (Voegelin and Voegelin, 1966). Before removal, they ranged in Montana, but as time progressed, they migrated south towards Oklahoma. They primarily hunted on the prairies, following herds of buffalo.

First contact was certainly with the Spanish, but the first treaty involving the Kiowa was signed in 1837. This treaty allowed for equal hunting rights on the southern prairies with the Osage, Kiowa Apache, Tawakoni, Creek tribes, as well as citizens of the United States (Brant, 1969).

The next treaty to be signed was in 1853, which guaranteed peace between the named indian tribes (Kiowa, Kiowa Apache, and Comanche) and the respective governments of Mexico and the United States. It also allowed roads to be built and military establishments to be constructed in the indians' territories.

The next ten years passed with the Kiowas, Kiowa Apache, Comanche, and Cheyenne warring with various tribes of eastern Kansas, often unsuccessfully. Their primary adversaries, the Sauk and Fox, were better armed. A treaty designed to stop the warring among the various tribes was signed in 1865, but it did not work, and another was signed in 1867. This treaty was somewhat stronger, as the federal government had grown tired of having railroad construction and overall development being interrupted by indian battles (Brant, 1969).

The Treaty of 1867 provided a reservation for the Kiowa, as well as Kiowa Apache and Comanche (Figure 2.8). It had been hoped that the tribes would give up their nomadic and war-like way of life in exchange for a more agrarian life. The hopes of the federal government were somewhat met, in that the Kiowa Apaches tended to "settle down and become farmers" (Brant, 1969:13), but the Kiowa and Comanche held on to raiding.

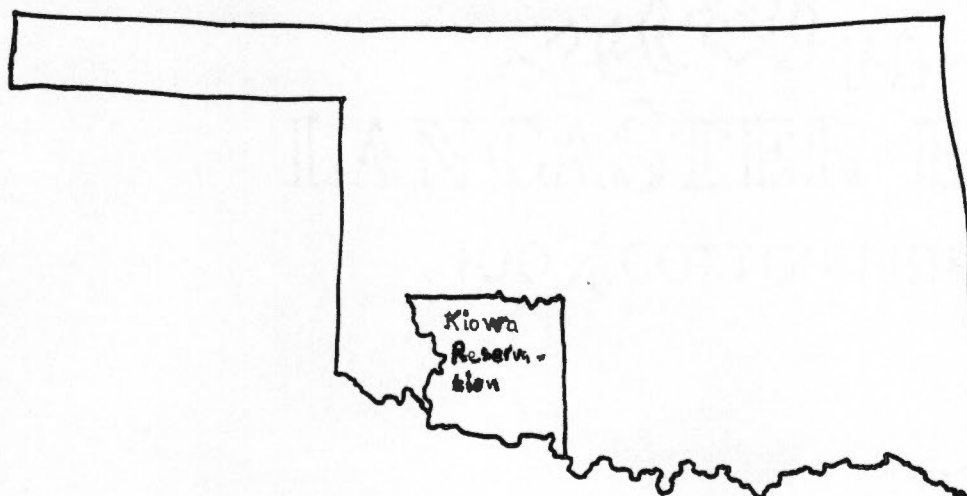


Figure 2.8 Kiowa Reservation (After Blaine, 1990).

In the 1880's, the tribe experienced several setbacks. Disease such as cholera was prevalent, and game was getting scarce. The federal government had set ration limits sent to the Kiowa based on the amount of food the indians could procure on their own. As the amount of available game dropped off, there was no government re-adjustment of rations to counteract it, so malnutrition became a problem. One can only imagine the state of the reservation when Boas or one of his colleagues arrived there to measure the Kiowa.

The Pawnee Indians

The Pawnees are Caddoan speakers, a family in the Macro-Siouan group (Voegelin and Voegelin, 1966) of Plains Indians, originally inhabiting the plains and river valleys of Nebraska (Figure 2.9). They lead a "semi-sedentary life, dwelling in fixed villages and cultivating the soil" (Hyde, 1974:3). The smaller villages were often subject to attack from more nomadic tribes, while the larger villages managed to stave off most attacks.

The first contact with Europeans was possibly with De Soto, who had armed conflict with Caddoan-speakers in 1541. After losing several horses in an ambush, De Soto decided to turn east across the Mississippi River, where he died (Hyde, 1974). Subsequent European contact was

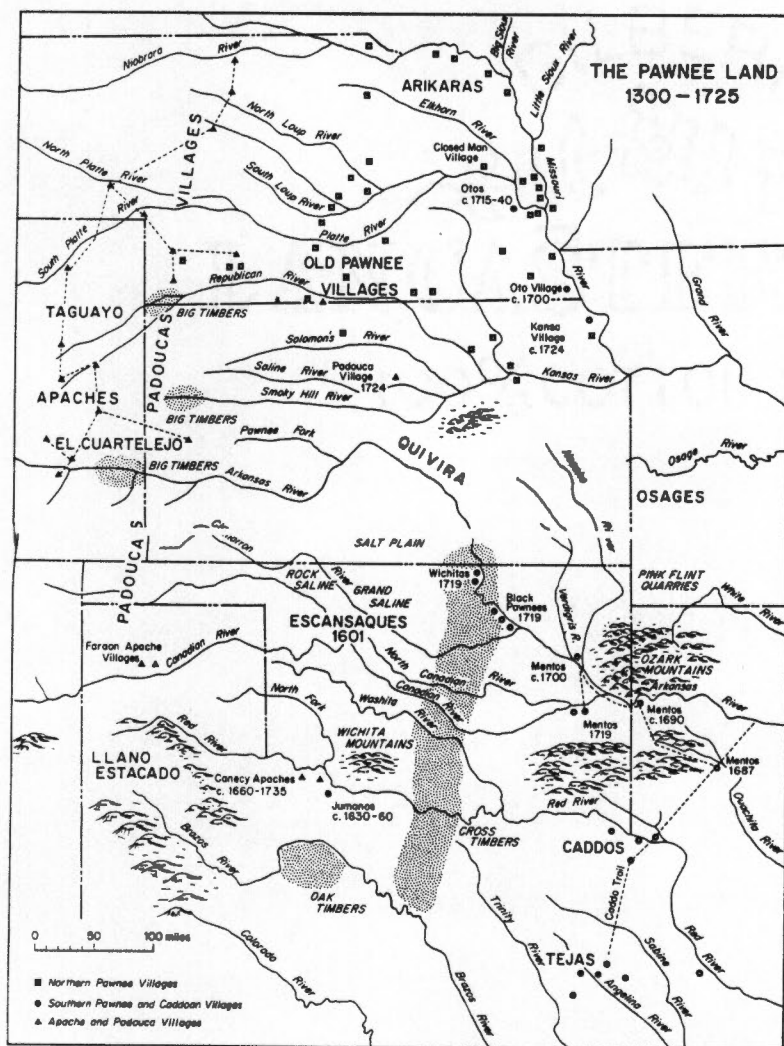


Figure 2.9 Pawnee Indian Lands, 1300-1725
(After Hyde, 1974).

with French traders and Spanish explorers. In the 1600's, the Pawnees were often attacked by Eastern Plains Indians armed with metal weapons from the French. Pawnee captives were oftentimes carried off as slaves, and this practice continued into the eighteenth century (Hyde, 1974).

The 1700's were marked by several skirmishes and battles among other indians and the Spanish. The control the Spanish had held over the area dropped off considerably, while French influences became stronger. Hyde (1974) gives considerable attention to French reports on battles the Pawnee had with their neighbors, captive stories, and travelers' tales. Based on these narratives, it can be determined that the Pawnees were being forced south out of Nebraska. But regardless of how well the Pawnee were doing, their traditional way of life was soon to come to an end.

As the United States began to push westward, contact with the Pawnees increased. In the 1820's the federal government started extending invitations for opening formal relations with the Pawnees. The main goal of the federal government was to convince the Pawnee that whites were quite powerful. Three chiefs were invited to tour the East, and while there they met several missionary organizations, all of which expressed interest in saving the Pawnee. The chiefs basically ignored both the federal government and the missionaries (Hyde, 1974).

Major items of importance in the 1830's included the influx of eastern tribes to the area, and smallpox epidemics. Ancient feuds with the Sioux were rekindled, and many Pawnees that managed to survive the smallpox epidemic were slaughtered during Sioux raids. Missionaries arrived in 1835, but had difficulties in converting or educating the Indians as the Pawnees had become less sedentary in order to hunt buffalo. Even after the establishing of a mission, the ravages of smallpox and Sioux raids took their toll. By 1846, the missionaries left the area, feeling that the Sioux were simply too big a threat to the whites in the area.

The general condition of the Pawnees worsened as time went by until, in 1857, they signed a treaty that robbed the Pawnee of any land they might have claimed in return for the Loup Reservation which was a small reservation in Nebraska. Another stipulation of the treaty was that the federal government would protect the Pawnees from Sioux raids. Needless to say, the Sioux continued to raid the reservation, killing Pawnees and stealing horses. The federal government was in the process of attempting to bribe the Sioux into being more passive by giving them firearms as gifts. Tribes like the Pawnees, which were friendly to the federal government were overlooked when the government was handling much needed weapons. This

policy contributed greatly to the decline of many of friendly tribes (Blaine, 1990).

The Quakers arrived at the Loup reservation in the 1860's and immediately started working to improve it. The Quakers required the Pawnees to discontinue buffalo hunting. This restriction worked sometimes; other times it did not. The main purpose of restricting the hunt was to reduce the number of conflicts between the Sioux and Pawnee. Another goal the missionaries had was to convince the Pawnee to relocate their reservation to the south. In 1874, they were successful.

The Pawnee settled in the Cherokee Outlet (Figure 2.10), with the last party arriving in 1875. As with practically every removal of Native Americans, much suffering was involved. Once there, the Pawnees found the buffalo hunting to be quite poor, and the Quakers would oftentimes not allow them to retaliate against other tribes stealing horses. The general level of health for the Pawnee was quite poor (Hyde, 1974; Blaine, 1990) during this time, and most likely was still bad at the time of Boas's work.



Figure 2.10 Pawnee Reservation (shaded area) (After Blaine, 1990).

CHAPTER 3

THE DATA BASE

Introduction

The four-hundredth anniversary of Columbus's landing in America was celebrated in 1892. In recognition of this event, the World's Columbian Exposition of 1892 was held in Chicago. Even from the planning stages of the exposition, the director, F.W. Putnam, wished to develop it into The Field Columbian Museum, which would contain both ethnographic materials as well as anthropometric information (Darnell, 1969). In order to accomplish this, he hired Dr. Franz Boas in 1891 to direct much of the anthropometric data collection (Jantz et al., 1992), while James Mooney was to supervise the ethnological museum collection (Darnell, 1969).

