Colonizing Behavior in an Agricultural Population: A Case Study of Seventeenth Century Hadley, Massachusetts

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Examination of the record of population growth and settlement expansion in colonial New England suggests that regulation of population growth and settlement size may have occurred. Demographic and historical data for the years 1659 through 1730, collected from Hadley, Massachusetts, show that regulation of growth, primarily through out-migration, did occur in that town. A high growth rate, a preference for small, nucleated settlements and concepts of religious and social solidarity were the major factors which combined to produce the observed pattern of regulation. The analysis indicates that regulation of growth and settlement size operated on a community level, not on the population as a whole. It was also observed that the high levels of out-migration from such small villages as Hadley contributed significantly to the process of settlement spread and expansion of the frontier.
The settlement process in colonial New England has attracted considerable attention from historians (Akagi 1924; Egleston 1886; Haller 1951; MacLear 1908; Mathews 1962; Powell 1963), geographers (McManis 1975; Trewartha 1946) and historical demographers (Greven 1970; Lockridge 1970). Although this work has generally been of high quality, it is often difficult to use for anthropological purposes. Answers to questions of what occurred and when are dealt with most satisfactorily. Explanations of how and why events came about are comparatively rare, although some attempts have been made (Swedlund 1975, 1978; Meindl and Swedlund 1977; Temkin-Greener and Swedlund 1978). General statements, applicable outside the New England region, are conspicuously absent. This is regrettable given the concern with colonization found in the anthropological literature (e.g., Green 1976; Moore 1976).

This paper is concerned with the processes of colonization and dispersal of population in seventeenth century New England. The focus is on a single village, Hadley, located in the Connecticut River Valley in Massachusetts. The analysis makes use of colonization theory from an ecological perspective. It is assumed that the processes observed during and after colonization are adaptive responses caused by environmental pressures. The demographic structure of the colonizing population and the consequences of that structure on the subsequent development of the colony are of particular interest.

Colonization Theory

Colonization theory from ecology is especially appropriate because it deals principally with the behavior and structure of small populations. Some aspects of this body of theory also contain explanatory linkages between available resources and colonizing behavior. It should be noted, however, that ecological models of colonization and dispersal do not normally take into account the social structure of the colonizing population. Modifications will, therefore, be necessary before these models can be applied to human populations.

A colonizing population must meet three general requirements in order to be successful. First, it must be able to survive long enough in the new environment for its members to reproduce (Udvardy 1969). Second, it must have strong competitive ability (MacArthur & Wilson 1967). Third, it must possess a high growth rate and reproductive potential (Dingle 1972; Lewontin 1965; MacArthur & Wilson 1967).

The first requirement is especially important in the colonization of an environment different from that previously occupied. The colonists must be able to rapidly assess the resources that are available and put them to use. Flexibility in adaptive responses is essential, particularly in groups like humans, which are not specialists in colonization.

Strong competitive ability has obvious advantages. Colonizing populations rarely encounter new habitats that are entirely empty of potential competitors. Such populations must therefore be capable of eliminating
potential competitors or at least partitioning the available resources so that competition is minimized.

The importance of high growth rates results from the fact that colonizing populations are generally small. Maintaining a high rate of growth reduces the possibility that random fluctuations in reproduction or unexpected variability in the environment will eliminate the population before it has a chance to become established. A variety of means exist which minimize this possibility.

One possibility is for the colonizing population to have an age structure which is biased toward pre-reproductive individuals. Ideally, all of the colonists should arrive and immediately begin to reproduce (Dingle 1972). Such a course of action obviously entails a high risk of total reproductive failure. It would only be expected in populations which are specialists in colonization, such as the so-called "weed" or "fugitive" species.

A second strategy involves the reduction of developmental time. By shortening the time between birth and first reproduction a colonizing population reduces generation time, thus increasing the rate of growth (Lewontin 1965). In a human population, this strategy would be apparent in a lower age at marriage in a colony than in longer established settlements.

