THESIS
V.1

MICHIGAN STATE UNIVERSITY LIBRARIES
3 1293 01029 6634

This is to certify that the

dissertation entitled

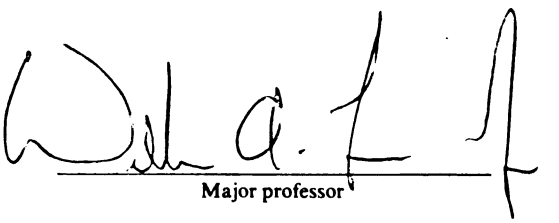
HUNTER-GATHERER SUBSISTENCE ADAPTATION
IN THE SAGINAW VALLEY, MICHIGAN

presented by

Kathryn Carey Egan

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Anthropology



Major professor

Date November 17, 1993

MSU is an Affirmative Action/Equal Opportunity Institution

O-12771

LIBRARY
Michigan State
University

PLACE IN RETURN BOX to remove this checkout from your record.
TO AVOID FINES return on or before date due.

DATE DUE	DATE DUE	DATE DUE
SEP 22 1998	FEB 2 4 2009	
FEB 1 9 2008		
APR 2 8 1999		
JUN 0 5 1999		
FEB 1 0 2004		
MAY 1 2 2001		
NOV 1 4 2004		
MAR 2 2 2008		

MSU Is An Affirmative Action/Equal Opportunity Institution
c:\circ\datedue.pm3-p.1

HUNTER-GATHERER SUBSISTENCE ADAPTATION IN THE SAGINAW VALLEY, MICHIGAN

VOLUME I

By

Kathryn Carey Egan

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Anthropology

1993

ABSTRACT

HUNTER-GATHERER SUBSISTENCE ADAPTATION IN THE SAGINAW VALLEY, MICHIGAN

By

Kathryn Carey Egan

Previous models of hunter-gatherer subsistence decision making have focused on a single subsistence goal (Hewitt 1983; Keene 1981; Winterhalder 1977; 1981a) or a set of subsistence goals (Cowan 1985; Jochim 1976), and anticipate normative responses to environmental conditions. The approach taken in this analysis addresses alternative subsistence goals, focusing on variations in cultural goals and the social relationships of production through time.

Three basic models of subsistence decision making are proposed: one based on efficiency as the sole criterion affecting subsistence choice; one based on taste, including preferences for both fatty and sweet foods, as the only criterion affecting subsistence choice; and one based on multiple goals, including prestige, taste and efficiency, affecting subsistence choice. Within each of the models, there are three exploitation groups providing food to the overall diet: male hunters; female and juvenile collectors; and a collective group that cooperates to exploit aggregated resources.

A computer program was developed to simulate these three models. Simulations were generated to predict hunter-gatherer subsistence decision making in the Saginaw Valley, Michigan, during the Late Archaic (3000 B.C. to 550 B.C.) and Early and Middle Woodland (550 B.C. to A.D. 500). Expectations based on these results were then compared with archaeological assemblages.

Comparing the simulations and archaeological expectations with a number of archaeological data sets, several variations in the short- and long-term subsistence goals have been identified. Concomitant changes in

the contribution of different exploitation groups are associated with these variations in subsistence goals. These variations appear to represent: 1) adaptive responses to seasonal and inter-annual variations in resource availability and productivity; 2) scheduling conflicts between food acquisition and other activities (e.g., tool manufacture and mortuary activities); and 3) increases in population size and "sedentism" (cf. Brown and Vierra 1983) through time. These results underscore the fact that subsistence decision making is a response not only to biological needs but also to social and cultural goals that are not exclusively linked to subsistence, and that understanding of subsistence adaptation requires more critical consideration of these competing goals and their dynamics through time.

Copyright by
KATHRYN CAREY EGAN
1993

To my family and friends
for their encouragement and support.

ACKNOWLEDGEMENTS

From its inception, through the analysis, and writing of this dissertation, I benefitted from the advise, assistance, support, and encouragement of a number of individuals without whom this manuscript would never have been completed. I would like to thank my dissertation committee for their efforts. Dr. William A. Lovis, Chair, obtained the financial support I received during my research, shared his ideas and enthusiasm for the prehistory of the Saginaw Valley, and led me through the maze of modeling. Dr. Richard I. Ford, of the University of Michigan, trained me in paleoethnobotanical methods and theory, guided me through all aspects of this research, and served as a invaluable advocate. Dr. Charles E. Cleland and Dr. Moreau S. Maxwell fostered my interests in hunter-gatherers and provided valuable input and comments on the dissertation. One other individual, not on my committee but who might just as well have been, deserves recognition for all of her efforts. Dr. Patricia Whittier, with humor and incomparable patience, saw me through the "process," shared her insights, and painstakingly edited a draft of the dissertation.

I would also like to thank those institutions and persons who provided collections, facilities, information, and talents necessary to produce this dissertation. The collections used in my analysis were provided by the Michigan State University Museum, the Michigan Bureau of History, and the Museum of Anthropology, at the University of Michigan. The Museum at Michigan State also provided laboratory facilities. Eden Diver translated my ideas into a computer program, enabling me to complete my research. Nancy N. Cleland's analyses of the Weber I and 20BY79 collections were a helpful foundation to my later research. Kathryn Parker provided valuable comparative data and performed the SEM

analysis of the Schultz site chenopodium. Donald E. Weir, CCRG, Inc., was extremely understanding and graciously provided logistical support and facilities necessary for the production of the dissertation. Dianna Linnabary patiently and meticulously entered several of the tables. Liz Hansen, Vicki Volk, and Eric Wyatt skillfully assisted in the production of the graphics.

Over the years there have been many friends and graduate student colleagues who have inspired and supported me. A few, however, have been there through it all: Dr. Carol Goland, Dr. Margaret A. Graham, Dr. Margaret B. Holman, Dr. James A. Robertson, Dr. Russell Skowronek, Beverley A. Smith, and Dr. Herbert L. Whittier. To them, I am eternally grateful.

Finally, I wish to thank my parents: my father, James L. N. Egan, for kindling my interest in the past and my mother, Barbara O'C. Egan, for believing in me.

TABLE OF CONTENTS

List of Tables xii

List of Figure xiv

Chapter 1: Introduction
- The Problem 1
- Economic Decision Making and Adaptation 4
- Analytical Approach 15

Chapter 2: Models of Subsistence Decision Making 23
- Assumptions 23
- Models 29
  - Information Needed 30
    - Population 30
    - Energy and Nutritional Requirements 33
    - Dietary Contribution of Hunting, Gathering, and Collective Exploitation 34
    - Quantitative Estimate of Goals 36
    - Inventory of Plant and Animal Resources 44
    - Implementing the Models 47

Chapter 3: Paleoecology and Effective Subsistence Environment 50
- Physiography and Geology 51
- Climate 61
- Vegetation 63
- Fauna 66
- The Effective Environment 67
  - Exploitive Group Options 68
  - Availability 71
  - Productivity 74
- Summary 80

Chapter 4: Alternative Foraging Strategies in the Saginaw Valley 83
- Subsistence Decision Simulations 84
  - Choices Based on Taste (Model 1) 84
  - Late Archaic Choices Based on Efficiency (Model 2) 89
  - Late Archaic Choices Based on Multiple Goals (Model 3) 93
  - Early and Middle Woodland Choices Based on Efficiency (Model 4) 97
  - Early and Middle Woodland Choices Based on Multiple Goals (Model 5) 100
- Comparison Between Simulated Subsistence Choices 104
  - Taste vs. Late Archaic Efficiency 105
  - Late Archaic: Efficiency vs. Multiple Goals 107
  - Late Archaic: Taste vs. Multiple Goals 108
  - Early and Middle Woodland: Taste vs. Efficiency 110
  - Early and Middle Woodland: Efficiency vs. Multiple Goals 112
  - Early and Middle Woodland: Taste vs. Multiple Goals 114
  - Late Archaic vs. Early and Middle Woodland: Choices Based on Efficiency 115
  - Late Archaic vs. Early and Middle Woodland: Choices Based on Multiple Goals 117

Archaeological Expectations 119
Late Archaic and Woodland Strategies Based on Taste 122
Late Archaic and Woodland Strategies Based on Efficiency 124
Late Archaic and Woodland Strategies Based on Multiple Goals 128
Conclusions 131

Chapter 5: Prehistoric Subsistence in the Saginaw Valley:
Archaeological Data 134
The Weber I Site 135
Paleoenvironmental Reconstruction 135
Features 139
Artifact Analysis 141
Subsistence Remains 142
Seasonality and Function 145
Comparison with Archaeological Expectations 146
The Schmidt Site 147
Paleoenvironmental Reconstruction 148
Features 148
Artifact Analysis 151
Subsistence Remains 153
Seasonality and Function 154
Comparison with Archaeological Expectations 155
The Feeheley Site 156
Paleoenvironmental Reconstruction 157
Features 161
Artifact Analysis 162
Subsistence Remains 164
Seasonality and Function 165
Comparison with Archaeological Expectations 166
The 20BY79 Site 167
Paleoenvironmental Reconstruction 169
Features 169
Artifact Analysis 169
Subsistence Remains 174
Seasonality and Function 176
Comparison with Archaeological Expectations 177
The Marquette Viaduct Locale of the Fletcher Site 178
Site Structure 180
Paleoenvironmental Reconstruction 180
Features 181
Artifact Analysis 185
Subsistence Remains 190
Seasonality and Function 190
Comparison with Archaeological Expectations 191
The Schultz Site at Green Point 192
Site Structure 195
Paleoenvironmental Reconstruction 197
Features 207
Artifact Analysis 210
Subsistence Remains 215
Seasonality and Function 221
Comparison with Archaeological Expectations 224
Summary 227

Chapter 6: Conclusions 230
Models of Subsistence Decision Making 230
Subsistence Adaptation in the Saginaw Valley 232
Implications 237

Appendix A: Biological Value of Key Nutrients 239

Appendix B: Nutrient Composition of Foods 242

Appendix C: Computer Program *by Eden Diver* 244
Program Description 244
Data Structure Listing 246
Program Listing 247

Appendix D: Reconstruction of Botanical Communities 253
Forest Reconstruction 253
Marshes 265
Densities of Plant Resources 266

Appendix E-1:
Simulated Resource Choices Based on Taste 309
Appendix E-2:
Simulated Late Archaic Resource Choices Based on Efficiency 325
Appendix E-3:
Simulated Late Archaic Resource Choices Based on Multiple Goals 335
Appendix E-4:
Simulated Early and Middle Woodland Resource Choices Based on Efficiency 346
Appendix E-5: Simulated Early and Middle Woodland Resource Choices Based on Multiple Goals 357

References Cited 370

LIST OF TABLES

Table		
Table 2.1.	Mean Nutritional Requirements for a Household/Day	35
Table 2.2.	Estimated Percentages of Subsistence Activities	37
Table 3.1.	Soil Classification: Bay and Saginaw Counties	62
Table 3.2.	Standardized Resource Coding	69
Table 3.3.	Seasonal Availability of Resources	72
Table 3.4.	Efficiency: Female/Juvenile Resource Choices	75
Table 3.5.	Efficiency: Collective Resource Choices	77
Table 3.6.	Efficiency: Male Resource Choices	78
Table 4.1.	Resource Choices Based on Taste	86
Table 4.2.	Late Archaic Resource Choices Based on Efficiency	91
Table 4.3.	Late Archaic Resource Choices Based on Multiple Goals	94
Table 4.4.	Early and Middle Woodland Resource Choices Based on Efficiency	98
Table 4.5.	Early and Middle Woodland Resource Choices Based on Multiple Goals	101
Table 5.1.	Weber I Site: Flora	138
Table 5.2.	Weber I Site: Fauna	140
Table 5.3.	Weber I Site: Chipped Stone Tools	141
Table 5.4.	Schmidt Site: Fauna	150
Table 5.5.	Schmidt Site: Chipped Stone Tools	152
Table 5.6.	Feeheley Site: Flora	159
Table 5.7.	Feeheley Site: Fauna	160
Table 5.8.	Feeheley Site: Chipped Stone Tools	163
Table 5.9.	20BY79 Site: Flora	170
Table 5.10.	20BY79 Site: Fauna	171
Table 5.11.	20BY79 Site: Chipped Stone Tools	173
Table 5.12.	Fletcher Site - Marquette Viaduct: Flora	182
Table 5.13.	Fletcher Site - Marquette Viaduct: Fauna	183
Table 5.14.	Fletcher Site: Ceramics	186
Table 5.15.	Fletcher Site: Chipped Stone Tools	187
Table 5.16.	Schultz Site: Correlation of Stratigraphic Sequences	196
Table 5.17.	Schultz Site: Flora	200
Table 5.18.	Schultz Site: Fauna	202
Table 5.19.	Schultz Site: Chipped Stone Tools	211
Table 5.20.	Schultz Site: Bone, Antler, and Shell Artifacts	212
Table 5.21.	Schultz Site: Ceramics	213
Table D.1.	Percentages of GLOS Tree Taxa by Soil Type	270
Table D.2.	Soil 1: Comparison of GLOS and Archaeological Wood Taxa	271
Table D.3.	Soils 1 and 7: Comparison of GLOS and Archaeological Wood Taxa	272
Table D.4.	Soil 2: Comparison of GLOS and Archaeological Wood Taxa	273
Table D.5.	Soil 3: Comparison of GLOS and Archaeological Wood Taxa	274
Table D.6.	Soil 4: Comparison of GLOS and Archaeological Wood Taxa	275
Table D.7.	Estimated Tree Densities in Soil 1: Northern and Southern Mesic, Hardwood Community	276
Table D.8.	Estimated Tree Densities in Soil 2: Northern and Southern Wet-Mesic, Hemlock and Hardwood Community	279

Table D.9 Estimated Tree Densities in Soil 3: Northern and Southern Mesic, Beech-Hardwood-Pine Community 282
Table D.10. Estimated Tree Densities in Soil 4: Southern Mesic, Beech-Maple Community 285
Table D.11. Estimated Tree Densities in Soil 5: Southern and Northern Dry-Mesic, Hardwood Community 287
Table D.12. Estimated Tree Densities in Soil 6: Northern Mesic to Wet-Mesic, Lowland Swamp Community 289
Table D.13. Estimated Tree Densities in Soil 7: Northern and Southern Wet-Mesic, Hardwood Community 291
Table D.14. Estimated Densities of Edible Groundlayer Plants in Soil 1: Northern and Southern Mesic, Hardwood Community 293
Table D.15. Estimated Densities of Edible Understory Plants in Soil 2: Northern and Southern Wet-Mesic, Hemlock and Hardwood Community 295
Table D.16. Estimated Densities of Edible Understory Plants in Soil 3: Northern and Southern Mesic, Beech-Hardwood-Pine Community 297
Table D.17. Estimated Densities of Edible Understory Plants in Soil 4: Southern Mesic, Beech-Maple Community 299
Table D.18. Estimated Densities of Edible Understory Plants in Soil 5: Southern and Northern Dry-Mesic, Hardwood Community 301
Table D.19. Estimated Densities of Edible Understory Plants in Soil 6: Northern Mesic to Wet-Mesic, Lowland Swamp Community 304
Table D.20. Estimated Densities of Edible Understory Plants in Soil 7: Northern and Southern Wet-Mesic, Hardwood Community 306
Table D.21. Estimated Importance Values of Edible Plants in Cattail Marsh Communities 308

LIST OF FIGURES

Figure 1.1. Location of Study Area 3

Figure 3.1. Dendritic River Network in the Saginaw Valley 52
Figure 3.2. Late Glacial and Post-Glacial Lake Levels and Archaeological Chronology for the Lake Huron Basin 53
Figure 3.3. Nipissing Lake Stage in Relation to Soil Types 56
Figure 3.4. Algoma Lake Stage in Relation to Soil Types 58
Figure 3.5. Modern Lake Stage in Relation to Soil Types 60

Figure 4.1. Dietary Contribution/Exploitive Group: Choices Based on Taste 88
Figure 4.2. Dietary Contribution/Exploitive Group: Late Archaic Choices Based on Efficiency 92
Figure 4.3. Dietary Contribution/Exploitive Group: Late Archaic Choices Based on Multiple Goals 95
Figure 4.4. Dietary Contribution/Exploitive Group: Early and Middle Woodland Choices Based on Efficiency 99
Figure 4.5. Dietary Contribution/Exploitive Group: Early and Middle Woodland Choices Based on Multiple Goals 102
Figure 4.6. Measures of Dissimilarity: Late Archaic Efficiency/Taste 106
Figure 4.7. Measures of Dissimilarity: Late Archaic Efficiency/ Late Archaic Multiple Goals 108
Figure 4.8. Measures of Dissimilarity: Taste/Late Archaic Multiple Goals 109
Figure 4.9. Measures of Dissimilarity: Taste/Early and Middle Woodland Efficiency 111
Figure 4.10. Measures of Dissimilarity: Early and Middle Woodland Efficiency/Early and Middle Woodland Multiple Goals 113
Figure 4.11. Measures of Dissimilarity: Taste/Early and Middle Woodland Multiple Goals 115
Figure 4.12. Measures of Dissimilarity: Late Archaic Efficiency/ Early and Middle Woodland Efficiency 117
Figure 4.13. Measures of Dissimilarity: Late Archaic Multiple Goals/Early and Middle Woodland Multiple Goals 118
Figure 4.14. Seasonal Diet Choices: Taste 123
Figure 4.15. Seasonal Diet Choices: Late Archaic Efficiency 125
Figure 4.16. Seasonal Diet Choices: Early and Middle Woodland Efficiency 126
Figure 4.17. Seasonal Diet Choices: Late Archaic Multiple Goals 129
Figure 4.18. Seasonal Diet Choices: Early and Middle Woodland Multiple Goals 130

Figure 5.1. Site Locations Within the Study Area 136
Figure 5.2. Weber I Site: Late Archaic (Occupation Zone 1) Features 137
Figure 5.3. Schmidt Site: Activity Areas 152
Figure 5.4. Feeheley Site: Excavations 158
Figure 5.5. 20BY79 Site: Late Archaic Features 168
Figure 5.6. Fletcher Site: Excavations 179
Figure 5.7. Schultz Site: Excavations 194

CHAPTER 1

Introduction

The Problem

Economics and the satisfaction of subsistence needs are central to understanding adaptation and adaptive processes. Economic behaviors are constantly evolving within a broader cultural system that is driven by multiple goals and the need to satisfy basic subsistence requirements. Several goals influence economic decision making. Efficiency, or the maximization of economic return, is one factor that is universally recognized as being an important component of economic behavior. Taste, prestige, economic security, and other cultural factors also affect subsistence decisions. While studies have demonstrated that all of these goals variously affect subsistence decision making and economic behavior, there has been no systematic consideration of their dynamics within the context of an adaptive system, that is evolving in response to changes in the natural and cultural environments. Within such a context, the available options may vary and in turn the relative importance of satisfying any given goal may also change.

The division of labor is a critical component of economic and subsistence behavior. It also provides a means by which multiple goals can be satisfied. Although studies of agricultural and more complex economic systems have integrated the division of labor into the interpretation of susbsistence adaptations, until recently hunter-gatherer studies have focused almost exclusively on male hunting. Ethnographic studies have begun to integrate the division of labor into the analysis of subsistence adaptation, but archaeological studies have been less attentive to this aspect of economic decision making.

Inductively derived models are hampered by variable preservation of plant remains that constitute the primary contribution of females. Deductively derived models have focused more on the goals affecting decision making than on the role of the division of labor in the realization of these goals. As a result, predicted subsistence patterns continue to focus on the economic contributions of males and only nominally consider the contributions of other exploitive groups.

The objective of this research is two-fold. First, this study seeks to examine the relative importance of efficiency, taste, and prestige in subsistence adaptation through the analysis of changing subsistence practices among prehistoric hunters and gatherers in the Saginaw Valley of Michigan (Figure 1.1). Secondly, the division of labor is incorporated into the analysis in order to more fully understand the means by which subsistence goals are achieved and how adaptive changes in these goals affect the contribution of any component of the labor force.

This analysis will examine the relative importance of efficiency, taste and prestige in subsistence decision making through simulation of three decision-making models, one based on taste, another on efficiency, and the third on a combination of factors including efficiency, taste, and prestige. The latter two models will be run using efficiency estimates based on changing environmental conditions within the research area. Finally, within each of the models, there will be three exploitation groups contributing to the satisfaction of subsistence goals: 1) females and juveniles, 2) males, and 3) a collective group. The results of the simulations will be compared with archaeological subsistence data from Late Archaic (3000 B.C. to 550 B.C.), Early Woodland (600 B.C. to 200 B.C.), and Middle Woodland (200 B.C. to A.D. 500) sites in the Saginaw Valley. Through this comparison, the primary goals affecting the subsistence patterns associated with each of the cultural periods will be identified and the relative contribution of each of the exploitation groups will be evaluated.

Figure 1.1. Location of Study Area

Construction of the models of subsistence decision making requires consideration of the relationship between decision making and adaptation. In addition, the goals affecting subsistence decision making and the role of the division of labor must be examined.

Economic Decision Making and Adaptation

The environment provides a range of possibilities from which choices are made. These choices are potential solutions to the problems of survival and cultural satisfaction. Cultural adaptations "are seldom the best solutions nor are they entirely rational" (Ellen 1986:251), because they are directed toward problems at different scales of time. Systems theory suggests that adaptations occur through a graded series of responses "of increasing magnitude with a distinct temporal structure, depending on the duration and severity of conditions that threaten individuals or populations" (Ellen 1986:247-8). Short-term adaptations may involve solutions to an immediate problem within a given year; medium-term adaptations entail solutions to longer term, multi-year, conditions; and long-term adaptations promote population survival over longer periods of time.

> The degree of consciousness of ecological consequences will vary, ... consciousness must always have been an important factor in both [the] origin and maintenance [of adaptations]. The complexity of an adaptation depends also on an awareness, not necessarily of intricacies or interconnections, but of approximate end-means relationships. Long term adaptation may periodically be re-affirmed through its occasional protrusion into consciousness, particularly in those critical periods when it is clearly operationalized [Ellen 1986:248].

To understand the nature of human adaptation, we must consider both the environmental context of adaptations and also the nature of human decision making. One of the striking characteristics of humans is the variety of habitats that they occupy. The manners in which they are met are quite variable, however, because economics affords a range of alternative ends. Humans populations can, therefore, pursue a variety of different subsistence strategies within any given habitat.

Decision making is guided by the opportunities afforded by the natural and social environments and a range of sometimes disparate goals. Biological requirements place certain constraints on strategies but cultural goals also influence economic decision making. Therefore, actions can be explained not only by opportunities but also by desires -- by what people can do and by what they want to do (Elster 1989:14).

Obtaining adequate food is the primary requirement to be satisfied by human adaptive strategies, although there are also many other concerns affecting resource use (e.g., shelter, retooling). Feeding strategies are solutions to a number of basic problems. These problems involve: 1) securing sufficient energy (caloric) intake for survival; 2) insuring sufficient nutritional intake for survival; 3) ensuring sufficient regularity of these intakes for survival; and 4) insuring satisfaction of other non-biological needs and goals (e.g., hides, antlers, taste, prestige, security). Solutions, therefore, require decisions about: 1) which resources to use; 2) how much of each resource to use; and 3) how and when to exploit resources (Jochim 1981:64).

Considerable anthropological attention has been directed toward understanding the principles underlying human subsistence decision making. Recent studies have keyed in on a few primary factors affecting human adaptive strategies and the fulfillment of human subsistence needs and desires. These factors include: energy and nutrient requirements, efficiency, economic security, the division of labor and food sharing, and goals such as taste and prestige.

Energy is a common denominator of all living systems. Populations are linked in a network or "web" of energy and nutrient exchanges. Energy is commonly used as a currency in ecological studies because it is easily quantifiable. Matter can be transformed into energy and the transaction can be measured. Food energy is measured in terms of

kilocalories;[1] products and work can also be quantified in terms of kilocalories.

Energy exchanges are commonly expressed in terms of input and output ratios. Energy input is often calculated as a ratio of time required for locating, capturing, transporting, maintaining/storing, and consuming food resources; output is measured in terms of the energy return from these activities (Kemp 1971; Rappaport 1984; Smith 1983; Winterhalder 1981a). For life to be sustained input must exceed output.

Satisfaction of nutritional requirements is also an essential component of human subsistence. Human populations require protein for growth and maintenance, and minerals and vitamins to insure proper skeletal development and metabolism. Protein, vitamin A, vitamin C, thiamin, riboflavin, niacin, calcium, phosphorous, and iron are among the most critical and well-studied nutrients for which minimum dietary requirements can be specified; (Appendix A describes the role of these nutrients in human metabolism and development).

Paleopathology and paleodemography studies indicate that prehistoric hunter-gatherer populations had few nutritionally related skeletal pathologies and experienced less nutritional stress than their agricultural counterparts (Cassidy 1972; Cook 1976; Russell *et al.* 1990). Therefore, it appears that satisfaction of minimal nutritional requirements was characteristic of prehistoric hunter and gatherer subsistence patterns.

While nutrition is a critical human requirement, it does not directly affect decisions regarding resource selection. Studies have shown that even when people have nutritional knowledge they choose in favor of taste, cost, and other economic factors (Messer 1984). Therefore, nutritional satisfaction is an indirect result or *implicit*

---

[1] Kilocalories are a standard unit of measuring energy. One kilocalorie is the amount of heat necessary to raise 1 kg of water from 15° C to 16° C.

goal of resource choices made on the basis of a number of other *implicit and explicit* goals.

Many ecological studies of human and non-human feeding strategies have emphasized energy/labor efficiency in resource exploitation. These economic models are guided by the Principle of Least Effort, (i.e., people tend to work no harder than they have to satisfy biological requirements and cultural goals [Zipf 1949]) and assume that the "minimization of cost is a central objective of 'primitive' people in fulfilling subsistence needs" (Reidhead 1980:141; see also Hewitt 1983; Keene 1981, 1983; Smith 1983; Winterhalder 1981a; Zipf 1949). These models assume rationality in goal formation and that a population has total knowledge of the availability, costs, and benefits of resources. Within certain definable limits, resources that provide the greatest energy (and nutritional) return[2] at the lowest cost are chosen.

Optimal Foraging Theory is one application of the Principle of Least Effort to economic decision making (e.g., Hewitt 1983; Reidhead 1976, 1980; Winterhalder 1977, 1981a, 1981b; Winterhalder and Smith 1981). Originally applied to studies of non-human animal behavior,

> ... optimal foraging theory represents an attempt to specify a general set of "decision rules for predators" [Krebs 1978] based on cost-benefit considerations that are in turn deducible from first principles of adaptation via natural selection [E. A. Smith 1983:627].

Three primary assumptions underlie Optimal Foraging Theory: 1) that selection operates consistently and intensively over long periods of time; 2) that optimal behavior is attainable; and 3) that selection favors energy efficiency (Keene 1983:163-164; see also Smith 1983). Thus, the primary tenet of Optimal Foraging Theory is that foragers maximize their net rates of energy intake while foraging and thus optimize their return.

---

[2] In some models (e.g., Reidhead 1976, 1980; Keene 1979; Hewitt 1983) resource utility is measured in terms of nutritional requirements and these requirements must also be satisfied for adaptive success.

At one level, Optimal Foraging Theory has been criticized for treating foraging behavior as resulting from choices made from alternatives for which the costs and consequences are *perfectly known* when, in fact, humans are incapable of omniscience (Bettinger 1991:104). Other criticisms are directed toward the assumption that economic efficiency is more important than other cultural concerns (Bettinger 1991; Styles 1984; see discussion Chapter 2). Finally, another set of criticisms is directed toward equating adaptation with energy efficiency. By definition, neither adaptation (change to better suit the environment) nor fitness (reproductive success) require energy efficiency, although both are often measured in these terms (Hardesty 1977; Harris 1971; Sahlins 1972; Service 1971; White 1949). It has never been demonstrated that increasing rates of energy acquisition during foraging increases fitness or adaptive success. In fact, fitness simply requires satisfaction of minimal energy and nutritient requirements. Further, the proposition that increasing rates of energy acquisition during foraging increases fitness or adaptive success assumes that it is possible to continually achieve a hypothetical maximum rate of energy intake. This achievement would not, however, necessarily guarantee an increasing ability to capture energy quickly and at a low cost. Returns begin to decline when foragers operate at a rate of maximum net energy capture because densities of selected resources begin to decline causing search costs to go up (Martin 1983:613).

The importance of a high rate of energy return is situational. Labor efficiency is not always critical for fitness. Rather, it is the context of adaptation that is most important in determining when labor efficiency is critical to fitness and when it is not (Jochim 1983). Energy efficiency in productive decisions depends on the perceived alternatives for labor and the priorities of the decision maker (Jochim 1981:72). Variations in the subsistence patterns of human populations of similar size living in the same or similar environments clearly

demonstrate that human decision making is driven by goals other than labor efficiency (Bettinger 1991; Clarke 1978; Ellen 1986; Jochim 1976, 1981). Depending on the situation, other measures of efficiency may be more useful in understanding decision making.

Output per unit time and land are other appropriate measures of efficiency (Jochim 1981:65-72). Efficient production per unit of time invested guides many choices, but the importance of time costs in decision making varies among individuals and cultures. The relevance of time costs to production activities is often partially explicable in terms of the availability of critical resources and competing demands on time. Time efficiency is often most critical among people living in northern latitudes with seasonal differences in resource availability and among horticulturalists/agriculturalists who are constrained by limited time to harvest food resources (Jochim 1981:66-72).

When the availability of land is constrained, humans may sacrifice labor and time efficiency to increase the output per unit of land. This occurs when land available for production is scarce and the most efficient use of land becomes the dominant goal of decision making (Jochim 1981:74).

If neither land nor time is limited, it is useful to assume that labor efficiency will guide decisions about productive activities. Ease of collection or net yields for labor input appear to be widespread criteria for resource selection (Jochim 1981:73, 1983). While humans do seek high yields for a minimum of effort (i.e., to increase the ratio of energy yield to input), they differ vastly in terms of the efficiency of their energy budgets (Jochim 1981:26, 34). Factors that affect efficiency include search, pursuit, capture, and processing costs, all of which are effected by resource productivity (see Chapter 2).

Technological and institutional circumstances also influence efficiency and the relationships of measures of efficiency (Jochim 1981:65). For example, the development of gill netting technology and the associated social changes during the Late Woodland period in the

Upper Great Lakes dramatically increased the efficiency of acquiring a temporally limited resource (i.e., spawning fish) (Cleland 1982). Thus, technology and institutional structures can significantly influence resource choices and energy budgets.

While maximization approaches, such as Optimal Foraging Theory, provide a useful baseline against which behavior can be compared, they often neglect the unique nature of economic decision making. It is clear from the differences in subsistence efficiency that competing goals can result in non-energy efficient decisions (Bettinger 1991; Clarke 1978; Jochim 1983; Kemp 1971). Generally, such decisions are only selected *against* during times of stress (see, for example, Rappaport 1984). Hence, when modeling human decision making, it is important to consider factors other than energy.

Economic security also affects subsistence choices. The security and predictability of alternative options are critical in the decision-making process (Cashdan 1990; Clark 1990; Cleland 1976; Jochim 1983; Tversky and Kahneman 1981). Given the potential payoffs available through a variety of alternative strategies, a decision will be made to pursue the strategy that best fits the needs of a population at the least risk (Coombs 1980). Decisions are generally made toward the option of future welfare, even at the risk of occasional losses (Clark 1990; Tversky and Kahneman 1981). Thus, long-term satisfaction of a variety of needs and desires is securely achieved.

The theory of decision making under risk[3] tells people to maximize the expected utility of each possible outcome. Actions, therefore, depend on the expected utility and possible losses associated with them. While people cannot anticipate future events and the circumstances of a single response with complete certainty, they are able to form *probability estimates* over the many future events that can happen

---

[3] Risk occurs when an individual facing a future of several possible states may be uncertain about which one will actually occur but may be able to assign probabilities to each of them (Knight 1921, in Cashdan 1990).

(Cashdan 1990; Elster 1989:112; Jochim 1981:25). Further, when presented with a series of options, people generally establish a hierarchy of preferences, ranking them according to the *schedule* and *value* of the goals they seek to satisfy at a particular time (Elster 1989; Jochim 1981:26). These preferences vary throughout the year depending on the seasonal availability and characteristics of the resource base and cultural factors. Over time, preferences change due to variations in the composition of the resource base and the evolution of cultural goals/objectives. Decisions are made through consideration of the potential payoffs of various strategies selecting the one which suits the environmental context and satisfies the perceived needs of the time. It is, therefore, critical to explore variations in both the environment and cultural goals/objectives when studying subsistence adaptation.

The division of labor and food sharing contribute to economic security by helping to regularize food supplies and insure the satisfaction of multiple goals. Among hunters and gatherers, the division of labor is generally based on gender and age, with males commonly hunting large game, females and juveniles gathering plants and easily captured game, and all three cooperating in the exploitation of aggregated resources, such as spawning fish (Classen 1991; Crabtree 1991; Jochim 1981, 1988). While the contribution of gathered resources to the diet varies according to latitude (Binford and Chasko 1976; Lee 1968), gathering represents the most consistent, predictable, and secure component of the diet (except in extreme northern environments where plant resources are a minimal yet invaluable component of the diet). In temperate environments, gathering generally occurs on a daily basis during the majority of the year. It is the mainstay of the diet while the contribution of hunting is more variable (Jochim 1988). Food is shared within the minimal economic unit and between segments of the community thus helping to level out the available food acquired by each of the sexes and variability in hunting return (Jochim 1981:35, 129;

Winterhalder 1986). The division of labor and food sharing, therefore, must be incorporated into models of human economic decision making.

Other, non-material goals also influence subsistence decisions. "At a basic biological level, food selection is governed by a number of sensory characteristics such as taste" (Messer 1984:218). Fat content and sweetness are two important components of taste preferences.

Fatty foods are often described both explicitly and implicitly as being desirable for their taste. Burton (1965:76) notes that "many of the substances responsible for the flavor and aroma of foods are fat soluble and are found in association with fat in the diet." In addition, "fat slows down the emptying time of the stomach and decreases intestinal mobility... Thus, fat-containing meals have a high satiety value" (Burton 1965:76).

There are biological reasons for fat preference, as well. Fat and protein content are associated, with most fatty foods being high in protein. Further, certain fatty acids are essential to the diet of infants and encourage adequate levels of vitamins A, D, E, and K, which are fat-soluble, as well as vitamin D, which facilitates the absorption of dietary calcium (Speth and Spielmann 1983).

Finally, fat is the most concentrated form of energy, so that with all other factors being equal, fatty foods have a higher energy yield per unit weight and cost than other foods (Jochim 1981:82-83; Speth and Spielmann 1983). This is particularly critical when an individual's caloric intake is already marginal and it may be nutritionally impractical to consume lean, low fat foods. Therefore, when presented with a choice between exploiting fatty or lean foods people will often pursue the fatty option (see for example, Speth and Spielmann 1983). This preference may, however, vary seasonally depending on the fat and nutritional characteristics of the resource base.

Sweetness is another factor affecting food choices. Studies indicate that the preference for sweet tasting foods is innate and, while the preference for sweet foods declines between childhood and

adulthood, it is a cross-culturally universal taste preference (Beauchamp and Cowart 1987; Desor *et al.* 1977; Glander 1982). Therefore, sweetness also affects resource decision making.

Prey size can also affect resource selection (Jochim 1976, 1981:84-87). Large game animals are often preferred over small game because they provide a larger meat package. It may also be more efficient, in terms of time and labor costs, to exploit large game animals; although size is only one characteristic of resources affecting exploitive efficiency. Big game may be relatively expensive to exploit, depending on attributes such as density, aggregation, wariness, mobility, and reliability (Cowan 1985; Hewitt 1983; Jochim 1976, 1981; Keene 1981, 1983; Winterhalder 1977, 1981a, 1981b). For example, Winterhalder (1977, 1981a) noted that among the Cree, these prey attributes often affected hunting choices and that small mammals, birds, or fish, at times, may be more efficient to exploit. Nonetheless, while not always the intended goal of a hunting foray, large animals will often be pursued if encountered because they provide more meat to be shared. Therefore, the capture of large game animals tends to bring a hunter more prestige (Jochim 1976:21, 1981:86-90; Winterhalder 1977, 1981a).[4]

Many non-food items are also sought as part of the food quest. Thus, game animals valued for hides used for clothing and shelter may be preferred (Keene 1981); bone and antler may be sought for technological purposes; and many plants are collected for their medicinal, technological, ritual, and symbolic value. Therefore, these needs must also be considered in decisions regarding resource selection.

Finally, social objectives such as information exchange, socializing, and the exchange value of a resource affect exploitive decisions. Maple sugaring, for example, is an extremely labor intensive

---

[4] Carnivores are also considered prestige items, although they are normally not food items. These animals are valued as prestige items becuase of their ideological value and because they are often dangerous to hunt.

activity that was commonly practiced among historic Native American groups. Maple sugar provided a valuable source of food during a time of scarcity (Henry 1969:211) and was a valuable exchange item. Sugaring also provided a much needed opportunity to socialize after a long winter of isolation (Baird 1898; Densmore 1974). An additional benefit of sugaring may have been the information exchanged in preparation for the upcoming economic cycle (M. B. Holman personal communication 1987).

Thus, many implicitly and explicitly acknowledged factors, including energy and nutritional requirements, efficiency, taste, and non-utilitarian goals such as prestige, and security influence economic decision making and energy budgets (Bettinger 1991; Cashdan 1990; Ellen 1986; Jochim 1976, 1981, 1983; Riches 1982; Speth and Spielmann 1983). These explicitly recognized factors are weighed and balanced against each other and evaluated in terms of the composition, structure, and productivity of the environment. Adaptive responses may involve varying the extent to which any of these explicit goals is weighted or satisfied.

The satisficer approach incorporates multiple goals into decision making. This approach was originally proposed by Simon (1955, 1957, 1959), as a response to marginal utility theory and game theory. According to Simon, satisfaction is a more realistic perspective on human choice because when confronted with the complexity of the environment, most real-life decisions are beyond the scope of rational maximization. Some researchers continue to adhere to the ethnocentric biases of Simon, claiming that humans satisfy needs "because they have not the wits to maximize" and so instead pursue "a course of action that is simply good enough" (Sullivan and Schiffer, in Limp and Carr 1985: 145). Others, like Jochim, prefer the use of a satisficer approach because,

> ... it represents an attempt to be descriptive rather than normative, it may reflect real-world decision processes more faithfully. Second, some hunter-gatherer decisions involve the procurement of nonedible material items such as hides, antler, and bone; the usual high mobility

> of these groups, however, militates against the maximization of material acquisitions. Third, the presence of conflicting goals or objectives guiding the decisions would dictate the acceptance of submaximal levels of attainment, which would lead to the development of submaximal levels of aspiration [Jochim:1976:7].

It is this latter position which best reflects the perspective taken here. Satisfaction is not considered a consequence of intelligence, or the lack thereof. Rather, it is the result of a balancing of multiple goals, ("needs" and "desires"), which results in suboptimal levels of attainment of any single objective, such as energy return.

Satisficer models assume that needs are achieved through consideration of the potential payoffs of various strategies, selecting the one which best fits its needs at the least risk (Coombs 1980), and thus provides the greatest security and predictability of the desired returns (see, Clarke 1978:94). This approach stands in marked contrast to maximizer models in which decisions are directed by the Principle of Least Effort (Zipf 1949). While labor efficiency is clearly an important factor influencing human decision making, many other considerations affect the result. Therefore, decision making guided by multiple goals results in the acceptance of "submaximal" levels of achievement of any single objective. These submaximal levels of achievement constitute what can be considered "satisfactory" levels of attainment, providing for the satisfaction of minimal energy and nutrient requirements (sufficient for human survival and reproductive success) while also providing latitude for fulfillment of other goals. Thus, through the modeling approach taken in this study a variety of cultural objectives can be explored and their relative importance in different situations can be examined.

Analytical Approach

While it has been demonstrated that the division of labor and the biological and cultural factors, described above, influence subsistence decision making within different contexts, there is no clear

understanding of their dynamics under conditions of environmental change. The objective of this research is, therefore, to examine several factors that affect how humans choose a diet that satisfies energy needs, nutritient requirements, and cultural desires within the context of a changing environment and thus to better understand adaptation.

The archaeological record provides an ideal context for examining adaptation because it reflects changing cultural responses to the environment and thus provides a diachronic perspective on human behavior and a range of variability that is not represented in the ethnographic record. It is, however, an imperfect record marred by the vagaries of preservation and site formation processes. Modeling and deductive modeling, in particular, allow for the reconstruction of behaviors that may not be clearly manifest in the archaeological record (Binford 1968; Clarke 1978).

Simplifying the subsistence system by modeling specific means and ends provides a valuable method of assessing options and competing demands and thus understanding human decision making and adaptation (Jochim 1976:104-5). Using deductive modeling, the analyst is able to identify the constraints on a system and specify expectations concerning the structure and dynamics of that system. An additional advantage of deductive models is that they employ an approach that can generate counter-intuitive hypotheses, thus securing against the fallacy of affirming the consequence. Finally, through systematic testing of deductively derived hypotheses, we can attempt to identify nomothetic principles regarding human behavior and adaptation (Bettinger 1980; Binford 1968).

Hunting and gathering strategies are perhaps the easiest economic systems to model (Kemp 1971). They are more bounded than other economic systems; there is less reliance on trade of subsistence goods than among more complex economic strategies and minimal reliance on storage from one year to the next. The low population density and egalitarian

structure of hunting and gathering societies further simplify the system by limiting the number and variety of competing goals.

Hunting and gathering was the predominant subsistence adaptation for 99% of human existence (Lee and DeVore 1968:3). Before 10,000 years ago, hunters and gatherers ranged throughout every environment currently occupied by humans and were constantly adapting to new conditions. Today, only a few hunting and gathering societies remain. These societies live in marginal environments and have adapted to contact with more complex societies for centuries. While they provide a glimpse at the nature of this adaptive strategy, our perspective is biased by their context. To more fully understand the nature of these adaptations requires a long term perspective on past cultures in non-marginal environmental contexts.

The Late Archaic, Early Woodland, and Middle Woodland periods in the Saginaw Valley are an ideal venue within which to examine hunter-gatherer subsistence strategies through time. Despite changes in the phytogeographic configuration of the valley, there is a continuity in the hunting and gathering adaptive strategy that developed in this region (Brashler and Holman 1985; Lovis, ed. 1986), thus providing a context in which to examine the long-term effects of subsistence decision making within a dynamic environment.

Although the valley has been the focus of archaeological investigation for more than a century (Peebles 1978), until recently, most studies have concentrated on land-use patterns implied by site distribution and occupational history. Settlement patterns described for the valley are primarily based on site size and intensity, duration and season of occupation, occupational homogeneity versus heterogeneity, type and density of artifactual remains, and ethnographic analogy.

A few researchers have directed their attention to subsistence patterns (Cleland 1966; Keene 1981; Lovis 1984, 1985, 1986, 1989, 1990; Yarnell 1964). Many of the subsistence models that have been developed for the Late Archaic through Middle Woodland are constrained by the

limited subsistence data and the assumptions and models employed by the investigators.

Brief review of the existing data and the models generated from these data points out the interpretive difficulties posed by meager data and the assumptions that, when dissected from the inductively derived explanations of the archaeological record, bias our interpretations and understanding of the underlying behavior patterns. Thus, the value of approaching questions of subsistence decision making from a deductive perspective are demonstrated.

The Saginaw Valley was sparsely occupied prior to the Late Archaic period. The Paleo-Indian period is characterized by low population densities throughout the Eastern Woodlands. Fitting (1969) has suggested that following the Paleo-Indian period, Early and Middle Archaic populations virtually abandoned Michigan because of low environmental productivity. Recent studies have shown, however, that the Saginaw Valley was occupied throughout the Early and Middle Archaic periods and that modern forest communities had begun to develop by the Middle Archaic (Holman 1990; see also Lovis, ed. 1989, for literature review). An increase in the size and number sites representing the Late Archaic period in the valley suggests that population densities increased during this period. Further, the Late Archaic settlement/subsistence pattern appears to have been directed toward exploitation of the valley as a territory ("homeland") (Brashler and Holman 1985). This may in part be a consequence of the rising lake levels and inundation of the Shiawassee Embayment (Nipissing Lake stage), which made the Saginaw Valley a relatively attractive and productive locale (Fitting 1969).

Based on the settlement size and material remains from the Feeheley and Schmidt sites, Taggart (1967) proposed a settlement model for the Late Archaic period. He argued that populations aggregated during the winter, primarily for deer hunting and that, during the summer, populations dispersed "for fishing, hunting aquatic mammals,

and, *presumably*, gathering wild plants" (Fitting 1969:367, emphasis added).

More recently, Keene (1981) applied an optimal foraging model to the Saginaw Valley, Late Archaic subsistence system. Using linear programming and average cost measures for energy, nine nutrients, and hides as the currency for measuring resource utility, his model predicted four basic economic seasons for the Late Archaic: broad spectrum subsistence activities in the winter; intensive fishing in the spring; broad spectrum subsistence activities in the summer; and intensive deer hunting in the fall. In comparing his model with the archaeological data, Keene finds a reasonable fit. Variances in the fit of the model to the data (e.g., nuts) are attributed to competing cultural goals or the benevolence of the environment to allow for deviation from the optimal pattern without risk of security or fitness.

An alternative approach is taken by Lovis (1984, 1986, 1989, 1990), who addresses the issue of Late Archaic settlement from the perspective of ecological productivity and land-use patterns. Lovis argues that the entire range of habitats, including the uplands, upland margins, and lowlands was exploited as an appropriate strategy for coping with the variability in habitat productivity of any one of these zones. Lovis' detailed analyses of lake level variations and ecological productivity (1984, 1986, 1989, 1990) suggest that hunter-gatherer decision making in this context was directed toward niche rather than species exploitation because of "risks incurred from periodicity in the physical environment, and variation in the targeted resource productivity" (Lovis 1990:2). The unique radial configuration of the river networks in the valley may have aided in maintaining a foraging adaptation because it allowed people to gather and exchange critical environmental information and to effectively maximize access to all parts of the region (Lovis 1990; Robertson 1987).

Lake levels dropped following the Nipissing high water stage and the Shiawassee Embayment began to drain. Lake levels briefly stabilized

at the Algoma stage around 3,200 B.P. and then lowered to their current elevation at around 2,600-2,500 B.P., during the Terminal Archaic (Lovis and Robertson 1989). Late Archaic and Woodland populations were, therefore, adapting to different environmental contexts.

Fitting (1969) argues that the Early Woodland settlement pattern appears to be the same as that which he proposed for the Late Archaic, with winter population aggregations at sites such as Schultz (20SA2) and summer dispersal and encampment at sites such as Kantzler, where fishing was of primary importance. Fitting goes on to say that there may have been a population decline in the valley following the drainage of the Shiawassee Embayment but that small population numbers and the settlement pattern were maintained by the use of squash (*Cucurbita pepo*) (Fitting 1969:368).

Ozker's (1982) model of the Early Woodland varies from Fitting's in both the occupational history of the Schultz site and the economic stability of the Early Woodland population after the drainage of the Shiawassee Embayment. According to Ozker, the introduction of squash and ceramics into the subsistence system increased the economic productivity of the valley considerably. She argues that squash provided vessels for storage and edible oily seeds and that ceramics increased nut oil processing efficiency sufficiently to make nut oils a storable resource. Thus, nut oil extraction and cultivation of squash were integrated into the annual round, creating a settlement pattern that reflects spring planting of squash; spring-summer occupation of locales such as Kantzler for fishing; reoccupation of spring encampments in the fall for squash and nut harvesting and processing; and winter dispersion into forest moraines for deer, elk, beaver, and bear hunting (Ozker 1982:164-166).

Interpretations of the Middle Woodland adaptation in the valley are equally disparate. Site seasonality for the Schultz site (Fitting 1975:125; Luxenberg 1972:106) and the Kantzler site (Crumley 1973:266; Fitting 1975:127) have been disputed and the proposed models (Allison

1972; Cleland 1966:143-144; Luxenberg 1972) explaining subsistence trends have been based on notions of an intensification of the Early Woodland adaptation and establishment of a Middle Woodland hunting and gathering economy with a greater reliance on horticulture. Since these models were proposed, understanding of Middle Woodland economies has changed considerably. While there is evidence for Middle Woodland horticulture, based primarily on native cultigens, throughout the Midwest (e.g., Asch and Asch 1985; Story 1985; Watson 1985), there is little clear evidence for such activities in the Upper Great Lakes region (Fecteau 1984; Parachini 1983). Hence, the observed trends of more restricted hunting of a few large mammals (deer, bear, and elk); increased exploitation of lacustrine and riverine fauna (e.g., walleye, pike, sturgeon); increasing exploitation of plant foods (e.g., species bearing edible seeds); and a decrease in nut meat and oil exploitation (Peebles 1978:121) may be accounted for by factors other than those associated exclusively with horticulture.

Based on recent data from 20SA620 and the Marquette Viaduct locale of the Fletcher site, an alternative scenario has been proposed. Some researchers (Egan 1990; Lovis 1985; Lovis *et al.* 1993) have argued that development of large tracts of wetland habitats during the post-Algoma period attracted Middle Woodland populations for the exploitation of wetland fauna (waterfowl and fish) and flora (tubers). Thus, the Middle Woodland subsistence trends described by Peebles (1978:121) are related to the increased exploitation of wetland resources. This pattern complements that observed in southwestern Michigan (Garland 1990).

In short, the majority of the settlement/subsistence models of the Late Archaic through Middle Woodland periods in the Saginaw Valley have focused on locational data. When subsistence is incorporated into models, there is often confusion about the roles and relative contributions of plant and animal resources and the affects of environmental change on subsistence decision making. Animal exploitation is often considered a prime mover. In part this is a

consequence of the poor preservation of plant remains and in part a result of the persistent bias toward hunting (Bertelesen *et al.* 1987; Watson and Kennedy 1991). Plants are often considered a minor component of the diet and overall subsistence pattern (Keene 1981; Taggart 1967).

In other contexts, when there is evidence of cultivated plants they are presumed to control the settlement/subsistence pattern (Ozker 1982) or account for other changes in the overall subsistence pattern (Allison 1972; Cleland 1966:143-144; Crumley 1973:266; Fitting 1975:125, 127; Luxenberg 1972:106). Studies in other regions of the Midwest and Great Lakes indicate, however, that the shift toward horticulture was gradual and did not involve a wholesale shift in settlement and subsistence strategies (Arzigian 1987; Ford 1985; Parachini 1983; Smith 1992). It is, therefore, doubtful that changes in settlement and subsistence patterns in the Saginaw Valley are a result of the shift to a horticultural economy.

Finally, the models that focus on ecological change (Egan 1990; Lovis 1984, 1986, 1989, 1990) tend to overemphasize the role of the environment and deemphasize human choice. Such an approach risks becoming environmentally deterministic.

Clearly, within the context of the Saginaw Valley, as well as in other archaeological situations, inductively derived models are biased by differential preservation of subsistence remains and by unstated assumptions about the nature of human decision making. Deductively derived models provide a valuable alternative approach to addressing questions of subsistence decision making.

In the following chapter, the theoretical issues introduced above are elaborated and a series of alternate models, based on several of these factors, are posed. By testing the results of these models against subsistence data from the Late Archaic, Early Woodland, and Middle Woodland periods in the Saginaw Valley, the factors affecting subsistence decision making and long-term adaptation can be objectively evaluated.

CHAPTER 2

Models of Subsistence Decision Making

There are two components to this research. The first is to expand our understanding of how hunter-gatherers choose a diet that satisfies energy needs, nutritional requirements, and cultural desires. The second is to examine the adaptive characteristics of subsistence decision making., To address these issues, I construct a series of deductively derived models in which subsistence choices are directed toward satisfying a variety of goals while indirectly fulfilling energy and nutritional requirements. In each of the models, explicitly recognized objectives are given priority in the decision-making process. These models are then compared with archaeological data sets ranging over a 5,000-year time span.

This study employs a deductive modeling technique because deductive modeling is predictive and requires explicit definition of the assumptions being made. In a deductive model, assumptions regarding the structure of human decision making, the goals to be satisfied, and the constraints on the choices made must be specified. These operational assumptions directly affect both the structure of the model(s) and the definition of the variables. The hypotheses generated by deductive models represent predictions of behaviors. For the models proposed herein, the assumptions are specified below.

Assumptions

A primary tenet of anthropology is that human behavior, and thus decision making, is patterned and therefore redundant. While people may not consciously recognize their needs, behaviors that lead to long-term fulfillment of a population's wants and needs are reinforced (Jochim

1981; Keene 1981). "Scheduling" decisions are made with respect to specific wants and needs and the means by which they can be satisfied. Successful attainment of the desired ends leads to a continuation of the pattern, whereas lack of success results in alternate decisions (Flannery 1968). Therefore, for the purposes of this research, it is assumed that:

> ***1) Human economic activities are directed toward achieving specific goals.***

A complex set of goals and needs underlies human subsistence decision making. Human health and reproductive success are dependent on satisfaction of specific energy (caloric) and nutritional requirements in the proper combinations (National Resource Council [NRC] 1989; Wing and Brown 1979). Adequate energy and nutritional returns represent two *implicit* goals of human subsistence decision making.

Because there is little evidence for nutrition-related pathologies among hunting and gathering populations (Cassidy 1972; Cook 1976; Dunn 1968; Russell *et al.* 1990; Truswell 1977), it is assumed that:

> ***2a) Energy and nutritional dietary requirements are satisfied by hunter-gatherer subsistence strategies.***

While it is assumed that subsistence decision making results in the tacit satisfaction of minimum energy and nutritional requirements among hunter-gatherers, the key to the decision-making process lies in the *explicit* or consciously recognized goals guiding decisions about which resources to choose. A common economic and anthropological principle is that humans seek to minimize the amount of effort expended in subsistence activities, while maximizing energy return (Polanyi 1959; Winterhalder 1981; Zipf 1949). Therefore, energy efficiency is often treated as a primary goal of subsistence decision making. Even in models that consider the satisfaction of cultural goals, minimization of effort and maximization of energy return are stressed as critical components of subsistence decision making (Jochim 1976, 1981; Riches 1982).

As discussed in Chapter 1, two factors that can mitigate against energy efficiency are constraints on available time and constraints on exploitable land. Economic and mortuary data from the Saginaw Valley suggest that the valley represented a "homeland" or circumscribed territory to Late Archaic, Early Woodland, and Middle Woodland populations (Brashler and Holman 1985:144-145). There is, however, no evidence of strict boundary maintenance or conflict to suggest that land use was constrained. In fact, ethnographic analogy suggests that these populations may have exploited areas that extended beyond the valley (Cleland 1992a, 1992b:Maps 1, 4, and 5, personal communication 1993). Time, however, does appear to have been constrained by the seasonal availability of food resources. Therefore, a correlate of the second assumption, is that:

> ***2b) Minimization of effort and efficient exploitation of seasonally available resources are critical components of subsistence decision making.***

In addition to adequate energy (caloric) return from subsistence activities, humans must satisfy basic nutritional requirements. Humans do not, however, generally know the nutritional and energy value of the foods available to them (except perhaps among technologically advanced modern populations). It has been demonstrated that even when people have this knowledge, decisions are often guided by other objectives (DeGarine 1972; Messer 1984). Consequently, many anthropologists have argued that satisfaction of objectives such as efficiency, taste, prestige, and security are important in subsistence decision making and that an observer's measure of cost may differ radically from that of the actor (Bettinger 1991; Jochim 1981:79; Messer 1984).

While most humans are unaware of and unable to calculate the nutritional returns of various foods, the fact that prehistoric hunters and gatherers enjoyed at least minimal nutritional well-being indicates that their overall strategy satisfies basic nutritional requirements even though that strategy is not explicitly directed by nutritional concerns. An adequate model of economic decision making must,

therefore, consider other measures of utility. Therefore, another correlate to the second assumption is that:

> ***2c) Fulfillment of goals, including efficiency, taste, prestige, and security, is important to subsistence decision making and indirectly results in the satisfaction of nutritional and energy needs of hunter-gatherers.***

Hence, subsistence decision making is a balance among several goals. The result is that minimum energy and nutritional requirements are fulfilled through satisfaction of culturally defined goals.

The manner in which goals are achieved is also critical to understanding the process by which human subsistence decisions are made. Psychological evidence suggests that decisions are generally made in favor of the option that provides the greatest long-term satisfaction of needs and desires, even given the possibility of occasional losses (Clark 1990; Jochim 1983; Tversky and Kahneman 1981). Rather than attempting to maximize the return from any given action, people make decisions based on satisfaction of long-term goals, even at the risk of short-term losses. Further, the "Law of the Minimum" suggests that organisms do *not* adapt to the average but to the minimum. Therefore, in the models proposed herein, it is assumed that:

> ***3) Decisions to satisfy monthly and annual objectives will be based on the probability of a minimum return for any given action and that economic security is achieved in this way.***

The question of how humans process information regarding potential economic returns is also critical to the understanding of subsistence decision making. Maximization models have been criticized for their approach to human information processing. Such models provide for the simultaneous evaluation of all resources in terms of their potential energy returns, as well as a specification of the mixture of resources that will provide the greatest return at the lowest costs.[1] Humans, however, must make decisions with incomplete information, derived from

---

[1] Others (Hewitt 1983; Keene 1979) include nutritional return as an indirect constraint on the system.

past experiences and probabilities based on those experiences. This information is simplified in two ways: 1) it is often restricted to the information that is considered most relevant, ignoring the rest; and 2) evaluations are made sequentially and hierarchically, allowing a further restriction of the amount of information considered at one time (Jochim 1981:80; see also, Limp and Carr 1985). Since humans are limited in their ability to process massive amounts of complex information simultaneously and to know the overall effect of a combination of choices, it is (operationally) assumed that:

> ***4) Decisions are rational, and information is processed in a hierarchical and sequential manner. Decisions are made by first selecting the option that provides the greatest potential for satisfaction of goal(s). Other options are added until minimal energy and nutritional requirements are satisfied.***

In considering human economic decision making, it is important to include differences in the composition of the decision-making group. Many animals employ a division of labor, but humans are unique in their dependence on a differentiation of subsistence responsibilities and the pooling of these separate efforts. Among hunters and gatherers in temperate environments, females and juveniles generally focus on foods that are less mobile, less dispersed, more abundant, and more predictable (e.g., plants, shellfish, turtles); males hunt and fish for resources that are more mobile and dispersed and less abundant and predictable; and large groups of males, females, and juveniles often cooperate in the exploitation of aggregated foods through game drives and collective hunting, fishing, and gathering (Jochim 1981, 1988; Watson and Kennedy 1991). For the purposes of the models presented here, it is assumed that:

> ***5) Economic activities are organized along the lines of age and gender, with men pursuing a variety of large and small game, women and juveniles collecting plant resources and easily harvested game, and both groups cooperatively exploiting aggregated resources (Jochim 1981:130; see also Cowan 1985:81).***

Finally, the cost of subsistence activities must be considered. In subsistence decision-making models, search time is often the most difficult cost to predict. Diet breadth models assume that resources are distributed in a fine-grained pattern and that hunters and gatherers encounter prey types at random (Smith 1983:628). Ethnographic evidence suggests, however, that hunters and gatherers know the habitats in which they can find resources. In addition, they can "read" the signs of resource presence in the environment and predict the probability of return from any given activity (see, for example, Brody 1981; Carver 1956; Henry 1969; Tanner 1956). Therefore, random foraging cannot be assumed under conditions in which resources are distributed and encountered in a spatially heterogenous pattern.

In a patchy environment, such as the Saginaw Valley, hunters and gatherers are faced with two problems: 1) which set of patches to forage in; and 2) how long to forage in each patch (see, for example, Optimal Foraging Theory patch use models [Smith 1983; Winterhalder 1981]). To date no general model has been constructed that can deal with both of these problems (Smith 1983:631). Thus, for purposes of this model, it is assumed that:

> ***6) While there are differences in the efficiency with which any given resource patch can be exploited, all resource patches are equally accessible.***

This assumption is appropriate in the Saginaw Valley where the radial configuration of rivers allowed prehistoric populations to gather and exchange critical information and provided access to all parts of the region (Lovis 1990; Robertson 1987).

Finally, the diachronic perspective of archaeology provides valuable insight into long-term adaptations to environmental change. In this study, it is assumed that:

> ***7) Over time, as the environment changes, the potential returns of any given action may vary and the means and extent to which cultural goals are satisfied will vary.***

Thus, through simulation of multiple responses to environmental change and comparison of the modeled solutions with archaeological subsistence data, we can better understand the nature of long-term adaptive responses.

These assumptions outline the basic structure of hunter-gatherer subsistence decision making, the goals to be satisfied, and the constraints on the choices made. In turn, they provide the structural basis for the models developed in this study and affect the definition of the variables.

Models

Several studies have focused on energy efficiency as the primary catalyst in subsistence decision making (Hewitt 1983; Keene 1981; Reidhead 1980; Winterhalder and Smith 1981). Despite many of the problems with the assumptions of these models, they have demonstrated that efficiency is an important factor affecting resource choice. These models, however, often poorly predict the diversity of resources exploited by hunter-gatherers and the contribution of resources, such as plants, that provide a lower energy return. Others (Cowan 1985; Jochim 1976) have modeled strategies based on multiple factors, including energy efficiency, taste, and prestige (as indicated by prey size). These latter models often more realistically predict the use of resources that provide lower energy returns, but they also fall short in their estimation of the contribution of plant resources and in the recognition of the interplay between decisions based on efficiency and those based on other goals.

This study takes an alternate approach to the modeling of subsistence decision making. This approach uses three simulations: one based exclusively on resource productivity as a measure of efficiency; the second on taste; and the third on a combination of factors that includes efficiency, taste, and prestige as measured by prey size.

In addition, each of these models is structured in terms of a hunter-gatherer division of labor. By incorporating the division of labor into the decision-making process the contributions of each of the exploitive groups can be more realistically simulated.

Finally, two separate data sets, based on environmental changes between the Late Archaic and Early and Middle Woodland periods, are employed. One is applied to the Late Archaic archaeological record and the other to the Early and Middle Woodland data. Thus, the simulations can be used to consider the effects of environmental change on subsistence decision-making.

Information Needed for the Models

The following information is needed to generate the models described above:

1) An estimate of the size and demographic composition of the economic unit.

2) Quantitative information pertaining to the energy and nutritional requirements of the population.

3) A quantitative estimate of the dietary contribution of a) male hunting and fishing, b) gathering of plants and easily captured game by females and juveniles, and c) cooperative hunting and collecting of aggregated resources by both.

4) An inventory of the plant and animal resources available in the region under investigation. This information must include quantitative data pertaining to the a) temporal and spatial availability and productivity of subsistence resources and b) estimates of resource, efficiency, size, and taste

Population

Definition of the size and structure of the population to be satisfied is critical to the construction of the model. The size of hunting and gathering groups varies over the course of the year (Binford 1980; Hallowell 1992; Henry 1969; Woodburn 1968), as does the extent of food sharing (Speth 1988). Therefore, this study uses the household

unit as the fundamental economic unit. Among hunters and gatherers household size tends to be relatively small, one to nine people (Howell 1979; Murdock 1967; Schoolcraft 1839).

The household lives together, moves together, and makes up the camps and bands that carry out corporate economic activities together. This group regularly cooperates in subsistence activities and shares resources internally and with other such groups. Households often operate independently during periods of scarcity, coming together to share labor and resources during seasons when resources are more productive or when communal activities demand it (e.g., Cleland 1982; Hallowell 1992; Henry 1969; Landes 1971; Steward 1938:97-98).

Reciprocity is the most common form of exchange among hunters and gatherers, and food sharing is widely held to be one of the hallmarks of the "egalitarian" hunter-gatherer social system (Issac 1978; Kaplan and Hill 1985; Lee and DeVore 1968; Polanyi 1959; Sahlins 1972; Service 1971). Food sharing plays an important role in maintaining social and economic bonds, as well as in improving group nutritional well-being by leveling out the effects of differential foraging success (Cashdan 1990; Halstead and O'Shea 1989; Lee and DeVore 1968; Wiessner 1982). While sharing is not necessarily a nutritionally equitable activity (Speth 1988), the nutritional requirements of the group are generally satisfied, and over time excesses are balanced against shortages (Halstead and O'Shea 1989). Therefore, strategies that satisfy the economic goals of the household or minimal economic unit are considered representative of the larger group.

Use of the household rather than band for definition of the decision-making population is appropriate to hunter-gatherer studies, in part, because it is so difficult to estimate population size among prehistoric groups. Ethnographic data indicate that band size is variable both seasonally and annually. Unfortunately, however, archaeological settlement data are often insufficient and confounded by site formation processes so that population estimates cannot be

accurately reconstructed. Therefore, the use of the household rather than band is appropriate for the Saginaw Valley and other archaeological contexts where band size cannot be accurately determined.

For the purposes of this study, the household will be treated as a nuclear family (one adult male, one reproductively active female and their offspring). Using the nuclear family as a prototype of household composition provides the gender differentiation necessary to model the division of labor. In addition, males, females, and juveniles have different nutritional requirements that may be important to the modeled solution.

The population estimate for the household is derived from census data on Ottawa and Ojibwa families in the Upper Great Lakes (Cleland 1992a; Schoolcraft 1839), demographic data on the Dobe !Kung (Howell 1979), and data from Murdock's Ethnographic Atlas (Coult and Hadenstein 1965). Census data from 56 Ottawa and Ojibwa bands living in the Michigan and Wisconsin in 1830s indicates that household size ranged from one to 16 individuals with the mean being 4.9 (Cleland 1992a:Table 1).

Among the !Kung, household size varies between one and nine individuals. Howell's (1979) compilation of demographic data indicated that among the 227 households sampled the mean household size was 2.6 people with a large percentage (62%) being families of one or two individuals who would be unable to subsist without assistance or cooperation with other households.

Unfortunately, household information from the Human Relation Area Files (HRAF) does not provide exact numbers of individuals. Cross tabulations on subsistence pattern and household composition indicate, however, that there is a statistically significant ($p=0.003$) relationship between hunting and gathering populations and nuclear family households ("one married couple and their children") (Coult and Hadenstein 1965:257).

The age and gender composition of hunter-gatherer households is variable. To compare the HRAF data with the household data on Ottawa, Ojibwa, and !Kung, it is necessary to calculate the average number of children in hunter-gatherer households. Schoolcraft's 1838 census data on the Ottawa and Ojibwa indicates that households included from one to 11 children while the average number of children was 2.4. Among the Dobe !Kung (n=62), the average number of live births is 4.69 (Howell 1979:123). These values are offset by mortality rates. Among the !Kung, there is a 70% survival rate to age 15 (Howell 1979:80-86). Based on these data, hunter-gatherer "families" have an average of 5.2 children with approximately 60% or 3.1 surviving to reproductive age. Therefore, for purposes of this study, the average hunter-gatherer household is estimated to include three juveniles (and the adult male and female).

For the purposes of this study, the juveniles include an infant (less than one year old), one juvenile who is one to ten years in age, and an adolescent between the ages of 11 and 14. This demographic profile of the juveniles is derived from Howell's (1979) compilation of demographic information on the Dobe !Kung. Among the 15 families of five represented in the !Kung sample, 21% of the individuals were less than five years old; 32% were between the ages of five and 14, and the remainder of the household population was 15 years of age and older (Howell 1979:45). This demographic profile will be important in determining the nutritional requirements of the population.

Energy and Nutritional Requirements

The energy and nutritional requirements of any given individual and population vary in terms of a number of factors, including genetic background, environmental conditions, physiology (age and gender), and activity schedule (Ellen 1986; Haas and Harrison 1977; Messer 1984; Wing and Brown 1979). It is, therefore, difficult to determine precise estimates of population requirements. International and U.S. Federal

standards for nutritional requirements (Food and Agriculture Organization [FAO] 1974; NRC 1989) are frequently criticized for overestimating standards necessary for sustaining human life (Haas and Harrison 1977:87; McArthur 1974; Stini 1975:28). For purposes of this study, however, these standards are considered appropriate since many of the resources in the models served additional material purposes (e.g., bulrush for thatching; deer for hides and antler billets). Overestimates may compensate for the alternative value of the resources.

The NRC (1989) standards for nutritional requirements will be used in this study because they are lower than the FAO standards, except for the estimate of calcium requirements. Average dietary requirements are estimated (Table 2.1) for the household on the basis of the age and gender because these variables will significantly affect the population average. In addition, since the models will run on a monthly cycle, aggregate monthly values for these requirements will be used in the model solutions.[2]

Dietary Contribution of Hunting, Gathering, and Collective Exploitation

Among temperate environment hunter-gatherers, men fish, women and juveniles collect plant resources and easily harvested game, and both groups cooperatively exploit aggregated animal resources (Jochim 1981:130; see also Cowan 1985: 81). In addition, the relative dependence on gathered versus hunted resources varies according to latitude (Binford and Chasko 1976; Lee 1968) and, more specifically, according to environmental variables including effective temperature and mean annual rainfall (Maulden 1987).

In this study, estimates of the dietary contributions of males and females are based on the comparative results of Lee's (1968) and

---

[2] Although studies have shown that energy and nutrient intakes vary seasonally (Hill *et al.* 1984; Speth and Spielmann 1983), there is not sufficient data available to specify seasonal or monthly variations in energy and nutrient requirements in the models proposed in this study.

Table 2.1. Mean Nutritional Requirements for a Household/Day[a]

	Kcal	Protein (gm)	Vitamin A (μG RE)[b]	Vitamin C (mg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg NE)[c]	Calcium (mg)	Phosphorous (mg)	Iron (mg)
Adult male	3,000	37	750	30	1.2	1.8	19.8	450	1,000	12
Adult female[d]	2,315	54	930	71	1.3	1.5	16.4	1,085	1,085	16.4
Infant <1	620	14	300	20	0.3	0.5	5.4	550	400	7.5
Child 1-10	1,793	20	317	20	0.7	1.1	11.9	450	800	7.5
Adolescent[e]	2,585	31.8	650	25	1.0	1.6	17.1	650	1,200	11.6
Daily Totals	10,040	198	3,738	257	5.2	6.1	67.5	4,585	4,485	58.4
Monthly Totals	301,200	5,940	112,140	7,710	156	183	2,025	137,550	134,550	1,752

[a] National Resource Council 1974

[b] Retinol equivalents. 1 retinol equivalent = 1 μg retinol

[c] α - Tocopopherol equivalents. 1 mg d - tocopherol = 1α-TE

[d] Mean for all adult females regardless of reproductive status

[e] Includes both males and females

Murdock's (1967)[3] estimates of the relative contribution of gathered wild plants and small land fauna and resources acquired through hunting, trapping, fowling, fishing, and shellfishing. Lee's analysis indicates that on average gathering contributed 35% to the !Kung diet. Murdock's (1967) estimates on hunter-gatherer populations, between 40° and 49° N, indicate that 31% of the diet is based on gathering, 35% on hunting, and 34% on fishing (Table 2.2). Interpolating between Lee's estimate and those derived from Murdock's work, it appears that plant and animal resources gathered by females and juveniles contribute approximately 33.3% of the diet; game and fish collected by males comprise approximately 33.3% of the diet; and collective aggregated resources make-up approximately 33.3% of the diet annually.

In this study, these contributions are simply treated as *choices*, with each of the three exploitive groups making one-third of the dietary choices. The models are structured in this way rather than in terms of actual percentages of food because there is no detailed data available on the specific nutritional contributions of males versus females and juveniles or on the relative nutritional contributions of plants versus animals in diet.

Quantitative Estimates of Goals

To determine which options will be selected in a decision-making model, it is necessary to assign values to options. A utility function is a way of assigning values to options so that more preferred options receive higher ranking. In this model, quantitative estimates of efficiency, prey size, and taste must be assigned to calculate the utility of any resource option. These estimates are scaled to rank order values between one and ten for comparative purposes (when considering multiple goals) and to provide a more realistic approximation of their relative utility (cf. Cowan 1985).

---

[3] Derived from the Human Relations Area Files (HRAF).

Table 2.2. Estimated Percentages of Subsistence Activities

HRAF Code	Cultural Group	Gathering	Hunting	Fishing
Na37	Rainy River	30	40	30
Na38	Katikitegon	30	30	40
Na39	E. Ojibwa	30	30	40
Nb2	Twana	10	30	60
Nb4	Yurok	40	10	50
Nb11	Nootka	20	20	60
Nb16	Klallam	10	30	60
Nb18	Quilieute	10	30	60
Nb19	Chinook	20	20	60
Nb21	Coos	10	30	60
Nb24	Makah	20	20	60
Nb25	Quinault	20	30	50
Nb27	Stalo	30	30	40
Nb28	Alsea	10	20	70
Nb31	Tututni	30	20	50
Nb32	Shasta	40	30	30
Nb33	Chimariko	40	30	30
Nb34	Karok	40	10	50
Nb35	Hupa	40	10	50
Nb36	Wiyot	40	10	50
Nb39	Sinkyone	40	30	30
Nc4	Atsugewi	40	30	30
Nc7	Yuki	40	30	30
Nc8	Klamath	30	20	50
Nc9	Modoc	50	30	20
Nc10	Achomawi	30	40	30
Nc11	Yana	50	20	30
Nc12	Maidu	50	30	20
Nc14	Wintu	30	30	40
Nd10	Tenino	30	20	50
Nd4	Sanpoil	30	20	50
Nd5	Hukundika	50	30	20
Nd12	Flathead	30	40	30
Nd14	Coeur d'Alene	30	40	30
Nd15	Sinkaietk	30	30	40
Nd18	Wishram	30	20	50
Nd19	Umatilla	30	30	40
Nd20	Nez Perce	30	30	40
Nd22	Wadadokado	50	30	20
Nd24	Kidutokado	40	40	20
Nd27	Kuyuidokado	50	20	30
Nd43	White Knife	50	40	10
Nd45	Bohogue	30	50	20
Nd46	Agaiduka	30	30	40
Nd48	Gosiute	50	40	10
Nd58	Uintah	30	40	30
Nd63	Bannock	30	50	20
Nd64	Wind River	30	50	20
Ne1	Gros Ventre	20	80	0
Ne4	Crow	20	80	0
Ne8	Teton	10	90	0
Ne9	Arapaho	20	80	0
Ne11	Assinibioin	20	70	10
Ne18	Piegan	20	80	0
Ne19	Plains Cree	20	60	20

Efficiency

Cost-benefit ratios provide useful measures of the utility of particular subsistence activities. These measures are frequently based on estimates of energy input and output. Energy is often subdivided into three cost estimates: search costs, pursuit costs, and processing costs. Search costs are based on the amount of time required to locate a resource; pursuit costs can be regarded as the energy expended from the time the quarry is detected until it is captured; and processing costs include the energy required to prepare food for consumption or storage. Benefit is measured in terms the energy yield from a particular resource. The higher the benefit, in relation to cost, the more efficient it is to exploit a resource.

While the application of cost-benefit ratios has been useful in the interpretation of diet choice among contemporary populations (Kemp 1971; Lee 1968, 1969; Rappaport 1984), there are numerous problems with the application of this approach to the understanding of subsistence practices among prehistoric populations (e.g., Hewitt 1983; Keene 1981). First, estimates depend on detailed ethnohistoric and historic accounts of aboriginal hunting and collecting costs. Despite the copious and detailed nature of the ethnohistoric documents from the Great Lakes region, for example, there are few references that would allow us to systematically quantify hunting and gathering costs. Second, there is little experimental data on the energy expenditure involved in collecting and processing foods (e.g., Asch and Asch 1978; Munson 1984) that can be used to derive cost estimates. Finally, the costs involved in many subsistence activities are environmentally and technologically specific.

An alternative approach to cost estimation is based on calculating search, pursuit, and processing costs in terms of easily quantifiable resource attributes such as density, mobility, aggregation, and predictability (Cowan 1985; Jochim 1976; Keene 1981). Thus, the environmental context and characteristics of the resource base are taken

into consideration when calculating costs involved in subsistence decision making.

"Search costs involve individuals per unit area and distance..." (Hewitt 1983:232). The manner in which hunters and gatherers approach a resource area is, therefore, in part related to search costs. It has been argued that hunters and gatherers search for food in a patterned, rather than random, fashion because they rely on shared information (Hewitt 1983; Keene 1981). Hunters and gatherers search for foods in locations where there is the highest probability of return. This probability is in part related to resource density (measure of resource numbers per unit area), in part to prey mobility, and in part to the hunting technology available.

The higher the density of a resource, the lower the search time; the lower the density, the higher the expected search time. Therefore, search time is often calculated as an inverse function of the density of food available (Hewitt 1983; Keene 1981; Smith 1983).

It has also been argued that the more mobile the resource, the higher the search costs. Mobility is clearly not a concern when considering plant resources and may not, in fact, be particularly critical in hunting for animals that have specialized feeding strategies. Further, while animals are mobile, ethnographic sources suggest that hunters often trap, employ a sit and wait approach, or surround an area in a communal fashion. Thus, they mitigate against the effect of animal mobility on search costs.

Pursuit costs are measured in terms of resource aggregation and an additional measure of distance:

> Pursuit costs are taken to be inversely proportional to the aggregation of prey and directly proportional to the difference between the distance at which prey begin to flee the predator and the distance at which the prey can be killed (the more aggregated prey are, the less pursuit will be necessary to obtain one; the farther beyond effective reach prey begin evasive action, the greater the pursuit necessary to obtain one) [Hewitt 1983:232; see also, Keene 1981].

"Handling costs are represented by the rank of a resource on a list of foods arranged on an ordinal scale of difficulty in processing" (Hewitt 1983:232), measured in terms of hours of labor expended relative to resource weights and technological efficiency. As noted above, however, technological efficiency is difficult to measure without detailed experimentation. Even the effects of technological change are difficult to quantify. For example, it has been argued that the introduction of ceramics increased the efficiency of processing nuts and small seeded grains (Braun 1987; Braun and Plog 1982; Ozker 1982), and that the use of ceramics for processing increased the nutritional value of the foods (Braun 1987; Braun and Plog 1982; Buikstra *et al.* 1986). Calculating the effect of such a technological change would require a complex calculation of changes in the processing efficiency of various types of foods, the nutritional effects of ceramic cooking, and some measure of the extent to which the increase in processing efficiency was offset by the costs of manufacturing ceramics. Without such detailed information, it is difficult to accurately assess the effect of technological changes and such an assessment is beyond the scope of this study. Therefore, technological change will not be factored into the models as a separate variable.

In addition, when considering handling costs, productivity (density × weight) must be factored into the calculation of processing costs since few resources are taken singly. Because it is so difficult to estimate technological efficiency, in the models presented here, it will be assumed that comparable amounts of time are required to process equal quantities of food. For example, if it takes ten times longer to process 100 pounds of deer than to process a 10-pound fish, it will take an equal length of time to process 100 pounds of deer and 100 pounds of 10-pound fish.

Finally, taking these diverse measures of energy efficiency into account, the derivation of a total cost estimate is confounded by the calculation of the relative effect of each on the other. Efficiency

measures calculated in different units often result in incongruent measures.[4] The problem is that it is difficult to arrive at accurate efficiency estimates without empirical data on costs measured in comparable units.

In this study, to simplify the problem of calculating separate measures of search, pursuit, and processing costs, the relative efficiency (cost-benefit ratio) of each resource will be measured in terms of productivity (weight [in kg] × resource density per unit area [in km^2]). This measure takes into consideration the environmental characteristics of search, pursuit, and processing costs that are most critical and avoids the difficulty of arriving at accurate time estimates. These efficiency measures are then standardized to a rank order value between one and ten.

The dietary contribution of each resource is calculated according to that fraction of its productivity within an area that could be effectively exploited by a household in a month. These are conservative estimates based on catchment studies (Styles 1981; Vita-Finzi and Higgs 1970), the initial results of simulations, and practical experience. Catchment studies suggest that females and juveniles collect resources within 1 km^2 of the camp and, while there is some disagreement, a hunter's range is frequently assumed to be within 5 km of the camp (Styles 1981; Vita-Finzi and Higgs 1970).[5] While there are no estimates of the area within which collective foods might be exploited, given the high yields provided by these resources, an estimate of approximately 1 km^2 adjacent to a camp seems appropriate.

---

[4] Keene (1981), for example, found that his estimates of search costs were minimal relative to pursuit and handling costs and resolved the problem by multiplying search costs by 100 before adding them to pursuit and handling costs.

[5] While ethnographic data from the Great Lakes (e.g., Carver 1956; Tanner 1956; Henry 1969) indicates that hunters frequently ranged as much as a day's walk from camp, many game animals were apparently taken in proximity to camp. Therefore, 5 km represents a useful estimate of average hunting range.

Estimates of the fraction of any resource that could be effectively exploited within these catchments were then calculated based empirical data and the simulation results. Females and juveniles were estimated to effectively collect the yield from 0.004 km^2 (1 acre) of any given resource; hunters were assumed to effectively take game available within 0.10 km^2 (25 acres); and the collective group to effectively exploit an area of 0.08 km^2 (20 acres) for game and 0.008 km^2 (2 acres) for maple sap.[6]

The predictability of economic return is also important to subsistence decision making. An ecological study of economic problem solving should examine the degree of risk or uncertainty in resource productivity.

Resource reliability and security vary along two dimensions. Plant, animal, and fish resources vary seasonally and inter-annually based on differences in productivity (density × weight) over time. In addition, there are differences in the reliability and security of animal resources based upon their wariness and mobility, which can also vary seasonally (e.g., deer become more gregarious during the rutting season; anadromous fish become more mobile yet also more aggregated during the spawning season).

Decision making under risk assumes that the decision maker has some knowledge of the reliability and security of the resources available. Thus, the most critical variable affecting decision making is productivity, which can be predicted from past experiences. The higher the productivity of a resource, the greater its predictability and security. Therefore, in this study, resource reliability will be subsumed under the measure of productivity. As discussed above, subsistence decisions are generally based on minimum productivity; unfortunately, most of the ecological literature provides information only on average densities; therefore, productivity estimates are based

---

[6] Providing one-tenth of the yield estimated by Henry (1969).

on these values. These values are higher than the minimum values that appear to be the scale at which decisions are based. The standardization to rank order values and use of conservative estimates of dietary contribution, derived from small areas, should offset the use of average densities. Security is assumed to be satisfied in the models developed in this study (Assumption 3).

Prestige

Prestige is culturally defined and differs among groups; however, its importance appears to be universal (Jochim 1976, 1981). Among many hunter-gatherer populations, successful hunters are afforded prestige, and prey size (weight) frequently is correlated with hunting prestige (Bettinger 1991:176-177, 202-203; Cowan 1985; Dunning 1959; Jochim 1976; Tanner 1956).

For the purposes of the models, prestige will be defined in terms of prey size and considered as an attribute of animal resources (independent of productivity estimates). Size will also be scaled according to rank order values between one and ten.

Taste

Taste preferences are influenced by cultural factors, although biological data suggest that preferences for fatty and sweet foods are innate in humans. Therefore, in this study, fat and sweetness will be calculated as the primary resource attributes affecting subsistence decisions based on taste.

The fat content of animal and plant resources fluctuates throughout the year. In temperate environments, most animals build up fat reserves during the late spring, summer, and fall seasons. Fat content is generally highest in the fall of the year and is depleted during the winter and early spring. The fat content of plants also varies seasonally because fatty plant foods, such as nuts and seeds become available in the fall (see Cowan 1985). Unfortunately,

quantitative data documenting these changes are not available for most resources. To calculate seasonal variations in fat loss from fall to spring, some researchers (Cowan 1985; Keene 1981) have assumed that fat loss for animals is linear over the course of the winter and that the spring fat content of an animal will be proportional to the fall fat content. Biological research indicates, however, that animals in temperate environments employ a variety of strategies (including improvements in fur insulation, hibernation to shallow torpor, and improvements in thermal conduciveness, as well as weight reduction) to reduce energy requirements during the winter (Heldmaier 1990). Hence, calculation of annual variations in fat becomes a more complex calculation, based on several variables, and use of a simple linear reduction in fat content from fall to spring may not be appropriate for many animals. Therefore, to simplify the calculation of fat value, average (kg) measures of fat will be used and then standardized to a rank order scale of one to ten.

Detailed nutritional information on the sucrose content of the foods considered in this study are not readily available. Therefore, sweetness will be treated as a ordinal scale variable. Sweet foods will be assigned values according to a subjective scale between one and ten, making them comparable to the other measures of resource utility.

Inventory of Plant and Animal Resources

The inventory of plant and animal resources available to the population is based on an environmental reconstruction of the region through time and published inventories of edible resources presently available in the area. This inventory is in no way complete but represents a primary set of food resources commonly referenced in ethnographic sources from this region (Cleland 1966; Densmore 1974; Erichsen-Brown 1979; Henry 1969; Smith 1923, 1928, 1932, 1933; Yarnell 1964).

In addition to the attributes discussed above, the following attributes must be calculated for each plant and animal resource available to the human hunters and gatherers of the Saginaw Valley:

1) the timing of availability during the course of the year.

2) the productivity (density × weight), that any given resource achieves per unit area of habitat, as well as the monthly, annual and inter-annual variability in productivity.

3) the size of the resource.

4) the nutritional value of each resource.

Availability

While many animal resources are available to hunters and gatherers throughout the year in a temperate environment, many plant and some animal resources are not continuously available and, at times, may not be desirable as food products for varying reasons (e.g., low fat). The timing of available and securable alternatives, affects decision-making outcomes. Since resource availability in this region varies seasonally and even within the course of any given season, the models proposed here will be based upon the monthly availability of resources.

Food storage, which was commonly practiced among hunting and gathering populations in this region (Densmore 1974; Henry 1969), extends the availability of resources (Halstead and O'Shea 1989; Ingold 1983). Ethnographic accounts suggest that gathered resources account for the significant proportion of the stored food used during the winter months (November through March). For purposes of this model, the gathered component (33.3%) of the winter diet will be derived from gathered resources available through storage.

The modeled solutions for gathering during the non-winter months must, therefore, exceed the monthly energy and nutritional requirements of the population. Since spring (April and May) is commonly conceived of as the leanest period of the year in temperate environments (when stored resources are depleted and animal resources are at their lowest

weight), storage estimates will be based on resources collected during the summer (June through August) and fall (September and October).

Productivity

Resource productivity estimates will be based on an environmental reconstruction of the composition and size of prehistoric habitats and specific and interpolated data on resource densities and weights. The density of any resource is based on the number of any particular animal or plant species/km^2. Estimates of aquatic resource densities are based on the number of any particular species/km^2 of water surface. Estimates of average densities of each resource, derived from wildlife management and natural resources literature, will be used in the model calculations. These estimates will vary from the Late Archaic through Middle Woodland periods because of variations in the size of different ecological zones as lake levels change through time.

The weight of each resource is measured in grams and kilograms. Although animals provide a wide range of products (e.g., hides, sinew, antler, bone) in addition to meat, weight of usable meat is generally used as the best measure of utility (e.g., Cleland 1966; White 1953). While plant resources also serve multiple functions (i.e., dietary, medicinal, technological, and ideological), the biomass of any given resource would certainly be an overestimate of its total subsistence utility. For this reason, plant weights will be based on the edible portion only.

Calculating Nutritional Value

The nutrient composition of all foods, and especially wild foods, is variable for several reasons, including the method(s) of processing and the physical characteristics of a species and its environmental context. Processing techniques can affect the quantities and types of nutrients available for human use (see, for example, Braun 1987; Buikstra *et al.* 1986; Farb and Armelogos 1980; Jochim 1981; Katz *et al.*

1974). In addition, variations in the nutrient content of plant foods may result from: intra-specific and varietal differences; differences in temperature, moisture, sunlight, soil conditions, and community composition; changes in season and phenology; and where on the plant samples are taken (Hewitt 1983; Kieckhefer 1962; Nagy and Haufler 1980; Thor and Smith 1935). Similar variations occur in the nutrient contents of animals (Boikova 1971; Taylor 1974); however, many reports of nutritional contents of wild foods are based on large samples that reflect intra-specific and varietal variations in nutrient content, at least at a regional level. In addition, analyses of plant resources are performed at times when edible parts reach maturity, thus providing a reliable estimate of the nutritional value for consumers.

Unfortunately, there is limited data available on the nutritional contents of some species of wild foods. Therefore, inter-specific values of nutritional composition will be used for foods for which there is limited nutritional information (see Hewitt 1983). The nutritional contents of the foods included in this study are provided in Appendix B.

Implementing the Models

To implement the models, a computer program was generated to operationalize the hierarchical subsistence decision-making process described (Appendix C). The primary tenet of the models is that hunters and gatherers adapt to the constraints of minimal energy and nutritional requirements through satisfaction of one or a combination of goals, including efficiency, prestige, and taste. This multiple modeling approach can be used to predict a range of potential subsistence choices that might be made by hunter-gatherers.

While many maximization models are based on complex calculations of cost-benefit ratios, the models proposed here are based on the assumption that most humans are unable to know the energy and nutritional value of resources and are limited in their ability to process huge masses of information. Therefore, decisions are made

hierarchically and sequentially. Each of the exploitive groups (males, females/juveniles, and the collective group) will first select the option that provides the greatest satisfaction to one or a combination of *explicit* goals of efficiency, prestige, taste (ranked on a scale from one to ten), while indirectly satisfying the *implicit* goal of meeting energy and nutritional requirements. The program will continue to iteratively select the next highest ranked resource for each of the three decision-making groups so that each component of the labor force makes one-third of the choices.

The program will simulate an annual subsistence round based on the availability and productivity of resources each month. Therefore, for each of the cultural time periods (Late Archaic and Early and Middle Woodland) there will be twelve data files, one for each month of the year. Each of these files will contain an inventory of the plant and animal resources, their average productivity and other attributes relevant to the satisfaction of the explicit and implicit goals. Additionally, there will be a designation of resources available to either males, females and juveniles, or cooperative labor groups.

The programs run on two temporal cycles simulating subsistence decision making first during the Late Archaic and second during the Early and Middle Woodland periods. For each of the cycles, the resource productivity values change to reflect differences in density per unit area (productivity) during the Nipissing/Algoma[7] and modern lake stages.

The simulated decision sets for the Nipissing/Algoma and modern ecological contexts, are then compared with the archaeological data sets from the Late Archaic and Early Woodland and Middle Woodland periods in the Saginaw Valley. The simulation that best predicts the subsistence pattern interpreted from the archaeological data is identified for each site. These results will provide information relating to the role of efficiency (as measured in terms of productivity [weight × density ×

---

[7] See Chapter 3 for the justification for combining the Nipissing and Algoma resource productivity values.

km^2]), taste (sweetness and fat content), and a combination of factors including productivity, taste, and prestige (prey size) on strategic choices and the relative contributions of females and juveniles, males, and collective exploitive groups.

CHAPTER 3

Paleoecology and Effective Subsistence Environment

The ecosystem of the Saginaw Valley region is structured by several physiographic factors, including: bedrock geology; glacial and post-glacial events; the network of rivers draining through the Saginaw River; climate; and location within the transition zone between the Carolinian and Canadian biotic provinces (Cleland 1966; Dice 1943; Potzger 1948). The transition zone supports a diversity of both southern and northern species. This environment provided the prehistoric inhabitants of this region with a rich array of resources, although changing environmental conditions (brought about by fluctuating lake levels) affected the productivity of the resources.

