Virginia colonists resided in the oligohaline and saltwater zones; 28 percent occupied the freshwater—almost a direct reversal of the pattern under Dale, when 68 percent lived in the freshwater zone.

Increased mortality accompanied the shift in population. Several thousand colonists died between 1618 and 1624, and disease was an important cause. Comments on summer sickness and death increasingly punctuated colonial correspondence. But disease was not the sole killer. Indian attacks, starvation, and plague also contributed. While the surviving evidence precludes a precise bill of mortality, some estimates of disease-related deaths can be made from the census of 1623–1624.

Here 1623–1624 is used as a benchmark year for estimating the usual mortality rate from typhoid, dysentery, and salt poisoning from 1618 to 1624. Several bits of evidence suggest these diseases as the principal causes of death in 1623–1624: the reports of summer sickness and death in that year; the absence of other reported causes of mortality; an abundant food supply, making starvation an unlikely cause of death; and the census listing of colonists killed, presumably by the Indians, so that these deaths can be excluded from our disease estimate.60 Typhoid and dysentery are also implicated by the spatial pattern of death recorded in the census of 1623–1624. Within those settlements reporting deaths during the year, 16.7 percent died in the freshwater zone; 37.1 percent in the oligohaline; and 23.3 percent in the saltier portion of the James estuary (table 2).61 The match between reality and our estuarine model is good, but not perfect. Freshwater death rates are higher than expected, perhaps reflecting the severe disruptions in this area caused by the massacre of 1622. Another peculiarity is Hog Island in the oligohaline, where only 8.8 percent died. A safer right-bank location, the removal of pollutants toward the north bank by a river meander, and the small population probably combined to make Hog Island a healthy micro-environment. Otherwise the census pattern points toward death by typhoid and dysentery in the oligohaline and the salty lower James.

Having isolated these diseases as probable causes of death, we can estimate their usual contribution to Virginia mortality. The annual

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Note:
This table includes only those settlements returning lists of dead. "Killed" colonists are not here included among the dead.

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60. Brown, First Republic in America, 569–570; Edmund S. Morgan, American Slavery, American Freedom: The Ordeal of Colonial Virginia (New York, 1975), 104–105. The year following the massacre of 1622 was very sickly, but the resultant mortality probably antedated the census of 1623–1624. Tyler, ed., Narratives of Early Virginia, 436; Morton, Colonial Virginia, I, 83–90.

TABLE 4. Disease-Related Death Estimates in Virginia, 1618–1624

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Population at Beginning</th>
<th>Population at End</th>
<th>Immigrants</th>
<th>Overall Mortality Rate</th>
<th>Disease-Related Deaths</th>
<th>Disease Death/Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec. 1618–</td>
<td>600</td>
<td>887</td>
<td>814–914</td>
<td>37.3%–41.4%</td>
<td>402–430</td>
<td>402–430</td>
</tr>
<tr>
<td>Mar. 1620</td>
<td></td>
<td></td>
<td></td>
<td>(52/7–627)</td>
<td>(28.3%)</td>
<td>(68–76%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1,414–1,514)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar. 1620–</td>
<td>887</td>
<td>843</td>
<td>1,051</td>
<td>56.5%</td>
<td>550(28.3%)</td>
<td>550/1,095</td>
</tr>
<tr>
<td>Mar. 1621</td>
<td></td>
<td></td>
<td></td>
<td>(1,095/1,938)</td>
<td></td>
<td>(50.2%)</td>
</tr>
<tr>
<td>Mar. 1621–</td>
<td>843</td>
<td>1,240</td>
<td>1,580</td>
<td>48.8%</td>
<td>688(28.3%)</td>
<td>688/1,183</td>
</tr>
<tr>
<td>Mar. 1622</td>
<td></td>
<td></td>
<td></td>
<td>(1,183/2,423)</td>
<td></td>
<td>(58.2%)</td>
</tr>
<tr>
<td>Mar. 1622–</td>
<td>1,240</td>
<td>1,241</td>
<td>695</td>
<td>35.9%</td>
<td>347/694</td>
<td>347/694</td>
</tr>
<tr>
<td>Apr. 1623</td>
<td></td>
<td></td>
<td></td>
<td>(694/1,935)</td>
<td></td>
<td>(50.0%)</td>
</tr>
<tr>
<td>Apr. 1623–</td>
<td>1,241</td>
<td>1,275</td>
<td>405</td>
<td>22.5%</td>
<td>371/371</td>
<td>371/371</td>
</tr>
<tr>
<td>Feb. 1624</td>
<td></td>
<td></td>
<td></td>
<td>(371/1,646)</td>
<td></td>
<td>(100.0%)</td>
</tr>
</tbody>
</table>