A third scheme for achieving a high growth rate relies on the relative magnitudes of the birth and death rates of the colonizing population (MacArthur & Wilson 1967). It is possible to maintain a given rate of growth by either of two extreme strategies. One is to have a low death rate combined with a relatively high birth rate. The other combines a very high death rate with a birth rate exactly \( r \) higher. The first strategy is obviously safer for a colonist population since fluctuations in the death rate are less likely to exceed the birth rate, resulting in the elimination of the population. In the second case, where both the birth and death rates are of similar magnitudes, the risk of demographic disaster is much higher.

Closely related to the behavior and structure of colonizing populations are the conditions in which dispersal from an established population is favored. Most authors have based their arguments on carrying capacity and population density considerations. These arguments apply with equal force to resource limitations.

During dispersal and subsequent colonization, an organism is subject to an increased risk of death. There must, therefore, be some advantage to dispersal if it is to occur. The advantage is probably the chance of reaching a site more favorable than the one presently occupied, that is, either less crowded or with better resources. Dispersal will occur when the expected gain, in terms of reproductive success or resource acquisition, exceeds 1) the expected loss from risk of death during dispersal and colonization and 2) the probability of reaching a poorer habitat than the one previously occupied (Gadgil 1971).
Lidicker (1962, 1975) distinguishes two forms of dispersal from populations, saturation emigration and pre-saturation emigration. In the first instance, the surplus population leaves when the population as a whole has reached or exceeded the carrying capacity of its environment. Under these conditions, emigrants would be expected to be in relatively poor condition and consequently would suffer a high mortality during emigration and colonization. In the second case, some portions of the population depart before a density limit is reached. Here, survivorship is higher since emigrants leave before a density limit is reached and are consequently in better condition. Lidicker proposed that pre-saturation dispersal must involve varying degrees of sensitivity to crowding or resource limitations among the individuals of the population if this response was to make sense in biological terms. He also observed that emigration could be a sensitive means of controlling the growth rate of small populations.

Demographic Characteristics of Seventeenth Century New England

Throughout the seventeenth century, overall population growth in New England occurred at a rapid pace. The general trends are well documented in the literature (Greene & Harrington 1966; Mathews 1962). After 1650, when large scale immigration from England had ceased, the major portion of this growth can be attributed to natural population increase. During this same period, the number of discrete settlements also increased at a rapid rate.

For the most part, new settlements were planned from the start as self-sufficient entities. Groups of individuals from one or a few neighboring towns would band together and move as a unit to a new region (Akagi 1924; Haller 1951). This process of settlement was controlled by the Massachusetts General Court which granted land and established minimum numbers of families for settling a new community. The minimum was usually on the order of 20 to 30 families (Haller 1951).

Once established, communities during the seventeenth century carefully controlled the number of new settlers who were admitted to the population. Immigrants to already established villages were often required to post bonds or otherwise indicate that they would not become a burden on the town. As a result, frontier communities very quickly became nearly closed populations with a minimum of new additions to their number from outside (Haller 1951; Powell 1963).

In the Connecticut Valley, at least, newly settled villages appear to act as founder populations. Within a generation or less in some cases, groups of individuals from these communities left to establish new settlements farther out along the frontier (Bacon 1907; Boltwood 1862; Judd 1863). Relatively few of the colonists of these new settlements seem to come from the more densely settled regions of the New England coast and interior. Once a new region is settled in New England, any further settlement in that region appears to be a result of internal growth.
Overall, the pattern of population growth and dispersal of settlements in New England strongly resembles that which would be expected from the models of colonization and dispersal discussed above. The closed, founder populations of Connecticut River Valley towns should be especially susceptible to an ecological interpretation. These towns, particularly Hadley, have another important characteristic—good demographic documentation.

Hadley, Massachusetts is located in the central Connecticut River Valley (see Figure 1 in Paynter above). Historical and demographic information of good quality exists from the time of the town's formation. Hadley was settled late enough that its population can be assumed to have had access to the nearly forty years of experience at colonization accumulated in the New England colonies. When formed, it was the northernmost settlement in the Connecticut Valley. Apart from Northampton, across the river, there were no other English settlements within 15 to 20 miles in any direction.

