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Geography and History of Periodical Cicadas (Hemiptera: Cicadidae) in DuPage County, Illinois

Carl A. Strang¹

Abstract.

The spatial distribution of periodical cicada (*Magicicada septendecim* L. and *M. cassini* Fisher) emergence in 2007 did not match either historical locations of woodlands or the cicadas' own geography in the 19th and early 20th centuries in DuPage County, Illinois. Cicadas were present in forest areas that had remained above 61 ha throughout historic times, and they were absent from areas which at some point had been reduced below 52 ha by tree removal, mainly for agriculture. Isolation of forest areas also may have contributed to local extinctions. The insects have spread into new, urban woodlands created by residential plantings. Their distribution is associated with the early growth of towns along commuter railways in the eastern part of the county (toward Chicago). A peculiar gap in the main emergence area (encompassing two adjacent cities) may be the result of the cicadas shifting their emergence four years early. An active dispersal on 9–11 June, coinciding with the peak in cicada singing in forested areas, apparently placed scattered small groups of cicadas outside the main emergence area.

Geographical interest in periodical cicadas (*Magicicada* Davis) has focused on the ranges of species and broods, the latter being multispecies sets of populations which emerge synchronously in a defined portion of the total range (the history of the brood numbering system was reviewed by Kritsky (2004)). Lloyd and Dybas (1966b) analyzed the temporal and geographic distribution of the 17-year broods and found adjacent and overlapping broods to be separated by one or four years, differences that could reflect histories of cool years delaying emergence by a year (as suggested earlier by Alexander and Moore (1962)) or the cicadas in an area emerging four years early. In 1969, Dybas documented such an early emergence of 17-year periodical cicadas across several counties in the Chicago area, four years ahead of the main emergence (Brood XIII). This was given context by White and Lloyd's (1975) finding that *Magicicada* spp. with 17-year periodicity (such as the Chicago area's *M. cassini* Fisher and *M. septendecim* L.) differ from more southern 13-year species through a four-year dormancy early in their nymphal lives. Subsequent study and analysis has questioned this finding, however (Maier 1996). Though Dybas believed that the cicadas had not reproduced in 1969 (he believed the weather that year was too cool), newsworthy numbers subsequently emerged in the same area in 1986 and 2003 (Fig. 1). Kritsky (2004) reported Lloyd's speculation that such "shadow broods" (Marshall 2001) may escape infection by a fungal parasite (*Massospora cicadina*), the only consumer specific to *Magicicada*, and conducted a series of dissections that provided some support for this idea. Nymphal crowding (Lloyd and White 1976) and climatic signals (Marshall et al. 2011) have been suggested as possible proximate stimuli for the early emergence of such shadow broods.

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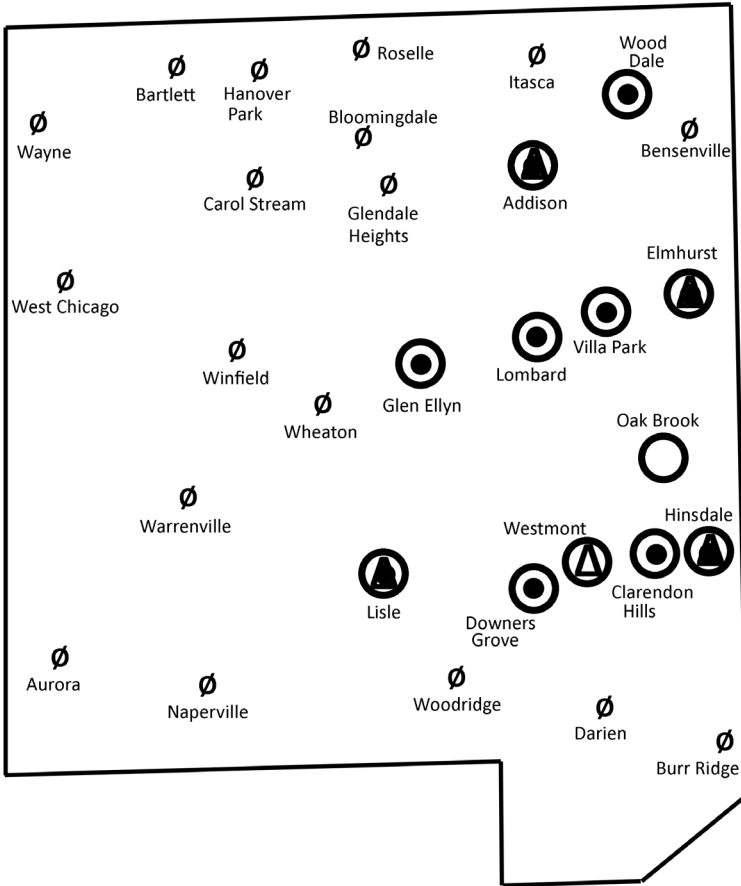