Delineation of the effective subsistence environment[1] of the Late Archaic, Early Woodland, and Middle Woodland populations is based on a reconstruction of the geologic history, hydrology, climate, and biotic communities. Key plant and animal resources, representing the primary categories of foods available to the study group, are identified in the reconstruction. For purposes of this study, these resources constitute the effective subsistence environment of the Late Archaic and Early and Middle Woodland populations in this area.

Changes in the productivity of resources in the effective subsistence environment were brought about by post-glacial fluctuations in lake levels and the configuration of the watershed and basin. By factoring in these changes in resource productivity through time, the relative merits of the resource options available to the Late Archaic,

---

[1] The effective subsistence environment represents resources that are selected for their food value, among other factors.

Early Woodland, and Middle Woodland decision-makers can be examined. Thus, the relative importance of resource productivity, as a measure of efficiency, can be compared with other cultural goals that affect subsistence decision making.

Physiography and Geology

The geology and physiography of the Saginaw Valley are strongly related to its glacial and post-glacial history (Dorr and Eschman 1971). Saginaw Bay is the terminus of the extensive Saginaw drainage system. To the north, west, and south, the region is bordered by beach terraces produced by Lake Saginaw and other pre- and post-glacial high water levels (Butterfield 1986). These terraces and moraines provide moderate relief and circumscribe the Cass, Shiawassee, and Tittabawassee rivers that drain into the Saginaw River, which drains into Saginaw Bay. The interior of the drainage basin has relatively level lacustrine deposits broken by a crescent of end moraines running parallel to the bay. The dendritic river network that drains the region gives it a highly dissected character (Figure 3.1). The presence of extensive wetlands is due to the limited topographic relief and poorly drained glacial and lacustrine soils.

Until around 12,050 B.C. (14,000 B.P.), this region was covered by the Saginaw lobe of the Wisconsinan stage glacial advance. By about 11,850 B.C. (13,800 B.P.), the Saginaw lobe had retreated from the basin. Glacial meltwater collected in the basin forming Lake Saginaw, which drained south and west to Lake Chicago. Continued recession of the Saginaw lobe resulted in an increase in the size of Lake Saginaw and creation of the Port Huron moraine and a second recessional moraine at Bay City.

Following the establishment of the Saginaw Basin, the region was alternately inundated and drained by a series of post-glacial lakestages (Figure 3.2). These long-term fluctuations in the Huron Basin

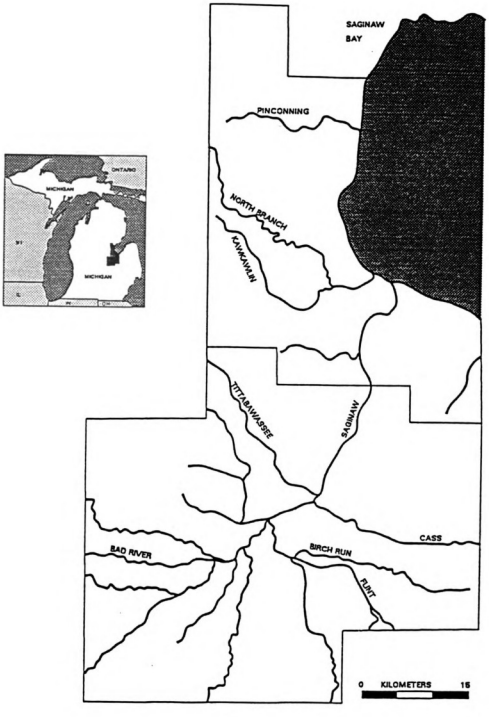


Figure 3.1. Dendritic River Network in the Saginaw Valley

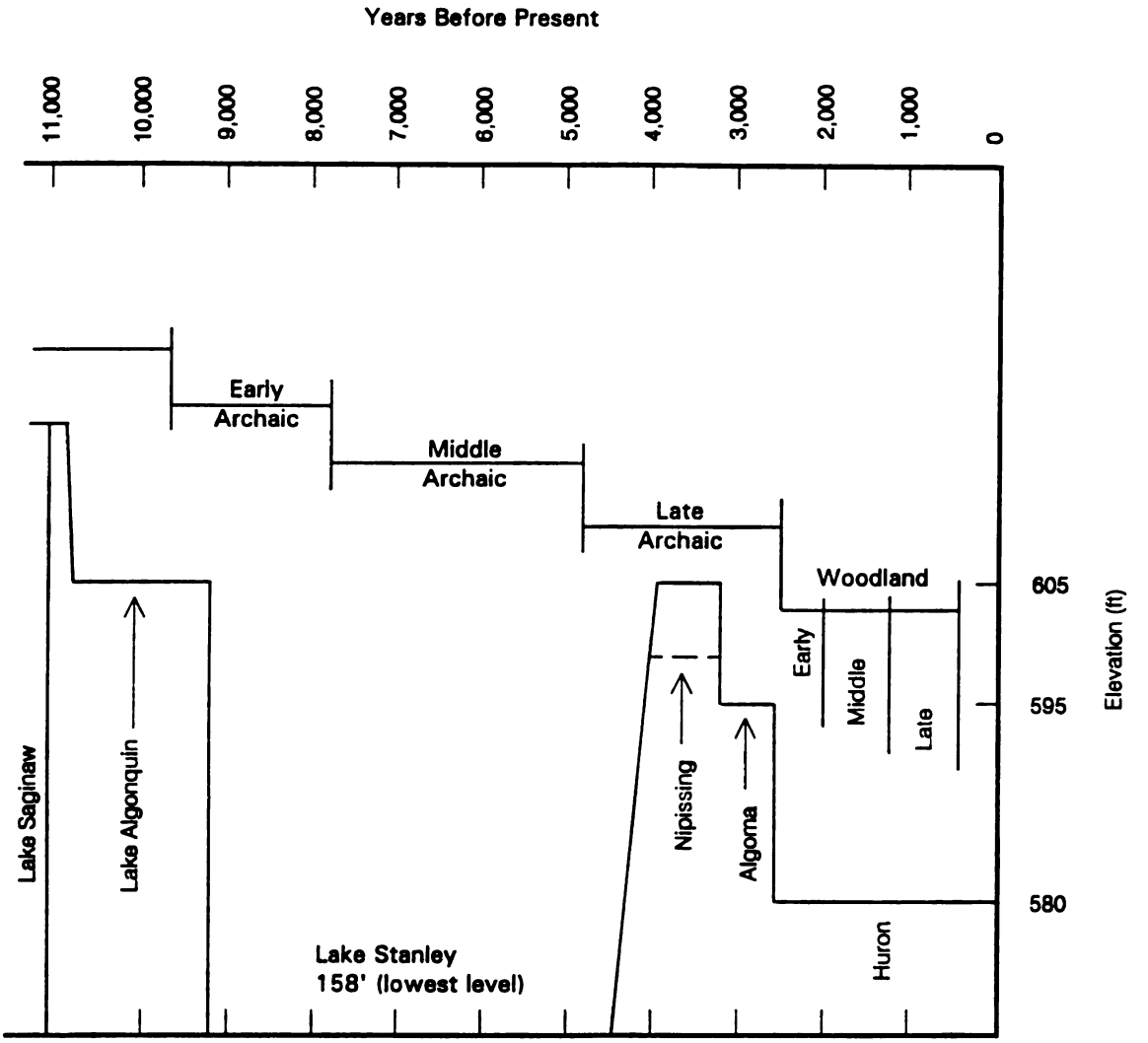


Figure 3.2. Late Glacial and Post-Glacial Lake Levels and Archaeological Chronology for the Lake Huron Basin

(Modified from Larsen 1985:95; Lovis 1986:5-6)

elevations were the result of continued glacial retreat, isostatic rebound, and incision of new drainage outlets (Larsen 1987).

Lakes Saginaw and Chicago combined in the Lake Algonquin stage (184 m [605 ft] amsl) when the basins of lakes Huron and Michigan were free of ice, ca. 9050 B.C (11,000 B.P.). By around 7550 B.C. (9500 B.P.), low outlets in the Huron Basin, exposed by crustal depression to the north and continued glacial retreat, initiated the drainage of Lake Algonquin and stabilization at the Lake Stanley stage (48 m [158 ft] amsl). Continued crustal warping increased the level of the outlets and thus the elevation of waters in the Huron Basin (Butterfield 1986).

The Nipissing lake stage (184 m [605 ft] amsl) began about 2750 to 2550 B.C. (4700 to 4500 B.P.) (Monaghan *et al.* 1986) (Figure 3.3). At this time, the Saginaw drainage system began to approximate its current configuration. Later closure of northern drainage outlets shifted outflow to the south (Nipissing II), and continued outlet incision allowed for drainage of the Nipissing high water levels.

Water elevations briefly stabilized at the Algoma stage (181 m [595 ft] amsl) approximately 1250 B.C. (3200 B.P.) (Figure 3.4). With continued drainage of the area, modern lake level elevations (177 m [580 ft] amsl) were established around 650 to 550 B.C. (2600 to 2500 B.P.) (Figure 3.5) (Speth 1972; see also, Lovis 1986, for a detailed description of post-glacial events). This drop in lake level elevation corresponds with the transition from the Late Archaic to Woodland periods.

Post-Algoma events strongly influenced the distribution of wetlands and locations of stream channels. Recession of the Algoma lake stage (181 m [594 ft]) to modern elevations (177 m [581 ft]) resulted in continued ponding of water between the moraines at what are now Saginaw and Bay City and created extensive marshes and swamps. Upstream, the remnant Shiawassee Bay, created during the Nipissing high water stage, remained a poorly drained wetland.

SOIL CLASSIFICATION:

Soil 1: Dominantly nearly level and very gently sloping, somewhat poorly drained and poorly drained soils, on lake plains and water worked till plains

Soil 2: Dominantly nearly level and gently undulating, poorly drained and somewhat poorly drained soils, on water-worked till plains

Soil 3: Dominantly nearly level, poorly drained and somewhat poorly drained soils, on flood plains

Soil 4: Dominantly nearly level to rolling, well drained, moderately well drained, and poorly drained soils, on lake plains, till plains, and flood plains

Soil 5: Dominantly nearly level and gently undulating, poorly drained and somewhat poorly drained soils, on lake plains

Soil 6: Nearly level to moderately sloping, well drained to somewhat poorly drained soils, on moraines

Soil 7: Nearly level and gently sloping, well drained to poorly drained soils, on outwash plains, lake plains, and beaches

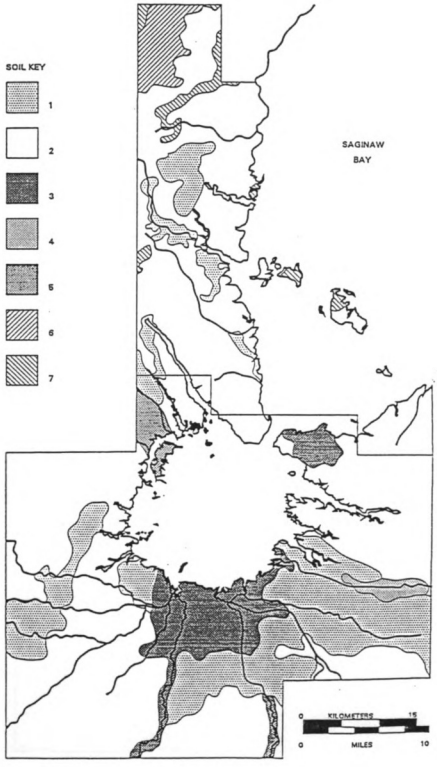


Figure 3.3. Nipissing Lake Stage in Relation to Soil Types

SOIL CLASSIFICATION:

Soil 1: Dominantly nearly level and very gently sloping, somewhat poorly drained and poorly drained soils, on lake plains and water worked till plains

Soil 2: Dominantly nearly level and gently undulating, poorly drained and somewhat poorly drained soils, on water-worked till plains

Soil 3: Dominantly nearly level, poorly drained and somewhat poorly drained soils, on flood plains

Soil 4: Dominantly nearly level to rolling, well drained, moderately well drained, and poorly drained soils, on lake plains, till plains, and flood plains

Soil 5: Dominantly nearly level and gently undulating, poorly drained and somewhat poorly drained soils, on lake plains

Soil 6: Nearly level to moderately sloping, well drained to somewhat poorly drained soils, on moraines

Soil 7: Nearly level and gently sloping, well drained to poorly drained soils, on outwash plains, lake plains, and beaches

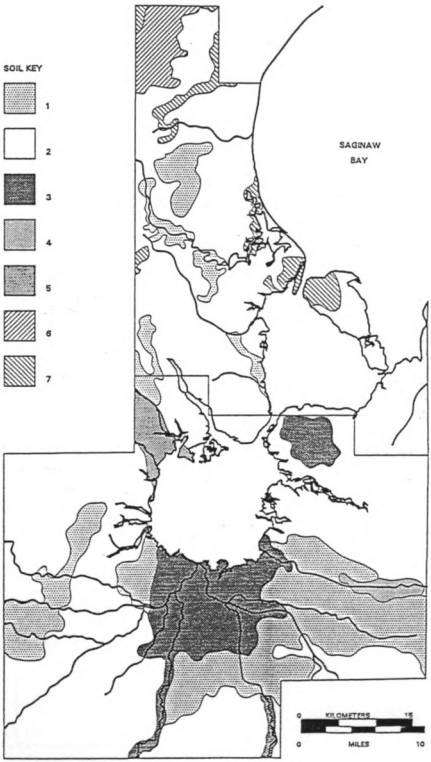


Figure 3.4. Algoma Lake Stage in Relation to Soil Types

SOIL CLASSIFICATION:

Soil 1: Dominantly nearly level and very gently sloping, somewhat poorly drained and poorly drained soils, on lake plains and water worked till plains

Soil 2: Dominantly nearly level and gently undulating, poorly drained and somewhat poorly drained soils, on water-worked till plains

Soil 3: Dominantly nearly level, poorly drained and somewhat poorly drained soils, on flood plains

Soil 4: Dominantly nearly level to rolling, well drained, moderately well drained, and poorly drained soils, on lake plains, till plains, and flood plains

Soil 5: Dominantly nearly level and gently undulating, poorly drained and somewhat poorly drained soils, on lake plains

Soil 6: Nearly level to moderately sloping, well drained to somewhat poorly drained soils, on moraines

Soil 7: Nearly level and gently sloping, well drained to poorly drained soils, on outwash plains, lake plains, and beaches

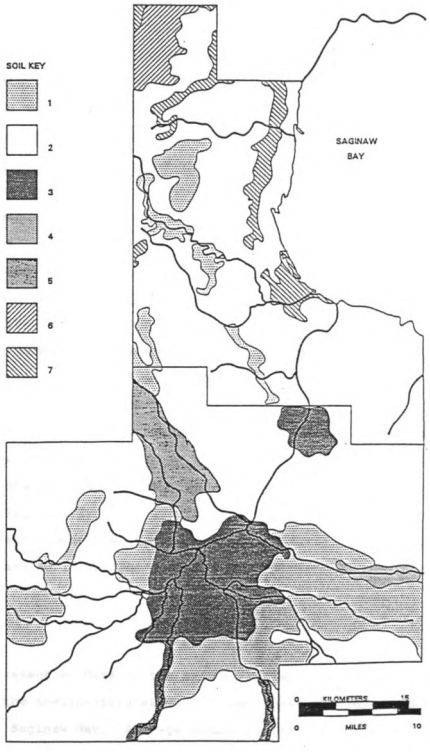


Figure 3.5. Modern Lake Stage in Relation to Soil Types

Following the drop from Algoma levels, there were several short periods of high water levels in the Huron Basin and Bay City area (Farrand 1990; Larsen 1985; Lovis *et al.* 1993; Speth 1972). These fluctuations have been correlated with changing patterns of temperature and precipitation (Larsen 1985). One such flood event is documented by Speth (1972) at the Schultz site (20SA2), located at the confluence of the Saginaw and Tittabawassee rivers.

The physiography of the Saginaw drainage basin is primarily the result of the glacial and post-glacial events described above. The basin is relatively flat, interrupted occasionally by low ridges, sand dunes, and moraines. Most of the interior of the region is a clay lake plain. Extensive glacial drainages dissect it. The majority of the glacial drainages are poorly drained and cross-cut by excessively drained beach ridges. Low sand dunes, some that are several miles long, have formed downwind of the drainages. A crescent of end moraines runs parallel to Saginaw Bay. Beach ridges and shallow depressions occur along the bay (Albert *et al.* 1986).

Within the study area (Saginaw and Bay counties) seven general soil classes have been defined on the basis of these physiographic and geologic characteristics (topography, drainage, and parent soil material) (Figure 3.5; Table 3.1). These soil types are important for defining plant communities because there is a close relationship between vegetation and soil texture, drainage characteristics, and moisture content.

Climate

The present climate of the Saginaw Valley is relatively mild because of the ameliorating effect of Lake Huron and the protection afforded by Saginaw Bay. Average annual rainfall for the region is 70-80 cm, and average annual snowfall is 1 m (Albert *et al.* 1986:11; Seeley 1917). The average growing season is 153 days (Albert *et al.* 1986:11). The last killing frost (< 0° C) occurs between May 2nd and May 15th and

Table 3.1. Soil Classification: Bay and Saginaw Counties

Soil 1: Dominantly nearly level and very gently sloping, somewhat poorly drained and poorly drained soils, on lake plains and water worked till plains:

Saginaw County
- **Pipestone-Granby-Wixom Association**
- **Pipestone-Wixom-Belleville Association**

Bay County
- **Wixom-Pipestone-Tappan Association**

Soil 2: Dominantly nearly level and gently undulating, poorly drained and somewhat poorly drained soils, on water-worked till plains:

Saginaw County
- **Tappan-Londo-Poseyville Association**
- **Tappan-Londo Association**
- **Parkhill-Capac Association**
- **Parkhill-Wixom Association**
- **Wixom-Capac-Parkhill Association**
- **Tappan Association**

Bay County
- **Tappan Association**
- **Londo-Tappan Association**
- **Tappan-Londo-Poseyville Association**
- **Tappan-Belleville Association**
- **Wixom-Londo-Poseyville Association**

Soil 3: Dominantly nearly level, poorly drained and somewhat poorly drained soils, on flood plains:

Saginaw County
- **Sloan-Zilwaukee-Misteguay Association**
- **Sloan-Ceresco Association**

Soil 4: Dominantly nearly level to rolling, well drained, moderately well drained, and poorly drained soils, on lake plains, till plains, and flood plains:

Saginaw County
- **Gagetown-Strawn-Sloan Association**

Soil 5: Dominantly nearly level and gently undulating, poorly drained and somewhat poorly drained soils, on lake plains:

Saginaw County
- **Pella-Frankenmuth Association**

Soil 6: Nearly level to moderately sloping, well drained to somewhat poorly drained soils, on moraines:

Bay County
- **Wixom-Londo-Guelph Association**

Soil 7: Nearly level and gently sloping, well drained to poorly drained soils, on outwash plains, lake plains, and beaches:

Bay County
- **Pipestone-Tobico-Rousseau Association**

the date for the first killing frost occurs between September 30th and October 15th (Seeley 1917). The growing season is comparable to that at the southern end of the state (Albert *et al.* 1986:18; Seeley 1917). This mild climate and long growing season were sufficient for prehistoric agriculture (Yarnell 1964).

Ecological studies, based on vertebrate and pollen data, indicate that by around 3850 B.C. the climate in southern Michigan was similar to its modern climate (Ahearn and Bailey 1980; Gilliam *et al.* 1967; Holman 1990; McMurray *et al.* 1978). There were, however, short cooling trends between A.D. 500 and 800 and again during the "Little Ice Age" between A.D. 1200 and 1700, and a warming trend between A.D. 1000 and 1200 (Bernabo 1981). These climatic fluctuations occurred after the Middle Woodland period, however, and the present climate in the Saginaw Valley is similar to that during the Late Archaic and Early and Middle Woodland periods.

Vegetation

Palynological sequences from Vestaburg Bog (Gilliam *et al.* 1967), Crystal Marsh (McMurray *et al.* 1978), and Chippewa Bog (Ahearn and Bailey 1980) in the south-central Lower Peninsula of Michigan (Montcalm and Lapeer counties) document the evolution of Holocene forest communities within this general region. Following deglaciation of the southern Lower Peninsula of Michigan and until ca. 6050 B.C., the area was forested first by spruce forest-tundra communities and then by mixed pine and deciduous communities. By about 6150 to 6050 B.C., an increasing diversity and abundance of hardwood species began to replace pine, and by 5550 B.C., the Carolinian/oak-hickory and Canadian/pine dominated biotic communities were established in central Michigan. By this time, the ecotone (a transitional zone between to distinct biomes) between the Carolinian and Canadian biotic provinces was established. Fluctuations in pollen frequencies of pine and hardwood species suggest that a warming trend, associated with the Hypsithermal, resulted in

vegetational shifts within the transition zone between about 4050 and 3050 B.C. Following this warming trend (ca. 3850 B.C.), the climate in this region became similar to that of today and an essentially modern forest community was established (Ahearn and Bailey 1980; Gilliam *et al.* 1967; Kapp 1977; McMurray *et al.* 1978).

The Saginaw Basin is a distinct ecosystem delimited by a unique set of environmental characteristics that has affected the composition and structure of the floral communities. Quick (1924) recognized the unique composition of this ecological region and describes the vegetation as follows:

> The dominants are *Acer saccharum, Betula lutea, Fagus grandifolia, Fraxinus americana, Tilia americana, Tsuga canadensis,* and *Ulmus americana.* The bitternut [*Carya cordiformus*] is only occasionally present, as are also *Fraxinus nigra* and *F. pennsylvanica.* As relicts from hydrarch successions *Acer rubrum, A. saccharinum,* are often present, while *Carya ovata, Pinus strobus, Populus grandifolia, P. tremuloides,* and *Quercus alba* are often relicts of xerarch successions. *Juglans cinerea* is rare... [1924:232].

Albert, Denton, and Barnes (1986:18) have defined the Saginaw Drainage Basin as the "Saginaw District." Their reconstruction of the presettlement vegetation in the Saginaw District indicates that communities contained a mix of southern and northern taxa. Areas with more poorly drained clay lake plain soils supported forests with hemlock, white pine, bur oak, swamp white oak, red ash, and American elm, while beech-sugar maple forests grew in moderately well drained clay soils. Beach ridges originally supported white pine, red pine, black oak, and white oak. Hemlock, northern white cedar, tamarack, red maple, trembling aspen, and other swamp species grew in wetter depressions; pin oak was found in poorly drained mineral soils; and beech-maple forest communities grew on the narrow bands of fine textured end moraines.

For this analysis, a more detailed reconstruction of the prehistoric forest communities of the Saginaw Valley is necessary. The reconstruction is based on four independent sets of data: the General

Land Office Survey (GLOS), archaeobotanical data, Curtis' (1971) ordination of Wisconsin forest communities, and pollen sequences, from locations in south-central Michigan (Appendix D). Soil type was used to define the boundaries of these botanical communities because soils strongly effect phytogeography (Albert *et al.* 1986; Bernabo and Webb 1977; Hushen *et al.* 1966; cf. Veatch 1959). Seven forest communities were identified within the region: 1) a northern and southern mesic, hardwood forest; 2) a northern and southern wet-mesic, hemlock and hardwood forest; 3) a northern and southern, mesic, beech-hardwood-pine forest; 4) a southern mesic, beech-maple forest; 5) a northern and southern dry-mesic, hardwood forest; 6) a northern mesic to wet-mesic, lowland swamp forest; and 7) a northern and southern wet-mesic, hardwood forest.

The GLOS records and other historic descriptions of the Saginaw Valley (Houghton 1838; Macomb *et al.* 1856) recount the presence of marsh communities occurring along the river margins and bay. Solute content and water depth influence the composition of marsh communities (Curtis 1971:389), which are dominated by wet loving-taxa including: cattail/*Typha* spp.; arrowhead/*Sagittaria latifolia*; sedge/*Carex* spp.; and bulrush/*Scirpus* spp. This ecological community type has a high biomass.

The reconstruction of the presettlement botanical communities compares well with other phytogeographic reconstructions of presettlement vegetation in the Saginaw Valley (Albert *et al.* 1986; Veatch 1959) and with pollen data from the south-central Lower Peninsula. These sequences indicate that a mixed hardwood forest community, similar to the presettlement forest, was established in this area some time after 3850 B.C. (Ahearn and Bailey 1980; Gilliam *et al.* 1967; McMurray *et al.* 1978). While the relative presence of specific woody genera varied through time, there is no clear pattern to suggest significant changes in the composition of the forest community

(comparable to those observed during the post-glacial and Hypsithermal periods) during the Late Archaic through Middle Woodland periods.

Palynological data also indicate that there was an increase in the presence of aquatic taxa (Cyperaceae, *Typha* sp./*Sparganium* sp. type, *Nuphar* sp., Nymphaceae, *Myriophyllum* sp., and *Typha latifolia*) reflected at the Vestaburg Bog at around 1200 B.C. This increase in aquatic taxa is probably due to the establishment of wetlands in this region following the post-Lake Stanley rise in lake levels and the post-Hypsithermal increase in moisture. This community type is comparable to the marsh community described above and suggests that it was a significant component of the prehistoric environment during the Late Archaic, Early Woodland, and Middle Woodland periods.

These botanical communities contain a variety of edible plant resources that are components of the effective subsistence environment. The reconstruction of the composition and structure of these communities is detailed in Appendix D. The spatial extents of the seven forest communities and marshes have varied through time. During the Nipissing and Algoma lake stages large areas of the interior valley were submerged (Figures 3.1 and 3.2). Consequently, there were larger areas of cattail marshes and smaller tracts of forested area. These variations are taken into account in the calculations of prehistoric resource availability.

Fauna

A variety of economically important faunal species occurs in the Saginaw Valley. Mammals characteristic of forest and aquatic habitats in both the Carolinian and Canadian biotic provinces are present (Baker 1983; Cleland 1966). Historically, 77% of the northern coniferous forest mammal species, 87% of the southern deciduous forest mammal species, 100% of the inter-biome species, and 71% of the Great Plains grasslands species of Michigan were present in the Saginaw Valley (Baker 1983). Many of these taxa are represented in Woodland assemblages from

the Saginaw Valley (see Chapter 5) and testify to the diversity of species available.

Currently, a wide range of species characteristic of lakes, rivers, and shallow, slow-moving waters such as marshes can be found in the Saginaw Valley (Cleland 1966; Keene 1981). Anadromous species such as lake sturgeon and sucker are present and seasonally abundant in rivers. While the productivity of these taxa varied as the aquatic configuration of the valley changed through time, archaeological evidence suggests that Late Archaic and Woodland populations in the Saginaw Valley exploited many of them.

Aquatic and semi-aquatic turtles are also represented in the Saginaw Valley. Archaeological remains from Late Archaic and Woodland period sites in the Saginaw Valley indicate that a variety of these species were exploited prehistorically.

Finally, the Saginaw Valley is located in a minor flyway and seasonally attracts migratory waterfowl. Although densities vary by species, they can be considered an important resource in this area (cf. Keene 1981).

Passenger pigeon (*Ectopistes migratorius*) was also seasonally abundant throughout Michigan in early historic times, as well as prehistorically. This species traveled in extremely large flocks (≥ 1 billion) and would have been a valuable resource to the prehistoric occupants of the Saginaw Valley (Cleland 1966; Keene 1981).

The availability and productivity of these resources varied annually and through time from the Late Archaic through the Middle Woodland period, as the phytogeography of the area changed. These variations are integrated into the decision-making model.

The Effective Subsistence Environment

Approximately a thousand species of plants and animals are described in the ethnographic and archaeological literature as having been used aboriginally in the Upper Great Lakes. Ethnographic sources

suggest that hunting and gathering populations recognize a wide range of edible resources but are selective in their choices of preferred foods (on the basis of efficiency, taste, size, and other factors). The foods that are selected constitute the effective subsistence environment.

For purposes of this study, the effective environment will be limited to 38 plant and 14 animal resources. While this is a relatively small set, it is representative of the major categories of food resources (i.e., nuts, fruits, seeds, greens, roots/tubers/corms, saps, small and large mammals, birds, fish, and shellfish) .

Each resource is coded for several attributes necessary for the model calculations: availability to hunters (males), gatherers (females and adolescents), and collective groups (males, females and adolescents); seasonal availability; productivity (weight x density); size; taste; and nutritional value. Productivity, size, and taste (fat and sweet) values were standardized to allow for comparable weighting in the model calculation. The manner in which each of these values was derived is described below.

Exploitive Group Options

As described in Chapter 2, different sets of resources are taken by 1) males, 2) females and juveniles, and 3) collective work groups. The ethnographic record suggests that males commonly exploit game, including large game and those that are considered higher risk species (i.e., more mobile and less aggregated); females and juveniles collect plant resources, shellfish, and easily captured small game (e.g., turtles); and collective unit exploit more highly aggregated resources that require larger labor groups for efficient capture and processing (i.e., fowl, fish, aggregated small game animals occurring in densities > 100/km^2, and tree sap). Each resource is coded accordingly (Table 3.2).

Table 3.2. Standardized Resource Coding

Resource	M/F/C[b]	Modern Productivity	Nipissing/Algoma Productivity	Prestige[a]	Fat	Sweet
Hickory	F	10	10	N/A	10	2.5
Beaked-hazelnut	F	7	7	N/A	9	2.5
Butternut	F	9	8	N/A	9	2.5
Black walnut	F	6	6	N/A	8	0.0
Beechnut	F	9	9	N/A	7	2.5
White Oak group	F	9	9	N/A	7	2.5
Red/Black Oak	F	8	7	N/A	7	0.0
Hackberry	F	2	2	N/A	0	7.5
Hawthorn	F	1	1	N/A	0	5.0
Strawberry	F	4	3	N/A	0	10.0
Mulberry	F	1	1	N/A	0	10.0
Pin cherry	F	7	7	N/A	0	7.5
Wild black cherry	F	10	10	N/A	0	10.0
Gooseberry/currant	F	10	10	N/A	0	5.0
Blackberry/raspberry	F	10	10	N/A	0	10.0
Elderberry	F	3	3	N/A	0	10.0
Blueberry	F	5	4	N/A	0	7.5
Nannyberry	F	5	5	N/A	0	5.0
Grape	F	4	5	N/A	0	5.0
Pigweed (seeds)	F	3	4	N/A	0	0.0
Goosefoot (seeds)	F	4	4	N/A	0	0.0
Knotweed (seeds)	F	3	3	N/A	0	0.0
Wild leek	F	6	6	N/A	0	0.0
Groundnut	F	1	2	N/A	0	0.0
Jack-in-the-pulpit	F	9	8	N/A	0	0.0
Spring beauty	F	6	6	N/A	0	0.0
J. artichoke	F	1	2	N/A	0	0.0
Arrowhead, wapato	F	8	9	N/A	0	0.0
Solomon's Seal Tuber	F	8	8	N/A	0	0.0
Bulrush	F	8	9	N/A	0	0.0
Cattail	F	7	8	N/A	0	0.0
Aster	F	7	7	N/A	0	0.0
Marsh-marigold	F	5	5	N/A	0	0.0
Goosefoot (greens)	F	3	3	N/A	0	0.0
Wood sorrel	F	6	6	N/A	0	0.0
Aquatic Turtle	F	3	3	N/A	2	0.0
Mussel	F	2	2	N/A	4	0.0

[a] Rank ordered from 1-10

[b] Males (M); Females and Juveniles (F); Collective Group (C)

[c] Prestige appropriate to male resources only

Table 3.2. (cont'd)

Resource	M/F/C[a]	Modern Productivity	Nipissing/Algoma Productivity	Prestige[a]	Fat	Sweet
Sugar Maple (sap)	C	10	10	N/A	0	2.5
Pigeon	C	4	4	N/A	7	0.0
Rabbit	C	3	3	N/A	5	0.0
Squirrel	C	5	5	N/A	5	0.0
Fish	C	6	6	N/A	1	0.0
(Winter, Summer, Fall)				N/A		
Fish	C	7	7	N/A	3	0.0
(Spring)				N/A		
Waterfowl	C	1	1	N/A	4	0.0
(March, August, October)				N/A		
Waterfowl	C	2	2	N/A	4	0.0
(April, September)				N/A		
Bear	M	3	3	8	10	0.0
Beaver	M	5	5	4	4	0.0
Deer	M	9	9	7	5	0.0
Elk	M	10	10	10	5	0.0
Muskrat	M	4	4	1	2	0.0
Raccoon	M	4	4	3	3	0.0
Woodchuck	M	2	2	2	3	0.0
Waterfowl	M	1	1	1	4	0.0
(Winter, Summer)						

Availability

The availability of resources is based on published sources (Baker 1983; Barnes and Wagner 1981; Keene 1981; Yarnell 1964). Resources are coded to reflect the month(s) in which they are most commonly available and most effectively exploited (Table 3.3). Coding in this way prevents inflating the potential dietary contribution of resources.

Depending on climatic conditions, many of the plant resources (i.e., nuts, fruits, seeds, and maple sap) in the Saginaw Valley are available during one or two months, but are productive for relatively short periods of time (2 to 3 weeks). Therefore, nuts, fruits, seeds and maple sap are coded to reflect the month(s) in which they most commonly occur.

Tubers and greens are treated in a somewhat different manner. Tubers are most nutritious during the spring and fall when their carbohydrate content is highest. They can, however, be taken at any time they are visible and are coded accordingly.

Although greens are available any time the plant is leafing, they are often edible only during the early part of their annual growth cycle before alkaloids (which make them bitter and noxious) accumulate and indigestible cellulose dominates their biomass. The effective availability of greens is, therefore, coded according to their early season growth.

Fruits, sap, greens ("seasonings"), and tubers were frequently preserved for winter use (Carver 1956; Charlevoix 1966; Densmore 1974, 1979; Erichsen-Brown 1979; Kinetz 1972:240; Tanner 1956). The availability of plant resources is extended by storage and is incorporated into the model at that level (see Chapter 4).

Passenger pigeon is the only bird that is not present in the Saginaw Valley on a year-round basis. It is coded according to its monthly availability.

Table 3.3. Seasonal Availability of Resources

Resource	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Chestnut	0	0	0	0	0	0	0	0	0	1	0	0
Hickory	0	0	0	0	0	0	0	0	0	1	0	0
Beaked-hazelnut	0	0	0	0	0	0	0	0	1	0	0	0
Butternut	0	0	0	0	0	0	0	0	0	1	0	0
Black walnut	0	0	0	0	0	0	0	0	0	1	0	0
Beechnut	0	0	0	0	0	0	0	0	1	0	0	0
White Oak group	0	0	0	0	0	0	0	0	1	0	0	0
Red/Black Oak	0	0	0	0	0	0	0	0	1	0	0	0
Serviceberry	0	0	0	0	0	0	1	1	0	0	0	0
Hackberry	0	0	0	0	0	0	0	0	1	0	0	0
Hawthorn	0	0	0	0	0	0	0	0	1	0	0	0
Strawberry	0	0	0	0	0	1	0	0	0	0	0	0
Mulberry	0	0	0	0	0	0	1	0	0	0	0	0
Pin cherry	0	0	0	0	0	0	0	1	0	0	0	0
Wild black cherry	0	0	0	0	0	0	0	1	0	0	0	0
Gooseberry/currant	0	0	0	0	0	0	1	1	0	0	0	0
Blackberry/raspberry	0	0	0	0	0	0	1	1	0	0	0	0
Elderberry	0	0	0	0	0	0	0	0	1	0	0	0
Blueberry	0	0	0	0	0	0	0	1	0	0	0	0
Nannyberry	0	0	0	0	0	0	0	0	1	0	0	0
Grape	0	0	0	0	0	0	0	1	1	0	0	0
Pigweed (seeds)	0	0	0	0	0	0	0	0	1	0	0	0
Goosefoot (seeds)	0	0	0	0	0	0	0	0	1	0	0	0
Knotweed (seeds)	0	0	0	0	0	0	0	0	1	0	0	0
Wild leek	0	0	0	0	1	1	1	1	1	1	0	0
Groundnut	0	0	0	1	1	1	1	1	1	1	0	0
Jack-in-the-pulpit	0	0	0	1	1	1	1	0	0	0	0	0
Spring beauty	0	0	0	1	1	1	0	0	0	0	0	0
J. artichoke	0	0	0	0	0	1	1	1	1	1	0	0
Arrowhead, wapato	0	0	0	0	1	1	1	1	1	1	0	0
Solomon's Seal (Tuber)	0	0	0	1	1	1	1	1	1	1	0	0
Bulrush	0	0	0	1	1	1	1	1	1	1	0	0
Cattail	0	0	0	1	1	1	1	1	1	1	0	0
Aster	0	0	0	0	1	1	1	0	0	0	0	0
Marsh-marigold	0	0	0	1	1	0	0	0	0	0	0	0
Goosefoot (greens)	0	0	0	0	1	1	0	0	0	0	0	0
Wood sorrel	0	0	0	1	1	1	1	0	0	0	0	0
Mussel	0	0	0	0	1	1	1	1	1	0	0	0
Aquatic Turtle	0	0	0	0	1	1	1	1	1	0	0	0

Table 3.3. (cont'd)

Resource	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Maple sugar (sap)	0	0	1	0	0	0	0	0	0	0	0	0
Waterfowl	1	1	1	1	1	1	1	1	1	1	1	1
Squirrel	1	1	1	1	1	1	1	1	1	1	1	1
Rabbit	1	1	1	1	1	1	1	1	1	1	1	1
Pigeon	0	0	0	1	1	0	0	0	1	1	0	0
Fish	1	1	1	1	1	1	1	1	1	1	1	1
Bear	1	1	1	1	1	1	1	1	1	1	1	1
Beaver	1	1	1	1	1	1	1	1	1	1	1	1
Deer	1	1	1	1	1	1	1	1	1	1	1	1
Elk	1	1	1	0	0	0	0	0	0	0	1	1
Raccoon	1	1	1	1	1	1	1	1	1	1	1	1
Muskrat	1	1	1	1	1	1	1	1	1	1	1	1
Woodchuck	1	1	1	1	1	1	1	1	1	1	1	1

Mussels and turtles are effectively available during the warmer months when the water is warm. They are coded according to this criterion.

The majority of the mammals considered in this model are available on a year-round basis and were coded as such. Elk (wapiti) and bear are, however, coded as being available only in the winter months. Elk is the one mammal whose availability, within the valley, varies seasonally. Elk and deer occur in similar environments but elk prefer more open habitats (Baker 1983:571; Banfield 1981:399-400; Cleland 1966:245). In the winter, they frequently move to grassy swamp habitats to browse and graze (Baker 1983:571; Banfield 1981:399-400). Elk would, therefore, be more available in the Saginaw Valley during the late fall (November) and winter months. Bear is coded as being available during the late fall and winter months because it was commonly taken when it was fattest and when hibernating and, therefore, less dangerous to hunt (Blair 1911:127; Carver 1956:286-287; Henry 1969:135-136).

Productivity

Productivity values were initially estimated through a calculation of the density x weight (yield) of each resource (Tables 3.4 - 3.6). Densities and yields of plant and animal resources were calculated in different ways.

Densities of plant taxa were calculated for each of the plant communities using GLOS data and comparative data from Wisconsin. (Appendix E provides a detailed description of the manner in which densities were calculated.) The average of these densities was then used to calculate the mean density of any given resource within the valley.

Yields of specific plant resources were derived from several sources (Cowan 1985; Hewitt 1983; Keene 1981; Reidhead 1979) that provide detailed summaries of studies on the habitat preferences and productive variability of these resources. Factors such as average

Table 3.4. Efficiency: Female/Juvenile Resource Choices

RESOURCE	DENSITY[a]	WEIGHT[b]	PRODUCTIVTY[c]	MODERN DENSITY	MODERN PRODUCTIVITY	ALGOMA DENSITY	ALGOMA PRODUCTIVITY	NIPISSING DENSTIY	NIPISSING PRODUCTIVITY
Beaked-hazelnut	10,500.6	0.060	2.52	6,936,061.0	416,163.66	4,888,136.6	293,288.2	4,378,210.7	262,692.6
Butternut	326.9	2.270	2.97	829,850.8	1,883,761.32	700,711.5	1,590,615.1	620,320.3	1,408,127.1
Black walnut	42.0	2.270	0.38	75,194.3	170,691.06	65,191.3	147,984.3	58,248.7	132,224.5
Beechnut	4,390.4	0.270	4.74	14,570,961.0	3,934,159.47	12,265,013.0	3,311,553.5	10,838,335.0	2,926,350.5
White oak group	1,565.5	0.540	3.38	8,550,703.0	4,617,379.62	7,006,131.8	3,783,311.2	6,114,292.0	3,301,717.7
Red/Black oak group	1,646.7	0.270	1.78	3,545,029.2	957,157.88	2,859,300.5	772,011.1	2,458,705.6	663,850.5
Hickory	1,428.3	2.830	16.17	3,585,415.7	10,146,726.43	2,904,968.6	8,221,061.1	2,525,732.8	7,147,823.8
Hackberry	369.4	0.480	0.71	2,766.8	1,328.06	4,234.0	2,032.3	4,599.5	2,207.8
Hawthorn	10.9	0.320	0.01	102.6	32.83	148.2	47.4	161.1	51.6
Strawberry	6,006.0	0.040	1.28	796,889.2	31,875.57	296,375.6	11,855.0	243,639.8	9,745.6
Mulberry	9.7	8.860	0.34	55.5	491.73	69.4	614.9	45.8	405.8
Pin cherry	33.4	8.570	1.14	39,795.5	341,047.44	37,507.7	321,441.0	34,211.2	293,190.0
Wild black cherry	198.9	11.420	9.09	652,309.3	7,449,372.21	541,436.1	6,183,200.3	475,225.6	5,427,076.4
Gooseberry/currant	13,319.4	0.250	13.32	74,625,312.0	18,656,328.00	59,971,888.0	14,992,972.0	51,823,937.0	12,955,984.3
Blackberry/raspberry	64,241.1	0.140	35.98	196,895,932.8	27,565,430.59	157,543,419.0	22,056,078.7	136,154,096.4	19,061,573.5
Elderberry	2,639.0	0.250	2.64	17,272.4	4,318.10	34,248.6	8,562.2	39,151.4	9,787.9
Blueberry	9,725.9	0.040	1.56	968,072.8	38,722.91	360,041.5	14,401.7	295,977.2	11,839.1
Nannyberry	8,006.0	0.120	3.84	796,889.2	95,626.70	296,375.6	35,565.1	243,639.8	29,236.8
Grape	4,872.8	0.620	12.08	43,660.4	27,069.45	65,977.8	40,906.2	74,602.7	46,253.7
Pigweed seeds	53,099.2	0.023	4.89	460,370.4	10,588.52	558,543.5	12,846.5	615,303.0	14,152.0
Goosefoot seeds	53,099.2	0.020	4.25	460,370.4	9,207.41	558,543.5	11,170.9	615,303.0	12,306.1
Knotweed seeds	53,099.2	0.011	2.34	460,370.4	5,064.07	558,543.5	6,144.0	615,303.0	6,768.3
Wild leek	36,042.0	0.010	1.44	19,452,468.0	194,524.68	17,377,576.0	173,775.8	15,907,043.0	159,070.4
Groundnut	33,755.1	0.010	1.35	51,757.8	517.58	182,727.6	1,827.3	204,105.9	2,041.1
Jack-in-the-pulpit	44,986.3	0.010	1.80	228,776,242.0	2,287,762.42	185,187,664.6	1,851,876.6	160,388,632.2	1,603,886.3
Spring beauty	38,216.5	0.010	1.53	25,895,937.0	258,959.37	23,440,294.0	234,402.9	21,688,604.0	216,886.0
J. artichoke	33,755.1	0.010	1.35	51,757.8	517.58	182,727.6	1,827.3	204,105.9	2,041.1
Arrowhead, wapato	1,000,000.0	0.020	80.00	66,209,000.0	1,324,180.00	146,853,000.0	2,937,060.0	131,054,000.0	2,621,080.0
Solomon's seal tuber	108,038.7	0.010	4.32	157,588,615.3	1,575,886.15	141,582,657.2	1,415,826.6	128,775,008.3	1,287,750.1

a. Density per km2
b. Weight in kilograms
c. Productivity = kg/0.004 km2

Table 3.4. (cont'd)

RESOURCE	DENSITY[a]	WEIGHT[b]	PRODUCTIVTY[c]	MODERN DENSITY	MODERN PRODUCTIVITY	ALGOMA DENSITY	ALGOMA PRODUCTIVITY	NIPISSING DENSTIY	NIPISSING PRODUCTIVITY
Bulrush	1,000,000.0	0.020	80.00	66,209,000.0	1,324,180.00	146,853,000.0	2,937,060.0	131,054,000.0	2,621,080.0
Cattail	370,000.0	0.020	29.60	24,497,330.0	489,946.60	54,335,610.0	1,086,712.2	48,489,980.0	969,799.6
Aster	28,522.8	0.007	0.80	86,384,588.0	604,692.12	69,301,528.0	485,110.7	59,934,080.0	419,538.6
Marsh-marigold	3,115.2	0.007	0.09	7,830,740.9	54,815.19	6,308,651.5	44,160.6	5,453,717.2	38,176.0
Goosefoot greens	53,099.2	0.007	1.49	460,370.4	3,222.59	558,543.5	3,909.8	615,303.0	4,307.1
Wood sorrel	16,812.7	0.007	0.47	42,285,513.0	295,998.59	34,066,717.0	238,467.0	29,450,072.0	206,150.5
Aquatic Turtle	100.0	6.400	2.56	538.0	3,443.20	551.0	3,526.4	542.0	3,468.8
Mussel	22,000.0	0.014	1.23	118,360.0	1,657.04	121,220.0	1,697.1	119,240.0	1,669.4

Table 3.5. Efficiency: Collective Resource Choices

RESOURCE	DENSITY[a]	WEIGHT[b]	PRODUC-TIVITY[c]	MODERN DENSITY	WOODLAND PRODUCTIVITY	ALGOMA DENSITY	ALGOMA PRODUCTIVITY	NIPISSING DENSITY	NIPISSING PRODUCTIVITY
Maple sap	10444.7	23.00	1,921.82 [d]	19,886,076.0	457,379,748.0	17,478,518.0	402,005,914.0	15,768,079.0	362,665,817.0
Fish-January	948	2.00	75.84	622,636.9	1,245,273.8	1,131,532.8	2,263,065.6	1,463,002.9	4,526,131.2
Fish-February	948	2.00	75.84	622,636.9	1,245,273.8	1,131,532.8	2,263,065.6	1,463,002.9	4,526,131.2
Fish-March	948	2.00	75.84	622,636.9	1,245,273.8	1,131,532.8	2,263,065.6	1,463,002.9	4,526,131.2
Fish-April	1423.5	2.00	113.88	934,940.6	1,869,881.1	1,699,089.6	3,398,179.2	2,196,819.2	6,796,358.4
Fish-May	1423.5	2.00	113.88	934,940.6	1,869,881.1	1,699,089.6	3,398,179.2	2,196,819.2	6,796,358.4
Fish-June	948	2.00	75.84	622,636.9	1,245,273.8	1,131,532.8	2,263,065.6	1,463,002.9	4,526,131.2
Fish-July	948	2.00	75.84	622,636.9	1,245,273.8	1,131,532.8	2,263,065.6	1,463,002.9	4,526,131.2
Fish-August	948	2.00	18.98	622,636.9	1,245,273.8	1,131,532.8	2,263,065.6	1,463,002.9	4,526,131.2
Fish-September	948	2.00	75.84	622,636.9	1,245,273.8	1,131,532.8	2,263,065.6	1,463,002.9	4,526,131.2
Fish-October	948	2.00	75.84	622,636.9	1,245,273.8	1,131,532.8	2,263,065.6	1,463,002.9	4,526,131.2
Fish-November	948	2.00	75.84	622,636.9	1,245,273.8	1,131,532.8	2,263,065.6	1,463,002.9	4,526,131.2
Fish-December	948	2.00	75.84	622,636.9	1,245,273.8	1,131,532.8	2,263,065.6	1,463,002.9	4,526,131.2
Pigeon	2717.0	0.30	32.60	2,400,295.6	720,088.7	2,057,105.9	617,131.8	2,259,739.8	677,921.9
Rabbit	117.7	1.37	6.45	406,892.4	557,442.6	335,932.4	460,227.3	294,073.6	402,880.9
Squirrel	494.00	0.60	11.86	1,708,353.3	1,025,012.0	1,410,424.8	846,254.9	1,234,679.4	740,807.6
Waterfowl-March	1199.4	1.20	57.57	79,411.1	95,293.3	176,135.5	211,362.6	157,186.2	188,623.4
Waterfowl-April	2398.8	1.20	115.14	158,822.1	190,586.6	352,271.0	422,725.2	314,372.3	377,246.8
Waterfowl-August	1199.4	1.20	57.57	79,411.1	95,293.3	176,135.5	211,362.6	157,186.2	188,623.4
Waterfowl-September	2398.8	1.20	115.14	158,822.1	190,586.6	352,271.0	422,725.2	314,372.3	377,246.8
Waterfowl-October	1199.4	1.20	57.57	79,411.1	95,293.3	176,135.5	211,362.6	157,186.2	188,623.4

a. Density per km2

b. Weight in kilograms

c. Productivity = kg per 0.04 km2

d. Productivity estimate for maple sap based on 0.008 km2

Table 3.6. Efficiency: Male Resource Choices

RESOURCE	DENSITY[a]	WEIGHT[b]	PRODUC-TIVITY[c]	MODERN DENSITY	WOODLAND PRODUCTIVITY	ALGOMA DENSITY	ALGOMA PRODUCTIVITY	NIPISSING DENSITY	NIPISSING PRODUCTIVIT
Bear	0.07	153.00	1.07	242.1	37,037.4	199.9	30,578.2	175.0	26,768.0
Beaver	5.10	20.55	10.48	5,151.2	105,857.3	3,882.5	79,784.7	3,932.0	80,803.1
Deer	6.10	86.48	52.75	21,095.1	1,824,300.0	17,416.2	1,506,151.0	15,246.0	1,318,477.6
Elk	3.05	312.25	95.24	10,547.5	3,293,464.8	8,708.1	2,719,100.6	7,623.0	2,380,288.2
Muskrat	54.75	1.20	6.57	55,299.7	66,359.7	41,679.4	50,015.3	42,211.4	50,653.7
Raccoon	3.86	9.50	3.67	13,348.7	126,812.4	11,020.7	104,696.9	9,647.5	91,651.2
Woodchuck	1.70	3.90	0.66	5,878.9	22,927.9	4,853.7	18,929.4	4,248.9	16,570.7
Waterfowl-January	26.00	1.20	3.12	1,721.4	2,065.7	3,818.2	4,581.8	3,407.4	4,088.9
Waterfowl-February	26.00	1.20	3.12	1,721.4	2,065.7	3,818.2	4,581.8	3,407.4	4,088.9
Waterfowl-May	26.00	1.20	3.12	1,721.4	2,065.7	3,818.2	4,581.8	3,407.4	4,088.9
Waterfowl-June	26.00	1.20	3.12	1,721.4	2,065.7	3,818.2	4,581.8	3,407.4	4,088.9
Waterfowl-July	26.00	1.20	3.12	1,721.4	2,065.7	3,818.2	4,581.8	3,407.4	4,088.9
Waterfowl-November	26.00	1.20	3.12	1,721.4	2,065.7	3,818.2	4,581.8	3,407.4	4,088.9
Waterfowl-December	26.00	1.20	3.12	1,721.4	2,065.7	3,818.2	4,581.8	3,407.4	4,088.9

[a] Density per km2

[b] Weight in kilograms

[c] Productivity = kg / 0.1 km2

bearing, predation, and percentage of edible biomass were taken into consideration when determining yields. Yield values were primarily derived from Hewitt's (1983) research which provides the most conservative and best documented values (Tables 3.4 to 3.6).

Plant productivity values per km^2 were calculated using the average density x yield values described above and in Appendix D. Productivity of plant resources for each of the lake stages were calculated using the total of the estimates of their overall densities within each of the defined communities (Appendix D).

Productivity values of animals are based on their densities within specific habitats. For purposes of this study, habitats were broadly defined as: woodland, river and lake margin, and lake and river proper. Densities of animals in each of these habitats were derived from sources that provide detailed descriptions of variability in animal densities within Michigan and the Great Lakes region (Baker 1983; Keene 1981; Lovis 1989). Average densities of animals per km^2 were used in this model. These values were multiplied by average live weights of animals to calculate animal productivity per km^2, during each of the lake stages considered (Table 3.4 to 3.6).

Fractions of the estimated productivity per km^2 were used to represent the dietary contribution of each resource selected within the model simulation. As discussed in Chapter 2, the dietary contribution of each resource collected by females and juveniles was calculated at kilograms of food per 0.004 km^2 (1 acre). Male resources were calculated as contributing kilograms of meat per 0.10 km^2 (25 acres). Collective resources, other than maple sap, were estimated to provide yields per 0.08 km^2 (20 acres); while maple sap was estimated as being collected from a 0.008 km^2 (2 acre) area (see justification Chapter 2).

For purposes of the simulation of resource options, estimates of the productivity values of each resource per lake stage and exploitive group (i.e., male; female and juvenile; and collective) were

standardized to rank order values between one and ten (Table 3.3). This allows for comparable weighting of each of the selection criteria.

Summary

Understanding of the prehistoric subsistence strategy in the Saginaw Valley requires a reconstruction of both the overall environment and the effective subsistence environment. The former provides the framework for defining the latter.

The Saginaw Basin is a distinct ecosystem defined by a unique set of geologic, climatic, and biotic characteristics. The basin is a relict of a series of glacial and post-glacial events. The region is bordered by beach terraces produced by Lake Saginaw and other pre- and post-glacial high water levels. These terraces and moraines provide moderate relief and circumscribe the Cass, Shiawassee, and Tittabawassee rivers that drain into the Saginaw River, which drains into Saginaw Bay. The interior of the drainage basin has relatively level lacustrine deposits broken by a crescent of end moraines running parallel to the bay. The dendritic river network that drains the region gives it a highly dissected character (Figure 3.1).

The present climate of the Saginaw Valley is relatively mild because of the ameliorating effects of Lake Huron and Saginaw Bay. The growing season is relatively long (153 days), given its latitude, and precipitation is moderate (average 1.75 m of annual precipitation).

Ecological studies indicate that by around 3850 B.C., the climate in southern Michigan was similar to that of today (Ahearn and Bailey 1980; Gilliam *et al.* 1967; Holman 1990; McMurray *et al.* 1978). While there were climatic fluctuations during the Holocene, conditions were fairly stable from the Late Archaic through the Middle Woodland period. Therefore, the present climate in the Saginaw Valley is reflective of its general character throughout the Late Archaic and Early and Middle Woodland periods.

Biotically, the Saginaw region is diverse because it is located in the transition zone between the Carolinian and Canadian biotic provinces (Cleland 1966; Dice 1943; Potzger 1948). The reconstruction of the presettlement environment presented here is based on GLOS, archaeobotanical data, and comparative community reconstructions (Curtis 1971; Kapp 1977) and includes seven forest communities, delineated on the basis of soil type. These communities were dominated by a range of northern and southern, dry-mesic, mesic, and wet-mesic taxa. Extensive wetlands were also present because of the limited topographic relief and poorly drained glacial and lacustrine soils.

Faunal resources in the valley include taxa characteristic of the Carolinian and Canadian biotic provinces (Baker 1983; Cleland 1966). The primary habitats of these species have been defined as woodland, floodplain/lake margin, riverine, and lacustrine.

The paleoecology of the Saginaw Valley changed between the Late Archaic period and the Middle Woodland period. Much of the variation in resource productivity relates to changes in the elevations of prehistoric lakes and the concomitant changes in the embayment and the phytogeography (Figures 3.3 - 3.5). The Nipissing and Algoma lake stages occurred during the Late Archaic period and lake levels stabilized at their current elevations by the Woodland era.

For purposes of this study, the effective subsistence environment has been confined to 52 resources. While the availability of these resources is assumed to remain constant from the Late Archaic to the Middle Woodland, their productivity varies through time. Late Archaic productivity estimates are based on calculations of the km^2 of forest, forest edge, wetland, and aquatic habitats and the Early and Middle Woodland productivity estimates on modern lake level habitat areas.

Although changes in (Nipissing and Algoma) lake level elevations resulted in variations in resource productivity during the Late Archaic period, no discernable change in resource use has been identified by previous analyses of this period. In contrast, there is a marked change

in the subsistence patterns from the Early Woodland to the Middle Woodland period (Allison 1972; Cleland 1966; Luxenberg 1972; Ozker 1982), although the environmental productivity of the area did not change decernibly during this time (when lake levels had essentially stabilized at modern elevation). The simulation of economic decision making during the Late Archaic, Early Woodland, and Middle Woodland may clarify the changing cultural goals affecting the prehistoric adaptation to this environment.

CHAPTER 4

Alternative Foraging Strategies in the Saginaw Valley

This research is directed toward simulating alternative subsistence strategies in the Saginaw Valley during the Late Archaic (3000 to 550 B.C.), Early Woodland (600 to 200 B.C.), and Middle Woodland (200 B.C. to A.D. 500) periods. The simulations of resource choices are structured in terms of three analytical dimensions: efficiency, taste (fat and sweet), and prestige (prey size). Decisions are made sequentially by each of three exploitive groups (females and juveniles, a collective group, and males) until energy (kcal) and eight nutrient requirements[1] are satisfied.

Five alternative models are presented. In the first model, taste[2] is the sole criterion on which resource choices are based. Two others simulate choices based solely on the efficiency of exploiting resources in the Late Archaic (Nipissing/Algoma lake stage) period (model 2) and in the Early and Middle Woodland (modern lake level) periods (model 3). In the last two models, the predicted subsistence patterns are based on the multiple goals of efficiency, taste, and prestige in the Late Archaic (model 4) and Early and Middle Woodland periods (model 5). The resulting five simulated subsistence patterns vary in terms of: 1) the resources that are chosen; 2) the order in which these resources are selected; 3) the relative dietary contributions of the members of different exploitive groups (females and juveniles, collective group, and males); and 4) the energy and nutrient inputs provided by the

---

[1] These nutrients include protein, vitamin A, vitamin C, thiamin, riboflavin, niacin, phosphorous, and iron.

[2] For the purposes of this study, taste is treated as a constant through time and is not modeled for each of the time periods.

different sets of resource choices. Variations in the simulated subsistence patterns *within* cultural periods (i.e., Late Archaic and Early and Middle Woodland) highlight the effects of efficiency, taste, and prestige on the predicted subsistence strategies. In contrast, variations in the simulated subsistence patterns *between* the cultural periods accent the effects of changes in resource productivity, and thus efficiency, on decisions that are otherwise based on the same factors. These variations are discussed and the archaeological expectations of each of the simulations are described. In the subsequent chapter, the expectations are compared with archaeological subsistence data from the Late Archaic, Early Woodland, and Middle Woodland periods in the Saginaw Valley. This comparison is directed toward evaluating the role of goals such as taste and prestige and the effect of changing environmental productivity, and thus efficiency, on subsistence decision making and adaptation.

	Choice Criteria	Time Period
Model 1	Taste	Late Archaic Early and Middle Woodland
Model 2	Efficiency	Late Archaic
Model 3	Efficiency	Early and Middle Woodland
Model 4	Multiple Goals	Late Archaic
Model 5	Multiple Goals	Early and Middle Woodland

Subsistence Decision Simulations
Choices Based on Taste (Model 1)

Taste is, to an extent, culturally defined, although some preference for sweet and fatty foods is innate and affects subsistence choice. The sugar and fat contents of foods can, therefore, be used as measures for ranking foods in terms of taste (see Chapter 3). By simulating choices based on taste and comparing them, and other simulations, with archaeological subsistence data, the relative importance of taste can be evaluated.

To simulate subsistence decision making based on taste, the program selects resources in descending order from the highest ranked options to lower ranked options until energetic and nutritional needs are satisfied (Appendix E, Section 1 [simulation outputs that detail the energetic and nutritional contribution of each set of monthly resource decisions]). The results of this simulation are applicable to both Late Archaic and Woodland populations because taste is not affected by changing environmental conditions.

In this simulation the female/juvenile group selects 22 of their 37 resource options (59%) and the collective and male groups exploit all of their options (i.e., 6 and 8 resources, respectively) (Table 4.1). Further, storage of 33% of the food collected by females/juveniles during the summer (June, July and August) and fall (September and October) accounts for approximately 8% to 9% of the winter (November, December, January, February, and March) diet.

The dietary contribution (quantity of food in kilograms) of each of the exploitive groups varies over the course of the annual round (Table 4.1; Figure 4.1). Overall, the collective group provides the greatest dietary contribution. In June and July, however, females/juveniles contribute as much or more food than the collective group. In the winter months, males contribute slightly more food than the collective group.

Table 4.1 lists the foods selected each month and the number of kilograms of each that are used by a household. Sweet fruits (i.e., strawberries, blackberries, gooseberries/currants, elderberries, mulberries, black cherries, and grapes), nuts with high fat content (i.e., hazelnut, hickory nuts, black walnut, and butternut), and mussels and turtles (which are somewhat fatty) are selected by the female/juvenile exploitive group during the months when they are available. The other female/juvenile choices are foods that are coded as being neutral in terms of taste. These foods are selected because there are no other alternatives available in the modeled simulation.

Table 4.1. All Lake Stage Environments: Resource Choices Based on Taste

Resource	June	July	Aug	Sept	Oct	Winter Months[a]	March	April	May
Female/Juvenile Choices									
Goosefoot (greens)	1.49[b]	0.00	0.00	0.00	0.00	0.10	0.10	0.00	0.00
Marsh Marigold	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00
Wood Sorrel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00
Jack-in-the-Pulpit	1.80	1.80	0.00	0.00	0.00	0.24	0.24	1.80	1.80
Groundnut	1.35	1.35	0.00	0.00	1.35	0.27	0.27	1.35	1.35
Jerusalem Artichoke	1.35	1.35	0.00	0.00	1.35	0.27	0.27	0.00	0.00
Spring Beauty	1.53	0.00	0.00	0.00	0.00	0.10	0.10	1.53	1.53
Wild Leek	1.44	1.44	0.00	0.00	0.00	0.19	0.19	0.00	0.00
Arrowhead	80.00	80.00	0.00	0.00	0.00	10.56	10.56	0.00	0.00
Strawberry	1.28	0.00	0.00	0.00	0.00	0.08	0.08	0.00	0.00
Blackberry	0.00	35.98	35.98	0.00	0.00	4.75	4.75	0.00	0.00
Gooseberry/Currant	0.00	13.32	0.00	0.00	0.00	0.88	0.88	0.00	0.00
Elderberry	0.00	0.00	0.00	2.64	0.00	0.17	0.17	0.00	0.00
Mulberry	0.00	0.34	0.00	0.00	0.00	0.02	0.02	0.00	0.00
Black cherry	0.00	0.00	9.09	0.00	0.00	0.60	0.60	0.00	0.00
Grape	0.00	0.00	12.08	0.00	0.00	0.80	0.80	0.00	0.00
Hazelnut	0.00	0.00	0.00	2.52	0.00	0.17	0.17	0.00	0.00
Hickory	0.00	0.00	0.00	0.00	16.17	1.07	1.07	0.00	0.00
Black walnut	0.00	0.00	0.00	0.00	0.38	0.03	0.03	0.00	0.00
Butternut	0.00	0.00	0.00	0.00	2.97	0.20	0.20	0.00	0.00
Mussels	1.23	1.23	0.00	0.00	0.00	0.16	0.16	0.00	1.23
Aquatic Turtle	2.56	0.00	0.00	0.00	0.00	0.17	0.17	0.00	0.00
Total Stored foods[c]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Female	94.03	136.81	57.15	5.16	22.22	20.81	20.81	4.68	5.91
% Total Kg	35.41	44.38	29.02	2.39	7.92	8.45	7.86	1.30	2.49
Collective Choices									
Fish	75.84	75.84	0.00	0.00	75.84	75.84	75.84	113.88	113.88
Squirrel	11.86	11.86	11.86	0.00	11.86	11.86	11.86	11.86	11.86
Rabbit	6.45	6.45	6.45	0.00	6.45	6.45	6.45	6.45	6.45
Waterfowl	0.00	0.00	57.57	115.14	57.57	0.00	57.57	115.14	0.00
Pigeon	0.00	0.00	0.00	32.60	32.60	0.00	0.00	32.60	32.60
Maple Syrup	0.00	0.00	0.00	0.00	0.00	0.00	48.05	0.00	0.00
Total Collective	94.15	94.15	75.88	147.74	184.32	94.15	199.77	279.93	164.79
% Total Kg	35.46	30.54	38.53	68.36	65.67	38.20	58.99	78.03	69.30

[a] Choices in November, December, January and February

[b] Kilograms

[c] 33% of summer and fall foods divided between five months

Table 4.1. (cont'd)

Resource	June	July	August	Sept	Oct	Winter Months	March	April	May
Male Choices									
Beaver	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.48
Deer	52.75	52.75	52.75	52.75	52.75	52.75	52.75	52.75	52.75
Raccoon	3.67	3.67	0.00	0.00	3.67	3.67	0.00	3.67	0.00
Muskrat	6.57	6.57	0.00	0.00	6.57	6.57	0.00	6.57	0.00
Elk	0.00	0.00	0.00	0.00	0.00	53.08	53.08	0.00	0.00
Bear	0.00	0.00	0.00	0.00	0.00	1.07	1.07	0.00	0.00
Woodchuck	0.66	0.66	0.66	0.00	0.66	0.66	0.66	0.66	0.66
Waterfowl	3.21	3.21	0.00	0.00	0.00	3.21	0.00	0.00	3.21
Total Male	77.34	77.34	63.89	63.23	74.13	131.49	118.04	74.13	67.10
% Total Kg	29.13	25.09	32.44	29.26	26.41	53.35	34.86	20.66	28.22

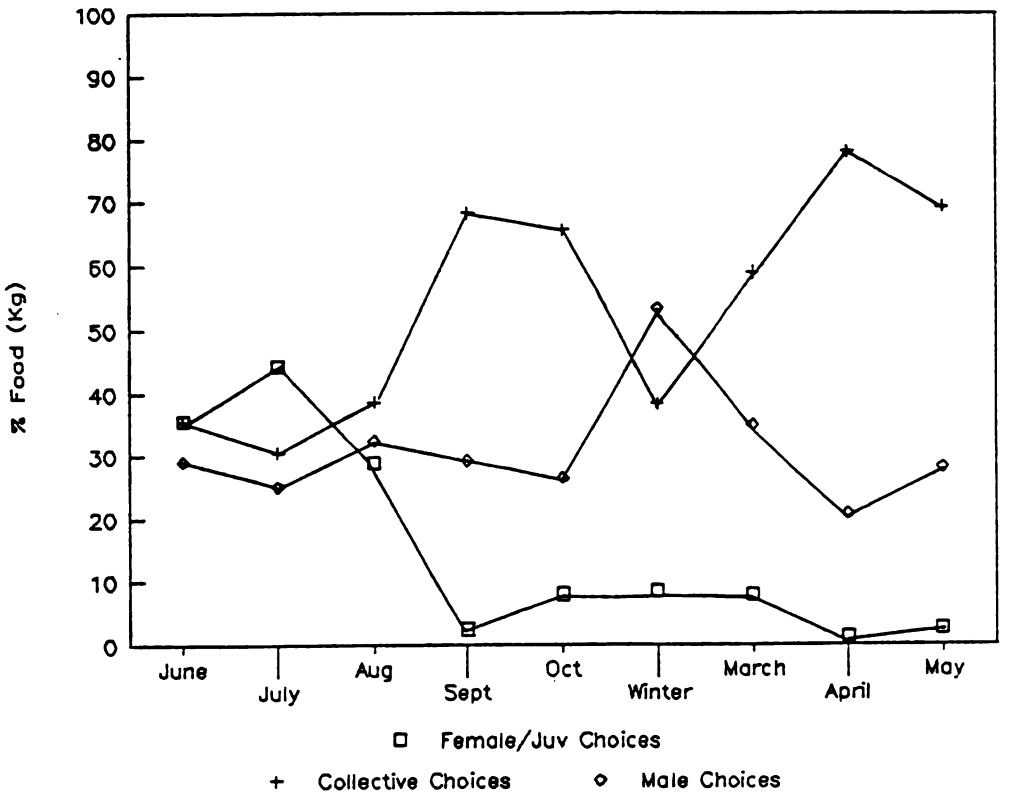


Figure 4.1. Dietary Contribution/Exploitive Group: Choices Based on Taste

Among the collective group's choices, fatty fowl (i.e., waterfowl and pigeon) are preferred above other foods (i.e., rabbit, squirrel, fish, and maple sap/syrup)[3] when they are available; however, for the majority of the annual round, rabbit, squirrel, and fish are exploited. Similarly, for males, bear (which is extremely fatty) and elk are preferred resource choices when they are available. During most of the year, however, deer, waterfowl, beaver, and woodchuck are the primary male resources, while muskrat and raccoon are occasionally selected when additional choices are required to satisfy dietary needs.

Vitamin C and calories (kcal) are consistently the last two requirements that are satisfied. Throughout the majority of the year

[3] Maple sap has been converted to syrup values to better estimate the food value of this resource.

(June through August and November through February), the need for additional calories forces the simulation to select resources beyond what is required to satisfy other nutrient requirements. In contrast, during September, October, March and April, vitamin C requirements drive the simulation to select resources in excess of the other dietary requirements. In May, calories and vitamin C requirements are simultaneously satisfied (Appendix E, Section 1).

In this simulation and in those discussed below, vitamin C may not be as "critical" as the results suggest because it can be derived from many sources (e.g., the stomach contents of animals) not specified in this study. The simulations do, however, point out the limitations of each of the seasonal diet choices that might be more significant over longer periods of time or when the productivity of preferred foods is low.

Late Archaic Choices Based on Efficiency (Model 2)

Several studies have demonstrated that efficiency is an important factor affecting subsistence decision making (Hewitt 1983; Keene 1981, 1983; Smith 1983; Winterhalder and Smith 1981). Other studies (e.g., Cowan 1985; Jochim 1976) have shown that factors including taste and prestige also influence subsistence choices. Therefore, by simulating choices based on efficiency during different cultural periods (Late Archaic and Early and Middle Woodland)[4] and comparing them, and other simulated choices, with archaeological subsistence data, the relative importance of efficiency on subsistence choice can be evaluated.

In the simulation of Late Archaic subsistence choices based on the efficiency of exploiting resources in the Nipissing/Algoma environment,[5] foods are again selected in descending order from the highest ranked

---

[4] Nipissing/Algoma and modern lake stage environments

[5] The efficiency of exploiting resources in the Nipissing and Algoma lake stages are ranked according to the same scale because the relative productivity of resources, to each other, does not vary (see Chapter 3 for further discussion).

options to lower ranked options until energy and nutritional needs are satisfied (Appendix E, Section 2). In this simulation, the female/juvenile group selects nine of the 37 resource options (24%), and the collective and male groups exploit all of their options (Table 4.2). Further, approximately 9% of the winter diet is derived from storage of 17% of the female/juvenile resources collected during the summer and fall months.

In this simulation of Late Archaic choices based on efficiency, the dietary contribution of each of the exploitive groups varies over the course of the annual round (Table 4.2, Figure 4.2). Further, the monthly contribution of each group is quite different from the simulation of decisions based on taste. Females/juveniles provide the greatest dietary contribution over the course of the year, although the collective group provides almost as much food as the females/juveniles. Males provide considerably less food overall. Females/juveniles contribute the highest percentages of food in June, July, September, October, and May. The collective group contributes the greatest percentages of food in March and April. Males contribute relatively low percentages of food (less than 25%) except in the winter months and March.

The resources selected each month and the number of kilograms of each are provided in Table 4.2. Wetland tubers (bulrush and arrowhead) are the primary resource contributed by females/juveniles throughout the majority of the year. Their relative importance in the summer and the fall is offset by other resources (i.e., blackberry, gooseberries/ currants, black cherries, hickory, and beechnut) that are highly productive and, therefore, efficient to collect but only available during specific seasons. Less productive tubers (jack-in-the-pulpit and cattail) are selected in April when other more productive resources (e.g., arrowhead, which is not fully visible and therefore difficult to procure) are unavailable.

Table 4.2. Late Archaic Resouce Choices Based on Efficiency

Resource	June	July	Aug	Sept	Oct	Winter Months[a]	March	April	May
Female/Juvenile Choices									
Jack-in-the-Pulpit	0.00[b]	0.00	0.00	0.00	0.00	0.00	0.00	1.80	0.00
Arrowhead	80.00	0.00	0.00	80.00	0.00	5.44	5.44	0.00	80.00
Bulrush	80.00	80.00	80.00	80.00	80.00	13.60	13.60	80.00	80.00
Cattail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.60	0.00
Blackberry	0.00	35.98	35.98	0.00	0.00	2.45	2.45	0.00	0.00
Gooseberry/Currant	0.00	13.32	13.32	0.00	0.00	0.91	0.91	0.00	0.00
Black cherry	0.00	0.00	9.09	0.00	0.00	0.31	0.31	0.00	0.00
Beechnut	0.00	0.00	0.00	4.74	0.00	0.16	0.16	0.00	0.00
Hickory	0.00	0.00	0.00	0.00	16.17	0.55	0.55	0.00	0.00
Total stored food[c]	0.00	0.00	0.00	0.00	0.00	23.41	23.41	0.00	0.00
Total Female	160.00	129.30	138.39	164.74	96.17	23.41	23.41	111.40	160.00
% Total Kg	52.61	44.53	38.06	46.81	40.02	9.40	9.25	33.09	46.76
Collective Choices									
Fish	75.84	75.84	75.84	75.84	75.84	75.84	75.84	113.88	113.88
Squirrel	11.86	11.86	11.86	11.86	11.86	11.86	0.00	11.86	11.86
Rabbit	0.00	6.45	6.45	0.00	0.00	6.45	0.00	0.00	0.00
Waterfowl	0.00	0.00	57.57	0.00	0.00	0.00	0.00	0.00	0.00
Pigeon	0.00	0.00	0.00	32.60	0.00	0.00	0.00	32.60	0.00
Maple Sap	0.00	0.00	0.00	0.00	0.00	0.00	48.05	0.00	0.00
Total Collective	87.70	94.15	151.72	120.30	87.70	94.15	123.89	158.34	125.74
% Total Kg	28.84	32.43	41.73	34.18	36.50	37.80	48.94	47.04	36.75
Male Choices									
Beaver	0.00	10.48	10.48	10.48	0.00	10.48	0.00	10.48	0.00
Deer	52.75	52.75	52.75	52.75	52.75	52.75	52.75	52.75	52.75
Raccoon	3.67	3.67	3.67	3.67	3.67	3.67	0.00	3.67	3.67
Muskrat	0.00	0.00	6.57	0.00	0.00	6.57	0.00	0.00	0.00
Elk	0.00	0.00	0.00	0.00	0.00	53.08	53.08	0.00	0.00
Bear	0.00	0.00	0.00	0.00	0.00	1.07	0.00	0.00	0.00
Woodchuck	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.00	0.00
Waterfowl	0.00	0.00	0.00	0.00	0.00	3.21	0.00	0.00	0.00
Total Male	56.42	66.90	73.47	66.90	56.42	131.49	105.83	66.90	56.42
% Total Kg	18.55	23.04	20.21	19.01	23.48	52.80	41.81	19.87	16.49

[a] Choices in November, December, January and February

[b] Kilograms

[c] 17% of summer and fall foods divided between five months

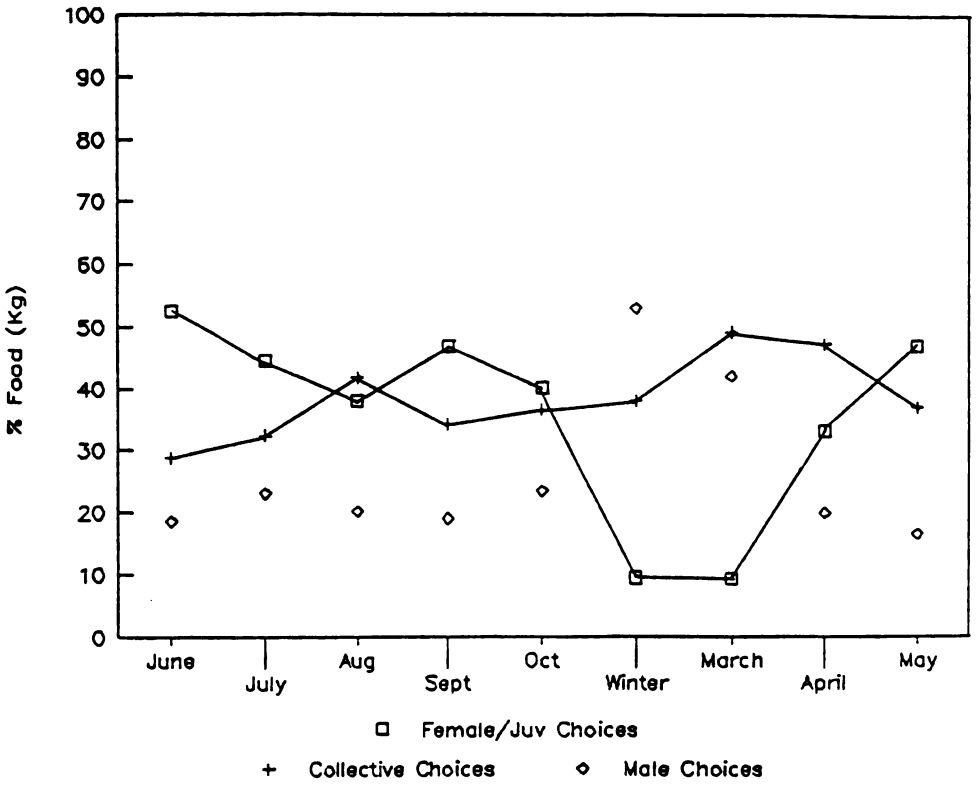


Figure 4.2. Dietary Contribution/Exploitive Group: Late Archaic Choices Based on Efficiency

Among the collective group's choices, fish is the staple and the first resource selected every month except March, when the productivity of maple sap/syrup exceeds that of any other collective food. Squirrel are also a primary resource, although during March the dietary contribution of maple sap/syrup (in combination with the stored foods and the male resources) offsets the need to hunt squirrel. Seasonally abundant foods such as waterfowl and pigeon are also harvested by the collective group, although the value of waterfowl is offset in the spring by the contribution of spring-spawning fish. Finally, rabbit are occasionally selected when dietary requirements force the inclusion of low ranked resources.

Deer, beaver, and raccoon are male staples; however, when elk are available, their productive value offsets the value of the staple resources. Game that are lower ranked in terms of efficiency (muskrat,

bear, and woodchuck) and waterfowl are exploited when additional choices are needed to satisfy dietary requirements.

Calories (kcal) are always the last dietary requirement to be satisfied. Vitamin C is occasionally not satisfied when other nutrients are, but it is never the critical value forcing continued selection of resources (Appendix E, Section 2).

Late Archaic Choices Based on Multiple Goals (Model 3)

The third simulation is of Late Archaic subsistence choices based on a category that includes the analytical dimensions of efficiency, taste, and prestige. As discussed in Chapter 2, these factors (other than sweetness) have been considered in other studies (e.g., Cowan 1985; Jochim 1976, 1983) and appear to be correlated with subsistence decision making; however, their relative importance in different environmental and cultural contexts has not been evaluated. Comparison of this and other simulations with archaeological subsistence data is directed toward this objective.

In the simulation of Late Archaic subsistence choices based on multiple goals foods are assigned the cumulative value of their rankings on the attributes taste, prestige, and efficiency (Chapter 3). Resources are selected in descending order from the highest cumulatively ranked options to lower ranked options until energy and nutritional needs are satisfied (Appendix E, Section 3).

Based on this simulation, the female/juvenile group selects 15 of the 37 resource options (41%) and the collective and male groups exploit all of their options (Table 4.3). Further, storage of 22% of the female/juvenile foods collected during the summer and fall months accounts for approximately 8% to 9% of the winter diet.

In this simulation, the dietary contribution of each of the exploitive groups also varies over the course of the annual round (Table 4.3, Figure 4.3). In addition, the relative monthly contribution of each exploitive group is different from the simulations of decisions

Table 4.3. Late Archaic Resource Choices Based on Efficiency, Taste, and Prestige

Resource	June	July	Aug	Sept	Oct	Winter Months[a]	March	April	May
Female/Juvenile Choices									
Arrowhead	80.00[b]	0.00	0.00	0.00	0.00	3.52	3.52	0.00	80.00
Bulrush	80.00	80.00	0.00	0.00	80.00	10.56	10.56	80.00	80.00
Strawberry	1.28	0.00	0.00	0.00	0.00	0.06	0.06	0.00	0.00
Blackberry	0.00	35.98	35.98	0.00	0.00	3.17	3.17	0.00	0.00
Gooseberry/Currant	0.00	13.32	13.32	0.00	0.00	1.17	1.17	0.00	0.00
Elderberry	0.00	0.00	0.00	2.64	0.00	0.12	0.12	0.00	0.00
Mulberry	0.00	0.34	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Black cherry	0.00	0.00	9.09	0.00	0.00	0.40	0.40	0.00	0.00
White Oak	0.00	0.00	0.00	3.38	0.00	0.15	0.15	0.00	0.00
Red Oak	0.00	0.00	0.00	1.78	0.00	0.08	0.08	0.00	0.00
Hazelnut	0.00	0.00	0.00	2.52	0.00	0.11	0.11	0.00	0.00
Beechnut	0.00	0.00	0.00	4.74	0.00	0.21	0.21	0.00	0.00
Hickory	0.00	0.00	0.00	0.00	16.17	0.71	0.71	0.00	0.00
Black walnut	0.00	0.00	0.00	0.00	0.38	0.02	0.02	0.00	0.00
Butternut	0.00	0.00	0.00	0.00	2.97	0.13	0.13	0.00	0.00
Total Stored Food[c]	0.00	0.00	0.00	0.00	0.00	20.41	20.41	0.00	0.00
Total Female	161.28	129.64	58.39	15.06	99.52	20.41	20.41	80.00	•••••
% Total Kg	50.04	44.50	29.03	4.55	36.12	8.30	8.80	32.27	59.77
Collective Choices									
Fish	75.84	75.84	0.00	75.84	0.00	75.84	0.00	0.00	0.00
Squirrel	11.86	11.86	11.86	11.86	11.86	11.86	0.00	0.00	11.86
Rabbit	6.45	6.45	6.45	6.45	6.45	6.45	0.00	0.00	0.00
Waterfowl	0.00	0.00	57.57	115.14	57.57	0.00	57.57	115.14	0.00
Pigeon	0.00	0.00	0.00	32.60	32.60	0.00	0.00	0.00	32.60
Maple Syrup	0.00	0.00	0.00	0.00	0.00	0.00	48.05	0.00	0.00
Total Collective	94.15	94.15	75.88	241.89	108.48	94.15	105.62	115.14	44.46
% Total Kg	29.21	32.32	37.72	73.06	39.37	38.26	45.55	46.45	16.61
Male Choices									
Beaver	10.48	10.48	10.48	10.48	10.48	10.48	0.00	0.00	10.48
Deer	52.75	52.75	52.75	52.75	52.75	52.75	52.75	52.75	52.75
Racoon	3.67	3.67	3.67	3.67	3.67	3.67	0.00	0.00	0.00
Muskrat	0.00	0.00	0.00	6.57	0.00	6.57	0.00	0.00	0.00
Elk	0.00	0.00	0.00	0.00	0.00	53.08	53.08	0.00	0.00
Bear	0.00	0.00	0.00	0.00	0.00	1.07	0.00	0.00	0.00
Woodchuck	0.00	0.66	0.00	0.66	0.66	0.66	0.00	0.00	0.00
Waterfowl	0.00	0.00	0.00	0.00	0.00	3.21	0.00	0.00	0.00
Total Male	66.90	67.56	66.90	74.13	67.56	131.49	105.83	52.75	63.23
% Total Kg	20.76	23.19	33.26	22.39	24.52	53.44	45.64	21.28	23.62

[a] Choices in November, December, January and February

[b] Kilograms

[c] 22 % of summer and fall foods divided between five months

based on either taste or efficiency. Females/juveniles provide the greatest dietary contribution over the course of the year, although the collective group and males provide nearly as much food as the females/juveniles. The female/juvenile group contributes more than half of the household's food in May, June, and July. The collective group contributes the greatest percentage of food in September and slightly greater amounts in April. The males contribute lower percentages of food overall, although their contribution is more consistent over the course of the year.

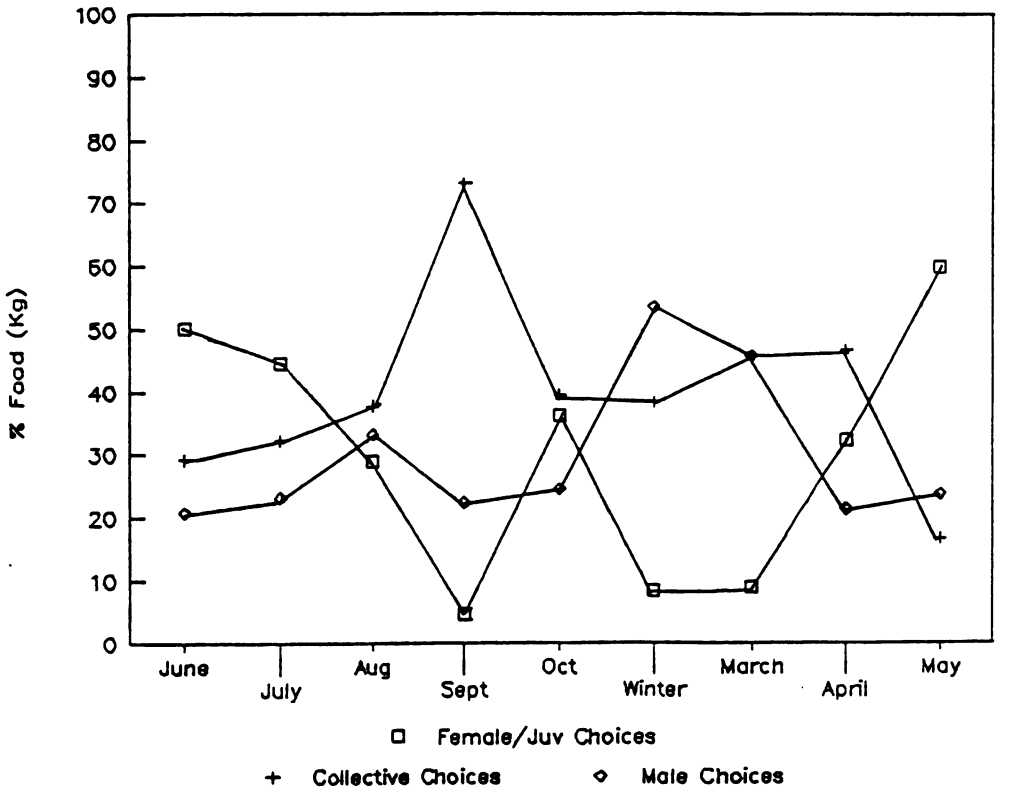


Figure 4.3. Dietary Contribution/Exploitive Group: Late Archaic Choices Based on Multiple Goals

The foods selected each month and the number of kilograms of each are provided in Table 4.3. As expected, the resource choices represent a compromise between the simulations based on taste and efficiency. Prey size only affects choices relating to small game that have similar taste and efficiency values. Large game have higher efficiency and

taste (fat) values than small game, and prey size is not an important factor discriminating between these resources.

Among female/juvenile resource choices, wetland tubers (bulrush and arrowhead) provide the greatest quantity of food overall because they yield the highest productivity per unit area during several months when alternative resources are unavailable. In the summer and fall, however, the value of tubers is exceeded by other foods that are more highly valued because of their productivity (efficiency) or taste (i.e., blackberry, gooseberries/currants, black cherries, hickory, beechnut, butternut, and black walnut). In these months, wetland tubers become less preferred, "second line" options (Asch, *et al*. 1972) or are completely replaced.

Among the collective group's choices, there is no single food that is a staple throughout the year. Small game (i.e., squirrel and rabbits) and, to a lesser extent, fish are commonly selected. When wetland tubers are exploited, the value of small game is superseded by other seasonally available resources that are more highly ranked in terms of efficiency or taste (e.g., waterfowl and pigeon).

Deer is the staple male resource throughout the year and is a first line choice except during months when elk are available. Beaver and raccoon are common secondary choices except during months when elk and deer provide the total male contribution (i.e., March and April), or when the dietary contribution of the other groups satisfies energy and nutritional needs before small game are selected. Other lower ranked game (woodchuck and muskrat) and waterfowl are occasionally hunted when additional choices are needed to satisfy dietary requirements.

Calories (kcal) are often the last dietary requirement to be satisfied although vitamin C is occasionally last. Vitamin C requirements are satisfied during most months through the use of wetland tubers, fruits and fish, which all have large quantities of vitamin C. During September and October, however, vitamin C is the last nutrient requirement to be satisfied. During these months, few fruits are

available, and nuts are exploited before or in lieu of tubers, while waterfowl and pigeon are exploited before or instead of fish. In this context, caloric and nutrient requirements (other than vitamin C) are satisfied far beyond the specifications of the simulation (Appendix E, Section 3). Again, the relative importance of vitamin C may be inflated beyond what is actually needed in any given month, but the modeled results do highlight the nutrients that occur in lower values.

Early and Middle Woodland Choices Based on Efficiency (Model 4)

In the simulation of Early and Middle Woodland subsistence choices based on the efficiency of exploiting foods from the modern lake level environment, resources are again selected in descending order from the highest ranked options to lower ranked options until energy and nutritional needs are satisfied (Appendix E, Section 4). In this simulation, the female/juvenile group selects 11 of the 37 resource options (30%), and the collective and male groups exploit all their options (Table 4.4). Further, in the winter months, storage of 18% of the foods collected by the females/juveniles during the summer and fall accounts for approximately 9% of the winter diet.

