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FOREST SUCCESSION AND HUMAN POPULATION
CHANGE IN A TEMPERATE FOREST ENVIRONMENT

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Abstract

In light of the impoverishment of archaeological data on human population dynamics and resource utilization during the Early Archaic through late Woodland periods in the Northeast, a testable predictive model is developed that will explain human behavioral responses to changes in the terrestrial resource potential during forest succession. Based on resource potential, it is demonstrated that following deglaciation in Southern New England, decreases in species diversity and increasing density of vegetational resources during succession may articulate with the increase in population size among foraging groups, development of territoriality, fluctuation of diet breadth, and expanding spatial distribution of habitation sites. It is proposed that frequencies of artifacts and sites for the Archaic and Woodland periods will be correlated with changes in population size, territoriality and site distribution, and that pollen data may be used to test the change in diversity during succession.

In a temperate forest foraging subsistence strategy there is a close relationship between human population dynamics and changes in the environment. Following deglaciation in Southern New England, several shifts in exploitative strategies and fluctuations in human population size appear to have taken place over the past 12,000 years in response to the changing post-glacial environment. Some of these changes were undoubtedly adaptive responses to climatic amelioration, some to deterioration of available faunal resources, some to the changing character of floral resources as natural forest succession proceeded, and some to factors such as changes in human population density.

Archaeologically it is difficult to deal with the problem of population change in the Northeast. Poor organic preservation prevents the use of early human skeletal material in population studies, but we are left with implications of population dynamics based on the changing frequency of artifacts, and changes in the frequency and spatial distribution of habitation sites over time. The data are suggestive of small human populations following the establishment of an immature deciduous forest (c. 10,000 to 9,000 B.P.), gradually increasing in size as the maturing forest increased in available biomass. The data further suggest that by approximately 4,000 B.P., populations had reached a peak and possibly remained high until approximately 3,000 B.P., after which population began to decrease in size.

It will be shown that these apparent changes in human populations may be associated with responses to changes in the diversity and density of vegetational resources. The simplifying assumption made is that all floral species at a given time are considered resources potentially important to human subsistence. This importance is based on two considerations: 1) many floral resources are used for direct consumption by human consumers, and as such are important nutritionally, and 2) they also support exploitable faunal populations. Floral resources are therefore a highly important factor in human survival. Use will be made of the variables "diversity" and "density" as they relate to a critical resource: vegetation. It is acknowledged that terrestrial fauna must also be considered a critical resource to human foragers in Southern New England; however, as with human skeletal material, high acidity soils have eliminated most faunal remains from the data base. Remains of marine fauna are also uncommon.

It is the aim of this paper to develop a testable model that will allow the prediction, and enhance the understanding of human behavioral responses to changes in the character of the vegetational resource base.

Definition of Terms

Many of the terms and concepts discussed in this paper have been used in numerous ways, some changing in meaning as the concepts evolved through time, and as they crossed disciplinary lines. In order to avoid ambiguity and misunderstanding, the following list is provided and includes terms as they are used in the paper.

Diversity - The number of distinct species existing in a region at a given time.

Density - The quantity or abundance of individuals of a distinct species within a given region.

Territoriality - The aggressive defense of space (Hamilton and Watt 1970: 269) by human populations.

Succession - "A predictable pattern of changes in the specific composition of a forest community after radical disturbance following the opening of a new patch in the physical environment for colonization by plants and animals" (Horn 1974:25) or in response to intraspecific competition over time.

Climax - A late stage of forest succession never actually reached in reality. A climax forest is ideally characterized by dense-canopy, shade producing species.

Quality - as used here, is really a desirability index: a level below which a resource becomes less desirable because of reduced availability.

Specific Background and Orientation

The following is a discussion of the concepts used in the model as they are derived and/or modified from other disciplines. Most of the hypotheses are based on studies of animal populations. The assumption is made that many of the same processes inherent in those populations are appropriate for human foragers exploiting plants and animals in their natural states.

The concept of increasing diversity of utilized resources as an indicator of increasing subsistence efficiency and subsequently increasing population size by human populations (Dragoo 1976) has been dispelled by Christenson (1977:2), who pointed out that an addition of resources to the subsistence mix increases the amount of energy expended in resource procurement activities, thereby decreasing subsistence efficiency. Therefore increased diversity correlates with decreasing subsistence efficiency. This portion of Christenson's model will be adopted here with the intent of establishing an inverse relationship of human population size to changes in resource diversity.

