

Spatial Analysis of the Impact of “Do Not Spray” Areas on Mosquito Adulticiding in the Suburbs of Northwest Chicago, Illinois

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Abstract Mosquito adulticides are tools to manage populations and reduce human disease risks. We examined the spatial impact of policies that affect the ability to conduct adult mosquito control. We used the Northwest Mosquito Abatement District (NWMAD) to illustrate how various constraints can impact vector control. Almost 12.7% of the 233 mi² covered by NWMAD is owned by the Forest Preserve District (FPD) or has been designated as a Nature Preserve Area (NPA). Pesticide application is prohibited in both FPDs and NPAs. Additionally, NWMAD allows residents to opt out of having their property parcel sprayed for mosquitoes by being placed on a “do not spray” (DNS) list. As of February 2019, 162 residential and beehive parcels encompassing 1,059.2 acres are listed. As a result of this policy, 2,686 residential and beehive parcels (1.3% of all parcels) received reduced or no mosquito adulticide sprays in 2018. These parcels were distributed unevenly across the district’s eight townships, with approximately 90% of residential DNS acreage in two townships. Nearly 14% of all NWMAD acreage is exempt from treatment, which could affect the ability to respond effectively to disease outbreaks.

Introduction

West Nile virus (WNV) was first discovered in 1937 as a new neuroinvasive virus in a febrile woman in the West Nile region of Uganda (Smithburn et al., 1940). In North America, WNV infections were first detected in 1999, with an outbreak among birds and humans in the Queens section of New York City (Nash et al., 2001). Since then, WNV has spread westward across the U.S. and is now found in every state in the continen-

tal U.S. (Brownstein et al., 2004). According to the Centers for Disease Control and Prevention (CDC, 2021), a total of 52,532 human cases of WNV infection, including 2,456 fatalities, were reported from 1999–2020. These cases represent only a fraction of the total persons exposed, as many cases are asymptomatic (Mostashari et al., 2001). Even apparently mild cases can have long-term deleterious effects on human health (Carson et al., 2006). Thus, the transmis-

sion of WNV is an important public health issue for the U.S.

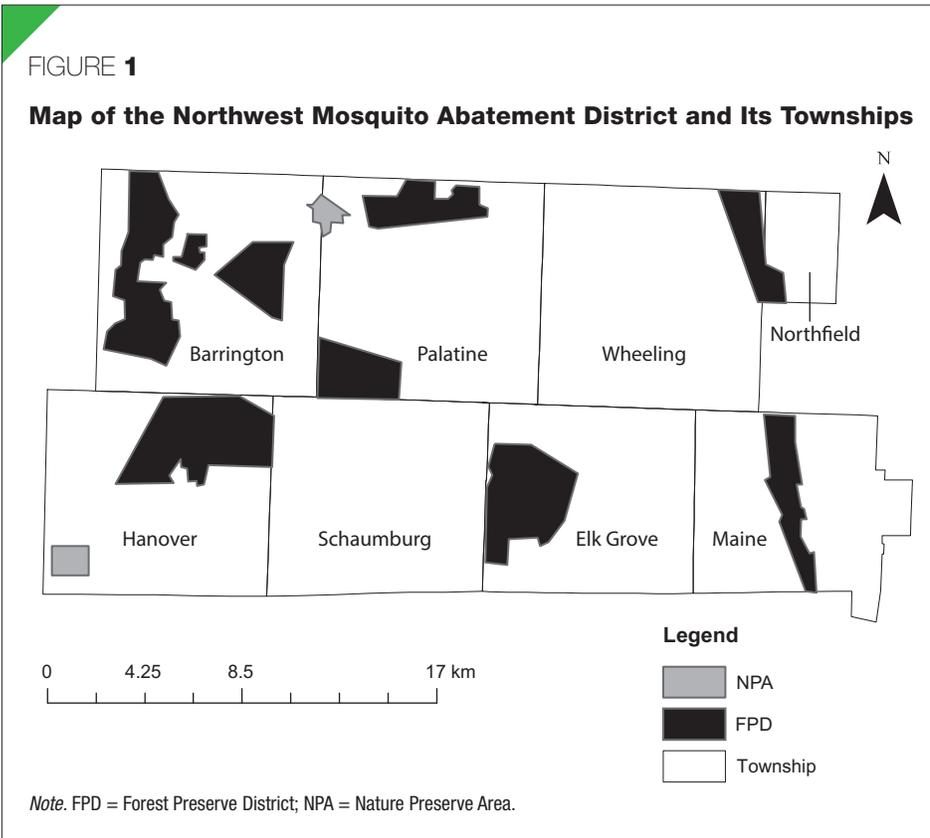
Cook County, Illinois, is considered a hot spot for human WNV infection, having had 1,202 human cases reported during 2002–2020 (Bertolotti et al., 2008; Cook County Department of Public Health, 2021). It is the only county east of the Mississippi River to have an annual human WNV case count of >21 every year from 2012–2018 (CDC, 2022).