Figure 1. The communities of DuPage County, their geographic centers identified with symbols representing their record of periodical cicada emergences 4 years before the main emergences of 1973, 1990, and 2007. Null symbols represent towns with no such records, filled circles represent reported emergences in 1969 (Dybas 1969), triangles represent reported emergences in 1986 (Philips 1986, Nixon 2003a, and unpublished notes), and open circles represent reported emergences in 2003 (Nixon 2003b, Van Matre 2003, and conversations with Wood Dale residents reported in this paper).

All the towns listed by Dybas (1969) in which the *Magicicada* shadow brood first appeared were located in eastern portions of the greater Chicago area. This was despite the presence of forested areas and urban tree plantings throughout. Furthermore, conversations with people who had been present for the Brood XIII emergence in 1990 did not produce recollections of cicadas in the more western areas, though memories were strong of emergences in much of the same area outlined by Dybas for the shadow brood. This puzzle led to the decision to perform a mapping study of one county during the 2007 Brood XIII emergence, documenting areas where the two species of periodical cicadas were abundant. The working hypothesis was that areas that long have been forested would have concentrations of cicadas, which then would have expanded into

adjacent towns and residential areas to the degree that such areas had enough old trees to be forest-like.

Materials and Methods

This study focused on DuPage County, immediately west of Chicago and bounded on the east and north by Chicago's Cook County. When the emergence was well underway in open areas such as residences and municipal parks (27 May–3 June), I drove, bicycled and walked around the county, mapping the edges of cicada concentrations, as well as spot-checking forest preserves both along rivers and old woodlands that are not on rivers. I noted where each species was chorusing (too many individuals to count), present in low enough numbers that singers were countable, or absent, and where persisting nymphal exoskeletons marked emergences.

At the end of July, visitors to the Forest Preserve District of DuPage County's booth at the DuPage County Fair were given the opportunity to stick colored pins in a large county map, recording their observations of the emergence around their homes. They had four choices of colors, corresponding to choruses that were small enough that the cicadas were countable or too large to count, and whether they peaked before or after 9 June (which coincided with both the end of the school year and an observed active dispersal of periodical cicadas, described below).

The earliest information on the geography of the periodical cicadas' woodland habitat in DuPage County comes from the original 1840 land survey (Bowles et al. 1998; Fig. 2). At that time the area was mostly prairie, with pockets of forest and savanna largely defined by topography and wetlands that blocked earlier prairie fires. Subsequent changes to the 18 major forest and savanna areas in the county were obtained from an 1874 county atlas (DHS 1974), from the earliest series of aerial photographs that covered the county in 1939 (ISGS 1997), and from present day images accessed through GoogleEarth (Google 2008). For each of these 18 areas, the largest forest remnant that survived from 1840 to the present day (the habitat bottleneck) was identified and its area measured by applying the ruler feature of GoogleEarth to its core area, and estimating the irregular peripheral portions with the same tool. Some of the forest remnants had abundant cicadas in 2007, others practically none, and their bottleneck sizes were ranked and compared with the nonparametric Mann-Whitney *U*-test (Mendenhall 1971). Old newspapers (Wheaton Illinoian 1888, 1905; Wheaton Progressive 1922) provided historical information on habitat and past cicada emergences.

Results

By 21 May 2007, significant cicada emergences had begun in some residential areas, especially in the southern part of the Chicago region. By the end of May both species were chorusing throughout the region, by the end of June chorusing was significantly reduced, and by mid-July both species were quiet or nearly so.

