# Geographic distribution and local incidence of invasive crane flies in the Northeast

The European and common crane fly are both established in western New York state and are expected to continue spreading throughout the Northeast.

Biological invasions of nonindigenous plants, pathogens and arthropods are serious threats to rural, urban and natural ecosystems worldwide (8). Turfgrass is no exception. In the northeastern U.S., for example, four exotic white grub species (Asiatic garden beetle, European chafer, Japanese beetle, Oriental beetle) have become established as damaging pests of turf since their accidental introduction in the 1900s. Because invasive insect populations are prone to outbreaks, they have essentially changed the landscape of turfgrass protection.

## Impact of crane flies

New York state is now undergoing another change with the 2004 detection of two species of turf-infesting crane flies of European origin (7). Larvae of both *Tipula paludosa* (European crane fly) and *T. oleracea* (common crane fly) injure turf as a consequence of feeding on below- and aboveground portions of the grass. Known as "leatherjackets" for the tough pupal case left behind by the emerging adult, larvae inhabit the top layer of the soil where they feed on their turfgrass hosts. Like white grubs, they cause damage in turfgrass by pruning and disrupting underground portions of the plant, which leads to severe thinning and extensive dieback when damaged turf is water-stressed (D.C. Peck et al., unpublished). Like black cutworms, larvae also surface to feed on aboveground portions of the stem and foliage. They attack grasses across the full spectrum of management intensity, from home lawns to golf courses, and essentially all turfgrass and forage

A newly emerged adult European crane fly. **Photo by T. Cook**

Crane fly larvae can cause extensive turf damage by pruning below-ground portions of the plant. **Photo by R. Ferrentino**

Environmental Institute for Golf

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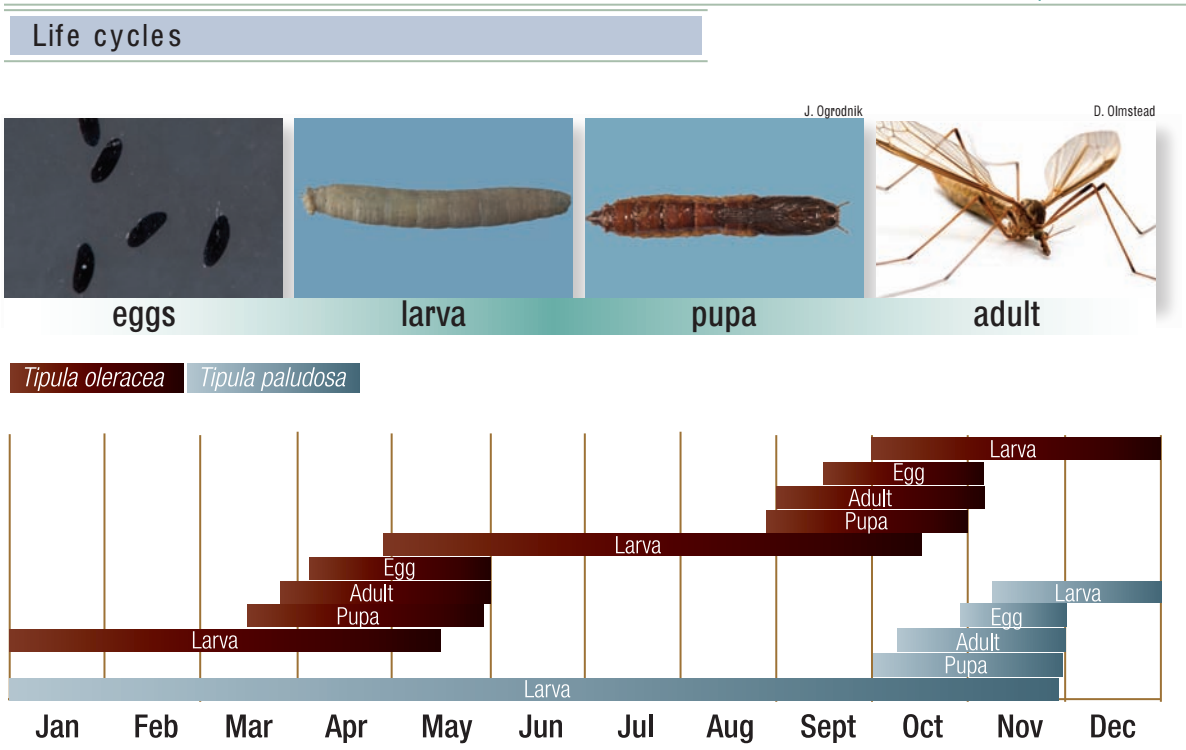


**Figure 1.** Generalized life cycles of ***Tipula oleracea*** and ***T. paludosa*** in New York state.
***Tipula paludosa*** completes only one generation a year, whereas ***T. oleracea*** completes two generations a year.

grass species are acceptable hosts.