Horn has established that in a plant-by-plant successional environment, diversity of species gradually declines as the forest moves toward a stable state. As one species outcompetes and eliminates another, the density of the more competitive species is increasing (1974:30). In an ideal climax stage, the forest is closed, consisting of few species and is considered a less than optimal environment for human populations. In reality this closed state is probably never realized, being prevented by disturbances caused by secondary environmental factors such as fire, tree-throws, and severe storms. Although the diversity of climax is

lower than that of preceding stages (Horn 1974:30), predictability is relatively high and subsistence efficiency should increase. The climax situation is generally short-lived due either to these secondary factors, or to climatic interference which results in a change in diversity and density. In Southern New England a change to a slightly cooler climate at approximately 3,000 B.P. caused an increase in forest diversity (R.B. Davis and others 1975).

I would expect that following deglaciation, as the climate warmed and soils developed, that temperate forest species would have become established as soon as they could arrive from glacial refugia, and as soon as the newly developed soils would support them (Dincauze and Mulholland 1977). The increase in forest diversity would be slow at first, but rising rapidly once the proper conditions were set. Early, while plant development was controlled by climatic, migrational, and edaphic factors, plant diversity would be expected to have been quite high, because tundra, northern hardwoods, open space shrubs, and deciduous species would all have been present as the species ranges moved northward. Species density at this time would have been low and human populations would be expected to exhibit what Levins refers to as a fine-grained response to randomly distributed resources (Levins 1968, Wiens 1976:84). Human foragers would be expected to exploit low density resources "in direct proportion to their occurrence" (Wiens 1976:84), adopting a generalized exploitative strategy, and populations would necessarily be small. As forest succession proceeded, increased resource density of fewer and fewer species occurred, caused by competitive reduction of diversity. Under these conditions resources would be expected to cluster or become less randomly distributed and spatially clustered. Human exploitative responses would then become coarse grained or selective.

With the decline in the variety of resources, diet breadth would be expected to become more restricted, focusing on fewer resources through time. This may result in the group being more vulnerable to crashes in the resource base, caused either by environmental factors or overutilization through competition. An obvious human behavioral response to the situation would be the aggressive defense of critical resources which is most effectively accomplished by the establishment of territoriality. A density related development of territory is supported by Schoener's model which states that its development occurs only when there is high enough density of resources to make their defense worthwhile (Schoener 1971). Winterhalder points out that territoriality is not only a function of increased resource density, but is an effort of individuals to increase foraging efficiency in the wake of population increase (1977). Optimally, territorial defense is more efficient, the larger the size of the group. In simpler terms, the more defenders the easier the defense task. Hamilton and Watt show that in both animals and man, increased population is an efficient response to increases in resource density (1970:277; Solomon 1949).

An increasing population will also cause a drain on available resources, a drop in subsistence efficiency and subsequently in an intensification of effort for each individual to obtain sufficient resources for survival

(Christenson 1977:2). As the resource base becomes depleted, resource quality is reduced and ultimately reaches a level that equals the quality of previously unexploited resources (Fretwell and Lucas 1969). An efficient response to this situation is niche expansion to include the new resource (Wiens 1976:92). It is at this stage that diet breadth becomes less restrictive.

In summary, (all things being equal), as forest succession proceeds, species diversity should decrease over time as the forest moves toward climax. As the number of distinct species declines, the density of surviving species should increase. The properties of these two variables cause an articulating chain of human responses that lead to an increase in population size, a decrease in subsistence efficiency, and finally to the development of territoriality, leading ultimately to a change in the spatial distribution of habitation sites to include previously undesirable resources.

Model for Population Change

The hypotheses that follow will be used as a predictive model to explain the apparent changes in population during the Archaic and Early Woodland periods in Southern New England. Once probabilistically validated, the model may be used to predict human responses to a changing resource base in a temperate forest.

- 1) - In a predictable successional environment, plant diversity varies inversely with density.
- 2) - A low diversity/high density forest causes a less randomly distributed clustering of species, and human populations exploiting this type of environment will exhibit a coarse grained response.
- 3) - A reduction in resource diversity is equivalent to a reduction in available resource types, and this causes a restriction of potential diet breadth.
- 4) - A group relying on a small number of resources is more vulnerable to crashes in the resource population than groups relying on a wide variety of resources. Therefore there is a higher threat of competition, and more incentive to defend those resources.
- 5) - Development of territoriality occurs when there is high enough density of resources to make their defense worthwhile (Schoener 1971) and is a function of the effort of individuals to increase foraging efficiency (Winterhalder 1977).
- 6) - Human populations increase in size in response to increases in resource density.
- 7) - Population increase causes a drain on the resource base and an intensification of effort is necessary on the part of individuals of that

population to obtain sufficient resources.

