ASIAN LONGHORNED BEETLE, OVER THE RIVER AND THROUGH THE WOODS: HABITAT-DEPENDENT POPULATION SPREAD

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ABSTRACT

The Asian longhorned beetle (ALB), *Anoplophora glabripennis* (Motschulsky) (Coleoptera: Cerambycidae), is an introduced pest of hardwood trees in North America. This paper addresses population spread in open landscapes and wooded areas, with emphasis on recent findings from Staten Island, NY, and Worcester, MA. ALB was first discovered in New York City and on Long Island, NY, in 1996; in Chicago, IL, in 1998; in Jersey City, NJ, in 2002; in Toronto, ON, in 2003, and in Carteret, NJ, in 2004. The landscape in all of these locations was primarily urban/suburban, in which ALB was typically found inhabiting such land use categories as urban centers, residential neighborhoods, commercial and industrial properties, institutional and municipal grounds, parks, cemeteries, golf courses, and greenways along streets and highways. Tree density in these habitats varies from moderate to high, with a high percentage of host species and high host diversity (a variety of maples, elms, birches, willows, horsechestnuts, poplars, London plane trees, and other species). In these settings infested trees are generally quite accessible for survey, treatment, and removal operations, and damage caused by ALB is readily apparent from the ground to experienced surveyors after the first year or two of infestation.

Research has shown that in such habitats populations of ALB tend to spread slowly, developing in the initial years on just a few trees near the point of origin. For example, in residential areas in Chicago, the majority of trees with ALB egg sites were found very near trees bearing exit holes, showing that when hosts were readily available nearby, females did not travel far after emerging as adults before laying eggs. The cumulative distribution function for ~ 1,000 trees in Chicago was P =1-0.734*EXP(-0.014*D), where P is the cumulative proportion of trees and D is the distance (m) from a tree with one or more egg sites to the nearest tree bearing one or more exit holes (Fig. 1). Key points on the distribution curve were 90 percent ~ 140 m, 95 percent ~ 200 m, and 99 percent ~ 300 m. Likewise, in a detailed study of population development and spread in Carteret, NJ, an ALB infestation remained confined to just a few trees within 260 m of the point of origin for 5 years, although hundreds of adults had emerged from some trees by that time.

In 2006, for the first time, an ALB population was discovered inhabiting what was primarily an open landscape. The infestation in Linden, NJ, east of the turnpike (I-95), was centered in an industrial wasteland that had sparse stands of red maple, gray birch, and poplar (quaking aspen and eastern cottonwood). The site was surrounded by freshwater and tidal marshes, open fields, vacant land, industrial plants, chemical tank farms, parking lots, highways, railroad tracks, and open water. The infestation originated in ca. 2000 from an unknown source. Although the population was genetically indistinguishable from

