1999 Imported Fire Ant Conference

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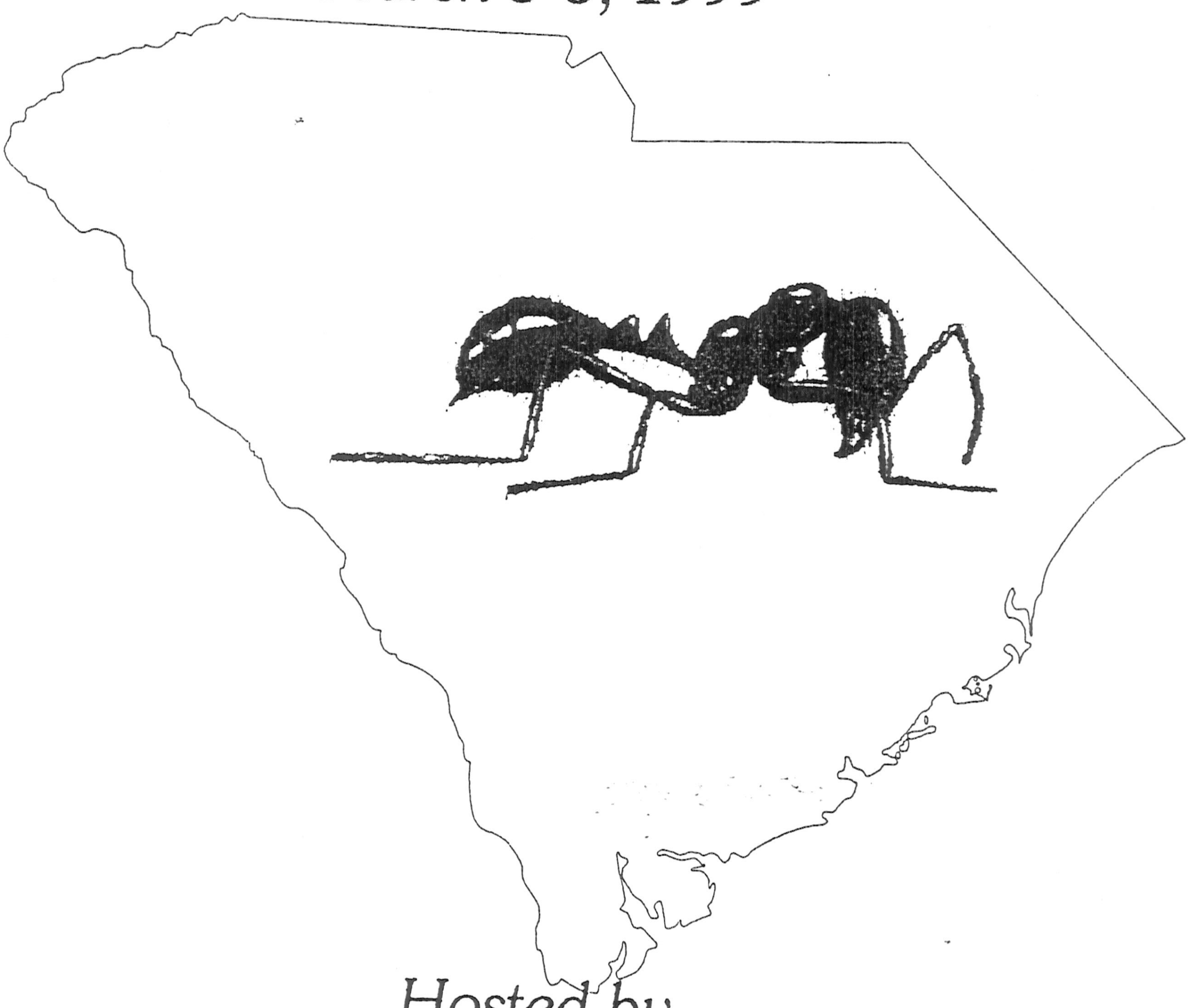

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Potential Red Imported Fire Ant Range Expansion - A GIS View

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INTRODUCTION

The advancing occupation of the Red Imported Fire Ant, *Solenopsis invicta* Buren, (RIFA) has caused much concern in southern and western areas of the United States. Because tremendous economic losses are at stake, it is imperative that we understand where and why future invasions may occur. Many attempts have been made to model RIFA range expansion (Pimm and Bartell, 1980; Cokendolpher and Phillips, 1989; Stoker, et al., 1993; Killion and Grant, 1995; Korzukhin, et al., 1997; Weih and Thompson, 1997; Thompson, et al., 1998). Thompson, Korzukhin and Porter (1999) have elaborated on their previous colony growth model and have predicted population range expansion from Virginia to Oregon. This paper uses Geographic Information Systems (GIS) software tools to visualize and spatially analyze the results of this model for 10 states.

MATERIALS AND METHODS

This GIS overview of RIFA range expansion was accomplished using Environmental Systems Research Institute, Inc. (ESRI) ArcView 3.1, along with the Spatial Analyst extension. Data layers were provided for Arkansas by the Spatial Analysis Laboratory at the School of Forest Resources, University of Arkansas, Monticello. Data layers for other states were obtained from the ArcUsa 1.2m database developed by ESRI and from the Conterminous US Land Cover Characteristics Data Set developed by the University of Nebraska, Lincoln.