The dietary contribution of each of the exploitive groups varies over the course of the annual round in this simulation (Table 4.4, Figure 4.4). Further, the monthly contribution of each exploitive group is in several respects different from the other simulations of subsistence patterns. Female/juvenile and collective groups provide almost equal amounts of food, while the males provide much less food than the females/juveniles or collective group. Females/juveniles contribute the highest percentages of food in May, June, and July. The collective group contributes the greatest percentages of food in August, September, October, March, and April. Their dietary contribution is equal to that of females/juveniles in May. Males contribute relatively low percentages of food (less than 25%) except in the winter months when

Table 4.4. Early and Middle Woodland Resource Choices Based on Efficiency

Resource	June	July	Aug	Sept	Oct	Winter Months[a]	March	April	May
Female/Juvenile Choices									
Jack-in-the-Pulpit	1.80[b]	1.80	0.00	0.00	0.00	0.06	0.06	1.80	1.80
Arrowhead	80.00	80.00	80.00	80.00	80.00	14.40	14.40	0.00	80.00
Bulrush	80.00	0.00	0.00	0.00	0.00	2.88	2.88	80.00	80.00
Cattail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.60	0.00
Blackberry	0.00	35.98	35.98	0.00	0.00	2.59	2.59	0.00	0.00
Gooseberry/Currant	0.00	13.32	13.32	0.00	0.00	0.96	0.96	0.00	0.00
Black cherry	0.00	0.00	9.09	0.00	0.00	0.33	0.33	0.00	0.00
White Oak	0.00	0.00	0.00	3.38	0.00	0.12	0.12	0.00	0.00
Beechnut	0.00	0.00	0.00	4.74	0.00	0.17	0.17	0.00	0.00
Hickory	0.00	0.00	0.00	0.00	16.17	0.58	0.58	0.00	0.00
Butternut	0.00	0.00	0.00	0.00	2.97	0.11	0.11	0.00	0.00
Total Stored Food[c]	0.00	0.00	0.00	0.00	0.00	22.20	22.20	0.00	0.00
Total Female	161.80	131.10	138.39	88.12	99.14	22.20	22.20	111.40	161.80
% Monthly kg	50.12	43.89	38.06	32.01	34.62	8.96	8.81	33.09	41.80
Collective Choices									
Fish	75.84	75.84	75.84	75.84	75.84	75.84	75.84	113.88	113.88
Squirrel	11.86	11.86	11.86	11.86	11.86	11.86	0.00	11.86	11.86
Rabbit	6.45	6.45	6.45	0.00	0.00	6.45	0.00	0.00	0.00
Waterfowl	0.00	0.00	57.57	0.00	0.00	0.00	0.00	0.00	0.00
Pigeon	0.00	0.00	0.00	32.60	32.60	0.00	0.00	32.60	32.60
Maple Syrup	0.00	0.00	0.00	0.00	0.00	0.00	48.05	0.00	0.00
Total Collective	94.15	94.15	151.72	120.30	120.30	94.15	123.89	158.34	158.34
% Monthly kg	29.16	31.52	41.73	43.69	42.01	37.99	49.18	47.04	40.91
Male Choices									
Beaver	10.48	10.48	10.48	10.48	10.48	10.48	0.00	10.48	10.48
Deer	52.75	52.75	52.75	52.75	52.75	52.75	52.75	52.75	52.75
Raccoon	3.67	3.67	3.67	3.67	3.67	3.67	0.00	3.67	3.67
Muskrat	0.00	6.57	6.57	0.00	0.00	6.57	0.00	0.00	0.00
Elk	0.00	0.00	0.00	0.00	0.00	53.08	53.08	0.00	0.00
Bear	0.00	0.00	0.00	0.00	0.00	1.07	0.00	0.00	0.00
Woodchuck	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.00	0.00
Waterfowl	0.00	0.00	0.00	0.00	0.00	3.21	0.00	0.00	0.00
Total Male	66.90	73.47	73.47	66.90	66.90	131.49	105.83	66.90	66.90
% Monthly kg	20.72	24.59	20.21	24.30	23.36	53.05	42.01	19.87	17.29

[a] Choices in November, December, January and February

[b] Kilograms

[c] 18% of summer and fall foods divided between five months

they provide more food than either the female/juvenile or collective groups.

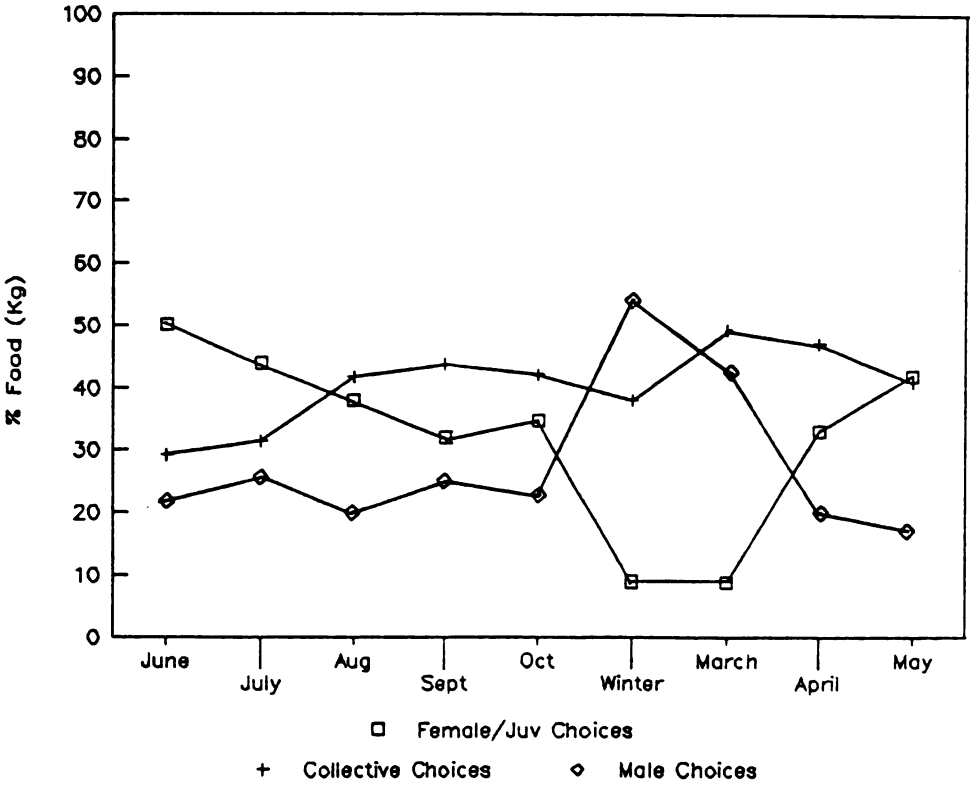


Figure 4.4. Dietary Contribution/Exploitive Group: Early and Middle Woodland Choices Based on Efficiency

The resources selected each month and the number of kilograms of each are provided in Table 4.4. Wetland tubers (bulrush, arrowhead, and cattail) are collected throughout most of the year (except winter) by females/juveniles. The productive importance of wetland tubers is, however, offset by other resources (i.e., jack-in-the-pulpit, blackberry, gooseberries/currants, black cherries, hickory, beechnut, white oak, and butternut) that are highly productive but only available during specific seasons. During these times, wetland tubers become less preferred, second line options.

Among the collective group's choices, fish is the staple resource and the first resource selected every month except March when the productivity of maple sap/syrup exceeds that of any other collective

foods including fish. Squirrels are also a primary resource, although during March the dietary contribution of maple sap/syrup (in combination with the stored foods and the male resources) offsets the need to hunt squirrel. As noted in the simulation of the Late Archaic choices based on efficiency, seasonally abundant resources such as pigeon and waterfowl are also harvested by the collective group. Finally, rabbit are occasionally exploited when dietary requirements force the selection of low ranked foods or when pigeon and waterfowl are not available.

Deer, beaver, and raccoon are the primary male staples although the productive value of elk offsets the value of these resources when elk are available. Other, lower ranked game (muskrat and woodchuck) and waterfowl are exploited when additional choices are needed to satisfy dietary requirements.

Over the course of the year, calories (kcal) are most often the last dietary requirement to be satisfied. In September, October and March, however, calories and vitamin C are the last requirements to be satisfied (Appendix E, Section 4).

Early and Middle Woodland Choices Based on Multiple Goals (Model 5)

The last simulation of Early and Middle Woodland subsistence choices incorporates the efficiency of exploiting resources from the presettlement environment, taste, and prestige into the decision-making process. In this simulation, resources are also selected in descending order from the highest cumulative ranked options to lower ranked options until energy and nutrititional needs are satisfied (Appendix E, Section 5).

The female/juvenile group selects 16 of the 37 resource options (43%) and the collective and male groups exploit all of their options (Table 4.5). Further, storage of 22% of the female resources collected during the summer and fall months accounts 6% to 8% of the winter diet.

In this simulation, as in the others, the dietary contribution of each of the exploitive groups varies over the course of the annual round

Table 4.5. Early and Middle Woodland Resource Choices Based on Efficiency, Taste, and Prestige

Resource	June	July	Aug	Sept	Oct	Winter Months[a]	March	April	May
Female/Juvenile Choices									
Jack-in-the-Pulpit	1.80[b]	1.80	0.00	0.00	0.00	0.08	0.08	1.80	1.80
Arrowhead	80.00	80.00	0.00	0.00	80.00	10.56	10.56	0.00	80.00
Bulrush	80.00	0.00	0.00	0.00	0.00	3.52	3.52	80.00	80.00
Strawberry	1.28	0.00	0.00	0.00	0.00	0.06	0.06	0.00	0.00
Blackberry	0.00	35.98	35.98	0.00	0.00	3.17	3.17	0.00	0.00
Gooseberry/Currant	0.00	13.32	13.32	0.00	0.00	1.17	1.17	0.00	0.00
Elderberry	0.00	0.00	0.00	2.64	0.00	0.12	0.12	0.00	0.00
Mulberry	0.00	0.34	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Black cherry	0.00	0.00	9.09	0.00	0.00	0.40	0.40	0.00	0.00
White Oak	0.00	0.00	0.00	3.38	0.00	0.15	0.15	0.00	0.00
Red Oak	0.00	0.00	0.00	1.78	0.00	0.08	0.08	0.00	0.00
Hazelnut	0.00	0.00	0.00	2.52	0.00	0.11	0.11	0.00	0.00
Beechnut	0.00	0.00	0.00	4.74	0.00	0.21	0.21	0.00	0.00
Hickory	0.00	0.00	0.00	0.00	16.17	0.71	0.71	0.00	0.00
Black walnut	0.00	0.00	0.00	0.00	0.38	0.02	0.02	0.00	0.00
Butternut	0.00	0.00	0.00	0.00	2.97	0.13	0.13	0.00	0.00
Total Stored Food[c]	0.00	0.00	0.00	0.00	0.00	20.49	20.49	0.00	0.00
Total Female	163.08	131.44	58.39	15.06	99.52	20.49	20.49	81.80	161.80
% Total Kg	50.21	44.35	29.03	4.55	36.12	8.32	6.00	27.94	41.80
Collective Choices									
Fish	75.84	75.84	0.00	75.84	0.00	75.84	75.84	0.00	113.88
Squirrel	11.86	11.86	11.86	11.86	11.86	11.86	11.86	0.00	11.86
Rabbit	6.45	6.45	6.45	6.45	6.45	6.45	6.45	0.00	0.00
Waterfowl	0.00	0.00	57.57	115.14	57.57	0.00	57.57	115.14	0.00
Pigeon	0.00	0.00	0.00	32.60	32.60	0.00	0.00	32.60	32.60
Maple syrup	0.00	0.00	0.00	0.00	0.00	0.00	48.05	0.00	0.00
Total Collective	94.15	94.15	75.88	241.89	108.48	94.15	199.77	147.74	158.34
% Total Kg	28.99	31.77	37.72	73.06	39.37	38.25	58.53	50.46	40.91
Male Choices									
Beaver	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.48
Deer	52.75	52.75	52.75	52.75	52.75	52.75	52.75	52.75	52.75
Raccoon	3.67	3.67	3.67	3.67	3.67	3.67	3.67	0.00	3.67
Muskrat	0.00	0.00	0.00	6.57	0.00	6.57	0.00	0.00	0.00
Elk	0.00	0.00	0.00	0.00	0.00	53.08	53.08	0.00	0.00
Bear	0.00	0.00	0.00	0.00	0.00	1.07	1.07	0.00	0.00
Woodchuck	0.66	0.66	0.00	0.66	0.66	0.66	0.00	0.00	0.00
Waterfowl	0.00	3.21	0.00	0.00	0.00	3.21	0.00	0.00	0.00
Total Male	67.56	70.77	66.90	74.13	67.56	131.49	121.05	63.23	66.90
% Total Kg	20.80	23.88	33.26	22.39	24.52	53.42	35.47	21.60	17.29

[a] Choices in November, December, January and February

[b] Kilograms

[c] 22% of summer and fall foods divided between five months

(Table 4.5, Figure 4.5). The collective exploitive group provides the greatest dietary contribution over the course of the year, although the female/juvenile group and males provide nearly as much food as the collective group. Females/juveniles contribute nearly half of the month's food in June and July, and nearly the same amount of food as the collective group in May. The collective group contributes the greatest percentage of food in September, March, and May. The males contribute lower percentages of food over the majority of the year, although they provide more food than the other expoitive groups in the winter months.

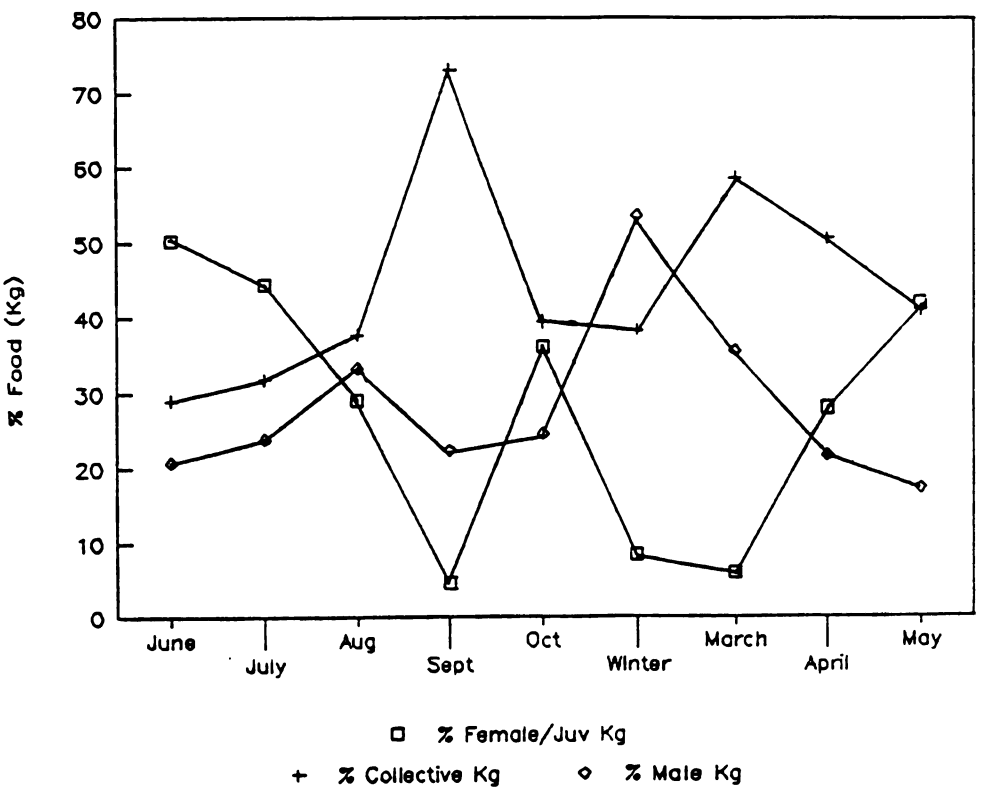


Figure 4.5. Dietary Contribution/Exploitive Group: Early and Middle Woodland Choices Based on Multiple Goals

The resources selected each month and the number of kilograms of each are provided in Table 4.5. Among female/juvenile resource choices, wetland tubers (bulrush and arrowhead) provide the greatest quantity of food because they have the highest productivity per unit area during several months when alternative resources are unavailable. There are,

however, months in which the productive value (i.e., efficiency of collecting) of wetland resources is exceeded by other foods that are more highly valued because of their efficiency or taste (i.e., jack-in-the-pulpit, strawberries, blackberries, gooseberries/currants, elderberries, mulberries, black cherries, hickory, beechnut, butternut, black walnut, hazelnut, and acorn). As in the previous simulations, during these months, wetland tubers become "second line" resources or are completely replaced.

Among the collective group's choices, there is no single food that is a staple throughout the year. Small game (i.e., squirrel and rabbits) and, to a lesser extent, fish are commonly selected. These resources are not selected when their value is superseded by other seasonally available foods that are more highly ranked in terms of efficiency or taste (e.g., waterfowl, pigeon, and maple sap).

Deer and beaver are the staple male resources throughout the year. Deer is the primary (i.e., "first line") choice, except during months when elk are available. Raccoon is a common tertiary choice, except during the winter when bear is available and in April when deer and beaver provide the total male contribution. Raccoon is also replaced when the dietary contribution of the other exploitive groups satisfies energy and nutritional needs before small game are selected. Other, lower ranked game (woodchuck and muskrat) and waterfowl are occasionally hunted when additional choices are needed to satisfy dietary requirements.

Calories (kcal) are most often the last dietary requirement to be satisfied. As noted in the discussion of the simulation of Late Archaic choices based on multiple goals, vitamin C is the second to the last dietary requirement to be satisfied. Wetland tubers, fruits and fish, which have large quantities of vitamin C, provide the majority of vitamin C requirements. During September, October, and March, however, vitamin C is the last nutrient requirement to be satisfied. During these months, few fruits are available and, as in the Late Archaic

simulation, nuts are exploited before or in lieu of tubers, while waterfowl and pigeon are exploited before or instead of fish. Thus, energy and nutrient requirements are satisfied far beyond the specifications of the simulation (Appendix E, Section 5).

Comparisons Between Subsistence Simulations

Comparison of the simulated subsistence choices *within* cultural periods highlights variations due to the effects of efficiency, taste and prestige on subsistence decision making and reflects differences in the scheduling of resource choices based on these criteria. Variations in the simulated subsistence choices *between* environmental periods accent the effects of environmental productivity on decisions that are based on the same criteria. These variations will be the baseline for defining the archaeological expectations of each simulation.

The Bray-Curtis measure of dissimilarity is used to evaluate the extent to which the simulated solutions differ. This statistic measures the dissimilarity between the sum of the differences between the values of each observed resource choice and the sum of the sums of each choice, in two simulations:

$$\frac{\sum_{1}^{n} | x_{ij} - x_{ik} |}{\sum_{1}^{n} (x_{ij} + x_{ik})}$$

The resultant statistic varies between 0.0, indicating that there is no dissimilarity between the two simulated solutions, and 1.0, which indicates that the two solutions are highly dissimilar. Although no probabilistic measure of significance can be determined from this statistic, it does provide a relative measure of difference between two simulated decision solutions.

Given the structure of the statistic, it tends to be strongly influenced by occasional outstanding values. It is, therefore, appropriate to this situation in which there may be only a few differences between two simulated solutions because the quantities of

food taken are standardized (per unit area). Unfortunately, however, values for male resource choices tend to be low because of the limited range of choices and the redundancy of choices given the small number of options.

Late Archaic: Taste vs. Efficiency

The simulations of Late Archaic subsistence choices based on efficiency alone and on taste alone differ in several respects. A greater variety of foods is selected by the female/juvenile exploitive group in the simulation based on taste, although they contribute much less food (< 50%) than in the simulation based on efficiency. The subsistence choices of the collective and male groups vary less than the female/juvenile choices, but there are notable differences in the contribution of any given resource.

Bray-Curtis measures of dissimilarity indicate that over the course of the annual round, the overall diets, selected on the basis of efficiency and taste, vary by a measure of less than 0.30, although there are varying degrees of dissimilarity (between 0.92 and 0.00) among the choices of each exploitive groups (Figure 4.6). The greatest differences between the two subsistence simulations are based on the female/juvenile resource choices. In September and October, a variety of fruits and nuts (selected for taste) are exploited in the simulation based on taste; while in the simulation based on efficiency, tubers (selected for efficiency) contribute significantly to the diet. In April and May, the differences between the two simulations are also high. These differences are based on the number of resources selected and their quantitative contributions.

Overall, differences between male and collective choices based on taste and efficiency are fairly low compared with female/juvenile choices based on these factors. While there is no difference in the specific resources selected, the amount of food contributed by each resource does vary considerably between the two simulations (Tables 4.1

and 4.2). For example, in the simulation based on taste, fatty foods such as rabbit and squirrel, as well as waterfowl and pigeon (when available) are selected above fish, which is the highest ranked resource in terms of efficiency. An exception to this is the highly ranked resource maple sap, which is available only in March. Further, while the relative importance of deer is the same in these two simulations, fatty small game animals (e.g., beaver and woodchuck) and waterfowl are more important in the simulation based on taste.

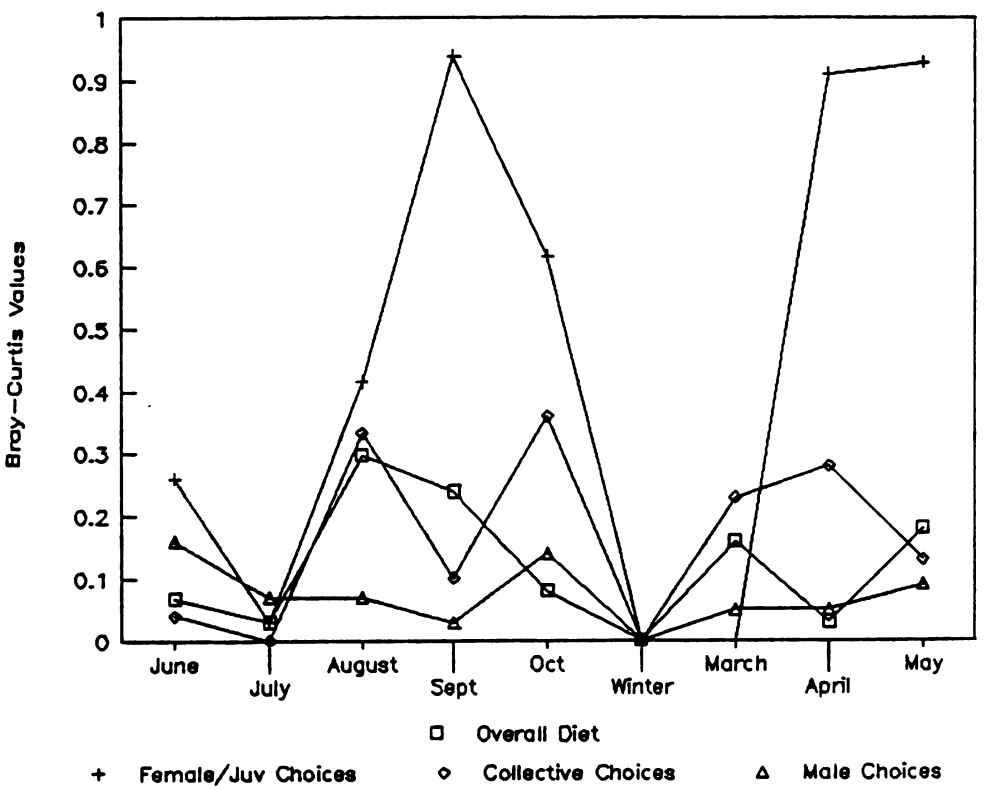


Figure 4.6. Measures of Dissimilarity: Late Archaic Efficiency/Taste

Finally, as noted above, the subsistence simulation based on taste is frequently driven to additional food choices by vitamin C requirements that are often left unsatisfied when other dietary requirements have been met. In the simulation based on efficiency, calories (kcal) are always the critical requirement.

Late Archaic: Efficiency vs. Multiple Goals

The simulations of Late Archaic subsistence choices based on efficiency and on multiple goals (prestige, taste, and efficiency) also differ in several respects. In these simulations, efficiency values remain constant and variations between the predicted choices are a result of the effects of taste and prestige on decision making.

Bray-Curtis measures of dissimilarity indicate that over the course of the annual round, the overall diets differ by a measure of less than 0.30, although there are varying degrees of dissimilarity (between 0.85 and 0.00) among the choices of each of the exploitive groups (Figure 4.7). The greatest differences between the two subsistence simulations are in the female/juvenile choices because the females and juveniles exploit a wider range of resources in the simulation based on the combination of factors than in that based solely on efficiency. For example, in September a variety of fruits and nuts are selected for taste, as opposed to a limited number of wetland tubers that are selected for productivity/efficiency.

The variation between the collective choices in the two simulations is relatively low, although there are some differences in the foods chosen. For example, more than twice as much fish is exploited in the simulation based on efficiency than in the simulation based on the combination of factors, while in the latter simulation waterfowl and pigeon, when they are available, are selected above fish. There are also minor variations in the contribution of small game animals.

Finally, there is little variation in the subsistence activities of the males in these two simulations. This is in part a reflection of the limited number of resources available to males in the models.

The subsistence simulation based on efficiency is frequently driven to additional food choices by caloric (kcal) requirements thus causing the other specified dietary requirements to be exceeded. Calories are also generally the last requirement to be satisfied in the

simulation based on multiple goals; however, in September and October, vitamin C is the last nutrient to be satisfied. This difference is related to the greater use of nuts, low in vitamin C, and the lesser use of tubers.

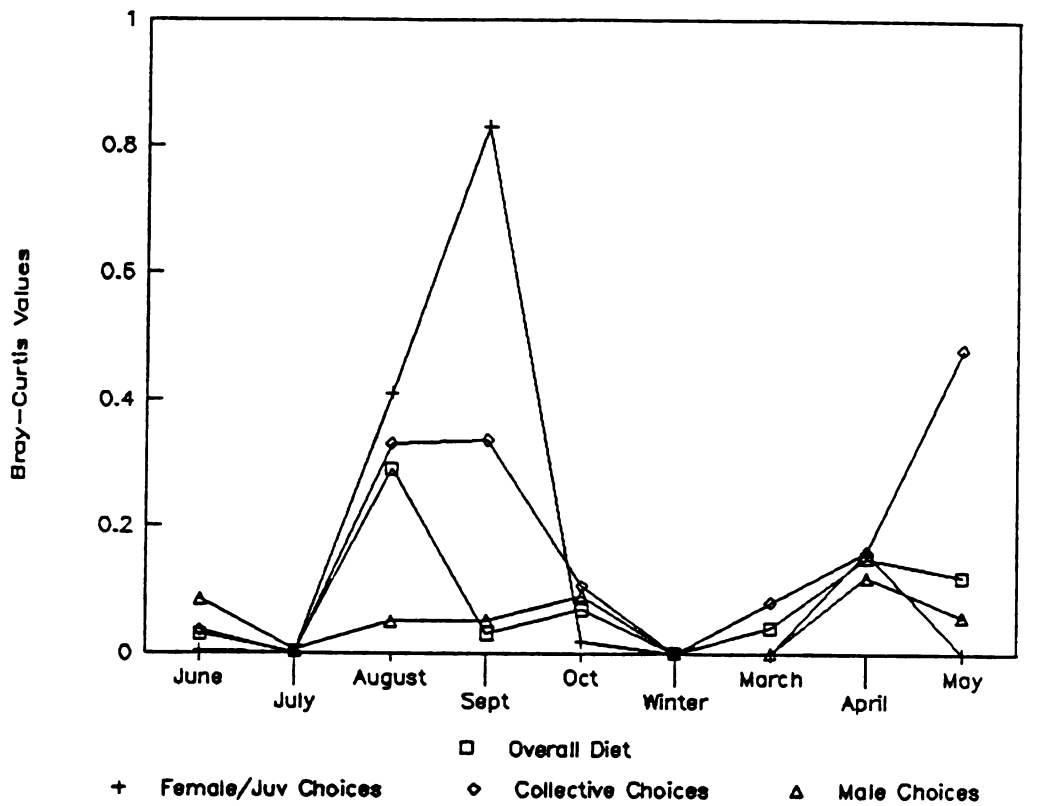


Figure 4.7. Measures of Dissimilarity: Late Archaic Efficiency/Late Archaic Multiple Goals

Late Archaic: Taste vs. Multiple Goals

There are several differences in the simulations of Late Archaic subsistence choices based on efficiency, taste, and prestige and the simulation of choices contingent upon taste alone. In these simulations, taste values remain constant and variations between the predicted choices are primarily a result of the effects of efficiency on choices, although prestige does influence the relative value of small game resources.

The Bray-Curtis measure of dissimilarity for the overall diets is relatively low, less than 0.25. The choices of each of the exploitive

groups, however, vary to greater (0.95) and lesser (0.00) extents over the course of the annual round (Figure 4.8) because of differences in the resource choices in several months. These differences are related to the type and number of foods exploited by the female/juvenile group, the subsistence contribution of each group, and the relative amount of food provided by each resource.

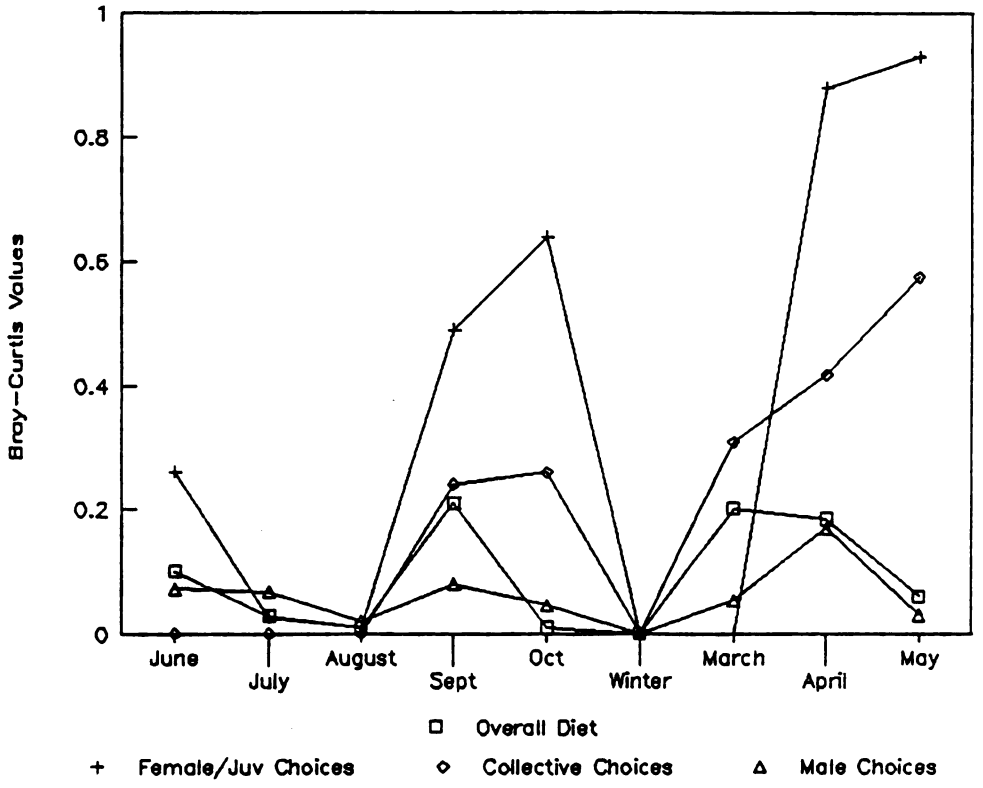


Figure 4.8. Measures of Dissimilarity: Taste/Late Archaic Multiple Goals

The greatest differences between the two subsistence simulations are in the female/juvenile choices in April, May, September, and October. These differences are related to the use of wetland tubers in the simulation that includes efficiency and the use of nuts in the simulation based on taste.

Among the collective resource choices based on taste alone, the greatest variance in decisions occurs in May when there is a greater dependence on fish and small game. Further, in the simulation that

includes efficiency, wetland tubers provide a large portion of the nutrient requirements in October, and there are, therefore, fewer collective resource choices than in the simulation based on taste.

Finally, the simulated male choices are similar. There is, however, a greater use of small game and waterfowl in the simulation based on taste alone.

In the simulation based on taste alone, decisions are frequently driven to additional food choices by vitamin C requirements, causing other dietary requirements to be satisfied well beyond their specified values. Vitamin C is far less difficult to satisfy in the simulation based on the combination of factors because of the use of wetland tubers and fish, which are both high in vitamin C. Vitamin C is, however, the critical nutrient in both simulations in the fall when nuts, valued for both taste and efficiency, are selected instead of wetland tubers and fish.

Early and Middle Woodland: Taste vs. Efficiency

The simulations of Early and Middle Woodland subsistence patterns based on efficiency and taste differ in several respects, as did those for the Late Archaic. Bray-Curtis measures of dissimilarity indicate that the variance between the overall diets are fairly low (</= 0.30) while the simulations of the female/juvenile diets are highly dissimilar (0.90) and the male and collective diets are fairly similar (0.30) (Figure 4.9).

A greater variety of resources is selected by the female/juvenile group in the simulation based on taste, although they contribute considerably less food (< 50%) than in the simulation based on efficiency. The greatest differences between the two subsistence simulations are based on the female/juvenile resource choices in September and October, when a variety of nuts (selected for taste) and a limited number of tubers (selected for efficiency) contribute significantly to each of the respective diets. In April and May, the

difference between the two simulations is based on the variety and quantity of resources selected. A wide range of terrestrial tubers with low productivity is selected in the taste simulation, while a limited range of highly productive wetland tubers is represented in the simulation based on efficiency.

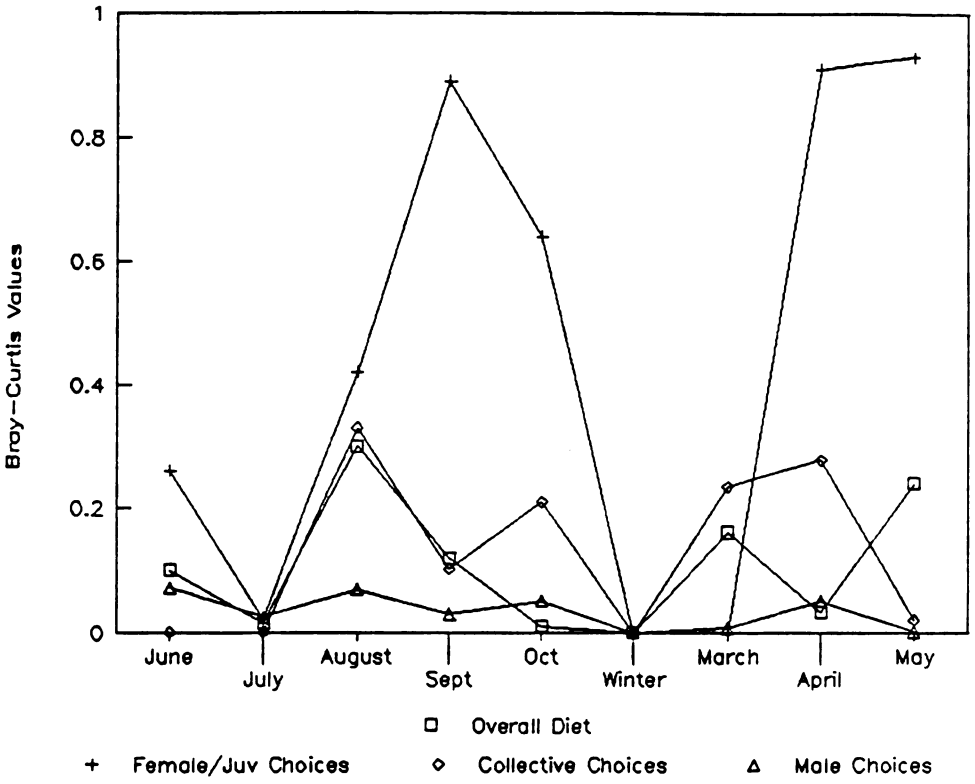


Figure 4.9. Measures of Dissimilarity: Taste/Early and Middle Woodland Efficiency

Overall, differences between male and collective choices are fairly low, compared with female/juvenile choices, although there are notable differences. While there is no difference in the specific resources selected, the amount of food contributed by each resource does vary considerably between the two simulations. Fatty foods such as waterfowl and small game (e.g., rabbit, beaver, raccoon, muskrat, and woodchuck) are more commonly exploited in the simulation that includes taste than in the simulation based on efficiency. In the latter simulation, fish are selected for their high productivity/efficiency.

Further, the subsistence simulation based on taste is frequently driven to additional food choices by vitamin C requirements, which results in the other dietary requirements being exceeded. In the simulation based on efficiency, calories (kcal) are always the critical requirement.

Early and Middle Woodland: Efficiency vs. Multiple Goals

There are also several differences between the simulations of Early and Middle Woodland subsistence decision making based on only the efficiency of exploiting resources in the presettlement environment and that based on a combination of goals (prestige, taste, and efficiency). In these simulations, efficiency values remain constant and variations between the predicted choices are a result of the effects of taste and prestige.

In general, the female/juvenile group exploits a wider range of resources in the simulation based on the combination of factors than in the simulation based only on efficiency; a greater amount of food is, however, procured from the few resources selected for efficiency. Among the collective and male choices, there is little difference in the amount of food, but the relative contributions of each of the resources are quite different.

Bray-Curtis measures of dissimilarity in this simulation, as in the Late Archaic, indicate that over the course of the annual round, the overall diets differ by a measure of less than 0.30, while differences between the choices of each of the exploitive groups differ by measures of 0.70 to 0.00 (Figure 4.10). The greatest differences between the two subsistence simulations are in the female/juvenile resource choices in September. The difference between the female/juvenile diet choices in September is due to the selection of a variety of nuts (selected for taste) as opposed to the contribution of a limited number of wetland tubers (selected for efficiency).

The collective choices in these two simulations are fairly similar. The primary differences are based on the amount of food contributed by each resource. For example, approximately one-third more fish is exploited in the simulation based on efficiency. In the simulation based on the combination of factors, seasonally available waterfowl and pigeon are selected above fish. There are also minor variations in the contribution of small game animals.

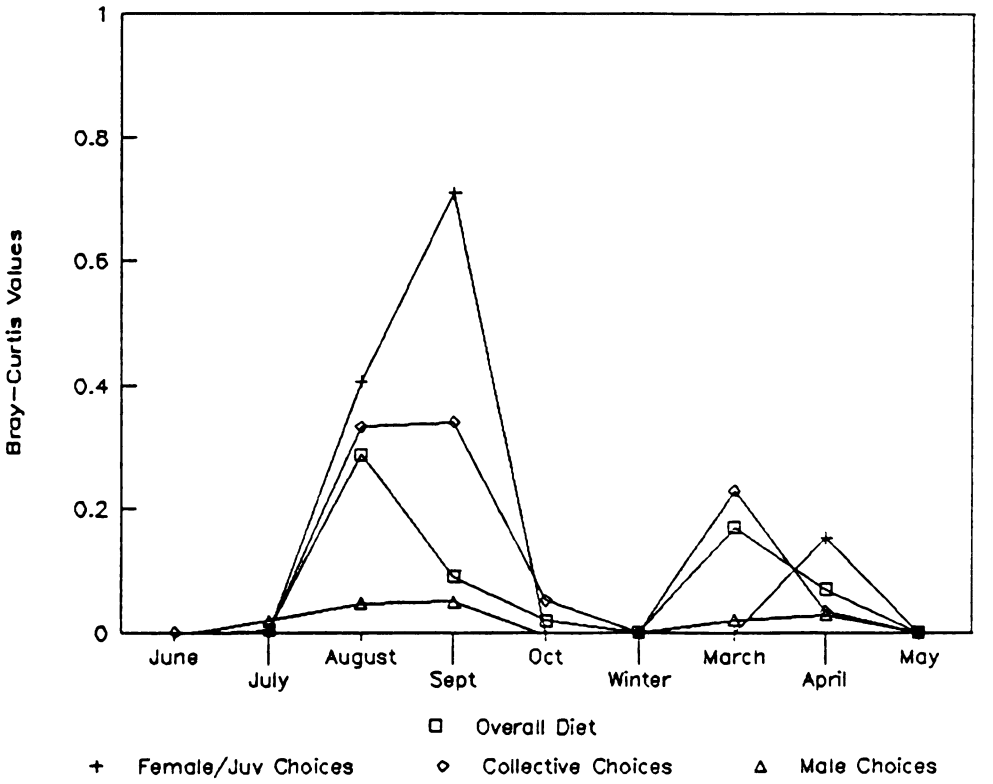


Figure 4.10. Measures of Dissimilarity: Early and Middle Woodland Efficiency/Early and Middle Woodland Multiple Goals

There is little variation in the subsistence activities of the males in these two simulations. Fatty small game animals and waterfowl do, however, contribute more to the diet in the simulation based on the combination of factors than in the simulation based solely on efficiency.

Further, as noted in the simulations of the Late Archaic choices based on efficiency and the combined category, calories (kcal) are the

last nutrient requirement to be satisfied, except during September and October. The use of nuts, low in vitamin C, during these months makes vitamin C the critical nutrient rather than calories.

Early and Middle Woodland: Taste vs. Multiple Goals

The simulation of Early and Middle Woodland subsistence choices derived on the basis of the combination of prestige, taste, and efficiency differs from that based on taste alone. In these simulations, taste values remain constant and variations between the predicted choices is a result of the effects of efficiency and prestige. A wider range of resources are selected by females/juveniles in the simulation based on taste alone and there are notable differences in the total amount of food provided by the female/juvenile and collective group, as well as in the specific resources provided by each group.

Therefore, while the Bray-Curtis measures of dissimilarity between the two simulations for the overall diet are relatively low (< 0.30), the resource choices in the two simulations are strikingly different in some months, resulting in Bray-Curtis values of more than 0.90 (Figure 4.11). The greatest differences between the two subsistence simulations are in the female/juvenile resource choices in April, May, September, and October. These differences are again related to the use of wetland tubers in the simulation that includes efficiency and the use of nuts and terrestrial tubers in the simulation that is based on taste.

There is little difference between the collective resource choices predicted by these two simulations. The relative importance of waterfowl and fish and the number of resources selected in any given month do, however, vary somewhat between the two.

The degree of dissimilarity in the male choices is less than that of the collective or female/juvenile choices. The only difference between the two simulated diets is that there is a greater use of small game and waterfowl in the simulation based on taste alone.

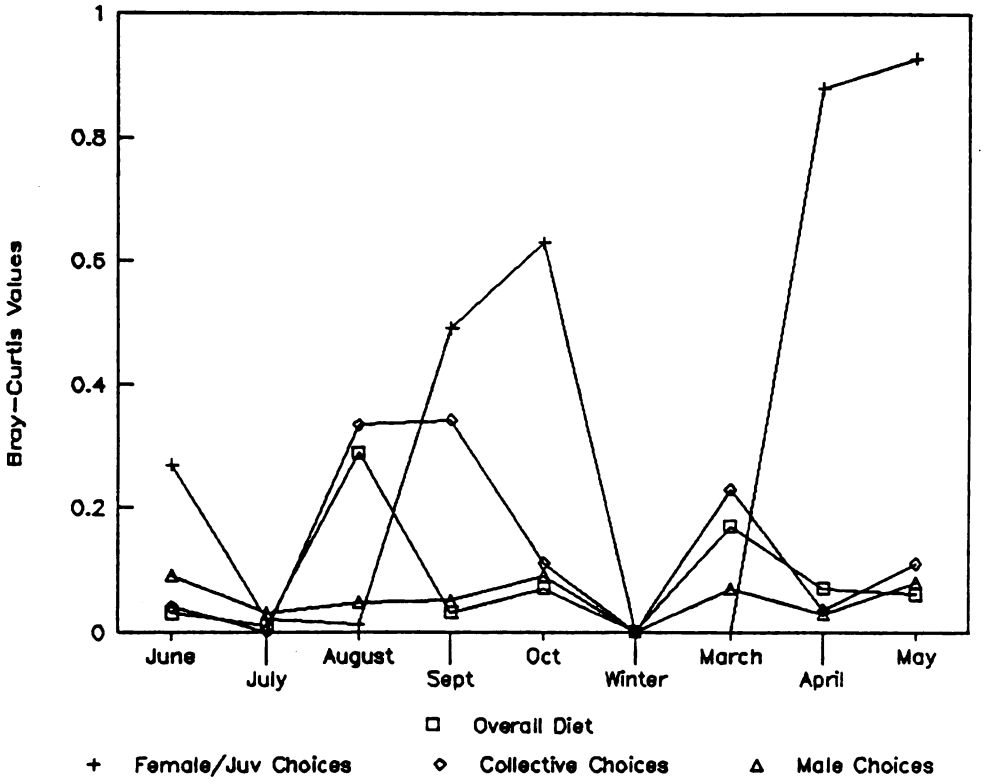


Figure 4.11. Measures of Dissimilarity: Taste/Early and Middle Woodland Multiple Goals

Finally, in the simulation based on taste, vitamin C is the critical nutrient that prompts selection of additional foods, thus causing the other dietary requirements to be satisfied beyond their specified values. Vitamin C is far less difficult to satisfy in the simulation based on the combination of factors because of the use of wetland tubers. It is, however, the critical nutrient in both simulations in the fall, when nuts that are valued for both taste and efficiency are selected instead of wetland tubers.

Late Archaic vs. Early and Middle Woodland: Choices Based on Efficiency

In comparing the simulations of Early and Middle Woodland and Late Archaic subsistence choices based on efficiency, differences and similarities in the productivity of the respective effective subsistence environments are highlighted. The primary difference between these two

simulations is that there is a narrower range of food choices and a greater dependence on wetland tubers in the Late Archaic simulation than in the simulation of Early and Middle Woodland choices. Conversely, in the simulation of Woodland diet choices, terrestrial tubers and nuts are more highly ranked than in the Late Archaic simulation, and consequently, they are selected prior to wetland tubers. In turn, this forces the simulation to select small game, not chosen by the Late Archaic model, because nutrient requirements are not satisfied.

The Bray-Curtis measures of dissimilarity indicate that the overall diets selected by the simulations are relatively similar, differing by a measure of less than 0.20 and that individual measures of dissimilarity are also low (≤ 0.30) (Figure 4.12). Female/juvenile choices are very similar, except in September when bulrush tubers (which contribute a large amount of food, 80.00 kg) are selected in the Late Archaic simulation over acorns (that provide a relatively small amount of food, 3.38 kg) in the Woodland.

Collective group choices vary the most in May and October, when pigeon are exploited in the modern simulation but not in the Late Archaic simulation. This is because in the Late Archaic, primary dependence on wetland tubers (which have large amounts of calories and vitamin C) and the contribution of the collective and male resources results in satisfaction of nutrient requirements through fewer choices than in the simulation of Woodland choices. In contrast, in the simulation of Woodland choices, the female/juvenile selection of terrestrial resources (acorns and jack-in-the-pulpit) prior to wetland tubers fails to satisfy nutrient (vitamin C) requirements and forces the simulation to select additional resources, including pigeon.

Finally, the Bray-Curtis measures of dissimilarity in male resource choices are low throughout the year, in these simulations. The variation that is reflected relates to the use of greater numbers of small game during the Early and Middle Woodland, again as a result of the need to make additional choices to satisfy nutrient requirements.

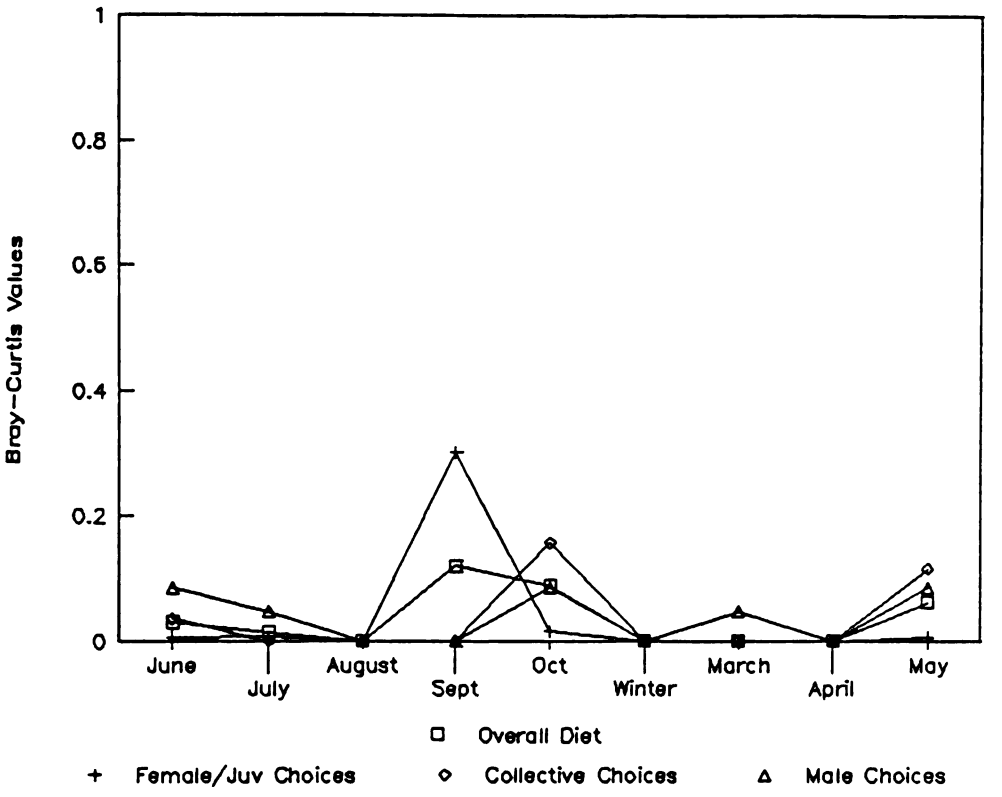


Figure 4.12. Measures of Dissimilarity: Late Archaic Efficiency/Early and Middle Woodland Efficiency

Late Archaic vs. Early and Middle Woodland: Choices Based on Multiple Goals

In comparing the Early and Middle Woodland and Late Archaic simulations of subsistence patterns based on the combination of factors, taste and prestige remain constant and the productivity of the resources changes. These simulations differ from the previous example, however, because the importance of efficiency is reduced by taste and prestige.

The Bray-Curtis measures of dissimilarity indicate that the overall diets are similar, differing by a measure of less than 0.25, and the choices of the exploitive groups differ little (< 0.05) except in March and May when the simulations differ by a measure of 0.60 (Figure 4.13). These differences are related to the relative productivity of wetland and terrestrial tubers and the effects of their priority on the selection of other foods. In the simulation of Early and Middle

Woodland choices, terrestrial tubers (jack-in-the-pulpit) are selected before wetland tubers by the females/juveniles because of their higher productivity/efficiency. The Woodland simulation is, therefore, prompted to select additional resources, beyond those selected in the Late Archaic simulation, because of the need for vitamin C that is satisfied later in the simulation. Consequently, the collective group selects fish and small game and the males bear and small game when nutrient requirements force the selection of additional resources.

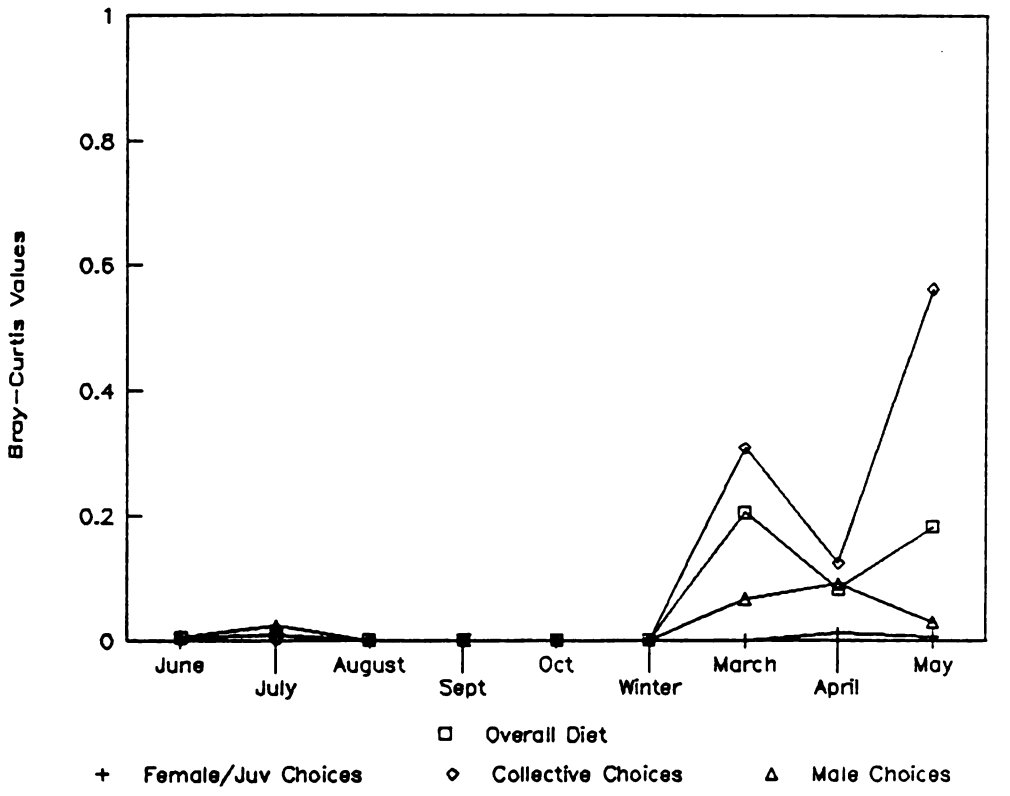


Figure 4.13. Measures of Dissimilarity: Late Archaic Multiple Goals/ Early and Middle Woodland Multiple Goals

Male choices also vary little between these two simulations. The only difference is that in the simulation of Woodland choices, small game are more important in the spring months because of the sequencing of the female/juvenile selection of terrestrial tubers before wetland tubers.

Overall, the simulations reflect a greater diversity of foods in the strategies that include taste as a factor in subsistence choice and less variety in those that include efficiency. Further, it is the choices of the female/juvenile exploitive group that vary the most, although the simulations do predict that contributions of each exploitive group will vary depending on the criteria affecting choice (Tables 4.1 - 4.5). While the variation in dietary contributions of females may appear to be an artificial by-product of the range of choices provided in the simulations, biologically there is, in fact, a greater diversity of edible plant resources available. Thus, it is realistic to expect that a greater diversity of plants would be selected for taste.
Although there is less disparity among the simulations of Late Archaic and Early and Middle Woodland, based on multiple goals, there are two consistent differences between the two sets of choices. First, the simulations suggest that Late Archaic populations rely more on aquatic and wetland resources when efficiency is a factor affecting resource choice. Woodland populations, however, exploit more forest resources. This difference is directly related to the relative productivity of these habitats. Because of this difference, the contribution of each of the exploitive groups also varies between the two sets of simulations. When choices are based exclusively on efficiency, there is a greater difference in the contributions of females; when choices are based on a combination of factors, the contributions of the collective groups differ more.

Archaeological Expectations

A series of archaeological expectations have been extrapolated from the results of the simulations. To facilitate identification of the factor(s) that have influenced the subsistence decision making, the expectations are structured according the analytical dimensions of taste, efficiency, and a strategy based on the combination of efficiency, taste and prestige. Further, because the simulations of the

subsistence strategies based on efficiency alone and on multiple goals (efficiency, taste, and prestige) are similar, expectations for these two sets of simulations are combined and the expected differences between the Late Archaic and Woodland periods are highlighted.

For the most part, expectations of the proportional contribution of resources are grouped in terms of general categories of plant (female/juvenile) and animal (collective and male) resources to best reflect the archaeological floral and faunal assemblages. Mussels, turtles, and maple sap, which do not fall neatly into the gender based division of female/juvenile-plants and collective and male-animals, are retained within their respective exploitive categories since their use offsets the contribution of other resources. Although the collective and male resources are categorically combined in the analysis, variations in the relative contribution of each exploitive group can be distinguished in terms of the resources selected.

Subsistence data from many of the sites considered in this study are not sufficient to address the fine grained variability of the monthly simulations. The Bray-Curtis measures of dissimilarity suggest a pattern of seasonal variability in resource choice. Therefore, the expectations for each simulation are summarized in terms of broad seasonal resource patterns rather than on a monthly basis.

As noted in the discussion of the simulated results, there are differences in both the types of resources selected and the relative contribution of any given resource to the diet. Therefore, the archaeological expectations posited here take into account both the relative contribution of different types of resources (e.g., terrestrial tuber, fruit, small game, etc.), as well as the specific resources chosen (e.g., acorn, grape, mulberry, etc).

In the development of the expectations, differences in natural and cultural factors affecting the preservation of food remains have also been taken into consideration (cf. Hastorf and Popper 1988; Knight 1985; Lopinot 1982, 1984). For example, dense plant parts (e.g., nutshells

and fruit pits) and bones (e.g., beaver) are more likely to be preserved than are fleshy, soft plant parts (e.g., tubers, nut meats) or cartilaginous bones (e.g., fish). Processing will also affect the preservation of subsistence remains. Since carbonization increases the preservational potential of organic materials, foods that are cooked will more likely be preserved than those that are consumed raw. Therefore, the proposed archaeological expectations are keyed to the those resources that are more likely to be preserved (nuts, seeds, and bone) and described in terms of anticipated proportions (e.g., nut is expected to be more important in a diet based on taste than in diets based on other criteria), which can be compared among different sites and occupations. Differences in the specific foods selected (e.g., fatty nuts such as black walnut and butternut as opposed to acorn) and the diversity of foods are also key attributes that differentiate the patterns in the simulations. They are, therefore, integrated into the archaeological expectations.

While some studies have integrated technological correlates into their expectations (Cowan 1985; Jochim 1976; Keene 1981), this one does not. Technological expectations are problematic because tool morphology is not necessarily an accurate reflection of tool function. Microwear studies (e.g., Robertson 1987; Yerkes 1987) demonstrate that morphology is, in fact, a poor indicator of function. Therefore, to argue for differences in subsistence activities on the basis of tool categories (see for example, Fitting 1969:367; Winters 1969) is considered inappropriate. In this study, microwear data, when available, will be integrated into the analyses of subsistence activities. Specific expectations regarding use-ware patterns will not be specified, however, because some of the lithic assemblages considered in this study have not been analyzed for microwear.

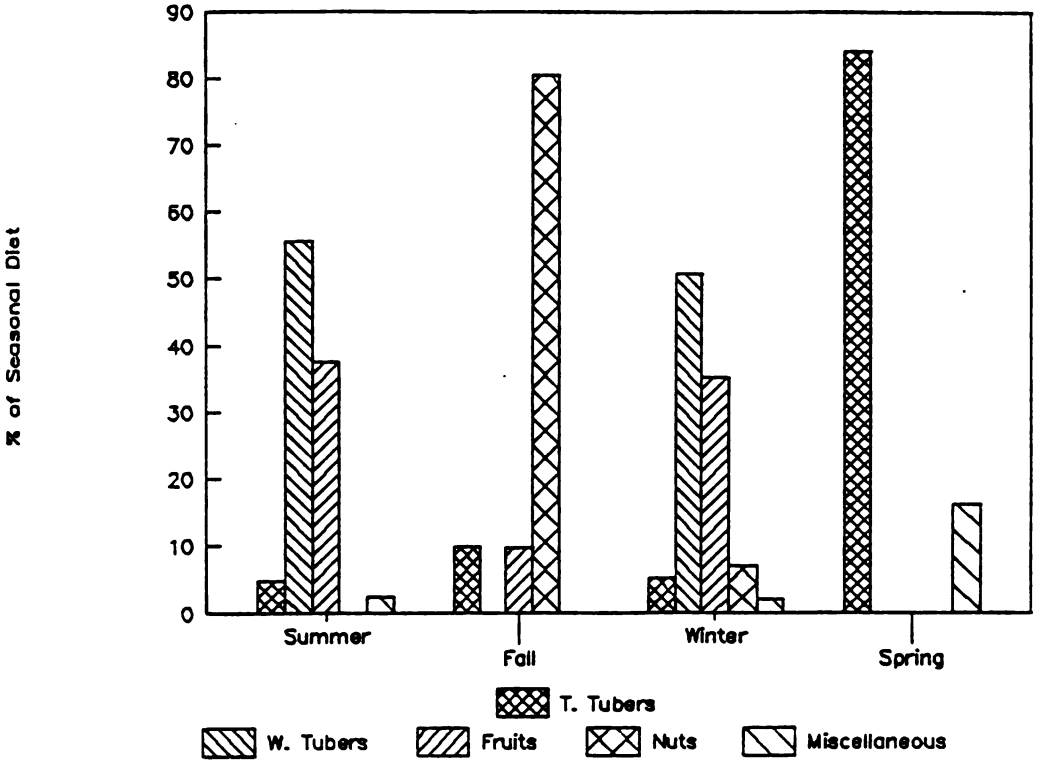
Archaeological Expectations:
Late Archaic and Woodland Strategies Based on Taste

Subsistence strategies based on taste alone favor foods that are high in fat or sugar. The simulation of Late Archaic and Early and Middle Woodland choices based on taste suggests that the diet would include a wide range of plant foods, mussels, turtles, game animals, waterfowl, pigeon, and fish (Table 4.1).

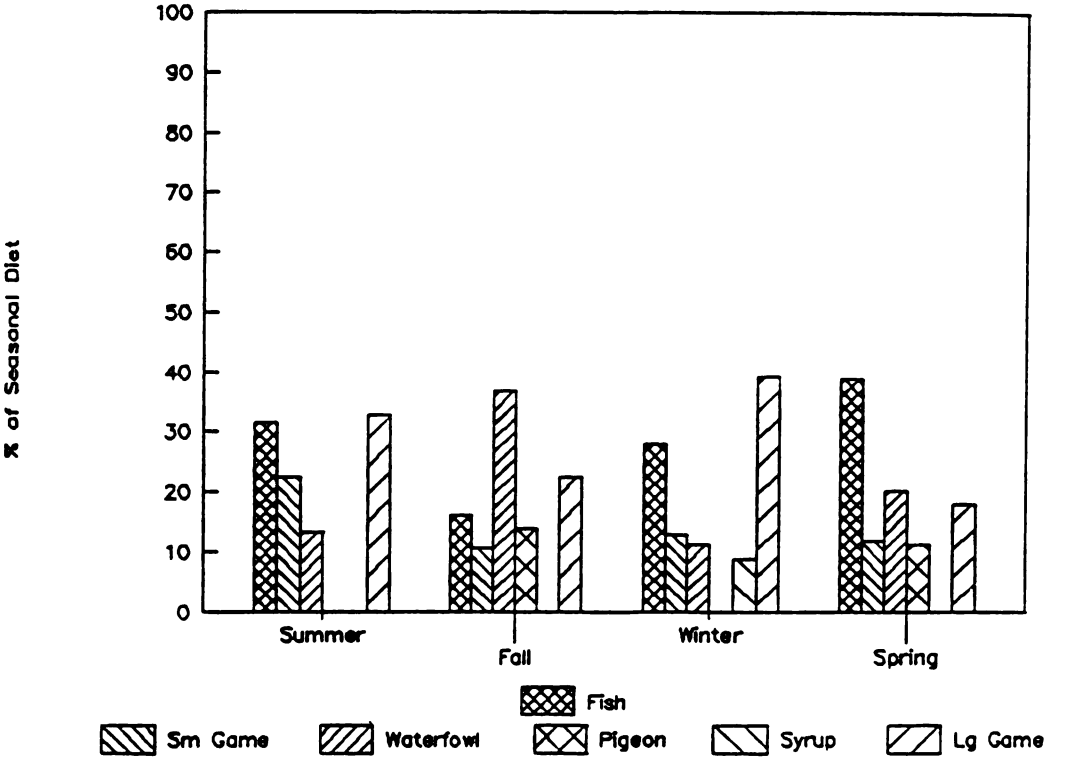
One would expect that in summer sites, fruits would be ubiquitous and a high diversity of taxa, including those that have relatively low productivity values (e.g., grape, strawberry, and mulberry) would be represented. Small animals (including turtles and fatty species such as muskrat and woodchuck), waterfowl, and mussels would comprise a relatively high percentage of the faunal assemblage (Figure 4.14a and 4.14b). Finally, nuts and pigeons, which are available during other seasons of the year would be virtually absent.

The simulation of choices based on taste indicates that at fall sites one would expect nuts to be ubiquitous and represented by a high diversity and high density of fatty taxa (i.e., hickory, hazelnut, butternut and black walnut). Low densities of fall fruit (e.g., elderberry and perhaps grape) seeds and terrestrial tubers are also expected components of the subsistence assemblage (Table 4.1, Figure 4.14a). Waterfowl and large game would be the most important sources of meat. Lesser amounts of fish, pigeon, and some small game would also be represented (Figure 4.14b).

The simulation of winter subsistence choices based on taste suggests that one would expect that sites would produce low densities of a wide range of plants, collected and stored during the summer and fall. A higher diversity and density of nuts and fruits would occur in these sites than in sites in which choices were based on efficiency alone or a combination of efficiency, taste, and prestige. The faunal assemblage should also contain a wide range of game. Large game are expected to be the primary source of meat, followed by fish, and small quantities of a variety of small game animals and waterfowl (Figures 4.14a and 4.14b).



a. Gathered



b. Hunted

Figure 4.14. Seasonal Diet Choices: Taste

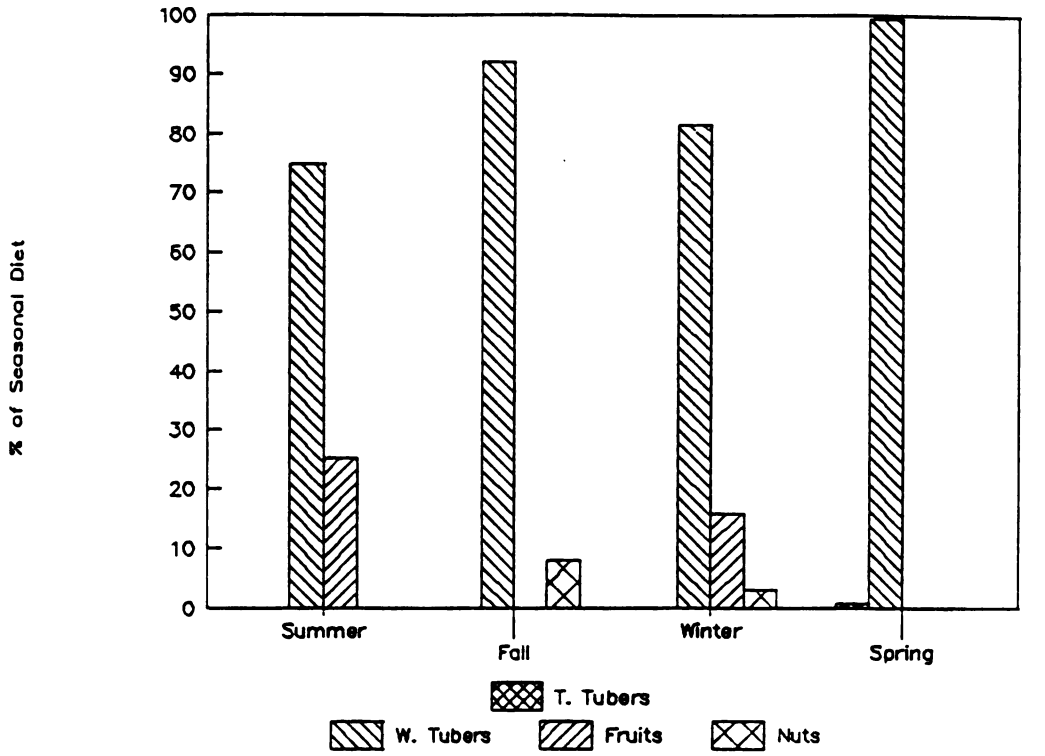
The simulation of spring choices based on taste suggests that, if they were preserved, low densities of a variety of terrestrial tubers would be among the only plant remains recovered. In contrast, the faunal assemblage would be characterized by a high diversity of resources. Fish would be the primary source of meat. Large game and waterfowl would be represented in lower, but relatively equal, percentages. Lesser amounts of fatty small game animals, pigeon, and mussels are also expected (Table 4.1; Figure 4.14a, 4.14b).

This type of broad-based subsistence pattern is characteristic of what might be classified as a diffuse economic strategy, which requires careful scheduling to ensure economic security (Cleland 1976). This simulation suggests, however, that diffuse economies may develop not only "where no one resource, or few resources, are abundant and reliable enough to promote economic security" (Cleland 1976:64) but also under circumstances in which a variety of preferred foods can be reliably exploited.

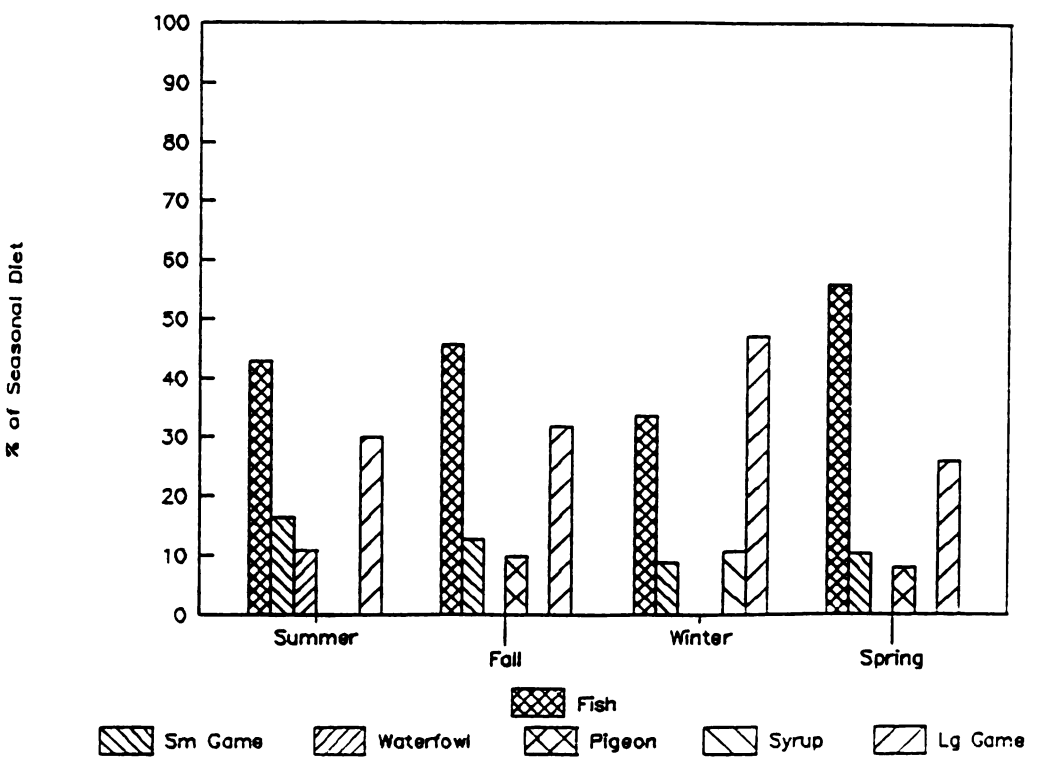
Archaeological Expectations:
Late Archaic and Woodland Strategies Based on Efficiency

Subsistence strategies based on efficiency alone favor foods that have high productivity values. The simulations of Late Archaic and Early and Middle Woodland subsistence choices based on efficiency suggest that a limited set of highly productive plant foods, game animals, waterfowl, and fish would have been exploited.

Late Archaic and Woodland summer sites in which resource choices were based on efficiency would be distinguished by a narrow range of plant and animal foods. A limited range of highly productive fruits (e.g., blackberry, gooseberry/currant, cherry) would be expected to be represented. Further, they should be less ubiquitous and occur in lower densities than in other summer assemblages. While often not well represented archaeologically, wetland tubers might occur in relatively high densities (Figures 4.15a and 4.16a). Fish remains would comprise a relatively high proportion of the faunal assemblage. Small game would

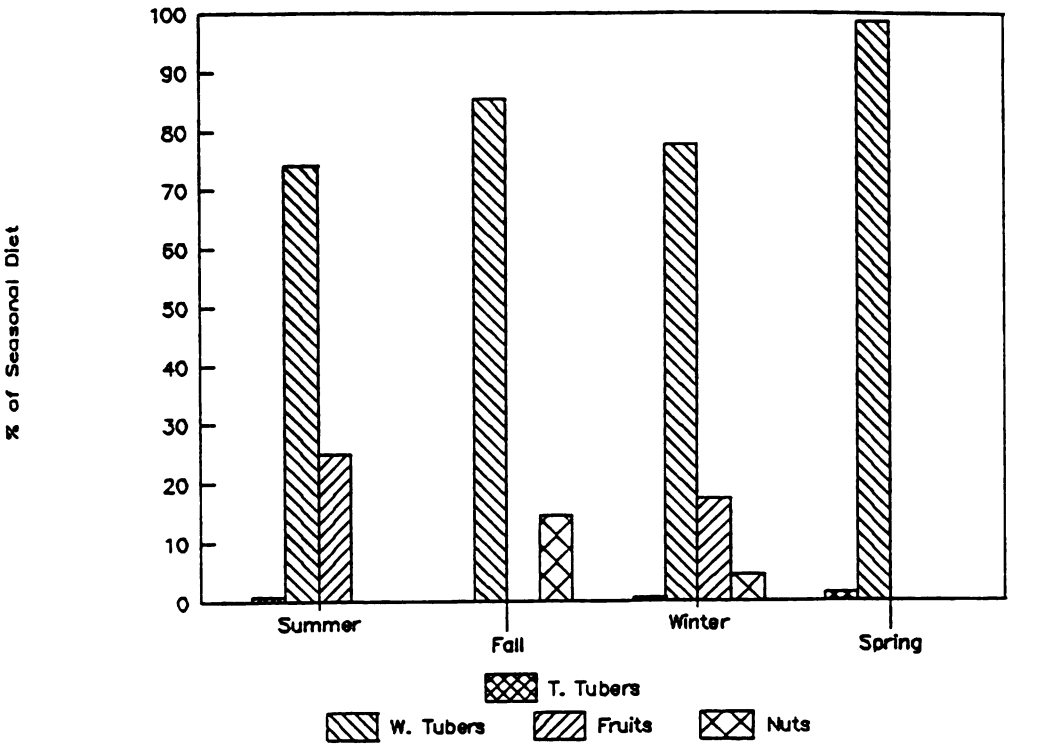


a. Gathered

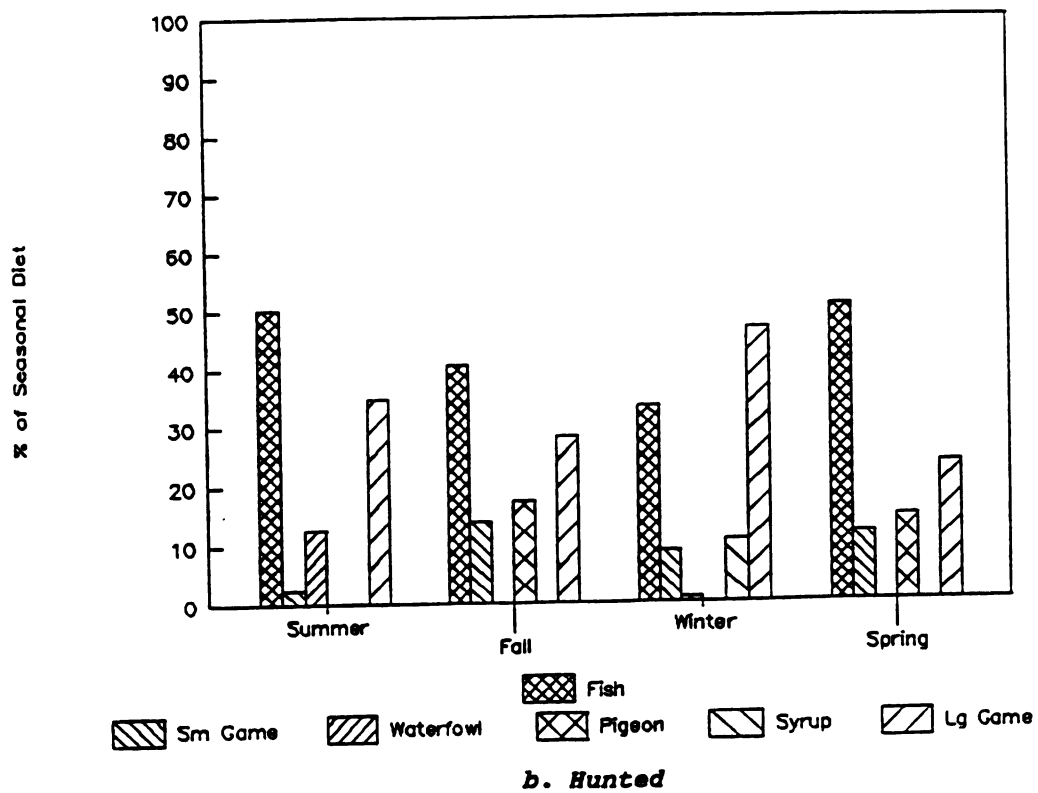


b. Hunted

Figure 4.15. Seasonal Diet Choices: Late Archaic Efficieny



a. Gathered



b. Hunted

Figure 4.16. Seasonal Diet Choices: Early and Middle Woodland Efficiency

be of relatively low importance (Figures 4.15b and 4.16b) and would be restricted to a few more productive taxa (e.g., rabbit, squirrel, raccoon, beaver, and muskrat). Nuts and pigeons, which are available during other seasons of the year, should be virtually absent.

The simulations of choices based on efficiency alone indicate that fall sites would also be distinguished by a limited variety of plants and animals (Tables 4.2 and 4.4). Nuts are expected to be fairly ubiquitous but represented by low densities of a few more productive taxa (e.g., hickory, butternut, acorn and beech). If preserved, relatively high densities of wetland tubers should also be present (Figures 4.15a and 4.16a). Fish and large game would be the primary sources of meat. In comparison, there would be relatively limited numbers of small game and pigeon, and little or no waterfowl represented (Figures 4.15b and 4.16b).

The simulations of choices based on efficiency alone suggest that winter sites would contain a variety of summer and fall plants, as well as a variety of game animals (Figures 4.15a, 4.15b, 4.16a, and 4.16b). Plant remains are not expected to be ubiquitous. Further, lower densities of fruits and nuts are expected in these sites than in those in which taste influenced resource choice. Large game would likely be the most important source of meat, although fish and small game would together comprise nearly as much food as the large game animals (Figures 4.15b and 4.16b). Finally, a key difference between winter sites and others is that waterfowl would likely be absent.

The simulations based on efficiency suggest that spring sites would be distinguished by relatively high percentages of fish, moderate amounts of large game, and lesser amounts of pigeon and small game. If preserved, aquatic tubers would also occur in relatively high densities.

This type of narrowly defined subsistence pattern is characteristic of a focal economic strategy. As described by Cleland (1976:61), this type of adaptive strategy is dependent upon a high degree of resource reliability. These simulations suggest that such an

adaptation may also be a response to a need to exploit more efficient but less preferred (in terms of taste and prestige) foods.

Archaeological Expectations: Late Archaic and Woodland Strategies Based on Multiple Goals

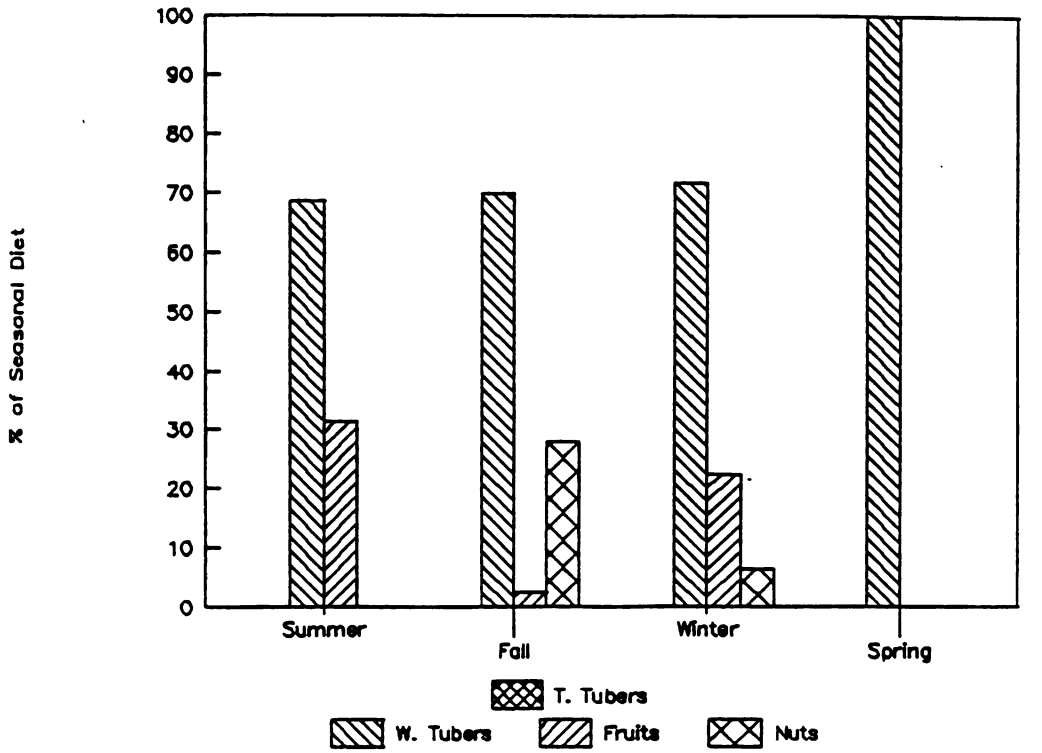
Late Archaic and Early and Middle Woodland subsistence strategies based on a combination of prestige, taste, and efficiency represent a compromise between the examples of choices based on taste alone and efficiency alone. The simulations suggest that a somewhat limited range of plant foods and a relatively high diversity of game animals,[6] waterfowl, and fish would have been exploited by hunting and gathering populations (Tables 4.3 and 4.5).

The simulation of choices based on the combination of factors suggests that one would expect summer sites to be distinguished by a moderate variety of plants and animals (Tables 4.3 and 4.5). Fruits would be fairly ubiquitous, although there may be few seeds of less productive taxa (e.g., strawberry, mulberry, or grape). If they are preserved, relatively high densities of wetland tubers should occur. Low densities of terrestrial tubers are also anticipated in the Woodland assemblage (Figures 4.17a and 4.18a). Fish and large game should be the primary sources of meat and comprise fairly equal percentages of the diet (in terms of pounds of usable meat). Lesser amounts of small game and waterfowl should also be present (Figures 4.17 and 4.18). While a variety of small game might be expected, there would be low numbers of these taxa and an absence or low representation of turtle and mussel. Resources such as pigeons and nuts, which are available in seasons other than the summer, would be absent.

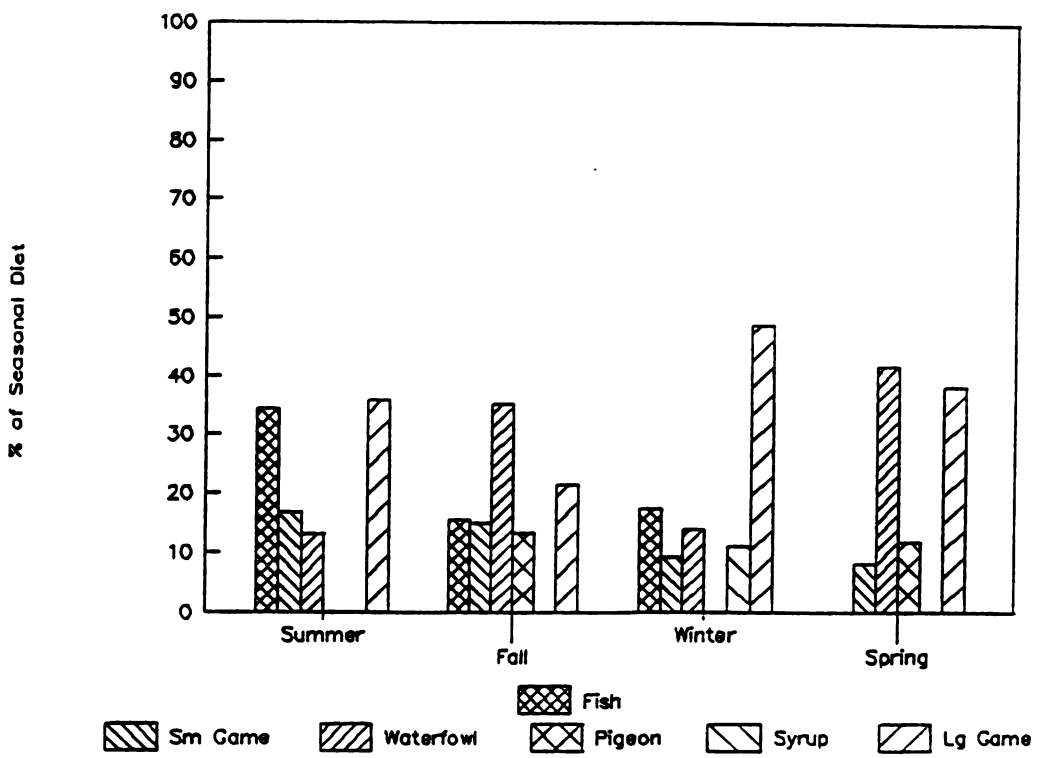
The simulations of fall choices based on a combination of factors indicate that a subsistence assemblage would represent a compromise between the other two fall site types. Nuts would be ubiquitous and

---

[6] Although carnivores are not components of the subsistence regime, they may be represented as prestige items in faunal assemblages.

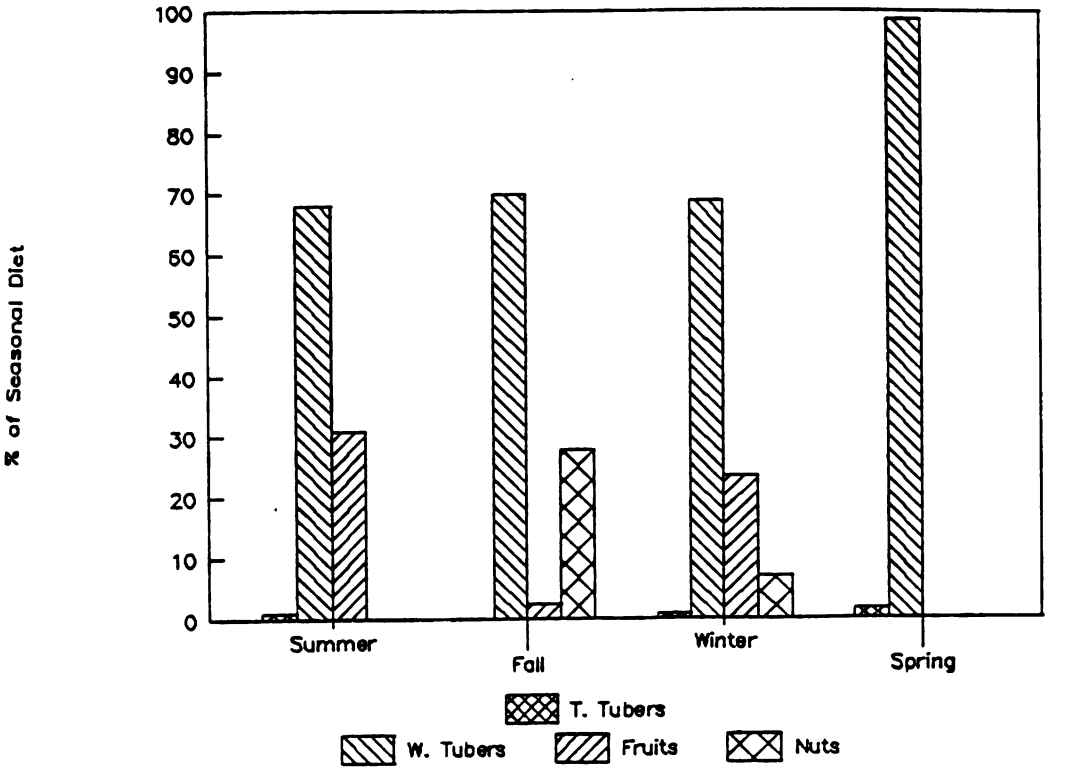


a. Gathered

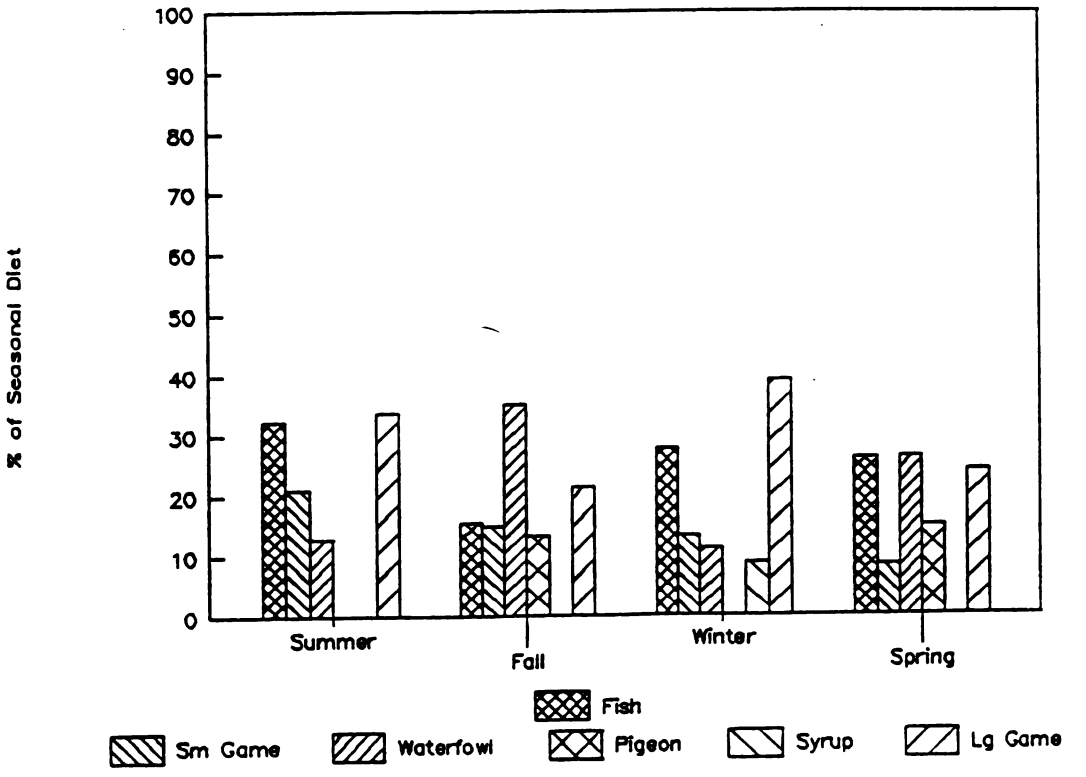


b. Hunted

Figure 4.17. Seasonal Diet Choices: Late Archaic Multiple Goals



a. Gathered



b. Hunted

Figure 4.18. Seasonal Diet Choices: Early and Middle Woodland Multiple Goals

would include a moderate density of a variety of taxa (e.g., hickory nut, butternut, black walnut, hazelnut, acorn, and beechnut). Low densities of fruit seeds (elderberry and perhaps other late fruiting taxa) may be present, and moderate densities of wetland tubers may also be represented (Figures 4.17a and 4.18a). Waterfowl and large game would be the primary sources of meat. Lesser and relatively equal amounts of meat would be contributed by small game, fish, and pigeon (Figures 4.17b and 4.18b).