One reason for alarm about the establishment and spread of these invasive insects in the eastern U.S. is that the potentially susceptible landscapes are vast. To date, outbreaks in New York state have been recorded from low- to high-maintenance turf, home lawns to golf courses, and roughs to greens (D.C. Peck et al., unpublished). Besides directly injuring grass, invasive crane flies can also lead to nuisance accumulations of larvae and swarms of adults, as well as turf disruption caused by vertebrate predators such as birds and skunks (D.C. Peck et al., unpublished). Impact on production systems, such as sod farms, pastures and hayfields is also inevitable (2). One study in Northern Ireland, for instance, showed a 74% increase in pasture yield after larvae were controlled (1).

## Establishment in the Northeast

Although invasive crane flies have previously established in the Pacific Northwest, Ontario and Quebec (3,9,10) and subsequently in Michigan (4), the scope of their establishment in the eastern U.S. is unknown. Baseline information on how widespread they are is essential for monitoring range expansion, making predictions about pest status, and guiding efforts to transmit information on pest management.

Certain diverging aspects of biology and behavior lead us to believe that the spread will be species-specific (6). For instance, *T. paludosa* are poor fliers, they mate and lay most of their eggs the first night they emerge and complete only one generation a year. In contrast, *T. oleracea* are capable fliers, lay eggs over a period of two weeks after emergence and complete two generations a year. These differences may translate to a higher rate of potential range expansion in *T. oleracea* compared to *T. paludosa*. In contrast, increased dispersal means that *T. oleracea* may build up local populations at a slower rate than *T. paludosa*.

To understand the scope of invasive *Tipula* establishment three years after their first detection, we addressed their occurrence at two spatial scales. To ascertain how widespread the insects were across the state, we documented the current known geographic distribution of each species to establish a baseline for monitoring future range expansion. To ascertain how widespread the insects were at sites of local establishment, we described the incidence of each species across newly infested golf courses to measure the extent of establishments within those landscapes. We

Top: An adult emerges from the pupa. Bottom: The exoskeleton that it sheds appears to be a twig protruding from the surface of the turf. Photos by T. Cook

predicted that *T. oleracea* would be more widespread both locally and geographically than *T. paludosa.*

## Materials and methods

*Geographic distribution*

We obtained locality data from specimens collected across New York state from 2004 to 2006. All identifications were based on adult specimens according to external characters such as distance between the eyes, number of antennal segments, male genitalia and the ratio of wing to abdomen length in females (7). There are currently no reliable morphological characters to distinguish between larvae of the two invasive species (5).

Data collected through spring 2005 showed invasive crane flies were present in the western half of New York state from Buffalo east to Syracuse. To build on that initial assessment and better define the boundaries of each species' range, additional delimiting surveys were conducted through 2006 along three main corridors. Two north-south corridors extended from Buffalo southwest to the Pennsylvania border (along the eastern shore of Lake Erie) and from Syracuse north to the Canadian border (along the eastern shore of Lake Ontario) and south through the Finger Lakes to the Pennsylvania border. A west-east corridor extended from Syracuse along the Erie Canal corridor to Albany.

Defining the boundaries of geographic distribution meant that we also needed to report sites where invasive crane flies were absent. We applied guidelines to standardize our search and reduce the chance of missing an infestation. Courses were scouted in spring or autumn when adults were known to be actively emerging. Crane flies were considered absent when a survey showed that no adults or pupal cases could be found on any of 10 to 15 greens or tees located across eight or more different fairways on a golf course. Pupal cases, sloughed off by adults as they emerge from pupae in the soil, are easy to spot because they protrude like small twigs from playing surfaces. Once adults were detected, we used a sweep net to capture them and verify their species identity.