The principal data set for this GIS overview reflects predictions of the dynamic model of colony survival described by Thompson, et al (1999). The data set contains over 3500 records. Each record reflects an estimate of total average life-time alate output of a colony for each weather station location. Colony growth rates were predicted based on certain life history parameters along with maximum and minimum soil temperatures. Total colony alate production was used to define three zones to estimate whether or not a population could be maintained. Production of 8300 or more alates will assure population survival. If alate production is between 8300 and 4500, the population may survive. If alate production is less than 4500, it is doubtful that the population will survive. Each record/weather station is identified by latitude and longitude in degrees, minutes and seconds. Station locations were transformed to decimal degrees, imported into an ArcView project, and projected to Albers Equal-Area. State and county boundaries were overlaid on the alate data. State boundaries and the three zones of predicted colony survival are depicted for southern and western United States in figure 1. Infested counties were identified based on the USDA-APHIS quarantine map of June 12, 1998. The results of these layers (predicted colony survival, state and county boundaries, and infested counties) are shown for 10 states on the advancing edge of RIFA invasion (figures 2-11).

For the state of Arkansas, additional data layers were used to further investigate factors which may influence colony survival. These layers included elevation, aspect, land cover, urban areas, and soil types. GIS provides an ideal tool to illustrate and spatially analyze these relationships where appropriate data are available. Efforts were also directed toward evaluating various methods of kriging using the spatial analyst extension of ArcView. Kriging is an advanced interpolation procedure that generates an estimated surface from a scattered set of points.

DISCUSSION

Predicted RIFA range expansion described by Thompsons' model drastically increases the current range. It is likely that fire ants may move into several western states where they have not yet been reported, as well as expand northward in southern states along the perimeter of their current range. Although fire ant range expansion is ultimately limited by temperatures set for colony mortality (Calabi and Porter, 1989), there are numerous other mitigating factors that may influence colony survival at a local scale. Water in the form of rainfall or irrigation is the most obvious factor. Because timing and the amount of precipitation is important to fire ant productivity, the model doesn't work well for arid regions. However, irrigated tracts are likely to mimic areas where precipitation is ample, making the model reliable for those areas.

Other relevant factors include elevation, aspect, land cover, and urban activity. The inclusion of these factors produces a heterogenious landscape for colony development. The validity of predicted colony survival at a specific point may be investigated using GIS. Data layers may be spatially analyzed to determine how the above factors may influence a colony in that particular location. It is important to consider the relationship of these factors, in addition to soil temperature, when analyzing the probability of population survival in a specific environment. Colonies are less likely to survive at higher elevations and more likely to survive on southern and western facing slopes. Colonies are more likely to survive in pasture or crop areas than in forested locations. Colonies are more likely to survive in urban areas where conditions are modified by human activities.

CONCLUSION

GIS provides the tools to build a spatial model using physiographic features to predict temperature suitability for RIFA colonization on a local scale. Spatial statistics techniques in a GIS framework can be used to incorporate heterogeneity into a landscape model. After additional research to determine the relative importance of individual mitigating factors, this model could be used to refine the predictions of the dynamic model developed by Thompson, et al (1999). Reliable forecasting of colonization success in areas threatened by RIFA infestation will allow policy makers and administrators to plan, fund, and implement regulatory activities. This may save millions of dollars in economic loses attributed to fire ants.

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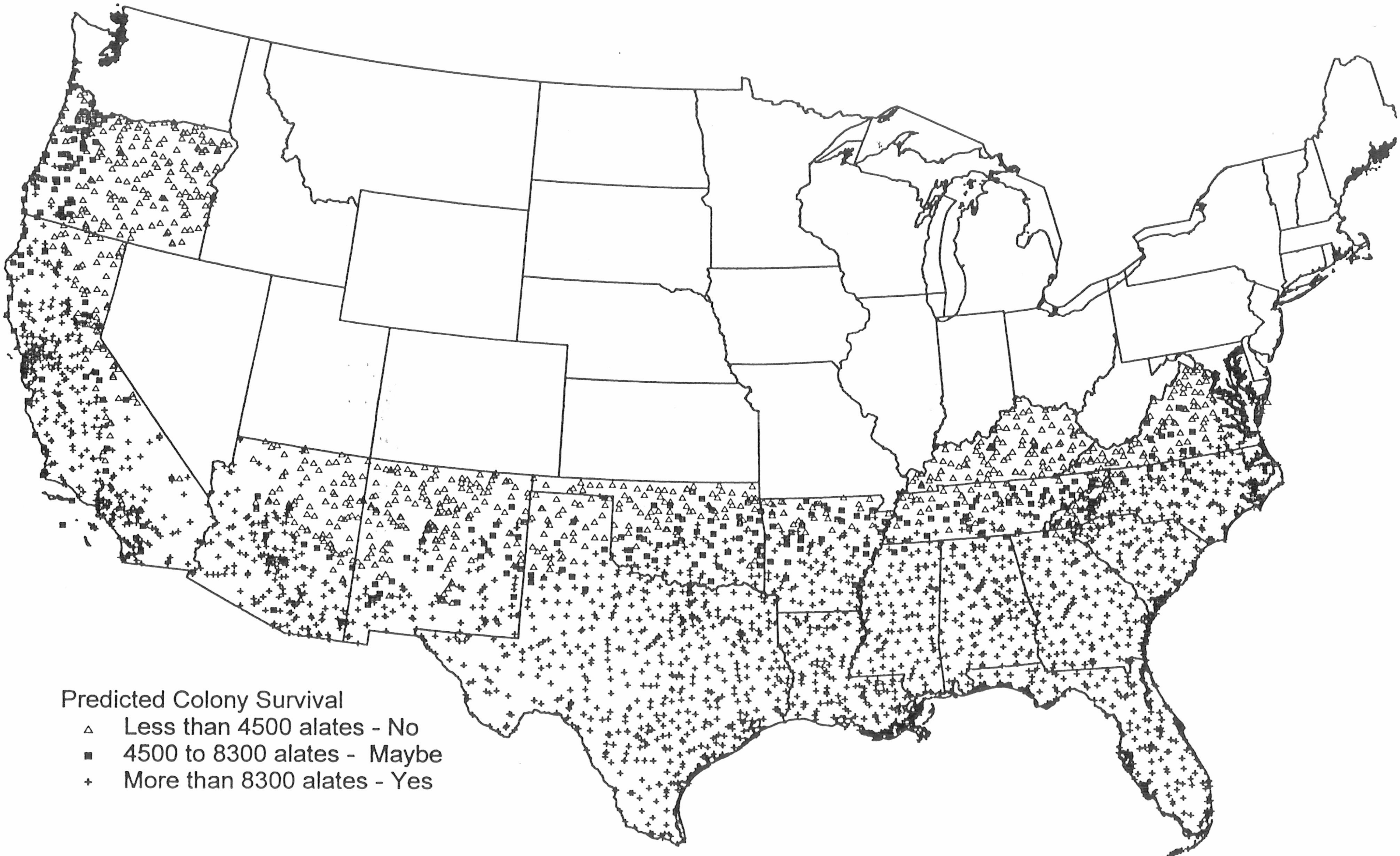