The simulation of winter resource choices based on the combination of factors suggests that one would expect these sites to be distinguished by small amounts of a wide range of plants collected and stored during the summer and fall. A variety of animal resources are also expected (Tables 4.3 and 4.5). Although not especially ubiquitous, nuts and fruits would occur in higher densities than in sites in which choices were based on efficiency alone and slightly lower densities than in sites in which choices were based on taste alone (Figures 4.17a and 4.18b). Large game are expected to be the primary source of meat, followed by fish, and small quantities of a variety of small game animals and waterfowl (Figures 4.17b and 4.18b). These sites may, however, be difficult to distinguish from sites in which choices were based exclusively on taste.

The subsistence pattern based on a combination of prestige, taste, and efficiency is neither a focal nor a diffuse economic strategy (Cleland 1976) because it represents a compromise between competing goals. This type of adaptive strategy may, in fact, represent the most flexible of the strategies predicted because it incorporates multiple goals and is likely to be more responsive to inter-annual variations in the predictability of any given resource.

Conclusions

The simulations of Late Archaic and Early and Middle Woodland resource choices based on taste alone, efficiency alone, and a

combination of goals (prestige, taste, and efficiency) represent three different adaptive strategies. The simulation of choices based on taste alone suggest that a wide variety of sweet and fatty foods would be selected. This type of diverse subsistence pattern is characteristic of a diffuse economic strategy (Cleland 1966, 1976). A more narrowly defined, focal subsistence pattern, based primarily on the use of a few highly productive resources, is predicted by the simulation of choices based on efficiency. The simulated choices based on a combination of prestige, taste, and efficiency reflect a mixed subsistence pattern that is, by definition, neither diffuse nor focal. A moderate range of resources, including those that are highly productive and those that are sweeter and fattier, are selected in the latter simulations. These variations between the simulated subsistence strategies highlight the effects of efficiency, taste, and prestige on subsistence decision making and reflect scheduling differences between strategies *within* the cultural and corresponding environmental periods (i.e., lake stages). Further, these variations primarily apply to resources selected by the female/juvenile exploitive group.

There is less variation in the predicted patterns *between* cultural periods based on the same criteria. The greatest dissimilarity between the simulated subsistence patterns is related to differences in the productivity (and thus relative efficiency) of fall and spring resources, particularly those of the female/juvenile and collective exploitive groups.

These archaeological expectations are keyed to seasonal differences in the subsistence patterns described. While the expectations are described in relative terms, they should be specific enough to differentiate variations in seasonal subsistence choices yet broad enough to deal with the ambiguities of the archaeological record. These expectations are compared with archaeological subsistence data from the Late Archaic, Early Woodland, and Middle Woodland periods in the Saginaw Valley in the following chapter. This comparison is

directed toward assessing the relative importance of criteria such as efficiency, taste, and prestige on subsistence decision making. Based on the results of this comparison, the factors affecting changes in the relative contribution of each of the exploitive groups may be better understood. Thus, the results of this analysis will clarify the relationship between the satisfaction of different subsistence goals and the division of labor within the context of changing adaptive strategies.

CHAPTER 5

Prehistoric Subsistence in the Saginaw Valley: Archaeological Data

In this chapter, archaeological data from Late Archaic, Early Woodland, and Middle Woodland sites are presented and evaluated relative to the expectations developed in Chapter 4. This aspect of the analysis is directed toward identifying the cultural goals that might account for the variations in subsistence patterns in this region and considering the relationship of the division of labor to the satisfaction of these goals.

First, the location and site structure of each site is briefly described. Then, the prehistoric habitat of each site is reconstructed from the geologic, floral, and faunal data. The features and technological and subsistence assemblages from each of the sites are then described. Subsistence data from archaeological sites are used to identify site seasonality and the food resources exploited. Technological information is used to elaborate on the subsistence and other activities represented at each site. These data are then compared with the archaeological expectations described in Chapter 4. This comparison is directed toward identifying the simulated subsistence strategy that best fits the data. The specific resources that were selected and the overall diet breadth reflected by the subsistence assemblages are the primary criteria used to identify the simulation that most closely parallels the observed subsistence pattern.

The site specific subsistence patterns are then grouped by time period. From these results, general conclusions are drawn regarding the goals affecting subsistence decision making and their relationship to

the division of labor within each of the periods and between the periods.

The Weber I Site

The Weber I site (20SA581) is located on the section line between Sections 27 and 28 in Frankenmuth Township, Saginaw County, Michigan. The site is situated on a small levee (182.9 m [600 ft] amsl) that runs parallel to the Cass River. This location is approximately 19.3 km (12 mi) east-southeast of where the Cass, Shiawassee, and Tittabawassee rivers converge to form the Saginaw River (Figure 5.1). It is also the most upriver extent of the Nipissing transgression into the Cass River drainage (Monaghan and Fay 1989; Monaghan *et al.* 1986).

In 1981, Brunett discovered and tested the Weber I site. Two stratigraphically superimposed middens were identified during extensive trenching of this locality. Michigan State University conducted a Phase III data recovery at the site in 1982 to mitigate the effects of a bridge replacement. A 98 m^2 area was opened within the impact area (Figure 5.2), and three stratigraphically separate occupation zones were identified: a Late Woodland component (plowzone and interface); a Late Archaic component (Occupation Zone I); and a Middle Archaic component (Occupation Zone II) (Lovis, ed. 1989). This analysis focuses on the Late Archaic component.

Paleoenvironmental Reconstruction

Geomorphological studies suggest that during the Late Archaic period, the physiography of the Weber I site was similar to its present environment. Floral and faunal analyses support this conclusion. The wood charcoal assemblage indicates that both mesic and wet-mesic mixed forest communities grew near the site during the Late Archaic period (Table 5.1). The ridge on which the site occurs probably supported a beech-maple forest community with beech, maple, red oak, white ash, black walnut, hickory, and elm. White pine, (bur and swamp white) oak,

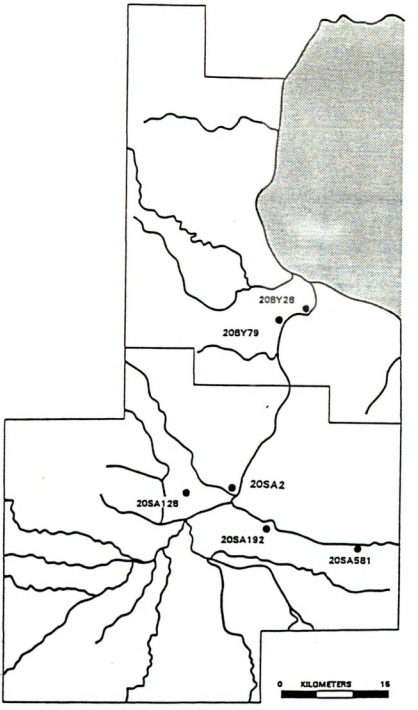
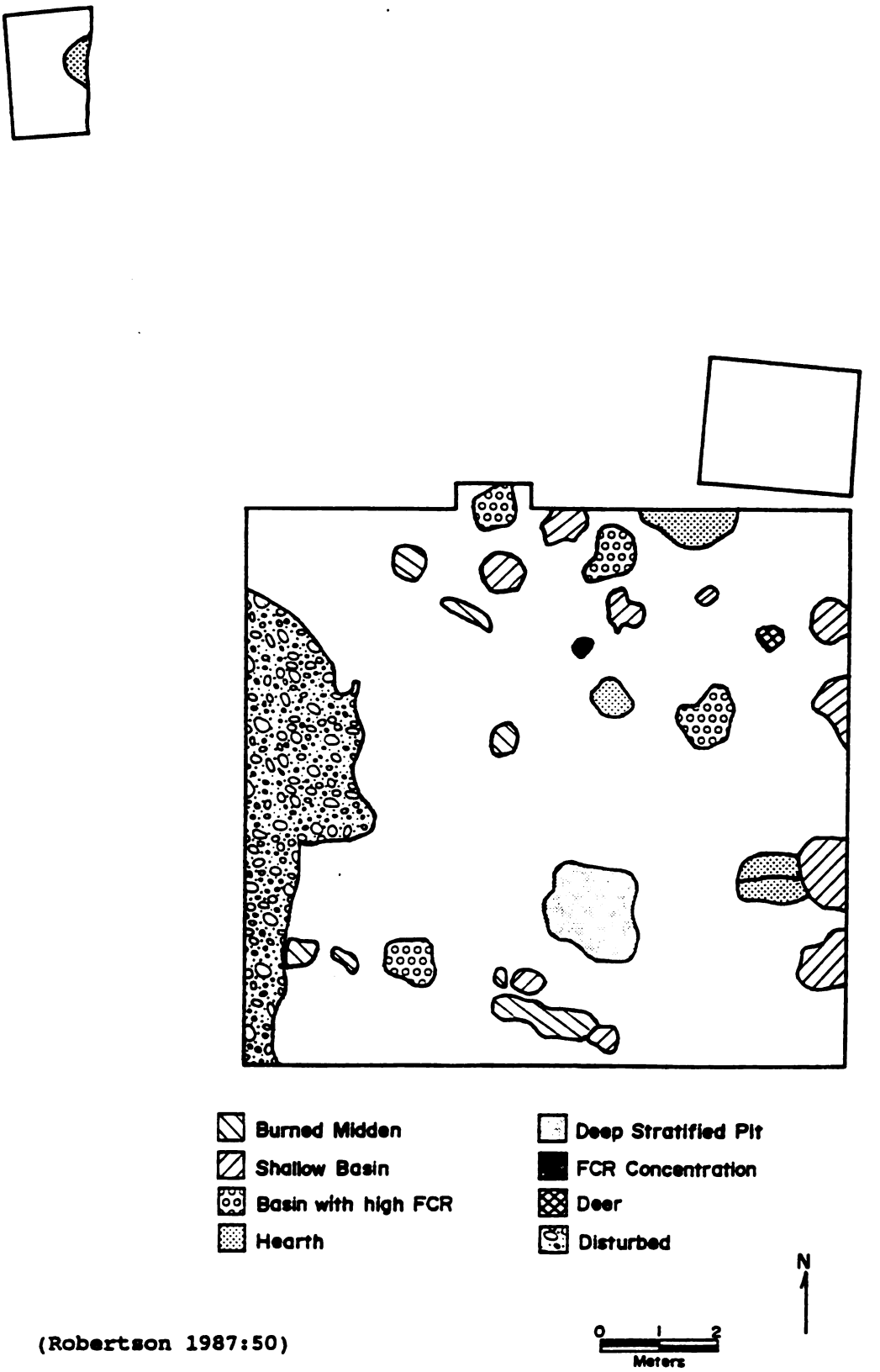


Figure 5.1. Site Locations Within the Study Area



(Robertson 1987:50)

Figure 5.2. Weber I Site: Late Archaic (Occupation Zone 1) Features

Table 5.1. Weber I Site: Flora

Flot Volume	684.5 ℓ		
Wood Charcoal	6877 ct/76.0 g		
Identified Taxa	**Ct**		**Percent**
Fagus grandifolia/Beech	18		2.0
Betula spp./Birch	4		0.5
Ulmus spp./Elm	19		2.1
Carya spp./Hickory	11		1.2
Acer spp./Maple	19		2.1
Quercus spp./Oak	161		18.1
Q. spp./White oak group	27		3.0
Q. spp./Red oak group	4		0.5
Pinus spp./Pine	64		7.2
Juglans spp./Walnut	8		0.9
cf. *Fraxinus* spp./Ash	2		0.2
Coniferous	1		0.1
Diffuse porous	66		7.4
Ring porous	155		17.4
Semi-ring porous	1		0.1
Unidentifiable	330		37.1
Bark Charcoal	2931 ct./77.1 g		
Nutshell	**Ct/Wt[1]**	**Percent**	**Ubiquity**
Juglandaceae/Walnut family	836/16.8	59.1	75.4
Juglans nigra/Black walnut	375/52.0	26.5	21.7
Juglans cinerea/Butternut	2/0.5	0.1	1.4
Carya spp./Hickory	24/0.9	1.7	8.7
Corylus americana/Hazelnut	2/0.1	0.1	1.4
Quercus spp./Acorn			
Shell	144/20.9	10.2	21.7
Cotyledon	32/2.7	2.3	2.9
(Total)	(1415/73.8)		
Tuber			
Terrestrial tuber	1/0.1	100.0	1.4
Seeds			
Gallium sp./Bedstraw	1	3.0	1.4
Rubus spp./Blackberry	4	12.1	5.8
Vaccinium sp./Blueberry	1	3.0	1.4
Sambucus canadensis/Elderberry	2	6.1	2.9
Geranium sp./Geranium	1	3.0	1.4
Ostrya virginiana/Hop-hornbeam	2	6.1	2.9
cf. *Lespedeza* sp./cf. Bush-clover	1	3.0	1.4
cf. *Najas* sp./cf. Naiad	1	3.0	1.4
Asteraceae/Aster	1	3.0	1.4
Poaceae/Grass	1	3.0	1.4
Convolvulaceae/Morning glory	1	3.0	1.4
Brassicaceae/Mustard	6	18.2	7.2
Rosaceae cf. *Rubus* sp./Blackberry	1	3.0	1.4
Unidentifiable	10	30.3	14.5
(Total)	33		

[1] Weights in grams

red ash, and elm grew in wetter soils along the river (Albert *et al.* 1986; Barnes and Wagner 1981). A higher percentage of oak (21.6%) is present than would be expected in this community type. This suggests that there may have been some cultural selection for oak, which is generally considered a good fuel wood.

The mixed forest community, with high percentages of mast producing trees (oak, black walnut, hickory, butternut, and hazelnut), would have supported white-tailed deer and other forest dwelling taxa. Open area is evidenced by the presence of grasses, ruderal (disturbed habitat) and other light-loving taxa (i.e., blueberry, blackberry, and elderberry [Table 5.1]), and wapiti (Table 5.2), which is primarily a grazing species. In addition, proximity to an aquatic environment, the Cass River, is evidenced by the presence of fish, turtle, and naiad.

Features

Twenty-eight features were defined in the Late Archaic occupation zone (Figure 5.2). The most common feature type (n=14) is a small, shallow basin-shaped pit. Seven of these pits contained little debris other than small quantities of wood charcoal. Three contained wood charcoal and moderate densities of nutshell and acorn cotyledons. The other four had high densities of firecracked rock (1.58 - 3.83 kg). Two of these features also contained calcined bone and charcoal.

Eleven features appear to be surface hearths. These features contained variable amounts of calcined bone, carbonized nutshell, and firecracked rock.

Of the three remaining features, one consisted of bones from the hind-end of a deer lying *in situ* within the midden. Another was a small concentration of firecracked rock. The third was a deep, stratified, basin-shaped pit containing 10.58 kg of firecracked rock and a lens of ash at the base.

Table 5.2. Weber I Site: Fauna

Taxon	NISP[a]	Percentage[b]	MNI[c]	Meat Yield[d] kg
Odocoileus virginianus				
White-tailed deer	56	3.7	2	76.5
Cervus elephus				
Wapiti	36	2.8	1	157.5
Cervidae				
Deer, wapiti family	3	0.2		
Ondatra zibethicus				
Muskrat	1	0.1	1	1.0
Other Mammal	339	22.5		
Acipenser fulvescens				
Lake sturgeon	13	0.9	1	16.2
Other Fish	9	0.6		
Chelydra serpentina				
cf. Snapping turtle	1	0.1	1	4.5
Shellfish	2	0.1		
Unidentifiable	1045	69.4		
Total	1505	100.0	6	229.0

(From Smith and Egan 1990:46)

---

[a] NISP: Number of Identified Specimens

[b] Percentage of specimens

[c] MNI: Minimum Number of Individuals

[d] Estimates based on "pounds of usable meat/individual" from Cleland 1966

Artifact Analysis

The lithic assemblage from the Late Archaic component of the Weber I site is dominated by firecracked rock, while debitage and tools comprise a small component of the assemblage. A total of 11,986 pieces of firecracked rock, weighing 292.3 kg, were recovered within this stratum. In contrast, the remainder of the lithic assemblage included: a mere 561 pieces of debitage, 19 formal tools, two hammerstones (one fragmentary), an anvil fragment, and two unidentifiable groundstone tool fragments (Table 5.3). The frequencies of raw material types reflect a dependence on locally available lithic resources (Robertson 1987:53, 1989).

Table 5.3. Weber I Site: Chipped Stone Tools

Tool Type	Frequency	Percentage
Projectile Points/Knives	5	26.32
Drills	1	5.26
Biface Tips	1	5.26
Miscellaneous Biface Fragments	2	10.53
(Total Bifaces)	(9)	(47.37)
Side-scrapers	1	5.26
Denticulates	1	5.26
Bores	1	5.26
(Total Unifaces)	(3)	(15.79)
Pieces Esquillees	7	36.84
Total Tools	19	100.00

(From Robertson 1987:55)

Debitage analysis indicates that chert reduction and tool manufacture were not important activities at the site. Further, tool maintenance and resharpening rarely occurred (Robertson 1987:52).

Among the few formal tools identified, bifaces are the most common tool form, followed by pieces esquillees, and then unifaces (Table 5.3). Only seven of the 19 tools identified had interpretable microware features. "Fifty percent of all uses, are subsistence related and only projectile points/knives are involved in these activities" (Robertson 1987:54). Wares reflective of manufacturing activities are also

limited. The drill tip was probably used to drill bone or antler, and three other tools were used to wedge wood (Robertson 1987:54-56).

Subsistence Remains

The faunal assemblage from the Late Archaic component is extremely fragmented. A large portion of the faunal assemblage (69.4%) could not be assigned with confidence to any class designation, although most of these fragments are probably from mammals (Table 5.2).

Of the identifiable specimens, mammalian remains are the most common, and cervids dominate the assemblage (Table 5.2). A minimum of two white-tailed deer (*Odocoileus virginianus*), one mature and one immature (four to six months old at death), and one wapiti (*Cervus elephus*) are represented. These taxa would have provided the majority of the meat at the site (approximately 207 kg) (Smith 1989; Smith and Egan 1990:46).

Other species represented in the faunal assemblage include: one muskrat (*Ondatra zibethicus*); a lake sturgeon (*Acipenser fulvescens*); another fish that could not be identified to genus; one large turtle (cf. snapping turtle/*Chelydra serpentina*); and two fresh-water clams (class: Pelecypoda). These taxa would have contributed small amounts of meat of the food supply (Table 5.2; Smith 1989:145-158; Smith and Egan 1990:46-47).

Relatively high densities of floral remains were recovered in systematically collected flotation samples from the Late Archaic stratum (Table 5.1; Cleland 1989; Egan 1988; Smith and Egan 1990). Higher densities (149.6 ct/10 ℓ; 1.39 g/10 ℓ) of wood charcoal were recovered from feature contexts than from the midden (15.6 ct/10 ℓ; 0.26 g/10 ℓ), although charcoal was ubiquitous throughout the feature and midden contexts (100% and 96%, respectively).

Bark occurred in association with charcoal. Bark was more ubiquitous (occurring in 72% of all Late Archaic features) in feature contexts and was represented in significantly higher densities (71.2

ct/10 ℓ; 1.16 g/10 ℓ) in feature contexts than in the midden (ubiquity = 40%; 0.9 ct/10 ℓ; 0.8 g/10 ℓ). Overall, the bark to charcoal ratio by weight is 1:2. Feature 227, however, contained an unusually high density of charcoal compared to the other features and also had far more bark than charcoal (2.6:1) by weight. Based on ethnographic analogy (cf. Waugh 1916:127), this high proportion of bark may be related to the feature's use as a smudge pit for smoking berries, tubers, hides, meat, or other perishable goods.

Acorn, hazelnut, black walnut, butternut, beechnut, and hickory would have been available in the reconstructed mixed forest. All except beechnut are present in the Late Archaic assemblage (Table 5.1). Overall, a total of 1405 fragments of nutshell and cotyledon weighing 73.8 g was recovered. The relatively high ratio of nuts to wood charcoal (1:4.8 ct) and the ubiquity of nuts (75.4% of the samples) indicate that they were an important component of the Late Archaic subsistence regime.

Black walnut (*Juglans nigra*) appears to have been the most important nut resource (based on count and weight; Table 5.1), although acorn may have been nearly as important. Acorn (*Quercus* spp.) shell accounts for 10.4% by count and 1.1% by weight of the total nutshell assemblage. The importance of acorn to the subsistence strategy of the Weber I Late Archaic may be greater than these values indicate, however. Lopinot (1982:729-743) found that acorn shell may be under-represented by as much as 300% (by weight) as compared to walnut shell; if that were true in this context, acorn would be more abundant than black walnut. Further, acorn is as ubiquitous as black walnut (Table 5.1).

Based on count, weight, and ubiquity, hickory (*Carya* spp.) was less important than acorn or black walnut. Hickory may also have been more important than these values suggest, however, because many of the fragments identified to family (Juglandaceae) may have been fragments of hickory nutshells.

Two hazelnut (*Corylus americana*) fragments were also recovered (Table 5.1). The low frequency and ubiquity (4%) of hazelnut are not unexpected given that they occur in low densities in forest communities such as that reconstructed for the site during the Late Archaic occupation. The hazelnut shells occur in association with other subsistence remains suggesting that were a component of the subsistence regime.

Thirty-three carbonized seeds were recovered from Late Archaic flotation samples (Table 5.1). Although these seeds occur in low densities (0.4 seeds/10 *l*) and are not ubiquitous (≤ 14.5%), they do consistently occur in association with charcoal, and 91% are found with nut remains. The co-occurrence of seeds and nut remains suggests that many of these seeds, or the fruits containing these seeds, were used as food. Summer fruits (blackberry/*Rubus* spp., elderberry/*Sambucus canadensis*, blueberry/*Vaccinium* sp., and rose family/Rosaceae [cf.*Rubus* spp.]) occur in low frequencies and collectively represent a relatively small percentage of the total seed assemblage; however, because fruits are often consumed uncooked, even if large quantities of the fruits were consumed, it is unlikely that large numbers of seeds would be carbonized. Therefore, the low frequency of fruit seeds is not considered representative of their potential dietary significance.

The other taxa represented (Composite family/Asteraceae; mustard/Brassicaceae; bedstraw/ *Gallium* sp., bush-clover/*Lespedeza* sp., morning glory/Convolvulaceae, geranium/*Geranium* sp., hop-hornbeam/ *Ostrya virginiana*, and grasses/Poaceae) (Table 5.1) are uninterpretable. Although, there are ethnographic references to medicinal and technological uses of these taxa, their small numbers and habitat preferences suggest that they could be accounted for by natural seed dispersal mechanisms. The single naiad (*Najas* sp.) seed is also considered to be of natural origin.

Finally, a single terrestrial tuber fragment weighing 0.1 g was recovered (Table 5.1). Associated archaeobotanical remains include wood

and bark charcoal, nutshell, and a blackberry seed. The association of this specimen with other subsistence remains and ethnographic references to use of tubers suggests that this fragment is culturally derived.

Seasonality and Function

The subsistence assemblage suggests that during the Late Archaic period, the Weber I site was occupied during the late summer (August) and early fall (September/October). This interpretation is based on the presence of summer fruits and nuts, as well as the warm season faunal resources (i.e., turtle, bivalves, and sturgeon). The presence of an immature deer (less than six months) complements this interpretation.

Nut procurement and processing appear to have been the primary activities at the site. In addition, the presence of deer teeth, innominate, sacrum, and lower lumbar vertebrae suggests that the entire deer was brought back to the site for processing (Smith 1989; Smith and Egan 1990), although use-wear analysis did not indicate any evidence for butchering or hide working.

The cervid bone and features were concentrated along the northern and eastern margins of the excavation area, while the nutshell and the majority of the tools (80%), firecracked rock, and debitage occurred in the southwest quadrant of the block (Robertson 1987:57). This distribution suggests that there were two primary activity loci, but the functional relationship between the subsistence remains and associated cultural remains and features is not completely clear (Robertson 1987:57).

The low density of all artifact types and the lack of superimpositioning of features suggests that the occupation(s) were short lived (Lovis, ed. 1989; Robertson 1987:57). Finally, the size of the site suggests that a residential group, rather than a special activity group, occupied the site.

Comparison with Archaeological Expectations

The composition of the Late Archaic subsistence assemblage from the Weber I site best fits the archaeological expectations of the simulation of Late Archaic choices based solely on taste, the only simulation in which large game and fatty nuts are identified as primary resources and fruits are recognized as important secondary foods. The presence of activity loci with relatively high densities of these foods suggests that these resources were "targeted" components of the subsistence regime.

Although there are some variations between the subsistence assemblages and the archaeological expectations of choices based on taste, the primary resources identified in the other simulations do not correspond well with the subsistence data. In the simulation based on efficiency, fish are identified as the primary source of meat and nuts are considered a low priority food. In the simulation based on multiple goals, large game are identified as a primary source of meat, but nuts are considered a fairly low priority food and fruits provide a nominal contribution.

Waterfowl is predicted by the simulation based on taste to be an important component of the subsistence regime but is absent in the Weber I faunal assemblage. The absence of waterfowl may be due to several factors, including the relative productivity of waterfowl in this location, the timing of the occupation, and limited contribution of collective subsistence activities in this subsistence regime.

Foods represented in the subsistence assemblages that are not anticipated components of the simulation based on taste include elk, acorns, turtle, and shellfish. Elk is incorporated into the simulations as a winter resource but may have been available in the valley throughout the year and would have been exploited when the opportunity was presented. Acorn are not highly ranked in terms of taste but might be exploited when fatty nuts were not readily available. Finally, turtle and shellfish are not predicted components of the fall diet but

are selected during other seasons in the simulation based on taste. Their presence is, therefore, not completely unexpected.

In the Weber I subsistence assemblages, male and female/juvenile resources comprise the majority of the diet. Fish is the only food that is classified, in this analysis, as a collective resource, and it is a small component of the diet. The limited contribution of collective resources may be due to the size of the residential group, the duration of the occupation, or the fact that the site was specifically occupied for the purposes of hunting and nut collecting.

The Schmidt Site

The Schmidt site (20SA192) lies on a narrow sand ridge that parallels the Cass River in Section 19 of Bridgeport Township, Saginaw County (Figure 5.1). At its closest point, the site is approximately 500 m southwest of the Cass River and less than 150 m from an extensive swampy wetland that parallels the river. While the apex of the ridge is 185.4 m (608 ft) amsl, the midden itself lies at 182.3 to 183.8 m (602 to 607 ft) amsl (Lovis and Robertson 1989:233-234).

The site has been formally excavated on four occasions: in 1962 by Spencer and Fairchild; in 1964 by the University of Michigan; in 1971 by Saginaw Valley College; and in 1973 by Western Michigan University. Published reports are, however, available only for the 1964 and 1973 excavations. Unfortunately, there are numerous discrepancies in the data presented in these reports.

The University of Michigan excavated an area 32.5 m^2 and identified six cultural strata, with a Dustin component superimposed and contemporaneous with a Laurentian component. Eight features were identified during this excavation; however, none can be clearly associated with the Dustin occupation (Harrison 1966).

The Western Michigan University excavations, directed by Fairchild, almost exclusively recovered materials associated with the Dustin occupation. Fairchild (1977:104) states that over 79 m^2 (850 ft^2) were

excavated, but his maps indicate that 95.2 m^2 (1025 ft^2) were excavated (Figure 5.3). Following Robertson (1987),[1] the mapped area is considered accurate.

This analysis focuses on the Western Michigan University data. This assemblage represents a more discrete cultural occupation and provides a larger sample size than the University of Michigan collection.

Paleoenvironmental Reconstruction

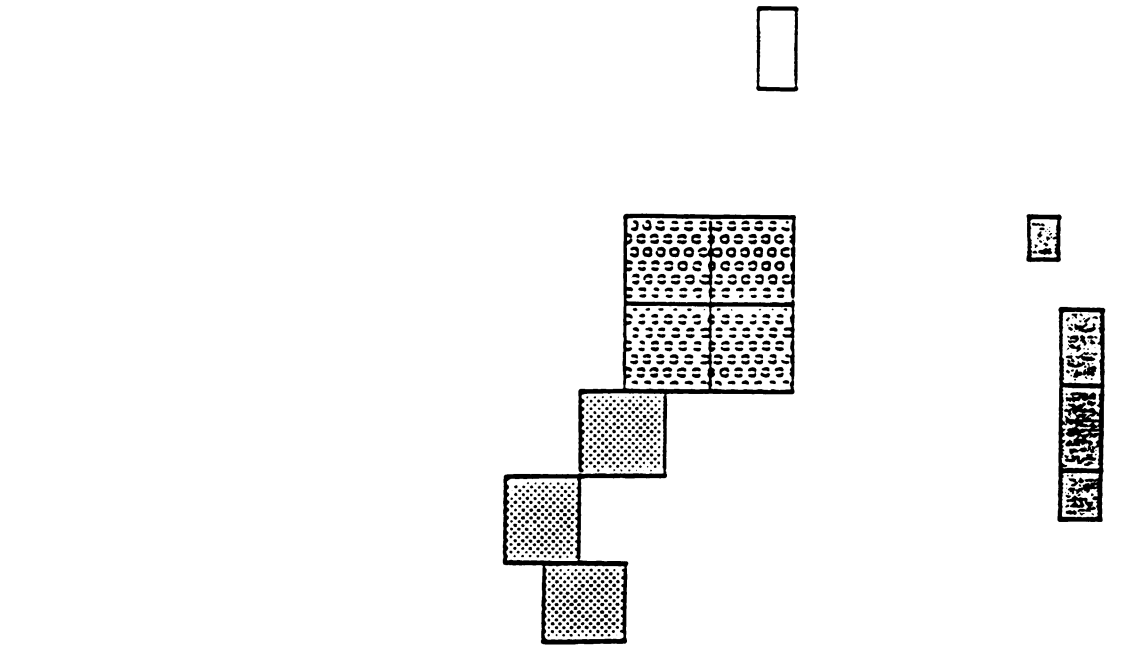
Because of problems of mixing and contamination, the floral assemblage from the Schmidt site is not considered an accurate reflection of the paleoenvironment. Faunal remains (Table 5.4) do, however, provide some perspective. Deer and rabbit indicate that a deciduous woodland habitat was present. Muskrat are common to marsh habitats and suggest a marsh was present along the shoreline, while the assemblage of identifiable fish indicates that the river was shallow, with a sandy or gravel bottom (Cleland 1966).

Features

Only nine pit features were identified during the Western Michigan University excavations at the Schmidt site (Fairchild 1977). Eight of the features occur in four adjacent 3.05 m x 3.05 m (10 ft x 10 ft) excavation units in the center of the site. Six features were basin-shaped pits with a dark organic fill. Most of the features contained small amounts of artifactual debris although three had large quantities of firecracked rock. Two features, one of which was only partially excavated, contained large quantities of bone, debitage, stone tools, and firecracked rock. One feature contained a concentration of cobble

---

[1] The scales and unit areas in Fairchild's (1977) figures (Figures 1, 3, 6, and 13) and verbal descriptions differ. Robertson's review of the field notes and collections suggests that Figure 13 is accurate and that 1025ft^2 were excavated.



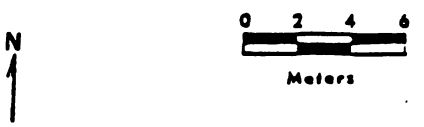
Area 1 - Moderate to low densities of bone, firecracked rock, debitage and tools

Area 2 - Moderate to low densities of bone, firecracked rock, debitage and tools

Area 3 - High densities of tools, bone and firecracked rock; low density of debitage

Area 4 - High densities of tools, debitage and bone; moderate density of firecracked rock

Area 5 - Moderate density of bone, firecracked rock and tools; low density of debitage



(Robertson 1987:139)

Figure 5.3. Schmidt Site: Activity Areas

Table 5.4. Schmidt Site: Fauna

Taxon	MNI[a]	Meat Yield[b] (kg)	Percentage[c]
Odocoileus virginianus			
White-tailed deer	2	76.5	
Ondatra zibethicus			
Muskrat	2	1.0	
Sylvilagus sp.			
Rabbit	1	1.9	
Procyon lotor			
Raccoon	3	23.6	
(Total Mammal)			(97.5)
Anas sp.			
Duck	4	2.2	
Ectopistes migratorius			
Passenger pigeon	13	4.2	
(Total Bird)			(1.0)
Acipenser fulvescens			
Lake sturgeon	7	113.4	
Aplodinotus grunniens			
Drum	1	3.0	
Micropterus sp.			
Bass	1		
(Total Fish)			(1.3)
Turtle			0.2
TOTAL	34	225.8	

(From Fairchild 1977:80-81)

---

[a] MNI: Minimum Number of Individuals

[b] Estimates based on "pounds of usable meat/individual" from Cleland 1966

[c] Percentages based on number of identified specimens

hammerstones in a black organic deposit that was mottled with ash (Fairchild 1977:27-32).

Artifact Analysis

Robertson's analysis of the lithic assemblage suggests that a significant proportion (73%) of the collection was derived from the plowzone. The remainder (27%) was recovered from undisturbed contexts (1987:130).

The artifact assemblage from the Western Michigan University excavations includes chipped stone tools, 1 bone tool fragment, 19 hammerstones, 2 anvils, and 18,082 pieces of firecracked rock weighing 552.7 kg. Bifacial tools are the dominant tool form in this assemblage (Table 5.5). Bayport chert was the primary source of raw material (99% of the debitage and 90% of the tools), while lesser amounts of unidentifiable/glacial cherts and small amounts of Onondaga, Norwood, and quartzite are also represented in the tool assemblage (Robertson 1987:131).

Omitting pieces esquillees from the comparison, bifaces constitute 77.37% of the formal tools. End-scrapers are the only unifacial tools present with a consistent pattern of retouch. Therefore, the biface to uniface ratio (3.42:1) is skewed. Many of the bifacial tools have direct morphological correlates with common unifacial end- and side-scrapers. Nonetheless, projectile points/knives and drills comprise 52.83% of the bifacial tool assemblage (Robertson 1987:133).

Debitage and cores comprise a significant proportion of the assemblage. A total of 20,030 pieces of debitage, including 75 cores, was recovered. Based on this data, Robertson (1987) concludes that the manufacture of stone tools was a primary activity at the Schmidt site.

Seventy-three of the 185 tools in Western Michigan University assemblage had interpretable microware features. Of the remaining tools, 47 were either not used or the working edge was not present, and 65 were either too refractive or had no diagnostic use-ware patterns.

Table 5.5. Schmidt Site: Chipped Stone Tools

Tool Type	Frequency	Percentage
Projectile Points/Knives	38	20.54
Ovate-Triangular Bifaces	5	2.70
Ovate-Triangular Bifaces With Steep Retouch	6	3.24
Keeled Ovate-Triangular Bifaces	6	3.34
Biface Mid-sections	4	2.16
Biface Tips	10	5.41
Drills	18	9.73
Bifacial End-Scrapers	4	2.16
Miscellaneous Biface Fragments & Bifacially Retouched Flakes	15	8.11
(Total Bifaces)	(106)	(77.30)
End-Scrapers	10	5.41
Side-Scrapers	2	1.08
Denticulates	3	1.62
Notches	1	0.54
Gravers	1	0.54
Miscellaneous Uniface Fragments & Unifacially Retouched Flakes	14	7.57
(Total Unifaces)	(31)	(16.76)
Pieces Esquillees	48	25.95
TOTAL	185	100.00

(From Robertson 1987:132)

Of the 73 tools with interpretable microware, 55 were bifaces, 22 were unifaces, and one was a pieces esquillee. One tool was used for two purposes, thus providing a total of 74 uses in the assemblage (Robertson 1987:133).

Thirty-five (47.30%) of these tools were used for subsistence related activities. Nineteen were used as projectiles and the remainder (n=16) for butchering. The other 39 chipped stone tools (52.70% of the activities) were used for manufacturing. A wide variety of activities (e.g., scrapping, sawing, drilling, incising, and whittling) on a variety of materials, including hides, wood, and bone and antler, is represented.

Subsistence Remains

A relatively large assemblage (n=12,737) of faunal remains was recovered during the Western Michigan University excavations. The majority of these remains are mammal bones (97.5%); small numbers of fish (1.3%), bird (1.0%), and turtle (0.2%) are also represented. Only nine species could be identified because the bones are extremely fragmentary and calcined. Identified species include deer, raccoon, muskrat, rabbit, duck, passenger pigeon, sturgeon, drum, and bass (Table 5.4) (Fairchild 1977:80-81).

Although mammals dominate the Western Michigan University assemblage, among the identified specimens, fish comprises more than 50% of the assemblage by weight. Identified large game animals and other mammals would have contributed 46% of the meat and birds approximately 2% (Table 5.4).

Cleland's (1966:115) analysis of the University of Michigan assemblage differs from that recovered by the Western Michigan University. In the former, mammals provided the majority of the meat to the diet.

Plant food remains are limited. Only 13 fragments of butternut shell were recovered (Fairchild 1977:87).

Seasonality and Function

Interpretations of site seasonality are variable. Based on the fauna recovered during the University of Michigan excavations, Cleland suggests that the site was occupied during the fall and perhaps early winter (1966:116). Taggart interprets the large proportion of large game recovered by the University of Michigan as an indication of a winter/spring occupation (1967:155). Comparing the faunal data from both the University of Michigan and Western Michigan excavations with his predictions, Keene finds that the data best fit his predictions for a summer site (1981:229). Finally, Fairchild argues for a year-round occupation (1977:84). This divergence of opinions is due to the fact that the majority of the species represented are available throughout the year. Only a few seasonally specific resources are present and include several seasons: sturgeon, bass and drum, which are available year-round but are most productive in the spring; passenger pigeon, which were most abundant during their fall and spring migrations; turtle which are available during the warm months of the year; and butternuts which are primarily available during October. Unfortunately, osteological indicators of seasonality (e.g., immature individuals or deer with shed antler), which might help to isolate the season of occupation, were not reported.

The question of seasonality is further complicated by the fact that the site was inhabited several times during its occupational history. It may, therefore, have been occupied during different seasons.

Robertson's (1987) analysis of the lithic assemblage and site structure provides additional criteria for evaluating seasonality. His analysis of the stone tool assemblage indicates that hunting, butchering, and hide working tools are the predominant tool types represented. This fits well with the faunal data, which indicates that deer were the predominant mammal resource (Cleland 1966:115; Fairchild 1977:81). While hunting can occur during any season, hides are of the

best quality in the fall, and ethnographic evidence suggests that hide working was a primary activity in the fall and winter (McCabe and McCabe 1984:43-47). Thus, the stone tool assemblage suggests a fall and/or winter occupation. Further, evidence for antler working suggests a winter occupation because antler becomes increasingly difficult to work as it dehydrates.

The tool assemblage also suggests some degree of residential longevity or stability (Robertson 1987:136-137), although there is little evidence of a year-round (Fairchild 1977) or long-term occupation (Robertson 1987:137-142). The density of features is only 0.1 per m^2 and there is no evidence for permanent structures. Further, there is limited evidence for spatial segregation of activities (Figure 5.3), which would suggest temporary rather than long-term occupations. Finally, the thickness of the deposit suggests that the site was occupied several times. Therefore, while the season and duration of occupation may have varied throughout the course of the site's occupational history, most evidence suggests that the site served as a fall/winter residential camp (cf. Robertson 1987).

Comparison with Archaeological Expectations

The range of faunal resources represented in the Schmidt site assemblage and the relative proportions of these resources suggest that the assemblage best fits the archaeological expectations proposed for Late Archaic, fall to fall/winter choices based on efficiency alone. In both the simulation and the faunal assemblage, fish and, to a somewhat lesser extent, large game are the primary sources of meat, while small game represent a relatively important secondary resource.

The simulations of choices based on taste alone and on multiple goals differ from the subsistence assemblage in their estimates of the relative importance of fish and large game. In both, large game is identified as a primary fall and fall/winter source of meat, and fish is ranked as a lower priority resource.

Because of the recovery techniques employed during the excavation and the small sample size, it is not possible to assess the relative importance of plant resources and to compare the floral assemblage with the proposed archaeological expectations. Nut remains, however, represent a predictable component of a diet based on efficiency.

Although the relative contribution of females/juveniles cannot be assessed in this context, the faunal assemblage does suggest that both male and collective resources were important components of the diet. The importance of collective resources in this context may be related to several factors, including the size of the residential unit, the duration of the occupation, and the relative importance of highly productive, aggregated resources, which are most efficiently exploited by large groups.

Feeheley

The Feeheley site (20SA128) is located on a sand dune approximately 2.4 km (1.5 mi) north of the Shiawassee River and 3.2 km (2 mi) southwest of the Tittabawassee River in Section 1 of James Township, Saginaw County (Figure 5.1). The dune is oriented northeast-southwest and is comprised of three imbricated, crest-shaped knolls. The apexes of the knolls lie on the eastern and southeastern sides of the dune. The crest of the ridge is at an elevation of 185.3 m (608 ft) amsl. The dune formed following the Nipissing recession and may have been an island or part of a peninsula extending into the Shiawassee Bay during the Algoma lake stage (Taggart 1966, 1967)

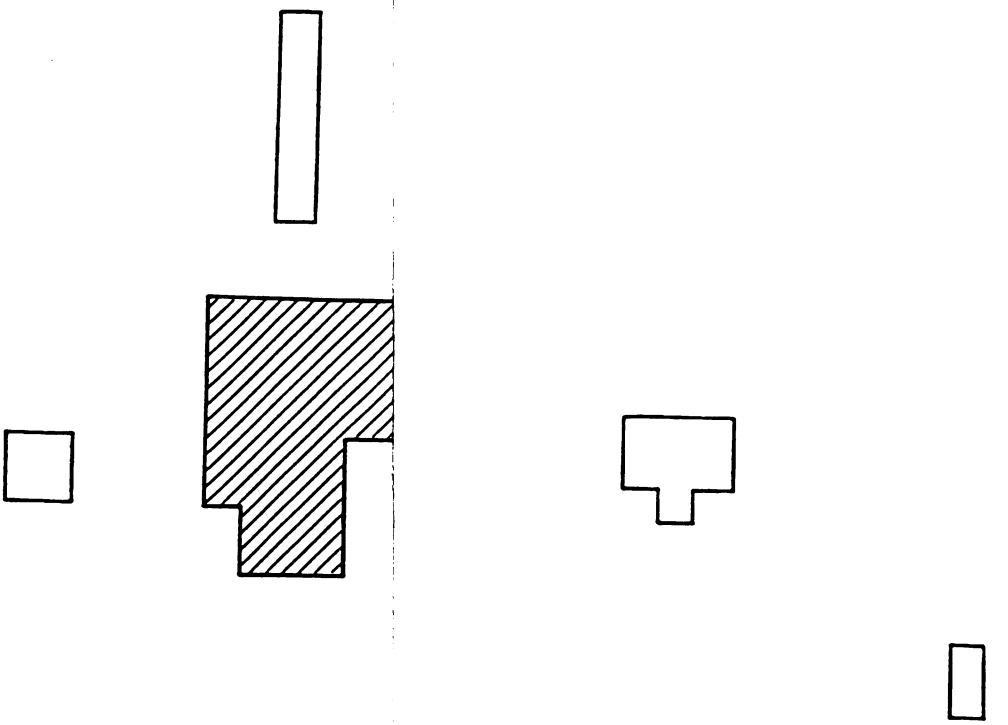
The site was initially tested by the University of Michigan in the spring of 1960, after burials were reported by a local avocational archaeologist. Taggart directed further excavations at the site later that summer and continued to salvage materials over the next few years until the site was effectively destroyed by sand removal operations (Robertson 1987:112-113).

The site has both a mortuary and a residential component, and Lovis and Robertson's (1989) analysis of the artifact assemblage and stratigraphy indicates three occupational components. The burial component is confined to the knoll on the northeastern portion of the ridge (Figure 5.4). This component dates to the terminal Middle Archaic (3930 B.P. ± 150 [M-1139]). The residential component occurs on three of the knolls. Stylistic data suggest that this component dates to the Late Archaic period, from 1300 B.C. to 800 B.C. (3250 B.P. to 2750 B.P.). A Middle Woodland component is also represented but it is restricted to the plowzone and plowscars (Robertson 1987).

Paleoenvironmental Reconstruction

In light of the physiography of the site, floral remains (Table 5.6) suggest that three types of forest communities were represented in the immediate vicinity of the site during the Late Archaic period. The beach ridge on which the site is located appears to have supported a dry-mesic forest community with white pine, black oak, red oak, and cherry. Less well drained soils would have been forested with a beech-maple forest community that included other taxa such as basswood, white ash, black walnut, hickory, slippery elm, and hop-hornbeam. Low lying, poorly drained soils most likely supported a wet-mesic community with black ash, sycamore, and elm (Albert *et al.* 1986:18; Barnes and Wagner 1986).

The faunal assemblage (Table 5.7) is limited and could not be separated into disturbed and undisturbed Late Archaic contexts. The few specimens that were identified indicate that both deep and shallow water aquatic (bullhead, drum, and perch) habitats and marshy (muskrat, turtle, and gastropods) environments were present during the Late Archaic occupation.



(Robertson 1987:125)

Table 5.6. Feeheley Site: Flora

Identified Wood Taxa	Ct	Percent
Acer sp./Maple	2	2.5
Betula sp./Birch	1	1.3
Carya sp./Hickory	1	1.3
Fagus grandifolia/Beech	11	13.6
Fraxinus sp./Ash	4	4.9
F. nigra/Black ash	5	6.2
F. americana/White ash	3	3.7
Ostrya virginiana/Hop-hornbeam	1	1.2
Pinus. sp./Pine	8	9.9
P. strobus/White pine	1	1.2
Platanus occidentalis/Sycamore	10	12.3
Prunus sp./Cherry	1	1.3
Quercus spp./Oak	1	1.3
Q. nigra/Black oak	14	17.3
Q. spp./White oak group	13	16.0
Ulmus rubra/Slippery elm	1	1.3
Ulmaceae/Elm family	2	2.5
(Total Identified)	81	

Nutshell	Ct	Percent	Ubiquity
Carya spp./Hickory	10	14.1	8.6
Carya ovata/Shagbark hickory	2	2.8	2.9
Juglandaceae/Walnut family	16	22.5	17.1
Juglans spp./Walnut	7	9.9	8.6
J. cinerea/Butternut	22	31.0	25.7
J. nigra/Black walnut	2	2.8	5.7
Quercus spp./Acorn Cotyledon	12	16.9	11.4
(Total)	(71)		
Seeds			
Rhus sp./Sumac	1		2.9

Table 5.7. Feeheley Site: Fauna

Taxon	NISP[a]	Percentage[b]
Mammalia	199	22.3
Ondatra zibethicus		
Muskrat	X	
Tamias sp.		
Chipmunk	X	
Fish	540	60.6
Aplodinotus grunniens		
Drum	X	
Ictalurus nebulosus		
Brown bullhead	X	
Perca flavescens		
Yellow perch	X	
Birds	66	7.4
Turtle	X	9.7
TOTAL	891	100.0

(From Cleland 1966:110)

[a] NISP: Number of Identified Specimens

[b] Percentage of Identified Specimens

Features

Both mortuary and domestic-related features were represented at the site. There were 13 burial features, which contained the remains of 15 individuals. At least one individual was cremated, but the majority were interred in tightly flexed positions. The degree of flexure suggests that they were wrapped in skin or bark. Grave goods included copper necklaces, celts and awls, shell pendants, and massive amounts of red ochre (Robertson 1987:113-114). This burial program is common to various Late Archaic mortuary complexes in the Midwest and especially to the Glacial Kame culture (Fitting 1975; Taggart 1966).

The residential component of the site appears to consist of a thin sheet and pit midden that was vertically dispersed within approximately a half-meter to a meter (Taggart 1967:160). As many as 50 pit features were identified, although the exact number and types are unclear. Four types have, however, been identified: shallow basins; oval shaped basins with steep sides; large deep pits, some of which are straight sided; and large "composite" pits (Robertson 1987:114). The smaller examples of the first three types of features are regarded as firepits, cooking pits, or storage pits; the larger pits have been interpreted as cleaned out firepits and storage pits used for hearth debris. Only small amounts of refuse were recovered in the small and large pits. Charcoal was the most frequent type of material recovered, but oxidized sands, indicative of direct firing (cf. Weber I), were noted in only four of the pits (Robertson 1987:114-115). The large "composite" pits contained small amounts of bone and debitage. Low densities of charcoal were also noted in these pits.

One to five, small basin-shaped pits occurred in the center or on the edge of each of the composite pits. Postmolds may also have been present in association with the composite pits, although they were rarely sectioned and could not be confirmed. It is unclear whether this configuration of pits and postmolds represented houses, activity areas, or some other phenomenon (Robertson 1987:115).

Artifact Analysis

The artifact assemblage from the Feeheley site includes chipped stone debitage, chipped stone tools, one polished celt, one possible milling stone, a few quartz hammerstones, a large number of amorphous clay lumps, and firecracked rock. The quantity of firecracked rock, from undisturbed contexts is unknown but approximates 175 kg (380 lbs) (Taggart 1967:167). The exact amount of debitage is also unknown because counts of chippage were not reported from all excavation units or from all levels of each unit. Further, several screen mesh sizes were used, making it difficult to compare quantities of debitage between different contexts. Based on his review of Taggart's (ca. 1966) report, Robertson (1987:116) estimates the total amount of debitage from undisturbed contexts to be 2,860 pieces and eight cores. The vast majority of the debitage was made from locally available Bayport chert. Other varieties of chert were present, but the exact amounts have not been published (Robertson 1987:116).

Taggart (1967:164-165) suggests that stone tool manufacture was a primary activity at the site. Robertson, however, argues that,

> the uneven recovery of debitage precludes a definitive assessment of what stages of chert reduction are present and calculation of an accurate tool to debitage ratio. Moreover, the stone tool assemblage itself suggests that stone tool manufacture was not a particularly important activity. Specifically, the Feeheley stone tool assemblage is dominated by finished tools[2] [1987:117].

Undisturbed contexts produced 83 formal, chipped stone tools (Table 5.8). All but three of these tools are made of Bayport chert. Robertson (1987:117) describes the assemblage as characterized by "a high degree of simplicity and in the case of the unifacial tools, formality." A narrow range of bifacial tools is represented, including projectile point/knives, ovate-triangular bifaces, drills, and fragments of bifaces. The edges of the projectile point/knives have been heavily

---

[2] Only 10.8 % of the formal, chipped stone tools could be considered preforms or preform fragments (Robertson 1987:116).

reworked, suggesting that there was a conscious effort to reuse or salvage tools (Robertson 1987:117).

Table 5.8. Feeheley Site: Chipped Stone Tools

Tool Type	Frequency	Percentage
Projectile Points/Knives	15	18.07
Ovate-Triangular Bifaces	6	7.23
Biface Tips	8	9.64
Drills	6	7.22
Miscellaneous Biface Fragments & Bifacially Retouched Flakes	8	9.64
(Total Bifaces)	(43)	(51.81)
End-Scrapers	8	9.64
Side-Scrapers	9	10.84
Denticulates	2	2.41
Miscellaneous Uniface Fragments & Unifacially Retouched Flakes	6	7.23
(Total Unifaces)	(25)	(30.12)
Pieces Esquillees	15	18.07
TOTAL	83	100.00

(From Robertson 1987:118)

Bifaces outnumber unifaces by a ratio of only 1.72:1, but Robertson argues that in fact, unifaces dominate the assemblage by virtue of their formality (1987:119). The two basic categories of scrapers can be further subdivided into 10 varieties. The extensive retouch of end-scrapers and side-scrapers and the presence of multiple working edges on many of the unifaces suggest that there was an effort to use these tools to their fullest extent.

Forty-three of the 83 tools had interpretable microware traces, 19 did not appear to have been used, and the remaining 21 were too refractive to have identifiable microware traces. Slightly more than half (53.49%, n=23) of the tools with interpretable polishes were used for subsistence activities such as hunting and butchering. These tools are predominantly bifaces (n=14). Several unifaces (n=9) were used for butchering or cutting meat or fresh hide (Robertson 1987:119-120).

Manufacturing tools, used for hide preparation, woodworking, and bone and antler working, were nearly as frequent (46.52%, n=20) as those

that were used for subsistence purposes. Robertson interprets the tool uses as: drilling bone or antler (n=1) and wood (n=1); whittling or planing bone or antler (n=1); scraping or planing wood (n=1); chopping or adzing wood (n=1); wedging wood (n=1), drilling some sort of hard material(s) (n=4); scraping hides (n=7); and cutting hides (n=3) (1987:120).

Subsistence Remains

A relatively small assemblage of subsistence remains was recovered from the Feeheley site. The faunal assemblage includes 891 fragments of bone (Table 5.7). These specimens are poorly preserved, calcined, and extremely fragmentary, with nearly 90% of the specimens measuring less than 10 mm. Only five species could be identified: drum, brown bullhead, yellow perch, muskrat, and chipmunk. The remainder of the assemblage could be identified only to class. Overall, fish comprised the largest percentage (60.7%) of the faunal assemblage; mammal (22.3%), turtle (9.6%), and bird (7.4%) occurred in lesser percentages (Cleland 1966:110).

The floral assemblage is also small and, unfortunately the wood charcoal could not be relocated for quantitative analysis. My analysis of the nut and seed collections from the undisturbed Late Archaic contexts complemented the analysis by Yarnell (1964:26-28). The largest percentage of the assemblage is butternut (31.0%), followed by acorn (16.9%), shagbark (2.8%) and perhaps other species of hickory (14.1%), and black walnut (9.9%) (Table 5.6). Unfortunately, it was not possible to determine the relative density of nuts to wood charcoal. Ubiquity values of 25.7% and less suggest that nuts were intentionally exploited and a moderately important component of the diet.

The only seed recovered from the Late Archaic component is sumac, which can be used to make a lemonade-like beverage. The low density of seeds is most likely a product of sampling error.

Seasonality and Function

Robertson's (1987:123-126) analysis of the spatial distribution of tools and activity areas indicates a clear separation between subsistence and ceremonial activities. In addition, he argues that the vertical dispersion of features and burials and the lack of overlapping pits reflect "a multiplicity of short term occupations" (1987:126).

Because of the limited subsistence assemblage from the Feeheley site, interpretations of site seasonality are variable. Yarnell suggests that the presence of a variety of nuts indicates that the site was occupied during the early autumn (1964:26). Based on the absence of large game and the relatively high percentage of fish, Cleland (1966:-110-113) suggests that the site was occupied during the summer. Taggart (1967:155) also supports a summer occupation. In Fitting's (1975:76) model of Late Archaic settlement/subsistence, he categorizes the Feeheley site as a spring-summer occupation. Keene (1981:226-228) argues that the site best fits the predicted pattern for a spring occupation.

Robertson's (1987) analysis of the lithic assemblage, in combination with his interpretation of the site structure, provides additional criteria for evaluating seasonality and site function. As he points out, the absence of large game is one of the primary criterion upon which the previous interpretations of site seasonality have centered. His analysis of the stone tool assemblage indicates, however, that 76.7% of the tools were used as projectiles, to butcher or cut meat, and to cut and work hides. He posits several possible explanations for the abundance of these tools in the absence of large game animals: sampling error; working of skins from small mammals; working of stored hides; or processing of large game at satellite sites and transportation of meat and hides to the site (1987:121-122). While these are all viable explanations for the absence of large game animals, the ceremonial function of the site and its affect on the subsistence activities must also be taken into consideration. Processing of meat

and hides from large game is time consuming. It is, therefore, posited that the absence of large game in this assemblage is, in fact, an accurate reflection of the subsistence regime and that the presence of hide working and cutting tools is related to preparation of conserved hides for the burials, which Taggart's (ca. 1966) analysis suggests were wrapped in hides or bark.

In conclusion, assuming that the site served as a burial site throughout its occupation, it is likely that the ceremonial activities were limited to a specific season. The subsistence assemblage suggests that the site was occupied in the summer and fall. The key indicators of a summer/fall occupation are the presence of nuts and the abundance of warm season resources such as fish and small game.

Comparison with Archaeological Expectations

The limited nature of the floral and faunal assemblages makes comparisons with the expectations generated from the models herein difficult. The faunal assemblage suggests a subsistence strategy predicated on efficiency because this is the only simulation that identifies fish as being the primary source of meat. The variety of fatty nuts represented in the floral assemblage suggests, however, that taste strongly influenced female/juvenile subsistence decisions.

The most parsimonious explanation for the difference in the goals affecting subsistence choice is that ceremonial responsibilities affected the goals and scheduling of subsistence activities. Male resources, such as large game, are notably absent, which suggests that males may have had primary responsibility for the mortuary activities. Use of aggregated, highly productive resources, such as fish, which could be efficiently expoited by a collective group would have offset the need for male hunting. Finally, it would appear that females/juveniles were able to target resources that were preferred for taste.

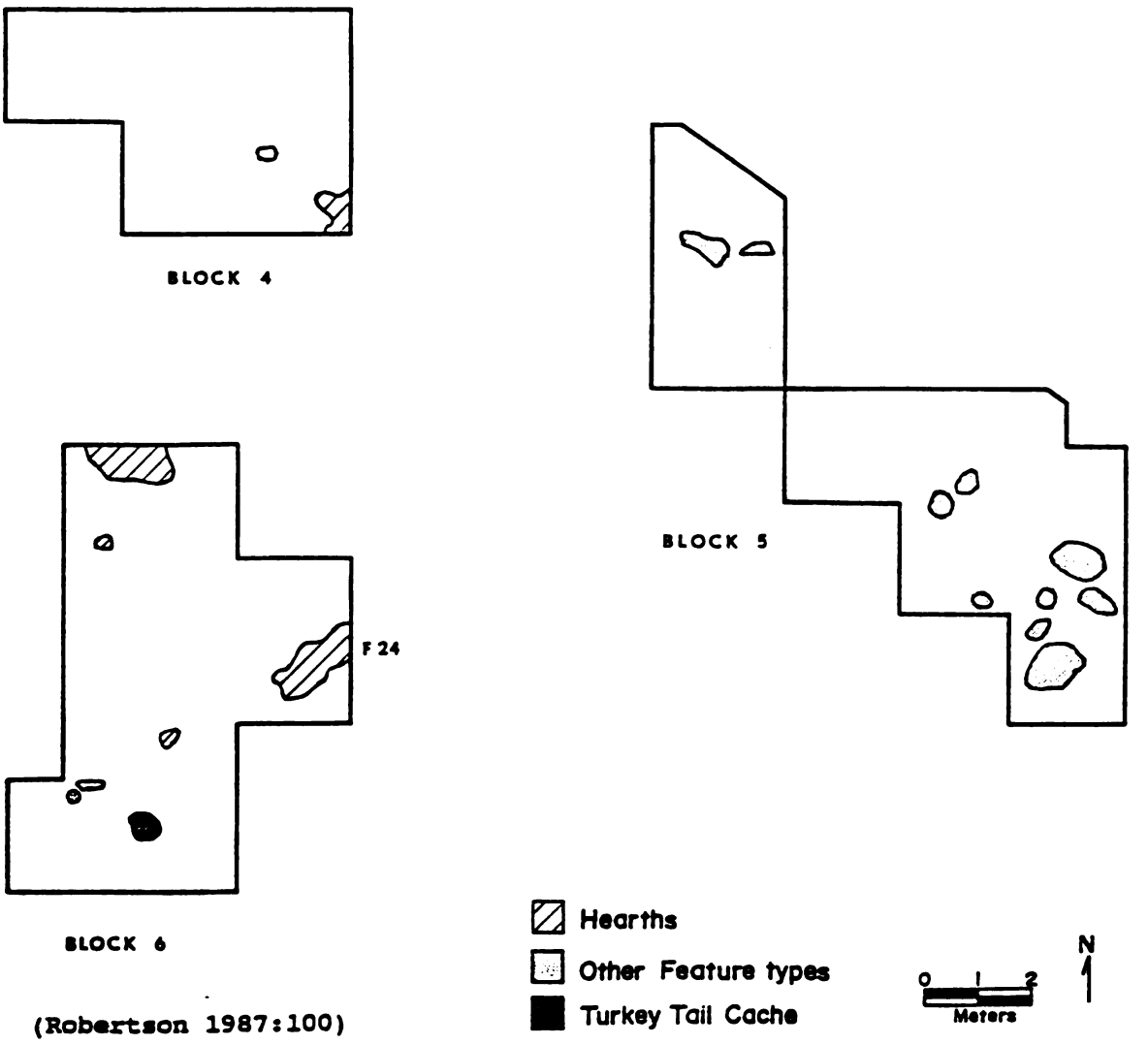
The 20BY79 Site

The 20BY79 site is located in the city of Bay City, in Section 20, Bay City Township, Bay County, Michigan. The site is on the west side of the Saginaw River, approximately 6.4 km (4 mi) upstream from where the Saginaw River flows into Saginaw Bay (Figure 5.1). The archaeological deposits are distributed along the Algoma beach ridge that runs north and south, parallel to the river. The maximum elevation of the ridge is 182.9 m (600 ft) amsl.

The 20BY79 site and two others were located by Brunett in 1979. In 1984, Michigan State University excavated 83 m^2, as part of the Third Street Bridge replacement project.

The area in which the sites are located has been heavily disturbed. Modern utility trenches, building foundations, and garbage dumps occur throughout the area and intrude on the archaeological deposits (Lovis, ed. 1986). Trenching revealed a stratigraphic sequence of sorted gravels overlain by an Algoma coarse to fine sand stratum, a 19th century organic stratum with remnant plowscars, a mixed or redeposited zone of sand, and a historic fill with modern organic materials.

Prehistoric cultural materials occur in all of the strata except the basal, sorted gravel stratum. The majority of these materials are Late Archaic in age and were recovered within or derived from the Algoma beach deposits (Lovis, ed. 1986:16; Monaghan 1986:50-51). Minor amounts of Middle and Late Woodland materials were also recovered. Woodland materials occur in the upper levels of the Algoma stage beach deposits and appear to be superimposed on the Late Archaic occupations. The stratigraphic separation of these deposits is most clearly defined in excavation Blocks 4, 5, and 6 (Figure 5.5). This analysis focuses on the Late Archaic component materials recovered in these blocks.



(Robertson 1987:100)

Figure 5.5. 20BY79 Site: Late Archaic Features

Paleoenvironmental Reconstruction

Using geomorphological evidence, Lovis (ed. 1986:8) posits that the site area was an unstable, windblown surface with little vegetation. The identified wood charcoal from the site indicates that a dry-mesic forest community grew in the area. This community was dominated by oaks (white and red oak groups), pine, and ash. Some hickory, maple, and chestnut were also present (Table 5.9) (cf. Cleland 1986). This environment provided an excellent habitat for deer. Painted turtle and aquatic tuber are common to marshes, and their remains at the site suggest that the shoreline was marshy; perch indicate that the river was shallow with a gravel or sand bottom (Table 5.10) (Cleland 1966).

Features

Nineteen features (Figure 5.5) were assigned to the Late Archaic occupation based on their stratigraphic position and contents. The majority of these features (n=12) were irregularly shaped organic basins that varied in depth from shallow basins to deep pits. These features often contained large quantities of firecracked rock and carbonized organic remains. Five other features were similar to the first feature type but distinguished by the presence of oxidized sands, suggesting that they were hearths. The largest of these hearths contained high densities of charcoal and nutshell. Two other features were identified within the Late Archaic component in Blocks 4, 5, and 6. One of these features was a rock dump and the other a cache of ten Turkey Tail points (Lovis, ed. 1986:237-257; Robertson 1987:96-101).

Artifact Analysis

Firecracked rock was ubiquitous in the excavated portion of the site. A total of 14,783 pieces weighing 415.6 kg (916.25 lbs) was recovered from Late Archaic contexts (Robertson 1987:101).

Table 5.9. 20BY79 Site: Flora

Flot Volume	378.5 ℓ

Total Wood Charcoal	1379 ct/19.2 g	
Identified Taxa	**Count**	**Percent**
Carya spp./Hickory	5	4.1
Castenea dentata/ Chestnut	1	0.8
Acer spp./Maple	2	1.6
Ostrya virginiana/Hop-hornbeam	1	0.8
Quercus spp./Oak	30	24.4
White oak group	22	17.9
Red oak group	12	9.6
Pinus spp./Pine	5	4.1
P. resinosa/Red pine	1	0.8
P. strobus/White pine	11	8.9
Fraxinus spp./Ash	4	3.3
Coniferous	3	2.4
Diffuse porous	6	4.9
Ring porous	20	16.3
(Total identified)	(123)	(100.0)

Total Bark Charcoal	1065 ct./12.38 g		
Total Nutshell	**Count/Wt[a]**	**Percent By Count**	**Ubiquity**
Juglandaceae/Walnut family	43/1.28	8.5	50.0
Juglans nigra/Black walnut	6/0.26	1.2	25.0
Juglans cinerea/Butternut	3/2.25	0.6	12.5
Carya spp./Hickory	43/1.28	8.5	37.5
Quercus spp./Acorn			
Shell	406/1.07	79.9	43.8
Cotyledon	6/0.15	1.2	12.5
Nutmeat	1/0.20	0.2	6.3
(Total)	(508/6.49)	(100.0)	

Other	**Count/Wt**
Aquatic tuber	2/0.08
Grass Root	1/0.1
Peduncle	1/0.01

Total Seeds	**Count**
Asteraceae/Composite family	1
Unidentifiable	1

[a] Weights in grams

Table 5.10. 20BY79 Site: Fauna

Taxon	NISP[a]	Percentage[b]	MNI[c]	Meat Yield[d] kg
Odocoileus virginianus				
White-tailed deer	2	0.6	1	38.3
Procyon lotor				
Raccoon	1	0.3	1	7.9
Mammalia				
Mammals	281	84.4		
Large mammals	7	2.1		
Perca flavescens				
Yellow perch	2	0.6	1	0.1
Percidae				
Walleye/sauger/perch	3	0.9		
Osteichthyes				
Bony fish	5	1.5		
Chryemys picta				
Painted turtle	8	2.4	1	2.3
Cryptodira				
Hidden-neck turtles	12	3.6		
Aves				
Bird	7	2.1		
Unidentifiable	5	1.5		
Total	305	100.0	4	48.6

(From Franz 1986:333)

---

[a] NISP: Number of Identified Specimens

[b] Percentage of specimens

[c] MNI: Minimum Number of Individuals

[d] Estimates based on "pounds of usable meat/individual" from Cleland 1966

A small assemblage of groundstone tools was also recovered from the site. This assemblage includes: two anvil stones, two combination anvil/hammerstones, and one mano (Robertson 1987:101).

Bifacial tools dominate the chipped stone tool assemblage, comprising 78.40% of the total assemblage. Generalized bifaces predominate. Projectile points are also numerous, although nearly half of these are Turkey-tails that are interpreted as having ceremonial or ritual connotations (Hall 1983). Drills, scrapers, retouched flakes, and pieces esquillees comprise the remainder of the chipped stone tool assemblage (Table 5.11).

Debitage constitutes the largest component of the artifact assemblage from the Late Archaic occupation, with 34,201 pieces recovered. All stages of lithic reduction are represented in the assemblage, although secondary flakes characteristic of the later stage(s) of tool manufacture predominate (83.49%). The frequency of debitage, the predominance of secondary flakes, the large number of bifaces and biface fragments in various stages of reduction, and a debitage to tool ratio of 273.6:1 indicate that tool manufacture was an important activity at the site during the Late Archaic occupation (Robertson 1986, 1987:102).

The vast majority of the debitage and tools are made of locally available Bayport chert. A small percentage (< 2%) of non-local raw materials is also represented (Robertson 1987:112).

A relatively small sample of tools (n=28, 24.35%) had interpretable microware. The remaining tools could not be analyzed because they were either highly refractive (n=16) or lacked evidence of microware or edge damage (n=71). The high percentage of tools lacking evidence of use (61.74%) is not unexpected given the importance of tool manufacture at the site (Robertson 1987:104-106).

Of the 28 tools with interpretable microware, 24 are bifaces, 1 is a uniface, and 3 are pieces esquillees. Eighteen of these tools (64.29%) were interpreted as having been used for subsistence purposes.

Table 5.11. 20BY79 Site: Chipped Stone Tools

Tool Type	Frequency	Percentage
Projectile Points/Knives	22	17.60
Ovate-Triangular Bifaces	8	6.40
Ovate-Triangular Bifaces Bases	11	8.80
Biface Mid-sections	5	4.00
Biface Tips	19	15.40
Drills	7	5.60
Bifacial End-Scrapers	2	1.60
Miscellaneous Biface Fragments & Bifacially Retouched Flakes	24	19.20
(Total Bifaces)	(98)	(78.40)
End-Scrapers	1	0.80
Side-Scrapers	2	1.60
Miscellaneous Uniface Fragments & Unifacially Retouched Flakes	4	3.20
(Total Unifaces)	(7)	(5.60)
Pieces Esquillees	20	16.00
TOTAL	125	100.00

(From Robertson 1987:105)

Nine of these appear to have been projectiles and nine appear to have been used for butchering. The other 10 tools were used for manufacturing: whittling wood (n=1); sawing wood (n=1); scraping hide (n=2); defleshing or scraping hides (n=2); drilling bone, antler, or a dense wood (n=2); and wedging a dense material (n=1) (Robertson 1987:106).

Subsistence Remains

A small assemblage of faunal remains was recovered through excavation and flotation. A total of 333 pieces of bone, weighing 78.81 g, was recovered. The majority of the bones were calcined and fragmented (<1 cm). Mammals comprise the largest percentage of the assemblage. Small percentages of reptiles, fish, birds, and unidentifiable taxa are also present. Only four species could be identified: deer, raccoon, painted turtle, and yellow perch. Based on these data, mammals and deer contributed the greatest quantity of meat, while the other taxa represented would have contributed relatively small quantities of meat (Table 5.10) (Franz 1986).

Moderate densities of floral remains occurred in flotation samples (378 ℓ) collected from 14 of the 19 Late Archaic features (Table 5.9) (cf. Cleland 1986). Wood charcoal was the most ubiquitous (86%) category of flora. It occurred in relatively low densities (33.4 ct/10 ℓ, 0.42 g/10 ℓ) overall but one feature did contain a significantly higher density of wood charcoal (228 ct/10 ℓ, 0.77 g/10 ℓ) than any other.

Bark charcoal was also relatively ubiquitous (86%) and occurred in moderate densities (22.3 ct/10 ℓ, 0.27 g/10 ℓ). The overall ratio of wood charcoal to bark charcoal was 1.5:1, although in three features densities of bark charcoal surpassed wood charcoal by a ratio of more than 4:1. One of these features had a significantly higher density of bark charcoal (214 ct ℓ/3.1 g/10 ℓ), while the density of wood charcoal was below the overall density. High densities of bark charcoal in these

features suggest that they were used as smudge pits (cf. Waugh 1916:127).

A wide variety of nuts is represented, including both highly productive taxa such as acorn and those that are highly ranked for taste (i.e., black walnut, butternut, and hickory). The density of nutshell (12.9 ct/10 ℓ; 0.23 g/10 ℓ) and the ratio of nutshell to wood charcoal (1:2.6) are both high. These values are, however, skewed by high densities (188 ct/10 ℓ; 0.6 g/10 ℓ and 212 ct/10 ℓ; 0.4 g/10 ℓ) of acorn shell that occur in two features (that have relatively low densities of other floral remains). Excluding these features, the density of nutshell is significantly lower (2.4 ct/10 ℓ; 0.1 g/10 ℓ), although nutshell is ubiquitous (occurring in 79% of the features; with values of individual taxa ranging between 47% and 13%). The densities and distribution of acorn shell indicate that acorn was an important resource to the prehistoric inhabitants of the site;[3] while the densities and ubiquity of the other nut taxa suggest that they were exploited to lesser degrees (Table 5.9).

Only two seeds were recovered in the Late Archaic assemblage (0.05 ct/10 ℓ). One seed was an Asteraceae (Composite family) the other was unidentifiable. Asteraceae are a cosmopolitan taxon and a leading family in dry-mesic forest communities (Curtis 1971) such as the one represented at the 20BY79 site. The co-occurrence of this seed and high densities of acorn shell suggests that this taxon may have been exploited.

Aquatic tuber occurs in extremely low densities (0.06 ct/10 ℓ) and is not ubiquitous (14%). Its presence and co-occurrence with nutshell does, however, suggest that it was exploited as a food resource.

The single grass root is uninterpretable. While it does occur with low densities of nuts, it may simply represent the unintentional

---

[3] If Lopinot's (1982:729-743) estimate that acorn is under-represented by 300%, as compared to walnut, then acorn would have been even primary source of food.

burning of plants growing around a hearth or the use of bunch grass as kindling.

Seasonality and Function

The subsistence assemblage suggests that the 20BY79 site was occupied during the fall. The ubiquity of nuts and presence of high densities of acorn suggest that nuts were collected and processed on site. Aquatic tuber and composites (Asteraceae) would also be available at this time. All of the faunal specimens recovered were mature individuals and do not suggest a specific season of death. A warm season occupation is suggested by the presence of turtles, which are only available during the warmer months of the year and could have been taken in the early fall.

The artifact assemblage and the presence of smudge pits indicates that some subsistence activities were carried out at the site. Tool manufacture was, however, a primary activity. "[T]he intensity of biface manufacture may be an example of 'anticipatory retooling' for hunting activities" (Robertson 1987:107). Further, the cache of Turkey Tail points suggests that the site served some magico-religious function, as well,

> The association of the Turkey Tails with stone tool manufacture and, by implication, the anticipation of hunting activities may not be accidental given Hall's (1983) discussion of the mythological connotations of Turkey Tails and flint [Robertson 1987:108].

The distribution of artifacts, feature types, and subsistence remains indicates that there are two distinct activity areas at the site. High densities of subsistence remains in association with hearths/fire pits and low densities of artifacts indicate that Blocks 4 and 6 were primary loci for subsistence related activities. The cache of Turkey-tails in Block 6 suggests that ritual activities were also carried out in this area. The low density of subsistence remains and high density of debitage and unused, finished bifaces in Block 5

indicates that this area was the primary locus of manufacturing activities.

The occupational intensity and duration of occupation are unclear given the distribution of artifacts in the meter thick deposit. The low percentage of tools associated with manufacturing activities other than tool production does, however, suggest that the occupation(s) were short lived.

Comparison With Archaeological Expectations

The subsistence assemblage from the 20BY79 site is limited but does provide some insight into the subsistence choices of the Late Archaic population. The range of floral and faunal resources represented in the 20BY79 site assemblage and the relative proportions of these resources suggest that the assemblage best fits the archaeological expectations proposed for Late Archaic, fall choices based on multiple goals. The key characteristics of this assemblage, which distinguish it as being selected on the basis of multiple goals, are the importance of acorn and fatty nuts and the relative importance of large game. This is the only simulation that identifies these as being high priority resources. The simulation of choices based on taste alone does not include acorn, and the simulation based on efficiency alone identifies nuts as being of limited subsistence value.

The most striking difference between the simulation of choices based on multiple goals and the faunal assemblage from 20BY79 is the absence of waterfowl. Several factors, including the relative productivity of waterfowl in this location, the timing of the occupation, and limited contribution of collective subsistence activities in this subsistence regime, may account for this. The limited contribution of collective resources, as compared with male and female/juvenile resources, may be because of the size of the residential group, the duration of the occupation, or scheduling conflicts and the importance of stone tool manufacture.

The Marquette Viaduct Locale of the Fletcher Site

The Fletcher site (20BY28) is on the west bank of the Saginaw River at the first major bend in the river, where it cuts through the Bay City moraine (Figure 6.1). The site lies on the cut bank of the bend at an elevation of ca. 177.7 to 178.3 m (583 to 585 ft) amsl, just off shore of the Lake Algoma beach (181.4 m [595 ft] amsl). The site was, therefore, inundated with water until the Early Woodland period and has since been subject to periodic inundations due to seasonal and long-term fluctuations in the water level of Lake Huron that lies only a few feet below the elevation of the site (Lovis 1985:157-158; Lovis *et al.* 1994).

The site was brought to public and professional attention in 1967, when the U. S. Army Corp of Engineers unearthed human skeletal remains and historic and prehistoric artifacts during excavation of a sediment retention basin. Maxwell of Michigan State University initiated salvage excavation at that time and returned in 1968 to conduct additional excavations. In 1970, Brown, then of Michigan State University, directed additional excavations at the site. A total of 3,747 m^2 (12,300 ft^2) was excavated during these three seasons (Figure 5.6). Analyses of collections from these investigations indicate that the site was occupied during the Early and Middle Woodland periods and that it became a major residential base locale during the Late Woodland period and subsequently during the 18th and early 19th centuries (Brashler 1973, 1981; Lovis 1985; Mainfort 1979; Sauer 1974; Tordoff 1972).

Prompted by impending construction at the site, Lovis, of Michigan State University, returned to the site in 1987 to collect additional geomorphological, geoarchaeological, and subsistence information on the prehistoric components at the site. Column samples were collected from undisturbed sediments identified in three backhoe trenches and two excavation blocks on the southern end of the site in the Marquette Viaduct locale. These data provide the baseline for the subsistence analysis described herein.

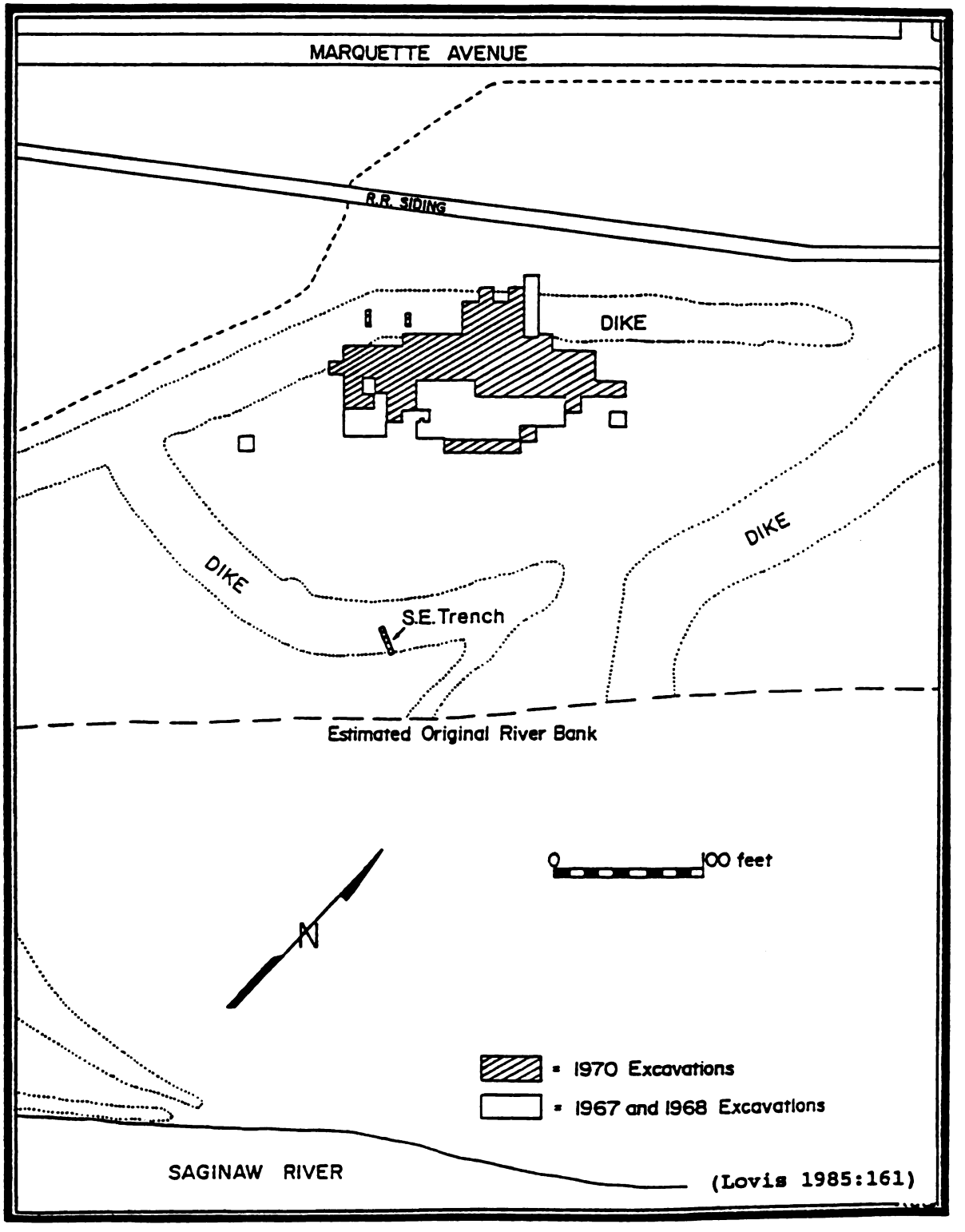


Figure 5.6. Fletcher Site: Excavations

Site Structure

The stratigraphic sequence at the site is that of a series of waterlaid deposits. The stratigraphy suggests that the site was immediately occupied following the recession of Lake Algoma. Terminal Archaic and Early Woodland materials were recovered at the top of and within the cross-bedded gravels, lying below a one to two meter thick midden. The midden dates to 1830 ± 85 B.P./A.D. 120 (Beta-17752), corrected to between A.D. 134 and A.D. 211 (Stuiver and Becker 1986), while the earliest occupation of the site predates A.D. 134 (Lovis *et al.* 1994).

Geomorphological characteristics of the stratigraphy and the absence of Middle Woodland deposits in some areas of the site suggest that "major parts of the site were scoured by high energy water action" (Lovis *et al.* 1994:11) during the Middle Woodland period. Late Woodland midden formation resumed after this inundation.

Paleoenvironmental Reconstruction

Maps from the 19th and 20th centuries provide detailed information about the environment surrounding the Fletcher site. The 1856 map by J. Macomb *et al.* shows an extensive marsh and wetland extending south and west of the site, between the site and the Algoma beachline. The river channel is noted as being relatively deep, with a mud and sand bottom, although there is considerable shoaling on the east side (opposite the site). Geomorphological studies conducted at the site complement this reconstruction (Lovis *et al.* 1994).

Open woodland is denoted inland of the site and on the Algoma shoreline (Houghton 1838), and Veatch (1959) shows a wet-mesic forest community in the general area of the site. The overall composition of the Middle Woodland wood charcoal assemblage and the physiography of the area suggest that a xeric forest community with white pine, red pine, black oak, and white oak grew along the Algoma beach ridge, and a wet-mesic community including bur oak, swamp white oak, red ash, elm,

hickory, beech, and walnut grew closer to the river (Table 5.12). Further, aquatic tuber indicates the presence of a marsh habitat along the river edge. Percentages of wood taxa suggest that there may have been a cultural selection for better quality fuel woods, including oaks and other ring porous and deciduous woods (73.6 percent of the assemblage), while resinous, coniferous taxa (i.e., pines) were less commonly used.

The faunal assemblage complements the environmental reconstruction provided above. Taxa characteristic of deciduous forest, swamp, and shallow water are all represented (Table 5.13; Lovis *et al.* 1994).

Features

A minimum of 543 prehistoric pit features, numerous postmolds (some of which display partial structural patterns), more than 100 18th century interments, three animal burials, one cenotaphic feature, and three prehistoric interments were identified during the 1967 and 1968 excavations (Lovis 1985:160). Feature densities at the Fletcher site are extremely high (mean density = $0.12/m^2$), and in some areas, there is an almost continuous overlap in features. It is impossible to isolate "individual prehistoric endeavors," although pit "complexes" were identified (Lovis 1985:160).

Many of the features contained small amounts of materials. While their function(s) are not clearly understood, preliminary analysis does suggest that there is some stratigraphic difference in feature types (Zamek 1984). Pits in the lower portion of the midden appear to be shallower, have a greater diameter, and contain higher frequencies of firecracked rock. Those in the upper midden tend to be basin shaped or flat bottomed. These differences suggest that those in the later part of the occupation were used for storage, while those used during the earlier occupation may have been used as roasting pits (Lovis, personal communication 1991).

Table 5.12. Fletcher Site - Marquette Viaduct Locale: Flora

Flot Volume 302.0 *l*

Total Wood Charcoal 1313 ct/12.65 g

Identified Taxa	Count	Percent
Carya spp./Hickory	7	3.3
Fagus sp./Beech	2	1.0
Quercus spp./Oak	11	5.3
White oak group	1	0.5
Red oak group	4	1.9
Pinus spp./Pine	2	1.0
P. strobus/White pine	21	10.0
Fraxinus spp./Ash	5	2.4
Ulmus sp./Elm	5	2.4
Ulmaceae/Elm family	2	1.0
Coniferous	25	12.0
Diffuse porous	4	1.9
Ring porous	117	56.0
Semi-ring porous	3	1.4
(Total identified)	(209)	(100.0)

Total Bark Charcoal 198 ct./2.34 g

Total Nutshell	Count/Wt[a]	Percent By Count	Ubiquity
Juglandaceae/Walnut family	33/0.54	62.3	70.0
Juglans nigra/Black walnut	3/0.20	5.7	30.0
Carya spp./Hickory	15/0.52	28.3	30.0
Quercus spp./Acorn shell	2/0.01	3.8	10.0
(Total)	(53/1.27)	(100.0)	

Other	Count/Wt
Aquatic tuber	5/0.22
Terrestrial tuber	1/0.03

Total Seeds	Count	Percent	Ubiquity
Chenopodium sp./Chenopodium	1	11.1	10.0
Crategus sp./Hawthorn	1	11.1	10.0
Gaylussacia baccata/Huckleberry	1	11.1	10.0
Parthenocissus quinquefolia/Woodbine	1	11.1	10.0
Scrophularia sp./Figwort	1	11.1	10.0
Asteraceae/Composite family	1	11.1	10.0
Unidentifiable	1	11.1	10.0

[a] Weights in grams

Table 5.13. Fletcher Site - Marquette Viaduct Locale: Fauna

Taxon	NISP[a]	MNI[b]	Meat Yield	Percentage[c]
MAMMALS				
Odocoileus virginianus/ White-tailed deer	23	4	153.0	15.9
Cervidae sp.-large/cf. Wapiti	2	2	315.0	32.8
Cervidae sp./Deer/Wapiti	7			
Urus americanus/Bear	6	4	378.0	39.3
Canis cf. *lupus*/Wolf	1	1	13.5	1.4
Lynx rufus/Bobcat	1	1	6.8	0.7
Castor canadensis/Beaver	10	2	28.4	3.0
Lutra canadensis/Otter	1	1	5.6	0.6
Ondatra zibethicus/Muskrat	9	2	1.0	0.1
Procyon lotor/Raccoon	4	2	15.7	1.6
Mammalia sp. medium +	182			
Mammalia sp. large	10			
Mammalia sp.	291			
(Total Mammalia)	(547)	(16)	(917.0)	(95.4)
BIRDS				
Aythya americana/Redhead	3	1	0.5	0.1
A. affinis/Lesser scaup	1	1	0.5	0.1
Aves sp. small	1			
Aves sp. medium +	2			
Aves sp.	1			
(Total Aves)	(8)	(2)	(1.0)	(0.2)
REPTILES				
Chrysemys picta/ Painted turtle	2	1	0.2	<0.1
Emydoidea blandingi/ Blanding's turtle	3	2	0.9	0.1
Chelydra serpentina/ Snapping turtle	1	1	0.1	<0.1
Trionyx spiniferus/ Spiny softshell	4	1	0.1	<0.1
Cryptodira sp. small	7			
Cryptodira sp.	3			
(Total Cryptodira)	(20)	(5)	(1.3)	(0.1)

[a] NISP: Number of Identified Specimens

[b] Minimum Number of Individuals

[c] Percentage based on total kg of usable meat

Table 5.13 (cont'd)

Taxon	NISP	MNI	Meat Yield	Percentage
FISH				
Acipenser fulvescens/ Lake sturgeon	26	2	32.4	3.4
Amia calva/Bowfin	2	1	0.9	0.1
Esox lucius/Northern pike	1	1	1.1	0.1
Ictalurus punctatus/ Channel catfish	4	2	3.0	0.2
I. cf. punctatus/ Channel catfish	2			
Ictaluridae sp./ Catfish/Bullhead family	6			
Percidae sp./ Perch/Walleye family	3	1		
Aplodinotus grunniens/Drum	9	2		
Sciaenidae sp./Drum family	2			
Osteichthyes sp.	60			
(Total Osteichthyes)	(115)	(9)	(43.0)	(4.5)
SHELLFISH				
Pelecypoda sp.	1			

(From Lovis *et al.* 1994:41)

Artifact Analysis

There is evidence for a limited Early Woodland occupation based on the presence of at least one Schultz Thick vessel. Tittabawassee, Green Point, and other Middle Woodland wares comprise a small percentage (3.11%) of the total ceramic assemblage, indicating that the Middle Woodland occupation was also fairly limited. The site was most intensively occupied early in the Late Woodland period, as evidenced by the high percentage of Wayne ware. Low percentages of other Late Woodland and Iroquoian wares indicate that the site continued to be occupied throughout the Late Woodland and into the historic period (Table 5.14) (Brashler 1973, 1981).

The lithic assemblage from the Fletcher site excavations has not been completely analyzed. Lovis (1985) has, however, presented some general observations based on the analysis of the assemblages collected in 1967 and 1968 (Table 5.15). First, it has been noted that the vast majority (96.37%) of the tools are made from locally available Bayport chert. Further, all stages of the lithic reduction sequence are represented. Among the identified tools, drills and scrapers comprise a relatively small percentage of the assemblage (2.90% and 4.35%, respectively), while preforms or "knives" are more abundant (37.92%). Finally, percentages of temporally diagnostic projectile points (Table 5.15) complement the occupational history suggested by the ceramic analysis (Brashler 1973, 1981). Unfortunately, generalizations regarding stone tool use and activities carried out during the Early and Middle Woodland occupations of the site (i.e., the time periods to which this analysis is directed) cannot be posited because of the complexity of the depositional history and limited analysis of the lithic assemblage.