While Boas had trained as a physical geographer, he is considered by many to be the Father of American Anthropology, having trained anthropologists such as Alfred Kroeber, Robert Lowie, and Ruth Benedict (Kaplan and Manners, 1972). When he was conducting geographical studies in northern Canada, he lived among the Central Eskimo. Because of his interest in the eskimo and anthropology in general, he gave up geography for anthropology (Garbarino, 1977). Most of his impact was on cultural anthropology, and he is noted for his

support of a holistic approach in data collection.

According to Falsetti (1989), Boas began field work in 1883 in the Baffin Islands, studying the relationship between topography and how the islanders perceived it. He studied various tribes in Western and Northwestern North America, and in 1889, he began to include anthropometry in his studies. Once hired by Putman in 1891 (Jantz, 1992), Boas went about coordinating volunteers and researchers for the extensive fieldwork, as it was Putman's desire to accumulate as much information as possible for the Exposition and the Field Columbian Museum (Darnell, 1969).

Boas, oftentimes having to use volunteers or outside sponsorship, trained as many as fifty anthropologists to go about the country to take anthropometric measurements of any Native American willing to participate. Boas's insight into the declining condition of the American Indians is to be lauded. He recognized that the culture of the Native Americans was all but erased, and that acculturation would change the Indian forever. It has been estimated that under his direction, 15,000 individuals were measured (Jantz, et al., 1992).

While the data set used in this thesis was taken from measurements procured during Boas's work for Putnam and the Columbian Exposition and the Columbian Field Museum, between 1888 and 1902 Boas continued to collect

anthropometric information from several Native American groups throughout the West and Northwest.

Boas used some of this data to publish as many as ten articles on the anthropometry of various Western Indians (Jantz et al. 1992). Besides these articles, little was done with Boas's data. Sullivan (1920) worked with the Siouian data, and Hall and MacNair (1972) used the Boas data from several Northwest tribes in a multivariate analysis. In 1982, the data were lent to the University of Tennessee from the American Museum and the American Philosophical Society at the request of Dr. Richard Jantz. The data were microfilmed and added to the computer database (Jantz et al., 1992).

Once the data were readily available, several studies were produced using data from Northwestern Tribes, as Boas collected more information from these groups than others (Hunt et al., 1988; Falsetti, 1989; Falsetti and Jantz, 1990; Jantz et al., 1992). Data from other regions is somewhat limited in quantity, but it is still used in research (Stivers, 1990; McKelway, nd).

Anthropometric Data

The data used in this project consist of 6 head and face (cranial) measurements and 6 body (post cranial) measurements. Jantz et al. (1992) point out that the head and face measurements provide a "more or less standard description of the head and face" (1992:437), but the body

measurements have only one breadth measure, demonstrating a somewhat longitudinal bias. The 12 measurements follow: standing height, shoulder height, finger height, finger reach, sitting height, shoulder breadth, head length, head breadth, facial height, facial breadth, nose height, and nose breadth. All measurements were recorded in millimeters. These measurements are defined in Table 3.1.

Boas recognized the problems of interobserver error and attempted to control for it by personally training many of his anthropometrists and ,when possible, having two anthropometrists measure the same tribe (but not the same subjects) (Jantz et al., 1992). Because the data for this thesis was also used in Jantz et al (1992), measurement error was already tested for. This is accomplished by plotting each measurement against another one, by tribe. Cranial measurements plots for the following dimensions are tested for inconsistencies: head length versus head breadth, facial breadth versus head breadth, facial height versus nose height, and nose height versus nose breadth.

For the postcranial measurements, stature was plotted against the each of the other postcranial scores. Any outlying scores on the plot would be an indication of incorrect or missing values. Using this technique,

Table 3.1 The 12 Anthropometric Measurements and Their Definitions.

<u>Measurement</u>	<u>Definition</u>
Standing Height	Distance from the floor to the top of head.
Shoulder Height	Distance from the floor to the tip of shoulder (acromion).
Finger Height	Distance from the floor to tip of the third digit, hands at side.
Finger Reach	Distance between the third fingers when the subject's arms are held apart.
Sitting Height	Distance from the top of the table to the top of head.
Shoulder Breadth	Distance between acromia.
Head Length	Maximum length of the subject's head.
Head Breadth	Maximum width of the subject's head.
Face Height	Distance between the zygomatic arches.
Nose Height	Distance between nasion and subnasal point.
Nose Breadth	Distance between alae.

approximately 400 erroneous values were found, producing an error rate of about 0.5% (Jantz et al., 1992:442).

Once the individuals with the erroneous values were identified, Jantz et al. (1992) predict the values, using a multiple regression approach. A within-sex and group covariance matrix is used for the prediction. This process allows for value estimation based on existing information. Using the above mentioned approaches, much of the error within the data base has been accounted for and corrected.

Samples

The samples used in this thesis come from measurements taken on members of the following tribes: Cherokee, Choctaw, Pawnee, and Kiowa. In addition to the above tribal classifications, the Cherokees and Choctaws are divided into four groups, either Eastern or Western bands. Eastern or Western band affiliation is assigned based on place of observation as noted on the original data sheets (Boas, nd), with Going Snake District and Flint District being examples of place of observation.

Both males and females are in this study, and only those subjects that stated they were full-blooded were included. Full-blooded individuals were determined by the subjects claim as such on the original data sheet as tribe, tribe of mother, and tribe of father. The subject was still included in the study if one of the parents was

noted as belonging to another tribe.

Based on the above requirements for interobserver error testing, tribal and band affiliation, purity, and sex, a total of 869 subjects were used. Table 3.2 shows the sample size distribution according to tribal affiliation, band (if applicable), and sex.

Descriptive Statistics

The statistical analyses used in this project were calculated by two processes. The General Linear Models Procedure was provided by SAS (SAS Institute, Inc. 1986). The Means and Canonical analysis was conducted through a program written by Dr. R.L. Jantz in TRUEBASIC. Both processes were graciously provided by Dr. Jantz.

Table 3.2. Sample Size Distribution by Tribe, Band, and Sex.

Tribe	Band	Sex	Sample Size
Cherokee	Eastern	Male	122
Cherokee	Eastern	Female	80
Cherokee	Western	Male	100
Cherokee	Western	Female	16
Choctaw	Eastern	Male	52
Choctaw	Eastern	Female	54
Choctaw	Western	Male	250
Choctaw	Western	Female	16
Kiowa	not applicable	Male	75
Kiowa	not applicable	Female	35
Pawnee	not applicable	Male	43
Pawnee	not applicable	Female	6

CHAPTER 4

ANALYTICAL METHODS

Introduction

The data that Dr. Boas and his colleagues collected during the late 1800's received little attention until recently. There are several factors which contributed to this some substantiated, some hypothetical. One possible reason is that Dr. Boas is known for his holistic approach to science (Darnell, 1969; Garbarino, 1977). Boas could have conceivably held off on producing any results from his research, feeling that synthesis of information should not occur "until data bearing on all facets of the problem had been obtained" (Jantz et al., 1992:436). Another and more plausible hypothesis concerns the amount of information Boas accumulated and the difficulty of statistical computations. During Boas's time even the simplest of calculations required considerable time and effort, as they had to be derived completely by hand. Based on this assumption, the sheer volume of the data could have easily discouraged researchers for attempting statistical analysis of the Boas data.

After the Boas data were added to the microcomputer at the University of Tennessee, several research projects involving this data came about. In addition to the studies mentioned earlier, the Boas data has been used in

research projects associated with seminars offered at the university, under the direction of Dr. R.L. Jantz. It is obvious that statistical analysis of Boas's data has been greatly facilitated by the use of computers. In this thesis, computer analysis of the Boas data was used for the following statistical analysis: Means, Analysis of Variance, and Canonical Analysis.

Statistical Analysis Techniques

One of the only early papers presented involving the Boas data set was written by Dr. Boas (1895). It concerns means and standard deviations on standing heights and some "limited analysis of cranial variation" (Jantz et al., 1992:436). The arithmetic mean (or central tendency) is "the sum of a set of scores divided by the number of scores in the set" (Ott et al., 1983:98). Arithmetic mean is determined mathematically by

$$\text{mean} = \text{sum of scores} / n$$

where the sum of scores is divided by the number of scores (n). Means can be useful in determining general trends in population studies, for instance, hypothetical tribe Qwerty males have a head length mean of 190.0cm and a head breadth mean of 134.0cm, while hypothetical tribe Uiop males have a head length mean of 180.0cm and a head breadth mean of 154.0cm. From this information it is seen

that hypothetical tribe Qwerty males, in general, have longer and narrower heads than the hypothetical tribe Uiop males.

Analysis of variance for this study was completed by General Linear Models Procedure (PROC GLM, for short), which was provided by the SAS Institute, Cary, NC.. Analysis of variance, simply put, is used to "make statistical inferences about of more than two means" (Fruend et al., 1986:51). Analysis of variance separates the variation among observations into portions associated with certain factors (called source of variation) that are defined by the data (Neter et al., 1985; Fruend et al., 1986). This separation is achieved by sums of squares (SS) with a corresponding separation of the associated degrees of freedom. Using three sources of variation, (A, B, C),

$$SS(\text{total}) = SS(A) + SS(B) + SS(C) + SS(\text{residual})$$

Where the term $SS(\text{total})$ is the sum of the squared deviation of each data value from the overall mean of

$$E(y - \bar{y})^2$$

and $SS(A)$, $SS(B)$, $SS(C)$ are the terms are sums of squared differences between the means. $SS(\text{residual})$ is the remainder of subtracting $SS(A)$, $SS(B)$, $SS(C)$ from $SS(\text{total})$.

The sources of variation in analysis of variance are

considered in this study are main effects, and interaction effects. Main effect sum of squares for factor A is given by

$$SS(A) = \sum_i n_i (\bar{y}_i - \bar{y})^2$$

where; n_i equals the number of observations in level i of factor A, $\bar{y}_i$ equals the mean of observations in level i of factor A, $\bar{y}$ equals the mean of observation in level i of factor A, n equals the total number of observations ($\sum_i n_i$), $\sum_i y_i$ equals the total of all observations ($\sum_i y_i$), and $\bar{y}$ equals the mean of all observations ($\sum_i y_i / n$) (Fruend et al. 1986).