*Local incidence*

To ascertain how widespread infestations were around sites of recent establishment, we measured the local incidence of invasive crane flies across greens and tees. These areas were ideal units for measuring and quantifying the extent of infestations across the golf course landscape. Surveys were conducted across eight golf courses in western New York. Two courses with establishments of *Tipula*

## *Tipula* species in New York state

| Species/year first detected | County | Municipalities | No. of localities by habitat | | |
|---|---|---|---|---|---|
| | | | Golf course | Lawn | Park |
| ***Tipula paludosa*** | | | | | |
| 2004 | Erie | Amherst, Orchard Park, Williamsville | 2 | 2 | 0 |
| 2005 | Monroe | Penfield, Pittsford, Rochester | 4 | 12 | 0 |
| 2004 | Niagara | Lewiston, Lockport, Niagara Falls, Youngstown | 4 | 0 | 2 |
| 2005 | Ontario | Victor | 1 | 0 | 0 |
| ***Tipula oleracea*** | | | | | |
| 2006 | Erie | Collins | 1 | 0 | 0 |
| 2006 | Livingston | Lima | 1 | 0 | 0 |
| 2005 | Monroe | Penfield, Pittsford, Spencerport | 4 | 0 | 0 |
| 2006 | Nassau | New Hyde Park | 0 | 1 | 0 |
| 2004 | Niagara | Lockport, Niagara Falls, Youngstown | 4 | 0 | 0 |
| 2006 | Onondaga | Baldwinsville, Cicero, Manlius, Marcellus | 4 | 0 | 0 |
| 2006 | Ontario | Canandaigua, Geneva | 3 | 0 | 0 |
| 2005 | Oswego | Fulton, Sandy Creek | 2 | 0 | 0 |
| 2006 | Seneca | Ovid, Seneca Falls | 2 | 0 | 0 |
| 2006 | Suffolk | Babylon, Riverhead | 0 | 2 | 0 |
| 2006 | Wayne | Lyons | 1 | 0 | 0 |
| 2006 | Wyoming | Varysburg | 1 | 0 | 0 |

Table 1. Occurrence of *Tipula paludosa* and *Tipula oleracea* in New York state based on collections conducted from 2004 to 2006.

*paludosa* were located in the towns of Lewiston and Niagara Falls, N.Y. Six courses with establishments of *T. oleracea* were located in the towns of Fulton, Geneva, Lockport, Penfield and Sandy Creek, N.Y. The specific courses were selected based on our opportunity to initiate monitoring in the same season that invasive crane flies were first detected on the course. We had identified the species but had no information on the scope of the infestation at that time. On each golf course, 18 to 68 greens and tees were surveyed during the seasonal windows of adult emergence. Surveys were conducted in the morning before mowing or on days when maintenance did not occur. Each site was scored as infested or uninfested based on whether larvae, pupae, pupal exuviae or adults were recovered from the playing surface.

## Results

*Geographic distribution*

*Tipula paludosa* was detected at a total of 27 locations in four counties and 11 municipalities (Table 1). It was originally reported from two counties in 2004 (Figure 2). Two more counties were added in 2005, and none were added in 2006. Pooling data collected over all three years, *T. paludosa* was collected from two parks, 11 golf courses and 14 home lawns. *Tipula oleracea* was detected at a total of 26 locations in 12 counties and 23 municipalities (Table 1). It was originally reported from one of the same counties as *T. paludosa* in 2004 (Figure 2). Two more counties were added in 2005, and nine were added in 2006. Pooling data collected over all three years, *T. oleracea* was collected from 23 golf courses and two home lawns. The most notable addition in 2006 was the detection of *T. oleracea* at two residences and one additional site on Long Island. A homeowner in New Hyde Park (Nassau County) reported nuisance swarms of adults after spring emergence. Both species co-occurred at five localities (all golf courses) situated in five munici-