Subsistence Remains

Analysis of the subsistence assemblages from the Fletcher site is primarily based on the materials collected during the 1988 excavations

Table 5.14. Fletcher Site: Ceramic Wares

	Frequency of Minimum Vessels	Percent of Minimum Vessels
Early Woodland		
Schultz Thick	1	0.18
Middle Woodland		
Tittabawassee	2	0.37
Green Point	12	2.19
Miscellaneous untyped	3	0.55
Late Woodland		
Wayne	292	53.38
Riviere	20	3.66
Bois Blanc	4	0.73
Mackinac	2	0.37
Traverse	1	0.18
Ontario Iroquois	1	0.18
Miniature untyped	13	2.38
Miscellaneous	8	1.46
Unidentifiable	188	34.37

(From Brashler 1973)

Table 5.15. Fletcher Site:[a] Chipped Stone Tools

Artifact Type	Frequency	Percent
Projectile Points	73	17.63
Early Archaic	1	0.24
large serrated bifurcate	1	
Transitional Archaic/Early Woodland	22	5.31
Meadowood/Hunt side notched	7	
Durst-like	5	
Kramer	3	
Adena	1	
Schultz	1	
"Ace-of-Spades"	4	
Waubesa/Dickson	1	
Middle Woodland	1	0.24
Snyders-like	1	
Transitional Late Middle to Early Late Woodland	28	6.76
large expanding stemmed	8	
small expanding stemmed (some serrated)	8	
Raccoon side notched	3	
Jack's Reef corner notched	9	
Late Late Woodland	12	2.90
Levanna	2	
Madison/Madison-like	7	
miscellaneous triangular	3	
Untypeable	9	2.17
eared triangular	1	
side notched	2	
corner notched	4	
unfinished notched	2	
Drills	12	2.90
T-base	2	
corner notched	1	
square base	1	
expanding base	3	
stemmed	1	
fragments	4	
Wedges	13	3.14
Preforms/"Knives"		37.92
miscellaneous notched	3	
flat base/parallel ovate blade	5	
basal fragments	21	
flat base/contracting blade	1	
basal fragments	3	

[a] *From 1967 and 1968 seasons*

Table 5.15. (cont'd)

Artifact Type	Frequency	Percent
Preforms/"Knives"		
convex base/parallel ovate blade	4	
basal fragments	10	
convex base/ovate blade		
basal fragments	2	
convex base/lanceolate blade	2	
convex base/triangular blade	6	
basal fragments	10	
unclassifiable		
"hump backed"	8	
flake bifaces	5	
medial blade fragments	25	
tip fragments	52	
Unclassifiable Bifaces	55	13.29
(Total Bifaces)	(310)	(74.88)
Transversely/Laterally Retouched Unifacial "Scrapers"	18	4.35
Unclassifiable Unifaces	86	20.77
(Total Unifaces)	(104)	(25.12)
Total Tools	414	100.00

(From Lovis 1985:163)

of the Marquette Viaduct locale of the Fletcher site (Lovis *et al.* 1994). Subsistence remains associated with the Middle and Late Woodland occupations were recovered, although this analysis focuses exclusively on the Middle Woodland assemblage.

The faunal assemblage from the Middle Woodland component contains a high diversity of both terrestrial and aquatic resources (Table 5.13). Among the specimens identified to taxon, large game animals (i.e., deer, wapiti, and bear) comprise the largest percentage (88.0%) of the meat yield. A variety of aquatic resources (i.e., muskrat, beaver, otter, waterfowl, turtle, and fish) are represented; these taxa constitute a moderate percentage of the meat yield (7.7%), which suggests that they were also a relatively important component of the diet. Other terrestrial game (including carnivorous taxa, such as wolf and bobcat, which are not commonly eaten), birds, reptiles, and shellfish comprise a small percentage of the faunal assemblage and probably constituted a minor part of the overall diet.

Wood charcoal (50.8 ct/10 ℓ; 0.48 g/10 ℓ) and bark (10.1 ct/10 ℓ; 0.12 g/10 ℓ) occur in higher densities than any other class of archaeobotanical remain (Table 5.12). The assemblage from Trench 3 suggests that water agitation effectively floated off lighter materials such as wood and bark charcoal, seeds, and possibly other classes of materials such as tuber. Such variations in the densities of charcoal and other floral remains from this component suggest that flooding occurred subsequent to the Middle Woodland occupation.

Low densities of nuts, seeds, and aquatic and terrestrial tubers were recovered in the Middle Woodland assemblage (Table 5.12). A small amount of maize was also identified. Radiocarbon dating of one maize cupule indicated that it was Late Woodland in age and, therefore, introduced by bioturbation.

Hickory, black walnut, acorn, and unidentifiable walnut family were recovered in the Middle Woodland assemblage (Table 5.12). All of these taxa would be represented in the forest communities surrounding

the site. While nutshell is relatively ubiquitous (among the small number of proveniences), the low density of nutshell (2.4 ct/10 ℓ; ratio of 1:27.1 nutshell to wood charcoal)[4] suggests that they were unintentionally burned components of the forest detritus rather than the refuse from intentional exploitation.

A small number of seeds (n=8; 0.3 ct/10 ℓ), including composite, chenopodium, hawthorn, huckleberry, Virginia-creeper, rose, and figwort, was also recovered from the Middle Woodland proveniences. These taxa are common to disturbed habitats, such as campsites and floodplains, and would, therefore, likely occur in the vicinity of the site. It is unclear whether they are remains of food refuse or were unintentionally burned. The fruits (hawthorn and huckleberry) were commonly exploited by Native American populations in this region (Erichsen-Brown 1979). Chenopodium was cultivated by prehistoric populations in the Midwest (Fritz 1990; Smith 1985, 1992). It has recently been identified in association with domesticates in a Late Woodland site (20SA1034) in the Saginaw Valley (Parker 1992) and in moderate frequencies at the Schultz site (see later discussion). The presence of these seeds may, therefore, be a result of intentional exploitation although the small sample size makes it difficult to access the potential importance of these resources.

Small numbers of aquatic and terrestrial tuber and root fragments were recovered from the Middle Woodland contexts (Table 5.12). While the terrestrial tuber and roots may have been accidentally burned components of the living surface, the aquatic tuber had to be brought up from the river edge. This suggests that aquatic tubers were exploited.

Seasonality and Function

The faunal assemblage suggests that the Marquette Viaduct Locale of the Fletcher site was occupied during the spring and summer. The

---

[4] Given the effects of flooding (discussed above), the ratio of nutshell to wood charcoal is probably higher than expected.

presence of spring spawning fish is the best seasonal indicator, while the diversity of other taxa complements the warm season interpretation.

Low densities of edible plant taxa, including summer fruits and aquatic tuber, also corroborate the interpretation of a warm season (spring to summer) occupation. The presence of low densities of nutshell, as discussed above, is ambiguous but may be related to the use of stored resources during the early spring.

The artifact assemblage from the earlier excavations at the site has not been thoroughly analyzed and differences between the Middle Woodland and earlier and later assemblages have not been determined. Therefore, at this time, these data do not contribute to our understanding of the activities represented at the site. Further, the intensity and duration of the Middle Woodland occupation are unclear because of the degree of (natural and cultural) post-depositional disturbance.

Comparison With Archaeological Expectations

The Marquette Viaduct subsistence assemblages suggest that subsistence choices were based on multiple goals. The data closely correspond to the expectations derived from this simulation. As anticipated, the assemblage contains a variety of species, including large game and fish as primary sources of meat, small game and waterfowl as an important secondary resources, and low densities of aquatic (wetland) tubers, and fruit. Although the simulation does not include elk and bear as spring and summer choices (due to coding, see Chapter 3), they are highly ranked in terms of taste, prestige, and efficiency. Inclusion of these resources in the spring and summer simulations would reduce the relative importance of other foods.

The other simulations rank fish as the primary source of meat. Inclusion of bear and elk as resource options would offset the importance of fish; however, in the simulation of choices based on efficiency, fish would remain a priority food because of their high

productivity in the spring. In the simulation of choices based on taste, selection of large game would reduce the diversity of resources taken. Therefore, the simulation based on multiple goals would still be most appropriate.

Turtles, shellfish, and carnivorous animals are not anticipated components of the simulation based on multiple goals. Turtles and shellfish are, however, components of the simulation based on taste, and their presence is not unexpected given that taste is one of the goals being satisfied. Further, within a habitat such as that represented at the Marquette Viaduct locale, turtles and shellfish would be relatively abundant and, therefore, opportunistically available.

Carnivorous animals were not included as subsistence options in these simulations. Their presence in the Marquette assemblage is not unexpected, however, because prestige seems to be a factor affecting resource choice. Killing carnivorous animals would bring prestige to the hunter because of their ideological value and because they are dangerous animals.

The subsistence assemblages suggest that male resources, female/juvenile resources, and collective resources were all important components of the diet. The seemingly large group size would have facilitated effective exploitation of aggregated resources that are commonly taken by collective groups. In addition, the duration of the occupation would afforded the time to exploit, process, store, and partially consume these resources. Finally, there is no evidence of activities (such as tool manufacture or Middle Woodland burial ceremonialism) that would have created scheduling conflicts among the exploitation groups.

The Schultz Site at Green Point

The Schultz site (20SA2) is located within the boundaries of the present-day city of Saginaw on a point of land commonly referred to as "Green Point." It lies on the north side of the Tittabawassee River

where the Tittabawassee joins the Shiawassee to form the Saginaw River (Figure 5.1). Thus, the site is located at "the very 'hub' of the Saginaw River Valley" (Fitting 1972a:5) and on the north end of the extensive wetlands known as the Shiawassee Flats.

There are two sites in this locality. The Schultz site (20SA2), or Green Point Village, is a large village site that lies on the levee (178 m to 180 m [585 to 590 ft] amsl). The Green Point site (20SA1) is a small, Late Archaic campsite located to the east of the Schultz site on a small knoll (177 m [580 ft] amsl) adjacent to the river.

The prehistoric occupation of Green Point has been recognized for over a century and has attracted the attention of both professional and avocational archaeologists. In the late 19th and early 20th centuries, both the habitation sites and the mounds associated with the Schultz (Green Point Village) site were illustrated on maps and described (Dustin 1929, 1930; McCormick 1883; Smith 1902). During the first-half of the twentieth century, the property owners discouraged archaeological investigation, but in the late 1950s archaeologists were allowed to return to further investigate the site.

Crews from the University of Michigan conducted several excavation projects at both the Schultz and Green Point sites between 1959 and the mid-1960s, although the majority of the work was accomplished between 1962 and 1965. During this time, approximately 6,700 ft^2 (603 m^2) were hand excavated, five machine trenches were excavated, and more than 300 ft^2 (27 m^2) were machine stripped (Figure 5.7). This work resulted in the identification of a stratified Early through Late Woodland midden, three burial mounds, and a stockade (Fitting 1972). Good stratigraphic data are available for approximately 5,000 ft^2 (450 m^2) of this area (Fitting 1972a:13).

Ozker (1982) reanalyzed the University of Michigan Early Woodland collections from the Schultz site. Her research renewed interest in the Early Woodland period in this region and demonstrated the value of reanalyzing extant archaeological collections.

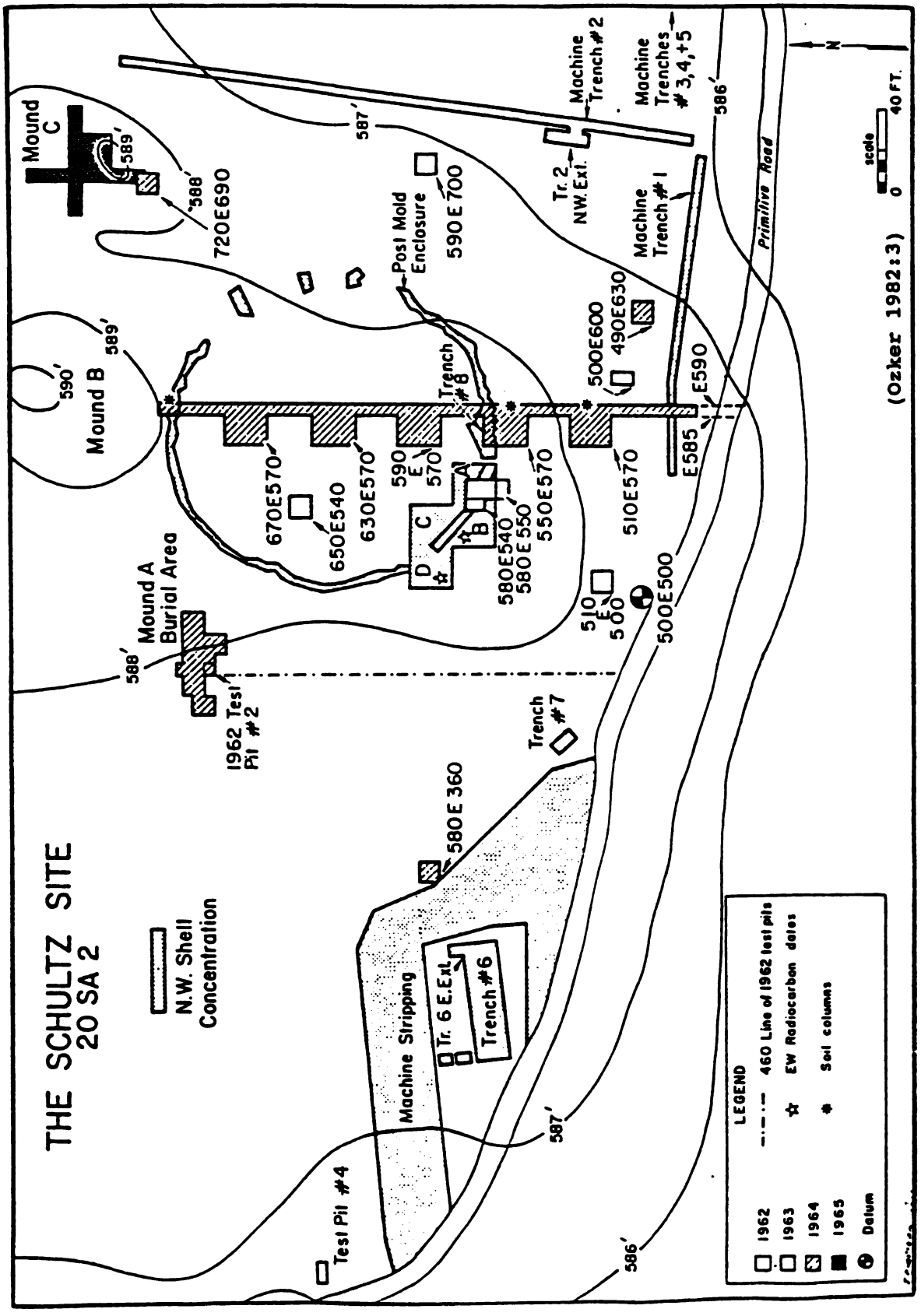


Figure 5.7. Schultz Site: Excavations

The most recent excavations at the Schultz site (20SA2) were conducted in 1991 by Lovis and a field school crew from Michigan State University. This investigation was directed toward recovery of small scale subsistence remains. Toward this end, a backhoe trench was excavated within the western portion of the site. The stratigraphic sequence identified in the trench corresponded to the sequence described by Speth (1972). Columns of flotation samples were collected from the strata identified and excavation units were excavated off of the trench.

The following analysis is based on the Early and Middle Woodland collections. These collections were recovered during the University of Michigan's excavations in 1963 and 1964 and a series of flotation samples from a column with a representative stratigraphic sequence collected by the Michigan State University crew.

Site Structure

For analytical purposes, Fitting (1972) divided the site into four areas: the old river channel; portions of the levee lying outside the stockade; portions of the levee lying inside the stockade; and the area covered with mound fill. Analysis of the features suggests that these areas correspond to varying degrees with the Woodland occupation localities (see discussion of features).

Taggart (1963) originally defined eight stratigraphic levels at the Schultz site. Fitting (1972) refined Taggart's sequence and based on the 1964 excavations eleven strata were defined (Table 5.16). These strata can be grouped according to time period. Levels IIa through IIc are associated with the Early Woodland occupation that dates to circa 500 B.C. Level IId dates to between 500 B.C. and 100 B.C. The low density of cultural materials associated with this stratum suggests that the site was only sporadically occupied at that time. Late Early Woodland (Shiawassee) and early Middle Woodland materials were recovered from Level IIIa, while levels IIIb and IVa contained late Middle

Table 5.16. Correlation of Stratigraphic Sequences Used at the Schultz Site

Taggart Sequence (1963)	Fitting Sequence (1964)	Speth Sequence (1972)	Radiocarbon Date	Ceramic Wares	Time Period
Plow zone	Plow zone	11		Mixed	Mixed
Upper dark silts	IV*c*	10	A.D. 1180	Cordmarked	Late Woodland
Intermediate dark silts	IV*b*	9	A.D. 450	Ruben Linear	Late Woodland
Middle dark silts	IV*a*	8*c*	A.D. 390	Green Point	Late Middle Woodland
	III*b*	8*b*		Green Point	Late Middle Woodland
		6?, 7, 8*a* (Channel area)		Tittabawassee Shiawassee	Early Middle to late Early Woodland
	III*a*	5*a*, 7, 8*a* (Outside channel area)			
Brown silts					
	II*d* (Occurs in channel only)	5*a*, 5*b*, 6?			Transitional (Cultural Hiatus)
Lower dark silts	II*c*	4	530 B.C. 540 B.C.	Schultz Thick	Early Woodland
	II*b*	3			Early Woodland
Gray silts	II*a*	2			Levee development
Bedded sands	I	1*a*, 1*b*			Lake bed

(From Speth 1972:53; Ozker 1982:27)

Woodland materials. Levels IVb and IVc represent the Late Woodland occupation. Finally, the plowzone includes a mix of cultural materials.

Speth (1972) provides the most detailed description of the stratigraphic sequence at the site. His stratigraphic sequence corresponds closely to Fitting's sequence (Table 5.16) and to the sequence identified during the Michigan State University excavations (Lovis, personal communication 1992). Further, Ozker's (1982) reanalysis of the stratigraphy from units containing Early Woodland collections confirmed the sequence identified by Speth (1972).

Paleoenvironmental Reconstruction

Stratigraphic profiles from the Schultz site indicate that the channel of the Tittabawassee River changed through time (Ozker 1982; Speth 1972). During the Early Woodland period, the levee and channel were situated north of their current position. During the initial Early Woodland occupation, the north bank of the channel crossed the 1964 trench at 540E590 and the south bank crossed the trench at approximately 490E590. Over time, the channel gradually shifted farther to the south, and at some point between the early Early Woodland (Schultz Thick) and the later Early Woodland (Shiawassee) occupation, the channel shifted to the south. The north bank of the newly formed channel lay between 515E590 and 510E590, but the southern bank could not be clearly distinguished (Ozker 1982:28-29; Speth 1972).

The Schultz site lies on a small rise (178 m to 180 m amsl). The site and surrounding area are slightly higher than the general level of the Shiawassee Flats, which was an extensive wet prairie and swamp prior to historic drainage. Ponding of flood waters behind the Saginaw Moraine and the slow release of water through the Saginaw River to the Bay helped to preserve the swamp and wet prairie in the area.

The physiography of the area and overall composition of the floral assemblage suggest that the area surrounding the site would have supported a mixed forest of hardwoods and conifers. A lowland forest of

elm, silver maple, black and white ash, basswood, and red maple, would have grown in low, poorly drained areas (below 178 m). Better drained, morainic uplands would have supported forests of beech, sugar maple, hemlock, yellow birch, basswood, oak, hickory, elm, and ash. Variations in the wood charcoal and gastropod assemblages suggest changes in the composition of the forest during the site's prehistoric occupation.

Early Woodland. Brose's (1972) analysis of the gastropods suggests that prior to the Early Woodland occupation of the site (Level IIa), the climate may have been somewhat drier and cooler. The gastropod assemblage also suggests that there were small swift creeks in the general area, while the southern portion of the site was the bank of a slough or stagnant pond that was replenished with seasonal overflow. The site area had little forest cover but gastropods common to wet-mesic, floodplain forests of elm and hickory comprise nearly 50% of the assemblage. Terrestrial gastropods found in dry shady forests of maple and oak or beech and maple represent approximately 5% of the assemblage (Brose 1972:127-129).

During the Early Woodland occupation (Levels IIb and c), the climate seems to have been somewhat moister although there appears to have been a decrease in the amount of swamp in the area. Drainage patterns appear to have improved but drainage in minor streams was still poor. There was frequent flooding during the earlier part of the Early Woodland occupation. During the latter part of the Early Woodland occupation, the Tittabawassee seems to have moved south, away from the site and flooding decreased in frequency (Brose 1972:127-129). Finally, the gastropod assemblages suggest that throughout the Early Woodland period there was an increase in the forest cover. Gastropods common to floodplain forests represent approximately 35% to 40% of the assemblage, but those found in drier maple and oak or beech-maple forests represent less than 5% of the assemblage. The floral assemblage is also dominated by taxa that occur in wet-mesic forest communities (e.g., birch, hackberry, ash, sycamore, and elm), although small percentages of taxa

that prefer drier sites (e.g., maple, beech, walnut, hickory, basswood, and oak) are also represented (Table 5.17). Finally, the faunal assemblage includes taxa that are common to northern forests (Table 5.18) with higher densities of coniferous trees than are present in the region at present; this suggests that the climate might have been somewhat cooler than at present (Cleland 1966).

Transitional - Early to Middle Woodland. Following the Early Woodland occupation of the site, there appears to have been a hiatus in the use of the site area (Level IId). The gastropod assemblage suggests that minor drainages ran through the site area, that flooding decreased, and that the climate was similar to that of today. There were, however, still areas near the site where water ponded seasonally. There is also a dramatic increase (circa 80% of the assemblage) in the presence of gastropods common to elm and hickory forests suggesting that this forest habitat increased during the transition between the Early and Middle Woodland periods (Brose 1972:127-129). The small assemblage of wood charcoal from the transitional Early to Middle Woodland contexts complements the gastropod data. There is a higher percentage of dry to dry-mesic taxa than in the preceding Early Woodland assemblage, although moderate percentages of wet-mesic taxa are also represented (Table 5.17).

Middle Woodland. Gastropods recovered from the Middle Woodland strata (Levels IIIa and b, and Level IVa) suggest that the climate fluctuated during the course of this period. Initially the climate seems to have been damper and warmer, but toward the end of the period, it appears to have become drier and cooler. During the most intensive Middle Woodland occupation of the site, minor drainage patterns appear to have increased but by the late Middle Woodland there is no evidence of minor drainages within the site area. Further, there was a continual decrease in the flooding of the Tittabawassee and Saginaw rivers. The gastropod assemblage also suggests that throughout the Middle Woodland occupation,

Table 5.17. Schultz Site: Flora

	Early Woodland		Early Middle Woodland		Late Middle Woodland	
Wood						
Ct	3797		3477		8865	
Wt[a]	94.1		79.9		259.4	
Identified Taxa[b]	**Count**	**Percent**	**Count**	**Percent**	**Count**	**Percent**
Acer sp./Maple	13	3.2	41	10.4	92	13.3
Betula sp./Birch	2	0.5	25	6.4	15	2.2
Carya sp./Hickory	22	5.4	19	4.8	62	8.9
Castenea dentata/ Chestnut	3	0.7	19	4.8	41	5.9
Celtis occidentalis/ Hackberry	-	-	36	9.2	20	2.9
Cercis canadensis/ Redbud	1	0.3	-	-	-	-
Fagus sp./Beech	6	1.5	5	1.3	27	3.9
Fraxinus sp./Ash	68	16.8	21	5.3	127	18.3
Juglans sp./Walnut	58	14.3	63	16.0	58	8.4
Morus ruba/Mulberry	2	0.5	7	1.8	14	2.0
Ostrya virginiana/ Hop-hornbeam	2	0.5	3	0.8	1	0.1
Pinus sp./Pine	3	0.7	1	0.3	11	1.6
P. resinosa/Red pine	-	-	1	0.3	3	0.4
P. strobus/White pine	11	2.7	3	0.8	16	2.3
Platanus occidentalis/ Sycamore	25	6.2	7	1.8	48	6.9
Quercus sp./Oak	26	6.4	22	5.6	27	3.9
Q./Red oak group	34	8.4	22	5.6	24	3.5
Q./White oak group	17	4.2	17	4.3	31	4.5
Tilia americana/ Basswood	2	0.5	2	0.5	5	0.7
Ulmaceae/Elm family	24	5.9	12	3.1	10	1.4
Ulmus sp./Elm	41	10.1	23	5.9	40	5.8
Ulmus cf. *americana*/ American elm	-	-	38	9.7	17	2.5
Ulmus rubra/ Slippery elm	-	-	6	1.5	4	0.6
Diffuse porous	40	18.7	31	18.5	71	20.1
Ring porous	140	65.4	118	70.2	264	74.8
Semi-ring	6	1.5	1	0.6	5	1.4
Coniferous	28	13.1	18	10.7	13	3.7
Unidentifiable	-	-	115	-	-	-
Bark						
Ct	3034		252		640	
Wt	36.77		3.32		26.05	

[a]Weights in grams

[b]Counts

Table 5.17. (cont'd)

	Early Woodland	Early Middle Woodland	Late Middle Woodland
Flot Volume	70	116	75
Seeds*			
Amphicarpa bracteata/ Hog-peanut	-	1	-
Aster cf. *cordifolius*/ Aster	1	-	-
Brassicaceae/ Mustard family	-	1	2
Celtis occidentalis/ Hackberry	-	3	-
Chenopodium sp./ Chenopodium	-	5	61
Convolvulaceae/ Morningglory family	-	1	-
Cornus rugosa/ Dogwood	-	-	1
Crategus sp./Hawthorn	-	4	22
Gaylussacia baccata/ Huckleberry	-	-	1
Hypericus sp./St. St. John's wort	-	5	-
Labiateae/Mint family	-	4	-
Poaceae (lg)/Grass family	-	8	55
Poaceae (sm)/Grass family	-	1	17
Polygonum sp./ Knotweed	-	-	1
Rosa cf. *palustris*/ Swamp rose	-	1	-
Sambucus canadensis/ Elderberry	-	2	1
Sassafras albidum/ Sassafras	-	-	2
Viburnum sp./ Nannyberry	-	1	-
Unidentifiable	-	10	18

*Counts

Table 5.18. Schultz Site: Fauna

Taxon	Early Woodland Meat Yield (kg)	Early Woodland %	Early Middle Woodland Meat Yield (kg)	Early Middle Woodland %	Late Middle Woodland Meat Yield (kg)	Late Middle Woodland %
MAMMALS						
Odocoileus virginianus Deer	720.0	52.4	1440.0	28.3	1710.0	26.3
Ondatra zibethicus Muskrat	12.1	0.9	53.0	1.0	38.0	0.6
Procyon lotor Raccoon	31.5	2.3	78.7	1.5	39.4	0.6
Castor canadensis Beaver	255.2	18.6	311.9	6.1	357.5	5.5
Cervus canadensis Elk	-	-	787.5	15.5	315.0	4.8
Urus americanus Bear	189.0	13.8	756.0	14.9	378.0	5.8
Canis familiaris Dog	6.8	0.5	33.8	0.7	40.6	0.6
Canis lupus Wolf	-	-	27.0	0.5	-	-
Marmota monax Woodchuck	-	-	5.0	0.1	2.5	<0.1
Mustela vison Mink	-	-	0.7	<0.1	0.7	<0.1
Martes americana Marten	0.9	0.1	0.9	<0.1	-	-
Lynx rufus Bobcat	-	-	-	-	6.8	0.1
Erthizon dorsatum Porcupine	-	-	-	-	4.5	0.1
Lutra canadensis Otter	5.6	0.4	16.9	0.3	28.3	0.4
Martes pennarti Fisher	2.2	0.2	2.3	<0.1	2.3	<0.1
Total Mammals	1223.3	89.1	3,513.7	69.1	2923.6	45.0

*Percentage based on total kg. of usable meat.

Table 5.18 (con't)

Taxon	Early Woodland MNI	Early Woodland Meat Yield (kg)	Early Woodland %	Early Middle Woodland MNI	Early Middle Woodland Meat Yield (kg)	Early Middle Woodland %	Late Middle Woodland MNI	Late Middle Woodland Meat Yield (kg)	Late Middle Woodland %
FISH									
Acipenser fulvescens Sturgeon	75.6	5.5		842.4	16.6		1,771.2	27.3	
Aplodinotus grunniens Freshwater Drum	10.8	0.8		85.5	1.7		170.6	2.6	
Esocidae Walleyed and Northern Pike	44.1	3.2		508.6	10.0		1,456.7	22.4	
Ictalurus punctatus Channel Catfish	8.7	0.6		37.3	0.7		60.7	0.9	
I. sp. Bullhead	2.2	0.2		1.4	<0.1		8.1	0.	
Lepisosteus osseus Longnose gar	-	-		10.8	0.2		12.2	0.2	
Amia calva Bowfin	1.8	0.1		9.0	0.2		27.0	0.4	
Percidae Perch	-	-		0.5	<0.1		1.8	<0.1	
Micropterus sp. Largemouth and Smallmouth Bass	-	-		2.5	<0.1		7.7	0.1	
Moxostoma sp. Northern redhorse and Sucker	-	-		0.2	<0.1		0.4	<0.1	
Salvelinus namaycush Lake Trout	-	-		13.0	0.3		6.5	0.1	
Total Fish	143.2	10.4		1,511.2	29.7		3,523.2	54.2	

Table 5.18 (con't)

Taxon	Early Woodland MNI	Early Woodland Meat Yield (kg)	Early Woodland %	Early Middle Woodland MNI	Early Middle Woodland Meat Yield (kg)	Early Middle Woodland %	Late Middle Woodland MNI	Late Middle Woodland Meat Yield (kg)	Late Middle Woodland %
BIRDS									
Anas discours Blue-winged teal	-	-		0.2	<0.1		0.5		<0.1
Botaurus lentiginosus American Bittern	-	-		3.6	0.1		1.8		<0.1
Ardea herodias Great Blue Heron	-	-		2.3	<0.1		-		-
Grus canadensis Sandhill Crane	-	-		3.8	0.1		3.8		0.1
Meleagris gall opavo Turkey	-	-		3.8	0.1		3.8		0.1
Lophodytes cucullatus Hooded Merganzer	-	-		0.9	0.1		0.9		<0.1
Anas platyrhychos Common Mallard	-	-		-	-		0.9		<0.1
Corvus brachyrhynchos Crow	-	-		-	-		1.6		<0.1
Gavia immer Common Loon	-	-		0.2	<0.1		0.2		<0.1
Ectopistes migratorius Passenger Pigeon	-	-		-	-		0.2		<0.1
Other Birds	0.9	0.1		-	-		0.2		<0.1
Total	1365.7	100.0		16.4	0.3		13.7		0.2

Table 5.18 (con't)

Taxon	Early Woodland MNI	Early Woodland Meat Yield (kg)	Early Woodland %	Early Middle Woodland MNI	Early Middle Woodland Meat Yield (kg)	Early Middle Woodland %	Late Middle Woodland MNI	Late Middle Woodland Meat Yield (kg)	Late Middle Woodland %
REPTILES									
Triunyx sp. Soft-shelled Turtles	5.4	0.4		21.6	0.4		21.6	0.3	
Emys blandingii Blanding's turtle	0.5	<0.1		0.9	<0.1		0.9	<0.1	
Chrysemys sp. Painted turtle	0.2	<0.1		-	-		-	-	
Chelydra serpentina Snapping Turtle	-	-		21.6	0.4		16.2	0.2	
Graptemys geographica Map Turtle	-	-		0.2	<0.1		0.2	<0.1	
Total Reptiles	6.1	0.4		38.9	1.3		30.8	0.7	

(Compiled from Cleland 1966:Appendix C and Luxenberg 1972:Table 27)

there was a continual decrease in the amount of forest cover on the site although the forest surrounding the site appears to have been fairly dense (Brose 1972:127-129). Percentages of wood charcoal do not support these environmental patterns. While the percentages of several wet and wet-mesic taxa are higher during the early Middle Woodland period than during the late Middle Woodland, there are also several taxa common to mesic and dry-mesic communities. Percentage of the latter are higher than during the late Middle Woodland (Table 5.17). Thus, there is no clear floral evidence for increased drying. The discrepancy between the wood charcoal and gastropod assemblages may, however, reflect cultural selection of wood through time.

The seed assemblage from the Middle Woodland strata (Table 5.17) does, however, complement the gastropod evidence for a decrease in forest cover throughout the period. Between the early and late Middle Woodland strata, there is a marked increase in the herbaceous taxa that are common to open, disturbed habitats (e.g., aster [*Aster* cf. *cordifolius*], chenopodium, *Crategus* sp./hawthorn, and Poaceae/grasses). While the increase in the abundance of these taxa may be related to changing exploitation patterns, it clearly indicates that an open habitat was present.

The floral assemblage also indicates that a marsh or backwater swamp habitat was present along the river bank. Aquatic tuber, swamp rose (*Rosa* cf. *palustris*), and grasses (cf. cordgrass [*Spartina* sp.]) are found in such habitats.

Cleland's (1966) analysis of the Middle Woodland faunal assemblage also suggests that there was a trend toward an increasingly open forest community. Animals that prefer such habitats (i.e., deer, elk, and woodchuck) increase in abundance during the Middle Woodland period (Table 5.18). Further, the fish taxa indicate that both marshy and clean, slow moving waters were present during the Middle Woodland.

Features

During the 1962, 1963, and 1964 field seasons, 202 features were identified. Three of these included two separate features under a single feature designation and twenty-four were identified in the machine stripped area and were not thoroughly examined. The 181 features that were examined and could be assigned to a specific stratum included four types of pit features, hearths, post molds, concentrations, portions of the midden, and at least one geologic feature (Fitting 1972a:20).

The geologic feature appears to have been a small anticline, measuring approximately eight feet in diameter. According to Fitting, "This would have formed after the site was occupied by man, for both Early and Middle Woodland deposits were found in a vertical rather than horizontal profile as we took down level floors..." (Fitting 1972a:20). A similar feature was identified during the 1963 excavations, but it was not assigned a feature number.

"Concentrations" were identified as "clusters of items found on living floors, usually along the interface between IIa and IIc" (Fitting 1972a:21). Most of these materials are interpreted as belonging to the IIc level. Concentrations occurred on living floors in other levels as well (Fitting 1972a:21).

Ozker's (1982) analysis of the Early Woodland features suggests that there were three types of Early Woodland "concentrations." She identified one linear band of concentrations (Features 58, 59a and 59) as a pile of debris amassed along the wall of a structure. Another set of concentrations contained large quantities of mussel shells (*Amblema costata*), suggesting shellfish processing areas. The third type of concentration included material remains suggesting a diverse range of activities. Some of these are interpreted as remnants of house floors (Ozker:152-153).

Midden deposits were identified in several levels but were most common in Level IIIb. These deposits frequently had an irregular

surface and peaks in the midden were often mistaken for hearths or pits during excavation and assigned feature designations (Fitting 1972a:21).

A number of single post molds were identified in living areas. Ozker's (1982) analysis of the post molds in the Early Woodland occupation strata suggests that there were two types of post molds. The three largest posts in these strata are interpreted as single free standing posts in open-air contexts. She posits that they may have served some symbolic function. The smaller post molds appear in groups and are associated with hearths suggesting that they may have been structural elements of a house or scaffold (Ozker 1982:147-150). There is no interpretation or analysis of the distribution or function of the other post molds.

In addition to the individual post molds, a circular pattern of post molds was identified. This feature measured approximately 44.8 m (147 ft) in diameter and is referred to as a stockade. It lay directly along the edge of the central mound and flanked the two smaller mounds. The post molds were sealed in several places by Level IV deposits and a late Middle Woodland feature overlay one of the post molds, suggesting that it predated this occupation. The distribution of early Middle Woodland features complements this interpretation (Fitting 1972a).

One hundred and twenty-two of the 181 features that were examined during the 1963 and 1964 field seasons were pits and hearths. As noted above, the pits were grouped into four types: A, B, C, and "empty." Type A pits are interpreted as being refuse pits or abandoned storage pits that were later used as refuse pits. The distribution and artifactual contents of these features indicate that the majority were associated with the Late Woodland occupation (Fitting 1972a:26). Type B pits appear to have been fire pits with refuse dumped on top; others appear to have been refuse pits that were later used as fire pits. These pits are associated with the early and late Middle Woodland occupations (Fittting 1972a:26,31). Type C pits appear to have been fire pits or to have been used for activities involving fire. All of

the Type C pits occur in the Early Woodland horizon (Fitting 1972a:31-32). The last group of pits is referred to as "empty pits." All but one of these pits was associated with the early Middle Woodland occupation and all but one of these occurred within the stockade. Further, more than half of the early Middle Woodland features within the stockade are empty pits despite the fact that empty pits comprise less than ten percent of the sample (Fitting 1972a:32-40).

"Hearths were large, oval to circular, shallow depressions with evidence of direct burning on the ground surface" (Fitting 1972a:33). Almost all of the hearths were found in the channel area. Although all of the transitional (Level IId) features are hearths, not all of the hearths are associated with this occupation. Many occur in the early and late Middle Woodland occupations.

Fitting's (1972a) analysis of the distribution of features provides further insight into the occupational history of the site. Geologic information suggests that the during the Early Woodland period, only the levee area of the site was habitable. Early Woodland features occur across the levee both inside and outside the stockade. Hearths are the only type of feature associated with this occupation, and they appear to be clustered around single post molds suggesting that they were associated with some sort of a structure. There is, however, no apparent spatial relationship between the Early Woodland features and the stockade.

While the entire site area was available during the transitional occupation, only the channel area was occupied. Hearths are the only feature type associated with this occupation, and negligible amounts of cultural materials were recovered from this horizon.

During the early Middle Woodland period, the entire site area was open for occupation and the distribution of features and artifacts indicates that all areas were occupied. A small concentration of early Middle Woodland features beneath the mounds suggests that the mounds post-date the early Middle Woodland occupation.

The overall distribution of early Middle Woodland features suggests "that the stockade itself is an early Middle Woodland structure with living debris and hearths concentrated outside the stockade and empty pits, perhaps of a ceremonial significance, inside the stockade" (Fitting 1972a:41). The presence of small numbers of hearths and refuse pits within the stockade suggests, however, that the stockade was built slightly after the initial occupation of the site by early Middle Woodland peoples (Fitting 1972a:541).

The majority of the late Middle Woodland features occur within channel area. Only two features and the mounds were found outside of the channel. Fitting (1972a:41) posits that the distribution of late Middle Woodland features indicates not only that economic activities were concentrated along the river, but also that the stockade was still standing and was considered a restricted area.

Finally, the density of features provides some indication of the occupational intensity of each cultural horizon. The Early Woodland and transitional occupations were both low intensity occupations with 0.006 and 0.007 features per cubic foot, respectively. A density of 0.017 features per cubic foot indicates that in the early Middle Woodland occupation the site was occupied for longer periods of time or by larger groups. The site was most intensively occupied during the late Middle Woodland period; the density of features associated with this occupation is 0.22 per cubic foot. The Late Woodland occupation was comparable to that of the early Middle Woodland period (Fitting 1972a:41).

Artifact Analysis

A large assemblage of artifacts was recovered during the University of Michigan investigations of the Schultz site. This assemblage includes over 705 chipped stone tools (Table 5.19), 118,907 pieces of debitage, firecracked rock, 346 bone, antler, and shell artifacts (Table 5.20), and 6577 pieces of ceramics (Table 5.21) that have been included in the formal analysis of the Early and Middle

Table 5.19. Schultz Site: Chipped Stone Tools

Chipped Stone Artifact	Early Woodland		Early Middle Woodland		Late Middle Woodland	
	n	%	n	%	n	%
Cores						
Block Cores	1	0.5	7	2.8	8	3.0
Plano-convex	14	7.5	17	6.9	10	3.7
Bipolar Cores	4	2.2	4	1.6	3	1.1
(Total)	(19)	(10.2)	(28)	(11.3)	(21)	(7.8)
Bifaces						
Stemmed Points	27	14.5	9	3.3	1	0.4
Ovate Bifaces	14	7.5	5	2.0	9	3.3
Large Triangular	3	1.6	4	1.6	7	2.6
Large Expanding Stem	--	--	12	4.8	12	4.4
Small Expanding Stem	3	1.6	11	4.4	18	6.6
Narrow Expanding Stem	--	--	--	--	4	1.5
Notched Knives	1	0.5	--	--	3	1.1
Small Triangular	--	--	1	0.4	1	0.4
Expanding Stem Bases	1	0.5	10	4.0	8	3.0
Point Tips	25	13.4	16	6.5	26	9.6
Corner Notched	--	--	4	1.6	4	1.5
Pomranky	--	--	--	--	--	--
Hafted Scrapers	--	--	1	0.4	1	0.4
Gravers	1	0.5	--	--	--	--
Drills/Perforators	4	2.2	--	--	3	1.1
Miscellaneous Bifaces	2	1.1	3	1.2	4	1.5
Biface Fragments	25	13.4	27	10.9	25	9.2
(Total)	(106)	(57.0)	(103)	(41.5)	(126)	(46.5)
Unifaces						
Unifacial Points	--	--	--	--	3	1.1
Steep Endscrapers	--	--	13	5.2	13	4.8
Sloping Endscrapers	9	4.8	7	2.8	5	1.8
Retouch Flakes	43	23.1	68	27.4	71	26.2
Bulbar Retouch Flakes	2	1.1	7	2.8	6	2.2
Blades	7	3.8	22	8.9	26	9.6
(Total)	(61)	(32.8)	(117)	(47.2)	(124)	(45.8)
TOTAL	186		248		271	

(Compiled from Fitting 1972:212)

Table 5.20. Schultz Site: Bone, Antler, and Shell Artifacts

	Early Woodland (IIb & IIc)		Early Middle Woodland (IIIa)		Late Middle Woodland (IIIb & IVa)	
	n	%[a]	n	%	n	%
Flat bone projectile points	-	-	2	50.0	2	50.0
Socketed conical projectile points	1	7.0	5	36.0	3	21.0
Toggle head harpoons	-	-	1	50.0	1	50.0
Solid conical projectile points	-	-	2	25.0	4	50.0
Cylindrical awls	-	-	2	40.0	2	40.0
Ulna awls	-	-	2	22.0	2	22.0
Splinter awls	2	15.3	2	15.3	2	15.3
Fish spine awls	-	-	-	-	3	75.0
Large shuttle	-	-	2	25.0	6	75.0
Small shuttle	-	-	1	100.0	-	-
Small socket handles	-	-	1	20.0	-	-
Large socket handles	-	-	1	33.0	-	-
Tine flakers	1	14.0	2	28.0	2	28.0
Percussion flakers	-	-	-	-	2	29.0
Cut antler	1	7.7	1	7.7		215.4
Hoes	-	-	1	33.3	1	33.3
Beaver chisels	-	-	-	-	4	40.0
Ground teeth	1	2.5	7	17.5	10	26.0
Beamers	1	25.0	-	-	1	25.0
Dentate Stamper	-	-	1	100.0	-	-
Bird bone tubes	-	-	2	29.0	4	58.0
Bird bone "tallies"	-	-	1	25.0	2	50.0
Dishes, turtle carapace	-	-	24	5.2	178	36.0
Dishes, engraved carapace	-	-	1	16.0	4	66.6
Tubular polished bone	-	-	1	100.0	-	-
Other polished bone	-	-	5	38.0	8	62.0
Effigy claw	-	-	-	-	1	100.0
Beads, spherical	-	-	1	3.1	24	85.1
Beads, cylindrical, columella	-	-	2	25.0	1	12.5
Columella	-	-	1	100.0	-	-
Spoons	-	-	-	-	1	20.0
TOTAL	7		71		268	

(compiled from Murray 1972:240-1)

[a]Percentage of tool type within total assemblage

Table 5.21. Schultz Site: Ceramics

	Early Woodland (IIb & IIc)	Early Middle Woodland (IIIa)	Late Middle Woodland (IIIb & IVa)
Schultz, Thick	142	78	-
Shiawassee, Cordmarked	30	91	2
Shiawassee, Plain	1	47	-
Shiawassee, Incised	-	19	-
(Total)	(31)	(157)	(2)
Tittabawassee Dentate Stick	8	52	16
Tittabawassee Cordmarked Stick Stamped	-	6	12
Tittabawassee Plain Noded	3	11	2
(Total)	(11)	(69)	(40)
Green Point Rocker Stamped, Plain	-	39	71
Rocker Stamped, Plain, Body	15	297	391
Green Point Rocker Stmp', Dentate	1	-	6
Rocker Stamped, Dentate, Body	8	31	34
Green Point Incised, Crosshatched	-	15	8
Incised Crosshatched, Body	-	3	7
Green Point Incised, Misc.	6	52	103
Green Point Plain	3	1	9
Green Point Brushed	-	2	2
Brushed (zoned) body	-	1	-
Green Point Undifferentiated body	5	42	84
Green Point Undifferentiated punctated body	1	6	33
(Total)	(39)	(489)	(748)
Ruben Linear Cord Impressed Plain Interior	2	11	27
Ruben Linear Cord Impressed Striated Interior	2	1	8
(Total)	(4)	(12)	(35)
Plain straight rim	3	3	16
Plain excavated rim	3	-	9
Cordmarked undecorated rim	1	9	8
Cordmarked noded	-	2	1
Cordmarked Cordwrapped Stick Impressed Lip	-	1	-
Saginaw Thin Cordmarked	2	28	2
Textile Impressed	-	5	-
Simple Stamped	-	1	1
Cordmarked Undecorated Body	42	204	119
Cordmarked Incised Body	-	3	12
Cordmarked Punctated Body	-	-	1
Plain Undecorated Body	66	928	1,640
Scraped Body	1	34	70
Cordmarked and Smoothed Body	21	148	109
Indeterminate	71	534	620
TOTAL	437	2705	3435

(From Fisher 1972:146)

Woodland occupations (Fitting 1972c). Some general observations regarding the composition of and relative importance of different tool categories are appropriate to this analysis of the Early, early Middle and late Middle Woodland occupations, (see Fischer 1972, Fitting 1972b, and Murray 1972 for a more detailed analysis of the artifact assemblages).

The Early and early Middle Woodland assemblages include higher percentages of cores than does the late Middle Woodland assemblage. In comparing these percentages with the mean weight of debitage, Fitting (1972b) posits that tools were more commonly manufactured from cores during the earlier two periods and from refurbished tools during the latter occupation.

Bifaces comprise a larger percentage of Early Woodland chipped stone tool assemblage than they do of the early Middle or late Middle Woodland assemblages. Notably, gravers, perforators, and drills are five times more abundant in the Early Woodland assemblage than they are in the latter two. There is, however, a greater diversity of bifacial tool forms in the Middle Woodland assemblages.

Unifaces are less prevalent in the Early Woodland assemblage than they are in the Middle Woodland assemblages. Further, blades comprise a larger percentage of the Middle Woodland assemblages than of the Early Woodland assemblage, and many of the Middle Woodland blades are made from exotic raw materials.

The Early Woodland artifact assemblage includes only a small number of bone, antler, and shell artifacts, but these tool forms are an important component of the Middle Woodland assemblages. The Middle Woodland assemblage includes not only a variety of utilitarian tool forms (e.g., projectile points, toggles, awls, flaker, and beamers) but also many non-utilitarian items including beads and tallies.

Ceramics first appear in the Saginaw Valley in the Early Woodland component of the Schultz site. Schultz and Shiawassee wares are characteristic of this period; other types found in the Early Woodland

assemblage are intrusive. There is, therefore, a low density of ceramics in the Early Woodland component of the site. The density and diversity of ceramics increases through the Middle Woodland period. Further, many of the ceramic styles represented in the Middle Woodland assemblage reflect Hopewell influence and are related to the ritual rather domestic component of the occupation.

Finally, densities of firecracked rock are relatively low in both the Early and early Middle Woodland strata. Higher densities of firecracked rock occur in the late Middle Woodland strata.

Subsistence Remains

The vast majority of the subsistence assemblage considered in this analysis is derived from screen recovered samples. Percentages and ubiquity values of nuts are based on these samples. Processing and analysis of flotation samples recovered by Michigan State University were incomplete at the time of this study. Six samples (70 ℓ) from Early Woodland contexts, seventeen samples (107 ℓ) from early Middle Woodland proveniences, and eight samples (75 ℓ) were reviewed for the presence of seeds and squash rind.

Cleland's (1966) and Luxenberg's (1972) analyses of faunal assemblages from the Schultz site resulted in different percentages of taxa and classes of fauna. Given that the samples employed in the two analyses were derived from different areas of the site, the discrepancies between the two analyses are likely the result of differences in activities carried out in these areas. Therefore, in this analysis the results of Cleland's (1966) and Luxenberg's (1972) analyses are combined to provide a more comprehensive view of the subsistence regimes.

Early Woodland. The Early Woodland assemblage includes a variety of mammals and fish and a small number of turtles and birds (Table 5.18). Mammals comprise the largest percentage of meat (89.1%). Deer is the primary source of meat. Beaver and bear contribute moderate amounts of

meat and small mammals, including raccoon, muskrat, otter, dog, fisher, and marten, lesser amounts.[5]

Fish contributed a significantly smaller percentage (10.4%) of the Early Woodland meat than mammals. The largest percentages are of sturgeon and pike; lesser amounts of drum, catfish, bullhead, and bowfin are also represented (Table 5.18). Shellfish were recovered in association with other food resources, which suggests that they were also consumed by the Early Woodland occupants of the site (Ozker 1982), although their relative dietary contribution cannot be determined from the data available. Turtles (0.4%) and birds (0.1%) comprised small percentages of the Early Woodland diet (Table 5.18).

The Early Woodland occupants of the site also exploited nuts and squash. Nuts are relatively ubiquitous, occurring in 37.5% of the samples and the ratio of nutshell to wood charcoal (1:8.5) is moderately high as well. A large percentage (32.2%) of the assemblage could only be identified to family, Juglandaceae. The majority of the identified specimens are hickory (35.0%) and black walnut (25.7%); lesser numbers of butternut (14.1%), walnut (*Juglans* sp.) (3.0%), and acorn (2.8%) were also recovered.

The identification of squash as a component of the subsistence regime is based on a seed impression identified in an Early Woodland ceramic sherd (Ozker 1982:38-40). Squash was not identified in the floral assemblage.

A single aster (*Aster cf. cordifolius*) seed was recovered from the Early Woodland samples. Although the ethnographic record shows that several species of aster were used for medicinal purposes (Moerman 1986), they are common to this region, and its presence may simply be a product of accidental burning at the site.

Early Middle Woodland. A wider variety of mammals, fish, turtles, and birds was recovered in the early Middle Woodland contexts (Table 5.18).

---

[5] In fact, the carnivorous taxa may not have been consumed.

Mammals again comprised the largest percentage of meat (69.1%), but were significantly less important than they were in the Early Woodland assemblage. Deer was the primary source of meat, although elk (15.5%) and bear (14.9%) contributed moderate amounts of meat as well. Small and medium sized mammals, including beaver, raccoon, muskrat, woodchuck, dog, wolf, otter, mink, marten, and fisher, contributed only slightly more than 10% of the meat, although several of these taxa may not have been subsistence items.

Fish contributed a significantly greater percentage to the early Middle Woodland diet (29.7% of the meat) than to the Early Woodland subsistence regime. Sturgeon and pike were again the most important sources of fish (16.6% and 10.0%, respectively), but small amounts of other fish are also represented (Table 5.18). Finally, shellfish become increasingly prevalent in the Middle Woodland proveniences, suggesting that their dietary contribution increased during this period (Brose 1972:120-125).

Turtles (1.3%) and a variety of birds, including waterfowl and other wetland birds (0.3%), comprised small percentages of the early Middle Woodland diet (Table 5.18). Carapace and bird bone artifacts recovered from the early Middle Woodland proveniences suggest that the relative contribution of these resources may be somewhat greater than the subsistence data indicates.

The early Middle Woodland occupants of the site also exploited a wide variety of plant resources, including nuts, fruits, tubers, starchy seeds, and squash. Nuts are relatively ubiquitous, occurring in 43.4% of the samples. In addition, the ratio of nuts to wood charcoal (1:1.9) is high. Acorn is the most abundant nut recovered (42.4%), although its relative importance is inflated by the presence of a large number of specimens in one feature. Black walnut is, however, much more ubiquitous, occurring in 43.4% of the samples and represents 32.1 % of the nutshell assemblage. Lower percentages of hickory (including *C. glabra*/pignut and *C. ovata*/shagbark) (16.2%), which is also ubiquitous

(43.4%), butternut (12.1%), unidentifiable walnut (7.3%), and walnut family (3.9%) were also recovered.

Five fruits (hackberry, hawthorn, rose [hips], elderberry, and nannyberry) and a variety of weed, vine, and grass taxa were recovered (Table 5.17). Fruit seeds comprise nearly 30% of the seed assemblage although they occur in only 27% of the flotation samples. This suggests that fruits were exploited but were not a particularly important resource.

A small number of chenopodium (*Chenopodium* sp.) seeds were recovered (Table 5.17). As noted above, this taxa is common to disturbed habitats but was also an important cultigen (Fritz 1990; Smith 1985, 1992) that was exploited during the Late Woodland period in the Saginaw Valley (Parker 1992). Scanning electron microscopy (SEM) analysis of the Schultz chenopodium indicates that they are a wild variety (*Chenopodium berlandieri*) (Parker, personal communication 1993).

A squash peduncle and fragments of squash rind have also been recovered from the early Middle Woodland samples. Presence of squash indicates that there was some reliance on cultigens during the Middle Woodland period.

Nineteen percent of the seeds recovered were grasses. The larger specimens look like cordgrass (*Spartina* sp.), which is a tall grass (ca. six feet) that would have been useful for thatching and other technological purposes. Interestingly, high percentages of grasses have also been identified in samples from a Late Woodland site (20SA1034) in the area (Parker 1992), supporting the interpretation that they were intentionally exploited.

The role of the other taxa is unclear at this time. Some may have been used for medicinal or technological purposes.

Finally, small amounts of terrestrial and aquatic tuber have been identified in the early Middle Woodland samples (Table 5.17). These remains were recovered in association with other food remains, suggesting that they were exploited as a food resource.

Late Middle Woodland. The late Middle Woodland faunal assemblage from the Schultz site reflects a further decrease in the relative importance of mammals and a concomitant increase in fish, while turtles and birds are also represented in minor amounts. Deer is the second most important source of meat (26.3%). Beaver (5.5%), elk (4.8%), bear (5.8%), and a variety of small and medium sized mammals (each comprising less than 1.0%) contributed significantly smaller amounts of meat. Bobcat (*Lynx rufus*) is also present, although it was probably not a food resource.

Fish are the primary source of meat in the late Middle Woodland assemblage (54.2%). Sturgeon (27.3%) and pike (22.4%) are again the most prevalent taxa, while a variety of other fish including shellfish are also present (Table 5.18; Brose 1972:120-125).

Turtles (0.7%) and birds (0.2%) represent small percentages of the faunal assemblage. Large numbers of carapace and bird bone artifacts (Table 5.20) suggest, however, that they were more important to the diet than these values indicate.

The subsistence assemblages indicate that the late Middle Woodland occupants of the site continued to exploit nuts, fruits, tubers, squash and possibly other cultigens. Nuts are relatively ubiquitous, occurring in 52.7% of the samples. The ratio of nut to wood charcoal (1:5.0) is moderately high, although it is lower than the ratio noted in the early Middle Woodland assemblage. Acorn is again the most abundant nut recovered (35.5%), although its relative importance is again inflated by the presence of a large number of specimens in a small number (n=2) of features. Hickory nuts are much more ubiquitous, occurring in 52.7% of the samples, and comprise 20.6% of the nutshell assemblage. Black walnut is nearly as abundant as hickory (20.4%), although it occurs in a slightly lower percentage of the samples (49.1%). Lower percentages of butternut (7.4%), unidentifiable walnut (2.3%), and walnut family (8.6%) were also recovered.

A narrower range of seeds was recovered from the late Middle Woodland samples, although this may be due to the smaller sample size. Fruit (hawthorn, huckleberry and elderberry), chenopodium, grasses, mustard, knotweed, and shrub (sassafras [*Sassafras albidum*] and dogwood [*Cornus rugosa*]) seeds were recovered (Table 5.17). Fruits are ubiquitous (occurring in 100% of the flotation samples). While they comprise a relatively small percentage (16%) of the total seed assemblage, they are outnumbered by taxa that produce much larger numbers of seeds. Therefore, based on their ubiquity, it can be argued that they represent a relatively important component of the diet.

Chenopodium seeds are significantly more ubiquitous and abundant in the late Middle Woodland assemblage. This increase in the presence of chenopodium suggests that they were used as a food resource.

Grasses are moderately ubiquitous, occurring in over one-half of the samples. They represent a fairly large percentage (31%) of the seed assemblage, although the majority (82%) were recovered from one sample. As noted above, these grasses may have been used for thatching and other technological purposes; although it is also possible that they may have been a food source.

The role of the other taxa is unclear. All would have been available in the vicinity of the site and could have been introduced by cultural or natural agencies.

Finally, small amounts of terrestrial and aquatic tuber have been identified in the late Middle Woodland samples. These remains were recovered in association with other food remains, suggesting that they were a food resource.

In sum, several changes in the Early through Middle Woodland subsistence regime are reflected in the faunal and floral assemblages. There is a marked trend toward increased exploitation of fish, particularly spring spawning taxa, and a concomitant decrease in the use of mammals. While previous analyses (Cleland 1966; Luxenberg 1972) have noted an increase in the use of large game animals, this pattern is *not*

supported by the results of the *combined* data sets. Rather, there appears to be an increase in the diversity of game animals exploited.

Based on this analysis, there is no reduction in the importance of nuts, as previously noted by Allison (1972). Rather, the data suggest that nut exploitation may have increased through time. There is a decrease in the importance of fatty nuts (e.g., hickory, walnut, and butternut), but acorn becomes a relatively important component of the Middle Woodland nut assemblages. Other notable changes in the floral exploitation patterns are the appearance of summer fruits in the Middle Woodland assemblages and the increase in the importance of starchy seeds.

Seasonality and Function

Interpretations of the seasonality of each of the occupations at the Schultz site vary. These interpretations will be briefly reviewed and evaluated relative to the analyses discussed above.

Early Woodland. Based on the small Early Woodland sample he had to work with, Cleland (1966) felt that the absence of waterfowl and turtles were indicative of a winter occupation. Luxenberg (1972) identified turtles and several species of fish, some of which are spring spawners, in the assemblage she analyzed. Allison (1972) identified only one nutshell in the sample available to her. Based on these results, Fitting (1972c:254) posited that during the Early Woodland period, the site was occupied during the late fall, winter, and spring. Based on her reanalysis of the Early Woodland collections, Ozker (1982) argued that the site was occupied during the spring and fall as a specialized extractive camp for the cultivation of squash and nut processing. Based on the results of the faunal and floral analyses discussed here, the most parsimonious interpretation is that the site was occupied during the fall. Deer and nut appear to have been targeted as primary resources. Aquatic resources were also heavily exploited, but the percentages

of fish noted to be spring spawners could in fact have been exploited during the fall.

Without the benefit of microware analysis, functional interpretations of the lithic assemblage are only tentative. In general, however, the high percentage of points, bifaces, and biface fragments confirms the interpretation that hunting was a primary activity at the site (Fitting 1972b:219). Assuming that scrapers are to some extent associated with hide processing, the relatively low percentage of these tool forms suggests that hide processing was not a primary activity. The presence of awls, drills, and adzes/celts suggests that other manufacturing activities were carried out during the Early Woodland occupation. The relatively high percentage of cores and the presence of antler tines and beamers suggests that tool manufacturing and maintenance activities were also carried out. Finally, the presence of ceramics suggests that the site served as a residential (base camp) locale rather than a logistical camp. Further, as Ozker (1982) has argued, the association of the Schultz Thick ceramics with relatively high densities of nutshell suggests that the ceramics were used in the processing of nuts (e.g., production of nut butter).

Early Middle and Late Middle Woodland. The results of the early and late Middle Woodland artifact and subsistence analyses are fairly similar. The floral and faunal analyses reflect: 1) relatively high percentages of spring spawning fish; 2) a diversity of mammals, turtles, and summer fruits; 3) an increase in the importance of late summer/early fall squash and starchy seeds; 4) a high ratio and ubiquity of nuts; and 5) the presence of aquatic tubers. Further, there is a marked trend toward increased reliance on fish and a decrease in the importance of hunting. The overall composition of the assemblages suggests that during the early and late Middle Woodland periods, the site was occupied as a base camp during the spring, summer, and fall.

Fitting (1972b:219) argues that the higher percentages of unifaces recovered in the early and late Middle Woodland assemblages is function-

ally related to the increased importance of fishing, clamming, and the gathering of plant foods. The presence of shuttles and toggle head harpoons seems to complement the interpretation that fishing was an important activity during these occupations. The presence of moderate percentages of stone and bone projectile points confirms the results of the subsistence analysis, which shows that hunting was also a relatively important activity. The bone hoe also complements the subsistence analyses and strongly suggests that some horticultural activities were being carried out during the Middle Woodland period. Finally, the ceramics and turtle carapace dishes reflect subsistence related activities associated with food preparation, serving, and storage.

Manufacturing and maintenance activities are reflected by the presence of the cores, awls, handles, flakers, cut antler, ground teeth, beamers, and the dentate stamp. These tools would have been used for a range of tasks including stone tool production and maintenance, basketry and fabric manufacture, and ceramic manufacture, as well as for other purposes.

Finally, some of the ceramic wares and the polished bones, "tallies," beads, columella shell, and carnivorous animal remains indicate that ritual activities were carried out during the Middle Woodland occupation. These activities appear to be associated with the stockade area. The low density of domestic artifacts and refuse within this area further supports the interpretation of ritual function.

The diversity of tool forms suggests that a wide variety of activities (including subsistence, maintenance, and ritual enterprises) were carried out at the site and lends support to the interpretation that the site was occupied for multiple seasons. Further, the diversity of activities suggests that the occupation was relatively stable and that the site functioned as a base camp/village locality.

Comparison with Archaeological Expectations

Early Woodland. The inductively derived conclusion is that the Early Woodland subsistence assemblage reflects a fall subsistence pattern. This does not, however, fit well with the deductively derived expectations predicated on the simulations of fall resource choices. The expectations of fall choices anticipate: primary reliance on waterfowl and fatty nuts and secondary use of large game, fruits, and terrestrial tubers when choices are based on taste; primary reliance on fish and wetland tubers, and secondary use of large game and nuts (both fatty species and acorns) when choices are based on efficiency; and primary reliance on waterfowl and wetland tubers and the secondary use of large game, nuts (fatty species and acorn) and, to a lesser extent, fruits when choices are based on a combination of goals. The subsistence assemblages, however, indicate that large game and fatty nuts were targeted resources and that small game and fish were of lesser importance. Therefore, the overall composition of the assemblage most closely parallels the simulation of late fall (October) and winter choices based on taste. This is the only simulation that identifies large game and fatty nuts as the primary resources. In contrast, the simulation and expectations of choices based exclusively on efficiency identify fish and large game as the primary sources of meat and nuts (fatty species and acorn) as resources of limited importance. The simulation and expectations of choices based on the combination of goals predict that large game will be a primary resource and that nuts again will be of limited importance in the diet.

Variations in the subsistence assemblage and the anticipated secondary importance of fish, waterfowl, small game, and plant resources are considered to be less significant than the overall pattern suggested by the simulation based on taste. These variations can be accounted for by several factors, including the timing or location of the occupation, the limited contribution of the collective exploitation group, and sampling error.

The subsistence assemblages also suggest that males and females/juveniles contribute more food to the diet than the collective group. Factors that may account for the limited contribution of the collective group include the timing of the occupation and availability of aggregated resources, and the size of the residential group.

Early Middle Woodland. Comparison of the Middle Woodland subsistence assemblages with the archaeological expectations is confounded by the fact that multiple seasons appear to be represented. The comparison is, therefore, directed toward a more general comparison of the overall structure of the subsistence assemblages, employing aggregated percentages of resources for spring, summer, and fall.

The simulation and expectations of resource choices based on multiple goals most closely correspond to the early Middle Woodland subsistence assemblage. The key similarities are that in both the expectations and subsistence assemblages, fish and large game are the primary sources of meat, nuts (including both fatty species and acorn) and fruits are relatively important, and small game are an important secondary resource. The expectations based on efficiency identify fish as the primary source of meat, large game as a secondary resource, and nuts (including both fatty species and acorn) as being of little import. A diet based on taste anticipates fish and fatty nuts to be primary resources and fruits, large game, and waterfowl to be of secondary importance.

The primary difference between the subsistence assemblages and the expectations based on the combination of goals is that waterfowl are not shown in the archaeological record to be an important resource. Again, however, this may be due to the timing or location of the occupation or scheduling conflicts with other resources.

Foods that are present in the assemblage but not anticipated by the simulations are squash and starchy seeds. Squash was not included in the model because, prior to this study, archeological evidence regarding its value was limited and, thus, estimates of its productivity

could not be assessed. If squash were included in the analysis, they may have been selected for their productivity (efficiency) or for sweet flesh and fatty seeds (taste). Starchy seeds were included in the model but were not selected. This may be due to the misestimate of their productivity which might be higher in "domestilocalities" [Smith 1992:52-53) and floodplain localities such as the Schultz site.

The relative importance of fish in the early Middle Woodland subsistence assemblage reflects a greater contribution of the collective exploitation group than was noted in the Early Woodland assemblage and a decrease in the contribution of male resources.[6] This shift in the contribution of the collective group may be related to the size of the residential group, the relative importance of aggregated, high productivity foods exploited by the collective group, the duration of the occupation and utility of such resources, or scheduling conflicts associated with mortuary activities.

Finally, the presence of carnivores in the early Middle Woodland assemblage is not unexpected, however, because prestige seems to be a factor affecting resource choice and because ritual activities were an important component of the occupation. Killing carnivorous animals would bring prestige to the hunter because of their ideological value and because they are dangerous animals.

Late Middle Woodland. The late Middle Woodland subsistence assemblage is most similar to the expectations predicated on the simulation of choices based on efficiency in the spring, summer, and fall. The primary similarities are that in both, fish is primary source of meat, and large game and to a lesser extent small game and nuts (including both fatty species and acorn) provide important secondary contributions. This assemblage differs from that anticipated by the simulation based on a combination of goals and that based on taste in the relative

---

[6] It is not possible to evaluate the relative contribution of the females/juveniles without density information on plant resources.

contribution of other resources, as discussed in the early Middle Woodland comparison.

Squash and starchy seeds are unanticipated components of the archaeological assemblage. As discussed above, squash and starchy seeds may have been selected for their taste (squash) or their productivity (both). If selected because of their productivity and availability within the domestilocality, then they would not be unexpected components of a diet based primarily on efficiency.

It is difficult to assess the relative importance of the fruits. Their presence may, therefore, not represent a significant variance with the simulation of choices based on efficiency.

The importance of fish in the late Middle Woodland subsistence assemblage reflects an even larger contribution of the collective exploitation group and a significant decrease in the contribution of male hunting. In this context, the importance of collectively derived aggregated resources and the decrease in male resources that were highly valued for prestige and taste appear to be related to the importance of efficiency in exploiting high productivity resources. Scheduling conflicts associated with mortuary and ceremonial activities may also have affected decisions regarding resource choice and the importance of efficiency.

It is difficult to assess the relative contribution of female/juvenile resources without density information on nuts, which were a primary food. While the increase in the presence of starchy seeds would suggest that females were providing more food, there may have been a minor decrease in the contribution of nuts.

Summary

The comparative analysis of the simulations and archaeological data from Late Archaic, Early Woodland, and Middle Woodland sites in the Saginaw Valley indicates that the goals affecting subsistence choice and the contribution of each exploitive group varied both within and between

time periods. Multiple goals, taste alone, and efficiency alone were all identified as goals affecting choice. In addition, the relative contribution of males and the collective group vary. These variations appear to be related to several factors including: 1) scheduling conflicts with other activities; 2) the timing and duration of the occupation; and 3) the size of the residential group.

This analysis suggests that subsistence decision making was guided by different goals in different contexts during the Late Archaic and Early and Middle Woodland periods. The Weber I site and Early Woodland component of the Schultz site appear to have been specifically occupied for hunting and nut collecting; choices were strongly affected by taste. Efficiency, alone or as one of multiple goals, has a greater influence on choices at sites that were occupied as base camps (Schmidt and Marquette Viaduct) or for purposes other than food acquisition alone (Feheeley, 20BY79, and Schultz during the Middle Woodland). Thus, efficiency in subsistence endeavors provided more time and labor for other activities such as tool manufacture and mortuary activities.

Some of the variation in the importance of efficiency may also be related to inter-annual variations in the availability and productivity of foods that may have been preferred for taste and prestige. The mast cycles of nuts, for example, vary inter-annually and at some sites (20BY79 and Schultz) that were occupied several times, both fatty nuts and acorns (more highly ranked in terms of efficiency) will be ubiquitous. This suggests that fatty nuts would have been taken when they could be efficiently exploited, but when availability and productivity were low, it was more efficient to use acorns which could be efficiently exploited.

Efficiency also appears to become a more important subsistence goal through time. This trend is correlated with an increase in population size and sedentism.

Prestige appears to have been a factor involved in subsistence choice, as well as in the use in ritual contexts. Large game, that were

favored as prestige resources, are consistently an important component of the subsistence assemblages. Further, the presence of carnivorous animals, which were probably not food resources, suggests that ideological goals and prestige were important goals in ritual contexts such as the Middle Woodland component of the Schultz site.

Changes in the relative contribution of the different components of the labor force correspond with these variations in subsistence goals. Collective resources were less important at small, short-term occupation sites such as Weber I and 20BY79. At base camp sites (i.e., Schmidt, Feeheley, Marquette Viaduct, and Schultz), which were occupied for longer periods of time, multiple seasons, collective resources appear to have been more important.

At task-specific sites, such as Weber I and 20BY79, the collective resources appear to be less important. At larger base camps, when subsistence choices are influenced by efficiency, either alone or as one of multiple goals, the contribution of the collective resources is greater.

Finally, the analyses of the Feeheley and Schultz sites suggest that collective resources may be more important in mortuary contexts, in which scheduling conflicts may affect the contribution of males (or females). Aggregated resources, which can be efficiently exploited and provide a large yield, may be preferred in such contexts.

Thus, these variations in the priority of specific subsistence goals and the relative contributions of each of the exploitive groups are linked to a number of factors. What remains to be considered is the adaptive nature of these variations in subsistence goals and the division of labor.

CHAPTER 6

Conclusions

Models of Subsistence Decision Making

Hunter-gatherer studies have demonstrated that efficiency, taste, and prestige affect subsistence decision making, but there has been no systematic consideration of factors that might affect the relative importance of these goals in different contexts. Nor has there been a serious effort to integrate the division of labor into the decision-making process when modeling prehistoric subsistence strategies. The models developed and evaluated in this study specifically address these two issues.

Three basic models of subsistence decision making are proposed: one based on efficiency as the sole criterion affecting subsistence choice; one based on taste, including preferences for both fatty and sweet foods, as the only criterion affecting subsistence choice; and one based on multiple goals, including prestige, taste, and efficiency, affecting subsistence choice. Within each of the models, there are three exploitive groups providing food to the overall diet: male hunters; female and juvenile collectors; and a collective group that cooperates to exploit aggregated resources. Finally, it is assumed that for a population to survive, the overall diet must include a set of foods that provides minimum energy and nutrient requirements to the population.

A computer program was developed to simulate these three models. The program runs on three cycles, one simulating resource choices based on efficiency alone, another simulating choices based solely on taste, and a third based on a set of multiple goals (prestige, efficiency, and taste). Resources are categorized as male, female/juvenile, or

collective options and are rank ordered on a scale of 1 to 10. In each of the simulations, resource choices are made by having the three exploitive groups iteratively select, in descending order, the resource options that provide the greatest satisfaction to one of the three goals. The simulation continues to select resources until energy and nutritional requirements are satisfied.

The simulations are applied to three cultural periods in the Saginaw Valley of Michigan: the Late Archaic; the Early Woodland; and the Middle Woodland. The productivity of forest, wetland, and aquatic resources changed between the Late Archaic and Woodland periods because of fluctuations in lake levels in the Huron and Saginaw basins. These variations in resource productivity affected the efficiency with which different resources could be exploited. Thus, modeling subsistence decision making during the Late Archaic and Woodland periods required the simulation of choices based on efficiency alone and the simulation based on multiple goals, which includes efficiency, to be run using two different sets of resource rankings.

Thus, five subsistence simulations were generated: one of choices based on taste; one of Late Archaic choices based on efficiency; one of Late Archaic choices based on multiple goals; one of Early and Middle Woodland choices based on efficiency; and one of Early and Middle Woodland choices based on multiple goals. The simulation of choices based on taste selects a diffuse diet based on a diversity of fatty and sweet foods. The simulations of Late Archaic and Early and Middle Woodland choices based on efficiency describe a focal subsistence regime based on a small number of highly productive resources. In these simulations, the Woodland diet is anticipated to include the greater variety of resources, while the Late Archaic subsistence needs are more quickly satisfied through selection of a few highly productive resources early in the simulation. Further, the dissimilarity between the two simulations is most notable in the fall. Finally, the simulations of Late Archaic and Early and Middle Woodland choices based on multiple

goals include a wide range of resources, including those that are highly ranked in terms of taste (fat and sweet) and those that are more productive. In these latter simulations, the Woodland diet is anticipated to include the greater variety of resources, while the Late Archaic subsistence needs are more quickly satisfied through selection of a few highly productive resources early in the simulation. The dissimilarity between these two resource sets is greatest during the spring.

Most of the variation in the simulated choices is due to differences in the resources selected by the female/juvenile and collective exploitive groups. These differences result in variations in the relative dietary contributions of these groups during the spring and fall. Male choices also vary to some extent in these simulations. The differences, however, have much less effect on the composition of the diet and the dietary contribution of males.

Taking into consideration the preservational characteristics of the resources selected by each of the simulations, a series of archaeological expectations was generated. These expectations are primarily directed toward identifying the relative contribution of different categories of foods that would be found in archaeological subsistence assemblages. Further, they focus on variations in the contributions of female/juvenile, collective, and male resources.

Subsistence Adaptation in the Saginaw Valley

Comparing the simulations and archaeological expectations with a number of archaeological data sets ranging over a 5,000 year period, several variations in the short- and long-term subsistence goals have been identified. Concomitant changes in the contribution of different exploitive groups are associated with these variations in subsistence goals. These variations appear to represent: 1) adaptive responses to seasonal and inter-annual variations in resource availability and productivity; 2) scheduling conflicts between food acquisition and other

activities (e.g., tool manufacture and mortuary activities); and 3) increases in population size and "sedentism" (cf. Brown and Vierra 1983) through time.

Ethnographic accounts of aboriginal life in the Upper Great Lakes (Henry 1969; Schoolcraft 1953; Tanner 1956) are replete with references to seasonal and inter-annual variations in the availability of foods and the use of alternative, less preferred foods. The analysis presented here indicates that prehistoric populations also varied their goals to include foods that were less preferred in terms of taste and prestige but could be efficiently exploited to satisfy subsistence needs.

Nuts were an important component of the subsistence regime of Late Archaic, Early Woodland, and Middle Woodland populations in the Saginaw Valley. Throughout this time, subsistence assemblages were dominated by fatty nuts that would have been preferred over acorns for their taste. Short-term, special activity sites such as Weber I indicate that fatty nuts were "targeted" as a preferred food; however, the majority of the base camps, which were occupied multiple times, reflect greater variation in the choice of nuts. This variation is interpreted as a response to inter-annual variations in the availability and productivity or mast of different species of nuts.

Inter-annual variations in resource productivity may also account for the differences in subsistence assemblages from the Schmidt site and the Early Woodland component of the Schultz site. Both sites are interpreted as being fall/winter base camps. The subsistence assemblage from the Schmidt site suggests that choices were based on efficiency and included relatively high percentages of fish. The subsistence assemblage from the Early Woodland component of the Schultz site, however, reflects a subsistence pattern based on taste and includes high percentages of large game and fatty nuts. One explanation for this difference in subsistence choices may be that large game were less available to the residents of the Schmidt site and that the diet was supplemented with resources that could be more efficiently exploited.

Efficiency appears to be a more important factor affecting subsistence decision making in sites such as Feheeley, 20BY79, and the Schultz site (during the Middle Woodland period), where activities other than food acquisition (e.g., tool manufacture and mortuary activities) were a priority. At these sites, the subsistence assemblages suggest that resource choices were based on efficiency alone or on multiple goals, which include efficiency. These subsistence assemblages also reflect a reduction in the contribution of male resources and an increase in collective resources. Scheduling conflicts associated with tool manufacture and mortuary activities may account for this pattern. Assuming that males were primarily responsible for these activities, they may have had less opportunity to hunt the large game that were preferred in terms of taste and afforded the hunter greater prestige. Aggregated resources, which are highly productive and can be efficiently exploited by a collective group, provided a useful supplement to the diet given the reduction in large game animals. This pattern has been noted in other mortuary camps (Styles and Purdue 1986).

At the sites in which non-subsistence activities were of some importance, choices of alternative resources were not exclusively directed by efficiency but included female/juvenile foods that are highly ranked in terms of taste (e.g., fatty nuts and sweet fruits). Interestingly, ethnographic sources (Erichsen-Brown 1979) frequently describe stews that include fruits, greens, nut oils, and syrup for flavoring. The archaeological and ethnographic data suggest that female/juvenile foods are commonly valued and that goals affecting subsistence choice may vary among different exploitive groups.

Exploitation of large game and carnivorous species indicates that prestige was also an important component of resource choice. Large game are often less efficient to exploit than small game but are valued as prestige resources because they provide large amounts of meat that can be shared (Jochim 1976:21, 1981:86-90; Winterhalder 1977, 1981a). Carnivorous species are generally not components of the diet but are

sought for their ideological value and the prestige associated with this aspect of cultural behavior.

Efficiency also appears to have become a more important goal in subsistence decision making through time and is correlated with an increase in population size, sedentism, and social stratification. This transformation has been noted by other researchers (Ford 1977, 1985; Keegan and Butler 1987; Smith 1983). Ford (1977, 1985) posits that, over the course of eastern North American prehistory, as population size increased and territorial ranges decreased in size, prehistoric populations began to turn to alternative resources. This transformation has been discussed largely in terms of the increasing importance of incipient cultigens. This study suggests that collectively derived resources may also have been important in sustaining larger populations within smaller "territories."

Thus, as noted by other researchers the use of squash and starchy seeds (e.g., chenopodium) in Middle Woodland contexts may reflect a shift toward use of alternative, "second line" resources (Asch *et al.* 1972; Ford 1977, 1985). The role of squash in the subsistence economy of the Woodland populations of the Saginaw Valley is difficult to interpret at this time. Squash may have been used for technological purposes, as well for as subsistence (King 1985; Ozker 1982). Until the evolutionary chronology of squash (from the hard shelled fruit with fatty seeds [*Cucurbita pepo* ssp. *ovifera*] to a fleshy fruit [*Cucurbita pepo* ssp. *pepo*]) is more fully documented, its importance to prehistoric subsistence economies cannot be fully appreciated. It would appear, however, that given the evolutionary trajectory of squash, the seeds and later flesh were components of the prehistoric diet of Woodland populations and that its use increased the carrying capacity of the region.

Although chenopodium is not a predicted choice in any of the simulations, it does appear to become an increasingiy important resource during the Middle Woodland period. Its utility has, therefore, been

undervalued in the resource estimates used in this study. This may be due, in part, to the fact that at sites such as Schultz, which were reoccupied over long periods of time, "anthropogenic open areas" were created around "domestilocalities." These areas increased the habitat in which starchy seeded annuals grew and, thus, their productivity (Smith 1992).

Use of chenopodium may be related to other factors as well. Chenopodium contains small amounts of fat and may, therefore, have been preferred over more productive resources, such as tubers. In addition, use of chenopodium would have added diversity to the diet. Finally, chenopodium may also have been preferred because it required less processing than wetland tubers and may have been more storable.

The increased importance of efficiency reflected in the faunal assemblages from the Middle Woodland components at the Schultz site may be related not only to scheduling conflicts associated with mortuary activities, but also to other economic constraints. During the Middle Woodland period, as population size increased and populations became more sedentary (i.e., regionalized and occupying base camps for longer periods of time), subsistence needs changed and efficiency became more important. Aggregated resources (such as fish and waterfowl) provide high yields per unit area but require a large, cooperative labor force to efficiently exploit and process them (cf. Cleland 1982). This requirement may have been satisfied by the populations occupying sites such as Schultz.

Thus, increased efficiency appears to be both a short- and long-term adaptive response to variations in resource productivity, scheduling conflicts associated with technological and cultural goals, and increasing economic demands associated with changing demographic needs. Efficiency is not, however, always a priority in subsistence decision making. Several of the assemblages considered in this analysis indicated that taste and prestige also influenced subsistence choices.

The division of labor often provided a means of satisfying these multiple subsistence goals.

Implications

Previous models of hunter-gatherer subsistence decision making have focused on a single subsistence goal (Hewitt 1983; Keene 1981; Winterhalder 1977; 1981a) or a set of subsistence goals (Cowan 1985; Jochim 1976), and anticipate normative responses to environmental conditions. These models fail to acknowledge that diverse behavioral responses characterize subsistence strategies and that these variations reflect social and cultural goals that are integral components of human adaptive strategies.

The approach taken in this analysis addresses alternative subsistence goals, focusing on variations in cultural goals and the social relationships of production. Thus, efficiency is conceived of not only as a means of increasing productive return but also as a means of satisfying ideological and social goals. Prestige, associated with hunting behavior, is viewed not only as a means of satisfying subsistence needs (through sharing of large amounts of meat) but can also be viewed as a goal associated with social status and ideological import. Taste is an innate desire that is inherently linked to subsistence choice. Its relative importance in subsistence decision making is, however, mediated by other social and cultural goals that affect the degree to which it influences subsistence choice. Finally, the division of labor and changes in the social relationships of production provide the means by which these multiple goals are satisfied.

The results of this study underscore the fact that subsistence decision making is a response not only to biological needs but also to social and cultural goals that are not exclusively linked to subsistence. If we are to more fully understand the dynamics of hunter-gatherer subsistence decision making, we must begin to consider social

and cultural goals other than those that are specifically related to subsistence choice (Bettinger 1991; Nassaney 1987). It is only through further examination of the cultural goals and the social implications of these goals that we can begin to understand the unique nature of human subsistence practices and cultural, versus biological, adaptation.

THESIS
V. 2

LIBRARY
Michigan State
University

PLACE IN RETURN BOX to remove this checkout from your record.
TO AVOID FINES return on or before date due.

DATE DUE	DATE DUE	DATE DUE
SEP 25 1998 JUN 05 1999		
FEB 10 2000		
MAY 12 2001		
NOV 14 2004		
MAR 26 2008		
FEB 24 2009		

MSU is An Affirmative Action/Equal Opportunity Institution
c:\circ\datedue.pm3-p.1

HUNTER-GATHERER SUBSISTENCE ADAPTATION IN THE SAGINAW VALLEY, MICHIGAN

VOLUME II

By

Kathryn Carey Egan

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Anthropology

1993

APPENDICES

APPENDIX A

Biological Value of Key Nutrients

The models employed in this study require satisfaction of energy and nutrient requirements. Critical nutrient requirements include: protein, vitamin A, vitamin C, thiamin, riboflavin, niacin, calcium, phosphorous, and iron. These nutrients are required for human metabolism and skeletal development.

The amino acids which make up proteins are required for the synthesis of body protein and other nitrogen-containing compounds, including creatine, peptide hormones, and some neurotransmitters. A constant dietary supply of proteins/amino acids is needed by the body because they are continually being degraded and resynthesized. Protein deficiency usually occurs in association with a deficiency in dietary energy and other nutrients because of insufficient food intake. In severe cases, children exhibit symptoms such as stunted growth, poor musculature, edema and biochemical changes. Edema and low muscle mass are common symptoms among adults (National Research Council [NRC] 1989:52-53).

Vitamin A assists in the formation of skin and mucous membranes, functions in visual processes and promotes the development of bones and teeth. Mild deficiencies of vitamin A can cause: night blindness, diarrhea, intestinal infections and impaired growth (NRC 1989:78-80).

Vitamin C forms substances, such as collagen, that hold body cells together, strengthening blood vessels and hastening the healing of wounds and bones thus increasing resistance to infection. Vitamin C also aids in the use of iron. A common symptom of severe vitamin C deficiency is scurvy (NRC 1989:115-117).

Thiamin (vitamin B_1) functions as part of the coenzyme promoting carbohydrate metabolism and production of ribose, a constituent of DNA and RNA. In addition, thiamin aids in normal functioning of the nervous system. Mild deficiencies of thiamin can lead to impaired growth, wasting of tissues, mental confusion, low morale and edema (NRC 1989:125-126).

Riboflavin functions as part of a coenzyme assisting cells in the use of oxygen for the release of energy from food. It also promotes good vision and healthy skin (NRC 1989:132-133).

Niacin serves many functions including acting as a coenzyme in fat synthesis, tissue respiration, and utilization of energy. Sufficient amounts of niacin promote digestion and the proper functioning of the nervous system. Mild deficiencies of niacin can cause gastrointestinal lesions, weakness and irritability while more severe deficiencies can result in pellagra (NRC 1989:137-138).

Ninety-nine percent of an adult's bone calcium occurs in the skeleton, while the other 1% is found in extracellular fluids, intracellular structures, and cell membranes. Calcium is essential to skeletal growth, development, and repair, as well as, playing an essential role in nerve conduction, muscle contraction, blood clotting and cell membrane permeability. Soft tissue calcium levels are maintained at the expense of bone in cases of calcium deficiency. In such cases, there is either an inadequate mineralization of bone in young individuals or calcium is withdrawn from bone resulting in a reduction in bone strength (NRC 1989:174).

Phosphorus is an essential component of bone mineral and also plays an important role in many chemical reactions within the body. "Energy for metabolic processes derives largely from phosphorous bonds" (NRC 1989:184).

Iron occurs in hemoglobin, myoglobin, and a number of enzymes and is also associated with a blood transport protein. It is, therefore, an essential nutrient for humans. Dietary iron deficiencies can affect

blood hemoglobin levels, impair ability to work, and lead to anemia (NRC 1989:195-196).

APPENDIX B

Nutrient Composition of Foods*

RESOURCE	Kcal	Protein	Vitamin A	Vitamin C	Thiamin	Ribo-flavin	Niacin	Calcium	Phosphorous	Iron
Chestnut	1940.0	29.0	1500.0	20.0	2.2	2.2	6.0	270.0	880.0	17.0
Hickory	6830.0	131.0	1500.0	10.0	3.4	2.6	8.0	50.0	3600.0	24.0
Beaked-hazelnut	7320.0	235.0	0.0	0.0	4.0	1.6	13.0	2000.0	3000.0	30.0
Butternut	6025.0	226.5	3000.0	20.0	2.2	1.1	7.0	100.0	5700.0	64.0
Black walnut	6233.7	152.1	3000.0	20.0	2.2	1.1	7.0	100.0	5700.0	60.0
Beechnut	5680.0	194.0	1500.0	0.0	3.0	3.0	15.0	1000.0	3000.0	30.0
White Oak group	3288.9	42.5	1500.0	0.0	1.7	0.4	20.0	2460.0	1250.0	13.0
Red/Black Oak	3988.2	44.1	1500.0	0.0	1.7	0.4	20.0	2546.2	669.2	13.0
Serviceberry	706.5	15.6	2110.3	234.3	12.0	7.9	5.2	700.0	400.0	11.4
Hackberry	1616.3	47.5	150.0	510.0	0.0	0.0	3.0	630.0	1240.0	28.0
Hawthorn	1061.6	7.2	8350.0	790.0	0.3	0.4	4.0	1090.0	343.3	18.5
Strawberry	370.0	16.2	870.7	427.4	0.3	0.6	9.2	305.8	230.8	9.4
Mulberry	556.3	11.7	166.7	150.0	0.3	0.9	9.0	570.0	385.0	20.5
Pin cherry	704.5	16.0	1066.2	98.4	0.5	0.6	4.0	400.2	393.3	11.7
Wild black cherry	704.5	16.0	1066.2	98.4	0.5	0.6	4.0	400.2	393.3	11.7
Gooseberry/currant	526.6	14.4	1850.0	926.6	0.4	0.5	1.6	377.7	295.5	9.4
Blackberry/raspberry	679.9	12.2	1550.0	211.7	0.3	0.6	5.7	323.3	255.0	9.0
Elderberry	720.0	26.0	6000.0	360.0	0.7	0.6	5.0	380.0	280.0	16.0
Blueberry	583.4	6.6	1000.0	140.0	0.3	0.6	0.5	125.0	115.0	10.0
Nannyberry	994.0	15.5	3030.0	223.0	0.5	0.5	4.3	336.7	473.3	10.0
Grape	928.8	20.5	745.6	46.0	0.4	0.4	6.3	546.3	388.7	9.9
Pigweed seeds	3270.0	167.0	76.1	36.9	9.6	5.6	43.3	5200.0	3400.0	66.0
Goosefoot seeds	3507.8	134.2	0.0	30.5	4.4	4.2	13.7	1220.1	3750.0	89.1
Knotweed seeds	3871.9	111.3	76.1	36.9	9.6	5.6	43.3	2750.0	3050.0	66.0
Wild leek	710.0	39.3	20332.5	193.3	1.3	0.9	22.3	853.0	1046.6	21.3
Groundnut	1090.0	69.0	17708.3	137.4	1.3	0.7	13.7	851.3	660.3	14.5
Jack-in-the-pulpit	928.4	42.3	17708.3	137.4	1.3	0.7	13.7	851.3	660.3	14.5

* Nutrient values per kg of food

Appendix B: (cont'd)

RESOURCE	Kcal	Protein	Vitamin A	Vitamin C	Thiamin	Ribo-flavin	Niacin	Calcium	Phosphorous	Iron
Spring beauty	928.4	42.3	17708.3	137.4	1.3	0.7	13.7	851.3	660.3	17.4
J. artichoke	783.6	12.9	289.0	50.0	2.0	0.6	7.5	49.5	675.3	17.4
Arrowhead, wapato	1070.0	50.0	0.0	50.0	1.4	0.4	1.4	130.0	1650.0	17.4
Solomon's Seal Tuber	1130.0	48.0	0.0	200.0	0.5	0.4	2.0	50.0	240.0	5.0
Bulrush	1162.1	13.2	0.0	345.0	1.1	0.6	5.8	100.0	1800.0	16.6
Cattail	1230.4	20.4	0.0	345.0	1.1	0.6	5.8	291.4	1428.6	16.6
Aster	450.0	27.0	140000.0	350.0	1.9	2.6	8.4	1870.0	660.0	31.0
Marsh-marigold	333.6	30.0	64144.0	682.1	0.9	2.4	8.4	1618.6	631.9	55.3
Goosefoot greens	453.3	45.6	73823.3	800.0	1.1	3.2	7.5	2800.0	1980.0	21.0
Wood sorrel	333.6	30.0	64144.0	682.1	0.9	2.4	8.4	1618.6	631.9	55.3
Sugar maple	72.0	0.0	2.9	0.0	0.0	0.0	0.0	29.7	2.3	0.3
Bear	1342.9	230.0	5510.0	13.0	8.5	4.7	68.2	0.0	2130.0	30.0
Beaver	2890.0	227.7	1760.0	18.0	0.7	3.4	19.0	150.0	2620.0	59.0
Deer	1250.0	212.0	8260.0	0.0	3.0	3.8	68.5	145.0	2160.0	50.0
Elk	1250.0	212.0	8260.0	0.0	3.0	3.8	68.5	145.0	2160.0	50.0
Fish	1030.0	186.0	0.0	20.0	1.1	1.0	19.5	475.0	1945.0	5.0
Muskrat	1340.0	272.2	2820.0	15.0	1.6	2.1	62.0	250.0	2200.0	76.0
Pigeon	2790.0	186.0	23.2	92.8	4.7	18.6	0.0	162.7	4116.3	23.2
Rabbit	1459.9	218.3	0.0	0.0	0.6	1.1	76.0	129.6	2480.5	26.4
Raccoon	2550.0	392.0	8260.0	15.0	5.9	5.2	84.3	90.0	2640.0	37.0
Squirrel	1083.3	186.0	2200.0	0.0	0.9	2.9	51.0	25.0	1840.0	32.0
Woodchuck	1083.3	186.0	2200.0	0.0	0.9	2.9	51.0	25.0	1840.0	32.0
Turtles	690.0	158.0	16520.0	0.0	2.2	4.7	70.0	1070.0	2200.0	20.0
Waterfowl	2946.7	177.0	0.0	0.0	0.1	2.2	61.5	123.3	1880.0	21.3
Mussel	723.3	58.7	333.5	31.7	0.1	2.3	13.7	2546.7	4780.0	119.3

APPENDIX C

Computer Program

by Eden Diver

Program Description

The simulation program is composed of modular subroutines and global variables used to hold data on resource and nutrient information. The subroutines modify and use the global variables throughout the program. When data is altered by the program, it is changed throughout the simulation. This approach allows greater diversity in manipulating the information.