An interaction effects refers to crossed factors, where each level of each factor occurs with each level of the other factors. It measures the failure of the effects of one factor to be the same at all levels of another factor, that is, the failure of $\bar{y}_{ij} - \bar{y}_{i'j'}$ to be the same as $\bar{y}_{ij} - \bar{y}_{i'j}$ for all i, j, i', j' , where $\bar{y}_{ij}$ refers to the mean of the observations in level i of A and level j of B. the sum of squares for the interaction between the factors A and B is

$$SS(A*B) = \sum_{ij} n (\bar{y}_{ij} - \bar{y}_i - \bar{y}_j + \bar{y}_{..})^2$$

where; n is the common number of observations in each ij

cell, a and b are the numbers of levels of A and B respectively, y_{ij} is the total of all observations in the ij cell, and y_i equals

$$E y_{ij}, y_{.j} = E y_i, y_{..} = E y_{ij}$$

The sum of squares for $A*B$ has

$$(a - 1)(b - 1) = ab - a - b + 1$$

degrees of freedom (Fruend et al., 1986). PROC GLM (SAS institute, Inc. 1986) is used because it is specifically designed for unbalanced cell sizes as in the case of this study.

Canonical Variates are a multivariate statistical process which explore the interrelationships between a number of populations simultaneously. The results show these interrelationships in a few dimensions, where the axis of variation are chosen to maximize the separation between populations, relative to the variation within each of the populations (Reyment et al., 1984).

The first canonical variate is that linear combination of characters that maximizes the ratio of the between-population sum of squares to the within-population sum of squares for a one-way analysis of variance of the resulting canonical variate scores. This ratio is called the canonical root. Subsequent canonical variates satisfy the same criterion, subject to being uncorrelated both within populations and between populations (Reyment et al.

1984). For v characters and g populations, the canonical variate scores are given mathematically by

$$y_{km} = c' x_{km}$$

where x_{km} is the m th of n_k observations for the k th group, and c is the first canonical vector.

The first canonical vector c is chosen to maximize the ratio

$$f = c' B c / c' W c$$

where B is the between-populations (or among-populations) sums of squares and products matrix, and W is the within-population sums of squares and products matrix.

The canonical vectors c and canonical roots f satisfy

$$(B - f W)c = 0$$

where B and W are the between- and among- group sums of squares and cross-product matrices, respectively (Reyment et al., 1984; Jantz et al., 1992). The canonical analysis was conducted by Dr. Richard Jantz, using a program he wrote in TRUEBASIC.

The relationship among tribe, band, sex of the subjects, and the anthropometric data will be studied using the above statistical procedures. An analysis of the means will relate general population tendencies. The analysis of variance and canonical variate studies will show the variation associated among the study groups by tribe, band, sex, and anthropometric data.

CHAPTER 5

RESULTS

Means

Mean scores from anthropometric measurements can provide insight into general population trends. For this project, mean scores from the data are used to observe some of the tendencies for the study groups. Definitions for abbreviations of the anthropometric measurements used in the project are listed in Table 5.1.. Mean scores from the anthropometric measurements for Cherokee and Choctaw males are given in Table 5.2.. This table breaks the two tribes down by band affiliation as well. A review of Table 5.2. shows that the Western Cherokee males have the highest number of large scores. Means for standing height, shoulder height, finger height, finger reach, head length, and head breadth are all high in the Western Cherokee males, relating long trunk and brachial measurements, with long, wide cranial measurements. Inversely, the Eastern Band Cherokee males have the lowest mean scores for five of the six scores which their western counterparts score highly on: standing height, shoulder height, finger height, finger reach, and head breadth. When these same measurements are compared between the Western and Eastern Band of Choctaws, one can see the Choctaws are more similar to each other in this regard.

Table 5.1. Definitions of Anthropometric Measurement Abbreviations.

Measurement	Abbreviation
1. Standing Height	StandHt
2. Shoulder Height	ShouldHt
3. Finger Height	FingrHt
4. Finger Reach	FingrRch
5. Sitting Height	SitHt
6. Shoulder Breadth	ShouldBr
7. Head Length	HeadLng
8. Head Breadth	HeadBr
9. Face Height	FaceHt
10. Face Breadth	FaceBr
11. Nose Height	NoseHt
12. Nose Breadth	NoseBr
1. Explanation of anthropometric measurements is given in Chapter 3.	

Table 5.2 Mean Scores from Anthropometric Measurements,
for Western and Eastern Cherokee and Choctaw
Males.

Measurement	Cherokee		Choctaw	
	West	East	West	East
StandHt	1711.310	1677.254	1703.672	1698.750
ShouldHt	1411.420	1397.959	1400.976	1398.077
FingerHt	660.410	626.426	638.448	634.769
FingerRch	1770.490	1739.270	1757.052	1757.923
SitHt	871.360	855.541	835.324	874.038
ShouldrBr	387.480	379.869	388.888	382.212
HeadLng	190.750	190.025	185.980	186.385
HeadBr	154.620	147.770	151.320	148.462
FaceHt	116.680	120.164	120.476	119.462
FaceBr	144.620	142.721	145.184	141.462
NoseHt	53.350	52.066	51.768	53.768
NoseBr	39.130	39.852	40.312	39.212

1. Definitions for Measurements are given in Table 5.1.
2. All measurements given in millimeters.

Mean scores for female Cherokee and Choctaw tribes' anthropometric measurements are given in Table 5.3. The tribe and band with the highest scores in this comparison is the Eastern Choctaw. These females score high on standing height, shoulder height, finger height, finger reach, and sitting height. This reflects a longer torso and brachial body type. The lowest scoring group was the Eastern Cherokee females, who score low on standing height, finger reach, and head breadth.

Table 5.4 covers the mean scores from the anthropometric data for both sexes of Kiowa and Pawnee. Kiowa males have the highest overall scores. Shoulder height, finger reach, sitting height, head breadth, face height, facial breadth, and nose height all score high for Kiowa males, reflecting long trunk and arm proportions, and wide and high head and facial features. In a comparison between the Kiowa and Pawnee females' scores, the Kiowas again have higher values. The only scores the Kiowa females are not high in are Finger height, head length, nose height, and nose breadth.

When a comparison by sex is done from the information on Tables 5.2, 5.3, and 5.4, one can note that the Western Cherokee Males have the highest mean for standing height, finger height, and head breadth. The Kiowa males have the greatest shoulder height, finger reach, sitting height, face height, face breadth, and nose height. Western

Table 5.3 Mean Scores from Anthropometric Measurements for Western and Eastern Cherokee and Choctaw Females.

Measurement	Cherokee		Choctaw	
	West	East	West	East
StandHt	1572.806	1548.787	1555.750	1575.981
ShouldHt	1295.944	1287.525	1273.500	1300.574
FingrHt	603.667	586.213	579.375	592.444
FingrRch	1618.861	1593.863	1616.125	1625.833
SitHt	803.722	799.875	780.313	809.870
ShouldBr	348.306	347.675	350.437	338.519
HeadLng	179.472	181.438	178.875	178.815
HeadBr	149.833	142.962	147.000	143.407
FaceHt	112.611	111.687	113.125	111.093
FaceBr	136.806	135.562	141.125	132.296
NoseHt	49.472	47.363	46.250	50.852
NoseBr	34.667	36.800	36.500	36.315

1. Definitions for Measurements are given in Table 5.1.
2. All measurements given in millimeters.

Table 5.4 Mean Scores from Anthropometric Measurements For Kiowa and Pawnee Males and Females.

<u>Measurement</u>	Kiowa		Pawnee	
	Male	Female	Male	Female
StandHt	1700.987	1577.514	1705.279	1552.000
ShouldHt	1427.320	1324.357	1413.233	1278.333
FingrHt	639.853	591.086	648.698	596.333
FingrRch	1786.400	1651.833	1780.488	1605.833
SitHt	893.573	821.257	892.651	821.167
ShouldrBr	381.747	342.714	382.349	340.000
HeadLng	190.000	181.857	191.442	184.333
HeadBr	153.640	147.629	153.209	147.000
FaceHt	126.040	116.229	122.953	115.333
FaceBr	146.333	137.914	145.395	136.500
NoseHt	56.440	49.743	54.930	51.333
NoseBr	39.533	36.257	40.023	36.500

1. Definitions for measurments are given in Table 5.1.
2. All measurements given in millimeters.

Choctaw males have the greatest shoulder breadth and nose breadth, while Pawnee males have the greatest head length.

For the female means scores, Kiowa females have the highest means for standing height, shoulder height, finger reach, sitting height, face height, and face breadth.

Pawnee females have the greatest head breadth and nose height. Western Cherokee females' scores for finger height and head breadth are quite high. Their Eastern tribe members score high in nose breadth. The Western Choctaw females have the greatest means for shoulder breadth, and the Eastern Choctaw females have the highest finger reach.

When one subtracts the female means from the male means for a specific tribe and band, an insight about degree of dimorphism (size difference based on sex) can be provided. Table 5.5 is the sum of such a process for the study group. By comparing standing height, for instance, we see that the Pawnees have the greatest amount of between-sex standing height difference than other groups, while the Eastern Choctaws exhibit the least. It should be noted though, that there can still be a large sum given in cases where both males and females from the same tribe and band had the highest mean scores for the study. We can see such a case in finger height for Western Band Cherokees. In general, the Pawnees relate the greatest amount of differences, while the Eastern Band of Cherokees exhibit the least.

Table 5.5 Male to Female Difference in Means from
Anthropometric Measurements, by Tribe and Band.

Measurment	Cherokee		Choctaw		Kiowa	Pawnee
	West	East	West	East		
StandHt	138.50	128.47	147.92	122.77	123.47	153.28
ShouldHt	115.47	110.43	127.48	97.50	102.96	134.90
FingrHt	56.74	40.21	59.07	42.32	48.77	52.37
FingrRch	151.63	145.41	140.93	132.09	134.37	174.66
SitHt	67.64	55.67	55.01	64.17	72.32	71.48
ShouldrBr	39.15	32.19	38.45	43.693	39.03	42.35
HeadLng	11.27	8.59	7.11	7.57	8.14	7.11
HeadBr	4.79	4.80	4.32	5.06	6.01	6.21
FaceHt	4.07	8.48	7.35	8.37	9.81	7.62
FaceBr	7.81	7.16	4.06	9.17	8.42	8.90
NoseHt	3.88	4.70	5.52	2.92	6.70	3.60
NoseBr	4.46	3.05	3.81	2.90	3.28	3.52

1. Definitions for abbreviations given in Table 5.1.
2. All differences shown are in centimeters.

Means studies are acceptable if all variables acting on a population are equal. If there is a difference in variables, a more complex analysis is in order to further investigate the variation (Iversen and Norpoth, 1976; Neter et al., 1985). One statistical technique to accomplish this is Analysis of Variance.