Figure 1. Predicted RIFA colony survival across the United States.

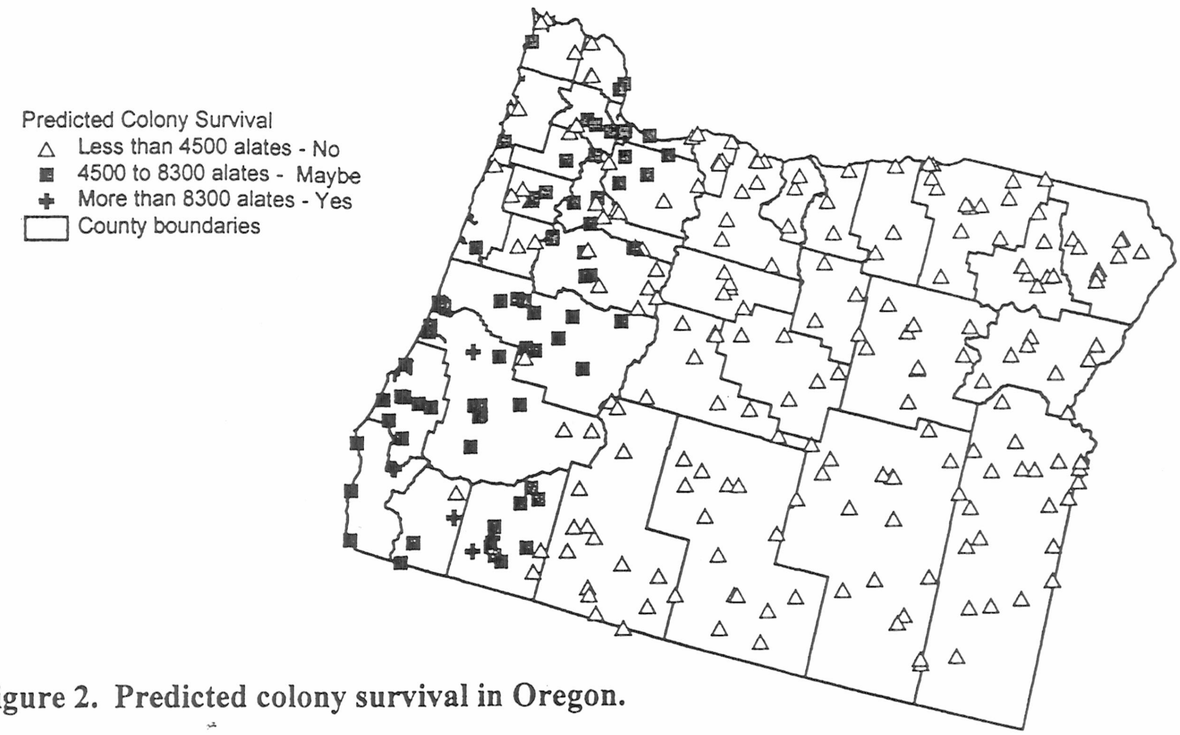

Figure 2. Predicted colony survival in Oregon.