In the first days following emergence, areas where cicadas were abundant were sharply defined, and mapping could be done block by block and sometimes tree by tree. Also, cicadas initially sang close to where they emerged. Though forested preserves lagged behind residential areas in cicada activity, enough cicadas were emerging at woods edges to make clear which preserves had abundant cicadas and which did not. Areas of abundant cicadas generally contained both *cassini* and *septendecim*. Typically the *septendecim* chorusing stopped short of the boundary of the high-density areas, and only *cassini* were singing in the outermost 100 m or so. Whether this was an indication of the spreading *septendecim* population trailing that of the louder *cassini*, or perhaps *septendecim*

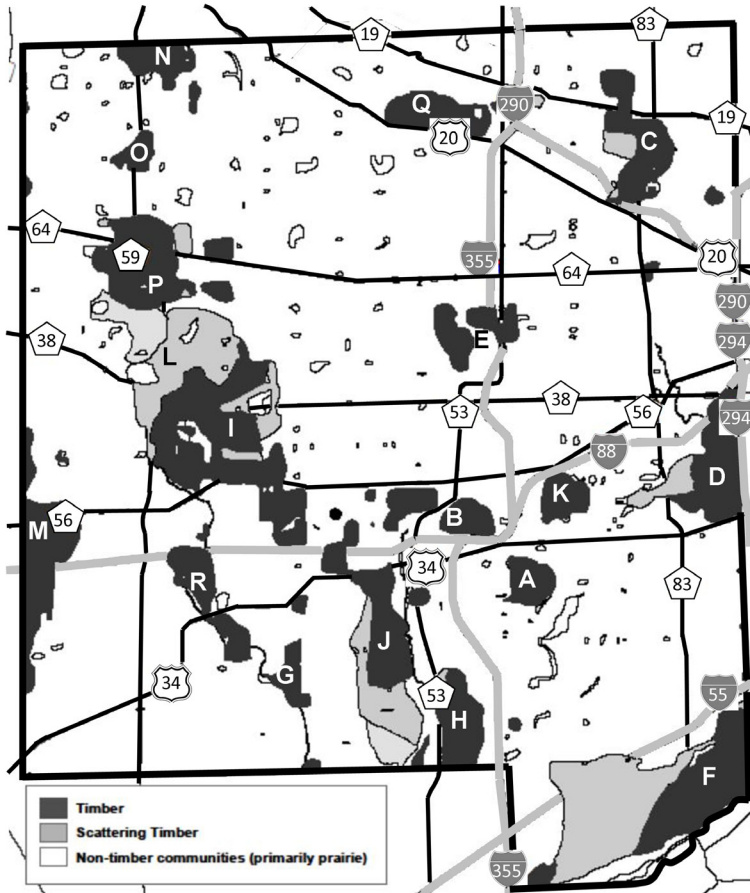


Figure 2. DuPage County map, showing vegetative communities at the time of the original land survey, 1821–1840 (Bowles et al. 1998). Most of the county then was prairie, with wetlands designated by small outlined areas. Forest and savanna area labels correspond to entries in Table 1. Interstate, federal and state highways are indicated.

choruses referencing their locations to *cassini* choruses, was not determined. Also, within the high-density areas there were places where *septendecim* were few or none while *cassini* remained abundant nearly throughout where checked. The resulting pattern (Fig. 3) shows a large area of cicada emergence in east central DuPage County, with separate branches extending NW and SW from a short stem that reached east into Cook County's western suburbs. These lobes appear to follow two of the three major commuter rail lines through the county. In addition there were islands of cicada abundance in Bensenville (adjacent to the third commuter rail line) and surrounding 3 forest preserve areas in the south central part of the county. Finally, the Des Plaines River corridor, bounding the south edge of DuPage County's southeastern panhandle, had high cicada densities. Otherwise, only scattered to countable *cassini* in some places, and no cicadas at all in others, could be found. On 7 June I returned to the western