## Distribution in New York state

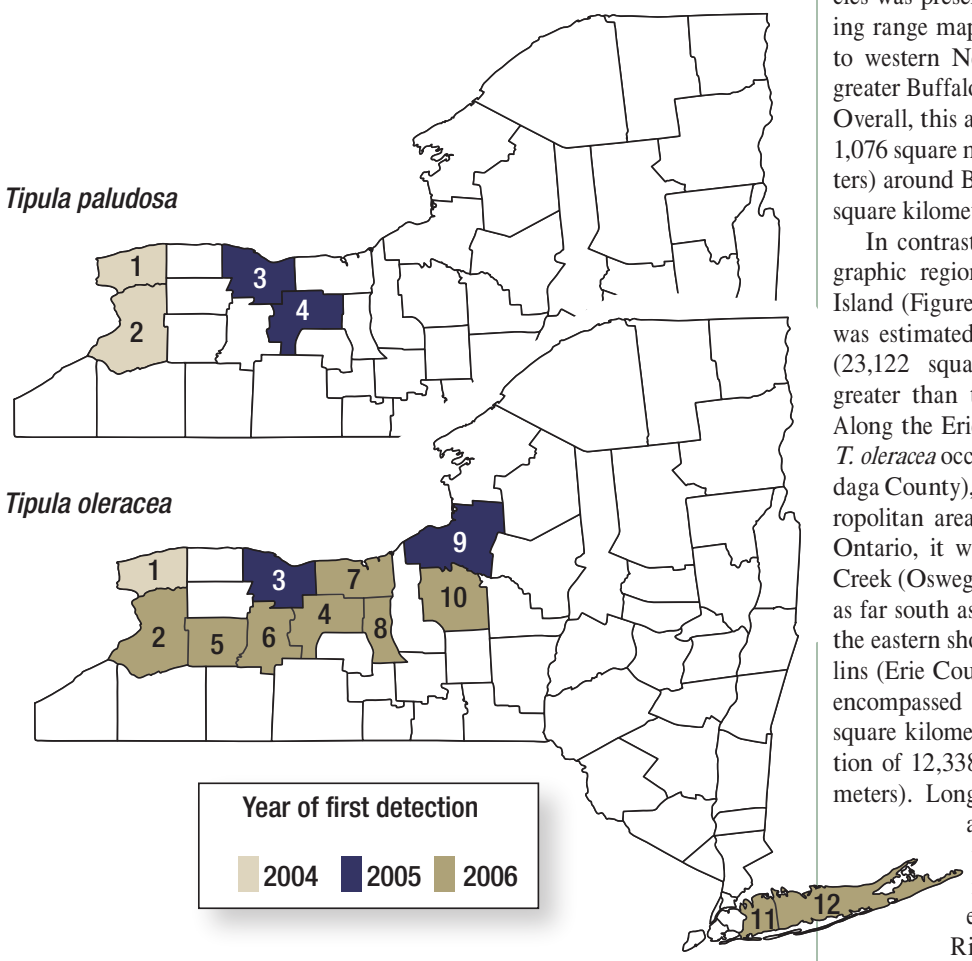


Figure 2. Distribution of *Tipula paludosa* and *T. oleracea* in New York state with respect to county and year of detection, based on field collections made from 2004 to 2006. Counties are: 1, Niagara; 2, Erie; 3, Monroe; 4, Ontario; 5, Wyoming; 6, Livingston; 7, Wayne; 8, Seneca; 9, Oswego; 10, Onondaga; 11, Nassau; and 12, Suffolk. Illustrations by K. Neis

palities and two counties (Niagara and Monroe). Based on the survey's criteria for absence, invasive crane flies were not present at 22 localities situated in 21 municipalities and 14 counties.

The distribution boundaries were defined with respect to the position of sites where each species was present or absent (Figure 3). The resulting range maps reveal that *T. paludosa* is limited to western New York and centered around the greater Buffalo and Rochester metropolitan areas. Overall, this area was estimated to cover 1,498 or 1,076 square miles (3,881 or 2,786 square kilometers) around Buffalo and 423 square miles (1,095 square kilometers) around Rochester.

In contrast, *T. oleracea* occurred in two geographic regions: western New York and Long Island (Figure 3). In western New York, the area was estimated to encompass 8,928 square miles (23,122 square kilometers), nearly six times greater than the area occupied by *T. paludosa.* Along the Erie Canal and Interstate 90 corridor, *T. oleracea* occurred as far east as Manlius (Onondaga County), including the greater Syracuse metropolitan area. Along the eastern shore of Lake Ontario, it was detected as far north as Sandy Creek (Oswego County); in the Finger Lakes area as far south as Ovid (Seneca County); and along the eastern shore of Lake Erie as far south as Collins (Erie County). The Long Island distribution encompassed another 3,411 square miles (8,834 square kilometers) for a total estimated distribution of 12,338 square miles (31,956 square kilometers). Long Island is depicted as a disjunct area of establishment because of the absence of *T. oleracea* in several intervening areas. This includes the eastern Erie Canal and Mohawk River Valley corridor, Hudson River Valley and the Southern Tier.