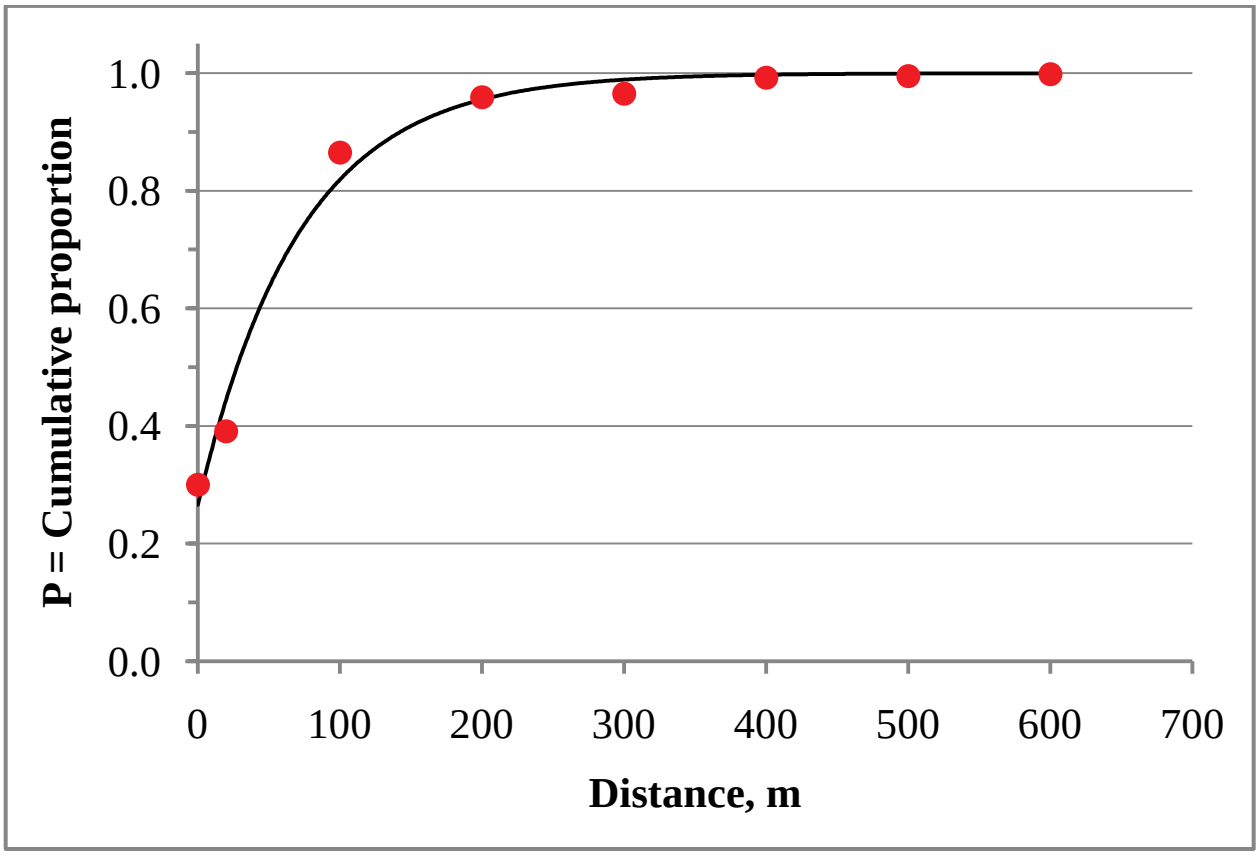

Figure 1.—Distance from trees with oviposition sites to nearest tree with ≥ 1 exit hole. Based on approximately 1,000 trees in Chicago, IL, 1998-2003. $P = 1 - 0.734_{e^{-0.014D}}$

beetles from the Carteret infestation, temporal and spatial discontinuities suggest an independent origin. Infested trees found up to 1.5 miles to the west in 2005 and 2006 could be tied to Linden as a source, but not to Carteret. In 2007 and 2008, additional sites were discovered on Prall's Island and Staten Island, up to 2 miles to the east. Again, these could be tied circumstantially to Linden as the likely source. The open landscape was characterized by a low overall density of trees, moderate to high percentage of host species, and low host diversity. Damage was readily apparent because of the generally small tree size and open habitat, but accessibility to the sites for survey, treatment, and host removal was variable and often poor. DNA evidence from beetles collected in Linden and on Prall's Island and Staten Island, along with temporal, spatial, and numerical population analyses, strongly suggests that these groups were related and all derived from the Linden focal point. That initial introduction had spread approximately 2 miles to both the east and the west in 5 years, in marked contrast to the much slower spread of the Carteret population. The key difference appears to have been the open nature of the landscape in Linden, which raised few impediments to population spread and offered only sparse resources to arrest dispersing beetles. We now know that ALB populations can spread rapidly across open landscapes and beetles are able to locate distant hosts, although behavioral mechanisms and the probability of doing so are unclear. In light of the knowledge gained by studying population spread in this new landscape, the ALB Eradication Program expanded the customary boundaries for host removal, chemical treatment, and survey on Staten Island. The small pocket of infested trees found on Staten Island in December 2008 was in a location that analysis had suggested might be reached by beetles dispersing from Linden or Prall's Island, in a broad greenbelt growing on the far side of an open expanse of marshes and industrial wasteland. In fact, the locations in Linden and on Prall's and

Staten Islands were all discovered by surveying areas specifically suggested by an improved understanding of landscape-dependent spatial dynamics.

Until 2008, only small wooded areas in New York, Illinois, New Jersey, and Toronto had been found to be infested by ALB. However, in August of that year, a well-established infestation was discovered in Worcester, MA. Because of the close proximity of affected areas to the extensive northeastern deciduous forests, alarm was raised about the potential impact of the ALB on this valuable resource and the greater challenges this presented to the ongoing eradication effort. Due to our lack of prior experience, little or nothing was known about how populations of ALB will behave in forested areas. Surveyors soon found hundreds of infested red and sugar maple trees in the densely wooded, 50-ha (120-acre) Bovenzi Park on the city's northwest side. The earliest damage, dating to around 1999, was located about 100 m in from the southeast corner of the woodlot, in the direction of the apparent epicenter of Worcester's ALB infestation. In general, the heaviest and oldest damage was concentrated along the eastern edge of the woods, strongly suggesting an edge effect during invasion. Still, by 2008 the population had permeated the wooded tract. One tree with exit holes was found more than 200 m into the woods, about halfway to the center. In the interior, infested trees (most bearing egg sites only) were concentrated in, although not limited to, riparian areas; this may simply reflect the distribution of the principal host species, red maple. Given the early date of invasion, it is surprising that damage levels on individual trees were not higher (45 exit holes on the most heavily infested tree). It appears that either the rate of increase of the population was lower in the woods than we've seen elsewhere, or insects were distributed over a greater number of trees because of their close proximity and the ease of moving from one to another.

The nature of the northeastern deciduous forest varies by latitude, elevation, soil class, and moisture regime, but in general is characterized by a high density of trees, a high percentage of ALB hosts, moderate host diversity including primarily red and sugar maples; paper, gray, river, yellow, and black birches; and poplars (eastern cottonwood and quaking and big-tooth aspen). ALB damage will not be readily apparent in this habitat because of the density of trees, tree size, and poorer lighting than in more open landscapes, so early detection is problematic. Accessibility for survey, treatment, and host removal is poor, and these operations will be difficult and costly. Modified sampling-based survey techniques (rather than complete inspection of all hosts) may be necessary. Chemical treatment plans for high host density situations are still under development. Many control options will be controversial, and eradication may be unfeasible should ALB become established in extensive wooded areas.

Through the study of ALB populations inhabiting a variety of landscapes, our understanding of the beetle's infestation dynamics has improved greatly in recent years. As a result, strategies for combating it have evolved as well. In both open landscapes and forested areas, detection is less likely because of the large areas involved and accessibility and apparency issues. Survey and control operations are more costly and problematical. We now realize that flexibility in operations and case-specific approaches to eradication must be employed. Making the case to the public for such flexibility is a new challenge faced by program managers.