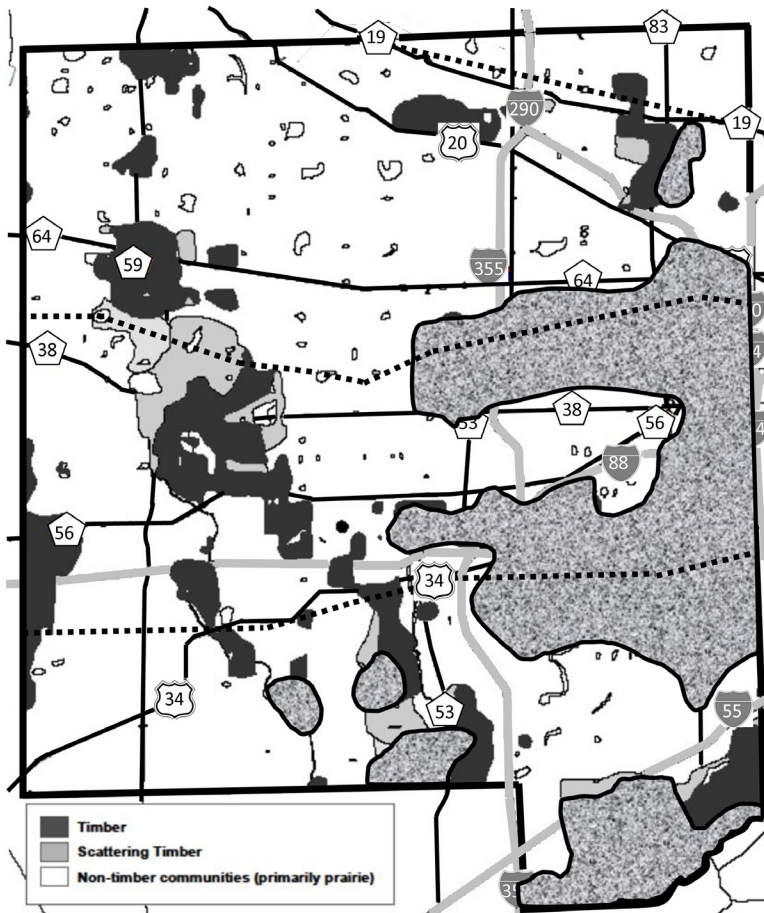


Figure 3. DuPage County map, showing areas (textured gray patterns, bounded by heavy lines) where periodical cicadas emerged in large numbers in 2007, superimposed over the forest and savanna areas from Fig. 2. Dotted lines show routes of the county's three major commuter railroads.

edge of the main cicada area at the end of the main northern lobe and walked it. This area is of interest because much of that edge is not bounded by habitat, i.e., the edge of cicada abundance is within an area that appears suitable for cicadas on both sides. It is composed of residential streets with many mature trees. In places the cicada choruses extended as much as 200 m beyond the zone of emergence, but on the whole that extension has to be described as small. In no place did signs of emergence extend beyond chorusing, i.e., the cicadas appeared to be expanding or at least maintaining their current range.

Cicadas were lacking in most of the western part of the county, including forested areas. This prompted the historical aspect of the study. Reviews of old newspapers revealed the presence of abundant cicadas in western DuPage communities (Wheaton, Bartlett and West Chicago) in 1888 (WI 1888) and persisting

at least in one of them (Wheaton) as late as 1939 (DJ 1939). DuPage County developed first as an agricultural area in the mid-19th Century (Blanchard 1882, Thompson 1985). Horse-based transportation soon was augmented by important railways radiating from nearby Chicago, and the county's communities competed to be included in the rail routings. Rail stops meant access to the Chicago market for farmers, made those communities attractive to industry, and facilitated commuting to work in the city. The influence of the city of Chicago as a place of work spread from east to west in the county, where commuters first augmented the growth of eastern towns while western DuPage remained agricultural (Thompson 1985). Those towns which succeeded prospered and grew, and tree planting around homes and along community streets was a priority (Russell 1977, Thompson 1985, Stewart 2006).

Comparisons of maps and aerial photos indicate that already by 1874, agricultural clearing had reduced the 18 major forest areas to a median value of around 67% of their original size. Between 1874 and 1939 that value had fallen to 30%. Housing and commercial construction further reduced forest patch size between 1939 and 2007 in 10 of the 18 forests. DuPage County's population growth accelerated after the 1950 census, its population tripling between 1940 and 1960 (USCB 1995), and nearly doing so again (reaching 904,161) by 2000 (USCB 2013).