The data presented here cover the period from 1659 to 1730. This corresponds to that period of history in which Hadley may be considered a frontier colony. Demographic data include year of birth, death and first and last appearance in the town for 1347 individuals. These were compiled from an excellent and detailed set of genealogies published in the mid-nineteenth century (Boltwood 1862) and supplemented with tax lists and birth and death records preserved in the town hall and elsewhere in Hadley. These records allow the reconstruction of population size for each year and all of the vital rates including in and out migration. It was also possible to construct life tables and age and sex pyramids at some points during the study period.

With these data, I will see to what extent the demographic patterns in Hadley are understandable with ecological models of colonizing populations. Doing this requires the development of specific expectations from these models with regard to the demographic behavior of a colonizing population. This is the subject of the next section.

Analytical Models for Colonizing Populations

General Expectations

Using the ecological theory introduced above, it is possible to construct an explanatory model which can be tested against the behavior of Hadley's population. The starting point is the high growth rate expected in successful colonizing populations. If this high growth rate is combined with limitations on community size, then it is likely that resource limitations can be reached very quickly. These are not necessarily absolute limits. Under such conditions, a population has a range of possible solutions to the resource limitation. These solutions can be arranged hierarchically according to their costs. The most likely solution should be that which has the lowest cost and causes the least disruption to the community while still easing the stress on resources.
If such a chain of events is applicable to Hadley in the seventeenth century, it will be necessary to demonstrate several points. First, it must be shown that the rate of population growth was rapid. Ideally, it should be higher than that of comparable populations who were not colonists. Second, there must be evidence for resource limitations. In the case at hand, the limited resource is postulated to be agricultural land. This resource is assumed to have become limited because of the interaction of the inheritance system used by the colonists, their preferences in community size and the threat of Indian attack.

The possible responses to this limited resource are primarily demographic. More or less in order of increasing cost, they are 1) out-migration, 2) increase in age at marriage, 3) decrease in birth rates and 4) increase in death rates. Non-demographic responses include intensification of agriculture and changes in the settlement pattern. At least one of these must be shown to have occurred. Finally, the response chosen by the population should actually lead to a decline in the rate of growth of the community as a whole and consequently a lessening of the pressure on resources.

Methods of Analysis

Data for the computation of the vital rates were derived from a Fortran program, Program HADLEY. This enumerated the total number of births, deaths, marriages and in and out-migrants for each year between 1659 and 1733. The program also calculated population sizes at annual intervals based on estimates of the year of first and last appearance of an individual in the town.

Crude rates of birth, death and in and out-migration were computed from these figures and converted to rates per thousand according to standard demographic methods (Barclay 1958). These rates were graphed and used in the analysis. In addition, five year moving averages were plotted to smooth the considerable annual variation in the vital rates which is expected in any small population.

Three estimates of the rate of population growth were made. The first is an estimate of the crude rate of growth, \( r_c \), which is simply the crude death rate subtracted from the crude birth rate. The second estimate, \( r_h \), is a corrected figure of the crude growth rate. It is calculated by including the rates of in and out-migration according to the equation:

\[
  r_c = (b+i)-(d+e)
\]

where \( b \) = birth rate, \( i \) = in-migration rate, \( d \) = death rate and \( e \) = out-migration rate.

The third estimate of \( r \) was made from the ratio of population size in successive years. The equation for this is:

\[
  r = \ln \frac{N_t}{N_o}
\]
Figure 1. Birth rate and in-migration rate: Hadley
Figure 2. Crude growth rate: Hadley.
where $N$ is the population size at times zero and $t$, and $\ln$ signifies the natural logarithm. This is generally a more precise estimate of the rate of population growth. It is used here primarily to provide an independent check on the values produced for $r$ from the crude estimates of growth.