Adult mosquito control using ground-based, ultra-low volume (ULV) pesticide application is one tool that mosquito abatement districts and public health agencies use to control WNV-infected mosquitoes (CDC, 2020). Adulticide application is an effective tool to reduce mosquito populations and the spread of WNV, especially when transmission could be at an outbreak level (Bellini et al., 2014; Lothrop et al., 2007; Mutebi et al., 2011).

In Cook County, there are five major mosquito abatement districts (MADs) or programs that cover Chicago and the surrounding suburbs. MADs are tasked with monitoring and abating mosquitoes to control human WNV transmission. All these agencies can conduct adult mosquito control but are committed to using it as a last resort, preferring to focus on larval control, breeding source reduction, and public education. Most of these programs offer the opportunity for residents to opt out of adult mosquito control on or near their property using a “do not spray” (DNS) list. Policies governing inclusion on the DNS list and size of the buffer around properties on a DNS list vary among the five MADs.

FIGURE 1

Map of the Northwest Mosquito Abatement District and Its Townships



An informal survey of other MADs and one national mosquito abatement company with locations in the Midwest and West Coast found that most have some mechanism for residents to opt out of adult mosquito control that would impact their property. Other reasons that allow one to opt out of adult vector control include having a nature preserve that does not allow adult mosquito control and/or having a registered organic farm. The buffer size around these DNS areas vary depending on the type of property and by the organization conducting the mosquito control.

The Northwest Mosquito Abatement District (NWMAD) encompasses 233 mi² (603 km²) in the suburbs northwest of Chicago, Illinois. This MAD serves approximately 759,000 residents and comprises more than 282,000 households (U.S. Census Bureau, 2021). Land use varies across NWMAD, with urban residential and industrial uses dominating the eastern two thirds, whereas residential, forest preserves, and agricultural lands are predominant in the western one third of the district. The current NWMAD DNS policy for residents includes anyone who makes a personal request, regard-

less of the reason. During adult mosquito sprays, NWMAD staff turn off the sprayer 150 ft before a DNS residence and leave it off for 150 ft past the residence. The DNS list is continuously updated with resident requests. A DNS request for a residence is removed when the resident no longer lives at the address.

For comparison, two other Chicago-area MADs, the North Shore Mosquito Abatement District (NSMAD) and Desplaines Valley Mosquito Abatement District (DVMAD), require a letter of exemption from a medical professional prior to placing a property on the DNS list. The letter must state that a resident has a medical condition that could be exacerbated by adulticiding activities; the medical condition does not need to be revealed (M. Tomek, personal communication, March 1, 2018; D. Zazra, personal communication, March 1, 2018). NSMAD turns off sprayers at the DNS property boundary, while DVMAD turns off sprayers for an approximately one-half block radius around the DNS property. The South Cook County Mosquito Abatement District has DNS policies similar to NWMAD, includ-

ing anyone who makes a personal request, regardless of reason (M. Slamecka, personal communication, March 5, 2018; J. Thenisch, personal communication, March 5, 2018). The program for the city of Chicago contracts a private company to do adulticide spraying and does not have a DNS list (C. Blanco, personal communication, March 14, 2018).

A concern with DNS policies is that these areas, coupled with other nonspray areas, could result in a significant reduction of the total area covered by adulticide. Ultimately, if the nonspray area is large enough, it could reduce the capacity of an agency to manage local mosquito populations and therefore disease transmission. The objective of our study was to use NWMAD data to quantify how much operational area was excluded by DNS sites, with the hope it would inform other agencies tasked with mosquito control of this issue. DNS sites include natural areas, residential properties, and beehive locations. The spatial analyses described here give perspective to the impact of DNS sites within the approximately 150,000 acres of NWMAD (Tables 1–4).

Methods

NWMAD uses GIS to maintain spatial integrity of mapping processes and to monitor mosquito control operations. The data used for GIS are gathered from county-level data, digitized from aerial imagery, or captured on field computers by district employees. For this study, GIS was used to accurately map and perform spatial analyses on parcels, DNS parcels, roadways, Forest Preserve Districts (FPDs), Nature Preserve Areas (NPAs), and district-defined sections based on the Public Land Survey System.