Analysis of Variance

An analysis of variance was run using PROC GLM from SAS (SAS Institute Inc. 1986). The model used was designed for the anthropometric measurements to be the dependent variables, while tribe, then sex, then a tribe-sex interaction were the independent variables. Indications of success or failure for the hypothesis that the dependent variable accounts for the variation, to a significant level, are the F and P values. The F values and the P values for this study are given in Table 5.6. It is generally assumed that a large F value is indicative of an accepted hypothesis. This is supported by a small P value, or the probability that the scores could be generated by random chance and not variation depending on the probability level for a null hypothesis, e.g. .05 (Ott et al., 1983; Neter et al., 1985; Thomas, 1986).

From Table 5.6 is apparent that sitting height and nose height are two dependent variables with corresponding F values. This relates that sitting height and nose height account for much of the variation among tribe, sex,

Table 5.6 F Values and P Values from Type III Sums of Squares for Analysis of Variance of Anthropometric Data from Cherokees, Choctaws, Kiowas, and Pawnees.

Dependent Variable and Source	F value	Pr > / F
StandHt		
Tribe	3.43	0.0167
Sex	1049.69	0.0001
Tribe*Sex	0.64	0.5865
ShouldHt		
Tribe	9.42	0.0001
Sex	332.99	0.0001
Tribe*Sex	0.91	0.4339
FingrHt		
Tribe	0.62	0.5991
Sex	126.86	0.0001
Tribe*Sex	0.04	0.9880
FingrRch		
Tribe	10.84	0.0001
Sex	344.84	0.0001
Tribe*Sex	1.50	0.2122
SitHt		
Tribe	30.04	0.0001
Sex	217.61	0.0001
Tribe*Sex	8.50	0.0001
ShouldBr		
Tribe	1.14	0.3337
Sex	320.41	0.0001
Tribe*Sex	4.25	0.0054

Table 5.6 (continued)

Dependent Variable and Source	F Value	Pr > F
HeadLng		
Tribe	16.67	0.0001
Sex	111.07	0.0001
Tribe*Sex	1.76	0.1533
HeadBr		
Tribe	8.02	0.0001
Sex	73.24	0.0001
Tribe*Sex	0.25	0.8644
FaceHt		
Tribe	32.13	0.0001
Sex	145.10	0.0001
Tribe*Sex	2.98	0.0305
FaceBr		
Tribe	6.05	0.0004
Sex	158.36	0.0001
Tribe*Sex	2.49	0.0589
Noseht		
Tribe	20.81	0.0001
Sex	108.85	0.0001
Tribe*Sex	11.71	0.0001
NoseBr		
Tribe	0.92	0.4323
Sex	84.56	0.0001
Tribe*Sex	0.23	0.8736

and the tribe*sex interaction. This supports the findings from Table 5.5, concerning sexual dimorphism. The tribe*sex interaction is a test for sexual dimorphism, and for sitting height and noes height it is present to a significant degree.

Canonical Variation Analysis

Canonical variation analysis is designed to take the amount of variation in a population study and augment this variation to reveal it to the researcher. The results for a canonical variate study for males are shown in Table 5.7. Results from this table reflect that Western Choctaw males scored highest, while the Kiowa males had a considerable negative score for vector 1. As the percent variation shows, 62.04% was accounted for in vector 1. Vector 2 contributes 22.74% of the variation for this study. Western Cherokee males have high positive scores, while the Eastern Cherokee scored the lowest. In vector 3, the Kiowa males scored the lowest and the Eastern Cherokee the highest. Vector 3 accounts for 8.23% of the variation for this model, and when added to vector 1 and 2, the total variation is 92.01% . Vector 4 has added another 5.06% variation to the model, with Eastern Cherokee males and Eastern Choctaw males scoring opposite of each other.

These results are graphically presented in Figures 5.1, 5.2, and 5.3. Figure 5.1 shows, for instance, that

Table 5.7. Group Canonical Variate Results for
Anthropometric Data versus Location for Males,
Including Eigenvalues and % of Variation.

Tribe	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5
Western Cherokee	0.012	1.621	0.182	0.340	0.170
Eastern Cherokee	-.450	-.926	0.714	0.475	-.041
Western Choctaw	1.331	-.224	-.419	-.206	-.069
Eastern Choctaw	-.490	0.179	0.702	-.705	0.114
Kiowa	-2.440	-.345	-.478	-.011	0.264
Pawnee	-1.642	0.543	-.033	-.067	-.470
Eigen- Values	10.87	3.982	1.441	0.885	.338
% Vari- abilitly	62.04	22.74	8.23	5.06	1.93

Study Group Males
Vector 1 & Vector 2

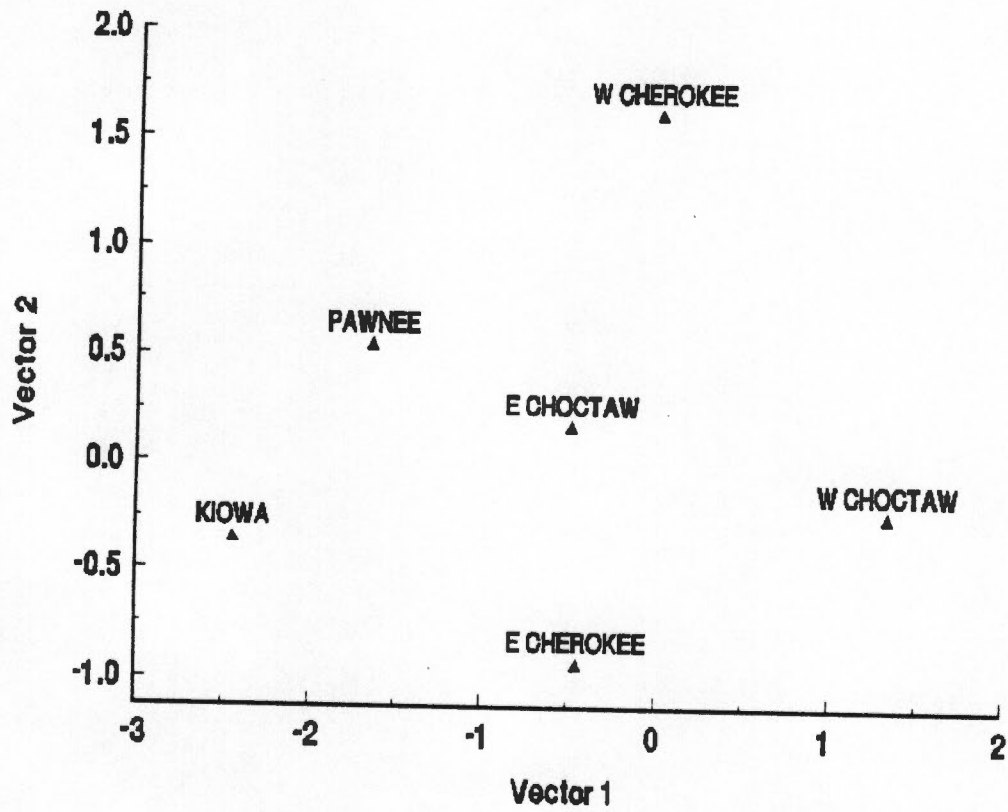


Figure 5.1 Study Group Males Vector 1
against Vector 2.

Study Group Males
Vector 1 & Vector 3

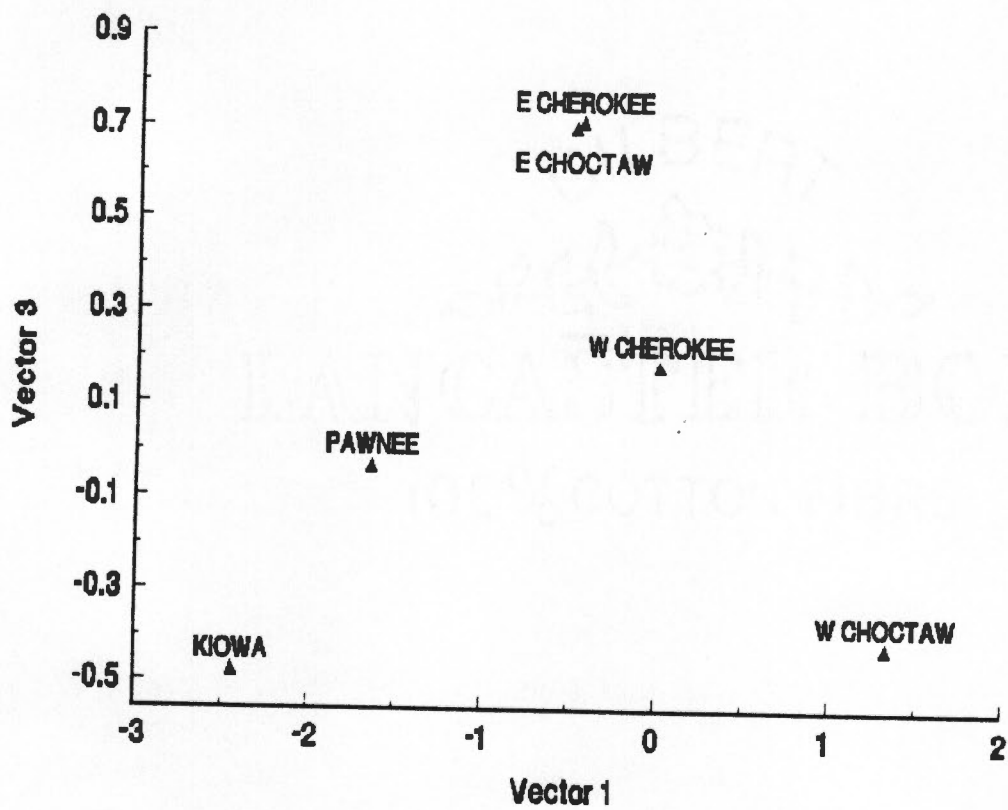


Figure 5.2 Study Group Males Vector 1
against Vector 3.