Summary:
- Population in Feb. 1624: 1,275
- Disease-related deaths, 1618–1624: 2,538
- Other causes of death or return to England: 1,332
- Total: 5,145

Notes:
*Includes deaths from all causes as well as those returning to England alive.
*Using estimate of 28.4% per year.
*Since 347 known deaths occurred in the massacre, the remainder are assigned to disease.
*Overall death rate fell below the disease rate, hence all were assigned to disease.
principal killers in some years, and they were significant contributors in all.\textsuperscript{63} The leaders of the company and the colony tried desperately to reduce summer mortality but failed because of their misconceptions of its causes. Preventive measures were aimed at the immigrants and not at the environment and at population distribution. Guest houses (hospitals) were established, and immigrant arrivals were scheduled for fall after the sickly summer months, all done on the false assumption that seasoned colonists would survive.\textsuperscript{64} But seasoned colonists stood little chance of survival in the oligohaline zone, as revealed in the muster of 1625. Then 57 settlers gave arrival dates before 1616; 24 resided in the freshes, 25 in the salt, and just 9 in the oligohaline. Older settlers, those arriving before 1620 of all giving arrival dates, made up about one-fifth of the population in the oligohaline, one-third in the saltwater zone, and two-fifths in the fresh.\textsuperscript{65} These spatial and environmental patterns of death went undetected by the company, and that oversight was instrumental in its dissolution.

The demise of the Virginia Company in 1624 signaled a new era in Virginia demography. The old constraints focusing the colony on Jamestown and the oligohaline were relaxed, and mortality fell. Between 1625 and 1634 Virginia’s population grew from 1,210 to 4,914, while receiving an estimated 9,000 immigrants.\textsuperscript{66} Although over half of the population died in the nine-year period, this figure obscures the marked improvement in annual mortality. Had the pre-1625 mortality rate of 28.3 percent per year continued, Virginia in 1634 would have numbered 2,456 instead of 4,914. In effect, annual mortality was cut in half (to about 14.2 percent) during the early royal period (see table 5).\textsuperscript{67}

Several factors caused the decline in mortality. By far the most important was the shift in population patterns. By 1634 the deadliest zone along the James, including James City, Warwick, and Warros-

\begin{table}
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
Date & Population & Mortality Rate & Fitted Mortality Rate & Survivors & 1625–1634 \\
\hline
1625–1626 & 1,210 + 1,000 & 1,582 & 1,210 + 1,000 & 1,582 & 1,896 \\
1626–1627 & 1,582 + 1,000 & 1,849 & 1,869 + 1,000 & 1,849 & 2,485 \\
1627–1628 & 1,849 + 1,000 & 2,040 & 2,485 + 1,000 & 2,040 & 2,990 \\
1628–1629 & 2,040 + 1,000 & 2,177 & 2,990 + 1,000 & 2,177 & 3,423 \\
1629–1630 & 2,177 + 1,000 & 2,275 & 3,423 + 1,000 & 2,275 & 3,794 \\
1630–1631 & 2,275 + 1,000 & 2,344 & 3,794 + 1,000 & 2,344 & 4,113 \\
1631–1632 & 2,344 + 1,000 & 2,394 & 4,113 + 1,000 & 2,394 & 4,387 \\
1632–1633 & 2,394 + 1,000 & 2,430 & 4,387 + 1,000 & 2,430 & 4,622 \\
1633–1634 & 2,430 + 1,000 & 2,456 & 4,622 + 1,000 & 2,456 & 4,824 \\
1634–1635 & 2,456 + 1,000 & 2,475 & 4,824 + 1,000 & 2,475 & 4,997 \\
\hline
\end{tabular}
\caption{Population Growth, 1625–1634, under Pre-1625 Disease Mortality Rates and a Fitted Mortality Rate}
\end{table}

Note:
The actual population in 1634 was 4,914. The above calculations assume no natural increase. Some children were born in the colony during the period, but the imbalanced sex ratio favoring males, and other evidence suggests that children contributed little to population growth at this time.