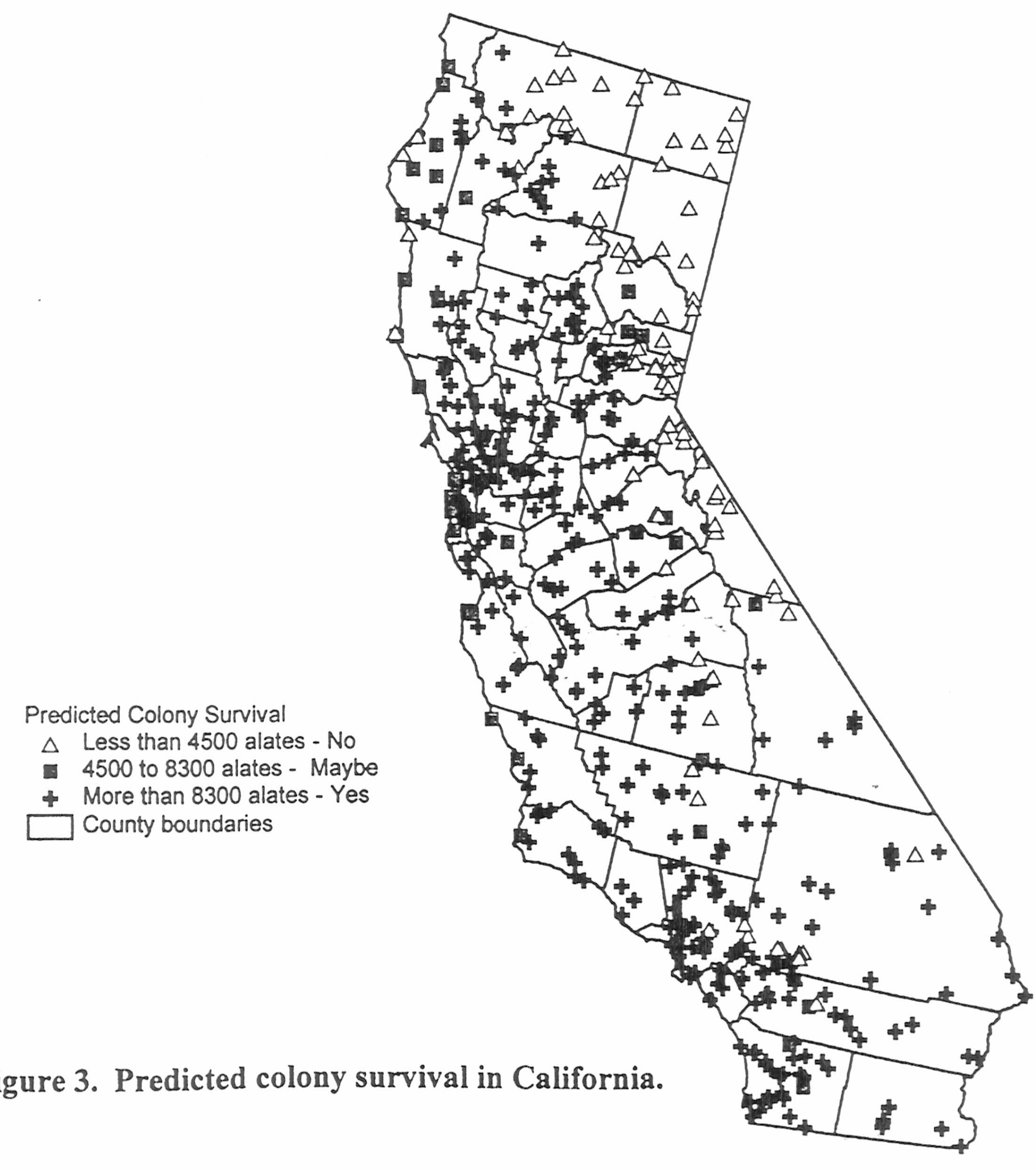

Figure 3. Predicted colony survival in California.

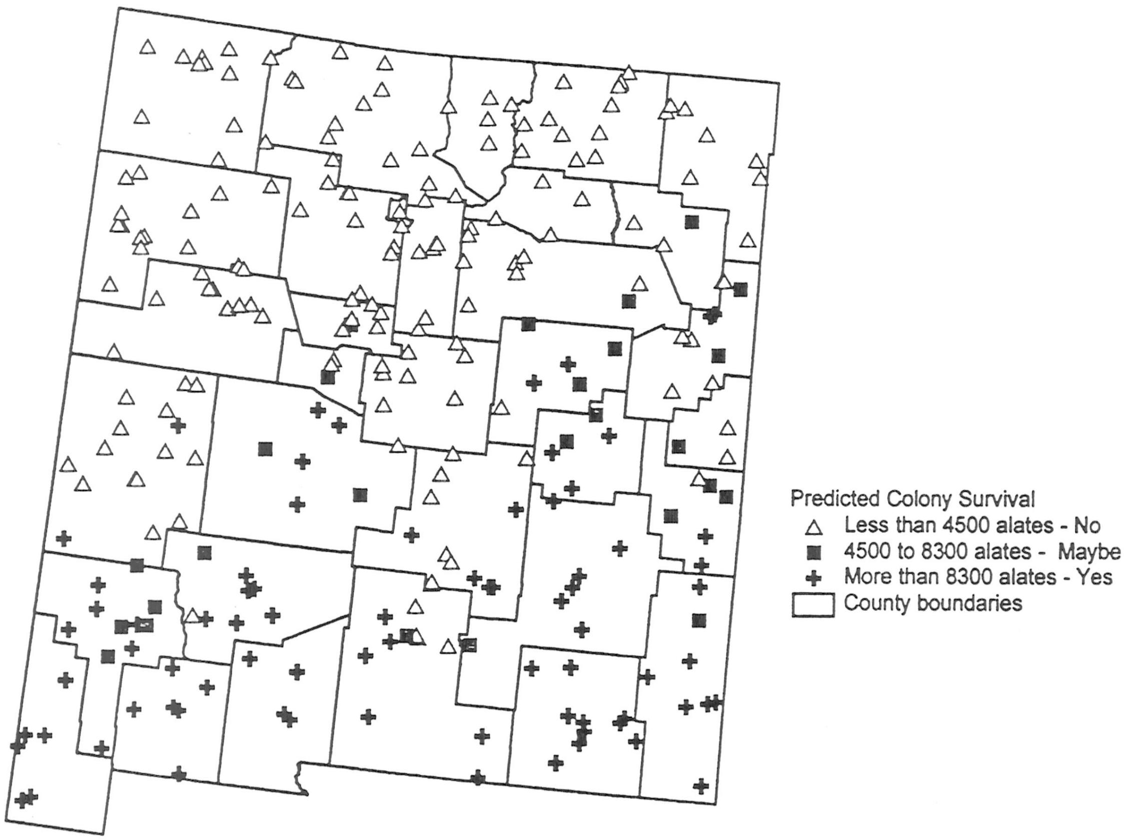

Figure 4. Predicted colony survival in New Mexico.