The figures for population size were plotted on both normal and semi-logarithmic graph paper. The semi-logarithmic plot is useful for estimating visually the existence of exponential growth. A straight line on such a scale indicates that the population is growing exponentially. Thus, periods of decline, growth and stagnation can be detected through time.

Average age at marriage was also computed for both males and females for four twenty-year intervals over the study period. In addition, life tables were constructed for both sexes. These include all individuals born before 1699 for whom both birth and death rates exist.

Evidence of resource scarcity and limitations was collected from a variety of sources. Town records and the town history (Judd 1863) contained valuable information of problems faced in Hadley. Historical sources dealing with the Connecticut River Valley and New England in general were used for background and comparative information (Bacon 1907, Mathews 1962).

Results

In Hadley, the growth rate of the population is clearly quite high (Figure 1). The crude birth rate rises rapidly to levels which frequently exceed 40 per thousand during the first forty years after the town was founded. It is also clear that in-migration adds little to the population after the first twenty years. The rapid decline in in-migration shows, too, that the population is relatively closed within a short time after colonization occurred. The crude growth rate is consistently high as well (Figure 2). Only three times during the first forty years after settlement does it drop below 20 per thousand.

Growth rates calculated from population size show the same trend (Figure 3). In the first twenty-five years, from 1659 to 1685, the average annual growth rate is 4.8%. This, of course, includes in-migrants. However, even when they are excluded, natural increase amounts to nearly 3% per year.

Population size figures also indicate the occurrence of rapid growth. Between 1660 and 1725, the population increased by a factor of nearly four times, from 119 individuals to 470 (Table 1). This quadrupling of size occurred in spite of occasional heavy out-migration throughout the period.

Hadley's high growth rates are caused by a combination of low death rates and high life expectancies. Although there are some marked fluctuations, the average annual death rate in Hadley was about 15 per thousand.
Figure 3. Annual rate of population growth, Hadley, Massachusetts from $r = \ln \frac{N_t}{N_{t-1}}$ 5 year moving average.
### TABLE 1

**POPULATION SIZE OF HADLEY AT FIVE YEAR INTERVALS**

<table>
<thead>
<tr>
<th>Year</th>
<th>Population Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1660</td>
<td>119</td>
</tr>
<tr>
<td>1665</td>
<td>216</td>
</tr>
<tr>
<td>1670</td>
<td>243</td>
</tr>
<tr>
<td>1675</td>
<td>279</td>
</tr>
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<td>1680</td>
<td>304</td>
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<td>1685</td>
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<td>1700</td>
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<td>427</td>
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<td>1715</td>
<td>439</td>
</tr>
<tr>
<td>1720</td>
<td>461</td>
</tr>
<tr>
<td>1725</td>
<td>470</td>
</tr>
<tr>
<td>1730</td>
<td>421</td>
</tr>
</tbody>
</table>

### TABLE 2

**AVERAGE AGE AT MARRIAGE THROUGH TIME IN HADLEY**

<table>
<thead>
<tr>
<th></th>
<th>MEAN</th>
<th>VARIANCE</th>
<th>ST. DEV.</th>
<th>SAMPLE SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1660-1680</td>
<td>Males 24.0</td>
<td>10.47</td>
<td>3.24</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Females 19.4</td>
<td>12.97</td>
<td>3.60</td>
<td>26</td>
</tr>
<tr>
<td>1681-1700</td>
<td>Males 24.5</td>
<td>11.16</td>
<td>3.34</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>Females 20.2</td>
<td>6.05</td>
<td>2.46</td>
<td>45</td>
</tr>
<tr>
<td>1701-1720</td>
<td>Males 26.3</td>
<td>24.28</td>
<td>4.93</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Females 22.9</td>
<td>15.42</td>
<td>3.93</td>
<td>55</td>
</tr>
<tr>
<td>1721+</td>
<td>Males 27.1</td>
<td>16.36</td>
<td>4.04</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>Females 25.4</td>
<td>35.09</td>
<td>5.92</td>
<td>131</td>
</tr>
</tbody>
</table>
Life expectancy at birth was 47.5 years for males and females combined. If an individual survived to age 5, life expectancy rises to 64 years. All of these figures are considerably better than those current in England for similar populations at the time. In Clayworth and Nottingham, for example, rates of mortality ranged from 35 to 45 per thousand (Chambers 1966; Laslett & Harrison 1963). Infant mortality ranged from 30 to 40%. In Hadley, the infant mortality rate was between 15 and 20%.