Procedure "MAIN" reads a fraction from the keyboard, this allows a user to vary the extra percentage of food gathered by the female gender group for storage in the winter months. The function then calls the procedure READ_DATA and reads resource information from the data file named "test3.dat" into the computer memory. Any data file can be used for this simulation. The only requirement being that a user must first rename the input data file to "test3.dat". While the data is being entered into the computer memory, the number of resources is calculated. This number is used throughout the program for looping through the resources.

While the data is being read from the file, the overall desirability of each resource is calculated and stored in each data structure. After all the data is entered, procedure "QS" is called and all the resources are sorted in order of most desirable to least desirable. The procedure "QS" is a quick-sort algorithm that is completely transparent to the user. This type of sorting function can be found in most computer algorithm books.

After sorting the resources, the "MAIN" function calls procedure "PROCESS". This is the function that takes over and calculated all the desired iterations for the model.

"PROCESS" first initializes a loop of twelve months beginning with June. A sub-loop is then started, and the program parses through the sorted list of resources starting at the top of the list. The first, and most desirable, male resource is chosen by the simulation, and the nutrient information for that resource is added to the overall nutrient 'pool'. This male resource is then flagged as used for the month of June. The resource data list is then rewound to the beginning and the above process for resource choice is repeated for the female gender group and the collective group. During the processing, the program checks the month number to see if the female group should be storing food for winter months. If this is so, the simulation makes the female group collect an extra percentage of food. This percentage is then saved in a 'storage pool' where it is used by the family unit during months when no female resources are available. The resource loop continues until the nutrient requirements are met for each month. At the end of each month, resource 'used' flags are reset, allowing the resources to be used again in future months.

At the end of each loop through the resources, output is directed to the computer screen, displaying what resources were chosen and what the running total of the resource 'pool' is. In addition, the program outputs a breakdown of the resource 'storage pool' and what is contains after one male, one female, and one collective resource have been chosen.

The program continues to loop through the months, each time sub-looping through the resource list until nutrients for the month of May have been satisfied. This terminates one year of modelling for the program.

Data Structure Listing

```
#include <conio.h>
#include <stdio.h>
#include <ctype.h>
#define MAXNUM 100

struct {
   char monthname[12];
}  monname[13];

struct {
   float calories[4];
   float protein[4];
   float vit_a[4];
   float vit_c[4];
   float thiamine[4];
   float ribo[4];
   float niacin[4];
   float calcium[4];
   float phos[4];
   float iron[4];
}  totnoots[13];

struct nutrient_list {
   float calories;
   float protein;
   float vit_a;
   float vit_c;
   float thiamine;
   float ribo;
   float niacin;
   float calcium;
   float phos;
   float iron;
} noots;

struct data_list {
   char name[80];
   int  used_flag;            /* int            = interger number       */
   float weight;        /* float    = decimal number              */
   char gender;         /* char     = character of character string
      */
   float prod;                /* prod     = weight(kg)/Area
      */
   float value;         /* float    = decimal number                    */
   int month[13];
   struct nutrient_list noots;            /*   sub-structure   of   above
nutrients  */
}  info[MAXNUM];

float minkcal     = 311340;   /* minimum monthly nutrient requirement for
  */
float minpro      = 4110;     /* a family of five persons               */
float minvita     = 85710;
float minvitc     = 3990;
float minthia     = 126;
float minribo     = 192;
float minniac     = 2097;
float mincalc     = 84300;
float minphos     = 134550;
float miniron     = 1788;

float frac;       /* fraction of nutrient to go into storage pool */
```

Program Listing

```
# include <anp8.h>

void gs (int, int);
void init_monnames ();
void init_monthlyNnoots();
void init_used_flags();
void process();
void insert nutrients();
void report();
void print_noots();
int check_nutrients();
Int read_data(int);

main()
{
int res_num;
printf("Please Enter fraction.\n");
scanf("%f",&frac);
getchar();

init_monnames();
res_num = read_data(1);
qs (1,res_num);
process (res_num);

getchar();
}
/* Quick-sort function to order resources from highest to lowest values.*/

void qs(int left, int right)
{
register int i, j;
float x;
struct data_list y;
i = left; j = right;
x=info[(int)(left+right)/2)].value;
do
{
      while(info[i].value > && i < right)
      i++;
      while(x > info[[j].value && j > left)
      j--;
      if(i<=j)
      {
      y = info[i];
      info[i] = info[j];
      info[j] = y;
      i++;
      j--;
            }
      } while (i<=j);
      if(left<j)
            qs(left,j);
      if(i<right)
            qs(i,right);
}
int read_data(int res_num)
{
```

```
      FILE *fp, *fopen();
      int exitflag, count, count2;  /* counting variables */
      char ch;
      float f:
      fp = fopen("test3.dat","r");
      printf("\n");
      count = 0;
      exitflag = 0;
      while (!feof(fp))
      {
         while((ch=getc(fp)) !='\n')   /* read in resource name */
         {
            if (ch ==EOF) { exitflag = 1; break; }
            info[res_num].name[count++] = ch;
         }
         if (exitflag) break;
         count = 0;
         info[res_num].used_flag = 0;
         info[res_num].gender = fgetc(fp);
         for (count2 = 8;count2 <= 12;count2++)     /* read in month
information */
         {
            fscanf(fp,"%f\n", &f);
            info[res_num].month[count2] = (int)f;
         }
         for (count2 = 1;count2 <= 7;count2++)  /* read in month
information */
         {
            fscantf(fp,"%f\n", &f);
            info[res_num].month[count2] = (int)f;
         }
         fscant(fp, "%f\n",&f);           /* prod(kg/area */
         info[res_num].prod = f;
         info[res_num].value = 0;   /* initialize the value to zero */
         fscanf(ft,"%f\n",&f);            /* weight kg */
         info[res_num].weight = f;
         if (info[res_num].gender == 'M'
         {
            info[res_num].value   =   info[res_num].value   +
info[res_num].weight;
         }
         fscant(fp,"%f\n",&f);            /* productivity */
         info[res_num].value = info[res_num].value + f;
         fscantf(fp,"f\n",&f);            /* fat */
         info[res_num].value = info[res_num].value + f;
         fscantf(fp,"f\n",&f);            /* sweet */
         info[res_num].value = info[res_num].value + f;
         fscantf(fp,"f\n",&f);
         info[res_num].noots.calories = f;
         fscantf(fp, "%f\n", & f;
         info[res_num].noots.protein = f;
         fscantf(fp, "%f\n", & f;
         info[res_num].noots.vit_a = f;
         fscantf(fp, "%f\n", & f;
         info[res_num].noots.vit_c = f;
         fscantf(fp, "%f\n", & f;
         info[res_num].noots.thiamine = f;
         fscantf(fp, "%f\n", & f;
         info[res_num].noots.ribo = f;
         fscantf(fp, "%f\n", & f;
         info[res_num].noots.niacin = f;
         fscantf(fp, "%f\n", & f;
         info[res_num].noots.calcium = f;
         fscantf(fp, "%f\n", & f;
```

```
         info[res_num].noots.phos = f;
         fscantf(fp, "%f\n", & f;
         info[res_num].noots.iron = f;
         res_num++;
      }
      fclose (fp)'
      return --res_num;
}
void process (num_res)
      int num_res;
{
      int mon;    /* counter for the months           */
      int res;    /* counter for the resources        */
      int done;   /* flag to signal nutrient requirements met     */
      int stop_flag;    /* resource found move on to next gender  */

      for (mon = 1;mon < 13;mon++)     /*Loop through months */
      {
         init_monthly_noots(mon);
      }
      for (mon = 1 mon < 13;mon++)     /*Loop through months */
      {
         init_used-flags(num_res);
         done = 0;
         printf("For the month of %s\n",monname{mon}.monthname);
         do
         {
            stop_flag = 0;
            for (res = 1;res <+ num_res;res++) /*Loop through resources */
            {
            if (stop flag) break;
      if ((info[res].month[mon] == 1) && (info[res].used_flag == 0) &&
      (info[res].gender == 'F'))
      {
      printf ("Gender: %c Kgs: %-10.2f\tResource: %s\n",info{res}.gender,
            info[res].prod,info[res].name);
      insert_nutrients(mon,2,res);
            info[res}.used_flag = 1;
            stop_flag = 1;
            }
      }
      stop_flag = 0;
      for (res = 1;res <= num_res;res++)  /* Loop through resources */
      {
      if (stop_flag) break;
         if((info[res].month[mon] ==1) && (info[res].used_flag == 0) &&
         (info[res].gender == 'C'))
         {
         printf("Gender:    %c        Kgs:    %-10.2f/tResource:    %s\n",
info[res].gender,
            info[res].prod,info[res].name);
            insert_nutrients(mon,1,res);
            info[res].used_flag = 1;
            stop_flag = 1;
         }
      }
      stop flag = 0;
      for (res = 1;res <= num_res;res++)  /* Loop through resources */
      {
      if (stop_flag) break;
          if((info[ress].month[mon] == 1) && (info[res].used_flag == 0) &&
             (info[res].gender == 'M'))
             {
```

```
            printf("Gender:    %C    Kgs:    %-10.2f\tResource:
%s\n",info[res].gender,
             info[res].prod,info[res].name;
            insert_nutrients(mon,0,res);
             info[res].used_flag = 1;
             stop_flag = 1;
            }
          }
          done = check_nutrients(mon);
          printf("Requirements met: %i\n",done);
          report(mon);
          printf("Running total of stored nutrients.\n"):
          report(8);
        }
        while (done < 10);
    }                    /* end monthly loop */
}                              /* end of process function */
void init_monnames()
{
   strcpy(monname[1].monthname, "June.\0");
   strcpy(monname[2].monthname, "July.\0");
   strcpy(monname[3].monthname, "August.\0");
   strcpy(monname[4].monthname, "September.\0");
   strcpy(monname[5].monthname, "October.\0");
   strcpy(monname[6].monthname, "November.\0");
   strcpy(monname[7].monthname, "December.\0");
   strcpy(monname[8].monthname, "January.\0");
   strcpy(monname[9].monthname, "February.\0");
   strcpy(monname[10].monthname, "March.\0");
   strcpy(monname[11].monthname, "April.\0");
   strcpy(monname[12].monthname, "May.\0");
}
void init_monthly_noots(mon)
   int mon;
{
   int count;
   for (count = 0;count <= 2;count++)
   {
      totnoots[mon].calories[count] = 0;
      totnoots[mon].protein[count] = 0;
      totnoots[mon].vit_a[count] = 0;
      totnoots[mon].vit_c[count] = 0;
      totnoots[mon].thiamine[count] = 0;
      totnoots[mon].ribo[count] = 0;
      totnoots[mon].niacin[count] = 0;
      totnoots[mon].calcium[count] = 0;
      totnoots[mon].phos[count] = 0;
      totnoots[mon].iron[count] = 0;
   }
}
void init_used_flags(num_res)
   int num_res;
{
   int i;
   for (i = 1;i <= num_res;i++)
   {
      info[i].used_flag = 0;
   }
}
void report (mon)
   int mon;
{
   printf("       Males              Collective        Females
```

```
Total\n");
   printf("cals         %-10.2f     %-10.2f     %-10.2f     %-10.2f\n",
      totnoots[mon].calories[0], totnoots[mon].calories[1],
      totnoots[mon].calories[2], totnoots[mon].calories[3]);
   printf("prot   %-10.2f     %-10.2f     %-10.2f     %-10.2f\n",
      totnoots[mon].protein[0], totnoots[mon].protein[1],
      totnoots[mon].protein[2], totnoots[mon].protein[3],
   printf("vita   %-10.2f     %-10.2f     %-10.2f     %-10.2f\n",
      totnoots[mon].vit_a[0], totnoots[mon].vit_a[1],
      totnoots[mon].vit_a[2], totnoots[mon].vit_a[3],
   printf("vitc   %-10.2f     %-10.2f     %-10.2f     %-10.2f\n",
      totnoots[mon].vit_c[0], totnoots[mon].vit_c[1],
      totnoots[mon].vit_c[2], totnoots[mon].vit_c[3],
   printf("thia   %-10.2f     %-10.2f     %-10.2f     %-10.2f\n",
      totnoots[mon].thiamine[0], totnoots[mon].thiamine[1],
      totnoots[mon].thiamine[2], totnoots[mon].thiamine[3],
   printf("ribo   %-10.2f     %-10.2f     %-10.2f     %-10.2f\n",
      totnoots[mon].ribo[0], totnoots[mon].ribo[1],
      totnoots[mon].ribo[2], totnoots[mon].ribo[3],
   printf("niac   %-10.2f     %-10.2f     %-10.2f     %-10.2f\n",
      totnoots[mon].niacin[0], totnoots[mon].niacin[1],
      totnoots[mon].niacin[2], totnoots[mon].niacin[3],
   printf("calc   %-10.2f     %-10.2f     %-10.2f     %-10.2f\n",
      totnoots[mon].calcium[0], totnoots[mon].calcium[1],
      totnoots[mon].calcium[2], totnoots[mon].calcium[3],
   printf("phos   %-10.2f     %-10.2f     %-10.2f     %-10.2f\n",
      totnoots[mon].phos[0], totnoots[mon].phos[1],
      totnoots[mon].phos[2], totnoots[mon].phos[3],
   printf("iron   %-10.2f     %-10.2f     %-10.2f     %-10.2f\n",
      totnoots[mon].iron[0], totnoots[mon].iron[1],
      totnoots[mon].iron[2], totnoots[mon].iron[3],
   printf("\n");
}
void insert_nutrients(mon,sex,res)
   int mon;
   int sex;
   int res;
{
   int count;
   totnoots[mon].calories[sex] = totnoots[mon].calories[sex] +
      info[res].noots.calories*info[res].prod;
   totnoots[mon].protein[sex] = totnoots[mon].protein[sex] +
      info[res].noots.protein *info[res].prod;
   totnoots[mon].vit_a[sex] = totnoots[mon].vit_a[sex] +
      info[res].noots.vit_a *info[res].prod;
   totnoots[mon].vit_c[sex] = totnoots[mon].vit_c[sex] +
      info[res].noots.vit_c *info[res].prod;
   totnoots[mon].thiamine[sex] = totnoots[mon].thiamine[sex] +
      info[res].noots.thiamine*info[res].prod;
   totnoots[mon].ribo[sex] = totnoots[mon].ribo[sex] +
      info[res].noots.ribo*info[res].prod;
   totnoots[mon].niacin[sex] = totnoots[mon].niacin[sex] +
      info[res].noots.niacin*info[res].prod;
   totnoots[mon].calcium[sex] = totnoots[mon].calcium[sex] +
      info[res].noots.calcium*info[res].prod;
   totnoots[mon].phos[sex] = totnoots[mon].phos[sex] +
      info[res].noots.phos*info[res].prod;
   totnoots[mon].iron[sex] = totnoots[mon].iron[sex] +
      info[res].noots.iron*info[res].prod;

if ((sex == 2) && (mon <= 5))
{
   for (count = 6;count <+ 10; count++)
   {
```

```
        totnoots[count].calories[sex] = totnoots[count].calories[sex] +
        (info[res].noots.calories*info[res].prod * .2 * frac);
        totnoots[count].protein[sex] = totnoots[count].protein[sex] +
        (info[res].noots.protein*info[res].prod * .2 * frac);
        totnoots[count].vit_a[sex] = totnoots[count].vit_a[sex] +
        (info[res].noots.vit_a*info[res].prod * .2 * frac);
        totnoots[count].vit_c[sex] = totnoots[count].vit_c[sex] +
        (info[res].noots.vit_c*info[res].prod * .2 * frac);
        totnoots[count].thiamine[sex] = totnoots[count].thiamine[sex] +
        (info[res].noots.thiamine*info[res].prod * .2 * frac);
        totnoots[count].ribo[sex] = totnoots[count].ribo[sex] +
        (info[res].noots.ribo*info[res].prod * .2 * frac);
        totnoots[count].niacin[sex] = totnoots[count].niacin[sex] +
        (info[res].noots.niacin*info[res].prod * .2 * frac);
        totnoots[count].calcium[sex] = totnoots[count].calcium[sex] +
        (info[res].noots.calcium*info[res].prod * .2 * frac);
        totnoots[count].phos[sex] = totnoots[count].phos[sex] +
        (info[res].noots.phos*info[res].prod * .2 * frac);
        totnoots[count].iron[sex] = totnoots[count].iron[sex] +
        (info[res].noots.iron*info[res].prod * .2 * frac);
    }
}
    totnoots[mon].calories[3] = totnoots[mon].calories[0] +
        totnoots[mon].calories[1] + totnoots [mon].calories[2];
    totnoots[mon].protein[3] = totnoots[mon].protein[0] +
        totnoots[mon].protein[1] + totnoots [mon].protein[2];
    totnoots[mon].vit_a[3] = totnoots[mon].vit_a[0] +
        totnoots[mon].vit_a[1] + totnoots [mon].vit_a[2];
    totnoots[mon].vit_c[3] = totnoots[mon].vit_c[0] +
        totnoots[mon].vit_c[1] + totnoots [mon].vit_c[2];
    totnoots[mon].thiamine[3] = totnoots[mon].thiamine[0] +
        totnoots[mon].thiamine[1] + totnoots [mon].thiamine[2];
    totnoots[mon].ribo[3] = totnoots[mon].ribo[0] +
        totnoots[mon].ribo[1] + totnoots [mon].ribo[2];
    totnoots[mon].niacin[3] = totnoots[mon].niacin[0] +
        totnoots[mon].niacin[1] + totnoots [mon].niacin[2];
    totnoots[mon].calcium[3] = totnoots[mon].calcium[0] +
        totnoots[mon].calcium[1] + totnoots [mon].calcium[2];
    totnoots[mon].phos[3] = totnoots[mon].phos[0] +
        totnoots[mon].phos[1] + totnoots [mon].phos[2];
    totnoots[mon].iron[3] = totnoots[mon].iron[0] +
        totnoots[mon].iron[1] + totnoots [mon].iron[2];
}
int check_nutrients(mon)
    int mon;
{
    int check = 0;
    if (totnoots[mon].calories[3] > = minkcal)  {check++:}
    if (totnoots[mon].protein[3] > = minpro)  { check++: }
    if (totnoots[mon].vit_a[3] > = minvita)  { check++: }
    if (totnoots[mon].vit_c[3] > = minvitc)  { check++: }
    if (totnoots[mon].thiamine[3] > = minthia)  { check++: }
    if (totnoots[mon].ribo[3] > = minribo)  { check++: }
    if (totnoots[mon].niacin[3] > = minniac)  { check++: }
    if (totnoots[mon].calcium[3] > = mincalc)  { check++: }
    if (totnoots[mon].phos[3] > = minphos)  { check++: }
    if (totnoots[mon].iron[3] > = miniron)  { check++: }
    return check;
}
```

APPENDIX D

Reconstruction of the Presettlement Vegetation

This botanical reconstruction is based on four independent sets of data: the General Land Office Survey (GLOS); archaeobotanical data; Curtis' (1971) ordination of Wisconsin forest communities; and pollen sequences from locations in south-central Michigan. Together these data provide an large inventory of potential food resources. Densities of individual taxa are derived from comparative data derived from modern botanical communities (Curtis 1971).

Forest Reconstruction

The GLOS were conducted as part of the Northwest Ordinance between 1821 and 1834. These records include information about "witness trees" that were blazed to permit relocation of survey stakes, notations about boundaries of plant communities, and general descriptions of forest types. These records provide the most detailed description of the presettlement vegetation in this region.

GLOS records are available for 75% of the townships in the study area. These data were grouped and analyzed according to soil type. Soil type was used to define the boundaries of the forest communities because plant communities are often associated with specific soil types (Albert *et al.* 1986; Bernabo and Webb 1977; Hushen *et al.* 1966; cf. Veatch 1959).

The GLO surveyors were instructed to mark two "witness trees" closest to the corner post in a different quadrant at every section and quarter section. Biases in selection of tree taxa to use as "witness trees" and differences in tree identification appear at times in the GLOS (Bourdo 1956; King 1978; King and Graham 1981; Wood 1976). The

GLOS data used in this study were evaluated for biases in the location and selection "witness trees" using quantitative techniques recommended by Bourdo (1956).

In testing for biases in the location of the trees recorded, it is assumed that the tree nearest a corner post may occur with equal frequency in any of the four quadrants. Thus, locational information can be used to provide a simple check on the presence and magnitude of bias (Bourdo 1956:761). Using a chi-square test, the GLOS data from each of the seven soil zones were evaluated for locational bias. The results of the test indicated that there is a 99% probability (χ^2 = 0.89/df = 6) that the distribution of corner post observations was random.

In testing for bias in the selection of "witness trees" it is assumed that:

> In a timber type which contains two or more dominants, the location of each with respect to the corner post depends on the density of trees of that species... However, mean distances from the post for each species... should be the same" [Bourdo 1956:762-3].

In this study, chi-square tests were used to test for biases in selection of "witness trees" in four of the seven soil types (soils 1, 2, 3, and 7). (The other three soil types did not contain a sufficient number of cases to perform a chi-square test.) The results of the chi-square tests indicated that there is a 99% probability that the distances recorded by taxa, at corner and quarter posts, were not biased in two of the four soil categories (soil 1 χ^2 = 3.7, df = 7; soil 3 χ^2 = 3.7, df = 5). There is, however, an apparent bias in the other two soils (soil 2 χ^2 = 101.4, df = 11; soil 7 χ^2 = 29.62, df = 8). In the latter contexts, "ash" (as opposed to "white ash" or "black ash") were recorded at significantly greater distances from the corner and quarter posts than any other taxa.

Red ash (*Fraxinus pennsylvanica*) is fairly common in Michigan, occurring in low densities in wet or seasonally wet environments (Barnes

and Wagner 1981). If the taxon identified as "ash" in the GLOS is red ash, then it may account for the higher distances noted in the surveyors' records. Deleting these cases from the chi-square analysis, there is a 99% probability that "witness trees" were selected without bias in soil 7 ($\chi^2 = 9.62$, df = 7). There appears, however, to be additional bias in the observation of pine and white oak, inflating the distance values in soil 2. Despite this bias, the majority of the GLOS data appear to be accurate. Bias tests conducted on GLOS data in adjacent counties indicate that there is no significant bias (Kapp 1977). Therefore, the GLOS data were used in the forest community reconstruction and the biases noted in soil 2 were taken into consideration when defining the forest community associated with this soil.

Trees were referred to by their common names in the GLOS records. Most of the names are common generic tree names used today. For genera that have multiple species, determining which species was recorded is more difficult if there is no specific modifier. The following list gives all of the taxa noted in the GLOS records for Bay and Saginaw counties and their Linnean taxonomic equivalents:

Ash	*Fraxinus americana*, *F. nigra*, and *F. pennsylvanica*
Black Ash	*Fraxinus nigra*
White Ash	*Fraxinus americana*
Aspen	*Populus tremuloides* and *P. grandidentata*
Beech	*Fagus grandifolia*
Birch	*Betula lutea*
Elm	*Ulmus americana* and *U. rubra*
Hackberry	*Celtis occidentalis*
Hickory	*Carya glabra*, *C. ovata*, and *C. cordiformis*
Ironwood	*Ostrya virginiana*
Lynn (Basswood)	*Tilia americana*
Maple	*Acer rubrum* and possibly *A. saccharinum*
Sugar Maple	*Acer saccharum*
Black Oak	*Quercus velutina*
Red Oak	*Quercus rubra*
White Oak	*Quercus alba*
Cedar	*Thuja occidentalis*
Fir	*Abies balsamea*
Hemlock	*Tsuga canadensis*
Pine	*Pinus banksiana* or *P. strobus*
White Pine	*Pinus strobus*
Tamarack	*Larix laricina*

Within each of the major soil types, the percentage occurrence of each of these taxa, occurring at corner and quarter posts, were calculated (Table D.1). These percentages reflect the general composition of the presettlement forest.

Archaeobotanical data is biased by cultural, preservational, and analytical factors but is useful for defining the general composition of prehistoric forest communities, when used with comparative modern ecological data (e.g., Curtis 1971; GLOS) (Smart and Hoffman 1988). Wood charcoal from archaeological sites was compared with the GLOS data to determine whether the GLOS forest inventories were similar to the prehistoric communities (Tables D.2-D.6). Pollen sequences from nearby locations (since none are available from the Saginaw Valley) were used to clarify and elaborate on deviations noted between the GLOS and archaeobotanical data.

Unfortunately, the GLOS and archaeobotanical data do not provide a complete enough inventory of woody and herbaceous taxa for reconstruction of the resource base available to the prehistoric occupants of the region. Nor can detailed estimates of species densities be generated from these data alone. Since the phytogeography of Wisconsin is similar to that of Michigan (Yarnell 1964), Curtis' (1971) quantitative descriptions of Wisconsin forest communities provide a useful comparative data set to establish a more detailed delineation of the prehistoric forest composition in the Saginaw Valley.

Soil 1: Northern and Southern Mesic, Hardwood Community

Ninety trees were recorded at corner and quarter posts in soil 1. A mesic forest type is associated with these somewhat poorly drained to poorly drained lake plain and till plain soils. The dominant species is beech/*Fagus grandifolia* (26.7%). Other taxa occurring in moderate densities are maple/*Acer* spp. (12.22%), white oak/*Quercus alba* (10%), ash/*Fraxinus* spp. (8.89%), tamarack/*Larix laricina* (8.89%), elm/*Ulmus*

spp. (7.78%), hemlock/*Tsuga canadensis* (6.67%), and other hardwood and coniferous taxa occurring in lower percentages.

The 20BY79 and Fletcher (20BY128) sites are both located in soil 1. Inventories of wood charcoal from the Late Archaic component of 20BY79 and the Middle Woodland component of the Marquette Viaduct locale at the Fletcher site were compared with the GLOS data (Table D.2). They are fairly similar to the GLOS inventory, reflecting a northern mesic community composition. A limited range of taxa (40% of those described in the GLOS records) is represented in the archaeobotanical collection from 20BY79, while a wider range of taxa (53%) was identified in the Marquette Viaduct assemblage. Sugar maple and some coniferous (i.e., hemlock and tamarack) and wet-loving taxa (i.e., birch and lynn [basswood]) are not represented in either of these assemblages. Specific species such as sugar maple are often difficult to identify in archaeobotanical assemblages; sugar maple may be absent for this reason. Coniferous and wet-loving taxa may be lacking because of selection and limited availability. These taxa are poorer quality fuel woods, and coniferous taxa generally shed fewer limbs and branches than deciduous taxa.

Two species (chestnut/*Castanea dentata* and ironwood/*Ostrya virginiana*), not listed in the GLOS records for soil 1, were identified in the 20BY79 and Marquette Viaduct assemblages. Both prefer mesic sites. Ironwood occurs throughout Michigan, while chestnut is adapted to more southerly locales. Historically chestnut did occur as far north as Bay County (Barnes and Wagner 1981:258; Voss 1985:85) and was a primary component of oak forests throughout the eastern United States (Braun 1950). It was, however, essentially decimated by a fungus introduced about A.D. 1900 and is, therefore, under represented in modern botanical inventories.

The Late Archaic Butterfield site (20BY29) is located within soil 1 and less than 0.5 km from soil 7. The inventory of wood charcoal from this site (Table D.3) suggests a northern mesic to wet mesic forest

composition, and includes 58% of the taxa identified in the GLOS records for these two soil communities. Some coniferous (i.e., hemlock, pine and tamarack) and wet-loving taxa (i.e., black ash) are absent in this assemblage. Other taxa that were not identified archaeologically include individual species (i.e., black ash, white ash, sugar maple, and black oak). The difficulties of identifying archaeobotanical specimens to species level may account for their absence.

Species that are represented in the Butterfield assemblage but were not described in the GLOS records include ironwood, spruce/*Picea* sp., sycamore/*Platanus occidentalis*, and walnut/*Juglans* sp. Ironwood and walnut are common components of mesic communities in the Saginaw Valley and often occur in northern mesic communities (Curtis 1971:534). Sycamore and spruce, however, are rare in modern forest communities in this area. Sycamore occurs in river bottoms, on floodplains, and along lake borders. While it is not present in modern communities in Bay County, it does occur in adjacent counties (Barnes and Wagner 1981:288; Voss 1985:343). The only native species of spruce present in this part of the state historically is black spruce/*P. mariana*, which occurs in bogs in association with larch, cedar, and fir. Black spruce is not present in modern forest communities in the Saginaw Valley but does occur in adjacent counties (Voss 1972:64). While slightly anomalous, both sycamore and spruce may have been components in soils 1 and 7 of the prehistoric forest communities around the Butterfield site.

The forest type associated with soil 1 is best defined as a mixed southern and northern mesic forest. It is similar to the Northern Hardwood community of the northern Lower Peninsula of Michigan (Barnes and Wagner 1981:43; Kapp 1977) but includes several species that have a more southerly adaptation (e.g., sycamore, chestnut, and hackberry). This mixed composition is not unexpected given the latitude of the valley and the relatively mild climate.

The majority (88%) of the taxa identified in the GLOS records and archaeological assemblages from soil 1 and 7 occur in northern and

southern mesic communities in Wisconsin (Curtis 1971). Taxa not represented in these forest communities include chestnut that occurred in association with white oak but did not range as far west as Wisconsin (Gleason and Cronquist 1963:248) and tamarack and spruce which are found in northern wet-mesic communities.

Soil 2: Northern and Southern Wet-Mesic, Hemlock and Hardwood Community

A total of 204 trees was recorded at corner and quarter posts in soil 2. Hemlock occurs at the highest percentage (21.08%) in these poorly drained to somewhat poorly drained water worked till plains. Maple (12.25), beech (10.78%), elm (10.78%), black ash/*Fraxinus nigra* (9.31%), ash (7.84%), pine/*Pinus* spp. (5.39%), and other hardwood and coniferous taxa occur in lower percentages.

The Late Archaic Feeheley site (20SA129) is the only archaeological site considered in this study that occurs in this soil type. Sixty-three percent of the taxa described in the GLOS records were identified in the archaeobotanical assemblage from the site (Table D.4). As noted in soil 1, some of the coniferous taxa (cedar, hemlock, white pine, and tamarack) and species (aspen, sugar maple, black oak) described in the GLOS are absent in the archaeological assemblage. Again this may be due to cultural selection, shed characteristics of these taxa, and difficulties associated with the identification of species.

Cherry and sycamore were also identified in the archaeobotanical assemblage from Feeheley, although they were not reported in the GLOS records in soil 2. While sycamore is common to more southerly habitats, cherry is ubiquitous throughout the state. Neither is an unexpected component of the forest community represented.

On the basis of the GLOS and archaeobotanical data, the prehistoric forest appears to have been a mixed northern and southern wet-mesic community. White and black oak are the only two taxa that do not occur in either northern or southern wet-mesic communities. Their

presence must be taken into consideration when reconstructing the resource base available to the prehistoric inhabitants of the area.

This community is best characterized as a mixed, wet-mesic, hemlock-hardwood forest. Such communities are found in low-lying areas with a relatively high water table and at higher elevations with poor drainage (see Barnes and Wagner 1981:96). Despite the bias noted in the selection of ash, pine, and white ash, this community is similar in overall composition to the white pine-hemlock forest noted in Kapp's (1977) reconstruction of the Pine River watershed and Curtis' (1971) northern wet-mesic community type. With the exception of oak, which comprises a small percentage of the GLOS community, and sycamore, all of the taxa in the GLOS and archaeobotanical inventory are represented in northern wet-mesic communities in Wisconsin.

Soil 3: Northern and Southern Mesic, Beech-Hardwood-Pine Community

Soil 3 is a poorly drained to somewhat poorly drained, mesic, floodplain soil type. Ninety trees were recorded at corner and quarter posts in this soil. Identified taxa include beech (26.67%), ash (16.67%), pine (13.33%), maple (10.00%), elm (8.89%), red oak (5.56%), and other hardwood taxa.

The Schmidt site (20SA192) and Schultz site (20SA2) occur in soil 3. Eighty-three percent of the taxa identified in the archaeobotanical assemblages from these sites were noted in the GLOS records for this soil type (Table D.5). As noted in soils 1 and 2, there is bias against coniferous taxa and some species (i.e., sugar maple and black oak) that may be accounted for by cultural selection, shed characteristics of these taxa, and identification problems.

Several taxa, including alder, black ash, cherry, chestnut, mulberry, spruce, swamp white oak, sycamore, walnut, and white ash, were identified in the archaeobotanical assemblages but are not described in the GLOS records. All of these taxa, except mulberry, can be found in modern forest communities in and immediately surrounding the Saginaw

Valley (Voss 1972, 1985). Their absence in the GLOS records may be a result of sampling error, since the GLOS data represents a relatively small sample in comparison to the analyzed archaeobotanical assemblages. The presence of mulberry is, however, anomalous. Mulberry occurs in more southerly counties in Michigan and its presence in the archaeobotanical assemblages suggests prehistoric range extension.

The forest community associated with soil 3 is best defined as a mixed, beech-hardwood-pine forest type. It is generally comparable to Kapp's (1977) beech-pine forest community in the Pine River watershed. While the presence of relatively high percentages of beech and pine suggest a northern mesic forest composition (cf. Curtis 1971), the presence of chestnut, mulberry, and sycamore in the archaeobotanical assemblages indicates that a mixed forest type, including both northern and southern mesic taxa grew in soil 3 prehistorically and that there were patches of wet-mesic forest (including alder, hemlock and tamarack).

Soil 4: Southern Mesic, Beech-Maple Community

Soil 4 is a relatively small area of dry-mesic soils on lake plains and floodplains. Only 18 trees were recorded in this area. Maple (22.22%) and ash (22.22%) are the most abundant taxa. Beech (11.11%), hickory (11.11%), lynn (11.11%), sugar maple (11.11%), and other hardwood taxa are also present.

The Weber I site (20SA581) is located within soil 4. Six of the nine (66%) taxa listed in the GLOS records were identified in the wood charcoal assemblage from Weber I (Table D.6). The same taxa that are absent or poorly represented in the other soil groups are absent in the Weber I assemblage (i.e., lynn, sugar maple, and cedar). Again their absence may be related to their lack of value as fuel, their shed characteristics, and identification problems.

Three taxa not listed in the GLOS records but identified in the Weber I wood charcoal assemblage are pine, walnut, and white oak. All

are commonly associated with the other taxa described in the GLOS records. Their absence in the GLOS records is likely due to the small sample size.

The forest type associated with soil 4 is best defined as a mesic, hardwood community similar to Kapp's (1977) beech-maple forest in the Pine River watershed and Curtis' (1971) southern mesic community. While some of the taxa identified in this soil type are more common to northern mesic forest communities, all of the genera except pine can be found in southern mesic communities.

Soil 5: Southern and Northern Dry-Mesic, Hardwood Community

Only 22 trees were recorded at corner and quarter posts in soil 5, which is a poorly to somewhat poorly drained mesic soil type common to lake plains. Pine (22.73%) is the most abundant taxon. Other taxa represented include ash (18,18%), elm (13.64%), sugar maple (13.13%), maple (9.09%), and beech (9.09%), as well as other hardwood taxa.

The nature of the prehistoric community cannot be appraised because none of the sites considered in this analysis occur in this soil type.

Based on the GLOS data, it appears that a highly mixed community grew in this area during presettlement times. This community is transitional between beech-sugar maple and northern hardwood forest communities described in Michigan (Barnes and Wagner 1981). It contains taxa that are common in both southern mesic and northern, dry-mesic communities in Wisconsin (Curtis 1971). All of the taxa described in the GLOS records occur in southern mesic and northern dry-mesic communities in Wisconsin.

Soil 6: Northern Mesic to Wet-Mesic, Lowland Swamp Community

Forty trees were recorded at corner and quarter posts in soil 6, which is comprised of morainic deposits with well drained to somewhat poorly drained soils. The dominant taxon in this soil is hemlock

(45.00%). In addition, black ash (10.00%), sugar maple (10.00%), elm (7.50%), maple (7.50%), and other hardwood and coniferous taxa occur in this area.

Unfortunately, the composition of the prehistoric community cannot be addressed because none of the sites considered in this analysis occur in this soil type.

The community described in the GLOS records in soil 6 is a mixed, wet-mesic, hemlock-hardwood forest similar to that noted in soil 2 but having a higher percentage of wet-loving taxa. As noted above, such communities are found in low-lying areas with a relatively high water table and at higher elevations with poor drainage (see Barnes and Wagner 1981:96). Dominant species in this soil type have optimal presence in both northern, wet-mesic and northern mesic forests in Wisconsin (Curtis 1971). All of the genera/species described in the GLOS records within this soil type occur in northern wet-mesic and mesic communities.

Soil 7: Northern and Southern Wet-Mesic, Hardwood Community

A total of 109 trees were recorded in soil 7 at corner and quarter posts. This soil type includes both poorly and well drained outwash plain, lake plain, and beach deposits. It supports both mesic and wet-loving tree taxa. Hemlock (14.68%) and ash (12.84%) are the most abundant taxa. Other taxa represented include maple (9.17%), black ash (8.26%), black oak (7.34%), red oak (7.34%), and beech (5.50%), as well as other hardwood and coniferous taxa.

The Butterfield site occurs in soil 1 but is less than 0.5 km from soil 7. Taxa represented in the archaeobotanical assemblage and not in the GLOS records include both northern (i.e., spruce) and southern (i.e., ironwood, sycamore and walnut) genera/species (Table D.3). As noted above, all of these taxa are common components of forest communities in the Saginaw Valley.

Based on the GLOS data, the forest type is soil 7 is best characterized as a mixed forest community containing taxa that occur in

both northern wet-mesic and southern wet-mesic forests. All of the taxa represented in the GLOS records and the archaeobotanical assemblage from the Butterfield site occur in these two communities in Wisconsin (Curtis 1971).

Overall, this reconstruction of the presettlement forest communities compares well with other phytogeographic reconstructions of presettlement vegetation in the Saginaw Valley (Albert *et al.* 1986; Veatch 1959). Further, the overall ecological reconstruction described above fits well with the pollen data from the south-central Lower Peninsula. These sequences indicate that a mixed hardwood forest community, similar to the presettlement forest, was established in this area some time after 3850 B.C. (Ahearn and Bailey 1980; Gilliam *et al.* 1967; McMurray *et al.* 1978). Oak was a dominant (10% to 70% presence) in the pollen sequences from about 8000 to 7000 B.C. to the historic period. While the relative presence of specific woody genera varied through time, there is no clear pattern to suggest significant changes in the composition of the forest community (comparable to those observed during the post-glacial and Hypsithermal periods) during the Late Archaic through Middle Woodland periods.

The majority (75%) of the woody genera represented in the GLOS records and archaeobotanical samples are present in the pollen sequences. Genera not represented in the pollen sequences include hackberry/*Celtis*, chestnut/*Castanea*, cedar/*Thuja*, cherry/*Prunus*, and mulberry/*Morus*. The absence of these taxa is not surprising given the physical characteristics of their pollen grains, the nature of their dispersal, and their relative presence in the presettlement forest communities of this region. *Thuja* pollens degrade easily and are, therefore, often poorly preserved. *Celtis* and *Prunus* are difficult to distinguish from other genera in their families (Ulmaceae and Rosaceae, respectively), and they are rarely specifically identified in pollen sequences. *Castanea* is not a copious producer of pollen, so when its presence is limited in a community, it is often missed in pollen

sequences based on counts of a specific number of specimens. *Morus* is insect pollinated and, therefore, rarely represented in pollen sequences. In addition, its presence in the presettlement communities of this area was probably quite limited (R. Taggart, personal communication 1992).

While the relative presence of specific woody genera varied through time, there is no clear pattern to suggest significant changes in the composition of the forest community (comparable to those observed during the post-glacial and Hypsithermal periods) during the Late Archaic through Middle Woodland periods. Further, while naturally and culturally generated fires can significantly affect the distribution and productivity of biota, fire has not been incorporated into the forest reconstruction in this study because the presettlement forest communities described by the GLO surveyors (in 1821 and 1834) are considered to be a fairly accurate representations of the presettlement environment. Natural factors are assumed to have remained constant from the prehistoric era to the first half of the nineteenth century. Further, at the time the GLO surveys were conducted, Native American populations were still residing in the valley (Cleland 1992b) and presumably would have been starting fires, the impact of which would have been noted in the GLOS.

Marshes

The GLOS records and other historic descriptions of the Saginaw Valley (Houghton 1838; Macomb *et al.* 1856) recount the presence of marsh communities occurring along the river margins and bay. Solute content and water depth influence the composition of marsh communities (Curtis 1971:389), which are dominated by wet loving-taxa including: cattail/*Typha* spp.; arrowhead/*Sagittaria latifolia*; sedge/*Carex* spp.; and bulrush/*Scirpus* spp. This ecological community type has a high biomass.

Palynological data indicate that there was an increase in the presence of aquatic taxa (Cyperaceae, *Typha* sp./*Sparganium* sp. type, *Nuphar* sp., Nymphaceae, *Myriophyllum* sp., and *Typha latifolia*) reflected at the Vestaburg Bog at around 1200 B.C. The presence of Cyperaceae continues to remain high until historic times, although the presence of other aquatic taxa drops to trace values (Gilliam *et al.* 1967). This increase in aquatic taxa is probably due to the establishment of wetlands in this region following the post-Lake Stanley rise in lake levels and the post-Hypsithermal increase in moisture. This community type is comparable to the marsh community described above and suggests that it was a significant component of the prehistoric environment during the Late Archaic, Early Woodland and Middle Woodland periods.

Densities of Plant Resources

Densities of plant resources were required to calculate productivity values for resources available in the effective environment. Calculation of botanical densities required several steps.

First, it was necessary to generate an inventory of edible taxa, which for purposes of this analysis are considered to be representative of the effective subsistence environment. Densities were calculated for these taxa only. The inventory and density information were based on three primary sources of information. The General Land Office Survey (GLOS) records provide a limited inventory of the tree and shrub taxa found in the presettlement forest of the Saginaw Valley but they do not provide any quantitatively useful information about understory vegetation. While systematic inventories are available which provide information about the habitat preferences of the gymnosperms, monocots and some of the dicotyledonous taxa found in the valley (Voss 1972, 1985; Barnes and Wagner 1981); these sources do not provide information about the densities of taxa that is requisite for a detailed environmental reconstruction. It was, therefore, necessary to supplement the GLOS and modern taxonomic inventories with comparative data from Wisconsin (Curtis 1971) to

construct an inventory of the woody and herbaceous taxa available to the prehistoric inhabitants of the valley and to calculate densities of these resources. Plant taxa were ascribed to the forest communities defined on the basis of soil type.

Densities of trees were estimated using comparative data, from Michigan and Wisconsin, on extant stands of climax and mature forests (Zager and Pippen 1977; Curtis 1971). Densities were calculated for each community type represented in the valley. These calculations were based on trees greater than or equal to 4" DBH (diameter breast height) in Wisconsin communities (Curtis 1971) and on canopy and midstory trees (assumed to be > 4" DBH) in the Michigan beech-maple community (Zager and Pippen 1977). Only trees greater than 4" were used because most trees (except some oaks) achieve productive maturity at 4" DBH.

Densities of individual tree taxon were based on estimated percentages of each within the seven forest communities represented in the study area. Percentages were estimated through a calculation of the mean percentage of each taxa from: the GLOS; representative communities in Wisconsin; and importance values (sum of the relative abundance, relative dominance, and relative frequency) within representative communities in Wisconsin (Curtis 1971).

There are a few tree taxa which historically and/or archaeologically occur in the Saginaw Valley for which there was no comparative information available in Wisconsin (i.e., red oak, chestnut, mulberry, and hawthorn). Therefore, percentages for red oak are based on GLOS data alone and percentages for chestnut, mulberry and hawthorn were estimated as equaling the minimum percentage values of other limited taxa.

Percentages were multiplied by tree densities calculated for each community type to arrive at an estimate of species density per square kilometer. These values were then multiplied by the number of square kilometers of each community type, for each lake stage, to arrive at overall species densities.

Densities of mulberry and hawthorn were calculated in a slightly different manner. Both of these taxa are associated with open disturbed sites such as river banks and their areal distribution is, therefore, restricted to these locations rather than to entire forest areas. Density values for these taxa were calculated accordingly. Data used in the calculation of tree densities and the final estimates of densities per forest type and lake level are provided in Tables D.7 to D.13.

The densities of shrubs and herbaceous taxa are rarely provided in phytosociological studies because clumping often makes it difficult to determine the number of individual stems (i.e., plants). Given this problem, Curtis suggests that:

> the best analytical method is a delimitation of simple frequency[1], a determination of the percentage of small quadrat samples which contain the species, irrespective of the number of individuals present in any sample... Species behavior diagrams based upon such frequency information are identical to those based upon density values [1971:273].

Frequency values can, in turn, be converted into expected density values through the following formulae:

$$D' = -\ln (1-f)$$
$$\text{or } D' = -2.3206 \log (1-f)$$

(Brower and Zar 1977:123)

Therefore, using frequency[2] information provided by Curtis (1971) expected density values were calculated for each of the edible shrub and herbaceous taxa available in the seven forest communities. Density values were then corrected by presence values (or the percentage of sampling units containing a given species) to reflect variability in density over space (Tables D.14 to D.20). These values compare well with those provided by

---

[1] Frequency (f) is defined as the proportion of the total number of sampling plots in which the individuals of a species occur (Brower and Zar 1977:122).

[2] Because many of the communities represented in the Saginaw Valley represent mixed communities types in Curtis' (1959) study, averaged frequency values were used to estimate their representative frequency in the Saginaw Valley communities.

Zager and Pippen (1977) in their description of the beech-maple forest in Cooper's Glen, as well as those estimated by Keene (1981).

Unfortunately, Curtis' (1971) data is not comprehensive and frequency and presence values are not provided for several taxa which occur in the Saginaw Valley (Voss 1972, 1985), (as well as in Wisconsin forest communities). For shrubby and herbaceous taxa, average density values for these types of vegetation were used. Several of these taxa are common to disturbed habitats (e.g., goosefoot, amaranth, grape) and estimates of their total density within the Saginaw Valley were based on the areal extents of disturbed habitats. The estimate of the areal extent of disturbed habitats was calculated as a narrow (15 m) river edge and lake border disturbed zone which would be subject to disturbance by seasonal flooding (Tables D.14 to D.20).

Densities of wetland taxa were based on Curtis' (1971) figures of densities per km^2 (Table D.21). Lovis' (1989) estimates of the spatial extents of the Algoma and Nipissing, shallow water (2 m) marsh habitats were employed and a similar calculation was generated for the modern lake elevation and river edge habitats.

These density estimates were used to calculate resource productivity within the valley during each of the lake stages and to calculate the estimated effective productivity of resources within exploitation areas. Calculation of these estimates are described in Chapter 3.

Table D.1. Percentages of GLOS Tree Taxa By Soil Type

	Soil 1	Soil 2	Soil 3	Soil 4	Soil 5	Soil 6	Soil 7
Ash	8.89	7.84	16.67	22.22	18.18	0.00	12.84
Black Ash	0.00	9.31	0.00	0.00	0.00	10.00	8.26
White Ash	0.00	0.98	0.00	0.00	0.00	2.50	3.67
Aspen	0.00	0.00	2.22	0.00	0.00	0.00	1.83
Beech	26.67	10.78	26.67	11.11	9.09	2.50	5.50
Birch	1.11	3.43	0.00	5.56	0.00	0.00	3.67
Elm	7.78	10.78	8.89	5.56	13.64	7.50	2.75
Hackberry	1.11	0.00	0.00	0.00	0.00	0.00	0.00
Hickory	1.11	0.49	1.11	11.11	4.55	0.00	0.92
Ironwood	0.00	0.00	0.00	0.00	0.00	2.50	0.00
Lynn	3.33	3.92	7.78	11.11	4.55	2.50	4.59
Maple	12.22	12.25	10.00	22.22	9.09	7.50	9.17
Sugar Maple	4.44	3.92	2.22	11.11	13.64	10.00	0.92
Black Oak	0.00	0.98	1.11	0.00	0.00	0.00	7.34
Red Oak	2.22	0.49	5.56	0.00	4.55	0.00	1.83
White Oak	10.00	2.45	4.44	0.00	0.00	0.00	7.34
Poplar	0.00	0.49	0.00	0.00	0.00	0.00	0.00
Sycamore	0.00	0.00	0.00	0.00	0.00	0.00	0.92
Willow	0.00	0.00	0.00	0.00	0.00	0.00	0.92
Cedar	0.00	1.47	0.00	0.00	0.00	5.00	0.00
Fir	0.00	0.00	0.00	0.00	0.00	2.50	0.00
Hemlock	6.67	21.08	0.00	0.00	0.00	45.00	14.68
Pine	5.56	5.39	13.33	0.00	22.73	0.00	3.67
White Pine	0.00	2.45	0.00	0.00	0.00	2.50	2.75
Tamarack	8.89	1.47	0.00	0.00	0.00	0.00	6.42
n =	90	204	90	18	22	40	109

Table D.2. Soil 3:
Comparison of GLOS and Archaeological Wood Taxa

GLOS Taxa	20BY79* Late Archaic	20BY128* Middle Woodland
Ash	X	X
Beech		X
Birch		
Elm		X
Hackberry		
Hickory	X	X
Lynn		
Maple		
Sugar Maple	X	
Red Oak	X	X
White Oak	X	X
Hemlock		
Pine		X
White Pine	X	X
Tamarack		
Taxa Not Identified in GLOS		
Chestnut	X	
Ironwood		X

* Author's identifications

Table D.3. Soils 1 and 7:
Comparison of GLOS and Archaeological Wood Taxa

GLOS Taxa	20BY29[•] Late Archaic
Ash	X
Black ash	
White ash	
Aspen	X
Beech	X
Birch	X
Elm	X
Hackberry	X
Hickory	X
Lynn	
Maple	X
Sugar maple	
Black oak	
Red oak	X
White oak	X
Hemlock	
Pine	
White pine	X
Tamarack	
Taxa Not Identified in GLOS	
Ironwood	X
Spruce	X
Sycamore	X
Walnut	X

• Wobst 1968:271

Table D.4. Soil 2:
Comparison of GLOS and Archaeological Wood Taxa

GLOS Taxa	20SA128[a] Late Archaic
Ash	X
Black ash	X
White ash	X
Aspen	
Beech	X
Birch	X[b]
Elm	X
Hickory	X
Lynn	X
Maple	X
Sugar maple	
Black oak	
Red oak	X
White oak	X
Cedar	
Hemlock	
Pine	X
White pine	
Tamarack	
Taxa Not Identified in GLOS	
Cherry	X[b]
Sycamore	X

[a] Yarnell 1964:22-229
[b] Author's identifications

Table D.5. Soil 3:
Comparison of GLOS and Archaeological Wood Taxa

GLOS Taxa	20SA192[a] LA[c]	20SA2[b] EW[d]	20SA2[b] EMW[e]	20SA2[b] MW[f]	20SA2[a] LMW[g]
Ash		X[h]			X
Aspen		X[h]			
Beech	X	X[e]	X[e]		X
Birch	X	X[e]	X		X
Elm	X	X[h]	X	X	X
Hackberry		X[e]	X	X	X
Hickory	X	X	X	X	X
Ironwood		X			X
Lynn		X[e]	X[e]		X
Maple	X	X	X		X
Sugar Maple					
Black Oak					
Red Oak		X	X		X
White Oak		X[e]	X		X
Cedar			X[e]		X
Hemlock		X			
Pine	X	X[e]	X[e]		X
White Pine	X		X[e]		
Taxa Not Identified in GLOS					
Alder		X[h]			
Black Ash		X		X	X
Cherry		X[h]			
Chestnut		X[e]	X	X	X
Mulberry		X[e]	X		X
Swamp White Oak				X	
Sycamore		X[h]	X[e]		X
Walnut		X[h]	X	X	X
White Ash		X	X	X	X

[a] Author's identifications
[b] Brunett 1972:87
[c] Late Archaic
[d] Early Woodland
[e] Early Middle Woodland
[f] Middle Woodland
[g] Late Middle Woodland
[h] Ozker 1982:38

Table D.6. Soil 4:
Comparison of GLOS and Archaeological Wood Taxa

GLOS Taxa	20SA581[a] Late Archaic
Ash	X
Beech	X
Birch	X[b]
Elm	X
Hickory	X
Lynn	
Maple	X
Sugar maple	
Cedar	
Taxa Not Identified in GLOS	
Pine	X
Walnut	X
White oak	X

[a] Author's identifications

Table D.7. Estimated Tree Densities in Soil 1: Northern and Southern Mesic, Hardwood Community

Taxa	% GLO	% WI[a]	IV WI[b]	% Tot IV[c]	Est %[d]	Species Density/km^2 [e]	Sp Density Modern[f]	Sp Density Algoma[g]	Sp Density Nipissing[h]
Nuts									
Castanea dentata Chestnut					0.02	8.84	5,072.1	4,952.2	4,875.0
Carya cordiformis Bitternut hickory	0.55	1.5	3	1	1	442.05	253,633.7	247,635.5	243,777.3
C. ovata Shagbark hickory	0.55		1	0.3	0.4	176.82	101,453.5	99,054.2	97,510.9
Fagus grandifolia beechnut	26.6	2.6	35.3	11.5	13.5	5,967.67	3,424,052.1	3,343,076.8	3,290,991.0
Juglans cinerea Butternut		0.6	2.8	1	0.8	353.64	202,907.0	198,108.4	195,021.9
Juglans nigra Black walnut		0.1	0.4	0.1	0.1	44.20	25,360.5	24,760.8	24,375.0
Quercus alba White oak	10	0.1	3	1	3.7	1,635.58	938,441.8	916,248.6	901,973.3
Quercus bicolor Swamp white oak			0.1	0.02	0.02	8.84	5,072.1	4,952.2	4,875.0
Quercus macrocarpa Bur oak			0.1	0.02	0.02	8.84	5,072.1	4,952.2	4,875.0
Quercus rubra Red oak	2.2				2.2	972.51	557,994.1	544,798.2	536,310.1
Quercus velutina Black oak			0.1	0.02	0.02	8.84	5,072.1	4,952.2	4,875.0

Table D.7. (cont'd)

Taxa	% GLO	% WI[a]	IV WI[b]	% Tot IV[c]	Est %[d]	Species Density/km^2 [e]	Sp Density Modern[f]	Sp Density Algoma[g]	Sp Density Nipissing[h]
Fruits									
Celtis occidentalis Hackberry	1.11	0.1	0.8	0.3	0.5	221.00	523.8	18.8	371.3
Crategus spp. Hawthorn					0.02	8.84	21.0	18.8	14.9
Morus rubra Mulberry					0.02	8.84	21.0	18.8	14.9
Prunus pensylvanica Pin cherry			0.3	0.1	0.1	44.20	25,360.5	24,760.8	24,375.0
P. serotina Wild black cherry		0.3	1.4	0.5	0.4	176.82	101,453.5	99,054.2	97,510.9
Sap									
Acer saccharum Sugar maple	4.44	50.6	116.	38.5	31.2	13,791.95	7,913,365.8	7,726,222.8	7,605,846.7

a. Percentages derived from Curtis' descriptions of typical northern and southern mesic forests in Door, Vilas and Green counties, Wisconsin (1959:520, 534), (trees >/= 4" dbh).

b. Mean importance values (sum of relative abundance, relative dominance, and relative frequency) for northern and southern mesic forests (1959: 520, 534)

c. Percentages of total importance value for northern and southern mesic forests, from Curtis (1959: 520, 534)

d. Est % = mean of percentages for GLO, Wisconsin forest communities, and importance values (for values > 0)

Table D.7. (cont'd)

e. Species density/km^2 based on estimate of 179.09 trees/acre, 44,204.96 trees/km^2

f. Modern species densities based on species density/km^2 x 573.767 km^2 (area of soil 1 at the modern lake level elevation) or 2.37 km^2 (estimated area of soil 1 floodplain at the modern lake level elevation)

g. Algoma species density based on species density/km^2 x 560.198 km^2 (area of soil 1 at the Algoma lake level elevation) or 2.13 km^2 (estimated area of soil 1 floodplain at the Algoma lake level elevation)

h. Nipissing species density based on species density/km^2 x 551.47 km^2 (area of soil 1 at the Nipissing lake level elevation) or 2.59 km^2 (estimated area of soil 1 floodplain at the Nipissing lake level elevation)

Table D.8. Estimated Tree Densities in Soil 2: Northern and Southern Wet-Mesic, Hemlock and Hardwood Community

Taxa	% GLO	% WI[a]	IV WI[b]	% Tot IV[c]	Est %[d]	Sp Density/ km^2[e]	Sp Density Modern[f]	Sp Density Algoma[g]	Sp Density Nipissing[h]
Nuts									
Carya cordiformis	0.3	1.6	1.5	0.5	0.8	506.1	1,189,486.8	956,694.5	825,129.2
Bitternut hickory									
C. ovata	0.3	1.4			0.9	569.3	1,338,025.8	1,076,163.2	928,168.5
Shagbark hickory									
Fagus grandifolia	10.8		1.3	0.4	5.6	3,542.4	8,325,702.7	6,696,294.4	5,775,415.6
Beechnut									
Juglans cinerea			0.9	0.3	0.3	189.8	446,086.9	358,784.1	309,443.8
Butternut									
Juglans nigra			0.1	0.02	0.02	12.7	29,848.8	24,007.2	20,705.7
Black walnut									
Quercus alba	2.5		2.2	0.4	1.5	948.9	2,230,199.7	1,793,731.3	1,547,056.2
White oak									
Quercus bicolor		2.9	7.35	2.4	2.7	1,708.0	4,014,312.4	3,228,678.5	2,784,668.5
Swamp white oak									
Quercus macrocarpa			1.2	0.4	0.4	253.0	594,625.9	478,252.7	412,483.1
Bur oak									
Quercus rubra	0.5				0.5	316.3	743,399.9	597,910.4	515,685.4
Red oak									
Quercus velutina	1		0.5	0.2	0.6	379.5	891,938.9	717,379.1	618,724.7
Black oak									

Table D.8. (cont'd)

Taxa	% GLO	% WI[a]	IV WI[b]	% Tot IV[c]	Est %[d]	Sp Density/ km^2[e]	Sp Density Modern[f]	Sp Density Algoma[g]	Sp Density Nipissing[h]
Fruits									
Celtis occidentalis Hackberry			2	0.6	0.6	379.5	899.4	2,352.9	2,956.3
Crategus spp. Hawthorn					0.02	12.7	30.1	78.7	98.9
P. serotina Wild black cherry			0.8	0.3	0.3	189.8	446,086.9	358,784.1	309,443.8
Sap									
Acer saccharum Sugar maple	3.9		11	3.6	3.8	2,403.8	5,649,651.1	4,543,968.0	3,919,078.6

a. Percentages derived from Curtis' descriptions of a typical northern wet–mesic forest in Vilas County (1959:543) and a southern wet–mesic forest in Rock County, Wisconsin (1971:530), (trees (>/= 4" dbh).

b. Mean importance values (sum of relative abundance, relative dominance, and relative frequency) for northern and southern wet–mesic forests (1959:529, 542)

c. Percentages of total importance value for northern and southern wet–mesic forests, from Curtis 1959:529, 542)

d. Est % = mean of percentages for GLO, Wisconsin forest communities, and importance values (for values > 0)

e. Species density/km^2 based on estimate of 256 trees/acre; 63,257.6 trees/km^2

f. Modern species density calculated as species density/km2 x 2530.3 (area of soil 2 at modern lake level) or 1.53 (estimated area of soil 2 floodplain at modern lake level elevation)

g. Algoma species density calculated as species density/km^2 x 1890.327 (area of soil 2 at Algoma lake level) or 10.00 (estimated area of soil 2 floodplain at Algoma lake level elevation)

Table D.8. (cont'd)

h. Nipissing species density calculated as species density/km2 x 1630.368 (area of soil 2 at Nipissing lake level) or 10.82 (estimated area of soil 2 floodplain at Nipissing lake level elevation)

Table D.9. Estimated Tree Densities in Soil 3: Northern and Southern Mesic, Beech-Hardwood-Pine Community

Taxa	% GLO	% WI[a]	IV WI[b]	% Tot IV[c]	Est %[d]	Sp Density/ km^2 [e]	Sp Density/ Modern[f]	Sp Density/ Algoma[g]	Sp Density/ Nipissing[h]
Nuts									
Castanea dentata Chestnut					0.02	8.8	2,725.4	2,389.3	1,809.8
Carya cordiformis Bitternut hickory	0.6	1.5	3	1	1	442.0	136,887.4	120,005.7	90,899.1
C. ovata Shagbark hickory	0.6		1	0.3	0.8	353.6	109,509.9	96,004.5	72,719.3
Fagus grandifolia beechnut	26.6	2.6	35.3	11.5	13.5	5,967.7	1,848,196.7	1,620,266.4	1,227,281.4
Juglans cinerea Butternut		0.6	2.8	1	0.8	353.6	109,509.9	96,004.5	72,719.3
Juglans nigra Black walnut		0.1	0.4	0.1	0.1	44.2	13,688.7	12,000.6	9,089.9
Quercus alba White oak	4.4	0.1	3	1	1.8	795.7	246,428.3	216,037.3	163,638.9
Quercus bicolor Swamp white oak			0.1	0.02	0.02	8.8	2,725.4	2,389.3	1,809.8
Quercus macrocarpa Bur oak			0.1	0.02	0.02	8.8	2,725.4	2,389.3	1,809.8
Quercus rubra Red oak	5.6				5.6	2,475.5	766,662.4	672,113.1	509,096.5
Quercus velutina Black oak	1.1		0.1	0.02	0.02	8.8	2,725.4	2,389.3	1,809.8

Table D.9. (cont'd)

Taxa	% GLO	% WI[a]	IV WI[b]	% Tot IV[c]	Est %[d]	Sp Density/ km^2 [e]	Sp Density/ Modern[f]	Sp Density/ Algoma[g]	Sp Density/ Nipissing[h]
Fruits									
Celtis occidentalis Hackberry	1.11	0.1	0.8	0.3	0.5	221.0	777.9	711.6	687.3
Crategus spp. Hawthorn					0.02	8.8	31.0	28.3	27.4
Morus rubra Mulberry					0.02	8.8	31.0	28.3	27.4
Prunus pensylvanica Pin cherry			0.3	0.1	0.1	44.2	13,688.7	12,000.6	9,089.9
P. serotina Wild black cherry		0.3	1.4	0.5	0.4	176.8	54,755.0	48,002.3	36,359.6
Sap									
Acer saccharum Sugar maple	2.2	50.6	116.	38.5	30.4	13,438.3	4,161,841.5	3,648,579.1	2,763,640.1

a. Percentages derived from Curtis' descriptions of typical northern and southern mesic forest communities in Door, Vilas, and Green counties (1959:520, 534), (trees >/= 4" dbh)

b. Mean importance values (sum of relative abundance, relative dominance, and relative frequency) for northern and southern mesic forests (1971:520, 534)

c. Percentages of total importance values for northern and southern mesic forests, from Curtis (1959: 520, 534)

d. Est % = mean of percentages for GLO, Wisconsin forest communities, and importance values (for values > 0)

Table D.9. (cont'd)

e. Species density/km^2 based on estimate of 179.09 trees/acre; 44,204.96 trees/km^2

f. Modern densities based on species density/km^2 x 309.669 (area of soil 3 at the modern lake level elevation) or 3.52 (area of soil 3 floodplain at the modern lake level elevation)

g. Algoma densities based on species density/km^2 x 271.506 (area of soil 3 at the Algoma lake level elevation) or 3.22 (area of soil 3 floodplain at the Algoma lake level elevation)

h. Nipissing densities based on species density/km^2 x 205.654 (area of soil 3 at the Nipissing lake level elevation) or 3.11 (area of soil 3 floodplain at the Nipissing lake level elevation)

Table D.10. Estimated Tree Densities in Soil 4: Southern Mesic, Beech-Maple Community

Taxa	% GLO	% WI[a]	IV WI[b]	% Tot IV[c]	Est %[d]	Sp Density/ km^2 [e]	Sp Density/ Modern[f]	Sp Density/ Algoma[g]	Sp Density/ Nipissing[h]
Nuts									
Castanea dentata Chestnut					0.02	11.4	260.5	260.5	260.5
Carya cordiformis Bitternut hickory	5.6	3.3	5.3	1.8	3.6	2,048.6	46,818.7	46,818.7	46,818.7
C. ovata Shagbark hickory	5.6		1.8	0.6	3.1	1,764.0	40,314.5	40,314.5	40,314.5
Fagus grandifolia beechnut	11.1		30.3	10.4	10.7	6,088.8	139,153.4	139,153.4	139,153.4
Juglans cinerea Butternut		1.3	5.2	1.8	1.5	853.0	19,494.5	19,494.5	19,494.5
Juglans nigra Black walnut		0.2	0.7	0.2	0.2	113.8	2,600.8	2,600.8	2,600.8
Quercus alba White oak		0.2	5.7	2	1.1	626.0	14,306.6	14,306.6	14,306.6
Quercus bicolor Swamp white oak		0.2	0.1	0.05	0.1	56.9	1,300.4	1,300.4	1,300.4
Quercus macrocarpa Bur oak			0.1	0.03	0.03	17.1	390.8	390.8	390.8
Quercus velutina Black oak			0.1	0.03	0.03	17.1	390.8	390.8	390.8
Fruits									
Celtis occidentalis Hackberry		3.3	1.6	0.1	1.7	967.4	299.9	299.9	299.9

Table D.10. (cont'd)

Taxa	% GLO	% WI[a]	IV WI[b]	% Tot IV[c]	Est %[d]	Sp Density/ km^2 [e]	Sp Density/ Modern[f]	Sp Density/ Algoma[g]	Sp Density/ Nipissing[h]
Crategus spp. Hawthorn					0.02	11.4	3.5	3.5	3.5
Morus rubra Mulberry					0.02	11.4	3.5	3.5	3.5
P. serotina Wild black cherry			1.9	0.7	0.7	398.3	9,102.7	9,102.7	9,102.7
Sap									
Acer saccharum Sugar maple	11.1	58.7	126	43	37.4	21,282.4	486,388.0	486,388.0	486,388.0

a. Percentages derived from Curtis' description of a typical southern mesic forest in Green County, Wisconsin (1959:520), (trees >/= 4" dbh).

b. Mean importance values (sum of relative abundance, relative dominance, and relative frequency) for southern mesic forest (Curtis 1959:520)

c. Percentages of total importance values for southern mesic forest, from Curtis (1959:520)

d. Est % = mean of percentages for GLO, Wisconsin forest communities, and importance values (for values > 0)

e. Species density/km^2 based on estimate of 230.3 trees/acre; 56,904.7 trees/km^2

f. Modern densities based on species density/km^2 x 22.854 km^2 (area of soil 4 at the modern lake level elevation) or 0.31 (estimated area of the soil 4 floodplain at the modern lake level elevation)

g. Algoma densities based on species density/km^2 x 22.854 km^2 (area of soil 4 at the Algoma lake level elevation) or 0.31 (estimated area of the soil 4 floodplain at the Algoma lake level elevation)

h. Nipissing densities based on species density/km^2 x 22.854 km^2 (area of soil 4 at the Nipissing lake level elevation) or 0.31 km^2 (estimated area of soil 4 floodplain at the Nipissing lake level elevation)

Table D.11. Estimated Tree Densities in Soil 5: Southern and Northern Dry-Mesic, Hardwood Community

Taxa	% GLO	% WI[a]	IV WI[b]	% Tot IV[c]	Est %[d]	Sp Density/ km^2 [e]	Sp Density/ Modern[f]	Sp Density/ Algoma[g]	Sp Density/ Nipissing[h]
Nuts									
Carya cordiformis Bitternut hickory	2.3	1.7	2.9	0.5	1.5	721.7	71,835.1	26,716.6	21,962.8
C. ovata Shagbark hickory	2.3		0.9	0.2	1.2	577.3	57,462.1	21,371.1	17,568.4
Fagus grandifolia beechnut	9.1		16.6	2.8	10.4	5,003.5	498,028.4	185,224.6	152,266.5
Juglans cinerea Butternut		0.7	2.8	0.5	0.6	288.7	28,736.0	10,687.4	8,785.7
Juglans nigra Black walnut		0.05	0.4	0.1	0.05	24.1	2,398.8	892.2	733.4
Quercus alba White oak		0.1	7.5	1.3	0.7	336.8	33,523.7	12,468.0	10,249.5
Quercus bicolor Swamp white oak			0.1	0.02	0.02	9.6	955.5	355.4	292.1
Quercus macrocarpa Bur oak			0.5	0.1	0.1	48.1	4,787.7	1,780.6	1,463.8
Quercus rubra Red oak	4.6				4.6	2,213.1	220,283.1	81,926.7	67,349.1
Quercus velutina Black oak			0.1	0.02	0.02	9.6	955.5	355.4	292.1
Fruits									
Amelanchier sp. Serviceberry			0.1	0.02	0.02	9.6	955.5	355.4	292.1

Table D.11. (cont'd)

Taxa	% GLO	% WI[a]	IV WI[b]	% Tot IV[c]	Est %[d]	Sp Density/ km^2 [e]	Sp Density/ Modern[f]	Sp Density/ Algoma[g]	Sp Density/ Nipissing[h]
Celtis occidentalis Hackberry		0.1	0.8	0.1	0.1	48.1	49.543	34.6	41.8
Crategus spp. Hawthorn					0.02	9.6	9.888	6.9	8.4
P. serotina Wild black cherry			1.6	0.3	0.3	144.3	14,363.0	5,341.8	4,391.3
Sap									
Acer saccharum Sugar maple	13.6	29.3	76.5	12.8	18.6	8,948.5	890,697.9	331,264.5	272,320.8

a. Percentages derived from Curtis' descriptions of typical southern mesic and northern dry–mesic forests Green, Oneida counties, Wisconsin (1959:520, 538), (trees >/= 4" dbh)

b. Mean importance values (sum of relative abundance, relative dominance, and relative frequency) for southern mesic and northern dry–mesic forests (Curtis 1959:520, 537)

c. Percentages of total importance value for southern mesic and northern dry–mesic forests, from Curtis (1959:520, 537)

d. Est % = mean of percentages for GLO, Wisconsin forest communities, and importance values (for values > 0)

e. Species density/km^2 based on estimate of 194.7 trees/acre; 48,104.4 trees/km^2

f. Modern densities calculated on species density/km^2 x 99.536 km^2 (area of soil 5 at the modern lake level elevation) or 1.03 km^2 (estimated area of soil 5 at the modern lake level elevation)

g. Algoma densities calculated on species density/km^2 x 37.019 km^2 (area of soil 5 at the Algoma lake level elevation) or 0.72 km^2 (estimated area of soil 5 at the Algoma lake level elevation)

h. Nipissing densities calculated on species density/km^2 x 30.43 km^2 (area of soil 5 at the Nipissing lake level elevation) or 0.87 km^2 (estimated area of soil 5 at the Nipissing lake level elevation)

Table D.12. Estimated Tree Densities in Soil 6: Northern Mesic to Wet-Mesic, Lowland Swamp Community

Taxa	% GLO	% WI[a]	IV WI[b]	% Tot IV[c]	Est %[d]	Sp Density/ km^2 [e]	Sp Density/ Modern[f]	Sp Density/ Algoma[g]	Sp Density/ Nipissing[h]
Nuts									
Carya cordiformis Bitternut hickory			0.4	0.1	0.1	59.6	3,737.9	3,737.9	3,737.9
C. ovata Shagbark hickory			0.1	0.1	0.1	59.6	3,737.9	3,737.9	3,737.9
Fagus grandifolia beechnut	2.5	2.4	20.8	6.6	3.8	2,265.3	142,072.8	142,072.8	142,072.8
Juglans cinerea Butternut			0.7	0.1	0.1	59.6	3,737.9	3,737.9	3,737.9
Quercus alba White oak			0.2	0.1	0.1	59.6	3,737.9	3,737.9	3,737.9
Fruits									
Prunus pensylvanica Pin cherry			0.1	0.02	0.02	11.9	746.3	746.3	746.3
P. serotina Wild black cherry		0.2	0.5	0.1	0.2	119.2	7,475.9	7,475.9	7,475.9
Sap									
Acer saccharum Sugar maple	10	2.2	12	19.1	17	10,134.2	635,586.6	635,586.6	635,586.6

Table D.12. (cont'd)

a. Percentages derived from Curtis' descriptions of typical northern wet–mesic and mesic forests in Door and Vilas counties (1959:534, 543), (trees >/= 4" dbh)

b. Mean importance values (sum of relative abundance, relative dominance, and relative frequency) for northern wet–mesic and mesic forests (1959:534, 542)

c. Percentages of total importance value for northern mesic and northern wet–mesic forests, from Curtis (1959: 534, 542)

d. Est % = mean of percentages for GLO, Wisconsin forest communities, and importance values (for values > 0)

e. Species density/km^2 based on estimate of 241.3 trees/acre; 59,612.9 trees/km^2

f. Modern densities based on species density/km^2 x 62.717 km^2 (area of soil 6 at the modern lake level elevation)

g. Algoma densities based on species density/km^2 x 62.717 km^2 (area of soil 6 at the Algoma lake level elevation)

h. Nipissing densities based on species density/km^2 x 62.717 km^2 (area of soil 6 at the Nipissing lake level elevation)

Table D.13. Estimated Tree Densities in Soil 7: Northern and Southern Wet-Mesic, Hardwood Community

Taxa	% GLO	% WI[a]	IV WI[b]	% Tot IV[c]	Est %[d]	Sp Density/ km^2 [e]	Sp Density/ Modern[f]	Sp Density/ Algoma[g]	Sp Density/ Nipissing[h]
Nuts									
Carya cordiformis Bitternut hickory	0.5	1.6	1.5	0.5	2.6	1,644.7	167,923.9	120,403.6	96,335.0
C. ovata Shagbark hickory	0.5	1.4			1	632.6	64,588.5	46,310.7	37,053.3
Fagus grandifolia beechnut	5.5		1.3	0.4	3	1,897.7	193,755.2	138,924.9	111,154.0
Juglans cinerea Butternut			0.9	0.3	0.3	189.8	19,378.6	13,894.7	11,117.2
Juglans nigra Black walnut			0.1	0.02	0.02	12.7	1,296.7	929.7	743.9
Quercus alba White oak	7.3		2.2	0.4	3.9	2,467.0	251,880.7	180,601.7	144,499.6
Quercus bicolor Swamp white oak		2.9	7.35	2.4	2.7	1,708.0	174,386.8	125,037.6	100,042.7
Quercus macrocarpa Bur oak			1.2	0.4	0.4	253.0	25,831.3	18,521.4	14,819.0
Quercus rubra Red oak	1.8				1.8	1,138.6	116,251.1	83,353.5	66,691.2
Quercus velutina Black oak	7.34		0.5	0.2	3.7	2,340.5	238,965.1	171,341.0	137,090.1

Table D.13. (cont'd)

Taxa	% GLO	% WI[a]	IV WI[b]	% Tot IV[c]	Est %[d]	Sp Density/ km^2 [e]	Sp Density/ Modern[f]	Sp Density/ Algoma[g]	Sp Density/ Nipissing[h]
Fruits									
Celtis occidentalis Hackberry			2	0.6	0.6	379.5	216.3	364.3	242.9
Crategus spp. Hawthorn					0.02	12.5	7.1	12.0	8.0
P. serotina Wild black cherry			0.8	0.3	0.3	186.8	19,072.3	13,675.1	10,941.4
Sap									
Acer saccharum Sugar maple	0.9		11	3.6	2.3	1,454.9	148,545.3	106,508.9	85,217.9

a. Percentages derived from Curtis' descriptions of typical northern and southern wet–mesic forest communities in Rock and Vilas counties, Wisconsin (Curtis 1959:530, 543), (trees >/= 4" dbh)

b. Mean importance values (sum of relative abundance, relative dominance, and relative frequency) for southern and northern wet–mesic forests (Curtis 1959:529, 542)

c. Percentages of total importance value for southern and northern wet–mesic forests, from Curtis (1959:529, 542)

d. Est % = mean of percentages for GLO, Wisconsin forest communities, and importance values (for values > 0)

e. Species density/km^2 based on estimate of 256.0 trees/acre; 62,257.6 trees/km^2

f. Modern species densities based on species density/km^2 x 102.115 km^2 (area of soil 7 at the modern lake level elevation) or 0.57 km^2 (estimated area of soil 7 floodplain at the modern lake level elevation)

g. Algoma species densities based on species density/km^2 x 73.207 km^2 (area of soil 7 at the Algoma lake level elevation) or 0.96 km^2 (estimated area of soil 7 floodplain at the Algoma lake level elevation)

h. Nipissing species densities based on species density/km^2 x 58.573 km^2 (area of soil 7 at the Nipissing lake level elevation) or 0.64 km^2 (estimated area of soil 7 floodplain at the Nipissing lake level elevation)

Table D.14. Estimated Densities of Edible Groundlayer Plants in Soil 1: Northern and Southern Mesic, Hardwood Community

Taxa	Avg Freq[a]	D'/Acre[b]	D'/km^2	Presence[c]	Sp D'/km^2 [d]	Sp Density Modern[e]	Sp Density Algoma[f]	Sp Density Nipissing[g]
Nuts								
Corylus cornuta Beaked-hazelnut	2.1	84	20,756.4	20.5	4,255.1	2,441,414.2	2,383,677.2	2,346,539.0
Fruits								
Ribes spp. Gooseberry/currant	1.6	64	15,814.4	23	3,637.3	2,086,969.6	2,037,614.9	2,005,868.4
Sambucus pubens Red-berried elder	0.9	36	8,895.6	22	1,957.0	4,638.2	4,168.5	5,068.7
Vitis spp. Grape					4,872.8	11,548.5	10,379.1	12,620.6
Seeds								
Amaranthus spp. Pigweed					51,451.2	121,939.3	109,591.1	133,258.6
Chenopodium spp. Goosefoot					51,451.2	121,939.3	109,591.1	133,258.6
Polygonum spp. Knotweed					51,451.2	121,939.3	109,591.1	133,258.6
Roots/Tubers/Corms								
Allium spp. Wild leek	4.7	188	46,454.8	39	18,117.4	10,395,150.2	10,149,315.6	9,991,187.1
Arisaema triphyllum Jack-in-the-pulpit	6.5	260	64,246.0	29	18,631.3	10,690,048.1	10,437,239.4	10,274,625.1

Table D.14. (cont'd)

Taxa	Avg Freq[a]	D'/Acre[b]	D'/km^2	Presence[c]	Sp D'/km^2 [d]	Sp Density Modern[e]	Sp Density Algoma[f]	Sp Density Nipissing[g]
Claytonia virginica Spring beauty	10.4	460	113,666.0	19	21,596.5	12,391,382.0	12,098,338.5	11,909,843.9
Polygonatum spp. Solomon's-seal	19.3	852	210,529.2	76	160,002.2	91,803,977.7	89,632,908.0	88,236,408.8
Greens								
Chenopodium alba Goosefoot					51,451.2	121,939.3	109,591.1	133,258.6

a. Avgerage frequency for southern and northern mesic forest communities (Curtis 1959:521,535)

b. Density per acre calculated as: D' = $-1n\ (1-f)$

c. Presence calculated as mean presence in southern and northern mesic corest communities (Curtis 1959:521, 535)

d. Species density per km^2 calculated as density per km^2 x percentage presence

e. Modern species density calculated as species density/km^2 x 573.767 (area of soil 1 at modern lake level elevation) or 2.37 (estimated area of soil 1 floodplain at the modern lake level elevation)

f. Algoma species density calculated as species density/km^2 x 560.198 (area of soil 1 at Algoma lake level elevation) or 2.13 (estimated area of soil 1 floodplain at the Algoma lake level elevation)

g. Nipissing species density calculated as species density/km^2 x 551.47 (area of soil 1 at Nipissing lake level elevation) or 2.59 (estimated area of soil 1 floodplain at the Nipissing lake level elevation)

Table D.15. Estimated Densities of Edibile Understory Plants in Soil 2: Northern and Southern Wet-Mesic, Hemlock and Hardwood Community

Taxa	Avg Freq[a]	D'/Acre[b]	D'/km^2	Presence[c]	Sp D'/Km^2 [d]	Sp Density Modern[e]	Sp Density/ Algoma[f]	Sp Density/ Nipissing[g]
Fruits								
Ribes spp. Gooseberry/currant	6.7	268	66,222.8	43	28,475.8	66,925,657.0	53,828,581.1	46,426,039.6
Rubus sp. blackberry/raspberry	16	680	168,028.0	46	77,292.9	181,658,673.3	146,108,818.0	126,015,838.2
Sambucus pubens Red-berried elder	1.6	64	15,814.4	21	3,321.0	3,852.4	20,590.3	25,870.8
Vitis spp. Grape	1.7	68	16,802.8	29	4,872.8	5,652.5	30,211.4	37,959.2
Seeds								
Amaranthus spp. Pigweed					26,200.9	30,393.0	162,445.6	204,105.0
Chenopodium spp. Goosefoot					26,200.9	30,393.0	162,445.6	204,105.0
Polygonum spp. Knotweed					26,200.9	30,393.0	162,445.6	204,105.0
Roots/Tubers/Corms								
Apios americana Groundnut					22,503.4	26,103.9	139,521.1	175,301.5
Arisaema triphyllum Jack-in-the-pulpit	12	520	128,492.0	66	84,804.7	199,313,480.4	160,308,651.9	138,262,901.7
Helianthus tuberosus Jerusalum artichoke					22,503.4	26,103.9	139,521.1	175,301.5

Table D.15. (cont'd)

Taxa	Avg Freq[a]	D'/Acre[b]	D'/km^2	Presence[c]	Sp D'/Km^2 [d]	Sp Density Modern[e]	Sp Density/ Algoma[f]	Sp Density/ Nipissing[g]
Greens								
Aster spp. Aster	7.8	312	77,095.2	44	33,921.9	79,725,392.2	64,123,460.8	55,305,160.7
Caltha palustris Marsh–marigold	1.5	60	14,826.0	21	3,113.5	7,317,453.0	5,885,457.5	5,076,085.6
Chenopodium alba Goosefoot					26,200.9	30,393.0	162,445.6	204,105.0
Oxalis spp. Wood sorrel	8.1	324	80,060.4	21	16,812.7	39,514,245.9	31,781,470.5	27,410,862.0

[a] Avgerage frequency for southern and northern wet–mesic forest communities (Curtis 1959:532,546)

[b] Density per acre calculated as: $D' = -1n\ (1-f)$

[c] Presence calculated as mean presence in southern and northern wet–mesic forest communities (Curtis 1959:532, 546)

[d] Species density per km^2 calculated as density per km^2 x percentage presence

[e] Modern species density calculated as species density/km^2 x 2350.264 (area of soil 2 at the modern lake level elevation) or 1.16 (estimated area of soil 2 floodplain at the modern lake level elevation)

[f] Algoma species density calculated as species density/km^2 x 1890.327 (area of soil 2 at the Algoma lake level elevation) or 6.20 (estimated area of soil 2 floodplain at the Algoma lake level elevation)

[g] Nipissing species density calculated as species density/km^2 x 1630.368 (area of soil 2 at the Nipissing lake level elevation) or 7.79 (estimated area of soil 2 floodplain at the Nipissing lake level elevation)

Table D.16. Estimated Densities of Edible Understory Plants in Soil 3: Northern and Southern Mesic, Beech-Hardwood-Pine Community

Taxa	Avg Freq[a]	D'/Acre[b]	D'/km^2	Presence[c]	Sp D'/km^2 [d]	Sp Density/ Modern[e]	Sp Density/ Algoma[f]	Sp Density/ Nipissing[g]
Nuts								
Corylus cornuta Beaked-hazelnut	2.1	84	20,756.4	20.5	4,255.1	1,317,660.8	1,155,274.9	875,070.5
Fruits								
Ribes spp. Gooseberry/currant	1.6	64	15,814.4	23	3,637.3	1,126,362.8	987,552.0	748,027.8
Sambucus pubens Red-berried elder	0.9	36	8,895.6	22	1,957.0	6,888.8	6,301.6	6,086.4
Vitis spp. Grape					4,872.8	17,152.3	15,690.4	15,154.4
Seeds								
Amaranthus spp. Pigweed					59,602.5	209,800.8	191,920.1	185,363.8
Chenopodium spp. Goosefoot					59,602.5	209,800.8	191,920.1	185,363.8
Polygonum spp. Knotweed					59,602.5	209,800.8	191,920.1	185,363.8
Roots/Tubers/Corms								
Allium spp. Wild leek	4.7	188	46,454.8	39	18,117.4	5,610,388.5	4,918,975.2	3,725,910.0

Table 16. (cont'd)

Taxa	Avg Freq[e]	D'/Acre	D'/km^2	Presence	Sp D'/km2	Sp Density/ Modern	Sp Density/ Algoma	Sp Density/ Nipissing
Arisaema triphyllum Jack-in-the-pulpit	6.5	260	64,246.0	29	18,631.3	5,769,548.4	5,058,520.6	3,831,609.6
Claytonia virginica Spring beauty	10.4	460	113,666.0	19	21,596.5	6,687,778.9	5,863,590.2	4,441,414.8
Polygonatum spp. Solomon's-seal	19.3	852	210,529.2	76	160,002.2	49,547,718.8	43,441,555.1	32,905,090.8
Greens								
Chenopodium alba Goosefoot					59,602.5	209,800.8	191,920.1	185,363.8

[a] Avgerage frequency for southern and northern mesic forest communities (Curtis 1959:521,535)

[b] Density per acre calculated as: D' = -1n (1-f)

[c] Presence calculated as mean presence in southern and northern mesic corest communities (Curtis 1959:521, 535)

[d] Species density per km^2 calculated as density per km^2 x percentage presence

[e] Modern species densities calculated as species density/km^2 x 309.669 (area of soil 3 at the modern lake level elevation) or 3.52 (estimated area of soil 3 floodplain at the modern lake level elevation)

[f] Algoma species densities calculated as species density/km^2 x 271.506 (area of soil 3 at the Algoma lake level elevation) or 3.22 (estimated area of soil 3 floodplain at the Algoma lake level elevation)

[g] Nipissing species densities calculated as species density/km^2 x 205.654 (area of soil 3 at the Nipissing lake level elevation) or 3.11 (estimated area of soil 3 floodplain at the Nipissing lake level elevation)

Table D.17. Estimated Densities of Edible Understory Plants in Soil 4: Southern Mesic, Beech-Maple Community

Taxa	Avg Freq[a]	D'/Acre[b]	D'/km^2	Presence[c]	Sp D'/km^2 [d]	Sp Density/ Modern[e]	Sp Density/ Algoma[f]	Sp Density/ Nipissing[g]
Fruits								
Ribes spp. Gooseberry/currant	3.1	124	30,640.4	46	14,094.6	322,117.6	322,117.6	322,117.6
Vitis spp. Grape					4,872.8	1,510.6	1,510.6	1,510.6
Seeds								
Amaranthus spp. Pigweed					104,594.5	32,424.3	32,424.3	32,424.3
Chenopodium spp. Goosefoot					104,594.5	32,424.3	32,424.3	32,424.3
Polygonum spp. Knotweed					104,594.5	32,424.3	32,424.3	32,424.3
Roots/Tubers/Corms								
Allium spp. Wild leek	9.3	372	91,921.2	78	71,698.5	1,638,598.3	1,638,598.3	1,638,598.3
Arisaema triphyllum Jack-in-the-pulpit	12.9	556	137,387.6	57	78,310.9	1,789,718.0	1,789,718.0	1,789,718.0
Claytonia virginica Spring beauty	20.6	940	232,274.0	38	88,264.1	2,017,188.2	2,017,188.2	2,017,188.2
Polygonatum spp. Solomon's-seal	19.2	848	209,540.8	76	159,251.0	3,639,522.5	3,639,522.5	3,639,522.5

Table 17. (cont'd)

Taxa	Avg Freq[a]	D'/Acre[b]	D'/km^2	Presence[c]	Sp D'/km^2 [d]	Sp Density/ Modern[e]	Sp Density/ Algoma[f]	Sp Density/ Nipissing[g]
Greens								
Chenopodium alba Goosefoot					104,594.5	32,424.3	32,424.3	32,424.3

a. Avgerage frequency for southern mesic forest community (Curtis 1959:521)

b. Density per acre calculated as: D' = −1n (1−f)

c. Presence based on presence values in southern mesic forest communities (Curtis 1959:521)

d. Species density per km^2 calculated as density per km^2 x percentage presence

e. Modern species densities calculated as species density/km^2 x 22.854 (area of soil 4 at the modern lake level elevation) or 0.31 (estimated area of soil 4 floodplain at the modern lake level elevation)

f. Algoma species densities calculated as species density/km^2 x 22.854 (area of soil 4 at the Algoma lake level elevation) or 0.31 (estimated area of soil 4 floodplain at the Algoma lake level elevation)

g. Nipissing species densities calculated as species density/km^2 x 22.854 (area of soil 4 at the Nipissing lake level elevation) or 0.31 (estimated area of soil 4 floodplain at the Nipissing lake level elevation)

Table D.18. Estimated Densities of Edible Understory Plants in Soil 5: Southern and Northern Dry-Mesic, Hardwood Community

Taxa	Avg Freq[a]	D'/Acre[b]	D'/km^2	Presence[c]	Sp D'/km^2 [d]	Sp Density/ Modern[e]	Sp Density/ Algoma[f]	Sp Density/ Nipissing[g]
Nuts								
Corylus cornuta Beaked-hazelnut	8.7	348	85,990.8	34	29,236.9	2,910,121.3	1,082,319.8	889,736.5
Fruits								
Fragaria virginiana Strawberry	3	120	29,652.0	27	8,006.0	796,889.2	296,375.6	243,639.8
Ribes spp. Gooseberry/currant	2.1	84	20,756.4	42	8,717.7	867,723.8	322,720.1	265,296.7
Rubus sp. blackberry/raspberry	9.2	376	92,909.6	27	25,085.6	2,496,919.5	928,643.5	763,404.7
Vaccinium angustifolium Blueberry	4.1	164	40,524.4	24	9,725.9	968,072.8	360,041.5	295,977.2
Vibernum acerifolium Nannyberry	2.7	108	26,686.8	30	8,006.0	796,889.2	296,375.6	243,639.8
Vitis spp. Grape					4,872.8	5,019.0	3,508.4	4,239.3
Seeds								
Amaranthus spp. Pigweed					47,973.6	49,412.8	34,541.0	41,737.0
Chenopodium spp. Goosefoot					47,973.6	49,412.8	34,541.0	41,737.0
Polygonum spp. Knotweed					47,973.6	49,412.8	34,541.0	41,737.0

Table D.18. (cont'd)

Taxa	Avg Freq[c]	D'/Acre	D'/km^2	Presence	Sp D'/km^2	Sp Density/ Modern	Sp Density/ Algoma	Sp Density/ Nipissing
Roots/Tubers/Corms								
Allium spp. Wild leek	4.7	188	46,454.8	39	18,117.4	1,803,330.7	670,687.0	551,347.9
Arisaema triphyllum Jack-in-the-pulpit	6.5	260	64,246.0	29	18,631.3	1,854,489.1	689,713.6	566,988.9
Claytonia virginica Spring beauty	10.4	456	112,677.6	19	21,408.7	2,130,940.7	792,530.3	651,510.9
Polygonatum spp. Solomon's-seal	15.8	672	166,051.2	73	121,217.4	12,065,492.7	4,487,346.0	3,688,887.2
Greens								
Aster spp. Aster	18	72	17,791.2	45	8,006.0	796,889.2	296,375.6	243,639.8
Chenopodium alba Goosefoot					47,973.6	49,412.8	34,541.0	41,737.0

[a] Avgerage frequency for southern mesic and northern dry-mesic forest communities (Curtis 1959:521,539)

[b] Density per acre calculated as: D' = $-1n\ (1-f)$

[c] Presence calculated as mean presence in southern mesic and northern dry-mesic forest communities (Curtis 1959:521, 539)

[d] Species density per km^2 calculated as density per km^2 x percentage presence

[e] Modern species densities calculated as species density/km^2 x 99.536 km^2 (area of soil 5 at the modern lake level elevation) or 1.03 km^2 (estimated area of soil 5 floodplain at the modern lake level elevation)

[f] Algoma species densities calculated as species density/km^2 x 37.019 km^2 (area of soil 5 at the Algoma lake level elevation) or 0.72 km^2 (estimated area of soil 5 floodplain at the Algoma lake level elevation)

Table D.18. (cont'd)

[8] Nipissing species densities calculated as species density/km^2 x 30.432 km^2 (area of soil 5 at the Nipissing lake level elevation) or 0.87 km^2 (estimated area of soil 5 floodplain at the Nipissing lake level elevation)

Table D.19. Estimated Densities of Edible Understory Plants in Soil 6: Northern Mesic to Wet-Mesic, Lowland Swamp Community

Taxa	Avg Freq[a]	D'/Acre[b]	D'/km^2	Presence[c]	Sp D'/km^2 [d]	Sp Density/ Modern[e]	Sp Density/ Algoma[f]	Sp Density/ Nipissing[g]
Nuts								
Corylus cornuta Beaked-hazelnut	2.1	84	20,756.4	20.5	4,255.1	266,864.7	266,864.7	266,864.7
Fruits								
Ribes spp. Gooseberry/currant	3.3	132	32,617.2	19	6,197.3	388,674.1	388,674.1	388,674.1
Rubus sp. blackberry/raspberry	16	680	168,026.0	46	77,292.9	4,847,577.6	4,847,577.6	4,847,577.6
Roots/Tubers/Corms								
Arisaema triphyllum Jack-in-the-pulpit	3.4	136	33,605.6	33	11,089.8	695,522.0	695,522.0	695,522.0
Polygonatum spp. Solomon's-seal	9.7	420	103,782.0	41	42,550.6	2,668,647.2	2,668,647.2	2,668,647.2
Greens								
Aster spp. Aster	7.3	292	72,153.2	53	38,241.2	2,398,373.1	2,398,373.1	2,398,373.1
Caltha palustris Marsh-marigold	1.5	60	14,826.0	21	3,113.5	195,266.9	195,266.9	195,266.9
Oxalis spp. Wood sorrel	8.1	324	80,060.4	21	16,812.7	1,054,441.1	1,054,441.1	1,054,441.1

Table D.19. (cont'd)

[a] Avgerage frequency for northern wet–mesic and mesic forest communities (Curtis 1959:535, 546)

[b] Density per acre calculated as: $D' = -1n\ (1-f)$

[c] Presence calculated as mean presence in northern wet–mesic and mesic forest communities (Curtis 1959:535, 546)

[d] Species density per km^2 calculated as density per km^2 x percentage presence

[e] Modern species densities calculated as species density/km^2 x 62.717 km^2 (area of soil 6 at the modern lake level elevation)

[f] Algoma species densities calculated as species density/km^2 x 62.717 km^2 (area of soil 6 at the Algoma lake level elevation)

[g] Nipissing species densities calculated as species density/km^2 x 62.717 km^2 (area of soil 6 at the Nipissing lake level elevation)

Table D.20. Estimated Densities of Edible Understory Plants in Soil 7: Northern and Southern Wet-Mesic, Hardwood Community

Taxa	Avg Freq[a]	D'/Acre[b]	D'/km^2	Presence[c]	Sp D'/km^2 [d]	Sp Density/ Modern[e]	Sp Density/ Algoma[f]	Sp Density/ Nipissing[g]
Fruits								
Ribes spp. Gooseberry/currant	6.7	268	66,222.8	43	28,475.8	2,907,806.7	2,084,628.2	1,667,913.3
Rubus sp. blackberry/raspberry	16	680	168,028.0	46	77,292.9	7,892,762.4	5,658,379.9	4,527,275.9
Sambucus pubens Red-berried elder	1.6	64	15,814.4	21	3,321.0	1,893.0	3,188.2	2,125.5
Vitis spp. Grape	1.7	68	16,802.8	29	4,872.8	2,777.5	4,677.9	3,118.6
Seeds								
Amaranthus spp. Pigweed					28,772.3	16,400.2	27,621.4	18,414.3
Chenopodium spp. Goosefoot					28,772.3	16,400.2	27,621.4	18,414.3
Polygonum spp. Knotweed					28,772.3	16,400.2	27,621.4	18,414.3
Roots/Tubers/Corms								
Apios americana Groundnut					45,006.8	25,653.9	43,206.5	28,804.4
Arisaema triphyllum Jack-in-the-pulpit	12	520	128,492.0	66	84,804.7	8,659,834.0	6,208,299.1	4,967,266.9
Helianthus tuberosus Jerusalum artichoke					45,006.8	25,653.9	43,206.5	28,804.4

Table D.20. (cont'd)

Taxa	Avg Freq[a]	D'/Acre[b]	D'/km^2	Presence[c]	Sp D'/km^2 [d]	Sp Density/ Modern[e]	Sp Density/ Algoma[f]	Sp Density/ Nipissing[g]
Polygonatum spp. Solomon's-seal	3.1	124	30,640.4	17	5,208.9	531,903.6	381,325.6	305,099.0
Greens								
Aster spp. Aster	7.8	312	77,095.2	44	33,921.9	3,463,933.6	2,483,319.7	1,986,906.7
Caltha palustris Marsh-marigold	1.5	60	14,826.0	21	3,113.5	317,931.0	227,927.1	182,364.7
Chenopodium alba Goosefoot					28,772.3	16,400.2	27,621.4	18,414.3
Oxalis spp. Wood sorrel	8.1	324	80,060.4	21	16,812.7	1,716,827.2	1,230,806.2	984,769.3

a. Avgerage frequency for southern and northern wet-mesic forest communities (Curtis 1959:532, 546)

b. Density per acre calculated as: D' = $-1n\ (1-f)$

c. Presence calculated as mean presence in southern and northern wet-mesic forest communities (Curtis 1959:532, 546)

d. Species density per km^2 calculated as density per km^2 x percentage presence

e. Modern species densities calculated as species density/km^2 x 102.115 km^2 (area of soil 7 at the modern lake level elevation) or 0.57 km^2 (estimated area of soil 7 floodplain at the modern lake level elevation)

f. Algoma species density calculated as species density/km^2 x 73.207 km^2 (area of soil 7 at the Algoma lake level elevation) or 0.96 km^2 (estimated area of soil 7 floodplain at the Algoma lake level elevation)

g. Nipissing species densities calculated as species density/km^2 x 58.573 km^2 (area of soil 7 at the Nipissing lake level elevation) or 0.64 km^2 (estimated area of soil 7 floodplain at the Nipissing lake level elevation)

Table D.21. Estimated Importance Values of Edible Plants in Cattail Marsh Communities

Taxa	IV WI[b]
Roots/Tubers/Corms	
Sagitaria latifolia Arrowhead, wapato	10.3
Scirpus spp. Bullrush	35
Typha spp. Cattail	30

APPENDIX E-1:

Simulated Resource Choices Based on Taste

Resource choices for the month of June.