\textsuperscript{63} These estimates of annual disease mortality permit an assessment of other causes of death. Morgan, for example, has suggested starvation and malnutrition, occasioned by control of Virginia’s food and labor supply by a handful of private capitalists. The most likely years for such class behavior were 1620 to 1622, when causes other than Indian killings and diseases contributed 40 to 50 percent of all deaths. Morgan, American Slavery, American Freedom, 92–107. Note, however, that immigration was also heaviest in these years—suggesting Craven’s point of inadequate provisioning of the immigrants by the company. Probably both company and private wheel-dealers were responsible for the increased death rate; in any case, the critical years were 1620–1622. Wesley Frank Craven, Dissolution of the Virginia Company: The Failure of a Colonial Experiment (New York, 1932), 152–153.

\textsuperscript{64} The company believed in the curative medicine of seasoning, rather than the preventive medicine of settlement dispersal. Craven, Dissolution of the Virginia Company, 148–175; Kingsbury, ed., Records of the Virginia Company, III, 275, 301–302.

\textsuperscript{65} John Camden Hotten, ed., The Original Lists of Persons of Quality; and Others Who Went from Great Britain to the American Plantations, 1600–1700 (New York, 1931), 200–205.

\textsuperscript{66} Morgan, American Slavery, American Freedom, 159, estimates 1,000 immigrants per year. Morgan underestimates the magnitude of declining mortality rates after 1624. A lower death rate is not inconsistent with his literary evidence. Ship captains experienced high mortality (42 percent in 1636) precisely because they piled in the oligohaline zone. And 1,800 deaths in 1636, given the population and increased immigration in that year, produces a mortality rate in between that of the period 1618 to 1624 (28.3 percent) and our post-1624 estimated rate (14.2 percent).

\textsuperscript{67} Morgan’s 1625 to 1640 estimate of 1,000 immigrants per year has been questioned as too high by Menard. He suggests that immigration varied directly with tobacco prices, and therefore Virginia immigration peaked at about 2,000 in 1635–1636 and in preceding years (1625–1635) immigration generally fell substantially below 1,000 per year. If Menard is correct, then annual mortality for the period 1625 to 1634 falls even lower than the 14.2 percent presented here. Russell R. Menard, "Economy and Society in Early Colonial Maryland" (Ph.D. dissertation, University of Iowa, 1979), 167–170.
in the saltwater zones. While I cannot prove this statement from the available evidence, the oligohaline zone appears to have been more deadly in the eighteenth century. The spatial pattern of mortality can be crudely reconstructed from a 1725-1726 parish census of births and burials (figure 2).

For all four Virginia estuaries, the pattern of mortality hypothesized by the estuarine model for early Virginia remains recognizable a century later. The proportion of burials to births generally is least in the freshwater zone, peaks in the oligohaline zone, and drops slightly in the saltwater zone of the lower estuaries. Left bank (north side) proportions are usually higher than the corresponding right bank (south side). The map's subtleties and its several departures from the model—notably the higher-than-expected mortality levels in the upper Rappahannock, lower James, and the Pamunkey estuary generally—warrant more attention, but to do so would push us beyond the limited scope of this essay. More important is the map's suggestion that typhoid and dysentery caused some

71. The census records births and burials for the year beginning April 15, 1725. I have assumed census recording procedures were uniform among Virginia parishes, but undoubtedly these procedures varied markedly. More thorough studies of Virginia demographic data may reveal whether the parishes departing from the estuarine-disease model reflect actual differences or recording biases in the census. C.O. 5/1320, t. 74, Public Record Office. Parish boundaries are roughly accurate. The four Henrico County parishes are incorrectly placed on the map. Charles Francis Cacock, Parish Lines, Diocese of Virginia, Virginia State Library Publications, no. 28 (Richmond, Va., 1967); George Carlington Mason, Colonial Churches of Tidewater Virginia (Richmond, Va., 1945). The freshwater-saltwater transition zone are located according to Nichols, "Sediments of the James River," 171-179, Evan Ruzek, Virginia Institute of Marine Science, personal communication; H. C. Whaley and T. C. Hopkins, Atlas of the Salisbury and Tidewater Area of Chesapeake Bay, Chesapeake Bay Institute, Johns Hopkins University, Graphical Summary Reports, nos. 1-2, Ref. 52-4, 63-1 (Baltimore, 1952, 1963); Chinard, A Huguenot Exile in Virginia, 174.