The pattern of life expectancy and mortality rates found in Hadley closely corresponds to that found elsewhere in New England. In Plymouth in the mid-seventeenth century, the expectation of life for 21-year-old males was 70 years, while that for women was 62 (Demos 1965). In Hadley, the corresponding figures are 66 and 64 years. Mortality rates in Dedham, Massachusetts were roughly 27 per thousand, slightly worse than Hadley’s during the same time period (Lockridge 1970).

Growth continues through most of the study period for two main reasons. First, the founder population of Hadley was quite young. Sixty percent were under thirty years old (Figure 4). It is virtually inevitable for population growth to be rapid in such an unusually young population, especially since contraceptive knowledge was minimal.

There was, in any case, little incentive to limit fertility. The subsistence base of the Hadley population involved a great deal of labor intensive agriculture. In such a situation, large families are valuable since they increase the available labor force for a wide variety of simple but time-consuming chores which are necessary on a farm. Evidence of the value of large families in an agricultural economy is not available for Hadley but can be inferred from reports on groups such as the Amish and Hutterites. These populations are very similar to the Hadley population in their social and religious organization as well as in their subsistence base (Bennett 1967; Hostetler 1968; Eaton & Mayer 1954).

Three constraints on community size can be identified in Hadley. These are the inheritance system, the settlement pattern and the threat of Indian attack. Together, these three factors effectively limited the amount of land available for agricultural and other purposes in Hadley for a considerable time after the village was settled.

Hadley, like virtually all seventeenth century settlements in New England (Trewartha 1946), was laid out as a nucleated village. House lots were located around a town common while agricultural lands were spread around the periphery. Inhabitants of the village were generally prohibited from building homes anywhere but in the house lots in the central village. Like the open field villages in England (Orwin & Orwin 1967) on which this pattern is based, close cooperation and contact among individuals was important to the success of the community.

Settlements in the Connecticut Valley, and indeed nearly all new communities after 1650, were granted enormous quantities of land. This was done to avoid the problems encountered around the Massachusetts Bay settlements where most villages had been laid out without much regard
Figure 4. Estimated population structure of Hadley in 1663.
to future growth (Haller 1951). As noted by both Greven (1970) and Lockridge (1970), lack of planning led quickly to serious problems of land availability. The large land grants were intended to allow expansion of a settlement or the budding off of daughter settlements as population expanded. Hadley's original grant consisted of about forty square miles of land on both sides of the Connecticut River (Figure 5).

Several problems were encountered with this otherwise intelligent idea. Much of the land was unused for many years. Large areas turned out to be unfit for any purpose the colonists could see. If the land was usable, it often had to be cleared of forest cover, a difficult and time-consuming process. As the settlers became more aware of what they actually had in the way of land, supplemental grants were often requested (Figure 5). Hadley did this three times, in 1673, 1683 and 1727. The first request was to compensate for land lost when Hatfield was formed out of what was originally Hadley land. Ultimately, a total of 80 square miles of land were contained within the borders of Hadley.

The grant of 1683 is particularly interesting in that it shows that the inhabitants of Hadley were concerned about problems of limited land. In a petition to the General Court, "they represented that their young people were straitened for want of enlargement and removed to remote places; and the 'inhabitants are shut up to the east and north by a desolate barren desert'" (referring to a pine forest) (Judd 1863). No settlements were made in the granted areas until 1715. The excess population evidently continued to remove to remote places.