The nonresidential DNS areas within the district were mapped first using the two feature classes: FPDs and NPAs (Figure 1). These areas are not sprayed by the request of the managing agencies. The primary data source for FPDs was shapefiles (an Esri vector data storage format for storing the location, shape, and attributes of geographic features) from Cook Central, the online geospatial data hub for Cook County (Cook County Government, 2021). Additional areas managed by the Cook County FPD, but not included in the shapefile, were added by digitizing 2016 aerial imagery obtained from the

Cook County GIS Department (Cook County Government, n.d.). NPAs were mapped based on the parcel(s) they covered and the same aerial imagery.

We evaluated residential DNS areas using a multilevel approach based on acreage and parcels. First, we calculated the impact of residential DNS requests on the district acreage to be sprayed based strictly on the parcel(s) owned by the resident. We then calculated the impact of the 150-ft (45.72 m) buffer around those parcels (Figure 2). This buffer size was based upon the standard truck-mounted ULV sprayer swath (Armed Forces Pest Management Board, 2019) and extends 150 ft from the edge of the parcel extent. Second, we assessed the impact of the buffer around the residential DNS area on a) parcels completely within the buffer distance and b) parcels partially affected by the buffer distance. We assessed the effect of residential DNS areas at the township level in three ways: 1) the percentage of residential DNS parcels in the township, 2) the percentage of residential DNS acreage in the township, and 3) the percentage of each township occupied by DNS parcels.