Study Group Males
Vector 3 & Vector 4

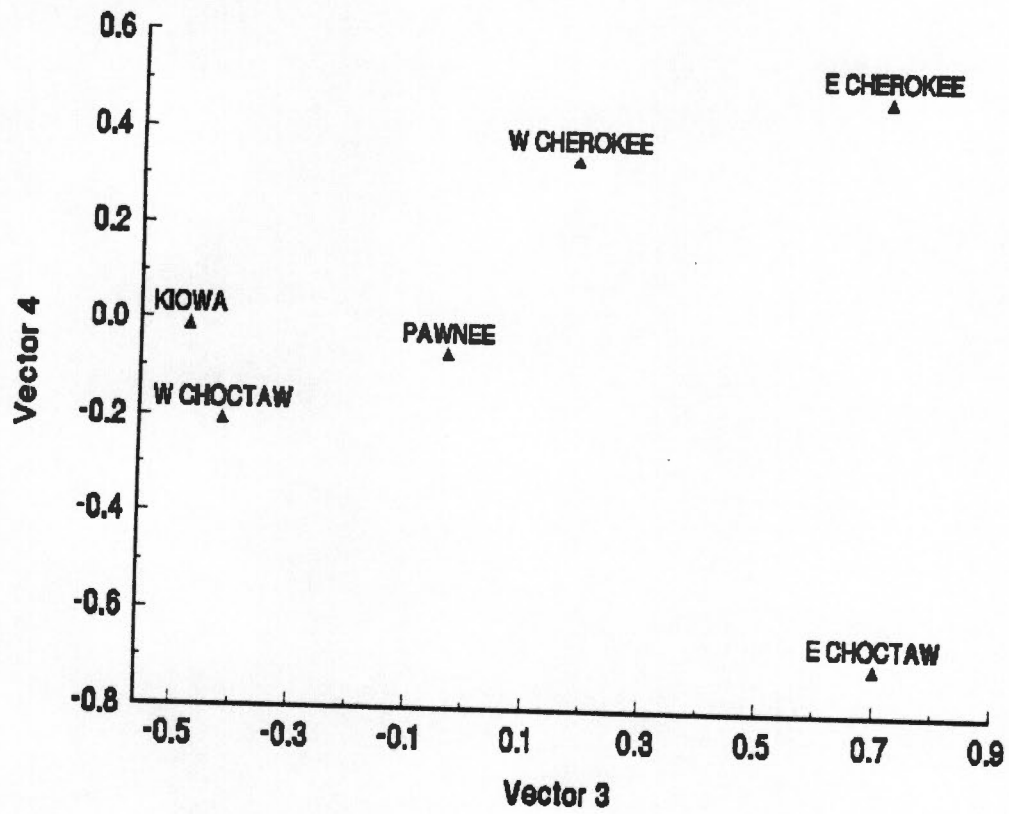


Figure 5.3 Study Group Males Vector 3
against Vector 4.

the Kiowa and the Western Choctaw males are plotted away from each when vector 1 and vector 2 are plotted against each other. Each group tends to cluster by tribe and band, with the Kiowa males and Pawnee males grouping, Eastern Cherokee and Choctaw males clustering, and the Western Bands of Cherokee and Choctaw males clustering too. On the axis for nose height, sitting height and shoulder height (vector 1) Cherokee males and Eastern Choctaws were similar, but were quite different in regards to vector 2, which scored finger height and head breadth high. Kiowa males and Western Choctaw males scored similar for this vector.

Vectors 1 and 3, when combined, account for 70.27% of the variability with the study, and when plotted (Figure 5.2), show a stronger cluster tendency than that shown in Figure 5.1. The Eastern Band males plot together on both axes, with the Kiowa and Pawnee males again grouped, as are the Western Cherokee and Western Choctaw. Figure 5.2 relates again that Kiowa males and Western Choctaw males were similar in some regards, in respect to vector 3, where head breadth and facial height scored high.

Results from Figure 5.3 do not reflect this, though. 13.29% of the study groups' variation is explained by adding Vector 3 and 4. The plot shows Kiowa and Western Choctaw males clustering, Pawnee Males clustering with Western Cherokees, with the head breadth and facial height

axis (vector 3) relating this similarity, as does the head length axis of vector 4. The Eastern Bands are located away from each other and are on the periphery of the graph, with the Eastern Cherokee and Choctaw being similar in the vector 3 axis, but differ considerably on the vector 4 axis.

The canonical structures coefficients for the anthropometric measures for the males are given in Table 5.8. High loading is derived from nose height (-.225) sitting height (-.219), shoulder breadth (0.154), and shoulder height (-.183), relating a tendency towards short, broad noses with long, thicker torsos, shorter torsos for groups that scored high in results in Table 5.7 (eg Kiowas) Vector 2 accounts for 22.74% of the variation for the study group. High loading is noted for finger height (0.212), standing height (0.164), head breadth (0.156), and face height (-.117). The general trend one can note in this vector is tendency towards males with shorter arms (finger height) and increased stature, with wider heads and shorter faces.

The canonical structure coefficient for vector 3, show that face height (-.129) and face breadth (-.238) account for the some of interpopulation variation. These scores show that as the face gets more narrow and, facial height decreases for groups that scored correspondingly

Table 5.8 Canonical Structure Coefficients for Males.

Variable	1	2	3	4	5
StandHt	0.005	0.164	-.110	-.061	0.003
ShouldHt	-.183	-.060	-.144	0.039	0.047
FingrHt	-.017	0.212	-.066	0.036	-.009
FingrRch	-.163	0.115	-.136	-.037	-.001
SitHt	-.219	0.077	0.010	-.025	-.008
ShouldBr	0.154	0.082	-.103	-.005	0.017
HeadLng	-.145	0.072	0.012	0.138	-.051
HeadBr	-.064	0.156	-.159	0.051	0.006
FaceHt	-.178	-.117	-.129	-.035	-.026
FaceBr	-.054	0.032	-.238	0.074	-.026
NoseHt	-.225	0.048	-.059	-.047	0.026
NoseBr	0.080	-.113	-.099	0.021	-.129

negative (eg. Kiowa). 17.43% of the variation for this model can be attributed to vector 3.

The last vector to be examined for the males as a separate group is vector 4, which, accounts for 9.76% of the study groups' variation. This highest loaded score is head breadth (0.138). Facial breadth (0.074) and standing height (-.061) are other loaded scores, in relation to all the scores for this vector, which could relate increased head breadth to increased facial breadth.

Group canonical variate results for anthropometric data versus location for females is given in table 5.9. The overall results for the females are somewhat different than that of the males. As with their male counterparts, Western Choctaw females (2.217) scored high on the positive end, with the most distant group from them being Kiowa females (-1.052). This vector accounts for as much as 41.62% of the variation for the female study group. Vector 2 for the females make up 25.48% of intragroup variation. The Plains tribes scored opposite of each other, with the Pawnees scoring 1.323 and the Kiowas scoring -.651. Vector 3 shows that Eastern Choctaw females have the highest positive score (0.706). Pawnee females relate the lowest negative number (-1.038), in this vector that contains 17.43% of the variation. When vector 4 is added to the first three vectors, 94.29% of the variation is accounted for, with 9.76% of this

Table 5.9 Group Canonical Variate Results for
Anthropometric Data versus Location for Females,
Including Eigenvalues and % of Variation.

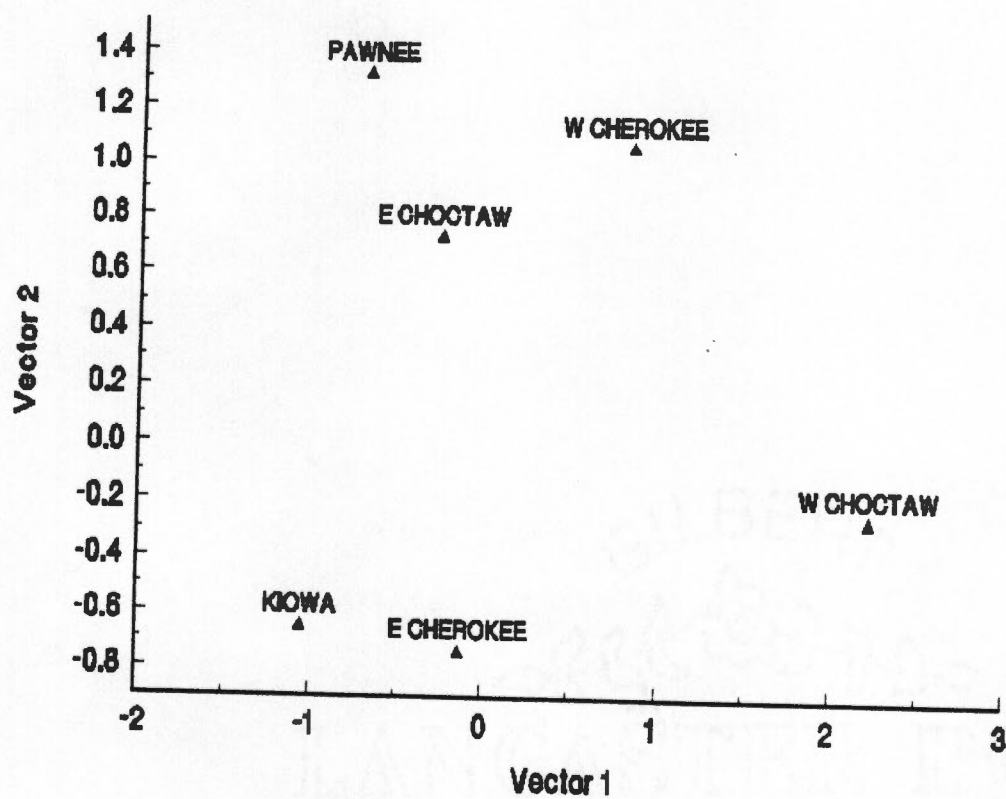
Tribe	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5
Western Cherokee	0.831	1.068	0.123	0.656	0.533
Eastern Cherokee	-.130	-.737	0.109	-.616	0.349
Western Choctaw	2.217	-.254	-.733	-.091	-.328
Eastern Choctaw	-.259	0.730	0.706	0.076	-.680
Kiowa	-1.052	-.651	-.952	0.754	-.147
Pawnee	-.692	1.323	-1.038	-.562	0.004
Eigen- Values	7.278	4.456	3.048	1.708	0.998
% Vari- ation	41.62	25.48	17.43	9.76	5.71

variation coming from vector 4. Kiowa females (0.754) score high in this vector, as do Eastern Cherokee females (-.616).

Figures 5.4, 5.5, and 5.6 graphically display the results from Table 5.9. As much as 67.10% of the study groups' variation accounted for by combining vectors 1 and 2. A plot of these two vectors (Figure 5.4) relate somewhat different results from the equivalent male plot. There are three distinct clusters for this plot. One is the Kiowa females and Eastern Cherokee females cluster. Another is the Pawnee, Eastern Choctaw, Western Cherokee group, and lastly, the Western Choctaw separate from the other two areas. Figure 5.4 plots vector 1 (shoulder breadth, head length, and face breadth) against vector 2 (finger height, nose height, and shoulder height). Eastern Cherokee and Choctaw females are similar on vector 1's axis. The Kiowa and Eastern Choctaw females are similar in regards to the vector 2 axis.