### *Local incidence*

Within one to two seasons after the first detection of invasive crane flies on golf courses, 22% to 97% of greens and tees were already infested. Based on pooled data, infestation rates were 54.3% for *T. paludosa* and 40.8% for *T. oleracea.* Because of its limited geographic distribution, *T. paludosa* was only assessed at two golf courses, both situated in the northwestern corner of western New York state. Monitoring over three consecutive seasons at one site showed that the infestation rate declined every year from 2004 (56%) to 2005 (36%) to 2006 (18%). We monitored another site for two years, and the infestation rate was high in 2005 (97%) and in 2006 (85%). Because of its more widespread geographic distribution, the

incidence of *T. oleracea* was monitored over single seasons. The mean incidence of infestations across those six golf courses was 39% (range 22%-56%).

## Discussion

The scope of invasive crane fly establishment in New York state was addressed at two spatial scales, and this study establishes baseline information that will be useful for monitoring future changes in the status of invasive crane flies in the Great Lakes and Northeast. *Tipula oleracea* is much more widespread geographically than *T. paludosa,* but not more widespread locally. This supports one original prediction, based on differences in the natural history of the two species, that *T. oleracea* would occur over a broader geographic area than *T. paludosa.* It does not support a second prediction, however, that the incidence of *T. oleracea* would be greater around sites of recent establishment. The different outcomes at two spatial scales should be taken into account when making predictions about differences in pest status between the two species.

In western New York, the estimated distribution of *T. oleracea* (8,928 square miles [23,122 square kilometers]) is nearly six times that of *T. paludosa* (1,498 square miles [3,881 square kilometers]). Moreover, because *T. paludosa* was not detected outside the greater Buffalo and Rochester areas (Figure 3), this raises questions as to whether it occurs very broadly at all and whether there might have been two original points of establishment. Beyond western New York, *T. oleracea* was detected on Long Island. The absence of both species from all sites surveyed in the intervening regions between western New York and Long Island matches the idea of a divided range. Although it is impossible to ensure that some populations did not go undetected, the overall concurrence between the position and number of localities is strong support for two separate geographic establishments for *T. oleracea* in New York state.

As constructed, the range maps depict a highly conservative estimate of species distribution through 2006 (Figure 3). Tracking future changes to those boundaries will reveal range expansion. Monitoring priorities should include the eastern Erie Canal and Mohawk River Valley corridor between Syracuse and Albany. Beyond that, the prevalence of invasive crane flies in coastal areas, along waterways and at lower elevations means that other corridors for natural range expansion could include the eastern shore of Lake Ontario northeast toward the St. Lawrence, the eastern and southern shores of Lake Erie toward Pennsylvania, and from Long Island up the Hudson River Valley. Furthermore, Long Island may also be *T. oleracea's* gateway to New England, New Jersey and the coastal areas of the Mid-Atlantic, parallel to its purported spread from British Columbia south to California (10).

Despite behaviors that match a greater dispersive capacity, *T. oleracea* was not more widespread across recently infested turf than *T. paludosa.* Within one or two seasons after first detection on golf courses, *T. paludosa* had already infested 56%-97% of the greens and tees and *T. oleracea* 22%-56%. One implication is that our current ability to detect incipient populations and