The smallest (bottleneck) sizes of the forest patches appear to relate to the presence or absence of abundant cicadas in 2007 (Table 1). It appears that below 52 ha, forests in DuPage County do not sustain periodical cicada populations. Forests that remained above 61 ha still contain them. Consideration of the 3 marginal forests in Table 1 raises the possibility that isolation may play

Table 1. History of periodical cicadas in DuPage County forest areas. Sizes (in ha, hectares) of the largest persisting forest remnants in each of the 18 original (1840) forest areas in DuPage County, in order of descending size, with presence/absence of abundant periodical cicadas in 2007 indicated. The difference in ranks of bottlenecks between those with versus those without abundant cicadas is statistically significant (Mann-Whitney $U = 2$, $P < 0.01$). Historical records from Bowles et al. (1998; for 1840), Wheaton Illinoian (1888, 1905) and Wheaton Progressive (1922).

Area	Size of bottleneck (ha)	Periodical Cicadas Abundant 2007?	Historically Largest (1840) Size (ha)	Early Record of Abundant Cicadas?
A	168	Yes	292	Yes (1888)
B	143	Yes	462	
C	140	Yes	865	
D	138	Yes	1012	Yes (1922)
E	136	Yes	439	Yes (1922)
F	120	Yes	2957	
G	76	Yes	177	Yes (1905)
H	63	Yes	572	
I	61	No	2241	Yes (1888)
J	58	Yes	1617	
K	52	Yes	281	Yes (1888)
L	47	No	1375	Yes (1888)
M	46	No	965	Yes (1922)
N	42	No	337	Yes (1888)
O	42	No	163	
P	36	No	980	Yes (1888)
Q	36	No	511	
R	30	No	487	Yes (1905)

a role: the 61-ha patch without abundant cicadas is 7.7 km from the nearest cicada concentration, while the 58- and 52-ha patches with cicadas are 1.0 and 1.8 km, respectively, from other concentration areas. That 61-ha woodland is the largest bottleneck in the western half of the county, hence its remoteness, and apparently, hence the near extinction of periodical cicadas in western DuPage by the mid-20th Century.

One of the more intriguing locations is the town of Wood Dale, in the northeast quarter of the county. Its nearest (780 m distant) original forest patch was a 140 ha piece in Bensenville, to the east, a city which had a concentrated cicada emergence in 2007 (Figs. 1, 3). Wood Dale had very few cicadas in 2007. This is based on conversations with 5–10 residents and park district staff, as well as my own 2007 surveys of the 4 forest preserves in that community and the adjacent town of Addison. None of those forested preserves had cicadas beyond the countable level in 2007, and as I traced the edges of areas where cicadas had emerged in chorusing numbers, these always ended outside the boundaries of those two cities. Though I did not cover all of Wood Dale or Addison in my survey, the portions I missed were mainly areas with concentrated houses or industrial parks with few trees. However, both Wood Dale and Addison are included in Dybas' (1969) list of towns that had cicadas in the original off-year emergence, and the Wood Dale residents reported that though there were few cicadas in Wood Dale in 2007, there were many more, implying a concentrated emergence, in the off year of 2003 (Fig. 1). Addison also had some in 2003 (Celmer 2003, Van Matre 2003).

There also was a regional emergence of this "shadow brood" (Marshall 2001) in 1986 (Philips 1986, Nixon 2003a), but less information on affected communities in DuPage County is available for that year (Fig. 1). The most specific indication is contained in Nixon's (2003a) prediction for 2003, based on his notes from 1986: "We expect the periodical cicadas to emerge through much of the Cook County suburbs, [and] the eastern half of DuPage County, ... arcing to Addison and Lisle on the west ..."