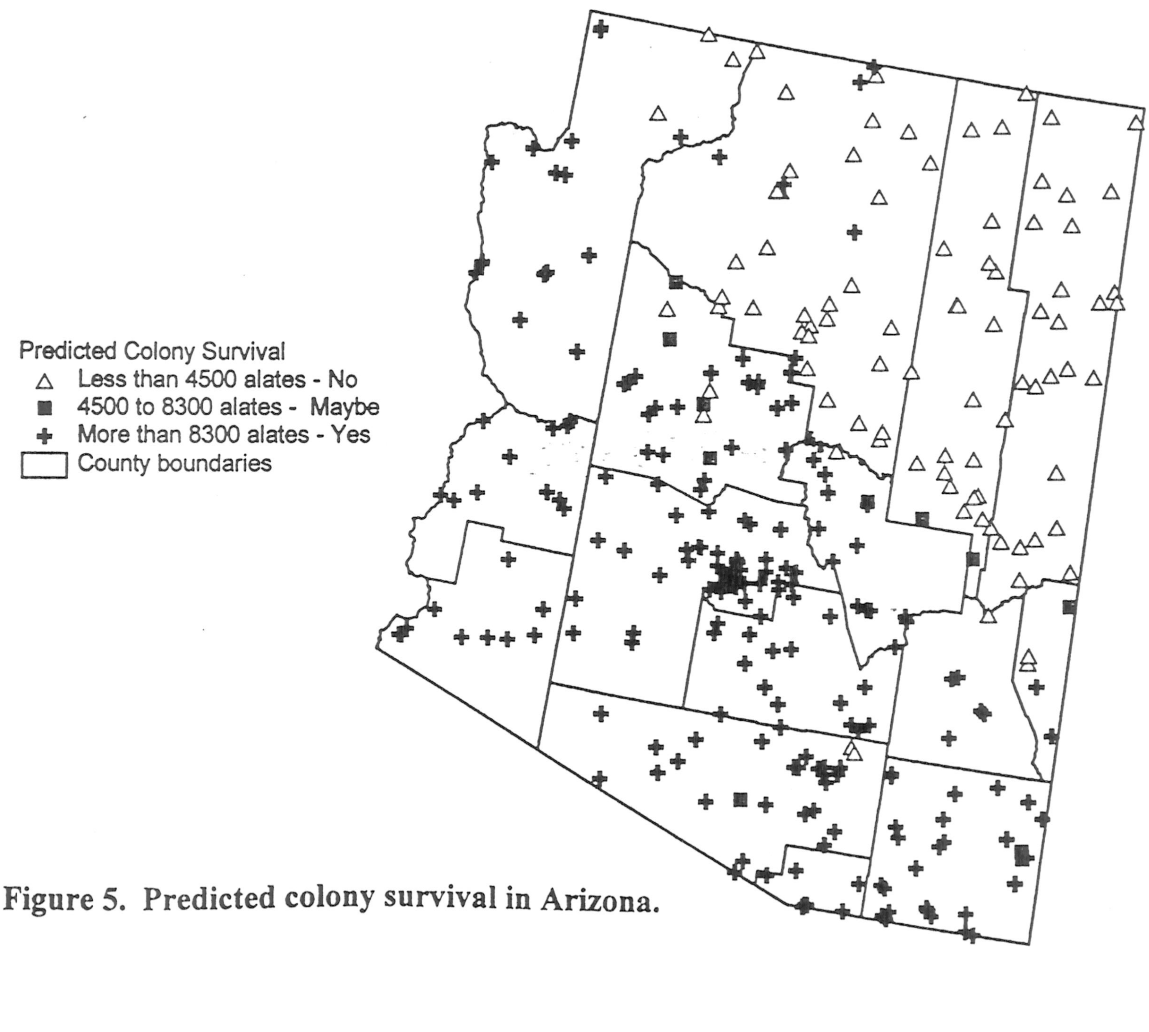

Figure 5. Predicted colony survival in Arizona.

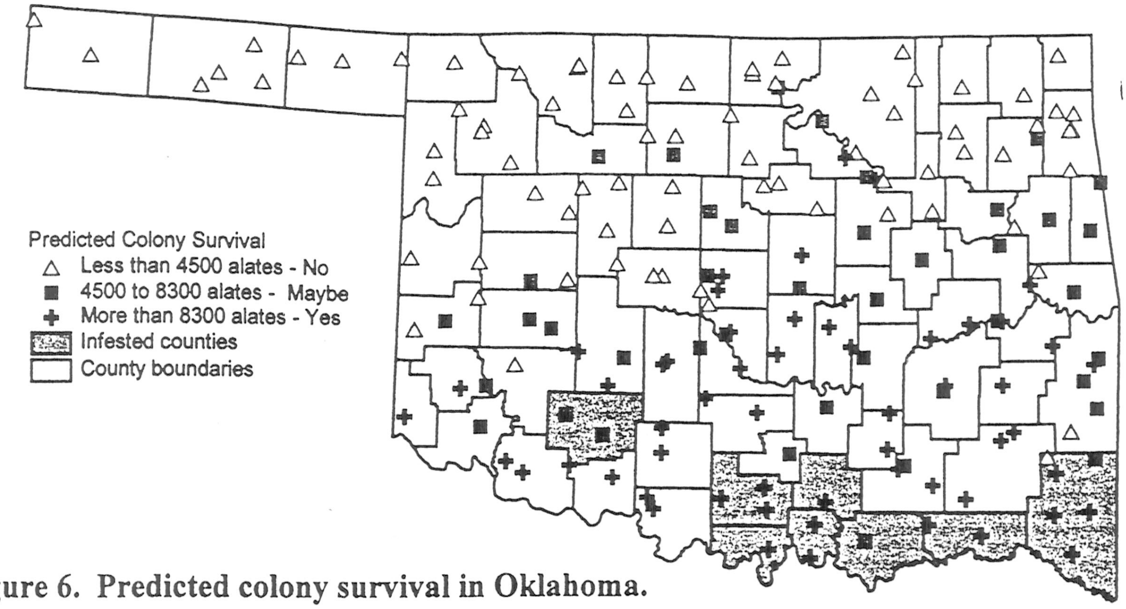

Figure 6. Predicted colony survival in Oklahoma.