The principal reason these lands were considered unusable was the threat of attack. Between 1675 and 1765, a series of conflicts starting with King Philip's War and ending with the Sixth French and Indian War made expansion of existing settlements difficult and often dangerous. Three towns not far from Hadley (Northfield, Deerfield and Brookfield) were burned out and abandoned temporarily. Every town north of the Connecticut border was attacked at least once. These attacks made it necessary to fortify most villages. Stockades and blockhouses were constructed in great numbers. In Hadley, no new houselots were added to the original 47 until the turn of the eighteenth century, although a number of lots had more than one house on them and some homes had more than one family in residence.

No new divisions of land in Hadley's grant occurred after the initial ones in 1659 and 1663 until the early 1700's. There were apparently insufficient numbers of people residing in the village to form a sufficiently large daughter community to meet either the General Court requirements or safety concerns.

The final constraint on land availability was inheritance. Ownership of land was one of the chief goals of nearly every individual in a seventeenth century New England village. All but a few craftsmen and artisans were dependent on agriculture for subsistence. Good farmland was essential for providing a secure economic base for a new family.
Figure 5. Changes in Hadley boundaries, 1661-1730.
Figure 6. Outmigration rate and death rate (—— outmigration rate; ------ death rate).
Land could be acquired either through inheritance, participation in town sponsored land divisions or by moving to a new settlement. Heads of families often tried to acquire land from divisions for the specific purpose of handing it on to their sons. New England law, unlike that in England, allowed all of the sons to inherit rather than just the oldest one (Demos 1965; Greven 1970). From the point of view of a young man eligible to inherit, there were several problems with the system. The French and Indian Wars often made land divisions unusable, as in Hadley, even if the divisions had been made. Long life expectancies meant the parents would often live longer than a son was willing to wait to attain independence.

To cope with the problems of land availability that existed in Hadley and elsewhere, there are a limited number of alternatives. Changes in fertility are possible. To judge from the crude birth rate (Figure 1), some reduction in fertility does seem to occur towards the end of the study period. However, the effects of fertility reduction take too long to be apparent to make it a practical means of reducing the pressure on available land.

Late marriage can also help to reduce problems of land availability by delaying the age of economic independence. Age at marriage in Hadley does decline slowly (Table 2). It is a very short term solution, however. Marriage as an institution was highly desirable and nearly everyone married. If land is limited, as it was in Hadley for nearly fifty years, some other solution must be found.

Out-migration offers the best solution since its effects are felt immediately. It is an easily mobilized response since, on the frontier, good land can normally be found within a reasonable distance of the original settlement. By banding together with people in a similar situation from nearby towns, a sufficiently large group can be organized to minimize the risk of failure from such things as Indian attacks.

It is quite clearly an option that was chosen by the population of Hadley (Figure 6). The out-migration rate at times exceeds all of the other vital rates, reaching peaks of 60 per thousand per year. The highest peaks occur roughly coincident with the times when Hadley was showing signs of problems with land availability, such as in 1683 and 1727, when the town petitioned the General Court for more land.

Out-migration is also effective in regulating growth rates in Hadley. The impact of out-migration on growth rates can be seen in the corrected growth rate (Figure 7). Population growth rates are considerably reduced. The largest declines occur at the same time as the greatest peaks of the out-migration rate.

Further evidence of regulation can be seen in the semi-log plot of population size (Figure 8). Three distinct periods of exponential growth can be detected. The end of each corresponds to a period of heavy out-migration. Furthermore, the growth rate is reduced after each one, from an average of 2.7% per year between 1663 and 1685 to 1.2% between...
Figure 7. Corrected growth rate: Hadley.
Figure 8. Population size estimate on semi-log scale.
between 1710 and 1730. This reduction in growth rates is probably an incidental result of out-migration. If, as suspected, the out-migrants consist mainly of recently married individuals, the population remaining should have a higher average age and consequently higher death rates and lower birth rates.

**Discussion**

The agreement of the results with theoretical expectations is remarkably good. The demographic structure of the founding population of Hadley is such that very high growth rates are nearly inevitable. Reproductive potential, and consequently the birth rate, is high because the population is concentrated in either pre-reproductive age classes or the peak reproductive years.