Gender: F Kgs: 1.28 Resource: Strawberry
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 6

	Males	Collective	Females	Total
kcal[1]	65937.50	941.64	473.60	67352.73
prot[2]	11183.00	1408.04	20.74	12611.77
vita[3]	435715.00	0.00	1114.50	436829.50
vitc[4]	0.00	0.00	547.07	547.07
thia[5]	158.25	3.87	0.38	162.50
ribo[6]	200.45	7.09	0.77	208.31
niac[7]	3613.38	490.20	11.78	4115.35
calc[8]	7648.75	835.92	391.42	8876.09
phos[9]	113940.00	15999.22	295.42	130234.65
iron	2637.50	170.28	12.03	2819.81

Gender: F Kgs: 1.23 Resource: Mussels
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.21 Resource: Waterfowl/Winter & Summer
Requirements met: 7

	Males	Collective	Females	Total
kcal	75396.41	13789.57	1187.00	90372.98
prot	11751.17	3613.99	116.68	15481.84
vita	435715.00	26092.00	1323.60	463130.59
vitc	0.00	0.00	550.27	550.27
thia	161.14	14.54	0.51	176.19
ribo	207.51	41.49	3.23	252.23
niac	3810.79	1095.06	22.85	4928.70
calc	8044.54	1132.42	4327.42	13504.39
phos	119974.80	37821.62	6691.42	164487.84
iron	2705.87	549.80	162.09	3417.77

---

[1] Calories

[2] Protein

[3] Vitamin A

[4] Vitamin C

[5] Thiamin

[6] Riboflavin

[7] Niacin

[8] Calcium

[9] Phosphorous

Gender: F Kgs: 1.80 Resource: Jack-In-The-Pulpit
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 7

	Males	Collective	Females	Total
kcal	105683.60	91904.77	2858.12	200446.48
prot	14137.47	17720.23	192.82	32050.52
vita	454159.81	26092.00	33198.54	513450.34
vitc	188.64	1516.80	797.59	2503.03
thia	168.48	97.97	2.85	269.29
ribo	243.14	117.33	4.49	364.96
niac	4009.91	2573.94	47.51	6631.36
calc	9616.54	37156.42	5859.76	52632.73
phos	147432.39	185330.42	7879.96	340642.78
iron	3324.19	929.00	188.19	4441.39

Gender: F Kgs: 1.35 Resource: Groundnut
Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 7

	Males	Collective	Females	Total
kcal	106398.58	91904.77	4329.62	202632.97
prot	14260.23	17720.23	285.97	32266.43
vita	455611.81	26092.00	57104.74	538808.56
vitc	188.64	1516.80	983.08	2688.52
thia	169.07	97.97	4.60	271.64
ribo	245.06	117.33	5.43	367.82
niac	4043.57	2573.94	66.00	6683.51
calc	9633.04	37156.42	7009.02	53798.48
phos	148646.80	185330.42	8771.37	342748.59
iron	3345.31	929.00	207.77	4482.08

Gender: F Kgs: 1.35 Resource: Jerusalem Artichoke
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 7

	Males	Collective	Females	Total
kcal	115757.08	91904.77	5387.48	213049.33
prot	15698.87	17720.23	303.38	33722.48
vita	485926.00	26092.00	57494.89	569512.88
vitc	243.69	1516.80	1050.58	2811.07
thia	190.72	97.97	7.30	295.99
ribo	264.14	117.33	6.24	387.71
niac	4352.95	2573.94	76.13	7003.02
calc	9963.34	37156.42	7075.84	54195.61
phos	158335.59	185330.42	9683.02	353349.03
iron	3481.10	929.00	231.26	4641.36

Gender: F Kgs: 1.53 Resource: Spring Beauty
Gender: M Kgs: 6.57 Resource: Muskrat
Requirements met: 7

	Males	Collective	Females	Total
kcal	124560.88	91904.77	6807.93	223273.58
prot	17487.22	17720.23	368.10	35575.55
vita	671200.00	26092.00	84588.59	781880.62
vitc	342.24	1516.80	1260.80	3119.84
thia	201.23	97.97	9.29	308.49
ribo	277.94	117.33	7.31	402.58
niac	4393.68	2573.94	97.09	7064.71
calc	11605.84	37156.42	8378.33	57140.59
phos	172789.59	185330.42	10693.28	368813.31
iron	3980.42	929.00	257.88	5167.30

Gender: F Kgs: 1.44 Resource: Wild Leek
Requirements met: 7

	Males	Collective	Females	Total
kcal	124560.88	91904.77	7830.33	224295.97
prot	17487.22	17720.23	424.69	35632.14
vita	671200.00	26092.00	113867.40	811159.38
vitc	342.24	1516.80	1539.15	3398.19
thia	201.23	97.97	11.16	310.36
ribo	277.94	117.33	8.61	403.88
niac	4393.68	2573.94	129.20	7096.82
calc	11605.84	37156.42	9606.65	58368.91
phos	172789.59	185330.42	12200.39	370320.41
iron	3980.42	929.00	288.55	5197.97

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Requirements met: 8

	Males	Collective	Females	Total
kcal	124560.88	91904.77	93430.33	309895.97
prot	17487.22	17720.23	4424.69	39632.14
vita	671200.00	26092.00	113867.40	811159.38
vitc	342.24	1516.80	5539.15	7398.19
thia	201.23	97.97	123.16	422.36
ribo	277.94	117.33	40.61	435.88
niac	4393.68	2573.94	241.20	7208.82
calc	11605.84	37156.42	20006.65	68768.91
phos	172789.59	185330.42	144200.39	502320.41
iron	3980.42	929.00	1680.55	6589.97

Gender: F Kgs: 1.49 Resource: Goosefoot (greens)
Requirements met: 8

	Males	Collective	Females	Total
kcal	124560.88	91904.77	94105.74	310571.38
prot	17487.22	17720.23	4492.64	39700.09
vita	671200.00	26092.00	209441.95	906733.94
vitc	342.24	1516.80	6555.48	8414.52
thia	201.23	97.97	124.50	423.71
ribo	277.94	117.33	44.19	439.45
niac	4393.68	2573.94	252.37	7220.00
calc	11605.84	37156.42	24178.65	72940.91
phos	172789.59	185330.42	147150.59	505270.62
iron	3980.42	929.00	1711.84	6621.26

Gender: F Kgs: 2.56 Resource: Aquatic turtle
Requirements met: 9

	Males	Collective	Females	Total
kcal	124560.88	91904.77	95879.05	312344.69
prot	17487.22	17720.23	4897.12	40104.57
vita	671200.00	26092.00	209935.27	907227.25
vitc	342.24	1516.80	6606.68	8465.72
thia	201.23	97.97	130.14	429.34
ribo	277.94	117.33	62.36	457.63
niac	4393.68	2573.94	431.57	7399.20
calc	11605.84	37156.42	26917.85	75680.11
phos	172789.59	185330.42	152782.59	510902.62
iron	3980.42	929.00	1763.04	6672.46

Total stored nutrients[10]: June

kcal	6328.02
prot	323.21
vita	13855.73
vitc	436.04
thia	8.59
ribo	4.12
niac	28.48
calc	1776.58
phos	10083.65
iron	116.36

Resource choices for the month of July.

Gender: F Kgs: 0.34 Resource: Mulberry
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 6

	Males	Collective	Females	Total
kcal	65937.50	941.64	189.14	67068.28
prot	11183.00	1408.04	3.98	12595.01
vita	435715.00	0.00	56.68	435771.69
vitc	0.00	0.00	51.00	51.00
thia	158.25	3.87	0.10	162.22
ribo	200.45	7.09	0.31	207.85
niac	3613.38	490.20	3.06	4106.63
calc	7648.75	835.92	193.80	8678.47
phos	113940.00	15999.22	130.90	130070.12
iron	2637.50	170.28	6.97	2814.75

Gender: F Kgs: 35.98 Resource: Blackberry/Raspberry
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.21 Resource: Waterfowl/Winter & Summer
Requirements met: 8

	Males	Collective	Females	Total
kcal	75396.41	13789.57	24651.95	113837.92
prot	11751.17	3613.99	442.93	15808.10
vita	435715.00	26092.00	55825.68	517632.69
vitc	0.00	0.00	7667.97	7667.97
thia	161.14	14.54	10.90	186.58
ribo	207.51	41.49	21.89	270.89
niac	3810.79	1095.06	208.15	5114.00
calc	8044.54	1132.42	11826.13	21003.10
phos	119974.80	37821.62	9305.80	167102.22
iron	2705.87	549.80	330.79	3586.46

Gender: F Kgs: 13.32 Resource: Gooseberry/Currant
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	105683.60	91904.77	31666.26	229254.62
prot	14137.47	17720.23	634.74	32492.44
vita	454159.81	26092.00	80467.67	560719.50
vitc	188.64	1516.80	20010.28	21715.72

---

[10] An additional 33% of female/juvenile resource choices are contributed to storage.

	Males	Collective	Females	Total
thia	168.48	97.97	16.22	282.67
ribo	243.14	117.33	22.56	383.03
niac	4009.91	2573.94	229.46	6813.31
calc	9616.54	37156.42	16857.10	63630.06
phos	147432.39	185330.42	13241.86	346004.69
iron	3324.19	929.00	456.00	4709.19

Gender: F Kgs: 1.23 Resource: Mussels
Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 8

	Males	Collective	Females	Total
kcal	106398.58	91904.77	32379.66	230683.00
prot	14260.23	17720.23	730.68	32711.14
vita	455611.81	26092.00	80676.77	562380.56
vitc	188.64	1516.80	20013.47	21718.91
thia	169.07	97.97	16.35	283.38
ribo	245.06	117.33	25.02	387.41
niac	4043.57	2573.94	240.53	6858.04
calc	9633.04	37156.42	20793.10	67582.56
phos	148646.80	185330.42	19637.86	353615.06
iron	3345.31	929.00	606.06	4880.37

Gender: F Kgs: 1.80 Resource: Jack-In-The-Pulpit
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	115757.08	91904.77	34050.78	241712.62
prot	15698.87	17720.23	806.82	34225.92
vita	485926.00	26092.00	112551.71	624569.69
vitc	243.69	1516.80	20260.79	22021.29
thia	190.72	97.97	18.69	307.38
ribo	264.14	117.33	26.28	407.75
niac	4352.95	2573.94	265.19	7192.08
calc	9963.34	37156.42	22325.44	69445.20
phos	158335.59	185330.42	20826.40	364492.41
iron	3481.10	929.00	632.16	5042.26

Gender: F Kgs: 1.35 Resource: Groundnut
Gender: M Kgs: 6.57 Resource: Muskrat
Requirements met: 8

	Males	Collective	Females	Total
kcal	124560.88	91904.77	35522.28	251987.92
prot	17487.22	17720.23	899.97	36107.43
vita	671200.00	26092.00	136457.92	833749.94
vitc	342.24	1516.80	20446.29	22305.32
thia	201.23	97.97	20.44	319.64
ribo	277.94	117.33	27.23	422.49
niac	4393.68	2573.94	283.68	7251.31
calc	11605.84	37156.42	23474.69	72236.95
phos	172789.59	185330.42	21717.80	379837.81
iron	3980.42	929.00	651.73	5561.16

Gender: F Kgs: 1.35 Resource: Jerusalem Artichoke
Requirements met: 8

	Males	Collective	Females	Total
kcal	124560.88	91904.77	36580.14	253045.78
prot	17487.22	17720.23	917.39	36124.84
vita	671200.00	26092.00	136848.08	834140.06
vitc	342.24	1516.80	20513.79	22372.82

	Males	Collective	Females	Total
thia	201.23	97.97	23.14	322.34
ribo	277.94	117.33	28.03	423.30
niac	4393.68	2573.94	293.81	7261.43
calc	11605.84	37156.42	23541.52	72303.78
phos	172789.59	185330.42	22629.46	380749.47
iron	3980.42	929.00	675.22	5584.65

Gender: F Kgs: 1.44 Resource: Wild Leek
Requirements met: 8

	Males	Collective	Females	Total
kcal	124560.88	91904.77	37602.54	254068.17
prot	17487.22	17720.23	973.98	36181.43
vita	671200.00	26092.00	166126.88	863418.88
vitc	342.24	1516.80	20792.14	22651.18
thia	201.23	97.97	25.01	324.22
ribo	277.94	117.33	29.33	424.60
niac	4393.68	2573.94	325.92	7293.54
calc	11605.84	37156.42	24769.84	73532.10
phos	172789.59	185330.42	24136.56	382256.56
iron	3980.42	929.00	705.89	5615.32

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Requirements met: 9

	Males	Collective	Females	Total
kcal	124560.88	91904.77	123202.53	339668.19
prot	17487.22	17720.23	4973.98	40181.43
vita	671200.00	26092.00	166126.88	863418.88
vitc	342.24	1516.80	24792.14	26651.18
thia	201.23	97.97	137.01	436.22
ribo	277.94	117.33	61.33	456.60
niac	4393.68	2573.94	437.92	7405.54
calc	11605.84	37156.42	35169.84	83932.09
phos	172789.59	185330.42	156136.56	514256.56
iron	3980.42	929.00	2097.90	7007.32

Total stored nutrients: June and July

kcal	14459.39
prot	651.49
vita	24820.10
vitc	2072.32
thia	17.63
ribo	8.16
niac	57.39
calc	4097.79
phos	20388.66
iron	254.82

Resource choices for the month of August.

Gender: F Kgs: 9.09 Resource: Wild Black Cherry
Gender: C Kgs: 57.57 Resource: Waterfowl/March, Aug, Oct
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal	65937.50	169641.52	6403.91	241982.92
prot	11183.00	10189.89	145.44	21518.33
vita	435715.00	0.00	9691.76	445406.75
vitc	0.00	0.00	894.46	894.46

	Males	Collective	Females	Total
thia	158.25	51.81	4.55	214.61
ribo	200.45	126.65	5.45	332.56
niac	3613.38	3540.55	36.36	7190.29
calc	7648.75	7098.38	3637.82	18384.95
phos	113940.00	108231.60	3575.10	225746.70
iron	2637.50	1226.24	106.35	3970.09

Gender: F Kgs: 35.98 Resource: Blackberry/Raspberry
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	96224.70	170583.16	30866.71	297674.56
prot	13569.30	11597.92	584.40	25751.62
vita	454159.81	0.00	65460.76	519620.56
vitc	188.64	0.00	8511.42	8700.06
thia	165.59	55.68	15.34	236.61
ribo	236.08	133.75	27.04	396.87
niac	3812.49	4030.75	241.45	8084.70
calc	9220.75	7934.30	15270.15	32425.20
phos	141397.59	124230.83	12750.00	278378.41
iron	3255.82	1396.52	430.17	5082.51

Gender: F Kgs: 12.08 Resource: Grape
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 9

	Males	Collective	Females	Total
kcal	96939.67	183431.09	42086.61	322457.38
prot	13692.06	13803.88	832.04	28327.98
vita	455611.81	26092.00	74467.60	556171.44
vitc	188.64	0.00	9067.10	9255.74
thia	166.18	66.36	20.17	252.71
ribo	238.00	168.14	31.87	438.01
niac	3846.15	4635.61	317.55	8799.32
calc	9237.25	8230.80	21869.46	39337.51
phos	142612.00	146053.23	17445.49	306110.72
iron	3276.94	1776.04	549.77	5602.75

Total stored nutrients: June, July, and August.

kcal	17237.10
prot	706.41
vita	29734.96
vitc	2670.75
thia	18.96
ribo	10.27
niac	78.34
calc	5541.17
phos	21540.07
iron	291.11

Resource choices for the month of September.

Gender: F Kgs: 2.52 Resource: Beaked-hazelnut
Gender: C Kgs: 115.14 Resource: Waterfowl/April, Sept
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	65937.50	339283.03	18446.40	423666.94
prot	11183.00	20379.78	592.20	32154.98
vita	435715.00	0.00	0.00	435715.00
vitc	0.00	0.00	0.00	0.00
thia	158.25	103.63	10.08	271.96
ribo	200.45	253.31	4.03	457.79
niac	3613.38	7081.11	32.76	10727.25
calc	7648.75	14196.76	5040.00	26885.51
phos	113940.00	216463.20	7560.00	337963.19
iron	2637.50	2452.48	75.60	5165.58

Gender: F Kgs: 2.64 Resource: Elderberry
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 9

	Males	Collective	Females	Total
kcal	96224.70	430237.03	20347.20	546808.94
prot	13569.30	81015.77	660.84	95245.91
vita	454159.81	756.32	15840.00	470756.12
vitc	188.64	3025.28	950.40	4164.32
thia	165.59	256.85	11.93	434.36
ribo	236.08	859.67	5.62	1101.37
niac	3812.49	7081.11	45.96	10939.56
calc	9220.75	19500.78	6043.20	34764.73
phos	141397.59	350654.56	8299.20	500351.34
iron	3255.82	3208.80	117.84	6582.46

Total stored nutrients: June, July, August, and September.

kcal	18580.02
prot	750.02
vita	30780.40
vitc	2733.48
thia	19.75
ribo	10.64
niac	81.38
calc	5940.02
phos	22087.81
iron	298.88

Resource choices for the month of October.

Gender: F Kgs: 16.17 Resource: Hickory
Gender: C Kgs: 57.57 Resource: Waterfowl/March, Aug, Oct
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	65937.50	169641.52	110441.10	346020.12
prot	11183.00	10189.89	2118.27	23491.16
vita	435715.00	0.00	24255.00	459970.00
vitc	0.00	0.00	161.70	161.70
thia	158.25	51.81	54.98	265.04
ribo	200.45	126.65	42.04	369.15
niac	3613.38	3540.55	129.36	7283.29
calc	7648.75	7098.38	808.50	15555.63
phos	113940.00	108231.60	58212.00	280383.59
iron	2637.50	1226.24	388.08	4251.82

Gender: F Kgs: 2.97 Resource: Butternut .
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	96224.70	260595.52	128335.35	485155.56
prot	13569.30	70825.89	2790.98	87186.16
vita	454159.81	756.32	33165.00	488081.12
vitc	188.64	3025.28	221.10	3435.02
thia	165.59	205.03	61.51	432.13
ribo	236.08	733.01	45.31	1014.40
niac	3812.49	3540.55	150.15	7503.20
calc	9220.75	12402.40	1105.50	22728.65
phos	141397.59	242422.97	75141.00	458961.56
iron	3255.82	1982.56	578.16	5816.54

Gender: F Kgs: 0.38 Resource: Black walnut
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 8

	Males	Collective	Females	Total
kcal	96939.67	261537.16	130704.16	489181.00
prot	13692.06	72233.92	2848.77	88774.75
vita	455611.81	756.32	34305.00	490673.12
vitc	188.64	3025.28	228.70	3442.62
thia	166.18	208.90	62.35	437.43
ribo	238.00	740.11	45.73	1023.83
niac	3846.15	4030.75	152.81	8029.72
calc	9237.25	13238.32	1143.50	23619.07
phos	142612.00	258422.19	77307.00	478341.19
iron	3276.94	2152.84	600.96	6030.74

Gender: F Kgs: 1.35 Resource: Groundnut
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	106298.17	274385.09	132175.66	512858.94
prot	15130.70	74439.88	2941.92	92512.50
vita	485926.00	26848.32	58211.21	570985.50
vitc	243.69	3025.28	414.19	3683.16
thia	187.83	219.58	64.10	471.51
ribo	257.08	774.50	46.67	1078.25
niac	4155.54	4635.61	171.30	8962.46
calc	9567.55	13534.82	2292.75	25395.12
phos	152300.80	280244.59	78198.41	510743.81
iron	3412.73	2532.36	620.54	6565.63

Gender: F Kgs: 1.35 Resource: Jerusalem Artichoke
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 6.57 Resource: Muskrat
Requirements met: 9

	Males	Collective	Females	Total
kcal	115101.97	352500.28	133233.52	600835.75
prot	16919.05	88546.12	2959.34	108424.52
vita	671200.00	26848.32	58601.36	756649.69
vitc	342.24	4542.08	481.69	5366.01
thia	198.34	303.00	66.80	568.15
ribo	270.88	850.34	47.48	1168.70
niac	4196.27	6114.49	181.43	10492.19
calc	11210.05	49558.82	2359.58	63128.45

	Males	Collective	Females	Total
phos	166754.80	427753.38	79110.06	673618.25
iron	3912.05	2911.56	644.03	7467.64

Total of stored nutrients: June, July, August, September and October.

kcal	27373.43
prot	945.34
vita	34648.09
vitc	2765.27
thia	24.16
ribo	13.77
niac	93.35
calc	6095.76
phos	27309.08
iron	341.39

Resource choices for the months of November through February

Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 1.07 Resource: Bear
Gender: F Kgs: 20.81 Resource: Stored foods
Requirements met: 0

	Males	Collective	Females	Total
kcal	1436.90	941.64	27373.43	29751.97
prot	246.10	1408.04	945.34	2599.47
vita	5895.70	0.00	34648.09	40543.79
vitc	13.91	0.00	2765.27	2779.18
thia	9.10	3.87	24.16	37.12
ribo	5.03	7.09	13.77	25.90
niac	72.97	490.20	93.35	656.53
calc	0.00	835.92	6095.76	6931.68
phos	2279.10	15999.22	27309.08	45587.40
iron	32.10	170.28	341.39	543.77

Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal	67374.41	13789.57	27373.43	108537.41
prot	11429.10	3613.99	945.34	15988.43
vita	441610.69	26092.00	34648.09	502350.78
vitc	13.91	0.00	2765.27	2779.18
thia	167.35	14.54	24.16	206.05
ribo	205.48	41.49	13.77	260.74
niac	3686.35	1095.06	93.35	4874.76
calc	7648.75	1132.42	6095.76	14876.93
phos	116219.10	37821.62	27309.08	181349.81
iron	2669.60	549.80	341.39	3560.79

Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 53.08 Resource: Elk
Requirements met: 8

	Males	Collective	Females	Total
kcal	133724.41	91904.77	27373.43	253002.61
prot	22682.06	17720.23	945.34	41347.63
vita	880051.50	26092.00	34648.09	940791.56
vitc	13.91	1516.80	2765.27	4295.98
thia	326.59	97.97	24.16	448.71
ribo	407.18	117.33	13.77	538.28

	Males	Collective	Females	Total
niac	7322.33	2573.94	93.35	9989.62
calc	15345.35	37156.42	6095.76	58597.52
phos	230871.91	185330.42	27309.08	443511.41
iron	5323.60	929.00	341.39	6593.99

Gender: M Kgs: 3.21 Resource: Waterfowl/Winter & Summer
Requirements met: 8

	Males	Collective	Females	Total
kcal	143183.31	91904.77	27373.43	262461.50
prot	23250.23	17720.23	945.34	41915.80
vita	880051.50	26092.00	34648.09	940791.56
vitc	13.91	1516.80	2765.27	4295.98
thia	329.47	97.97	24.16	451.60
ribo	414.25	117.33	13.77	545.35
niac	7519.74	2573.94	93.35	10187.04
calc	15741.14	37156.42	6095.76	58993.32
phos	236906.70	185330.42	27309.08	449546.19
iron	5391.97	929.00	341.39	6662.36

Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	173470.52	91904.77	27373.43	292748.72
prot	25636.53	17720.23	945.34	44302.10
vita	898496.31	26092.00	34648.09	959236.38
vitc	202.55	1516.80	2765.27	4484.62
thia	336.81	97.97	24.16	458.94
ribo	449.88	117.33	13.77	580.98
niac	7718.86	2573.94	93.35	10386.16
calc	17313.14	37156.42	6095.76	60565.32
phos	264364.31	185330.42	27309.08	477003.81
iron	6010.29	929.00	341.39	7280.68

Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 8

	Males	Collective	Females	Total
kcal	174185.50	91904.77	27373.43	293463.69
prot	25759.29	17720.23	945.34	44424.86
vita	899948.31	26092.00	34648.09	960688.38
vitc	202.55	1516.80	2765.27	4484.62
thia	337.40	97.97	24.16	459.53
ribo	451.79	117.33	13.77	582.89
niac	7752.52	2573.94	93.35	10419.82
calc	17329.64	37156.42	6095.76	60581.82
phos	265578.72	185330.42	27309.08	478218.22
iron	6031.41	929.00	341.39	7301.80

Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	183544.00	91904.77	27373.43	302822.19
prot	27197.93	17720.23	945.34	45863.50
vita	930262.50	26092.00	34648.09	991002.56
vitc	257.60	1516.80	2765.27	4539.67
thia	359.06	97.97	24.16	481.18
ribo	470.88	117.33	13.77	601.98
niac	8061.91	2573.94	93.35	10729.20
calc	17659.94	37156.42	6095.76	60912.12
phos	275267.53	185330.42	27309.08	487907.03

	Males	Collective	Females	Total
iron	6167.20	929.00	341.39	7437.59

Gender: M Kgs: 6.57 Resource: Muskrat
Requirements met: 9

	Males	Collective	Females	Total
kcal	192347.80	91904.77	27373.43	311626.00
prot	28986.28	17720.23	945.34	47651.85
vita	1115536.50	26092.00	34648.09	1176276.62
vitc	356.15	1516.80	2765.27	4638.22
thia	369.57	97.97	24.16	491.70
ribo	484.67	117.33	13.77	615.77
niac	8102.64	2573.94	93.35	10769.93
calc	19302.44	37156.42	6095.76	62554.62
phos	289721.53	185330.42	27309.08	502361.03
iron	6666.52	929.00	341.39	7936.91

Resource choices for the month of March.

Gender: C Kgs: 57.57 Resource: Waterfowl/March, Aug, Oct
Gender: M Kgs: 1.07 Resource: Bear
Gender: F Kgs: 20.81 Resource: Stored foods
Requirements met: 3

	Males	Collective	Females	Total
kcal	1436.90	169641.52	27373.43	198451.86
prot	246.10	10189.89	945.34	11381.33
vita	5895.70	0.00	34648.09	40543.79
vitc	13.91	0.00	2765.27	2779.18
thia	9.10	51.81	24.16	85.07
ribo	5.03	126.65	13.77	145.45
niac	72.97	3540.55	93.35	3706.88
calc	0.00	7098.38	6095.76	13194.14
phos	2279.10	108231.60	27309.08	137819.78
iron	32.10	1226.24	341.39	1599.73

Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal	67374.41	170583.16	27373.43	265331.00
prot	11429.10	11597.92	945.34	23972.36
vita	441610.69	0.00	34648.09	476258.78
vitc	13.91	0.00	2765.27	2779.18
thia	167.35	55.68	24.16	247.19
ribo	205.48	133.75	13.77	353.00
niac	3686.35	4030.75	93.35	7810.46
calc	7648.75	7934.30	6095.76	21678.81
phos	116219.10	124230.83	27309.08	267759.00
iron	2669.60	1396.52	341.39	4407.51

Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 53.08 Resource: Elk
Requirements met: 8

	Males	Collective	Females	Total
kcal	133724.41	183431.09	27373.43	344528.94
prot	22682.06	13803.88	945.34	37431.29
vita	880051.50	26092.00	34648.09	940791.56
vitc	13.91	0.00	2765.27	2779.18
thia	326.59	66.36	24.16	417.10

	Males	Collective	Females	Total
ribo	407.18	168.14	13.77	589.10
niac	7322.33	4635.61	93.35	12051.30
calc	15345.35	8230.80	6095.76	29671.91
phos	230871.91	146053.23	27309.08	404234.22
iron	5323.60	1776.04	341.39	7441.03

Gender: C Kgs: 1921.82 Resource: Maple Sap
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	164011.61	321802.12	27373.43	513187.16
prot	25068.36	13803.88	945.34	39817.58
vita	898496.31	30512.19	34648.09	963656.56
vitc	202.55	0.00	2765.27	2967.82
thia	333.92	66.36	24.16	424.44
ribo	442.82	168.14	13.77	624.73
niac	7521.45	4635.61	93.35	12250.42
calc	16917.35	65308.86	6095.76	88321.96
phos	258329.50	150473.42	27309.08	436112.00
iron	5941.92	2352.59	341.39	8635.90

Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 9

	Males	Collective	Females	Total
kcal	164726.59	399917.31	27373.43	592017.31
prot	25191.12	27910.12	945.34	54046.58
vita	899948.31	30512.19	34648.09	965108.56
vitc	202.55	1516.80	2765.27	4484.62
thia	334.52	149.78	24.16	508.46
ribo	444.73	243.98	13.77	702.48
niac	7555.11	6114.49	93.35	13762.96
calc	16933.85	101332.85	6095.76	124362.46
phos	259543.91	297982.22	27309.08	584835.19
iron	5963.04	2731.79	341.39	9036.22

Resource choices for the month of April.

Gender: F Kgs: 1.80 Resource: Jack-In-The-Pulpit
Gender: C Kgs: 115.14 Resource: Waterfowl/April, Sept
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	65937.50	339283.03	1671.12	406891.66
prot	11183.00	20379.78	76.14	31638.92
vita	435715.00	0.00	31874.94	467589.94
vitc	0.00	0.00	247.32	247.32
thia	158.25	103.63	2.34	264.22
ribo	200.45	253.31	1.26	455.02
niac	3613.38	7081.11	24.66	10719.14
calc	7648.75	14196.76	1532.34	23377.85
phos	113940.00	216463.20	1188.54	331591.75
iron	2637.50	2452.48	26.10	5116.08

Gender: F Kgs: 1.35 Resource: Groundnut
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	96224.70	430237.03	3142.62	529604.38
prot	13569.30	81015.77	169.29	94754.36
vita	454159.81	756.32	55781.15	510697.28
vitc	188.64	3025.28	432.81	3646.73
thia	165.59	256.85	4.09	426.53
ribo	236.08	859.67	2.20	1097.95
niac	3812.49	7081.11	43.15	10936.76
calc	9220.75	19500.78	2681.59	31403.13
phos	141397.59	350654.56	2079.94	494132.09
iron	3255.82	3208.80	45.67	6510.30

Gender: F Kgs: 1.53 Resource: Spring Beauty
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 8

	Males	Collective	Females	Total
kcal	96939.67	431178.66	4563.07	532681.38
prot	13692.06	82423.80	234.01	96349.87
vita	455611.81	756.32	82874.85	539243.00
vitc	188.64	3025.28	643.03	3856.95
thia	166.18	260.72	6.08	432.98
ribo	238.00	866.76	3.28	1108.03
niac	3846.15	7571.31	64.12	11481.58
calc	9237.25	20336.70	3984.08	33558.04
phos	142612.00	366653.78	3090.20	512356.00
iron	3276.94	3379.08	72.30	6728.32

Gender: F Kgs: 0.09 Resource: Marsh-marigold
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	106298.17	444026.59	4593.10	554917.88
prot	15130.70	84629.77	236.71	99997.17
vita	485926.00	26848.32	88647.81	601422.12
vitc	243.69	3025.28	704.42	3973.39
thia	187.83	271.39	6.16	465.39
ribo	257.08	901.16	3.49	1161.73
niac	4155.54	8176.17	64.87	12396.58
calc	9567.55	20633.20	4129.76	34330.51
phos	152300.80	388476.19	3147.07	543924.06
iron	3412.73	3758.60	77.27	7248.61

Gender: F Kgs: 0.47 Resource: Wood sorrel
Gender: C Kgs: 113.88 Resource: Fish/Spring
Gender: M Kgs: 6.57 Resource: Muskrat
Requirements met: 9

	Males	Collective	Females	Total
kcal	115101.97	561323.00	4749.89	681174.88
prot	16919.05	105811.45	250.81	122981.30
vita	671200.00	26848.32	118795.49	816843.81
vitc	342.24	5302.88	1025.01	6670.13
thia	198.34	396.66	6.59	601.59
ribo	270.88	1015.04	4.62	1290.53
niac	4196.27	10396.83	68.82	14661.92
calc	11210.05	74726.20	4890.50	90826.75
phos	166754.80	609972.81	3444.07	780171.69
iron	3912.05	4328.00	103.26	8343.32

Resource choices for the month of May.

Gender: F Kgs: 1.23 Resource: Mussels
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal	65937.50	90953.99	713.40	157604.89
prot	11183.00	60636.00	95.94	71914.94
vita	435715.00	756.32	209.10	436680.41
vitc	0.00	3025.28	3.20	3028.48
thia	158.25	153.22	0.12	311.59
ribo	200.45	606.36	2.46	809.27
niac	3613.38	0.00	11.07	3624.45
calc	7648.75	5304.02	3936.00	16888.77
phos	113940.00	134191.38	6396.00	254527.38
iron	2637.50	756.32	150.06	3543.88

Gender: F Kgs: 1.80 Resource: Jack-In-The-Pulpit
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 3.21 Resource: Waterfowl/Winter & Summer
Requirements met: 7

	Males	Collective	Females	Total
kcal	75396.41	91895.62	2384.52	169676.55
prot	11751.17	62044.03	172.08	73967.28
vita	435715.00	756.32	32084.04	468555.38
vitc	0.00	3025.28	250.52	3275.80
thia	161.14	157.09	2.46	320.69
ribo	207.51	613.45	3.72	824.69
niac	3810.79	490.20	35.73	4336.72
calc	8044.54	6139.94	5468.34	19652.82
phos	119974.80	150190.59	7584.54	277749.94
iron	2705.87	926.60	176.16	3808.63

Gender: F Kgs: 1.35 Resource: Groundnut
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 7

	Males	Collective	Females	Total
kcal	105683.60	104743.56	3856.02	214283.19
prot	14137.47	64249.99	265.23	78652.69
vita	454159.81	26848.32	55990.25	536998.38
vitc	188.64	3025.28	436.01	3649.93
thia	168.48	167.76	4.22	340.46
ribo	243.14	647.85	4.66	895.66
niac	4009.91	1095.06	54.22	5159.19
calc	9616.54	6436.44	6617.59	22670.58
phos	147432.39	172013.00	8475.95	327921.34
iron	3324.19	1306.12	195.74	4826.05

Gender: F Kgs: 1.53 Resource: Spring Beauty
Gender: C Kgs: 113.88 Resource: Fish/Spring
Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 9

	Males	Collective	Females	Total
kcal	106398.58	222039.95	5276.47	333715.00
prot	14260.23	85431.67	329.95	100021.84
vita	455611.81	26848.32	83083.95	565544.06
vitc	188.64	5302.88	646.23	6137.75
thia	169.07	293.03	6.21	468.31

	Males	Collective	Females	Total
ribo	245.06	761.73	5.74	1012.52
niac	4043.57	3315.72	75.19	7434.48
calc	9633.04	60529.44	7920.08	78082.56
phos	148646.80	393509.59	9486.20	551642.62
iron	3345.31	1875.52	222.36	5443.19

APPENDIX E-2

Late Archaic Resource Choices Based on Efficiency

Resource choices for the month of June.

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal[1]	65937.50	78115.20	92968.00	237020.69
prot[2]	11183.00	14106.24	1056.00	26345.24
vita[3]	435715.00	0.00	0.00	435715.00
vitc[4]	0.00	1516.80	27600.00	29116.80
thia[5]	158.25	83.42	88.00	329.67
ribo[6]	200.45	75.84	48.00	324.29
niac[7]	3613.38	1478.88	464.00	5556.25
calc[8]	7648.75	36024.00	8000.00	51672.75
phos[9]	113940.00	147508.80	144000.00	405448.81
iron	2637.50	379.20	1328.00	4344.70

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 9

	Males	Collective	Females	Total
kcal	75296.00	90963.13	178568.00	344827.12
prot	12621.64	16312.20	5056.00	33989.84
vita	466029.19	26092.00	0.00	492121.19
vitc	55.05	1516.80	31600.00	33171.85
thia	179.90	94.10	200.00	474.00
ribo	219.53	110.23	80.00	409.77
niac	3922.76	2083.74	576.00	6582.50
calc	7979.05	36320.50	18400.00	62699.55
phos	123628.80	169331.20	276000.00	568960.00
iron	2773.29	758.72	2720.00	6252.01

---

[1] Calories

[2] Protein

[3] Vitamin A

[4] Vitamin C

[5] Thiamin

[6] Riboflavin

[7] Niacin

[8] Calcium

[9] Phosphorous

Total stored nutrients[10]: June.

kcal	6071.31
prot	171.90
vita	0.00
vitc	1074.40
thia	6.80
ribo	2.72
niac	19.58
calc	625.60
phos	9384.00
iron	92.48

Resource choices for the month of July.

Gender: F Kgs: 35.98 Resource: Blackberry/Raspberry
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	65937.50	78115.20	24462.80	168515.50
prot	11183.00	14106.24	438.96	25728.20
vita	435715.00	0.00	55769.00	491484.00
vitc	0.00	1516.80	7616.97	9133.77
thia	158.25	83.42	10.79	252.47
ribo	200.45	75.84	21.59	297.88
niac	3613.38	1478.88	205.09	5297.34
calc	7648.75	36024.00	11632.33	55305.08
phos	113940.00	147508.80	9174.90	270623.69
iron	2637.50	379.20	323.82	3340.52

Gender: F Kgs: 13.32 Resource: Gooseberry/Currant
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	75296.00	90963.13	31477.11	197736.25
prot	12621.64	16312.20	630.76	29564.60
vita	466029.19	26092.00	80411.00	572532.19
vitc	55.05	1516.80	19959.28	21531.13
thia	179.90	94.10	16.12	290.12
ribo	219.53	110.23	22.25	352.02
niac	3922.76	2083.74	226.40	6232.89
calc	7979.05	36320.50	16663.30	60962.85
phos	123628.80	169331.20	13110.96	306070.97
iron	2773.29	758.72	449.03	3981.04

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 9

	Males	Collective	Females	Total
kcal	105583.20	91904.77	124445.11	321933.06
prot	15007.94	17720.23	1686.76	34414.93
vita	484474.00	26092.00	80411.00	590977.00
vitc	243.69	1516.80	47559.28	49319.77

[10] An additional 17% of the female/juvenile foods are collected and contributed to storage.

	Males	Collective	Females	Total
thia	187.24	97.97	104.12	389.33
ribo	255.17	117.33	70.25	442.75
niac	4121.88	2573.94	690.40	7386.21
calc	9551.05	37156.42	24663.30	71370.77
phos	151086.39	185330.42	157110.95	493527.75
iron	3391.61	929.00	1777.03	6097.64

Total stored nutrients: June and July.

kcal	10302.45
prot	229.25
vita	2733.97
vitc	2691.42
thia	10.34
ribo	5.11
niac	43.06
calc	1464.15
phos	14725.77
iron	152.90

Resource choices for the month of August.

Gender: F Kgs: 9.09 Resource: Wild Black Cherry
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal	65937.50	78115.20	6403.91	150456.59
prot	11183.00	14106.24	145.44	25434.68
vita	435715.00	0.00	9691.76	445406.75
vitc	0.00	1516.80	894.46	2411.26
thia	158.25	83.42	4.55	246.22
ribo	200.45	75.84	5.45	281.74
niac	3613.38	1478.88	36.36	5128.61
calc	7648.75	36024.00	3637.82	47310.57
phos	113940.00	147508.80	3575.10	265023.91
iron	2637.50	379.20	106.35	3123.05

Gender: F Kgs: 35.98 Resource: Blackberry/Raspberry
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	75296.00	90963.13	30866.71	197125.84
prot	12621.64	16312.20	584.40	29518.23
vita	466029.19	26092.00	65460.76	557581.94
vitc	55.05	1516.80	8511.42	10083.27
thia	179.90	94.10	15.34	289.34
ribo	219.53	110.23	27.04	356.81
niac	3922.76	2083.74	241.45	6247.94
calc	7979.05	36320.50	15270.15	59569.70
phos	123628.80	169331.20	12750.00	305710.00
iron	2773.29	758.72	430.17	3962.18

Gender: F Kgs: 13.32 Resource: Gooseberry/Currant
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	105583.20	91904.77	37881.02	235368.98
prot	15007.94	17720.23	776.20	33504.38
vita	484474.00	26092.00	90102.76	600668.75
vitc	243.69	1516.80	20853.73	22614.22
thia	187.24	97.97	20.67	305.87
ribo	255.17	117.33	27.71	400.20
niac	4121.88	2573.94	262.76	6958.57
calc	9551.05	37156.42	20301.12	67008.59
phos	151086.39	185330.42	16686.06	353102.88
iron	3391.61	929.00	555.38	4875.99

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 57.57 Resource: Waterfowl/March, Aug, Oct
Gender: M Kgs: 6.57 Resource: Muskrat
Requirements met: 9

	Males	Collective	Females	Total
kcal	114386.99	261546.28	130849.02	506782.28
prot	16796.29	27910.12	1832.20	46538.62
vita	669748.00	26092.00	90102.76	785942.75
vitc	342.24	1516.80	48453.73	50312.77
thia	197.75	149.78	108.67	456.20
ribo	268.96	243.98	75.71	588.65
niac	4162.61	6114.49	726.76	11003.86
calc	11193.55	44254.80	28301.12	83749.47
phos	165540.39	293562.03	160686.06	619788.50
iron	3890.93	2155.24	1883.38	7929.55

Total stored nutrients: June, July, and August.

kcal	14751.31
prot	291.55
vita	5797.47
vitc	4338.84
thia	14.03
ribo	7.68
niac	67.77
calc	2426.39
phos	20189.10
iron	216.93

Resource choices for the month of September.

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	65937.50	78115.20	92968.00	237020.69
prot	11183.00	14106.24	1056.00	26345.24
vita	435715.00	0.00	0.00	435715.00
vitc	0.00	1516.80	27600.00	29116.80
thia	158.25	83.42	88.00	329.67
ribo	200.45	75.84	48.00	324.29
niac	3613.38	1478.88	464.00	5556.25
calc	7648.75	36024.00	8000.00	51672.75
phos	113940.00	147508.80	144000.00	405448.81
iron	2637.50	379.20	1328.00	4344.70

Gender: F Kgs: 4.74 Resource: Beechnut
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	75296.00	90963.13	119891.20	286150.31
prot	12621.64	16312.20	1975.56	30909.40
vita	466029.19	26092.00	7110.00	499231.19
vitc	55.05	1516.80	27600.00	29171.85
thia	179.90	94.10	102.22	376.22
ribo	219.53	110.23	62.22	391.99
niac	3922.76	2083.74	535.10	6541.60
calc	7979.05	36320.50	12740.00	57039.55
phos	123628.80	169331.20	158220.00	451180.00
iron	2773.29	758.72	1470.20	5002.21

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 9

	Males	Collective	Females	Total
kcal	105583.20	181917.12	205491.19	492991.50
prot	15007.94	76948.20	5975.56	97931.69
vita	484474.00	26848.32	7110.00	518432.31
vitc	243.69	4542.08	31600.00	36385.77
thia	187.24	247.32	214.22	648.78
ribo	255.17	716.59	94.22	1065.98
niac	4121.88	2083.74	647.10	6852.72
calc	9551.05	41624.52	23140.00	74315.57
phos	151086.39	303522.56	290220.00	744828.94
iron	3391.61	1515.04	2862.20	7768.85

Total stored nutrients: June, July, August, and September.

kcal	21738.01
prot	494.72
vita	6039.21
vitc	5413.24
thia	21.32
ribo	10.89
niac	89.77
calc	3213.15
phos	30056.58
iron	314.25

Resource choices for the month of October.

Gender: F Kgs: 16.17 Resource: Hickory
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal	65937.50	78115.20	110441.10	254493.80
prot	11183.00	14106.24	2118.27	27407.51
vita	435715.00	0.00	24255.00	459970.00
vitc	0.00	1516.80	161.70	1678.50
thia	158.25	83.42	54.98	296.65
ribo	200.45	75.84	42.04	318.33
niac	3613.38	1478.88	129.36	5221.61
calc	7648.75	36024.00	808.50	44481.25
phos	113940.00	147508.80	58212.00	319660.81

	Males	Collective	Females	Total
iron	2637.50	379.20	388.08	3404.78

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 9

	Males	Collective	Females	Total
kcal	75296.00	90963.13	203409.09	369668.22
prot	12621.64	16312.20	3174.27	32108.11
vita	466029.19	26092.00	24255.00	516376.19
vitc	55.05	1516.80	27761.70	29333.55
thia	179.90	94.10	142.98	416.98
ribo	219.53	110.23	90.04	419.81
niac	3922.76	2083.74	593.36	6599.86
calc	7979.05	36320.50	8808.50	53108.05
phos	123628.80	169331.20	202212.00	495172.00
iron	2773.29	758.72	1716.08	5248.09

Total stored nutrients: June, July, August, September, and October.

kcal	28653.92
prot	602.64
vita	6863.88
vitc	6357.14
thia	26.18
ribo	13.95
niac	109.94
calc	3512.64
phos	36931.79
iron	372.60

Resource choices for the months of November through February.

Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 53.08 Resource: Elk
Gender: F Kgs: 23.41 Resource: Stored foods
Requirements met: 8

	Males	Collective	Females	Total
kcal	66350.00	78115.20	28653.92	173119.12
prot	11252.96	14106.24	602.64	25961.84
vita	438440.81	0.00	6863.88	445304.69
vitc	0.00	1516.80	6357.14	7873.94
thia	159.24	83.42	26.18	268.84
ribo	201.70	75.84	13.95	291.49
niac	3635.98	1478.88	109.94	5224.80
calc	7696.60	36024.00	3512.64	47233.24
phos	114652.80	147508.80	36931.79	299093.38
iron	2654.00	379.20	372.60	3405.80

Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	132287.50	90963.13	28653.92	251904.56
prot	22435.96	16312.20	602.64	39350.80
vita	874155.81	26092.00	6863.88	907111.69
vitc	0.00	1516.80	6357.14	7873.94
thia	317.49	94.10	26.18	437.77
ribo	402.15	110.23	13.95	526.34

	Males	Collective	Females	Total
niac	7249.36	2083.74	109.94	9443.04
calc	15345.35	36320.50	3512.64	55178.49
phos	228592.81	169331.20	36931.79	434855.81
iron	5291.50	758.72	372.60	6422.82

Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	141646.00	91904.77	28653.92	262204.69
prot	23874.60	17720.23	602.64	42197.48
vita	904470.00	26092.00	6863.88	937425.88
vitc	55.05	1516.80	6357.14	7928.99
thia	339.14	97.97	26.18	463.29
ribo	421.24	117.33	13.95	552.51
niac	7558.74	2573.94	109.94	10242.62
calc	15675.65	37156.42	3512.64	56344.71
phos	238281.61	185330.42	36931.79	460543.81
iron	5427.29	929.00	372.60	6728.89

Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	171933.20	91904.77	28653.92	292491.91
prot	26260.90	17720.23	602.64	44583.77
vita	922914.81	26092.00	6863.88	955870.69
vitc	243.69	1516.80	6357.14	8117.63
thia	346.48	97.97	26.18	470.63
ribo	456.87	117.33	13.95	588.15
niac	7757.86	2573.94	109.94	10441.74
calc	17247.65	37156.42	3512.64	57916.71
phos	265739.22	185330.42	36931.79	488001.44
iron	6045.61	929.00	372.60	7347.21

Gender: M Kgs: 6.57 Resource: Muskrat
Requirements met: 8

	Males	Collective	Females	Total
kcal	180737.00	91904.77	28653.92	301295.69
prot	28049.25	17720.23	602.64	46372.13
vita	1108188.88	26092.00	6863.88	1141144.75
vitc	342.24	1516.80	6357.14	8216.18
thia	356.99	97.97	26.18	481.14
ribo	470.67	117.33	13.95	601.94
niac	7798.59	2573.94	109.94	10482.47
calc	18890.15	37156.42	3512.64	59559.21
phos	280193.22	185330.42	36931.79	502455.44
iron	6544.93	929.00	372.60	7846.52

Gender: M Kgs: 1.07 Resource: Bear
Requirements met: 8

	Males	Collective	Females	Total
kcal	182173.91	91904.77	28653.92	302732.59
prot	28295.35	17720.23	602.64	46618.23
vita	1114084.62	26092.00	6863.88	1147040.50
vitc	356.15	1516.80	6357.14	8230.09
thia	366.09	97.97	26.18	490.23
ribo	475.70	117.33	13.95	606.97
niac	7871.56	2573.94	109.94	10555.45
calc	18890.15	37156.42	3512.64	59559.21

	Males	Collective	Females	Total
phos	282472.31	185330.42	36931.79	504734.53
iron	6577.03	929.00	372.60	7878.62

Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 8

	Males	Collective	Females	Total
kcal	182888.89	91904.77	28653.92	303447.59
prot	28418.11	17720.23	602.64	46740.99
vita	1115536.62	26092.00	6863.88	1148492.50
vitc	356.15	1516.80	6357.14	8230.09
thia	366.68	97.97	26.18	490.83
ribo	477.61	117.33	13.95	608.89
niac	7905.22	2573.94	109.94	10589.11
calc	18906.65	37156.42	3512.64	59575.71
phos	283686.72	185330.42	36931.79	505948.94
iron	6598.15	929.00	372.60	7899.75

Gender: M Kgs: 3.21 Resource: Waterfowl/Winter & Summer
Requirements met: 9

	Males	Collective	Females	Total
kcal	192347.80	91904.77	28653.92	312906.50
prot	28986.28	17720.23	602.64	47309.16
vita	1115536.62	26092.00	6863.88	1148492.50
vitc	356.15	1516.80	6357.14	8230.09
thia	369.57	97.97	26.18	493.72
ribo	484.67	117.33	13.95	615.95
niac	8102.64	2573.94	109.94	10786.52
calc	19302.44	37156.42	3512.64	59971.50
phos	289721.53	185330.42	36931.79	511983.75
iron	6666.52	929.00	372.60	7968.12

Resource choices for the month of March.

Gender: C Kgs: 1921.82 Resource: Maple Sap
Gender: M Kgs: 53.08 Resource: Elk
Gender: F Kgs: 23.41 Resource: Stored foods
Requirements met: 8

	Males	Collective	Females	Total
kcal	66350.00	138371.03	28653.92	233374.95
prot	11252.96	0.00	602.64	11855.60
vita	438440.81	4420.19	6863.88	449724.88
vitc	0.00	0.00	6357.14	6357.14
thia	159.24	0.00	26.18	185.42
ribo	201.70	0.00	13.95	215.65
niac	3635.98	0.00	109.94	3745.92
calc	7696.60	57078.05	3512.64	68287.30
phos	114652.80	4420.19	36931.79	156004.78
iron	2654.00	576.55	372.60	3603.14

Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 9

	Males	Collective	Females	Total
kcal	132287.50	216486.23	28653.92	377427.66
prot	22435.96	14106.24	602.64	37144.84
vita	874155.81	4420.19	6863.88	885439.88
vitc	0.00	1516.80	6357.14	7873.94
thia	317.49	83.42	26.18	427.09

	Males	Collective	Females	Total
ribo	402.15	75.84	13.95	491.94
niac	7249.36	1478.88	109.94	8838.18
calc	15345.35	93102.05	3512.64	111960.05
phos	228592.81	151928.98	36931.79	417453.59
iron	5291.50	955.75	372.60	6619.84

Resource choices for the month of April.

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 113.88 Resource: Fish/Spring
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	65937.50	117296.40	92968.00	276201.91
prot	11183.00	21181.68	1056.00	33420.68
vita	435715.00	0.00	0.00	435715.00
vitc	0.00	2277.60	27600.00	29877.60
thia	158.25	125.27	88.00	371.52
ribo	200.45	113.88	48.00	362.33
niac	3613.38	2220.66	464.00	6298.04
calc	7648.75	54093.00	8000.00	69741.75
phos	113940.00	221496.59	144000.00	479436.59
iron	2637.50	569.40	1328.00	4534.90

Gender: F Kgs: 1.80 Resource: Jack-In-The-Pulpit
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	75296.00	130144.34	94639.12	300079.44
prot	12621.64	23387.64	1132.14	37141.42
vita	466029.19	26092.00	31874.94	523996.12
vitc	55.05	2277.60	27847.32	30179.97
thia	179.90	135.94	90.34	406.18
ribo	219.53	148.27	49.26	417.07
niac	3922.76	2825.52	488.66	7236.94
calc	7979.05	54389.50	9532.34	71900.89
phos	123628.80	243319.00	145188.55	512136.34
iron	2773.29	948.92	1354.10	5076.31

Gender: F Kgs: 29.60 Resource: Cattail
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 9

	Males	Collective	Females	Total
kcal	105583.20	221098.33	131058.96	457740.50
prot	15007.94	84023.63	1735.98	100767.55
vita	484474.00	26848.32	31874.94	543197.25
vitc	243.69	5302.88	38059.32	43605.89
thia	187.24	289.16	122.90	599.30
ribo	255.17	754.63	67.02	1076.82
niac	4121.88	2825.52	660.34	7607.74
calc	9551.05	59693.52	18157.78	87402.35
phos	151086.39	377510.38	187475.11	716071.88
iron	3391.61	1705.24	1845.46	6942.31

Resource choices for the month of May.

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 113.88 Resource: Fish/Spring
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	65937.50	117296.40	92968.00	276201.91
prot	11183.00	21181.68	1056.00	33420.68
vita	435715.00	0.00	0.00	435715.00
vitc	0.00	2277.60	27600.00	29877.60
thia	158.25	125.27	88.00	371.52
ribo	200.45	113.88	48.00	362.33
niac	3613.38	2220.66	464.00	6298.04
calc	7648.75	54093.00	8000.00	69741.75
phos	113940.00	221496.59	144000.00	479436.59
iron	2637.50	569.40	1328.00	4534.90

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 9

	Males	Collective	Females	Total
kcal	75296.00	130144.34	178568.00	384008.34
prot	12621.64	23387.64	5056.00	41065.28
vita	466029.19	26092.00	0.00	492121.19
vitc	55.05	2277.60	31600.00	33932.65
thia	179.90	135.94	200.00	515.84
ribo	219.53	148.27	80.00	447.81
niac	3922.76	2825.52	576.00	7324.28
calc	7979.05	54389.50	18400.00	80768.55
phos	123628.80	243319.00	276000.00	642947.81
iron	2773.29	948.92	2720.00	6442.21

APPENDIX E-3

Simulated Late Archaic Resource Choices Based on Multiple Goals

Resource choices for the month of June.

Gender: F Kgs: 1.28 Resource: Strawberry
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal[1]	65937.50	12847.94	473.60	79259.04
prot[2]	11183.00	2205.96	20.74	13409.70
vita[3]	435715.00	26092.00	1114.50	462921.50
vitc[4]	0.00	0.00	547.07	547.07
thia[5]	158.25	10.67	0.38	169.31
ribo[6]	200.45	34.39	0.77	235.61
niac[7]	3613.38	604.86	11.78	4230.01
calc[8]	7648.75	296.50	391.42	8336.67
phos[9]	113940.00	21822.40	295.42	136057.83
iron	2637.50	379.52	12.03	3029.05

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	96224.70	13789.57	93441.60	203455.88
prot	13569.30	3613.99	1076.74	18260.03
vita	454159.81	26092.00	1114.50	481366.31
vitc	188.64	0.00	28147.07	28335.71
thia	165.59	14.54	88.38	268.51
ribo	236.08	41.49	48.77	326.34
niac	3812.49	1095.06	475.78	5383.33
calc	9220.75	1132.42	8391.42	18744.59
phos	141397.59	37821.62	144295.42	323514.62
iron	3255.82	549.80	1340.03	5145.65

---

[1] Calories

[2] Protein

[3] Vitamin A

[4] Vitamin C

[5] Thiamin

[6] Riboflavin

[7] Niacin

[8] Calcium

[9] Phosphorous

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 9

	Males	Collective	Females	Total
kcal	105583.20	91904.77	179041.59	376529.56
prot	15007.94	17720.23	5076.74	37804.91
vita	484474.00	26092.00	1114.50	511680.50
vitc	243.69	1516.80	32147.07	33907.56
thia	187.24	97.97	200.38	485.59
ribo	255.17	117.33	80.77	453.26
niac	4121.88	2573.94	587.78	7283.59
calc	9551.05	37156.42	18791.42	65498.89
phos	151086.39	185330.41	276295.44	612712.25
iron	3391.61	929.00	2732.03	7052.64

Total stored nutrients[10]: June.

kcal	7877.83
prot	223.38
vita	49.04
vitc	1414.47
thia	8.82
ribo	3.55
niac	25.86
calc	826.82
phos	12157.00
iron	120.21

Resource choices for the month of July.

Gender: F Kgs: 35.98 Resource: Blackberry/Raspberry
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	65937.50	12847.94	24462.80	103248.24
prot	11183.00	2205.96	438.96	13827.92
vita	435715.00	26092.00	55769.00	517576.00
vitc	0.00	0.00	7616.97	7616.97
thia	158.25	10.67	10.79	179.72
ribo	200.45	34.39	21.59	256.43
niac	3613.38	604.86	205.09	4423.32
calc	7648.75	296.50	11632.33	19577.58
phos	113940.00	21822.40	9174.90	144937.30
iron	2637.50	379.52	323.82	3340.84

Gender: F Kgs: 13.32 Resource: Gooseberry/Currant
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	96224.70	13789.57	31477.11	141491.38
prot	13569.30	3613.99	630.76	17814.05
vita	454159.81	26092.00	80411.00	560662.81
vitc	188.64	0.00	19959.28	20147.92

---

[10] An additional 22% of female/juvenile resource choices are contirbuted to storage.

	Males	Collective	Females	Total
thia	165.59	14.54	16.12	196.25
ribo	236.08	41.49	22.25	299.83
niac	3812.49	1095.06	226.40	5133.95
calc	9220.75	1132.42	16663.30	27016.47
phos	141397.59	37821.62	13110.96	192330.17
iron	3255.82	549.80	449.03	4254.65

Gender: F Kgs: 0.34 Resource: Mulberry
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	105583.20	91904.77	31666.26	229154.22
prot	15007.94	17720.23	634.74	33362.91
vita	484474.00	26092.00	80467.68	591033.69
vitc	243.69	1516.80	20010.28	21770.77
thia	187.24	97.97	16.22	301.43
ribo	255.17	117.33	22.56	395.05
niac	4121.88	2573.94	229.46	6925.27
calc	9551.05	37156.42	16857.10	63564.57
phos	151086.39	185330.41	13241.86	349658.66
iron	3391.61	929.00	456.00	4776.61

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 9

	Males	Collective	Females	Total
kcal	106298.17	91904.77	124634.25	322837.19
prot	15130.70	17720.23	1690.74	34541.67
vita	485926.00	26092.00	80467.68	592485.69
vitc	243.69	1516.80	47610.28	49370.77
thia	187.83	97.97	104.22	390.02
ribo	257.08	117.33	70.56	444.97
niac	4155.54	2573.94	693.46	7422.93
calc	9567.55	37156.42	24857.10	71581.06
phos	152300.80	185330.41	157241.86	494873.06
iron	3412.73	929.00	1784.00	6125.73

Total stored nutrients: June and July.

kcal	13361.74
prot	297.77
vita	3589.62
vitc	3509.32
thia	13.40
ribo	6.66
niac	56.37
calc	1920.53
phos	19075.64
iron	198.71

Resource choices for the month of August.

Gender: F Kgs: 9.09 Resource: Wild Black Cherry
Gender: C Kgs: 57.57 Resource: Waterfowl/March, Aug, Oct
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal	65937.50	169641.52	6403.91	241982.92

	Males	Collective	Females	Total
prot	11183.00	10189.89	145.44	21518.33
vita	435715.00	0.00	9691.76	445406.75
vitc	0.00	0.00	894.46	894.46
thia	158.25	51.81	4.55	214.61
ribo	200.45	126.65	5.45	332.56
niac	3613.38	3540.55	36.36	7190.29
calc	7648.75	7098.38	3637.82	18384.95
phos	113940.00	108231.60	3575.10	225746.70
iron	2637.50	1226.24	106.35	3970.09

Gender: F Kgs: 35.98 Resource: Blackberry/Raspberry
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	96224.70	182489.45	30866.71	309580.84
prot	13569.30	12395.85	584.40	26549.54
vita	454159.81	26092.00	65460.76	545712.56
vitc	188.64	0.00	8511.42	8700.06
thia	165.59	62.49	15.34	243.41
ribo	236.08	161.05	27.04	424.17
niac	3812.49	4145.42	241.45	8199.36
calc	9220.75	7394.88	15270.15	31885.78
phos	141397.59	130054.00	12750.00	284201.59
iron	3255.82	1605.76	430.17	5291.75

Gender: F Kgs: 13.32 Resource: Gooseberry/Currant
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 9

	Males	Collective	Females	Total
kcal	105583.20	183431.09	37881.02	326895.31
prot	15007.94	13803.88	776.20	29588.02
vita	484474.00	26092.00	90102.76	600668.75
vitc	243.69	0.00	20853.73	21097.42
thia	187.24	66.36	20.67	274.26
ribo	255.17	168.14	27.71	451.02
niac	4121.88	4635.62	262.76	9020.25
calc	9551.05	8230.80	20301.12	38082.97
phos	151086.39	146053.22	16686.06	313825.66
iron	3391.61	1776.04	555.38	5723.03

Total stored nutrients: June, July, and August.

kcal	15028.50
prot	331.92
vita	7554.14
vitc	4426.89
thia	14.31
ribo	7.88
niac	67.94
calc	2813.78
phos	19809.83
iron	223.14

Resource choices for the month of September.

Gender: F Kgs: 4.74 Resource: Beechnut
Gender: C Kgs: 115.14 Resource: Waterfowl/April, Sept
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	65937.50	339283.03	26923.20	432143.72
prot	11183.00	20379.78	919.56	32482.34
vita	435715.00	0.00	7110.00	442825.00
vitc	0.00	0.00	0.00	0.00
thia	158.25	103.63	14.22	276.10
ribo	200.45	253.31	14.22	467.98
niac	3613.38	7081.11	71.10	10765.58
calc	7648.75	14196.76	4740.00	26585.51
phos	113940.00	216463.20	14220.00	344623.19
iron	2637.50	2452.48	142.20	5232.18

Gender: F Kgs: 2.52 Resource: Beaked-hazelnut
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	96224.70	430237.03	45369.60	571831.31
prot	13569.30	81015.77	1511.76	96096.83
vita	454159.81	756.32	7110.00	462026.12
vitc	188.64	3025.28	0.00	3213.92
thia	165.59	256.85	24.30	446.73
ribo	236.08	859.67	18.25	1114.00
niac	3812.49	7081.11	103.86	10997.46
calc	9220.75	19500.78	9780.00	38501.53
phos	141397.59	350654.56	21780.00	513832.16
iron	3255.82	3208.80	217.80	6682.42

Gender: F Kgs: 3.38 Resource: White Oak Group
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	105583.20	443084.97	56486.08	605154.25
prot	15007.94	83221.73	1655.41	99885.08
vita	484474.00	26848.32	12180.00	523502.31
vitc	243.69	3025.28	0.00	3268.97
thia	187.24	267.52	30.05	484.80
ribo	255.17	894.06	19.60	1168.83
niac	4121.88	7685.97	171.46	11979.31
calc	9551.05	19797.28	18094.80	47443.13
phos	151086.39	372476.97	26005.00	549568.38
iron	3391.61	3588.32	261.74	7241.67

Gender: F Kgs: 1.78 Resource: Red Oak Group
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 8

	Males	Collective	Females	Total
kcal	106298.17	444026.59	63585.07	613909.81
prot	15130.70	84629.77	1733.91	101494.37
vita	485926.00	26848.32	14850.00	527624.31
vitc	243.69	3025.28	0.00	3268.97
thia	187.83	271.39	33.07	492.29

	Males	Collective	Females	Total
ribo	257.08	901.16	20.32	1178.55
niac	4155.54	8176.17	207.06	12538.77
calc	9567.55	20633.20	22627.04	52827.79
phos	152300.80	388476.19	27196.17	567973.19
iron	3412.73	3758.60	284.88	7456.21

Gender: F Kgs: 2.64 Resource: Elderberry
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 6.57 Resource: Muskrat
Requirements met: 9

	Males	Collective	Females	Total
kcal	115101.97	522141.78	65485.88	702729.62
prot	16919.05	98736.01	1802.55	117457.60
vita	671200.00	26848.32	30690.00	728738.31
vitc	342.24	4542.08	950.40	5834.72
thia	198.34	354.81	34.92	588.08
ribo	270.88	977.00	21.90	1269.77
niac	4196.27	9655.05	220.26	14071.58
calc	11210.05	56657.20	23630.24	91497.49
phos	166754.80	535985.00	27935.37	730675.19
iron	3912.05	4137.80	327.12	8376.97

Total stored nutrients: June, July, August, and September.

kcal	17909.88
prot	411.23
vita	8904.50
vitc	4468.70
thia	15.85
ribo	8.84
niac	77.63
calc	3853.51
phos	21038.98
iron	237.54

Resource choices for the month of October.

Gender: F Kgs: 16.17 Resource: Hickory
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal	65937.50	90953.99	110441.10	267332.59
prot	11183.00	60636.00	2118.27	73937.27
vita	435715.00	756.32	24255.00	460726.31
vitc	0.00	3025.28	161.70	3186.98
thia	158.25	153.22	54.98	366.45
ribo	200.45	606.36	42.04	848.85
niac	3613.38	0.00	129.36	3742.74
calc	7648.75	5304.02	808.50	13761.27
phos	113940.00	134191.38	58212.00	306343.38
iron	2637.50	756.32	388.08	3781.90

Gender: F Kgs: 2.97 Resource: Butternut
Gender: C Kgs: 57.57 Resource: Waterfowl/March, Aug, Oct
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	96224.70	260595.50	128335.35	485155.56

	Males	Collective	Females	Total
prot	13569.30	70825.88	2790.98	87186.16
vita	454159.81	756.32	33165.00	488081.12
vitc	188.64	3025.28	221.10	3435.02
thia	165.59	205.03	61.51	432.13
ribo	236.08	733.01	45.31	1014.40
niac	3812.49	3540.55	150.15	7503.20
calc	9220.75	12402.40	1105.50	22728.65
phos	141397.59	242422.97	75141.00	458961.56
iron	3255.82	1982.56	578.16	5816.54

Gender: F Kgs: 0.38 Resource: Black walnut
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	105583.20	273443.44	130704.16	509730.78
prot	15007.94	73031.84	2848.77	90888.55
vita	484474.00	26848.32	34305.00	545627.31
vitc	243.69	3025.28	228.70	3497.67
thia	187.24	215.71	62.35	465.29
ribo	255.17	767.41	45.73	1068.30
niac	4121.88	4145.42	152.81	8420.10
calc	9551.05	12698.90	1143.50	23393.45
phos	151086.39	264245.38	77307.00	492638.75
iron	3391.61	2362.08	600.96	6354.65

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 9

	Males	Collective	Females	Total
kcal	106298.17	274385.06	223672.16	604355.38
prot	15130.70	74439.88	3904.77	93475.34
vita	485926.00	26848.32	34305.00	547079.31
vitc	243.69	3025.28	27828.70	31097.67
thia	187.83	219.58	150.35	557.76
ribo	257.08	774.50	93.73	1125.31
niac	4155.54	4635.62	616.81	9407.96
calc	9567.55	13534.82	9143.50	32245.87
phos	152300.80	280244.59	221307.00	653852.38
iron	3412.73	2532.36	1928.96	7874.05

Total stored nutrients: June, July, August, September, and October.

kcal	27751.45
prot	583.04
vita	10413.92
vitc	5693.17
thia	22.46
ribo	12.97
niac	104.77
calc	4255.83
phos	30776.49
iron	322.41

Resource choices for the months of November through February.

Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 53.08 Resource: Elk
Gender: F Kgs: 20.41 Resource: Stored foods
Requirements met: 8

	Males	Collective	Females	Total
kcal	66350.00	12847.94	27751.45	106949.39
prot	11252.96	2205.96	583.04	14041.96
vita	438440.81	26092.00	10413.92	474946.72
vitc	0.00	0.00	5693.17	5693.17
thia	159.24	10.67	22.46	192.38
ribo	201.70	34.39	12.97	249.06
niac	3635.98	604.86	104.77	4345.61
calc	7696.60	296.50	4255.83	12248.93
phos	114652.80	21822.40	30776.49	167251.70
iron	2654.00	379.52	322.41	3355.93

Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	132287.50	13789.57	27751.45	173828.53
prot	22435.96	3613.99	583.04	26633.00
vita	874155.81	26092.00	10413.92	910661.75
vitc	0.00	0.00	5693.17	5693.17
thia	317.49	14.54	22.46	354.50
ribo	402.15	41.49	12.97	456.61
niac	7249.36	1095.06	104.77	8449.18
calc	15345.35	1132.42	4255.83	20733.60
phos	228592.81	37821.62	30776.49	297190.94
iron	5291.50	549.80	322.41	6163.71

Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 1.07 Resource: Bear
Requirements met: 8

	Males	Collective	Females	Total
kcal	133724.41	91904.77	27751.45	253380.62
prot	22682.06	17720.23	583.04	40985.34
vita	880051.50	26092.00	10413.92	916557.44
vitc	13.91	1516.80	5693.17	7223.88
thia	326.58	97.97	22.46	447.02
ribo	407.18	117.33	12.97	537.48
niac	7322.33	2573.94	104.77	10001.04
calc	15345.35	37156.42	4255.83	56757.60
phos	230871.91	185330.41	30776.49	446978.81
iron	5323.60	929.00	322.41	6575.01

Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	164011.61	91904.77	27751.45	283667.84
prot	25068.36	17720.23	583.04	43371.63
vita	898496.31	26092.00	10413.92	935002.25
vitc	202.55	1516.80	5693.17	7412.52
thia	333.92	97.97	22.46	454.35
ribo	442.82	117.33	12.97	573.11
niac	7521.45	2573.94	104.77	10200.16
calc	16917.35	37156.42	4255.83	58329.60
phos	258329.50	185330.41	30776.49	474436.41

	Males	Collective	Females	Total
iron	5941.92	929.00	322.41	7193.33

Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	173370.11	91904.77	27751.45	293026.34
prot	26507.00	17720.23	583.04	44810.27
vita	928810.50	26092.00	10413.92	965316.44
vitc	257.60	1516.80	5693.17	7467.57
thia	355.57	97.97	22.46	476.01
ribo	461.90	117.33	12.97	592.19
niac	7830.83	2573.94	104.77	10509.54
calc	17247.65	37156.42	4255.83	58659.90
phos	268018.31	185330.41	30776.49	484125.22
iron	6077.71	929.00	322.41	7329.12

Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 8

	Males	Collective	Females	Total
kcal	174085.09	91904.77	27751.45	293741.31
prot	26629.76	17720.23	583.04	44933.04
vita	930262.50	26092.00	10413.92	966768.44
vitc	257.60	1516.80	5693.17	7467.57
thia	356.17	97.97	22.46	476.60
ribo	463.81	117.33	12.97	594.11
niac	7864.49	2573.94	104.77	10543.20
calc	17264.15	37156.42	4255.83	58676.40
phos	269232.72	185330.41	30776.49	485339.62
iron	6098.83	929.00	322.41	7350.24

Gender: M Kgs: 3.21 Resource: Waterfowl/Winter & Summer
Requirements met: 8

	Males	Collective	Females	Total
kcal	183544.00	91904.77	27751.45	303200.22
prot	27197.93	17720.23	583.04	45501.20
vita	930262.50	26092.00	10413.92	966768.44
vitc	257.60	1516.80	5693.17	7467.57
thia	359.06	97.97	22.46	479.49
ribo	470.88	117.33	12.97	601.17
niac	8061.91	2573.94	104.77	10740.61
calc	17659.94	37156.42	4255.83	59072.19
phos	275267.53	185330.41	30776.49	491374.44
iron	6167.20	929.00	322.41	7418.61

Gender: M Kgs: 6.57 Resource: Muskrat
Requirements met: 9

	Males	Collective	Females	Total
kcal	192347.80	91904.77	27751.45	312004.03
prot	28986.28	17720.23	583.04	47289.56
vita	1115536.50	26092.00	10413.92	1152042.38
vitc	356.15	1516.80	5693.17	7566.12
thia	369.57	97.97	22.46	490.00
ribo	484.67	117.33	12.97	614.97
niac	8102.64	2573.94	104.77	10781.35
calc	19302.44	37156.42	4255.83	60714.69
phos	289721.53	185330.41	30776.49	505828.44
iron	6666.52	929.00	322.41	7917.93

Resource choices for the month of March.

Gender: C Kgs: 1921.82 Resource: Maple Sap
Gender: M Kgs: 53.08 Resource: Elk
Gender: F Kgs: 20.41 Resource: Stored foods
Requirements met: 8

	Males	Collective	Females	Total
kcal	66350.00	138371.03	27751.45	232472.48
prot	11252.96	0.00	583.04	11836.00
vita	438440.81	4420.19	10413.92	453274.91
vitc	0.00	0.00	5693.17	5693.17
thia	159.24	0.00	22.46	181.70
ribo	201.70	0.00	12.97	214.67
niac	3635.98	0.00	104.77	3740.75
calc	7696.60	57078.05	4255.83	69030.48
phos	114652.80	4420.19	30776.49	149849.48
iron	2654.00	576.55	322.41	3552.96

Gender: C Kgs: 57.57 Resource: Waterfowl/March, Aug, Oct
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 9

	Males	Collective	Females	Total
kcal	132287.50	308012.53	27751.45	468051.50
prot	22435.96	10189.89	583.04	33208.89
vita	874155.81	4420.19	10413.92	888989.94
vitc	0.00	0.00	5693.17	5693.17
thia	317.49	51.81	22.46	391.77
ribo	402.15	126.65	12.97	541.77
niac	7249.36	3540.55	104.77	10894.68
calc	15345.35	64176.44	4255.83	83777.62
phos	228592.81	112651.78	30776.49	372021.09
iron	5291.50	1802.79	322.41	7416.70

Resource choices for the month of April.

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 115.14 Resource: Waterfowl/April, Sept
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 9

	Males	Collective	Females	Total
kcal	65937.50	339283.03	92968.00	498188.53
prot	11183.00	20379.78	1056.00	32618.78
vita	435715.00	0.00	0.00	435715.00
vitc	0.00	0.00	27600.00	27600.00
thia	158.25	103.63	88.00	349.88
ribo	200.45	253.31	48.00	501.76
niac	3613.38	7081.11	464.00	11158.48
calc	7648.75	14196.76	8000.00	29845.51
phos	113940.00	216463.20	144000.00	474403.19
iron	2637.50	2452.48	1328.00	6417.98

Resource choices for the month of May.

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	65937.50	90953.99	92968.00	249859.50
prot	11183.00	60636.00	1056.00	72875.00
vita	435715.00	756.32	0.00	436471.31
vitc	0.00	3025.28	27600.00	30625.28
thia	158.25	153.22	88.00	399.47
ribo	200.45	606.36	48.00	854.81
niac	3613.38	0.00	464.00	4077.38
calc	7648.75	5304.02	8000.00	20952.77
phos	113940.00	134191.38	144000.00	392131.38
iron	2637.50	756.32	1328.00	4721.82

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 9

	Males	Collective	Females	Total
kcal	96224.70	103801.93	178568.00	378594.62
prot	13569.30	62841.96	5056.00	81467.25
vita	454159.81	26848.32	0.00	481008.12
vitc	188.64	3025.28	31600.00	34813.92
thia	165.59	163.89	200.00	529.48
ribo	236.08	640.75	80.00	956.84
niac	3812.49	604.86	576.00	4993.35
calc	9220.75	5600.52	18400.00	33221.27
phos	141397.59	156013.78	276000.00	573411.38
iron	3255.82	1135.84	2720.00	7111.66

APPENDIX E-4

Simulated Early and Middle Woodland Resource Choices Based on Efficiency

Resource choices for the month of June.

Gender: F Kgs: 1.80 Resource: Jack-In-The-Pulpit
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal[1]	65937.50	78115.20	1671.12	145723.81
prot[2]	11183.00	14106.24	76.14	25365.38
vita[3]	435715.00	0.00	31874.94	467589.94
vitc[4]	0.00	1516.80	247.32	1764.12
thia[5]	158.25	83.42	2.34	244.01
ribo[6]	200.45	75.84	1.26	277.55
niac[7]	3613.38	1478.88	24.66	5116.92
calc[8]	7648.75	36024.00	1532.34	45205.09
phos[9]	113940.00	147508.80	1188.54	262637.34
iron	2637.50	379.20	26.10	3042.80

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	75296.00	90963.13	87271.12	253530.25
prot	12621.64	16312.20	4076.14	33009.98
vita	466029.19	26092.00	31874.94	523996.12
vitc	55.05	1516.80	4247.32	5819.17
thia	179.90	94.10	114.34	388.34
ribo	219.53	110.23	33.26	363.03
niac	3922.76	2083.74	136.66	6143.16
calc	7979.05	36320.50	11932.34	56231.89
phos	123628.80	169331.20	133188.55	426148.56
iron	2773.29	758.72	1418.10	4950.11

---

[1] Calories

[2] Protein

[3] Vitamin A

[4] Vitamin C

[5] Thiamin

[6] Riboflavin

[7] Niacin

[8] Calcium

[9] Phosphorous

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 9

	Males	Collective	Females	Total
kcal	105583.20	91904.77	180239.11	377727.06
prot	15007.94	17720.23	5132.14	37860.31
vita	484474.00	26092.00	31874.94	542440.94
vitc	243.69	1516.80	31847.32	33607.81
thia	187.24	97.97	202.34	487.55
ribo	255.17	117.33	81.26	453.76
niac	4121.88	2573.94	600.66	7296.48
calc	9551.05	37156.42	19932.34	66639.81
phos	151086.39	185330.42	277188.56	613605.38
iron	3391.61	929.00	2746.10	7066.71

Total stored nutrients[10]: June.

kcal	6488.61
prot	184.76
vita	1147.50
vitc	1146.50
thia	7.28
ribo	2.93
niac	21.62
calc	717.56
phos	9978.79
iron	98.86

Resource choices for the month of July.

Gender: F Kgs: 35.98 Resource: Blackberry/Raspberry
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	65937.50	78115.20	24462.80	168515.50
prot	11183.00	14106.24	438.96	25728.20
vita	435715.00	0.00	55769.00	491484.00
vitc	0.00	1516.80	7616.97	9133.77
thia	158.25	83.42	10.79	252.47
ribo	200.45	75.84	21.59	297.88
niac	3613.38	1478.88	205.09	5297.34
calc	7648.75	36024.00	11632.33	55305.08
phos	113940.00	147508.80	9174.90	270623.69
iron	2637.50	379.20	323.82	3340.52

Gender: F Kgs: 13.32 Resource: Gooseberry/Currant
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	75296.00	90963.13	31477.11	197736.25
prot	12621.64	16312.20	630.76	29564.60
vita	466029.19	26092.00	80411.00	572532.19
vitc	55.05	1516.80	19959.28	21531.13

---

[10] An additional 18% of the female/juvenile foods are collected and contributed to storage.

	Males	Collective	Females	Total
thia	179.90	94.10	16.12	290.12
ribo	219.53	110.23	22.25	352.02
niac	3922.76	2083.74	226.40	6232.89
calc	7979.05	36320.50	16663.30	60962.85
phos	123628.80	169331.20	13110.96	306070.97
iron	2773.29	758.72	449.03	3981.04

Gender: F Kgs: 1.80 Resource: Jack-In-The-Pulpit
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	105583.20	91904.77	33148.23	230636.19
prot	15007.94	17720.23	706.90	33435.07
vita	484474.00	26092.00	112285.94	622851.94
vitc	243.69	1516.80	20206.60	21967.09
thia	187.24	97.97	18.46	303.67
ribo	255.17	117.33	23.51	396.01
niac	4121.88	2573.94	251.06	6946.87
calc	9551.05	37156.42	18195.64	64903.11
phos	151086.39	185330.42	14299.50	350716.31
iron	3391.61	929.00	475.13	4795.74

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Gender: M Kgs: 6.57 Resource: Muskrat
Requirements met: 9

	Males	Collective	Females	Total
kcal	114386.99	91904.77	118748.23	325040.00
prot	16796.29	17720.23	4706.90	39223.43
vita	669748.00	26092.00	112285.94	808125.94
vitc	342.24	1516.80	24206.60	26065.64
thia	197.75	97.97	130.46	426.18
ribo	268.96	117.33	55.51	441.81
niac	4162.61	2573.94	363.06	7099.61
calc	11193.55	37156.42	28595.64	76945.61
phos	165540.39	185330.42	146299.50	497170.31
iron	3890.93	929.00	1867.13	6687.06

Total stored nutrients:June and July.

kcal	10763.54
prot	354.21
vita	5189.79
vitc	2017.94
thia	11.98
ribo	4.92
niac	34.69
calc	1747.01
phos	15245.57
iron	166.08

Resource choices for the month of August.

Gender: F Kgs: 35.98 Resource: Blackberry/Raspberry
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	65937.50	78115.20	24462.80	168515.50
prot	11183.00	14106.24	438.96	25728.20
vita	435715.00	0.00	55769.00	491484.00
vitc	0.00	1516.80	7616.97	9133.77
thia	158.25	83.42	10.79	252.47
ribo	200.45	75.84	21.59	297.88
niac	3613.38	1478.88	205.09	5297.34
calc	7648.75	36024.00	11632.33	55305.08
phos	113940.00	147508.80	9174.90	270623.69
iron	2637.50	379.20	323.82	3340.52

Gender: F Kgs: 13.32 Resource: Gooseberry/Currant
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	75296.00	90963.13	31477.11	197736.25
prot	12621.64	16312.20	630.76	29564.60
vita	466029.19	26092.00	80411.00	572532.19
vitc	55.05	1516.80	19959.28	21531.13
thia	179.90	94.10	16.12	290.12
ribo	219.53	110.23	22.25	352.02
niac	3922.76	2083.74	226.40	6232.89
calc	7979.05	36320.50	16663.30	60962.85
phos	123628.80	169331.20	13110.96	306070.97
iron	2773.29	758.72	449.03	3981.04

Gender: F Kgs: 9.09 Resource: Wild Black Cherry
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	105583.20	91904.77	37881.02	235368.98
prot	15007.94	17720.23	776.20	33504.38
vita	484474.00	26092.00	90102.76	600668.75
vitc	243.69	1516.80	20853.73	22614.22
thia	187.24	97.97	20.67	305.87
ribo	255.17	117.33	27.71	400.20
niac	4121.88	2573.94	262.76	6958.57
calc	9551.05	37156.42	20301.12	67008.59
phos	151086.39	185330.42	16686.06	353102.88
iron	3391.61	929.00	555.38	4875.99

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Gender: C Kgs: 57.57 Resource: Waterfowl/March, Aug, Oct
Gender: M Kgs: 6.57 Resource: Muskrat
Requirements met: 9

	Males	Collective	Females	Total
kcal	114386.99	261546.28	123481.02	499414.28
prot	16796.29	27910.12	4776.20	49482.62
vita	669748.00	26092.00	90102.76	785942.75
vitc	342.24	1516.80	24853.73	26712.77
thia	197.75	149.78	132.67	480.20
ribo	268.96	243.98	59.71	572.65
niac	4162.61	6114.49	374.76	10651.86
calc	11193.55	44254.80	30701.12	86149.47
phos	165540.39	293562.03	148686.06	607788.50
iron	3890.93	2155.24	1947.38	7993.55

Total stored nutrients: June, July, and August.

kcal	15208.86
prot	526.15
vita	8433.49
vitc	2912.68
thia	16.76
ribo	7.07
niac	48.19
calc	2852.25
phos	20598.27
iron	236.18

Resource choices for the month of September.