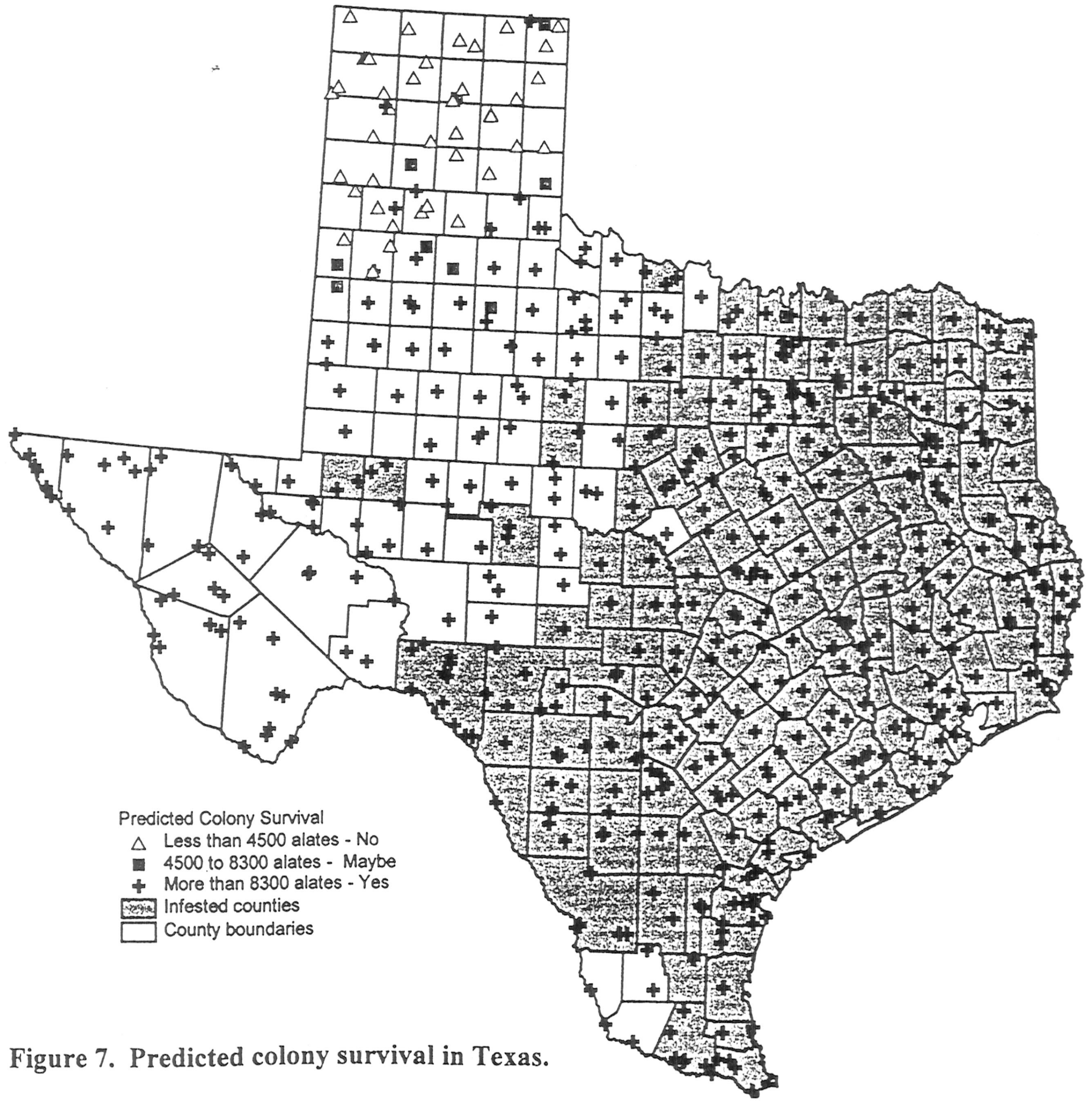

Figure 7. Predicted colony survival in Texas.