Figure 5.5 conforms more to its male counterpart in the aspect that the Western Indian Females, the Kiowa and Pawnee, cluster quite close. Both bands of Cherokee cluster with the Eastern Band of Choctaw, while the Western Choctaw are again separate from the other groups. In Figure 5.5, the Plains groups are similar in regards to both vector 1 and vector 3 (head length, face height, and face breadth. The Cherokees are similar based on results

Study Group Females
Vector 1 & Vector 2



**Figure 5.4 Study Group Females Vector 1
against Vector 2.**

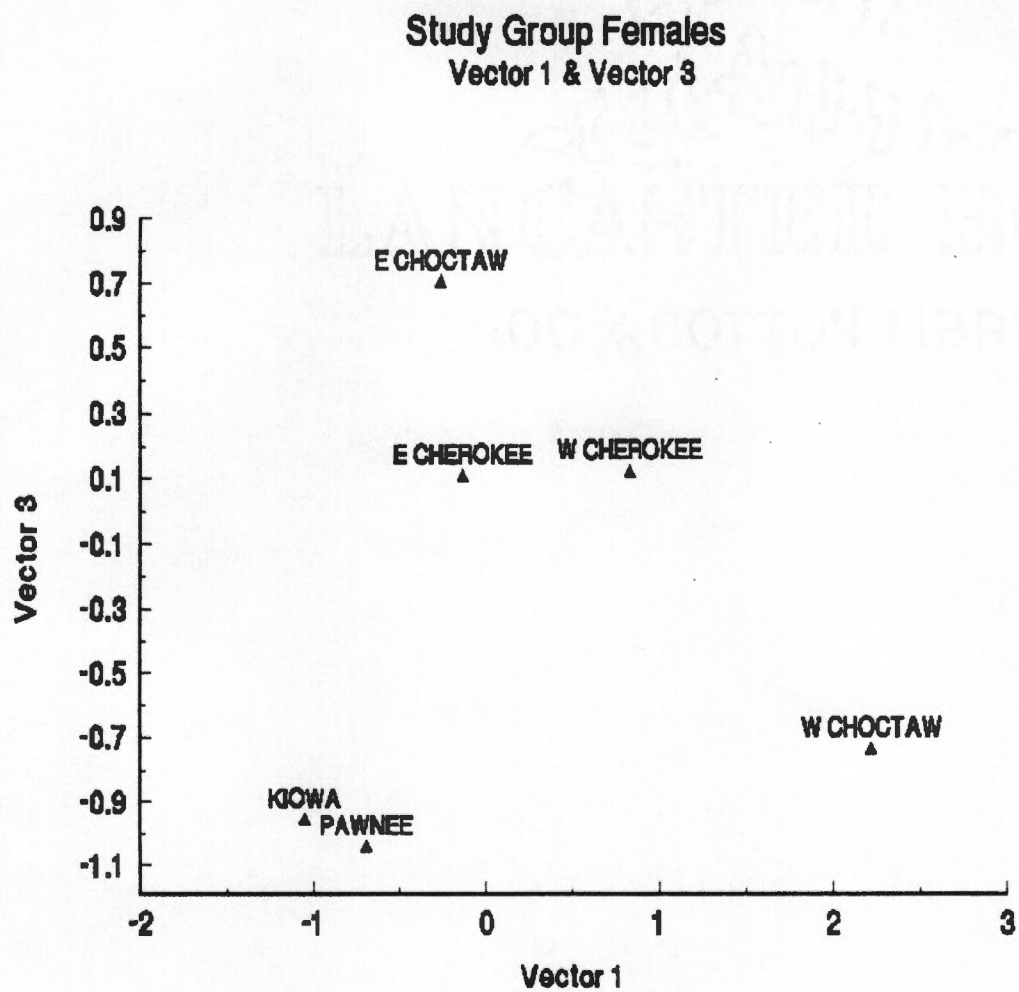


Figure 5.5 Study Group Females Vector 1
against Vector 3.

Study Group Females
Vector 3 & Vector 4

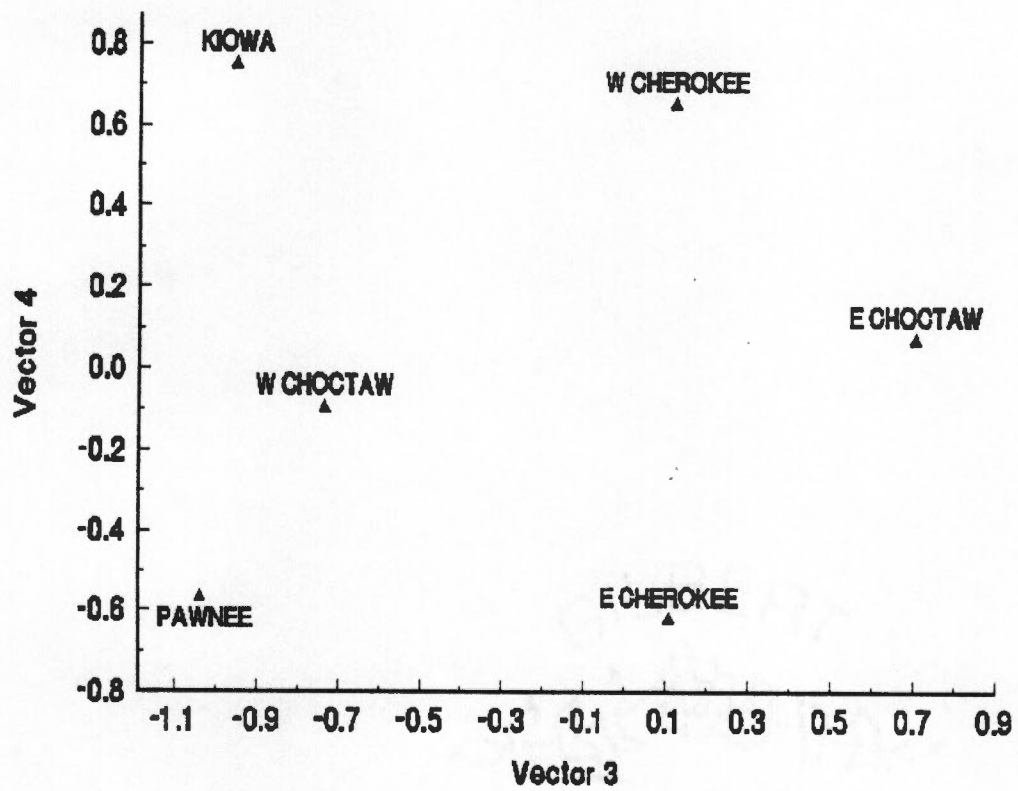


Figure 5.6 Study Group Females Vector 3
against Vector 4.

from the axis of vector 3. Approximately 59.05% of the variation is accounted for when these two vectors are combined.

With 27.19% of the variation is given when combining vectors 3 and 4 (Figure 5.6). When vector 3 and vector 4 were plotted, there were dual axes similarities. Vector 3 consisted of face breadth, face length, and head length. Kiowa and Pawnee were similar in this respect, as were the Cherokees. Vector 4 revealed similarities in shoulder height, standing height, finger reach, and head breadth among Kiowas and Western Cherokees. Pawnee and Eastern Cherokee were similar on vector 4 as well.

For the canonical structure coefficients for the females of the study group (Table 5.10), vector 1 shows high loading occurring on head length (-.318), sitting height (-.455), shoulder breadth (0.289), and face breadth (0.249). This relates females with a tendency towards short torsos, wide shoulders, a short head with broad faces. As much as 41.62% of the variation for the model is held in vector 1.

As the torso gets shorter, the shoulders get less broad and arm length measurements get smaller in the females for this study, according to vector 2. There are high loadings for shoulder height (-.136), shoulder breadth (-.157), and finger height 0.296. Nose height was

Table 5.10 Canonical Structure Coefficients for Females

Variable	1	2	3	4	5
StandHt	-.077	0.037	0.090	0.298	-.093
ShouldHt	-.265	-.136	0.064	0.313	-.030
FingrHt	-.155	0.296	0.063	0.162	0.177
FingrRch	-.076	-.037	-.078	0.278	-.136
SitHt	-.455	0.154	-.090	0.089	0.001
ShouldBr	0.289	-.157	-.016	0.018	0.197
HeadLng	-.318	0.081	-.321	-.189	0.132
HeadBr	0.097	0.145	-.201	0.209	0.110
FaceHt	-.126	0.029	-.381	0.104	0.001
FaceBr	0.249	-.089	-.321	0.060	0.048
NoseHt	-.286	0.285	-.004	0.069	-.074
NoseBr	-.078	-.173	-.068	-.243	-.163

also loaded (0.285). Approximately 25.48% of the variation exhibited in the females was in vector 2.

Vector 3 holds 17.43% of the variation, where there is heavy loading in the facial measurements. Face height (-.381) and face breadth (-.321) scores relate that as the face gets shorter, it also gets to be more narrow for female subjects in this study. Other loaded scores include standing height (0.90) and shoulder height (0.064).

Vector 4 supports the findings from vector 3 about standing height (0.298) and shoulder height (0.313), relating long torsos and legs to greater stature measurements. Cranial measurements scored high as well, with nose height (-.243) and head length (-.189), showing a relationship between head length and nose height, where the trend appears to be as the head gets shorter in length, so does the nose. Vector 4 contains 9.76% of the variation for the study using females only.

Overall results are somewhat different when a canonical variate is conducted where the sexes are pooled. The results are given in Table 5.11. For vector 1, Eastern Cherokee females (-2.511) scored high, as did Pawnee females (-2.356), Western Cherokee males (0.996), and Pawnee (0.997). This vector accounted for 53.13% of the variation for the entire study group. The next vector, vector 2, holds 23.65% of the variation for the

Table 5.11 Group Canonical Variate Results for
Anthropometric Data versus Location for Both
Sexes, Including Eigenvalues and % Variation.