72. This geographical pattern of mortality might be explained by other models, such as the Rutmans' malarial endemicity. According to the Rutmans, malarial "morbidly climbs as endemicity rises, since a greater percentage of infectious bites by Anopheles leads to symptomatic malarial attacks. Yet the rate of morbidity will be balanced at some point by the rate of immunities in the population and then begin to decline until, in a hypendemic situation, morbidity is limited to nontoxic, non-immune newcomers to the community, and pregnant women." Put geographically this process of endemicity should move roughly with the frontier of settlement, i.e., old settled areas being hyperendemic, newly settled areas having low but rising morbidity, and middle-aged areas having very high morbidity. If I have reasoned correctly, the entire James River area, as the oldest settled zone, should show low values on our map, followed by very high values in the middle-aged tier of Gloucester, Middlesex, Lancaster, Westmoreland, and Northumberland counties, and low values elsewhere. I do not detect such a pattern, and accordingly favor the three-zone estuarine model of enteric diseases. Rutman and Rutman, "Ages and Fevers," WMQ, 3d Ser., XXXIII (1976), 37-59, 44-45.

68. "A List of the number of men, women and children, ... Within the Colony of Virginia. Anno Dom, 1632," Colonial Records of Virginia, 1, 122-133; Hecht, "The Virginia Colony, 1607-1640," 195-207; Craven, "Dissolution of the Virginia Company," 170-171. In a revealing note, Governor Wyatt in 1623 blamed the colony's ill fortune on "the intemperate drinking of water." "To plant a colony by water drinkers was an inexcusable error in those who laid the first foundation and have made it a received custom," Kingsbury, ed., Records of the Virginia Company, IV, 10-11, 453; Wharton, "The Bounty of the Chesapeake, 46; William Ancisiz and C. B. Kelly, "Self-Purification of the Soft Clam Mya arenaria," Public Health Reports, LXV (1950), 605-634.

70. Gilbert Chinard, ed., A Huguenot Exile in Virginia, or Voyages of a Frenchman Exile for His Religion with a Description of Virginia and Maryland (New York, 1934), 130, 174. Recognition of the freshwater-saltwater transition and its dangers is implicit in Bullock's 'flowing of the salt.' Clayton thought all saltwater bad, as it imprecated the air and thus damaged the human body. William Bullock, Virginia Impersonally examined, and left to public view, to be considered by all judicious and honest men (London, 1694), 4; Edmund Berkeley and Dorothy Smith Berkeley, eds., The Reverend John Clayton ... His Scientific Writings and Other Related Papers (Charlottesville, Va., 1965), 54.
eighteenth-century mortality, perhaps enough to account for the high rates of the oligohaline zone and the intermediate rates in the saltwater zone.

The demographic history of early Virginia is both sad and tragic. Sad because so many died; tragic because they died needlessly. Smith, Dale, and others knew that epidemics of typhoid, dysentery, and salt poisoning were recurrent; they knew that these epidemics were spawned by a contaminated water supply in the vicinity of Jamestown and the freshwater-saltwater transition on the James estuary. They knew that dispersing in the summer or shifting permanently into the freshwater zone were the only ways to save lives. And they knew that scattered settlements required the protection of an aggressive Indian policy. Smith and Dale saved lives, but their insights were abandoned with the arrival of new colonial leaders or a new company administration. Jamestown was reclaimed, mortality rose, and the painful environmental learning process began again at ground level. The Sandys administration never learned. The nexus of environment and mortality confounded and eluded them. They mistakenly believed that the seasoning process would eventually take hold and Virginia’s population would grow. But typhoid and dysentery were no respecters of flawed theories of immunity. From a demographic standpoint, the best thing that happened in early Virginia was the dissolution of the company with its fixation on Jamestown.