Gender: F Kgs: 4.74 Resource: Beechnut
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal	65937.50	78115.20	26923.20	170975.89
prot	11183.00	14106.24	919.56	26208.80
vita	435715.00	0.00	7110.00	442825.00
vitc	0.00	1516.80	0.00	1516.80
thia	158.25	83.42	14.22	255.89
ribo	200.45	75.84	14.22	290.51
niac	3613.38	1478.88	71.10	5163.35
calc	7648.75	36024.00	4740.00	48412.75
phos	113940.00	147508.80	14220.00	275668.78
iron	2637.50	379.20	142.20	3158.90

Gender: F Kgs: 3.38 Resource: White Oak Group
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 7

	Males	Collective	Females	Total
kcal	75296.00	90963.13	38039.68	204298.81
prot	12621.64	16312.20	1063.21	29997.05
vita	466029.19	26092.00	12180.00	504301.19
vitc	55.05	1516.80	0.00	1571.85
thia	179.90	94.10	19.97	293.97
ribo	219.53	110.23	15.57	345.34
niac	3922.76	2083.74	138.70	6145.20
calc	7979.05	36320.50	13054.80	57354.35
phos	123628.80	169331.20	18445.00	311405.00
iron	2773.29	758.72	186.14	3718.15

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 9

	Males	Collective	Females	Total
kcal	105583.20	181917.12	123639.68	411140.00
prot	15007.94	76948.20	5063.21	97019.34
vita	484474.00	26848.32	12180.00	523502.31
vitc	243.69	4542.08	4000.00	8785.77
thia	187.24	247.32	131.97	566.52
ribo	255.17	716.59	47.57	1019.33
niac	4121.88	2083.74	250.70	6456.32
calc	9551.05	41624.52	23454.80	74630.37
phos	151086.39	303522.56	150445.00	605053.94

	Males	Collective	Females	Total
iron	3391.61	1515.04	1578.14	6484.79

Total stored nutrients: June, July, August, and September.

kcal	19659.89
prot	708.42
vita	8871.97
vitc	3056.68
thia	21.51
ribo	8.79
niac	57.21
calc	3696.62
phos	26014.29
iron	292.99

Resource choices for the month of October.

Gender: F Kgs: 16.17 Resource: Hickory
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal	65937.50	78115.20	110441.10	254493.80
prot	11183.00	14106.24	2118.27	27407.51
vita	435715.00	0.00	24255.00	459970.00
vitc	0.00	1516.80	161.70	1678.50
thia	158.25	83.42	54.98	296.65
ribo	200.45	75.84	42.04	318.33
niac	3613.38	1478.88	129.36	5221.61
calc	7648.75	36024.00	808.50	44481.25
phos	113940.00	147508.80	58212.00	319660.81
iron	2637.50	379.20	388.08	3404.78

Gender: F Kgs: 2.97 Resource: Butternut
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 7

	Males	Collective	Females	Total
kcal	75296.00	90963.13	128335.35	294594.50
prot	12621.64	16312.20	2790.98	31724.81
vita	466029.19	26092.00	33165.00	525286.19
vitc	55.05	1516.80	221.10	1792.95
thia	179.90	94.10	61.51	335.51
ribo	219.53	110.23	45.31	375.08
niac	3922.76	2083.74	150.15	6156.65
calc	7979.05	36320.50	1105.50	45405.05
phos	123628.80	169331.20	75141.00	368101.00
iron	2773.29	758.72	578.16	4110.17

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 9

	Males	Collective	Females	Total
kcal	105583.20	181917.12	213935.34	501435.66
prot	15007.94	76948.20	6790.98	98747.11
vita	484474.00	26848.32	33165.00	544487.31
vitc	243.69	4542.08	4221.10	9006.87
thia	187.24	247.32	173.51	608.07

	Males	Collective	Females	Total
ribo	255.17	716.59	77.31	1049.07
niac	4121.88	2083.74	262.15	6467.77
calc	9551.05	41624.52	11505.50	62681.07
phos	151086.39	303522.56	207141.00	661749.94
iron	3391.61	1515.04	1970.16	6876.81

Total stored nutrients: June, July, August, September and October.

kcal	27361.56
prot	952.90
vita	10065.91
vitc	3208.64
thia	27.75
ribo	11.57
niac	66.65
calc	4110.82
phos	33471.37
iron	363.92

Resource choices for the months of November through February.

Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 53.08 Resource: Elk
Gender: F Kgs: 22.20 Resource: Stored Foods
Requirements met: 8

	Males	Collective	Females	Total
kcal	66350.00	78115.20	27361.56	171826.77
prot	11252.96	14106.24	952.90	26312.10
vita	438440.81	0.00	10065.91	448506.72
vitc	0.00	1516.80	3208.64	4725.44
thia	159.24	83.42	27.75	270.42
ribo	201.70	75.84	11.57	289.11
niac	3635.98	1478.88	66.65	5181.51
calc	7696.60	36024.00	4110.82	47831.42
phos	114652.80	147508.80	33471.37	295632.97
iron	2654.00	379.20	363.92	3397.12

Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	132287.50	90963.13	27361.56	250612.20
prot	22435.96	16312.20	952.90	39701.06
vita	874155.81	26092.00	10065.91	910313.75
vitc	0.00	1516.80	3208.64	4725.44
thia	317.49	94.10	27.75	439.34
ribo	402.15	110.23	11.57	523.96
niac	7249.36	2083.74	66.65	9399.74
calc	15345.35	36320.50	4110.82	55776.67
phos	228592.81	169331.20	33471.37	431395.38
iron	5291.50	758.72	363.92	6414.14

Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	141646.00	91904.77	27361.56	260912.33
prot	23874.60	17720.23	952.90	42547.73
vita	904470.00	26092.00	10065.91	940627.94

	Males	Collective	Females	Total
vitc	55.05	1516.80	3208.64	4780.49
thia	339.14	97.97	27.75	464.87
ribo	421.24	117.33	11.57	550.14
niac	7558.74	2573.94	66.65	10199.32
calc	15675.65	37156.42	4110.82	56942.89
phos	238281.61	185330.42	33471.37	457083.41
iron	5427.29	929.00	363.92	6720.21

Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	171933.20	91904.77	27361.56	291199.53
prot	26260.90	17720.23	952.90	44934.03
vita	922914.81	26092.00	10065.91	959072.75
vitc	243.69	1516.80	3208.64	4969.12
thia	346.48	97.97	27.75	472.20
ribo	456.87	117.33	11.57	585.77
niac	7757.86	2573.94	66.65	10398.44
calc	17247.65	37156.42	4110.82	58514.89
phos	265739.22	185330.42	33471.37	484541.00
iron	6045.61	929.00	363.92	7338.53

Gender: M Kgs: 6.57 Resource: Muskrat
Requirements met: 8

	Males	Collective	Females	Total
kcal	180737.00	91904.77	27361.56	300003.34
prot	28049.25	17720.23	952.90	46722.38
vita	1108188.88	26092.00	10065.91	1144346.75
vitc	342.24	1516.80	3208.64	5067.68
thia	356.99	97.97	27.75	482.71
ribo	470.67	117.33	11.57	599.57
niac	7798.59	2573.94	66.65	10439.18
calc	18890.15	37156.42	4110.82	60157.39
phos	280193.22	185330.42	33471.37	498995.00
iron	6544.93	929.00	363.92	7837.85

Gender: M Kgs: 1.07 Resource: Bear
Requirements met: 8

	Males	Collective	Females	Total
kcal	182173.91	91904.77	27361.56	301440.25
prot	28295.35	17720.23	952.90	46968.48
vita	1114084.62	26092.00	10065.91	1150242.50
vitc	356.15	1516.80	3208.64	5081.58
thia	366.09	97.97	27.75	491.81
ribo	475.70	117.33	11.57	604.59
niac	7871.56	2573.94	66.65	10512.15
calc	18890.15	37156.42	4110.82	60157.39
phos	282472.31	185330.42	33471.37	501274.09
iron	6577.03	929.00	363.92	7869.95

Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 8

	Males	Collective	Females	Total
kcal	182888.89	91904.77	27361.56	302155.22
prot	28418.11	17720.23	952.90	47091.24
vita	1115536.62	26092.00	10065.91	1151694.50
vitc	356.15	1516.80	3208.64	5081.58
thia	366.68	97.97	27.75	492.40
ribo	477.61	117.33	11.57	606.51

	Males	Collective	Females	Total
niac	7905.22	2573.94	66.65	10545.81
calc	18906.65	37156.42	4110.82	60173.89
phos	283686.72	185330.42	33471.37	502488.50
iron	6598.15	929.00	363.92	7891.07

Gender: M Kgs: 3.21 Resource: Waterfowl/Winter & Summer
Requirements met: 9

	Males	Collective	Females	Total
kcal	192347.80	91904.77	27361.56	311614.12
prot	28986.28	17720.23	952.90	47659.41
vita	1115536.62	26092.00	10065.91	1151694.50
vitc	356.15	1516.80	3208.64	5081.58
thia	369.57	97.97	27.75	495.29
ribo	484.67	117.33	11.57	613.57
niac	8102.64	2573.94	66.65	10743.23
calc	19302.44	37156.42	4110.82	60569.68
phos	289721.53	185330.42	33471.37	508523.31
iron	6666.52	929.00	363.92	7959.44

Resource choices for the month of March.

Gender: C Kgs: 1921.82 Resource: Maple Sap
Gender: M Kgs: 53.08 Resource: Elk
Gender: F Kgs: 22.20 Resource: Stored Foods
Requirements met: 7

	Males	Collective	Females	Total
kcal	66350.00	138371.03	27361.56	232082.59
prot	11252.96	0.00	952.90	12205.86
vita	438440.81	4420.19	10065.91	452926.91
vitc	0.00	0.00	3208.64	3208.64
thia	159.24	0.00	27.75	186.99
ribo	201.70	0.00	11.57	213.27
niac	3635.98	0.00	66.65	3702.63
calc	7696.60	57078.05	4110.82	68885.47
phos	114652.80	4420.19	33471.37	152544.36
iron	2654.00	576.55	363.92	3594.47

Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 9

	Males	Collective	Females	Total
kcal	132287.50	216486.23	27361.56	376135.31
prot	22435.96	14106.24	952.90	37495.10
vita	874155.81	4420.19	10065.91	888641.94
vitc	0.00	1516.80	3208.64	4725.44
thia	317.49	83.42	27.75	428.67
ribo	402.15	75.84	11.57	489.56
niac	7249.36	1478.88	66.65	8794.88
calc	15345.35	93102.05	4110.82	112558.22
phos	228592.81	151928.98	33471.37	413993.16
iron	5291.50	955.75	363.92	6611.17

Resource choices for the month of April.

Gender: F Kgs: 1.80 Resource: Jack-In-The-Pulpit
Gender: C Kgs: 113.88 Resource: Fish/Spring
Gender: M Kgs: 52.75 Resource: Deer

Requirements met: 7

	Males	Collective	Females	Total
kcal	65937.50	117296.40	1671.12	184905.02
prot	11183.00	21181.68	76.14	32440.82
vita	435715.00	0.00	31874.94	467589.94
vitc	0.00	2277.60	247.32	2524.92
thia	158.25	125.27	2.34	285.86
ribo	200.45	113.88	1.26	315.59
niac	3613.38	2220.66	24.66	5858.69
calc	7648.75	54093.00	1532.34	63274.09
phos	113940.00	221496.59	1188.54	336625.12
iron	2637.50	569.40	26.10	3233.00

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	75296.00	130144.34	94639.12	300079.44
prot	12621.64	23387.64	1132.14	37141.42
vita	466029.19	26092.00	31874.94	523996.12
vitc	55.05	2277.60	27847.32	30179.97
thia	179.90	135.94	90.34	406.18
ribo	219.53	148.27	49.26	417.07
niac	3922.76	2825.52	488.66	7236.94
calc	7979.05	54389.50	9532.34	71900.89
phos	123628.80	243319.00	145188.55	512136.34
iron	2773.29	948.92	1354.10	5076.31

Gender: F Kgs: 29.60 Resource: Cattail
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 9

	Males	Collective	Females	Total
kcal	105583.20	221098.33	131058.96	457740.50
prot	15007.94	84023.63	1735.98	100767.55
vita	484474.00	26848.32	31874.94	543197.25
vitc	243.69	5302.88	38059.32	43605.89
thia	187.24	289.16	122.90	599.30
ribo	255.17	754.63	67.02	1076.82
niac	4121.88	2825.52	660.34	7607.74
calc	9551.05	59693.52	18157.78	87402.35
phos	151086.39	377510.38	187475.11	716071.88
iron	3391.61	1705.24	1845.46	6942.31

Resource choices for the month of May.

Gender: F Kgs: 1.80 Resource: Jack-In-The-Pulpit
Gender: C Kgs: 113.88 Resource: Fish/Spring
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal	65937.50	117296.40	1671.12	184905.02
prot	11183.00	21181.68	76.14	32440.82
vita	435715.00	0.00	31874.94	467589.94
vitc	0.00	2277.60	247.32	2524.92
thia	158.25	125.27	2.34	285.86
ribo	200.45	113.88	1.26	315.59
niac	3613.38	2220.66	24.66	5858.69
calc	7648.75	54093.00	1532.34	63274.09

	Males	Collective	Females	Total
phos	113940.00	221496.59	1188.54	336625.12
iron	2637.50	569.40	26.10	3233.00

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	75296.00	130144.34	87271.12	292711.44
prot	12621.64	23387.64	4076.14	40085.42
vita	466029.19	26092.00	31874.94	523996.12
vitc	55.05	2277.60	4247.32	6579.97
thia	179.90	135.94	114.34	430.18
ribo	219.53	148.27	33.26	401.07
niac	3922.76	2825.52	136.66	6884.94
calc	7979.05	54389.50	11932.34	74300.89
phos	123628.80	243319.00	133188.55	500136.34
iron	2773.29	948.92	1418.10	5140.31

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 9

	Males	Collective	Females	Total
kcal	105583.20	221098.33	180239.11	506920.62
prot	15007.94	84023.63	5132.14	104163.71
vita	484474.00	26848.32	31874.94	543197.25
vitc	243.69	5302.88	31847.32	37393.89
thia	187.24	289.16	202.34	678.74
ribo	255.17	754.63	81.26	1091.06
niac	4121.88	2825.52	600.66	7548.06
calc	9551.05	59693.52	19932.34	89176.91
phos	151086.39	377510.38	277188.56	805785.31
iron	3391.61	1705.24	2746.10	7842.95

APPENDIX E-5

Simulate Early and Middle Woodland Resource Choices Based on Multiple Goals

Resource choices for the month of June.

Gender: F Kgs: 1.28 Resource: Strawberry
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal[1]	65937.50	12847.94	473.60	79259.04
prot[2]	11183.00	2205.96	20.74	13409.70
vita[3]	435715.00	26092.00	1114.50	462921.50
vitc[4]	0.00	0.00	547.07	547.07
thia[5]	158.25	10.67	0.38	169.31
ribo[6]	200.45	34.39	0.77	235.61
niac[7]	3613.38	604.86	11.78	4230.01
calc[8]	7648.75	296.50	391.42	8336.67
phos[9]	113940.00	21822.40	295.42	136057.83
iron	2637.50	379.52	12.03	3029.05

Gender: F Kgs: 1.80 Resource: Jack-In-The-Pulpit
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 7

	Males	Collective	Females	Total
kcal	96224.70	13789.57	2144.72	112158.99
prot	13569.30	3613.99	96.88	17280.17
vita	454159.81	26092.00	32989.44	513241.25
vitc	188.64	0.00	794.39	983.03
thia	165.59	14.54	2.72	182.85
ribo	236.08	41.49	2.03	279.60
niac	3812.49	1095.06	36.44	4943.99
calc	9220.75	1132.42	1923.76	12276.93
phos	141397.59	37821.62	1483.96	180703.17
iron	3255.82	549.80	38.13	3843.75

---

[1] Calories

[2] Protein

[3] Vitamin A

[4] Vitamin C

[5] Thiamin

[6] Riboflavin

[7] Niacin

[8] Calcium

[9] Phosphorous

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	105583.20	91904.77	87744.72	285232.69
prot	15007.94	17720.23	4096.88	36825.05
vita	484474.00	26092.00	32989.44	543555.44
vitc	243.69	1516.80	4794.39	6554.88
thia	187.24	97.97	114.72	399.93
ribo	255.17	117.33	34.03	406.52
niac	4121.88	2573.94	148.44	6844.25
calc	9551.05	37156.42	12323.76	59031.23
phos	151086.39	185330.41	133483.97	469900.75
iron	3391.61	929.00	1430.13	5750.74

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 9

kcal	106298.17	91904.77	180712.72	378915.66
prot	15130.70	17720.23	5152.88	38003.80
vita	485926.00	26092.00	32989.44	545007.44
vitc	243.69	1516.80	32394.39	34154.88
thia	187.83	97.97	202.72	488.52
ribo	257.08	117.33	82.03	456.44
niac	4155.54	2573.94	612.44	7341.91
calc	9567.55	37156.42	20323.76	67047.73
phos	152300.80	185330.41	277483.97	615115.19
iron	3412.73	929.00	2758.13	7099.86

Total stored nutrients[10]: June.

kcal	7951.36
prot	226.73
vita	1451.54
vitc	1425.35
thia	8.92
ribo	3.61
niac	26.95
calc	894.25
phos	12209.29
iron	121.36

Resource choices for the month of July.

Gender: F Kgs: 35.98 Resource: Blackberry/Raspberry
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	65937.50	12847.94	24462.80	103248.24
prot	11183.00	2205.96	438.96	13827.92
vita	435715.00	26092.00	55769.00	517576.00
vitc	0.00	0.00	7616.97	7616.97
thia	158.25	10.67	10.79	179.72
ribo	200.45	34.39	21.59	256.43

[10] An additional 22% of female/juvenile foods are collected and set aside for storage.

	Males	Collective	Females	Total
niac	3613.38	604.86	205.09	4423.32
calc	7648.75	296.50	11632.33	19577.58
phos	113940.00	21822.40	9174.90	144937.30
iron	2637.50	379.52	323.82	3340.84

Gender: F Kgs: 13.32 Resource: Gooseberry/Currant
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	96224.70	13789.57	31477.11	141491.38
prot	13569.30	3613.99	630.76	17814.05
vita	454159.81	26092.00	80411.00	560662.81
vitc	188.64	0.00	19959.28	20147.92
thia	165.59	14.54	16.12	196.25
ribo	236.08	41.49	22.25	299.83
niac	3812.49	1095.06	226.40	5133.95
calc	9220.75	1132.42	16663.30	27016.47
phos	141397.59	37821.62	13110.96	192330.17
iron	3255.82	549.80	449.03	4254.65

Gender: F Kgs: 0.34 Resource: Mulberry
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	105583.20	91904.77	31666.26	229154.22
prot	15007.94	17720.23	634.74	33362.91
vita	484474.00	26092.00	80467.68	591033.69
vitc	243.69	1516.80	20010.28	21770.77
thia	187.24	97.97	16.22	301.43
ribo	255.17	117.33	22.56	395.05
niac	4121.88	2573.94	229.46	6925.27
calc	9551.05	37156.42	16857.10	63564.57
phos	151086.39	185330.41	13241.86	349658.66
iron	3391.61	929.00	456.00	4776.61

Gender: F Kgs: 1.80 Resource: Jack-In-The-Pulpit
Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 8

	Males	Collective	Females	Total
kcal	106298.17	91904.77	33337.38	231540.31
prot	15130.70	17720.23	710.88	33561.81
vita	485926.00	26092.00	112342.62	624360.62
vitc	243.69	1516.80	20257.60	22018.09
thia	187.83	97.97	18.56	304.36
ribo	257.08	117.33	23.82	398.23
niac	4155.54	2573.94	254.12	6983.59
calc	9567.55	37156.42	18389.44	65113.41
phos	152300.80	185330.41	14430.40	352061.59
iron	3412.73	929.00	482.10	4823.83

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Gender: M Kgs: 3.21 Resource: Waterfowl/Winter & Summer
Requirements met: 9

	Males	Collective	Females	Total
kcal	115757.08	91904.77	118937.38	326599.22
prot	15698.87	17720.23	4710.88	38129.98
vita	485926.00	26092.00	112342.62	624360.62

	Males	Collective	Females	Total
vitc	243.69	1516.80	24257.60	26018.09
thia	190.72	97.97	130.56	419.25
ribo	264.14	117.33	55.82	437.29
niac	4352.95	2573.94	366.12	7293.01
calc	9963.34	37156.42	28789.44	75909.20
phos	158335.59	185330.41	146430.41	490096.41
iron	3481.10	929.00	1874.10	6284.20

Total stored nutrients: June and July.

kcal	13184.60
prot	434.01
vita	6394.61
vitc	2492.69
thia	14.66
ribo	6.07
niac	43.06
calc	2160.98
phos	18652.23
iron	203.82

Resource choices for the month of August.

Gender: F Kgs: 9.09 Resource: Wild Black Cherry
Gender: C Kgs: 57.57 Resource: Waterfowl/March, Aug, Oct
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal	65937.50	169641.52	6403.91	241982.92
prot	11183.00	10189.89	145.44	21518.33
vita	435715.00	0.00	9691.76	445406.75
vitc	0.00	0.00	894.46	894.46
thia	158.25	51.81	4.55	214.61
ribo	200.45	126.65	5.45	332.56
niac	3613.38	3540.55	36.36	7190.29
calc	7648.75	7098.38	3637.82	18384.95
phos	113940.00	108231.60	3575.10	225746.70
iron	2637.50	1226.24	106.35	3970.09

Gender: F Kgs: 35.98 Resource: Blackberry/Raspberry
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	96224.70	182489.45	30866.71	309580.84
prot	13569.30	12395.85	584.40	26549.54
vita	454159.81	26092.00	65460.76	545712.56
vitc	188.64	0.00	8511.42	8700.06
thia	165.59	62.49	15.34	243.41
ribo	236.08	161.05	27.04	424.17
niac	3812.49	4145.42	241.45	8199.36
calc	9220.75	7394.88	15270.15	31885.78
phos	141397.59	130054.00	12750.00	284201.59
iron	3255.82	1605.76	430.17	5291.75

Gender: F Kgs: 13.32 Resource: Gooseberry/Currant
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 9

	Males	Collective	Females	Total
kcal	105583.20	183431.09	37881.02	326895.31
prot	15007.94	13803.88	776.20	29588.02
vita	484474.00	26092.00	90102.76	600668.75
vitc	243.69	0.00	20853.73	21097.42
thia	187.24	66.36	20.67	274.26
ribo	255.17	168.14	27.71	451.02
niac	4121.88	4635.62	262.76	9020.25
calc	9551.05	8230.80	20301.12	38082.97
phos	151086.39	146053.22	16686.06	313825.66
iron	3391.61	1776.04	555.38	5723.03

Total stored nutrients: June, July, and August.

kcal	14851.37
prot	468.16
vita	10359.13
vitc	3410.25
thia	15.57
ribo	7.28
niac	54.62
calc	3054.23
phos	19386.42
iron	228.25

Resource choices for the month of September.

Gender: F Kgs: 4.74 Resource: Beechnut
Gender: C Kgs: 115.14 Resource: Waterfowl/April, Sept
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	65937.50	339283.03	26923.20	432143.72
prot	11183.00	20379.78	919.56	32482.34
vita	435715.00	0.00	7110.00	442825.00
vitc	0.00	0.00	0.00	0.00
thia	158.25	103.63	14.22	276.10
ribo	200.45	253.31	14.22	467.98
niac	3613.38	7081.11	71.10	10765.58
calc	7648.75	14196.76	4740.00	26585.51
phos	113940.00	216463.20	14220.00	344623.19
iron	2637.50	2452.48	142.20	5232.18

Gender: F Kgs: 2.52 Resource: Beaked-hazelnut
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	96224.70	430237.03	45369.60	571831.31
prot	13569.30	81015.77	1511.76	96096.83
vita	454159.81	756.32	7110.00	462026.12
vitc	188.64	3025.28	0.00	3213.92
thia	165.59	256.85	24.30	446.73
ribo	236.08	859.67	18.25	1114.00
niac	3812.49	7081.11	103.86	10997.46
calc	9220.75	19500.78	9780.00	38501.53
phos	141397.59	350654.56	21780.00	513832.16
iron	3255.82	3208.80	217.80	6682.42

Gender: F Kgs: 3.38 Resource: White Oak Group
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	105583.20	443084.97	56486.08	605154.25
prot	15007.94	83221.73	1655.41	99885.08
vita	484474.00	26848.32	12180.00	523502.31
vitc	243.69	3025.28	0.00	3268.97
thia	187.24	267.52	30.05	484.80
ribo	255.17	894.06	19.60	1168.83
niac	4121.88	7685.97	171.46	11979.31
calc	9551.05	19797.28	18094.80	47443.13
phos	151086.39	372476.97	26005.00	549568.38
iron	3391.61	3588.32	261.74	7241.67

Gender: F Kgs: 1.78 Resource: Red Oak Group
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 8

	Males	Collective	Females	Total
kcal	106298.17	444026.59	63585.07	613909.81
prot	15130.70	84629.77	1733.91	101494.37
vita	485926.00	26848.32	14850.00	527624.31
vitc	243.69	3025.28	0.00	3268.97
thia	187.83	271.39	33.07	492.29
ribo	257.08	901.16	20.32	1178.55
niac	4155.54	8176.17	207.06	12538.77
calc	9567.55	20633.20	22627.04	52827.79
phos	152300.80	388476.19	27196.17	567973.19
iron	3412.73	3758.60	284.88	7456.21

Gender: F Kgs: 2.64 Resource: Elderberry
Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 6.57 Resource: Muskrat
Requirements met: 9

	Males	Collective	Females	Total
kcal	115101.97	522141.78	65485.88	702729.62
prot	16919.05	98736.01	1802.55	117457.60
vita	671200.00	26848.32	30690.00	728738.31
vitc	342.24	4542.08	950.40	5834.72
thia	198.34	354.81	34.92	588.08
ribo	270.88	977.00	21.90	1269.77
niac	4196.27	9655.05	220.26	14071.58
calc	11210.05	56657.20	23630.24	91497.49
phos	166754.80	535985.00	27935.37	730675.19
iron	3912.05	4137.80	327.12	8376.97

Total stored nutrients: June, July, August, and September.

kcal	17732.75
prot	547.47
vita	11709.49
vitc	3452.07
thia	17.11
ribo	8.25
niac	64.31
calc	4093.96
phos	20615.58
iron	242.65

Resource choices for the month of October.

Gender: F Kgs: 16.17 Resource: Hickory
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal	65937.50	90953.99	110441.10	267332.59
prot	11183.00	60636.00	2118.27	73937.27
vita	435715.00	756.32	24255.00	460726.31
vitc	0.00	3025.28	161.70	3186.98
thia	158.25	153.22	54.98	366.45
ribo	200.45	606.36	42.04	848.85
niac	3613.38	0.00	129.36	3742.74
calc	7648.75	5304.02	808.50	13761.27
phos	113940.00	134191.38	58212.00	306343.38
iron	2637.50	756.32	388.08	3781.90

Gender: F Kgs: 2.97 Resource: Butternut
Gender: C Kgs: 57.57 Resource: Waterfowl/March, Aug, Oct
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	96224.70	260595.50	128335.35	485155.56
prot	13569.30	70825.88	2790.98	87186.16
vita	454159.81	756.32	33165.00	488081.12
vitc	188.64	3025.28	221.10	3435.02
thia	165.59	205.03	61.51	432.13
ribo	236.08	733.01	45.31	1014.40
niac	3812.49	3540.55	150.15	7503.20
calc	9220.75	12402.40	1105.50	22728.65
phos	141397.59	242422.97	75141.00	458961.56
iron	3255.82	1982.56	578.16	5816.54

Gender: F Kgs: 0.38 Resource: Black walnut
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	105583.20	273443.44	130704.16	509730.78
prot	15007.94	73031.84	2848.77	90888.55
vita	484474.00	26848.32	34305.00	545627.31
vitc	243.69	3025.28	228.70	3497.67
thia	187.24	215.71	62.35	465.29
ribo	255.17	767.41	45.73	1068.30
niac	4121.88	4145.42	152.81	8420.10
calc	9551.05	12698.90	1143.50	23393.45
phos	151086.39	264245.38	77307.00	492638.75
iron	3391.61	2362.08	600.96	6354.65

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 9

	Males	Collective	Females	Total
kcal	106298.17	274385.06	216304.16	596987.38
prot	15130.70	74439.88	6848.77	96419.34
vita	485926.00	26848.32	34305.00	547079.31
vitc	243.69	3025.28	4228.70	7497.67
thia	187.83	219.58	174.35	581.76

	Males	Collective	Females	Total
ribo	257.08	774.50	77.73	1109.31
niac	4155.54	4635.62	264.81	9055.96
calc	9567.55	13534.82	11543.50	34645.87
phos	152300.80	280244.59	209307.00	641852.38
iron	3412.73	2532.36	1992.96	7938.05

Total stored nutrients: June, July, August, September, and October.

kcal	27250.13
prot	848.82
vita	13218.91
vitc	3638.13
thia	24.78
ribo	11.67
niac	75.96
calc	4601.87
phos	29825.09
iron	330.34

Resource choices for the months of November through February.

Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 53.08 Resource: Elk
Gender: F Kgs: 20.49 Resource: Stored foods
Requirements met: 7

	Males	Collective	Females	Total
kcal	66350.00	12847.94	27250.13	106448.07
prot	11252.96	2205.96	848.82	14307.74
vita	438440.81	26092.00	13218.91	477751.72
vitc	0.00	0.00	3638.13	3638.13
thia	159.24	10.67	24.78	194.70
ribo	201.70	34.39	11.67	247.77
niac	3635.98	604.86	75.96	4316.80
calc	7696.60	296.50	4601.87	12594.97
phos	114652.80	21822.40	29825.09	166300.28
iron	2654.00	379.52	330.34	3363.86

Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal	132287.50	13789.57	27250.13	173327.20
prot	22435.96	3613.99	848.82	26898.77
vita	874155.81	26092.00	13218.91	913466.75
vitc	0.00	0.00	3638.13	3638.13
thia	317.49	14.54	24.78	356.82
ribo	402.15	41.49	11.67	455.31
niac	7249.36	1095.06	75.96	8420.38
calc	15345.35	1132.42	4601.87	21079.64
phos	228592.81	37821.62	29825.09	296239.53
iron	5291.50	549.80	330.34	6171.64

Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 1.07 Resource: Bear
Requirements met: 8

	Males	Collective	Females	Total
kcal	133724.41	91904.77	27250.13	252879.31
prot	22682.06	17720.23	848.82	41251.11
vita	880051.50	26092.00	13218.91	919362.44

	Males	Collective	Females	Total
vitc	13.91	1516.80	3638.13	5168.84
thia	326.58	97.97	24.78	449.33
ribo	407.18	117.33	11.67	536.18
niac	7322.33	2573.94	75.96	9972.23
calc	15345.35	37156.42	4601.87	57103.64
phos	230871.91	185330.41	29825.09	446027.41
iron	5323.60	929.00	330.34	6582.94

Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	164011.61	91904.77	27250.13	283166.50
prot	25068.36	17720.23	848.82	43637.41
vita	898496.31	26092.00	13218.91	937807.25
vitc	202.55	1516.80	3638.13	5357.48
thia	333.92	97.97	24.78	456.67
ribo	442.82	117.33	11.67	571.81
niac	7521.45	2573.94	75.96	10171.35
calc	16917.35	37156.42	4601.87	58675.64
phos	258329.50	185330.41	29825.09	473485.00
iron	5941.92	929.00	330.34	7201.26

Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 8

	Males	Collective	Females	Total
kcal	173370.11	91904.77	27250.13	292525.00
prot	26507.00	17720.23	848.82	45076.05
vita	928810.50	26092.00	13218.91	968121.44
vitc	257.60	1516.80	3638.13	5412.53
thia	355.57	97.97	24.78	478.32
ribo	461.90	117.33	11.67	590.90
niac	7830.83	2573.94	75.96	10480.73
calc	17247.65	37156.42	4601.87	59005.94
phos	268018.31	185330.41	29825.09	483173.81
iron	6077.71	929.00	330.34	7337.05

Gender: M Kgs: 0.66 Resource: Woodchuck
Requirements met: 8

	Males	Collective	Females	Total
kcal	174085.09	91904.77	27250.13	293240.00
prot	26629.76	17720.23	848.82	45198.80
vita	930262.50	26092.00	13218.91	969573.44
vitc	257.60	1516.80	3638.13	5412.53
thia	356.17	97.97	24.78	478.92
ribo	463.81	117.33	11.67	592.81
niac	7864.49	2573.94	75.96	10514.39
calc	17264.15	37156.42	4601.87	59022.44
phos	269232.72	185330.41	29825.09	484388.22
iron	6098.83	929.00	330.34	7358.17

Gender: M Kgs: 3.21 Resource: Waterfowl/Winter & Summer
Requirements met: 8

	Males	Collective	Females	Total
kcal	183544.00	91904.77	27250.13	302698.91
prot	27197.93	17720.23	848.82	45766.98
vita	930262.50	26092.00	13218.91	969573.44
vitc	257.60	1516.80	3638.13	5412.53
thia	359.06	97.97	24.78	481.81
ribo	470.88	117.33	11.67	599.87
niac	8061.91	2573.94	75.96	10711.81

	Males	Collective	Females	Total
calc	17659.94	37156.42	4601.87	59418.23
phos	275267.53	185330.41	29825.09	490423.03
iron	6167.20	929.00	330.34	7426.54

Gender: M Kgs: 6.57 Resource: Muskrat
Requirements met: 9

	Males	Collective	Females	Total
kcal	192347.80	91904.77	27250.13	311502.69
prot	28986.28	17720.23	848.82	47555.33
vita	1115536.50	26092.00	13218.91	1154847.38
vitc	356.15	1516.80	3638.13	5511.08
thia	369.57	97.97	24.78	492.32
ribo	484.67	117.33	11.67	613.67
niac	8102.64	2573.94	75.96	10752.54
calc	19302.44	37156.42	4601.87	61060.73
phos	289721.53	185330.41	29825.09	504877.03
iron	6666.52	929.00	330.34	7925.86

Resource choices for the month of March.

Gender: C Kgs: 1921.82 Resource: Maple Sap
Gender: M Kgs: 53.08 Resource: Elk
Gender: F Kgs: 20.49 Resource: Stored foods
Requirements met: 7

	Males	Collective	Females	Total
kcal	66350.00	138371.03	27250.13	231971.16
prot	11252.96	0.00	848.82	12101.78
vita	438440.81	4420.19	13218.91	456079.91
vitc	0.00	0.00	3638.13	3638.13
thia	159.24	0.00	24.78	184.02
ribo	201.70	0.00	11.67	213.37
niac	3635.98	0.00	75.96	3711.94
calc	7696.60	57078.05	4601.87	69376.53
phos	114652.80	4420.19	29825.09	148898.08
iron	2654.00	576.55	330.34	3560.88

Gender: C Kgs: 57.57 Resource: Waterfowl/March, Aug, Oct
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	132287.50	308012.53	27250.13	467550.16
prot	22435.96	10189.89	848.82	33474.67
vita	874155.81	4420.19	13218.91	891794.94
vitc	0.00	0.00	3638.13	3638.13
thia	317.49	51.81	24.78	394.08
ribo	402.15	126.65	11.67	540.48
niac	7249.36	3540.55	75.96	10865.87
calc	15345.35	64176.44	4601.87	84123.66
phos	228592.81	112651.78	29825.09	371069.69
iron	5291.50	1802.79	330.34	7424.63

Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 1.07 Resource: Bear
Requirements met: 8

	Males	Collective	Females	Total
kcal	133724.41	320860.47	27250.13	481835.00
prot	22682.06	12395.85	848.82	35926.73
vita	880051.50	30512.19	13218.91	923782.62

	Males	Collective	Females	Total
vitc	13.91	0.00	3638.13	3652.04
thia	326.58	62.49	24.78	413.85
ribo	407.18	161.05	11.67	579.90
niac	7322.33	4145.42	75.96	11543.71
calc	15345.35	64472.94	4601.87	84420.16
phos	230871.91	134474.19	29825.09	395171.19
iron	5323.60	2182.31	330.34	7836.25

Gender: C Kgs: 6.45 Resource: Rabbit
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	164011.61	321802.09	27250.13	513063.84
prot	25068.36	13803.88	848.82	39721.05
vita	898496.31	30512.19	13218.91	942227.44
vitc	202.55	0.00	3638.13	3840.68
thia	333.92	66.36	24.78	425.06
ribo	442.82	168.14	11.67	622.63
niac	7521.45	4635.62	75.96	12233.03
calc	16917.35	65308.86	4601.87	86828.09
phos	258329.50	150473.41	29825.09	438628.00
iron	5941.92	2352.59	330.34	8624.85

Gender: C Kgs: 75.84 Resource: Fish/Winter, Summer & Fall
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 9

	Males	Collective	Females	Total
kcal	173370.11	399917.28	27250.13	600537.50
prot	26507.00	27910.12	848.82	55265.94
vita	928810.50	30512.19	13218.91	972541.62
vitc	257.60	1516.80	3638.13	5412.53
thia	355.57	149.78	24.78	530.14
ribo	461.90	243.98	11.67	717.55
niac	7830.83	6114.50	75.96	14021.29
calc	17247.65	101332.86	4601.87	123182.38
phos	268018.31	297982.19	29825.09	595825.56
iron	6077.71	2731.79	330.34	9139.83

Resource choices for the month of April.

Gender: F Kgs: 1.80 Resource: Jack-In-The-Pulpit
Gender: C Kgs: 115.14 Resource: Waterfowl/April, Sept
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 8

	Males	Collective	Females	Total
kcal	65937.50	339283.03	1671.12	406891.66
prot	11183.00	20379.78	76.14	31638.92
vita	435715.00	0.00	31874.94	467589.94
vitc	0.00	0.00	247.32	247.32
thia	158.25	103.63	2.34	264.22
ribo	200.45	253.31	1.26	455.02
niac	3613.38	7081.11	24.66	10719.14
calc	7648.75	14196.76	1532.34	23377.85
phos	113940.00	216463.20	1188.54	331591.75
iron	2637.50	2452.48	26.10	5116.08

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 9

	Males	Collective	Females	Total
kcal	96224.70	430237.03	94639.12	621100.88
prot	13569.30	81015.77	1132.14	95717.21
vita	454159.81	756.32	31874.94	486791.06
vitc	188.64	3025.28	27847.32	31061.24
thia	165.59	256.85	90.34	512.77
ribo	236.08	859.67	49.26	1145.01
niac	3812.49	7081.11	488.66	11382.26
calc	9220.75	19500.78	9532.34	38253.88
phos	141397.59	350654.56	145188.55	637240.69
iron	3255.82	3208.80	1354.10	7818.72

Resource choices for the month of May.

Gender: F Kgs: 1.80 Resource: Jack-In-The-Pulpit
Gender: C Kgs: 32.60 Resource: Pigeon
Gender: M Kgs: 52.75 Resource: Deer
Requirements met: 7

	Males	Collective	Females	Total
kcal	65937.50	90953.99	1671.12	158562.61
prot	11183.00	60636.00	76.14	71895.13
vita	435715.00	756.32	31874.94	468346.25
vitc	0.00	3025.28	247.32	3272.60
thia	158.25	153.22	2.34	313.81
ribo	200.45	606.36	1.26	808.07
niac	3613.38	0.00	24.66	3638.03
calc	7648.75	5304.02	1532.34	14485.11
phos	113940.00	134191.38	1188.54	249319.92
iron	2637.50	756.32	26.10	3419.92

Gender: F Kgs: 80.00 Resource: Arrowhead/Wapato
Gender: C Kgs: 11.86 Resource: Squirrel
Gender: M Kgs: 10.48 Resource: Beaver
Requirements met: 8

	Males	Collective	Females	Total
kcal	96224.70	103801.93	87271.12	287297.75
prot	13569.30	62841.96	4076.14	80487.39
vita	454159.81	26848.32	31874.94	512883.06
vitc	188.64	3025.28	4247.32	7461.24
thia	165.59	163.89	114.34	443.82
ribo	236.08	640.75	33.26	910.10
niac	3812.49	604.86	136.66	4554.01
calc	9220.75	5600.52	11932.34	26753.61
phos	141397.59	156013.78	133188.55	430599.94
iron	3255.82	1135.84	1418.10	5809.76

Gender: F Kgs: 80.00 Resource: Bullrush
Gender: C Kgs: 113.88 Resource: Fish/Spring
Gender: M Kgs: 3.67 Resource: Raccoon
Requirements met: 9

	Males	Collective	Females	Total
kcal	105583.20	221098.33	180239.11	506920.62
prot	15007.94	84023.63	5132.14	104163.71
vita	484474.00	26848.32	31874.94	543197.25
vitc	243.69	5302.88	31847.32	37393.89
thia	187.24	289.16	202.34	678.74

	Males	Collective	Females	Total
ribo	255.17	754.63	81.26	1091.06
niac	4121.88	2825.52	600.66	7548.06
calc	9551.05	59693.52	19932.34	89176.91
phos	151086.39	377510.38	277188.56	805785.31
iron	3391.61	1705.24	2746.10	7842.95

REFERENCES CITED

Ahearn, P. J., and R. E. Bailey
1980 Pollen Record from Chippewa Bog, Lapeer County, Michigan. *Michigan Academician* 12(3):297-308.

Albert, D. A., S. R. Denton, and B. V. Barnes
1986 *Regional Landscape Ecosystems of Michigan*. School of Natural Resources, University of Michigan, Ann Arbor.

Allison, A. L.
1972 Plant Remains. In *The Schultz Site at Green Point: A Stratified Occupation Area in the Saginaw Valley of Michigan*, edited by J. E. Fitting, pp. 77-85. Memoirs 4, Museum of Anthropology, University of Michigan, Ann Arbor.

Arzigian, C.
1987 The Emergence of Horticultural Economies in Southwestern Wisconsin. In *Emergent Horticultural Economies of the Eastern Woodlands*, edited by W. F. Keegan, pp. 217-242. Occasional Papers No. 7, Center for Archeological Investigations, Southern Illinois University at Carbondale, Carbondale.

Asch, D. L., and N. B. Asch
1978 The Economic Potential of *Iva annua* and Its Prehistoric Importance in the Lower Illinois Valley. In *The Nature and Status of Ethnobotany*, edited by R. I. Ford, pp. 301-341. Anthropological Papers No. 67, Museum of Anthropology, University of Michigan, Ann Arbor.

1985 Prehistoric Plant Cultivation in West-Central Illinois. In *Prehistoric Food Production in North America*, edited by R. I Ford, pp. 149-203. Anthropological Papers No. 75, Museum of Anthropology, University of Michigan, Ann Arbor.

Asch, N. B., R. I. Ford, and D. L. Asch
1972 *Paleoethnobotany of the Koster Site: The Archaic Horizons*. Reports of Investigations No. 24, Illinois State Museum, Springfield.

Baird, E. T.
1898 Reminiscences of Early Days on Mackinac Island. *Collections of the State Historical Society of Wisconsin* 14:29-34.

Baker, R. H.
1983 *Michigan Mammals*. Michigan State University Press, East Lansing.

Banfield, A. W. F.
1981 *The Mammals of Canada*. National Museum of Natural Sciences, National Museum of Canada, University of Toronto Press, Toronto, Ontario.

Barnes, B. V., and W. H. Wagner
1981 *Michigan Trees*. University of Michigan Press, Ann Arbor.

Beauchamp, G. K., and B. J. Cowart
1987 Development of Sweet Taste. In *Sweetness*, edited by J. Dobbing, pp. 127-138. Springer-Verlag, New York.

Bernabo, J. C.
1981 Quantitative Estimates of Temperature Changes Over the Last 2700 Years in Michigan Based on Pollen Data. *Quaternary Research* 15:143-159.

Bernabo, J. C., and T. Webb III
1977 Changing Patterns in the Holocene Pollen Record of Northeastern North America: A Mapped Summary. *Quaternary Research* 8:64-96.

Bertelsen, R., A. Lillehammer, and J. R. Naess
1987 *Were They All Men? An Examination of Sex Roles in Prehistoric Society*. Arkeologisk Museum, Stavanger. Stavanger, Norway.

Bettinger, R. L.
1980 Explanatory/Predictive Models of Hunter-Gatherer Adaptations. In *Advances in Archaeological Method and Theory, Vol 3*, edited by M. Schiffer, pp. 189-255. Academic Press, New York.

1991 *Hunter-Gatherers: Archaeological and Evolutionary Theory*. Plenum Press, New York.

Binford, L. R.
1968 Archaeological Perspectives. In *New Perspectives in Archaeology*, edited by S. R. Binford and L. R. Binford, pp. 5-32. Aldine Publishing Co., Chicago.

1980 Willow Smoke and Dogs Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation Processes. *American Antiquity* 45:4-20.

Binford, L. R., and W. J. Chasko
1976 Nunamiut Demographic History: A Provocative Case. In *Demographic Anthropology*, edited by I. Zubrow, pp. 136. University of New Mexico Press, Albuquerque.

Blair, E.
1911 *The Indian Tribes of the Upper Mississippi Valley and Region of the Great Lakes*. A. H. Clark, Cleveland, Ohio.

Boikova, F.
1971 Seasonal Variations in Vitamin "A" Content in the Liver of Certain Mammals of the Far North. *Ekologiya {Ecology}* 2(2):148-152.

Bourdo, E. A.
1956 A Review of the General Land Office Survey and of Its Use in Quantitative Studies of Former Forests. *Ecology* 37:754-768.

Brashler, J. G.
1973 *A Formal Analysis of Prehistoric Ceramics from the Fletcher Site*. Unpublished Master's Thesis, Department of Anthropology, Michigan State University, East Lansing.

1981 *Early Late Woodland Boundaries in Interaction: Indian Ceramics of Southern Lower Michigan*. Museum Anthropological Series Vol. 3, Michigan State University, East Lansing.

Brashler, J. G., and M. B. Holman
1985 Late Woodland Continuity and Change in the Saginaw Valley of Michigan. *Arctic Anthropology* 22:141-152.

Braun, D. P.
1987 Coevolution of Sedentism, Pottery Technology, and Horticulture in the Central Midwest, 200 B.C. - A.D. 600. In *Emergent Horticultural Economies of the Eastern Woodlands*, edited by W. F. Keegan, pp. 153-181. Occasional Papers No. 7, Center for Archaeological Investigations, Southern Illinois University at Carbondale, Carbondale.

Braun, D. P., and S. Plog
1982 Evolution of "Tribal" Social Networks: Theory and Prehistoric North American Evidence. *American Antiquity* 47(3):504-525.

Braun, E. L.
1950 *Deciduous Forests of Eastern North America*. Blakiston Company, Philadelphia.

Brody, H.
1981 *Maps and Dreams*. Pantheon Books, New York.

Brose, D. S.
1972 The Mollusc Fauna. In *The Schultz Site at Green Point: A Stratified Occupation Area in the Saginaw Valley of Michigan*, edited by J. Fitting, pp. 117-130. Memoirs 4, Museum of Anthropology, University of Michigan, Ann Arbor.

Brower, J. E., and J. H. Zar
1977 *Field and Laboratory Methods for General Ecology*. Wm. C. Brown Company, Dubuque.

Brown, J. A., and R. K. Vierra
1983 What Happened in the Middle Archaic? Introduction to an Ecological Approach to Koster Site Archaeology. In *Archaic Hunters and Gatherers in the American Midwest*, edited by J. L. Phillips and J. A. Brown, pp. 165-195. Academic Press, New York.

Buikstra, J. E., L. W. Konigsberg, and J. Bullington
1986 Fertility and the Development of Agriculture in the Prehistoric Midwest. *American Antiquity* 51:528-546.

Burt, W. H.
1946 *Mammals of Michigan*. The University of Michigan Press, Ann Arbor.

Burton, B. T.
1965 *The Heinz Handbook of Nutrition*. McGraw-Hill Book Co., New York.

Butterfield, I.
1986 Water Configuration in the Human Environment from the Main Algonquin to the Nipissing I Stages of the Great Lakes in the Saginaw Valley, Michigan. *The Michigan Archaeologist* 32(3):101-137.

Carver, J. Esq.
1956 *Travels Through the Interior Parts of North America in the Years 1766, 1767, and 1768*. 3rd ed. Ross and Haines, Minneapolis.

Cashdan, E.
1990 Introduction. In *Risk and Uncertainty in Tribal and Peasant Societies*, edited by E. Cashdan, pp. 1-10. Westview Press, Boulder.

Cassidy, C. M.
1972 *Comparison of Nutrition in Preagricultural and Agricultural Skeletal Populations*. Unpublished Ph.D. dissertation, University of Wisconsin, Wisconsin, Madison.

Charlevoix, Pierre de
1966 *Journal of a Voyage to North-America*. University Microfilms, Inc., Ann Arbor.

Clark, C. W.
1990 Uncertainty in Economics. In *Risk and Uncertainty in Tribal and Peasant Societies*, edited by E. Cashdan, pp. 47-63. Westview Press, Boulder.

Clarke, D.
1978 *Analytical Archaeology*. Methuen and Co., Ltd., London.

Classen, C. P.
1991 Gender, Shellfishing, and the Shell Mound Archaic. In *Engendering Archaeology: Women and Prehistory*, edited by J. M. Gero and M. W. Conkey, pp. 276-300. Basil Blackwell, Inc., Cambridge, Massachusetts.

Cleland, C. E.
1966 *The Prehistoric Animal Ecology and Ethnozoology of the Upper Great Lakes Region*. Anthropological Papers No. 29, Museum of Anthropology, University of Michigan, Ann Arbor.

1976 The Focal-Diffuse Model: An Evolutionary Perspective on the Prehistoric Cultural Adaptations of the Eastern United States. *Midcontinental Journal of Archaeology* 1(1):59-75.

1982 The Inland Shore Fishery of the Northern Great Lakes: Its Development and Importance in Prehistory. *American Antiquity* 47(4)761-784.

1992a From Ethnohistory to Archaeology: Ottawa and Ojibwa Band Territories of the Northern Great Lakes. In *Text-Aided Archaeology*, edited by B. J. Little, pp. 97-102. CRC Press, Ann Arbor, Michigan.

1992b *Rites of Conquest: A History and Culture of Michigan Native Americans*. The University of Michigan Press, Ann Arbor.

Cleland, N. N.
1986 A Preliminary Analysis of the Botanical Remains from Sites 20BY77 and 20BY79, Bay City, Michigan. In *Archaeological Investigations at Sites 20BY77, 20BY78, and 20BY79, at the Third Street Bridge Replacement, Bay City, Michigan*, edited by W. A. Lovis, pp. 198-207. Report submitted to the City of Bay City, Michigan Department of Transportation, Michigan Department of State, Federal Highway Administration, and U.S. Department of Transportation.

1989 An Analysis of the Botanical Remains and Paleoenvironment of the Weber I Site. In *Archaeological Investigations at the Weber I and Weber II Sites, Frankenmuth Township, Saginaw County, Michigan*, edited by W. A. Lovis, pp. 175-189. Michigan Cultural Resource Investigations Series Vol 1, Michigan Department of Transportation, Michigan Department of State, Federal Highway Administration, Lansing.

Cook, D. C.
1976 Pathologic States and Disease Processes in Illinois Woodland Populations: An Epidemiologic Approach. Unpublished Ph.D. dissertation, Department of Anthropology, University of Chicago, Chicago.

Coombs, G.
1980 Decision Theory and Subsistence Strategies: Some Theoretical Considerations. In *Modeling Change in Prehistoric Subsistence Economies*, edited by T. K. Earle and A. L. Christenson, pp. 187-208. Academic Press, New York.

Coult, A. D., and R. W. Habenstein
1965 *Cross Tabulations of Murdock's World Ethnographic Sample*. University of Missouri Press, Columbia.

Cowan, C. W.
1985 *From Foraging to Incipient Food Production: Subsistence Change and Continuity on the Cumberland Plateau of Eastern Kentucky*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Michigan, Ann Arbor.

Crabtree, P. J.
1991 Gender Hierarchies and the Sexual Division of Labor in the Natufian Culture of the Southern Levant. In *The Archaeology of Gender: Proceedings of the Twenty-Second Annual Conference of the Archaeological Association of the University of Calgary*, edited by D. Walde and N. D. Willows, pp. 384-391. Archaeological Association, The University of Calgary, Calgary.

Crumley, C. S.
1973 The Kantzler Site (20BY30): A Multicomponent Woodland Site in Bay County, Michigan. *The Michigan Archaeologist* 19:183-291.

Curtis, J. T.
1971 *Vegetation of Wisconsin*. 2nd ed. University of Wisconsin Press, Madison.

DeGarine, I.
1972 The Socio-Cultural Aspects of Nutrition. *Ecology of Food and Nutrition* 1:143-63.

Densmore, F.
1974 *How Indians Use Wild Plants for Food, Medicine, and Crafts*. Dover Publications, Inc., New York.

1979 *Chippewa Customs*. Reprinted. Minnesota Historical Society Press, Minneapolis.

Desor, J. A., O. Maller, and L. S. Greene
1977 Preference for Sweet In Humans: Infants, Children, and Adults. In *Taste and Development: The Genesis of Sweet Preference. DHEW Publication No. (NIH) 77-1068*, edited by J. M. Weiffenbach, pp. 161-72. U.S. Department of Health, Education, and Welfare, Bethesda, Maryland.

Dice, L. R.
1943 *The Biotic Provinces of North America*. University of Michigan Press, Ann Arbor.

Dorr, J. A., and D. F. Eschman
1971 *Geology of Michigan*. University of Michigan Press, Ann Arbor.

Dunn, F. L.
1968 Epidemiological Factors: Health and Disease in Hunter-Gatherers. In *Man the Hunter*, edited by R. B. Lee and I. DeVore, pp. 221-8. Aldine Press, Chicago.

Dunning, R. W.
1959 *Social and Economic Change Among the Northern Ojibwa*. University of Toronto Press, Toronto.

Dustin, F.
1929 Some Ancient Fire-Beds In Saginaw County, Michigan. *Michigan History Magazine* 12(4):301-307.

1930 Some Ancient Indian Village Sites in Saginaw County, Michigan. *Papers of the Michigan Academy of Science, Arts and Letters* 12:75-93.

Egan, K. C.
1988 Middle and Late Archaic Phytogeography and Floral Exploitation in the Upper Great Lakes. *Midcontinental Journal of Archaeology* 13(1):81-107.

1990 Archaeobotanical Remains from 20SA620. In *The Bridgeport Township Site: Archaeological Investigations at 20SA620 Saginaw County, Michigan*, edited by J. M. O'Shea and M. Shott, pp. 203-231. Anthropological Papers No. 81, Museum of Anthropology, University of Michigan, Ann Arbor.

Ellen, R.
1986 *Environment, Subsistence, and System: The Ecology of Small-Scale Social Formations*. Cambridge University Press, New York.

Elster, J.
1989 *Nuts and Bolts for the Social Sciences*. Cambridge University Press, New York.

Erichsen-Brown, C.
1979 *Use of Plants: For the Past 500 Years*. Breezy Creeks Press, Ontario.

Fairchild, J. D.
1977 The Schmidt Site: A Pre-Nipissing Village in the Saginaw Valley. Unpublished Master's thesis, Department of Anthropology, Western Michigan University, Kalamazoo.

Farb, P., and G. Armelagos
1980 *Consuming Passions: The Anthropology of Eating*. Washington Square Press, New York.

Farrand, W.
1990 Geologic Observations on 20SA620. In *The Bridgeport Township Site: Archaeological Investigations at 20SA620 Saginaw County, Michigan*, edited by J. M. O'Shea and M. Shott, pp. 45-57. Anthropological Papers No. 81, Museum of Anthropology, University of Michigan, Ann Arbor.

Fecteau, R.
1985 *The Introduction and Diffusion of Cultivated Plants into Southern Ontario*. Unpublished Master's thesis, Department of Geography, York University, Toronto.

Fischer, F. W.
1972 Schultz Site Ceramics. In *The Schultz Site at Green Point: A Stratified Occupation Area in the Saginaw Valley of Michigan*, edited by J. E. Fitting, pp. 137-190. Memoirs 4, Museum of Anthropology, University of Michigan, Ann Arbor.

Fitting, J. E.
1969 Settlement Analysis in the Great Lakes Region. *Southwestern Journal of Anthropology* 25:360-377.

1972a Excavations at the Schultz Site. In *The Schultz Site at Green Point: A Stratified Occupation Area in the Saginaw Valley of Michigan*, edited by J. E. Fitting, pp. 5-42. Memoirs 4, Museum of Anthropology, University of Michigan, Ann Arbor.

1972b Lithic Industries at the Schultz Site. In *The Schultz Site: A Stratified Occupation Area in the Saginaw Valley of Michigan*, edited by J. E. Fitting, pp. 191-224. Memoirs 4, Museum of Anthropology, University of Michigan, Ann Arbor.

1972c Occupational History. *The Schultz Site: A Stratified Occupation Area in the Saginaw Valley of Michigan*, edited by J. E. Fitting, pp. 253-266. Memoirs 4, Museum of Anthropology, University of Michigan, Ann Arbor.

1975 *The Archaeology of Michigan: A Guide to the Prehistory of the Great Lakes Region*. 2nd ed. Cranbrook Institute of Science, Bloomfield Hills, Michigan.

Flannery, K. V.
1968 Archaeological Systems Theory and Early Mesoamerica. In *Anthropological Archaeology in the Americas*, edited by B. J. Meggars, pp. 67-87. Anthropological Society of Washington, Washington, D.C.

Food and Agriculture Organization (FAO)
1974 *Handbook on Human Nutritional Requirements*. FAO Nutritional Studies, No. 228. Food and Agriculture Organization of the United Nations, New York.

Ford, R. I.
1977 Evolutionary Ecology and the Evolution of Human Ecosystems: A Case Study from the Midwestern U.S.A. In *Explanation of Prehistoric Change*, edited by J. N. Hill, pp. 153-184. University of New Mexico Press, Albuquerque.

1985 The Processes of Plant Food Production in Prehistoric North America. In *Prehistoric Food Production in North America*, edited by R. I. Ford, pp. 1-18. Anthropological Papers No. 75, Museum of Anthropology, University of Michigan, Ann Arbor.

Franz, P. J.
1993 The Faunal Assemblage from Sites 20BY77 and 20BY79 Bay City, Michigan. In *Archaeological Investigations at Sites 20BY77, 20BY78, and 20BY79, at the Third Street Bridge Replacement, Bay City, Michigan*, edited by W. A. Lovis, pp. 154-197. Michigan Cultural Resource Investigations Series Vol. 3, Michigan Department of Transportation, Michigan Department of State, and Federal Highway Administration, Lansing.

Fritz, G. J.
1990 Multiple Pathways to Farming in Precontact Eastern North America. *Journal of World Archaeology* 4(4):387-435.

Garland, E. (editor)
1990 *Late Archaic and Early Woodland Adaptation in the Lower St. Joseph River Valley*. Michigan Cultural Resource Investigations Series Vol 2, Michigan Department of Transportation, Michigan Department of State, and Federal Highway Administration, Lansing.

General Land Office Survey (GLOS)
1821-34 *Descriptions of Townships in Bay and Saginaw Counties*. Notebooks on file at the State of Michigan Archives, Lansing.

Gero, J. M., and M. W. Conkey (editors)
1991 *Engendering Archaeology: Women and Prehistory*. Basil Blackwell, Ltd., Cambridge, Massachusetts.

Gilliam, J. A., R. O. Kapp, and R. D. Bogue
1967 A Post-Wisconsin Pollen Sequence from Vestaburg Bog, Montcalm County, Michigan. *Papers of the Michigan Academy of Sciences, Arts, and Letters* 52:3-17.

Glander, K. E.
1982 The Impact of Plant Secondary Compounds on Primate Feeding Behavior. *Yearbook of Physical Anthropology* 25:1-18.

Gleason, H. A., and A. Cronquist
1963 *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*. D. Van Nostrand Company, Inc., New York.

Haas, J. D., and G. G. Harrison
1977 Nutritional Anthropology and Biological Adaptation. *Annual Review of Anthropology* 6:69-101.

Hall, R. L.
1983 A Pan-Continental Perspective in Red Ocher and Glacial Kame Ceremonialism. In *Lulu Linear Punctated: Essays in Honor of George Irving Quimby*, edited by R. C. Dunnell and D. K. Grayson, pp. 75-108. Anthropological Papers No. 72, Museum of Anthropology, University of Michigan, Ann Arbor.

Hallowell, A. I.
1992 *The Ojibwa of Berrens River Manitoba: Ethnography into History*, edited by J. S. H. Brown. Harcourt Brace Jovanovich College Publishers, New York.

Halstead, P., and J. O'Shea
1989 Introduction: Cultural Responses to Risk and Uncertainty. In *Bad Year Economics: Cultural Responses to Risk and Uncertainty*, edited by P. Halstead and J. O'Shea, pp. 1-7. Cambridge University Press, New York.

Hardesty, D. C.
1977 *Ecological Anthropology*. Wiley, New York.

Harris, M.
1971 *Culture, Man, and Nature: An Introduction to General Anthropology*. Crowell, New York.

Harrison, S.
1966 The Schmidt Site (20SA192), Saginaw County, Michigan. *The Michigan Archaeologist* 12(2):49-70.

Hastorf, C. A., and V. S. Popper (editors)
1988 *Current Paleoethnobotany: Analytical Methods and Cultural Interpretations of Archaeological Plant Remains*. The University of Chicago Press, Chicago.

Heldmaier, G.
1990 Seasonal Acclimatization of Energy Requirements in Mammals: Functional Significance of Body Weight Control, Hypothermia, Torpor and Hibernation. In *Proceedings of the 10th Conference of the European Society for Comparative Physiology and Biochemistry*, edited by W. Wieser and E. Gnaiger, pp. 130-9. Georg Thieme Verlag Stuttgart, New York.

Henry, A.
1969 *Travels and Adventures in Canada and the Indian Territories: Between 1760 and 1776*. M. G. Hurtig Ltd., Edmonton.

Hewitt, J. S.
1983 *Optimal Foraging Models for the Lower Illinois River Valley*. Unpublished Ph.D. dissertation, Department of Anthropology, Northwestern University, Evanston, Illinois.

Hill, K., K. Hawkes, M. Hurtado, and H. Kaplan
1984 Seasonal Variance in Diet of Ache Hunter-Gatherers in Eastern Paraguay. *Human Ecology* 12:101-143.

Holman, J. A.
1990 Vertebrates From the Harper Site and Rapid Climatic Change in Mid-Holocene Michigan. *Michigan Academician* XXII:205-17.

Houghton, D.
1838 Manuscript map in possession of the University of Michigan Library. Ann Arbor.

Howell, N.
1979 *Demography of the Dobe !Kung*. Academic Press, New York.

Hushen, T. W., R. O. Kapp, R. D. Bogue, and J. T. Worthington
1966 Presettlement Forest Patterns in Montcalm County, Michigan. *The Michigan Botanist* 5:192-211.

Ingold, T.
1983 The Significance of Storage in Hunting Societies. *Man* 18:553-71.

Issac, G.
1978 The Food Sharing Behavior of Protohominids. *Scientific American* 238(4):90-108.

Jochim, M. A.
1976 *Hunter-Gatherer Subsistence and Settlement: A Predictive Model*. Academic Press, New York.

1981 *Strategies for Survival: Cultural Behavior in an Ecological Context*. Academic Press, New York.

1983 Optimization Models in Context. In *Archaeological Hammers and Theories*, edited by J. A. Moore and A. S. Keene, pp. 157-172. Academic Press, New York.

1988 Optimal Foraging and the Division of Labor. *American Anthropologist* 90:130-136.

Kaplan, H., and K. Hill
1985 Food Sharing Among Ache Foragers: Tests of Explanatory Hypotheses. *Current Anthropology* 26:223-46.

Kapp, R. O.
1977 Late Pleistocene and Postglacial Plant Communities of the Great Lakes Region. In *Geobotany*, edited by R. C. Romans, pp. 1-27. Plenum Press, New York.

Katz, S. H., M. L. Hegiger, and L. A. Valleroy
1974 Traditional Maize Processing Techniques in the New World. *Science* 184:765-773.

Keegan, W. F., and B. M. Butler
1987 The Microeconomic Logic of Horticultural Intensification in the Eastern Woodlands. In *Emergent Horticultural Economies of the Eastern Woodlands*, edited by W. F. Keegan, pp. 109-127. Occasional Papers No. 7, Center for Archeological Investigations, Southern Illinois University at Carbondale, Carbondale.

Keene, A. S.
1981 *Prehistoric Foraging in a Temperate Forest: A Linear Programming Model*. Academic Press, New York.

1983 Biology, Behavior, and Borrowing: A Critical Examination of Optimal Foraging Theory in Archaeology. In *Archaeological Hammers and Theories*, edited by J. A. Moore and A. S. Keene, pp. 139-55. Academic Press, New York.

Kemp, W.
1971 The Flow of Energy in a Hunting Society. *Scientific American* 224(3):104-15.

Kieckhefer, B.
1962 Correlation Between Phenology and Caloric Content in Forest Herbs. *Transactions of the Illinois Academy of Sciences* 55(3-4):215-23.

King, F. B.
1978 Additional Cautions of the Use of the GLO Survey Records in Vegetational Reconstructions in the Midwest. *American Antiquity* 43:99-103.

King, F. B., and R. W. Graham
1981 Effects of Ecological and Paleoecological Patterns on Subsistence and Paleoenvironmental Reconstructions. *American Antiquity* 48:128-142.

Kinietz, W. V.
1972 *Indians of the Western Great Lakes 1615-1760*. 2nd printing. The University of Michigan Press, Ann Arbor.

Knight, J. A.
1985 *Differential Preservation of Calcined Bone at the Hirundo Site, Alton, Maine*. Unpublished Master's thesis, Institute of Quaternary Studies, University of Maine at Orono.

Landes, R.
1971 *The Ojibwa Woman*. W. W. Norton & Co., Inc., New York.

Larsen, C. E.
1985 Geoarchaeological Interpretation of Great Lakes Coastal Environments. In *Archaeological Sediments in Context*, edited by J. Stein and W. Farrand, pp. 91-110. Institute of Quaternary Studies, University of Maine, Orono.

1987 *Geological History of Glacial Lake Algonquin and the Upper Great Lakes*. U.S. Geological Survey Bulletin 1801. United States Government Printing Office, Washington D.C.

Lee, R. B.
1968 What Hunters Do for a Living or How They Make Out on Scarce Resources. In *Man the Hunter*, edited by R. B. Lee and I. DeVore, pp. 30-43. Aldine Publishing Co., Chicago.

1969 !Kung Bushman Subsistence: An Input-Output Analysis. In *Environment and Cultural Behavior: Ecological Studies in Cultural Anthropology*, edited by A. P. Vayda, pp. 47-79. Natural History Press, New York.

Lee, R. B., and I. DeVore (editors)
1968 *Man the Hunter*. Aldine Publishing Company, Hawthorne, New York.

Limp, F., and C. Carr
1985 The Analysis of Decision Making: Alternative Applications in Archaeology. In *For Concordance in Archaeological Analysis: Building Data Structure, Quantitative Techniques and Theory*, edited by C. Carr, pp. 128-72. Westport Publications, Inc., Kansas City, Missouri.

Lopinot, N.
1982 Significance of Nuts. In *The Carrier Mills Archaeological Project: Human Adaptation in the Saline Valley, Illinois*, edited by R. W. Jefferies and B. M. Butler, pp. 717-743. Research Papers No. 33, Center for Archaeological Investigations, Southern Illinois University Press at Carbondale, Carbondale.

1984 *Archaeological Formation Processes and Late Middle Archaic Human-Plant Interactions in the Midcontinental U.S.A.* Unpublished Ph.D. dissertation, Department of Anthropology, Southern Illinois University, Carbondale.

Lovis, W. A.
1984 Drainage Evolution and Its Effects on Archaic and Early Woodland Adaptations in the Saginaw Valley of Michigan. Paper presented at the 49th Annual Meeting of the Society for American Archaeology, Portland.

1985 Seasonal Settlement Dynamics and the Role of the Fletcher Site in the Woodland Adaptation of the Saginaw Drainage Basin. *Arctic Anthropologist* 22(2):153-70.

1986 Environmental Periodicity, Buffering, and the Archaic Adaptations of Saginaw Valley of Michigan. In *Foraging, Collecting, and Harvesting: Archaic Period Subsistence in the Eastern Woodlands*, edited by S. W. Neusius, pp. 99-116. Occasional Papers No. 6, Center for Archeological Investigations at Carbondale, Carbondale, Illinois.

1989 Variations in Late Archaic Resource Availability as a Consequence of Lake Level Periodicity in the Huron Basin. Paper presented at the symposium "Rethinking the Terminal Archaic-Woodland Period Transition in the Northeast," 54th Annual Meeting of the Society for American Archaeology. Atlanta.

1990 Potential Impacts of Environmental Periodicity on Late Archaic Lacustrine Adaptations in the Saginaw Valley of Michigan. Paper presented at the 55th Annual Meeting of the Society for American Archaeology, Las Vegas.

Lovis, W. A. (editor)
1989 *Archaeological Investigations at the Weber I and Weber II Sites, Frankenmuth Township, Saginaw County, Michigan*. Michigan Cultural Resource Investigations Series Vol 1, Michigan Department of Transportation, Michigan Department of State, and Federal Highway Administration, Lansing.

1993 *Archaeological Investigations at Sites 20BY77, 20BY78, and 20BY79, at the Third Street Bridge Replacement, Bay City Michigan*. Michigan Cultural Resource Investigations Series Vol. 3, Michigan Department of Transportation, Michigan Department of State, and Federal Highway Administration, Lansing.

Lovis, W. A., K. C. Egan, G. W. Monaghan, B. A. Smith, and E. J. Prahl
1994 *Environment and Subsistence at the Marquette Viaduct Locale of the Fletcher site*. In *Investigating the Archaeolgical Record of the Great Lakes State: Essays in Honor of Elizabeth Baldwin Garland*, edited by M. B. Holman, J. G. Brashler, and K. E. Parker. New Issues Press, Western Michigan University, Kalamazoo.

Lovis, W. A., and J. A. Robertson
1989 Rethinking the Archaic Chronology of the Saginaw Valley, Michigan. *Midcontinental Journal of Archaeology* 14(2):226-260.

Luxenberg, B.
1972 Faunal Remains. In *The Schultz Site: A Stratified Occupation Area in the Saginaw Valley of Michigan*, edited by J. E. Fitting, pp. 91-115. Memoirs 4, Museum of Anthropology, University of Michigan, Ann Arbor.

Macomb, J. N., *et al.*
1856 Preliminary Chart, Lower Reach of Saginaw River and Bar Front. Surveyed under the direction of Captain J. N. Macomb TE by W. H. Hearding, J. H. Foster, I. L. Beghein.

Mainfort, R. C.
1979 *Indian Social Dynamics in the Period of European Contact.* Michigan State University, Museum Anthropological Series Vol., 1 No. 4, East Lansing.

Martin, J. F.
1983 Optimal Foraging Theory: A Review of Some Models and Their Applications. *American Anthropologist* 85(3):612-29.

Maulden, R.
1987 An Ethnographic Overview of Hunter-Gatherer Subsistence. Paper presented at the 52nd Annual Meeting of the Society for American Archaeology, Toronto.

McArthur, M.
1974 Pigs for the Ancestors: A Review .Article. *Oceania* 45(2):87-123.

McCabe, R. E., and T. R. McCabe
1984 Of Slings and Arrows: An Historical Retrospection. In *White-tailed Deer; Ecology and Management*, edited by L. K. Halls, pp. 19-72. Stackpole Books, New York.

McCormick, W. R.
1883 Mounds and Mound Builders of the Saginaw Valley, Michigan. *Michigan Pioneer and Historical Collections* 4:379-383.

McMurray, M., G. Kloos, R. Kapp, and K. Sullivan
1978 Paleoecology of Crystal Marsh, Montcalm County, Based on Macrofossil and Pollen Analysis. *Michigan Academician* 10:403-17.

Messer, E.
1984 Anthropological Perspectives on Diet. *Annual Review of Anthropology* 13:205-49.

Moerman, D. E.
1986 *Medicinal Plants of Native America*. Technical Reports No. 19, Museum of Anthropology, University of Michigan, Ann Arbor.

Monaghan, G. W.
1993 Geology of the Third Street Bridge Right-of-Way, Bay City, Michigan. In *Archaeological Investigations at Sites 20BY77, 20BY78, and 20BY79, at the Third Street Bridge Replacement, Bay City, Michigan*, edited by W. A. Lovis, pp. 45-52. Michigan Cultural Resource Investigations Series Vol. 3, Michigan Department of Transportation, Michigan Department of State, and Federal Highway Administration, Lansing.

Monaghan, G. W., and L. Fay
1989 The Geology of the Weber I Site. In *Archaeological Investigations at the Weber I and Weber II Sites, Frankenmuth Township, Saginaw County, Michigan*, edited by W. A. Lovis, pp. 41-50. Michigan Cultural Resource Investigations Series Vol 1, Michigan Department of Transportation, Michigan Department of State, and Federal Highway Administration, Lansing.

Monaghan, G. W., L. Fay, and W. A. Lovis
1986 Nipissing Transition in the Saginaw Bay Region, Michigan. *Canadian Journal of Earth Science* 23(11):1851-54.

Munson, P. J. (editor)
1984 *Experiments and Observations on Aboriginal Wild Plant Utilization in Eastern North America*. In *Prehistory Research Series VI(2)*. Indiana Historical Society, Indianapolis.

Murdock, G. P.
1967 Ethnographic Atlas: A Summary. *Ethnology* VI:109-236.

Murray, P. F.
1972 Bone, Antler, and Shell Artifacts. In *The Schultz Site: A Stratified Occupation Area in the Saginaw Valley of Michigan*, edited by J. E. Fitting, pp. 225-244. Memoirs 4, Museum of Anthropology, University of Michigan, Ann Arbor.

Nagy, J., and J. Haufler
1980 Wildlife Nutrition. In *Wildlife Management Techniques Manual*, 4th ed., edited by S. Schemnitz, pp. 129-42. Wildlife Society, Washington.

Nassaney, M. S.
1987 On the Causes and Consequences of Subsistence Intensification in the Mississippi Alluvial Valley. In *Emergent Horticultural Economies of the Eastern Woodlands*, edited by W. F. Keegan, pp. 129-151. Occasional Papers No. 7, Center for Archeological Investigations, Southern Illinois University at Carbondale, Carbondale.

National Research Council [NRC]
1989 *Recommended Dietary Allowances*. 10th ed. National Academy Press, Washington, D.C.

Ozker, D. B.
1982 *An Early Woodland Community at the Schultz Site 20SA2 in the Saginaw Valley and the Nature of the Early Woodland Adaptation in the Great Lakes Region*. Anthropological Papers No. 70, Museum of Anthropology, University of Michigan, Ann Arbor.

Parachini, K. E.
1983 Natural Harvest: Prehistoric Relationships Between Man and the Environment in Southwestern Michigan. Paper presented in a symposium, "Late Archaic and Early Woodland in Southwestern Michigan: The US-31 Mitigation Project," Midwest Archaeological Conference, Iowa City.

Parker, K. E.
1992 Plant Remains From Archeological Excavations at Site 20SA1034 in the Saginaw Valley of Michigan. Report submitted to The Institute of Minnesota Archaeology, Minneapolis.

Peebles, C. S.
1978 Of Archaeology and Archaeologists in Saginaw County, Michigan. *The Michigan Archaeologist* 24:81-129.

Polanyi, K.
1959 Anthropology and Economic Theory. In *Readings in Anthropology II*, edited by M. Fried. Crowell-Collier, New York.

1977 The Two meanings of Economic. In *The Livelihood of Man*, edited by H. W. Pearson, pp. 19-34. Academic Press, New York.

Potzger, J. E.
1948 A Pollen Study in the Tension Zone of Lower Michigan. *Butler University Botanical Study* 8:161-77.

Quick, B. E.
1923 A Comparative Study of the Distribution of the Climax Association in Southern Michigan. *Papers of the Michigan Academy of Science, Arts and Letters* Vol. III:211-243.

Rappaport, R.
1984 *Pigs for the Ancestors*. 2nd ed. Yale University Press, New Haven.

Reidhead, V. A.
1976 *Optimization and Food Procurement at the Prehistoric Leonard Haag Site, Southeastern Indiana: A Linear Programming Approach*. Unpublished Ph.D. dissertation, Department of Anthropology, Indiana University, Bloomington.

1980 Economics of Subsistence Change. In *Modeling of Prehistoric Subsistence Economies*, edited by T. K. Earle and A. L. Christensen, pp. 141-186. Academic Press, New York.

Riches, D.
1982 *Northern Nomadic Hunter-Gatherers: A Humanistic Approach*. Academic Press, New York.

Robertson, J. A.
1989 The Lithic Assemblage from Sites 20BY77, 20BY78, and 20BY79, Bay City, Michigan. In *Archaeological Investigations at Sites 20BY77, 20BY78, and 20BY79, at the Third Street Bridge Replacement, Bay City, Michigan*, edited by W. A. Lovis, pp. 53-119. Report submitted to the City of Bay City, Michigan Department of Transportation, Michigan Department of State, Federal Highway Administration, and U.S. Department of Transportation.

1987 *Inter-Assemblage Variability and Hunter-Gatherer Settlement Systems: A Perspective From the Saginaw Valley of Michigan*. Unpublished Ph.D. dissertation, Department of Anthropology, Michigan State University, East Lansing.

1993 Lithic Assemblage of 20SA581: Description and Analysis. In *Archaeological Investigations at the Weber I and Weber II Sites, Frankenmuth Township, Saginaw County, Michigan*, edited by W. A. Lovis, pp. 51-137. Michigan Cultural Resource Investigations Series Vol. 2, Michigan Department of Transportation, Michigan Department of State, and Federal Highway Administration, Lansing.

Russell, K. F., I. Choi, and C. S. Larsen
1990 The Paleodemography of Santa Catalina de Guale. In *The Archaeology of Mission Santa Catalina de Guale: 2, Biocultural Interpretations of a Population in Transition*, edited by C. S. Larsen, pp. 36-49. Anthropological Papers of the American Museum of Natural History No. 68, New York.

Sahlins, M.
1972 *Stone Age Economics*. Aldine Press, Chicago.

Sauer, N. J.
1974 *An Analysis of the Human Skeletal Material for the Fletcher Site (20BY28)*. Unpublished Ph.D. dissertation, Department of Anthropology, Michigan State University, East Lansing.

Schoolcraft, H. R.
1839 Census of Michigan Indian Populations Under the Treaty of Washington 1836. In The Papers of Henry R. Schoolcraft 1821-1878. Library of Congress Microfilm R66:41828.

1953 *Narrative Journal of Travels: Through the Northwestern Regions of the United States Extending from Detroit through the Great Chain of American Lakes to the Source of the Mississippi River in the Year 1820*, edited by M. L. Williams. The Michigan State College Press, East Lansing.

Seeley, D. A.
1917 *The Climate of Michigan and Its Relation to Agriculture*. Reprint of report of State Board of Agriculture, Lansing.

Service, E.
1971 *Primitive Social Organization*. 2nd ed. Random House, New York.

Simon, H.
1955 A Behavioral Model of Rational Choice. *Quarterly Journal of Economics* 69:99-114.

1957 *Models of Man*. John Wiley & Sons, New York.

1959 Theories of Decision-Making in Economics and Behavioral Science. *American Economic Review* 49:253-283.

Smart, T. L., and E. S. Hoffman
1988 Environmental Interpretation of Archaeological Charcoal. In *Current Paleoethnobotany: Analytical Methods and Cultural Interpretation of Archaeological Plant Remains*, edited by C. A. Hastorf and V. S. Popper, pp. 167-205. University of Chicago Press, Chicago.

Smith, B. A.
1989 Analysis of the Faunal Remains from the Weber I Site. In *Archaeological Investigations at the Weber I and Weber II Sites, Frankenmuth Township, Saginaw County, Michigan*, edited by W. A. Lovis, pp. 143-174. Michigan Cultural Resource Investigations Series Vol. 1, Michigan Department of Transportation, Michigan Department of State, and Federal Highway Administration, Lansing.

Smith, B. A., and K. C. Egan
1990 Middle and Late Archaic Faunal and Floral Exploitation at the Weber I Site (20SA581), Michigan. *Ontario Archaeology* 50:39-61.

Smith, B. D.
1985 The Role of *Chenopodium* as a Prehistoric Domesticate in Eastern North America: Evidence From Russell Cave, Alabama. *Southeastern Archaeology* 4:51-72.

1992 *Rivers of Change: Essays on Early Agriculture in Eastern North America*. Smithsonian Institution, Washington, D.C.

Smith, E. A.
1983 Anthropological Applications of Optimal Foraging Theory: A Critical Review. *Current Anthropology* 24(5):625-51.

Smith, H. H.
1923 Ethnobotany of the Menomini Indians. *Bulletin of the Milwaukee Public Museum* 4(1):1-174.

1928 Ethnobotany of the Meskwaki Indians. *Bulletin of the Milwaukee Public Museum* 4(2):175-326.

1932 Ethnobotany of the Ojibwe Indians. *Bulletin of the Milwaukee Public Museum* 4(3):327-525.

1933 Ethnobotany of the Forest Potawatomi Indians. *Bulletin of the Milwaukee Public Museum* 7(1):1-230.

Smith, H. I.
1902 The Antiquities of Michigan, Their Value and Impending Loss. *Michigan Pioneer and Historical Collections* 31:23-252.

Speth, J. D.
1972 Geology of the Schultz site. In *The Schultz Site at Greene Point: A Stratified Occupation Area in the Saginaw Valley of Michigan*, edited by J. E. Fitting. Memoirs 4, Museum of Anthropology, University of Michigan, Ann Arbor.

1988 Nutritional Aspects of Food Sharing in Egalitarian Foraging Societies. In *Diet and Subsistence: Current Archaeological Perspectives*. Proceedings of the 19th annual conference of the Archaeological Association of the University of Calgary, edited by B. V. Kennedy and G. M. LeMoine, pp. 108-14. The University of Calgary Archaeological Association, Calgary.

Speth, J. D., and K. A. Spielmann
1983 Energy Source, Protein Metabolism, and Hunter-Gatherer Subsistence Strategies. *Journal of Anthropological Archaeology* 2:1-31.

Steward, J. H.
1933 Ethnography of the Owens Valley Paiute. *University of California Publication in American Archaeology and Ethnology* 33:233-350.

1938 *Basin Plateau Aboriginal Socio-Political Groups*. Bureau of American Ethnology, Bulletin, 120, Washington, D.C.

Stini, W.
1975 Adaptive Strategies of Human Populations Under Nutritional Stress. In *Biosocial Interactions in Population Adaptation*, edited by E. Watts, F. Johnson, and G. Lasker, pp. 19-41. Mouton, The Hague.

Story, D. A.
1985 Adaptive Strategies of Archaic Cultures of the West Gulf Coastal Plain. In *Prehistoric Food Production in North America*, edited by R. I. Ford, pp. 19-56. Anthropological Papers No. 75, Museum of Anthropology, University of Michigan, Ann Arbor.

Stuiver, M., and B. Becker
1986 High Precision Decadal Calibration of the Radiocarbon Time Scale, A.D. 1950-2500 B.C. *Radiocarbon* 28:863-910.

Styles, B. W.
1981 *Faunal Exploitation and Resource Selection: Early Late Woodland Subsistence in the Lower Illinois Valley*. Northwestern University Archaeological Program, Scientific Papers Vol. 3, Evanston, Illinois.

1984 Review of *Prehistoric Foraging in a Temperate Forest: A Linear Programming Model*, by A. S. Keene. *American Antiquity* 49:433-435.

Styles, B. W., and J. R. Purdue
1986 Middle Woodland Faunal Exploitation. In *Woodland Period Occupation of the Napoleon Hollow Site in the Lower Illinois Valley*, edited by M. D. Wiant and C. R. McGimsey, pp. 513-526. Research Series Vol. 6, Kampsville Archeological Center, Center for American Archeology, Kampsville, Illinois.

Taggart, D. W.
1963 Field Summary of the University of Michigan Museum of Anthropology Excavations at the Green Point (Schultz Site, 20SA2) Saginaw County, Michigan, During the Summer of 1963. Manuscript on file, Great Lakes Range, Museum of Anthropology, University of Michigan, Ann Arbor.

1966 The Feheeley Site: A Late Archaic Site in the Saginaw Valley. Manuscript on file, Great Lakes Range, Museum of Anthropology, University of Michigan, Ann Arbor.

1967 Seasonal Patterns in Settlement, Subsistence, and Industries in the Saginaw Late Archaic. *The Michigan Archaeologist* 13(4):153-170.

Tanner, J.
1956 *A Narrative of the Captivity and Adventures of John Tanner*. Ross and Haines, Inc., Minneapolis.

Taylor, F.
1974 Phenodynamics of Production in a Mesic Deciduous Forest. In *Phenology and Seasonality Modeling*, edited by H. Lieth, pp. 237-54. Springer-Verlag, New York.

Thor, C., and C. Smith
1935 A Physiological Study of Seasonal Changes in the Composition of the Pecan During Fruit Development. *Journal of Agricultural Research* 50(2):97-121.

Tordoff, J. D.
1972 *The Dental Anthropology of the Fletcher Site, 20BY28*. Unpublished Master's thesis, Department of Anthropology, Michigan State University, East Lansing.

Truswell, A. S.
1977 Diet and Nutrition of Hunter-Gatherers. In *Health and Disease in Tribal Societies*. Ciba Foundation Symposium 49, Elsevier Excerpta Medica, New York.

Turnbull, C. M.
1961 *The Forest People: A Study of the Pygmies of the Congo*. Simon and Schuster, New York.

Tversky, A., and D. Kahnemann
1981 The Framing of Decisions and the Psychology of Choice. *Science* 211(January):453-58.

Veatch, J. O.
1959 *Presettlement Vegetation of Michigan (Map)*. Department of Resource Development, Michigan State University, East Lansing.

Vita-Finzi, C., and E. Higgs
1970 Prehistoric Economy in the Mount Carmel Area of Palestine: Site Catchment Analysis. *Proceedings of the Prehistoric Society* 36:1-37.

Voss, E. G.
1972 *Michigan Flora: Part I Gymnosperms and Monocots*. Cranbrook Institute of Science, Bloomfield Hills, Michigan.

1985 *Michigan Flora: Part II Dicots*. Cranbrook Institute of Science, Bloomfield Hills, Michigan.

Watson, P. J.
1985 The Impact of Early Horticulture in the Upland Drainages of the Midwest and Midsouth. In *Prehistoric Food Production in North America*, edited by R. I. Ford, pp. 99-147. Anthropological Papers No. 75, Museum of Anthropology, University of Michigan, Ann Arbor.

Watson, P. J., and M. C. Kennedy
1991 The Development of Horticulture in the Eastern Woodlands of North America: Women's Role. In *Engendering Archaeology: Women and Prehistory*, edited by J. M. Gero and M. W. Conkey, pp. 255-275. Basil Blackwell, Inc., Cambridge, MA.

Waugh, F. W.
1916 *Iroquois Foods and Food Preparation*. Anthropological Series 12, Memoir 86, Canada Department of Mines, Ottawa.

White, L.
1949 *The Science of Culture*. Grove Press, New York.

White, T.
1953 A Method of Calculating the Dietary Percentage of Various Food Animals Utilized by Aboriginal Peoples. *American Antiquity* 18:396-398.

Wiessner, P.
1982 Risk, Reciprocity, and Social Influences on !Kung San Economics. In *Politics and History in Band Societies*, edited by E. R. Leacock and R. B. Lee. Cambridge University Press, New York.

Wing, E. S., and A. B. Brown
1979 *Paleonutrition: Method and Theory in Prehistoric Foodways*. Academic Press, New York.

Winterhalder, B.
1977 *Foraging Strategy Adaptations of the Boreal Forest Cree: An Evaluation of Theory and Models from Evolutionary Ecology*. Unpublished Ph.D. dissertation, Cornell University, Ithaca, New York.

1981a Foraging Strategies in the Boreal Forest: An Analysis of Cree Hunting and Gathering. In *Hunter-Gatherer Foraging Strategies: Ethnographic and Archaeological Analyses*, edited by B. Winterhalder and E. A. Smith, pp. 66-98. University of Chicago Press, Chicago.

1981b Optimal Foraging Strategies and Hunter-Gatherer Research in Anthropology: Theory and Methods. In *Hunter-Gatherer Foraging Strategies: Ethnographic and Archaeological Analyses*, edited by B. Winterhalder and E. A. Smith, pp. 13-35. University of Chicago Press, Chicago.

1986 Diet Choice, Risk, and Food Sharing in a Stochastic Environment. *Journal of Anthropological Archaeology* 5:369-392.

Winterhalder, B., and E. A. Smith (editors)
1981 *Hunter-Gatherer Foraging Strategies: Ethnographic and Archaeological Analyses*. University of Chicago Press, Chicago.

Winters, H. D.
1969 *The Riverton Culture: A Second Millennium Occupation in the Central Wabash Valley*. Illinois State Museum, Reports of Investigations, No. 13. Published jointly by the Illinois State Museum and the Illinois Archaeological Survey, Springfield.

Wood, W. R.
1976 Vegetational Reconstructions and Climatic Episodes. *American Antiquity* 41:206-207.

Woodburn, J.
1968 Stability and Flexibility in Hadza Residential Groupings. In *Man the Hunter*, edited by R. B. Lee and I. DeVore, pp. 103-10. Aldine Publishing Co., New York.

Yarnell, R. A.
1964 *Aboriginal Relations Between Culture and Plant Life in the Upper Great Lakes Region*. Anthropological Papers No. 23, Museum of Anthropology, University of Michigan, Ann Arbor.

Yerkes, R. W.
1987 *Prehistoric Life on the Mississippi Floodplain: Stone Tool Use, Settlement, and Subsistence Practices of the Labras Lake Site, Illinois*. University of Chicago Press, Chicago.

Zager, P. E., and R. W. Pippen
1977 Fifteen Years of Change in a Southwest Michigan Hardwood Forest. *The Michigan Botanist* 16:201-211.

Zamek, S. M.
1984 Analysis of the Pit Features from the Fletcher Site. Manuscript on file, Michigan State University Museum, East Lansing.

Zipf, G. K.
1949 *Human Behavior and the Principle of Least Effort*. Addison-Wesley, Reading, MA.