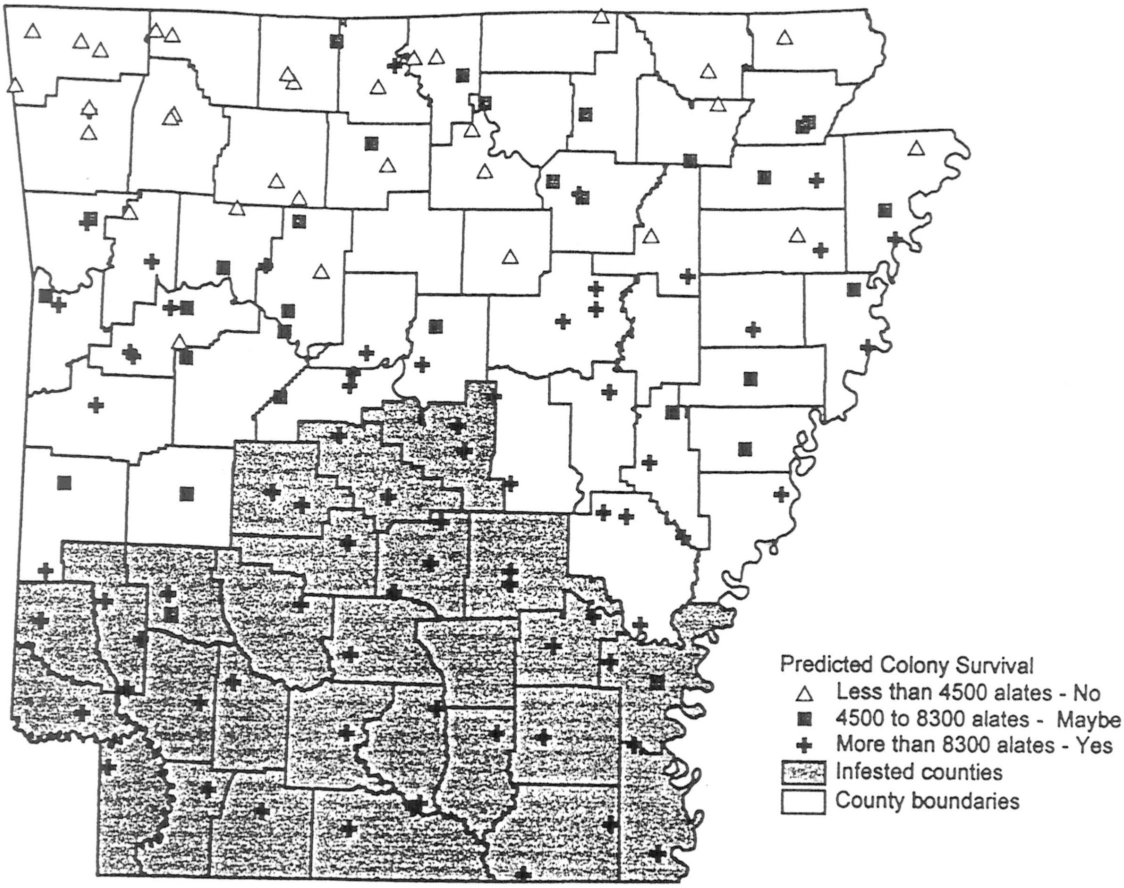

Figure 8. Predicted colony survival in Arkansas.

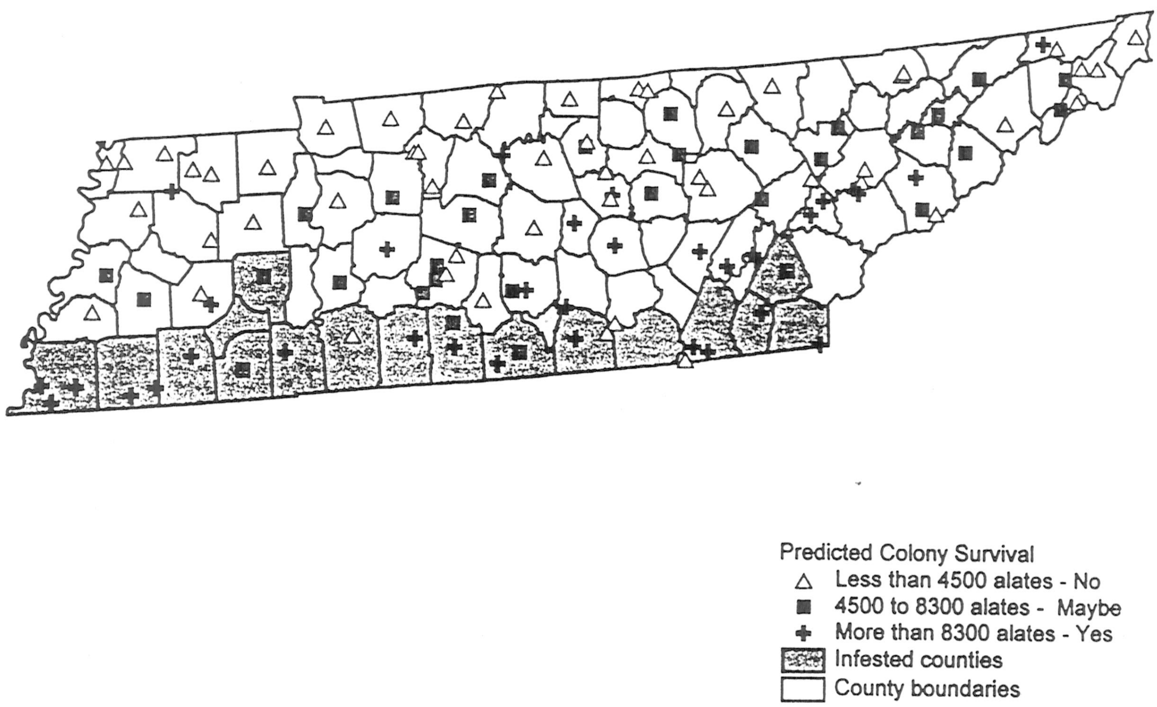

Figure 9. Predicted colony survival in Tennessee.