Tribe	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5
Western Cherokee	0.996	0.002	1.499	0.122	0.016
Eastern Cherokee	0.379	-.460	-.932	-.476	-.281
Western Choctaw	0.948	1.452	-.110	0.250	0.064
Eastern Choctaw	0.663	-.443	0.366	-.509	-.175
Kiowa	0.973	-2.356	-.467	0.571	0.338
Pawnee	0.997	-1.593	0.440	0.440	-.436
western cherokee	-2.195	0.267	1.048	0.444	0.541
eastern cherokee	-2.511	0.010	-.699	-.536	-.344
western choctaw	-.254	1.376	-.418	1.052	-.345
eastern choctaw	-2.336	-.343	0.672	-.993	0.316
kiowa	-2.117	-1.282	-.791	0.297	0.578
pawnee	-2.356	-1.309	0.757	0.215	-.753

Table 5.11 (continued)

	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5
Eigen- Values	36.043	16.044	7.085	3.794	1.949
% Vari- ation	53.13	23.65	10.44	5.59	2.87

1. Upper case letters denotes males, lower case letters denotes females

project. Kiowa males (-2.356) and Pawnee males (-1.593) have the highest loadings, as do Western Choctaw females (1.376), and Western Choctaw males (1.452). Both Western Cherokee males (1.499) and Western Cherokee females (1.1048) scored high. The Eastern Cherokee males (-.932) and females (-.699) did as well, with 10.44% of the overall variation being contributed to by vector 3. Five point fifty-nine percent of the variation is attributed to by vector 4. The highest loadings are with two female groups, the Western Cherokee females (1.052) and Eastern Choctaw females. Kiowa males (0.571) and Eastern Cherokee females (-.536) scored relatively high also. With the sexes pooled, it is apparent that the variation is spread out more through the vectors

Figure 5.7 graphically displays the relationship between vector 1 and 2, which make up 76.78% of the variation. This plot relates much of the size differences associated with sexual dimorphism. On the axis formed by vector 1, separation by sex is apparent, with vector 1 showing high loading in standing height, shoulder height, finger reach, and shoulder breadth. Vector 2 consists of scores for nose height, face height, sitting height, and head length. Females that cluster together include Eastern Cherokees, Western Cherokees, Pawnees, and Kiowas. Male Western Cherokees, Eastern Choctaws, and Eastern Cherokees cluster as well, as do the Pawnee and Kiowa

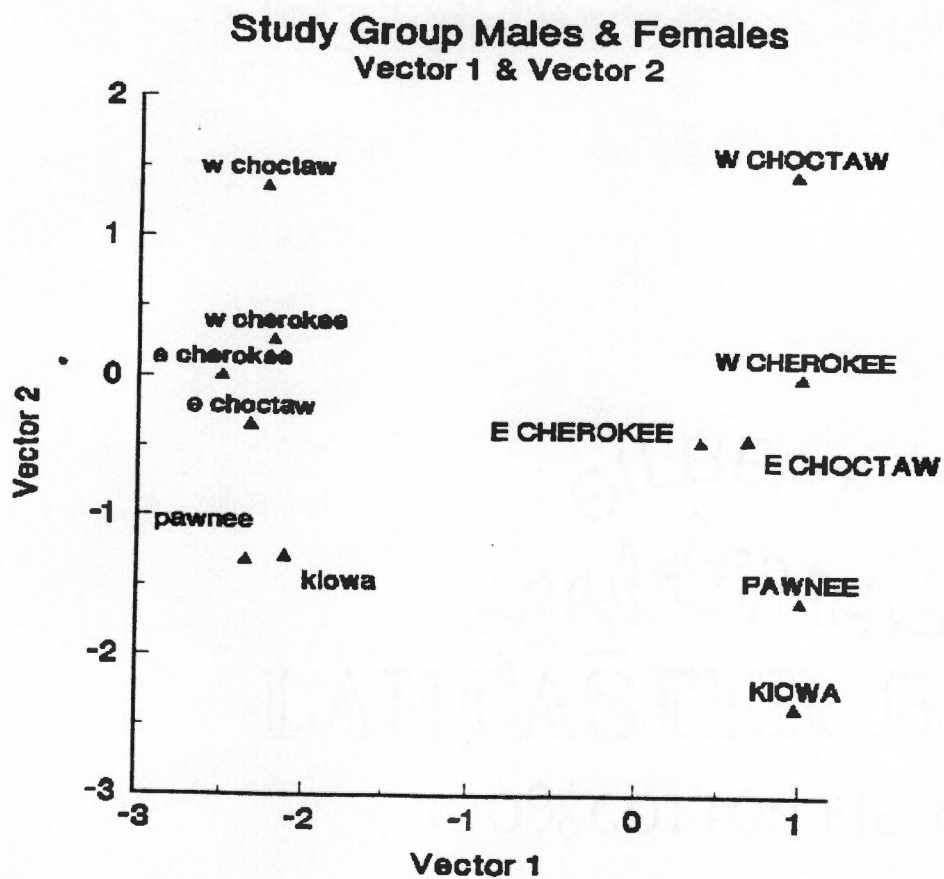


Figure 5.7 Study Group Both Sexes Vector 1 against Vector 2.

males, though in a separate cluster. The Western Choctaw females and males are not associated with any clusters, but are similar on the vector 2 axis. The Eastern Choctaw females plot close in relation to size to the Eastern Cherokee, but do not cluster close to any other group on vector 2's axis. Band similarities on this axis can be found with Western Choctaw males and females, but with both bands of the Cherokee and Eastern Choctaw the similarities were not by band. The Eastern Cherokees and Western Cherokees females were quite similar. The Eastern Choctaw females were quite different from the Eastern Choctaw males on both axes.

All but 1 group forms clusters when vectors 1 and 3 are plotted against each other (Figure 5.8). These vectors when combined form 53.37% of the variation within the study groups. The sexes were divided by vector 1, and many of the groups did not line up with by group and sex on the axis from vector 3 (finger height and head breadth). Vectors 2 and 3 (Figure 5.9) show clustering by group when a majority of factors for sexual dimorphism are removed. Clusters are formed by group or band affiliation, though there is still some evidence for sexual dimorphism related in this plot. The Kiowa males and Females have the greatest amount of distance between them. Once again, the Western Choctaws plot somewhat away from the rest of the study groups. Vectors 3 and 4 make

Study Group Males & Females Vector 1 & Vector 3

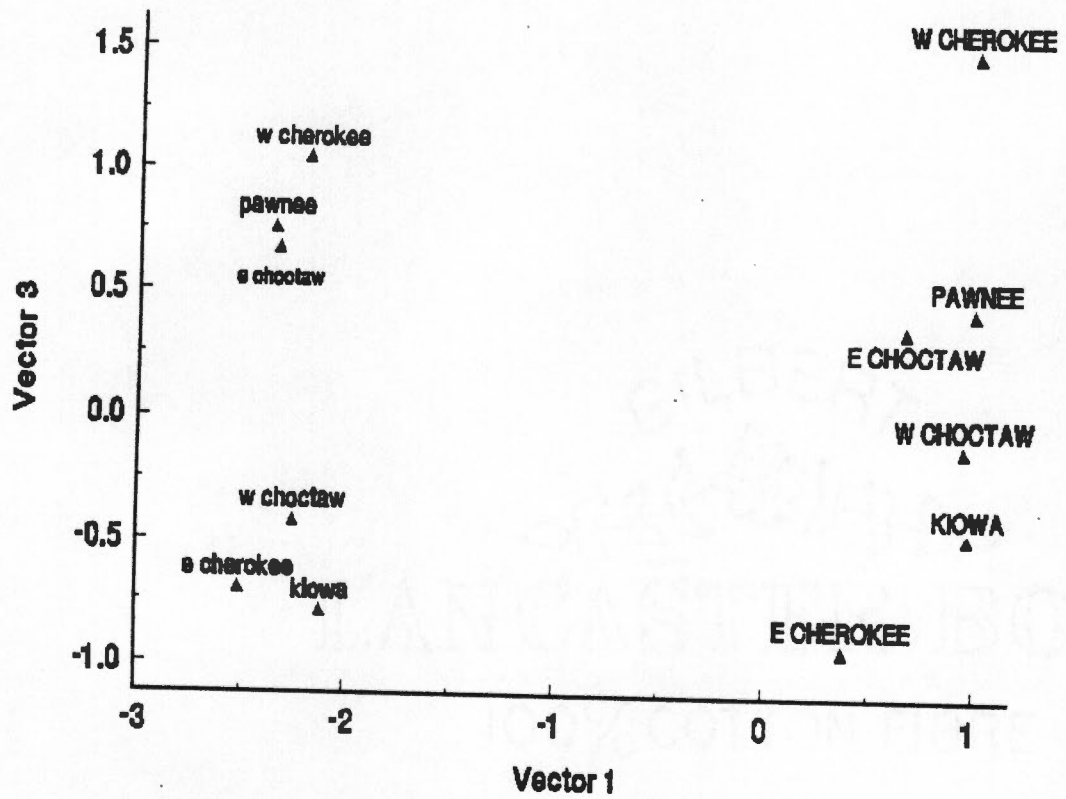


Figure 5.8 Study Group Both Sexes Vector 1 against Vector 3.

Study Group Males & Females Vector 2 & Vector 3

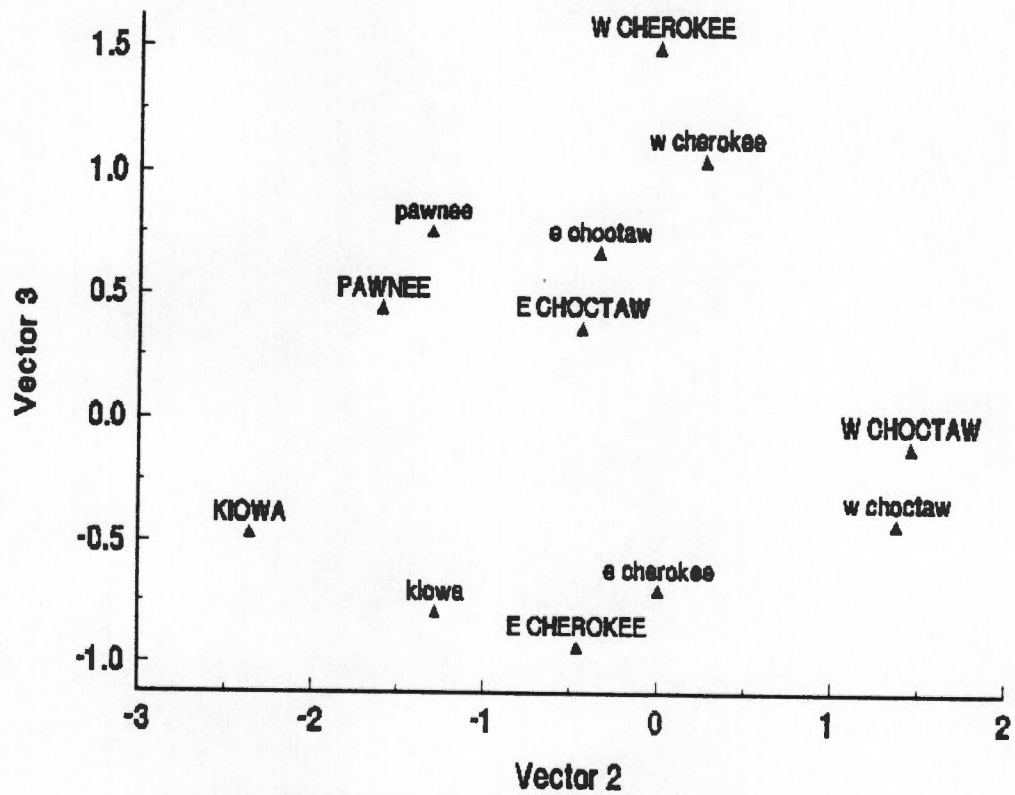


Figure 5.9 Study Group Both Sexes Vector 2 against Vector 3.

up 16.03% of the variation for project (Figure 5.10). When plotted, the groups tend to plot according to tribe, showing variables that are associated with each specific tribe, except Western Choctaws, who are split by Kiowa males and females. Figure 5.10 is a plot of vector 3 (head breadth and face breadth) against vector 4 (head breadth and finger height).