8) - An excessive drain on the resource base results in a reduction of the quality of the resource to the level of previously unutilized resources. At this point the population will expand its niche to include the new resource, thus diet breadth is increased, and response moves toward fine grain.

Methods and Testing

The following is not intended to be an exhaustive test of the model. It is an attempt to establish a method for testing the model, and to examine the feasibility of using pollen data and artifact and site frequencies as data for testing the validity of the hypotheses.

In order to test the model, the dynamics of forest succession in Southern New England must be documented from palynological studies, and the relationship of population increase to a decrease in species diversity over time must be established. An attempt must be made to gather quantitative data on site location and site and artifact frequency for the different periods throughout forest succession. An increase in the number of sites and the number of artifacts for each period is a loose indicator of positive population change. The assumption is made that an increase in population results in an increase in production rates. Frequencies are expected to be low during the Early Archaic, gradually increasing during the Middle Archaic, and high during the Late Archaic, a time that is characterized by something akin to forest climax, and would decline after the climax. This data collection could be accomplished by researching the literature and the site data repositories for Southern New England at the Universities, the State Archaeological Societies, State Historical Commissions, Cultural Resource Management Institutes, museums, educational institutions and those belonging to collectors throughout the region.

In a recent paper, a map was compiled of all the known sites represented by Early and Middle Archaic artifacts in Southern New England (Dincauze and Mulholland 1977). Early Archaic sites numbered 34 and Middle Archaic sites 69 (see Figure 1). As yet, no quantification of Late Archaic sites has been completed for Southern New England; however, the preliminary results of a comprehensive collection of site locational data being conducted by the Institute for Conservation Archaeology at the Peabody Museum at Harvard University for the Bureau of Land Management's Northeastern Continental Shelf study, substantiate a dramatic increase in the number of Late Archaic sites. A subjective glance at the number of artifacts and sites for that period in the literature alone suggests a phenomenal increase. A study conducted in Western Connecticut on the Housatonic River Drainage shows a significant increase in projectile point frequency from the Early Archaic to Early Woodland (see Figure 1) (Swigart 1977:70). The Early Archaic is represented by 7 sites and 14 artifacts, Late Archaic by 26 sites and 1,441 artifacts, and if Susquehanna/Orient traditions are included with the Late Archaic, there are 46 sites and 1637 artifacts for that period. Finally, the Early Woodland is represented