Death rates are exceptionally low. This appears to be a result of several factors acting together. By the time Hadley was settled, the major adjustments to the New England environment had been made. The population as a whole was young and apparently vigorous. Epidemic diseases such as smallpox were comparatively rare. Even when such diseases did occur, their effects were relatively minor since most communities were quite small and quarantines were generally intelligently applied. The opportunity for epidemic infection to spread was much less than was the case in the more densely populated English countryside.

Resource limitations develop quickly because the increase in numbers outstrips the ability of the population to provide for the needs of its members. The problem was not one of absolute limits. At no time does Hadley appear to have reached a saturation density, carrying capacity or limits of agricultural productivity. Rather, the limits of land availability were essentially socially defined.

All of the possible responses to resource limitations can be shown to have occurred in the order they were predicted. Out-migration and increasing age at marriage appear first, more or less simultaneously. Decreasing birth rates and increases in death rates begin to be evident at the very end of the time studied. Changes in settlement pattern and agricultural methods do not appear during the study period although they are evident later in time. Environmental conditions changed considerably through time making such responses more necessary.

While Hadley's position on the frontier strongly influences the desirability and practicality of the different responses to resource limitations, other New England towns can be interpreted within a similar ecological framework. In Andover, Massachusetts, for example, Greven (1970) found similar problems of land availability forcing regulation of growth within a relatively short time after colonization. The outcome was different there than in Hadley. Andover was surrounded by other communities with similar problems, whereas in the Connecticut Valley almost all of the nearby land was unoccupied. Out-migration from Andover was discouraged because removal to areas where land was more plentiful required traveling a considerable distance and separation from family and
friends. Greven found that there was considerable reluctance to move in spite of the economic inducement of cheap land. This is attributed to the strong family ties of Andover residents. In Hadley, on the other hand, the distance to open lands was much shorter and did not disrupt families as greatly as did the longer moves forced on the residents of the eastern settlements.

In other areas of New England, problems similar to those encountered in Hadley do not seem to occur at all. In Ipswich, Massachusetts, a coastal settlement, exponential growth appears to have continued unchecked until the middle of the seventeenth century (Norton 1971). Economically, however, this town differed radically from the Connecticut River Valley settlements. The dependence in Ipswich on fishing and shipping evidently led to a much higher density of population than was possible in an agricultural community.

War or the threat of war may limit the generality of the particular pattern of events observed in Hadley. However, the overall agreement with theoretical expectations suggests that Hadley's problems are a fairly common situation in agricultural colonies. That is, the nature of successful colonization produces conditions which encourage further colonization.

The utility of using ecological models of colonization extends well beyond comparing seventeenth century New England towns. For example, there are two competing hypotheses to explain the spread of village agriculture in Europe during the Neolithic. One is that farming spread by diffusion of farmers, the second that farming technology spread by the diffusion of the techniques to pre-existing gathering-hunting populations (Ammerman & Cavalli-Sforza 1971). In either case, archaeological information indicates that village agriculture spread quite rapidly from its place or places of origin (Butzer 1971; Waterbolk 1971). The evidence, archaeological and more recently genetic (Menozzi and others 1978), tends to support the hypothesis of an expanding agricultural population rather than a transfer of technology.

The Hadley experience suggests that there is a large potential for population growth in an agricultural population with an opportunity to colonize. Not only is the rate of growth high, but the incentive for further colonization appears very early. Furthermore, the speed with which New England was settled makes it easier to understand how Europe was filled with farmers in a period of only 3000 years. This is just one case for which studies in historical demography can shed light on anthropological problems in prehistory and elsewhere.

In conclusion, this study suggests that useful research can be done on the demographic behavior of historical populations of New England from an ecological perspective. Hadley's good fit within this framework is very encouraging. Using this model to study other New England towns will result in a better understanding of the North American colonization experience on a regional scale. It will also lead to refinement of the analytic
models, making ecological models more sensitive to socially complex populations. Developing these generalizations should prove most useful for understanding how human populations have adapted to frontiers.

Acknowledgements

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