Canonical structure coefficients for both sexes are given in Table 5.12. For vector 1, a tendency is shown for dimension increases. This association is with shoulder height (0.503), standing height (0.488), finger reach (0.479) and shoulder breadth (0.476). Vector 1 contributes a little over half (53.65%) of the variation to the overall model.

Vector 2 shows high loading in cranial loading and some association between torso measurements. Nose height loads high (-.249) as does head length (-.142), relating that as head length decreases, so does nose height. For the torso dimensions, as the torso shortens, (sitting height [-.231]), shoulders get broader (shoulder breadth [0.068]). Vector 2 accounts for 23.65% of the variation.

Vector 3 shows a relationship among the cranial measurements of head breadth (0.111), facial height (-.104), and nose breadth (-.096). Finger height (0.110) is loaded as well. Excluding finger height, the general trend reflected is one where as head breadth increases,

Study Group Males & Females Vector 3 & Vector 4

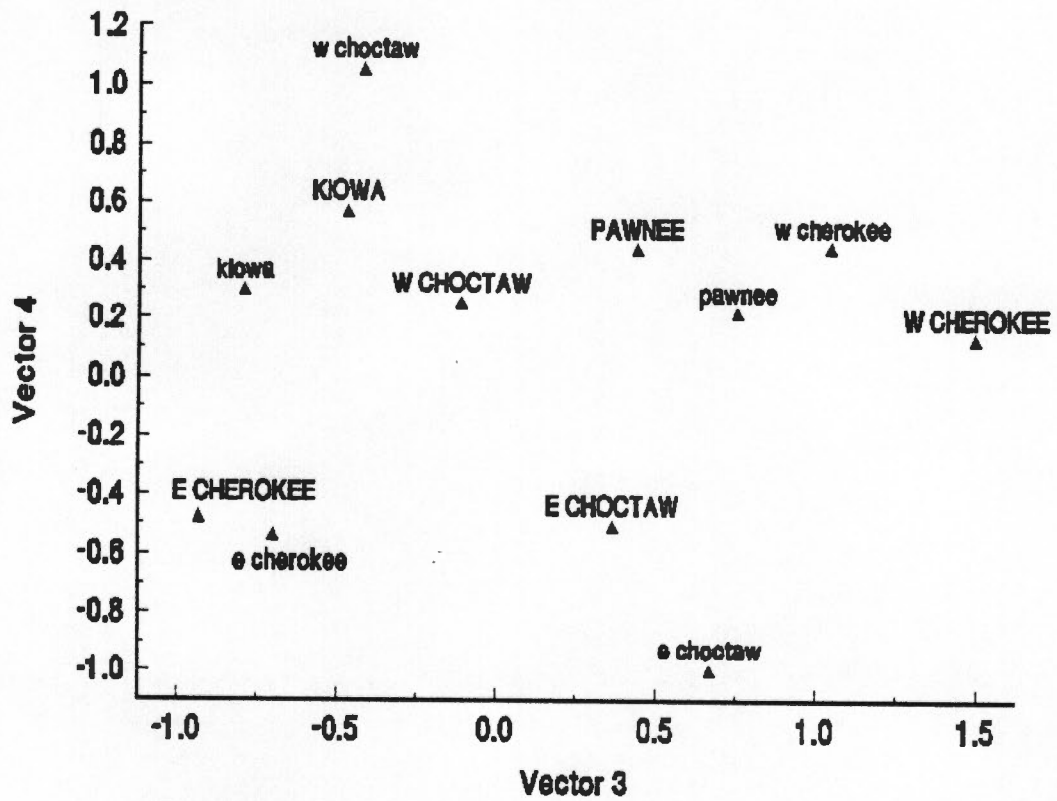


Figure 5.10 Study Group Both Sexes Vector 3 against Vector 4.

Table 5.12 Canonical Structure Coefficients for Both Sexes

Variable	1	2	3	4	5
StandHt	0.488	-.002	0.016	-.023	0.029
ShouldHt	0.503	-.058	-.030	-.028	0.059
FingrHt	0.457	-.029	0.110	-.004	0.015
FingrRch	0.479	-.048	-.007	0.010	0.037
SitHt	0.411	-.231	0.045	-.018	-.011
ShouldBr	0.476	0.068	-.019	0.008	-.014
HeadLng	0.418	-.142	0.002	0.007	-.099
HeadBr	0.314	-.049	0.111	0.195	0.065
FaceHt	0.375	-.151	-.104	0.091	-.004
FaceBr	0.395	0.020	-.062	0.169	-.026
NoseHt	0.377	-.249	0.097	-.031	0.031
NoseBr	0.460	0.019	-.096	-.048	-.086

facial height decreases. Vector 3 accounts for 10.44% of the variation.

High loading for vector 4 can be seen in cranial measurements of head breadth (0.169) and face breadth (0.169). This reflects a tendency for dimensional increases in face and head width. This vector contains 5.59% of the variation in the study.

CHAPTER 6

CONCLUSIONS

The goal of this thesis was to examine the differences witnessed among the Western Bands of Cherokees and Choctaws and their Eastern Band counterparts. Three hypotheses were put forth as reasons for morphological differences noted between the Western and Eastern Bands. One known negative influence on standing height is childhood nutritional stress. The history of the Cherokees and Choctaws was reviewed as well as that of two Plains tribes, the Kiowa and Pawnee, to determine the general health of the study groups up to the point of their anthropometric measuring by Boas. Other influences on standing height can be attributed to gene flow from groups with greater stature. Anthropometric data from the Boas material was statistically analyzed to ascertain any morphological differences in standing height and other dimensions, which could relate other influences on stature besides the presence or absence of an adequate diet.

The historical review showed that all the study tribes experienced environmental stress. Smallpox, cholera, and tuberculosis epidemics added to the other environmental stresses. The 70 years preceding Boas's measuring were often difficult ones for Native Americans. As it was clearly shown in Chapter 2, long term stress was

applied to the study groups. The Cherokee and Choctaw tribes both experienced considerable stress in association with the removal process. After separation, environmental stress on all four bands increased in many ways, including: Eastern Band members being forced to live in agriculturally marginal areas, Western Band members not receiving promised goods upon arrival to Indian Territory. Later, after a short period of relative calm, the Civil War and reconstruction imposed environmental stresses which, in some cases, negatively effected the Bands through the time of Boas's work. We know from Chapter 1 that long term environmental stress can have an adverse effect on a population. Therefore, it is reasonable to expect the study tribes to have some indicators from environmental stress reflected in their anthropometric data.

Recognizing that the data were derived from an analysis of stressed populations is important to the overall project. Goodman (1973) warns that environmental factors must be accounted for when conducting anthropometrical studies. While it would be difficult to identify exactly which tribe or band was the most stressed, it can be stated with confidence that all of the study tribes were conceivably stressed to the point of having drastic biological responses.

Because long term nutritional stress has such a negative effect on stature, other traits, for example means, must be examined. An examination of means showed many differences among the study groups, specifically in terms of sexual dimorphism. The Kiowa and Pawnee clearly show the greatest degree of sexual dimorphism.

An analysis of variance was conducted on the study group, which reflected measurements which contribute significantly to variation among the study groups. Two anthropometric measurements were singled out as contributing variation, sitting height and facial breadth. While sitting height could be effected by nutritional stress, there is little information stating that facial height (a strong genetic variable) is not as affected by malnutrition.

A canonical variate analysis would relate if there were other similarities or differences among the groups, and would maximize these differences. Plots from the canonical analysis proved interesting. Based on this analysis of the males for the study group, it can be seen that the Western Choctaws and Kiowa are similar in some aspects that are not specifically diet-related, such as head breadth and facial height. Results for the female group was somewhat different.

Based on these results, it is apparent that both environmental stress and gene flow are responsible for the

differences noted between the Western Bands and the Eastern Bands of Cherokee and Choctaw. Analysis of plots shows that intra-band variation is greater than that which could be accounted for by malnutrition alone. Within the time frame of this project, emigrations to Indian Territory from the East occurred as late as 1870, contributing new genes into the Western Bands. Even with these contributions there are notable differences in such genetically linked traits as nose breadth. In several of the plots, either Western Choctaws or Western Cherokees are associated with Plains groups.

As stated earlier, in order for the first hypothesis (environmental stress) to be accepted, certain criteria must be met. If the morphological differences seem between the Western and Eastern Bands were a matter of nutritional status and environmental stress, the Western Band would be similar to their Eastern Counterparts in aspects such as facial dimensions, and dissimilar in aspects such as standing and sitting height. This is clearly not the case.

The second hypothesis offered is that the Western Bands experienced gene flow from Plains groups. For this hypothesis to be accepted we would expect to see the Western Bands to plot close to the Plains groups in all aspects, having received genetic admixture which affected

both stature and cranial dimensions. In some cases this is true, the Western Bands do plot more similar to the Plains Groups, leading support to acceptance of the second hypothesis.

For the third hypothesis to be accepted, where the Western Bands were made up of individuals who were somewhat morphologically different than those tribe members which avoided removal, the Western Bands would plot away from both the Plains groups and the Eastern Band Indians. Once again, there is both historical and statistical data present to support this hypothesis.

Based on these findings, it can be determined, then, that gene flow from both other Amerindians and Non-indians is one of the contributing factors to morphological differences exhibited among the Bands of Cherokee and Choctaw.

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