An unexpected widespread active dispersal of *cassini* occurred around 9–11 June. This coincided with the peak in singing volume in forested areas (emergence began earlier in more open residential neighborhoods, and singing may have peaked a few days sooner there as well). Cicadas were flying across wide highway corridors and other open areas they had avoided earlier, with specific distances of 200 m, 260 m and 1200 m gaps noted. This was not a wind-pushed dispersal. These were relatively calm days, and in fact cicadas were not moving on a very windy 7 June. The result was that after 11 June, *cassini* were to be found in noticeably greater numbers beyond the mapped areas of abundant emergence. None of these choruses had densities beyond the countable level of abundance, but the numbers of individuals involved were remarkable (examples noted with more than a dozen males chorusing miles from the nearest concentrated emergence). *M. septendecim* accompanied the dispersing *cassini* in only 2 known locations, both of which were unusual in having concentration areas within 2 km on 2–3 sides. The dispersal did not consist of males alone, as females both living and dead were found in several locations. The contrast between the time before and after the period of observed dispersal was stark. The small choruses formed in areas where there had been no previous observations of enough scattered males to gather and form them, and the challenge of surviving predation long enough to do so further argues against these being late-forming groups of locally eclosed males.

An opportunity further to document this process was provided by participants who placed pins in the map at the DuPage County Fair in late July. The resulting pattern was clear, with pre-dispersal pins coinciding closely with the pattern shown in Fig. 3, and post-dispersal pins, almost entirely representing countable choruses, spread widely through the county though concentrated in regions surrounding the areas where cicadas had emerged in large numbers.

Few pins of any color were placed in the extreme northeast corner of the county. In the Wood Dale-Addison area there were only 5 pins indicating “none,” and 1 indicating only countable cicadas after the 9–11 June dispersal.

Discussion

The areas of abundant emerging periodical cicadas (Fig. 3) did not match expected patterns, except that they did include locations where cicadas were known to be abundant in the 1990 emergence. The lobes of the main emergence area had between them an extensive zone with only scattered *cassini*. Furthermore, only one area in western DuPage County had large numbers of emerging cicadas. In addition to the main eastern area were a few separate islands, as well as the Des Plaines River corridor. These results recall the fact that 200 years ago DuPage County had some forested areas, but these were mainly isolated pockets surrounded by prairie (Fig. 2). With the arrival of large scale agriculture in the 19th century, most of the county became farmland. Both prairie and farmland are unsuitable for periodical cicadas. As the city of Chicago grew to the east, DuPage County became increasingly suburban. Railways supported the growth of the earliest major communities along three major commuter rail lines. These areas, where people planted trees around their homes, have supported woodlands for the longest time (outside the original forest remnants). It is no coincidence, in this light, that the shape of the major cicada emergence area has branches that roughly follow those rail lines. It seems likely that periodical cicadas spread from refuges in the original forests into the newer urban plantings, limited by their 17-year generation time and the communities' expansion rate.

The difference between the cicada abundance in the eastern and western halves of the county thus appears to be traceable to the influence of the growing city of Chicago. The eastern communities, particularly those along commuter railways, made an earlier transition from agriculture and preserved more of their forests in the 1800s and early 1900s, though these woodlands later became depleted by development. By that point, however, mature trees residents had planted around their homes were augmenting the effective forest habitat area available to periodical cicadas. In the western half of the county, the longer period of agricultural clearing and the more recent depletion of forests by development appear to be responsible for the local extinctions of periodical cicadas. Potential cicada habitat has increased in recent years as housing areas and the trees planted within them mature.

There appears to be little information in the literature on minimal forest size needed to sustain periodical cicada populations. The most relevant study I have seen is Rodenhouse et al. (1997). They imply that areas as small as 16 or even 3–4 ha may be enough, at least in their southwest Ohio study area, but do not provide information on distance of separation between such areas. They focused on comparison of edge and interior of forest areas, but emphasized that disturbance of forests is an important factor in the history of cicada persistence. Indications are that in the DuPage County forest areas, populations have been able to persist as long as they are able to emerge at high densities in areas of at least 61 hectares. Smaller areas can sustain populations only if they are not isolated from others.

A further hint of the possible importance of forest isolation is the report that at Raccoon Grove Forest Preserve in Will County, south of DuPage, there were few cicadas emerging in 2007 (Wisby 2007, Cooley et al. 2013). That was the study area for the Dybas and Davis (1962) study frequently cited for measured high densities of periodical cicadas. Though that preserve is only 23.5 ha in size, it is part of a larger woodland of 130 ha. Such a size would seem safe, but that area is 5.2 km from the nearest woodland, Thorn Creek Woods Forest Preserve, a much larger area that had abundant cicadas in 2007 according to Will County Forest Preserve District staff.