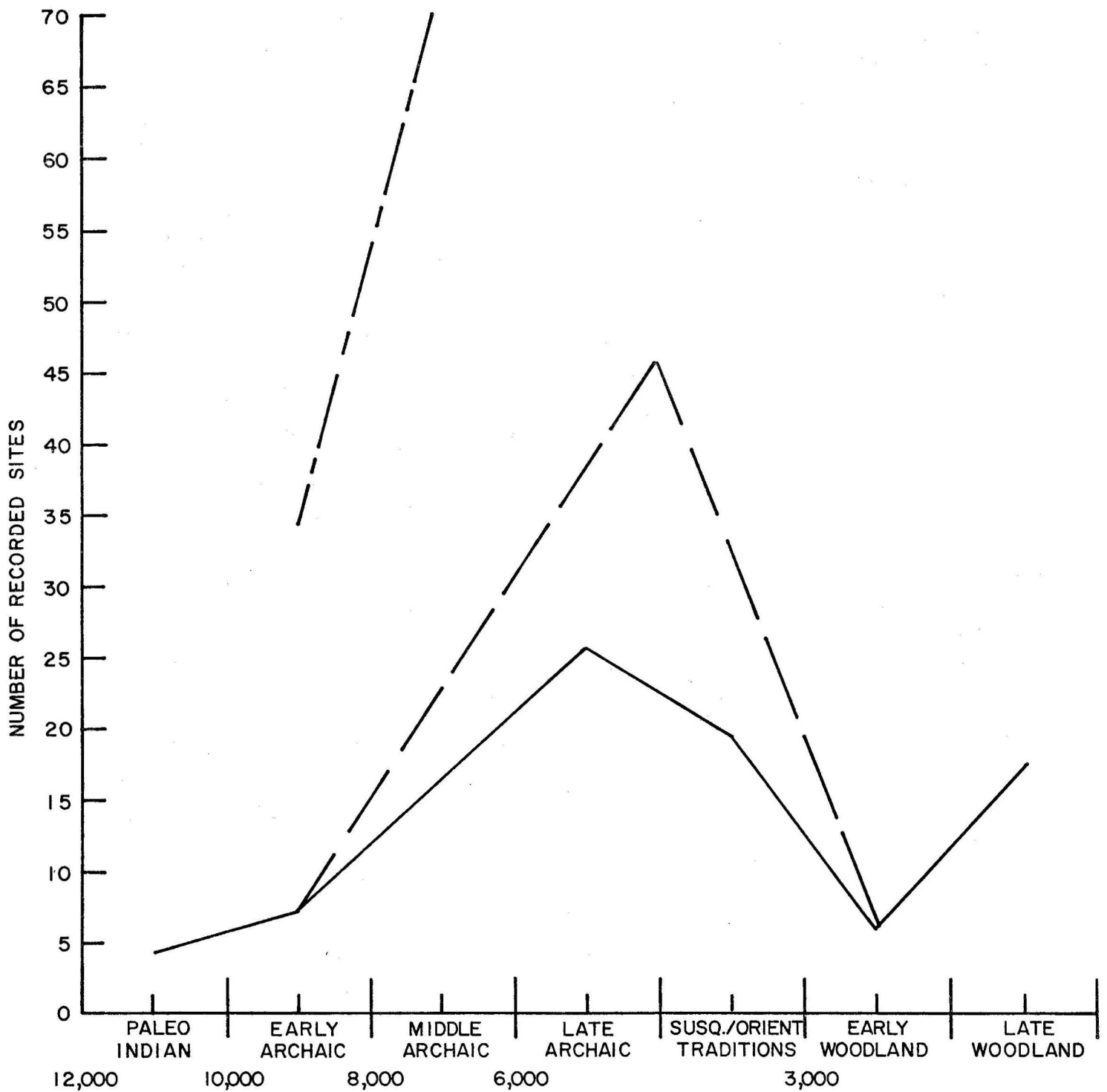


Figure 1. Site frequency chart: — western Conn. (Swigart 1977); — — — Late Archaic/Susq. combined (Swigart 1977); - - - southern New England (Dincauze and Mulholland 1977).

by 8 sites and 21 artifacts (see Figure 1). Funk and Rippeteau have recently compiled data on the number of period components per century for the Upper Susquehanna Drainage to the southwest of the region. Their data also suggest a similar trend (Funk and Rippeteau 1977). (Note, the distorted time scale on Figure 1. This was to make the graph compatible with Swigart (1977). An appropriate scale would make the drop more dramatic and strengthen my argument).

Obviously there is a need for more rigorous analysis of site and artifact frequencies throughout the entire region, but the studies mentioned here are suggestive of population increase and decline during the period of concern.

Available quantitative data on site distribution is also lacking, and has not been attempted here. It has been demonstrated that sites during the Early and Middle Archaic were expanding up the river valleys and along the coastal plain and lower elevations throughout Southern New England (Dincauze and Mulholland 1977). Also, survey data compiled by Dincauze indicate that Late Archaic sites not only dramatically increased in number, but occupied many previously unutilized locations in addition to the locations occupied by earlier populations (1974). At present there are few data on Early Woodland site distributions.

In order to demonstrate that vegetational species diversity varies inversely with human population size in Southern New England, use was made of pollen diagrams for Rogers Lake, Connecticut (Davis 1969). Species counts were made at 1,000 year intervals, with a readjustment of 730 years, a figure subtracted by Davis from the original radiocarbon dates taken from her pollen core (Davis 1969:412). The assumption is made here that species in the pollen profile should be representative of actual species in the forest at the time of deposition. Tests were made to determine if different categories of species represented changes in species diversity. Counts were taken of arboreal pollen, shrubs and herbs (see Figure 2). Although the trend is evident in each count, of the three categories the count based on arboreal pollen, shrubs and herbs provided the closest parallel with the model. The Rogers Lake species count shows a dramatic increase in species from 12,000 B.P. to approximately 9,000 B.P. This high diversity peak marks the end of post-glacial colonization and primary succession and the establishment of a deciduous-coniferous forest. During the early stage, species density was undoubtedly quite low, and absolute pollen influx counts verify this assumption. The dramatic nature of the curve may be somewhat exaggerated because of the openness of the forests. From 9,000 B.P., diversity gradually dropped until approximately 3,000 B.P., reflecting steady-state conditions. The human population curve inversely varies with the decrease in diversity (see Figure 1).