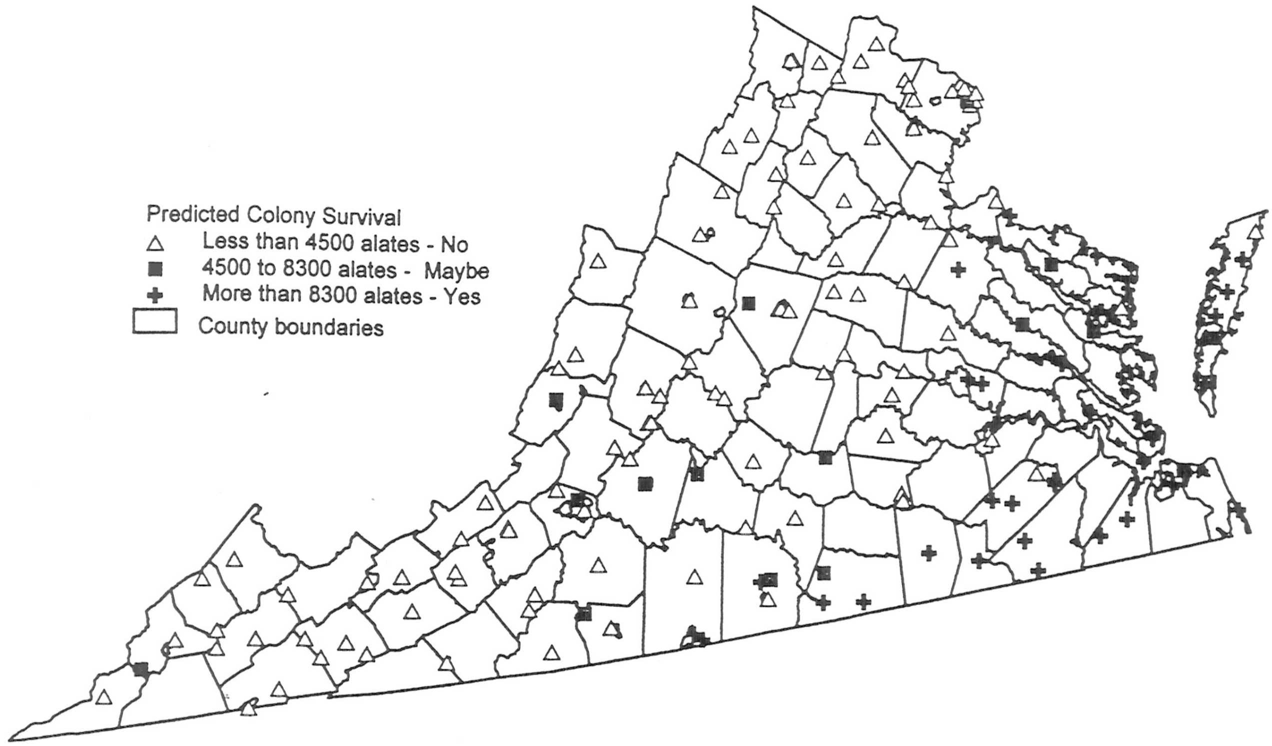

Figure 10. Predicted colony survival in Virginia.

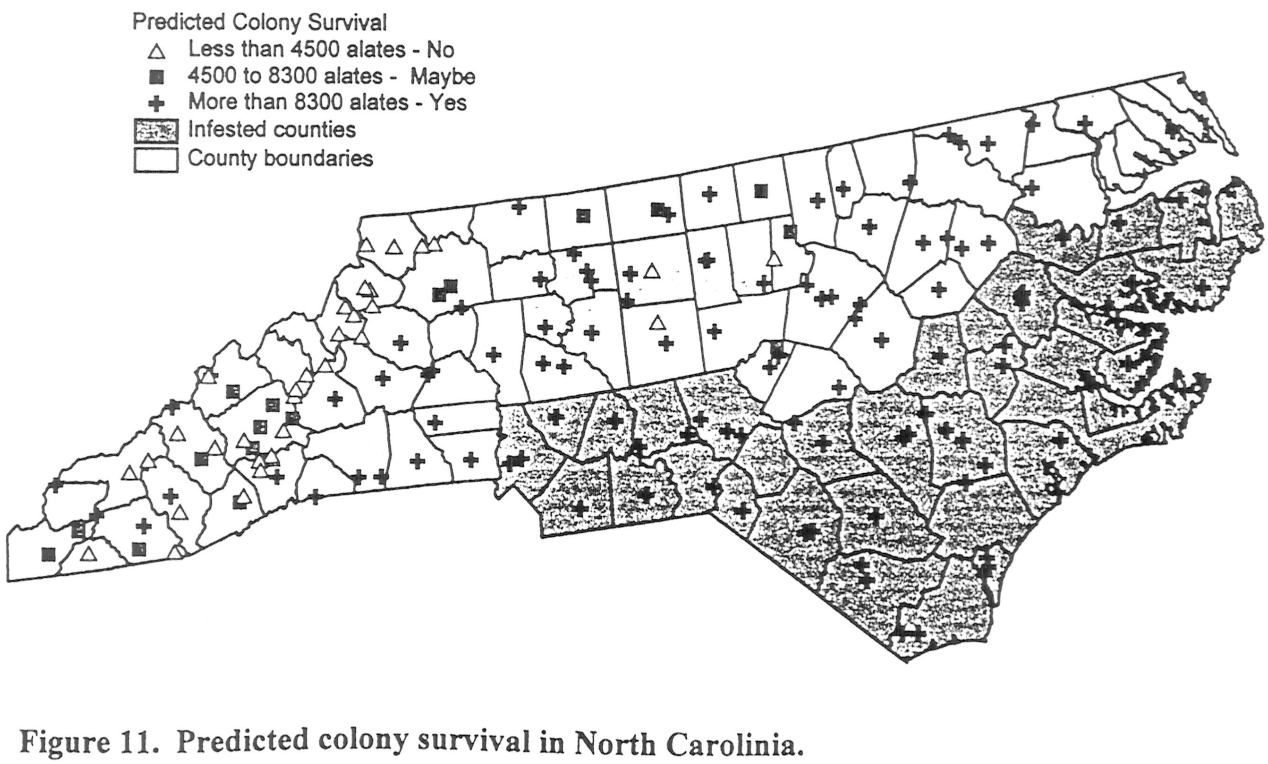

Figure 11. Predicted colony survival in North Carolinia.