### Distribution in New York state

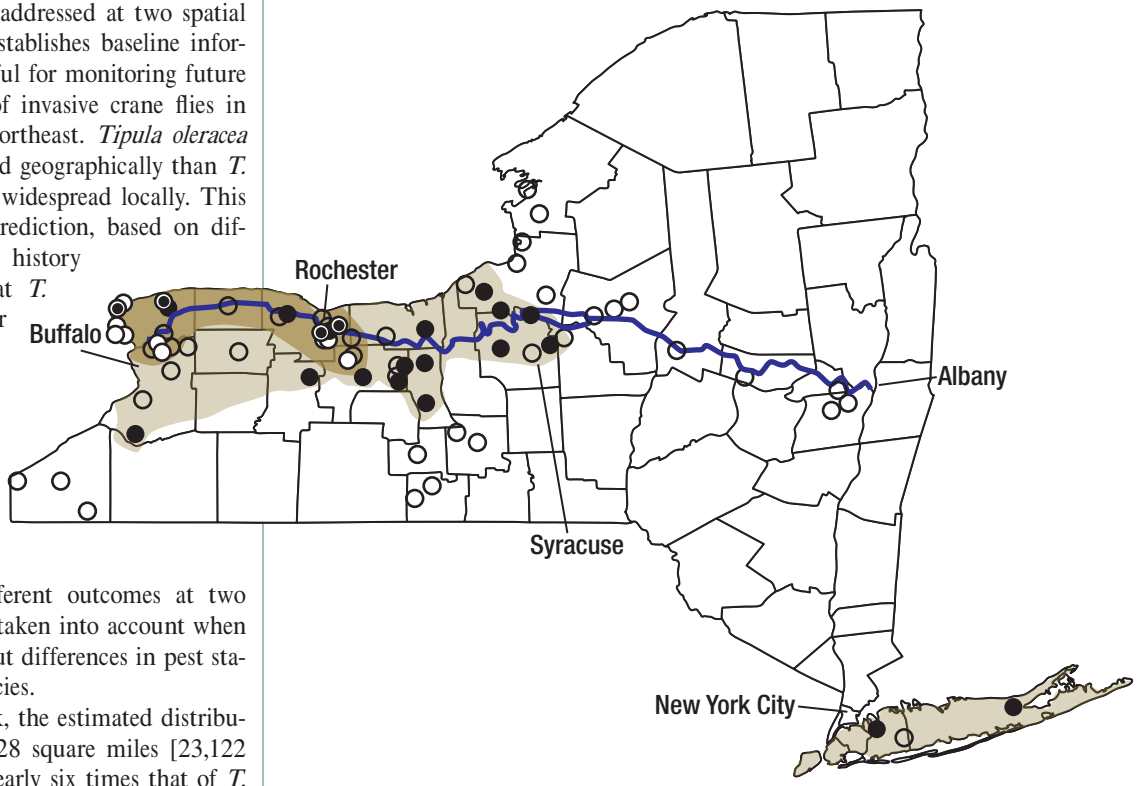


**Figure 3.** Known sites of occurrence and estimated geographic distribution of *Tipula oleracea* (black circles, light tan range) and *T. paludosa* (white circles, dark tan range) in New York, 2006. Circles with bull's-eyes have both species; open circles indicate that both species are absent.

## The research says

- European and common crane flies are invasive pests of turf that have become established in the Pacific Northwest and are becoming established in the northeastern U.S.
- This study established baseline information that will be useful for monitoring future changes in the status of crane fly pests in the Great Lakes and the Northeast.
- In New York state, *Tipula oleracea* is more widespread geographically than *T. paludosa,* but not more widespread locally.
- Both species were absent from all sites surveyed between western New York and Long Island, indicating that there may have been two separate geographic establishments in New York state.
- Our ability to detect infestations early may be poor. Awareness of turf injury and of crane fly life stages may promote early detection of the insect.

new establishments may be poor. Healthy turf is able to support high densities before any injury is expressed. On roughs and fairways, this could greatly delay the detection of a local establishment and allow the population to expand substantially. The same would likely not be true for injury to greens, which would not go undetected for long given the extremely low tolerance thresholds. Scalping caused by larvae to those highly maintained surfaces has emerged as a major class of damage in New York state (D.C. Peck et al., unpublished). Improved monitoring techniques would help turf managers identify infestations earlier and thereby have more success in mitigating the severity of outbreaks. Just as important as injury recognition will be approaches to detect the insect itself, such as pupal cases on short-mown turf as used here, adults during emergence flights or larvae through soil extractions. Therefore, scouting for the insect, rather than its injury, will promote earlier detection because of the relatively high damage thresholds.

The last invasive insect to threaten turfgrass of the Northeast was the European chafer, which arrived in 1940 and first established in western New York. Today it remains one of the most troublesome turf-infesting insects across the state. Based on the pest status of *T. paludosa* and *T. oleracea* in the Pacific Northwest and observations to date in New York state, these species will have serious repercussions for turfgrass management in new areas of establishment. Future studies should refine our understanding of differences between the two species and how those might be relevant for management. Other studies should fill gaps in our understanding of habitat preferences and invasibility so we can better predict which environments are most favorable for crane fly establishment and development.

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