Conclusions and Recommendations

The analysis of changes in species counts based on published pollen data suggests that in Southern New England the general trend in species decline during succession can be demonstrated. Inconsistencies in changes in diversity following climax in the diagrams were not explained. Data

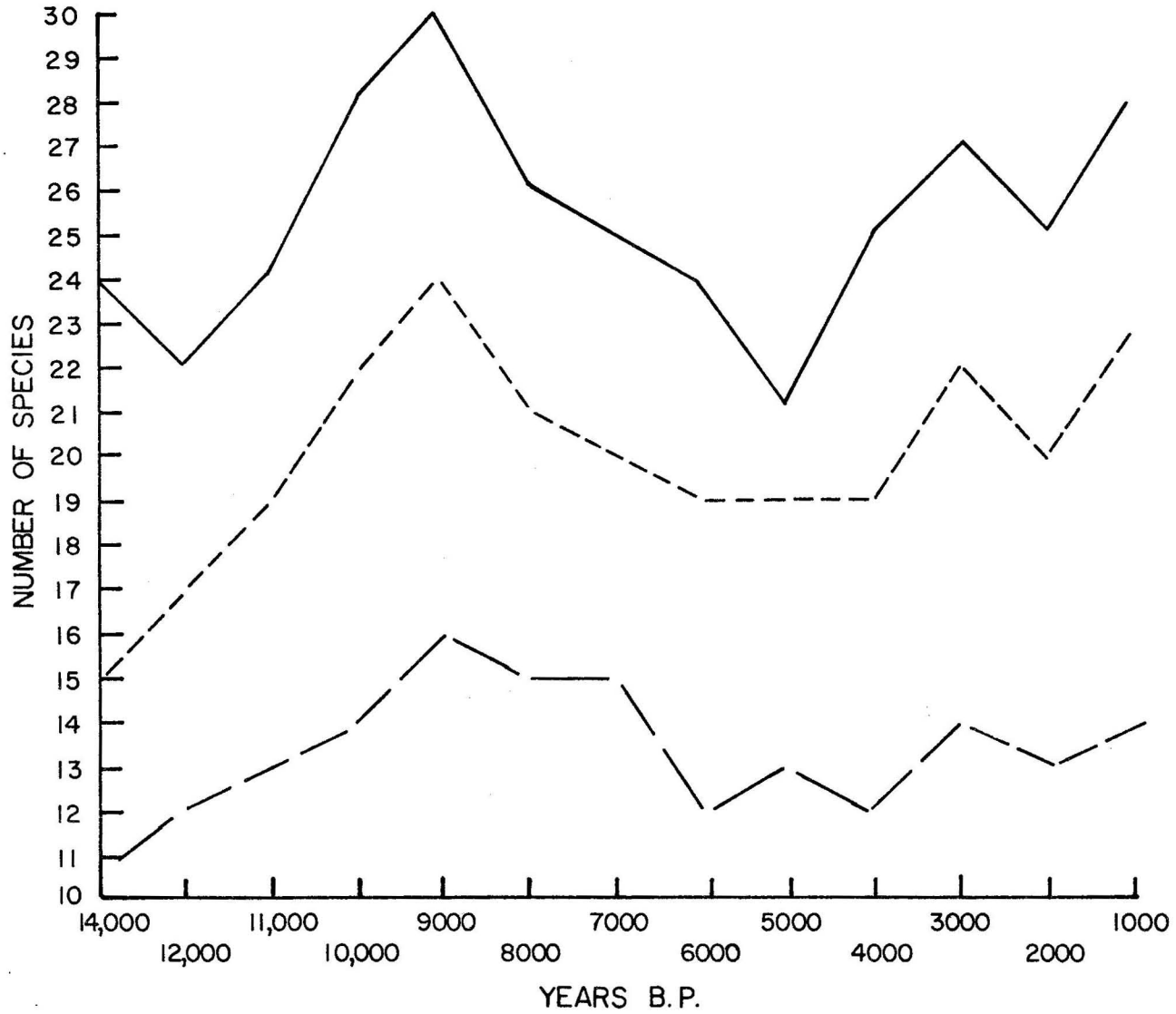


Figure 2. Species counts for Rogers Lake, Conn. : ——— All species; - - - - - Arboreal and shrubs; — · — Arboreal (after Davis 1969).

on site and artifact frequencies, and the spatial distribution of habitation sites over time is available for compilation and analysis. An attempt at obtaining some hard figures has begun, but rigorous quantification of site distributional data will be necessary in order to demonstrate population change. Perhaps more important, the theoretical tools to deal with population dynamics based on material culture must be developed.

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