While persistence of local populations has been associated with habitat patch size and isolation in this study, earlier studies have emphasized population density without reference to those other measures (e.g., Alexander and Moore 1962, Dybas and Davis 1962, Lloyd and Dybas 1966b, Karban 1982, Maier 1982, Marshall et al. 2011). What may be most critical is a combination of these measures that gives a total population size, along with habitat patch isolation.

The significant emergence of periodical cicadas in Brood XIII four years ahead of schedule, first reported by Dybas (1969), has received increased attention as more instances of this are documented, and as it has persisted within the same area Dybas described in subsequent cicada generations (Fig. 1). Kritsky (2004) pointed out the need to demonstrate reproduction and raised the possibility that the 1969 and 2003 emergences were independent events (he did not mention the 1986 emergence). It also should be understood that these records are mainly the result of citizen reports to scientists or to news media rather than thorough surveys by knowledgeable investigators. The potential contribution of developmental plasticity was reviewed by Marshall et al. (2011). While citing various potential causes, they pointed to climatic influences (mediated by tree physiology) as perhaps having the most traction. This makes some intuitive sense, at least, in the case of 17-year species shifting to a 13-year pattern typical of more southern forms in a time of climatic warming. The large numbers involved, the regional appearance of this shadow brood for three sequential generations, and especially the indications that the primary year for emergence in the communities of Wood Dale and Addison is now 4 years ahead of the Brood XIII timing, suggest that reproduction may be occurring. However, climatic stimuli could be confusing the issue. I plan to survey the area in question thoroughly in the next shadow brood year of 2020. In the absence of clear demonstration that reproduction is occurring in the early emergences, and until the possible shift of the entire Wood Dale-Addison area cicadas to the new pattern is better documented, developmental plasticity repeated in every generation needs to be considered as an alternative hypothesis (i.e., a false or "shadow brood," Marshall 2001). Furthermore, those two communities need to be examined in 2016. If that local population has indeed shifted, some of them may come out 4 years ahead of that shifted timing (i.e., the next Brood XIII emergence is anticipated in 2024, a four years early shift would occur in 2020 and developmental plasticity could bring some out in 2016).

The secondary dispersal beginning around 9 June 2007 in DuPage County was unexpected. There is not much said in the literature about dispersal, and I have seen nothing comparable to the distances apparently covered here. Karban (1981) investigated cicada movements around forest edges. The longest displacement he noted (149 m) was within the same forest block. The longest flight across an open area he observed was 72 m, by an individual crossing a field from one edge to another of the same forest block. The degree to which the DuPage County dispersal was vehicle facilitated or the result of capture and release by residents disappointed by the lack of emerging cicadas in their neighborhoods is not known, but in at least 2 cases these choruses were in blocks of forest rather than residential areas. There are suggestions in the literature (Lloyd and Dybas 1966a, White et al. 1979, Williams and Simon 1995) that competition among nymphs is severe and may lead to high mortality. This might provide an advantage to individuals that lay their eggs a short distance beyond the main emergence area. Such dispersal might also carry offspring beyond the fungal parasites (White et al. 1979). The risk of predation, both to dispersing prospective parents and to emerging offspring in the next generation, would be a counterbalance. The fact of this dispersal opens a range of possibilities for the 2024 emergence. First, no observations in 2007 suggest that a reduction in the range of cicada abundance is likely, except where trees may be removed through human activity. The comparison of emergence and chorusing at the end of the main emergence area's northern lobe supports the possibility of a gradual

spread into new areas where the edge of cicada abundance is within, or at least close to, new areas of suitable habitat.

Finally there is the wild card of that wider, 9–11 June dispersal, which potentially established local abundances of *cassini* in many new places. However, the next times to survey periodical cicadas will be 2020, when the next off-year emergence is anticipated, and 2016, to test the developmental plasticity idea and the possibility of a complete shift in the Wood Dale-Addison area.

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