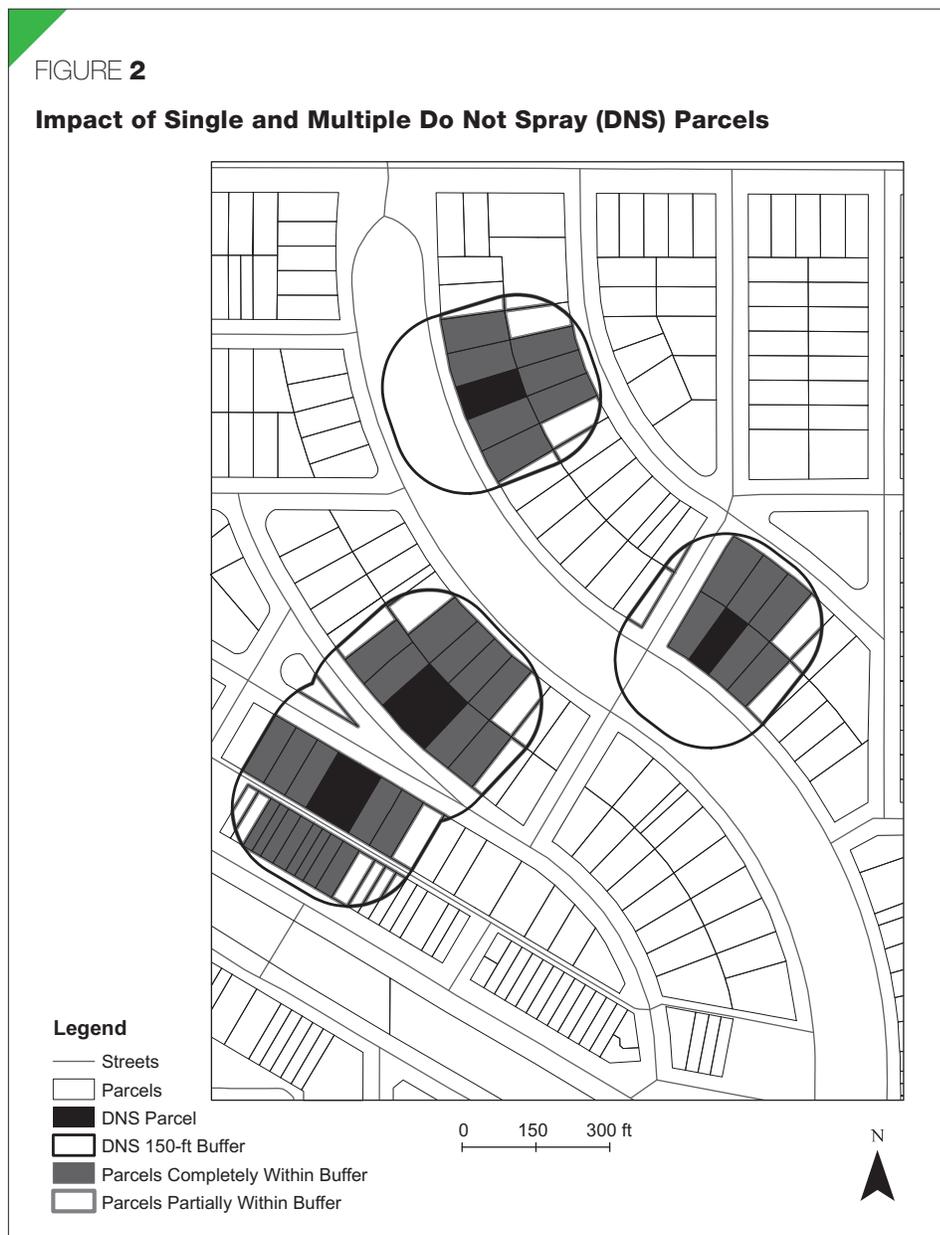
Results

We identified over 20,500 acres of FPDs and almost 140 acres of NPAs within NWMAD (Table 1). The total loss of acreage due to FPDs and NPAs is almost 18,950 acres. The total loss is less than the raw acreage of FPDs and NPAs due to treatment of these areas from nearby roadways.

At the time of this study (February 2019), NWMAD had 137 residential DNS parcels. The initial approach (based solely on the DNS parcel extent) determined that approximately 1,035 acres (0.7% of the potentially treatable area of the district) were eliminated from treatment, which is the minimum impact of the DNS policy. When the buffer is applied to each DNS parcel, however, the area affected increased by 580 acres, totaling approximately 1,600 acres (1% of the potentially treatable area of the district; Table 2). Within the 580 acres of the DNS buffer, 656 parcels were completely within the buffer and excluded from treatment. This finding brings the total to 793 parcels receiving no adulticide treatment. The buffer extends to include 1,491 parcels that receive partial treatment, which brings the total to 2,284 parcels receiving reduced or no adulticide treatment (Table 2).

FIGURE 2

Impact of Single and Multiple Do Not Spray (DNS) Parcels



In addition to the 137 residential DNS parcels, an additional 25 parcels were included in the DNS area because the residents housed beehives on the property (Table 3). The buffer around these areas included 83 parcels completely within the buffer and 294 parcels partially within the buffer, which totals 402 parcels receiving reduced or no adulticide treatment.

The total loss of acreage due to the DNS policy is 20,773 acres, almost 14% of the total area within NWMAD (Table 4). Most of the treatment area lost is due to FPDs and NPAs, but residential and beehive parcel loss is considerable.

NWMAD encompasses, either fully or partially, eight separate townships: Barrington, Elk Grove, Hanover, Maine, Northfield, Palatine, Schaumburg, and Wheeling (Figure 1). We used these data to determine where DNS parcels have a larger impact in more localized areas. We found 90% of the residential DNS acreage in two townships: Barrington and Hanover (Table 5).

Discussion

There is no statutory requirement for DNS lists (Mosquito Abatement District Act, 1925). Listing is offered to residents with health issues that could be exacerbated by

TABLE 1

Forest Preserve Districts (FPDs) and Nature Preserve Areas (NPAs) in the Northwest Mosquito Abatement District (NWMAD)

Area	Acreage (Hectare)	% of NWMAD Acreage
NWMAD (total)	149,632.88 (60,554.28)	100
FPDs	20,552.04 (8,317.12)	13.73
NPAs	139.15 (56.31)	0.01
FPDs and NPAs (total)	20,691.19 (8,373.43)	13.83
FPDs and NPAs that received adulticide from roadway	1,749.67 (708.07)	1.17
Total loss from FPDs and NPAs	18,941.52 (7,665.36)	12.66

TABLE 2

Residential Do Not Spray (DNS) Areas Within the Northwest Mosquito Abatement District (NWMAD)

Area	Acreage (Hectare)	% of NWMAD Acreage	Total # of Parcels	% of Parcels in NWMAD
NWMAD (total)	149,632.88 (60,554.28)	100	213,796	100
Residential DNS parcels	1,035.66 (418.85)	0.69	137	0.06
Non-DNS parcels completely within DNS buffer	140.68 (56.93)	0.09	656	0.31
Non-DNS parcels partially within DNS buffer	329.78 (133.78)	0.22	1,491	0.70
Total loss from residential DNS parcels	1,621.25 (656.09)	1.08	2,284	1.07

exposure to pesticide applications. There has been an increase in the public's concern over the past few decades regarding the use of pesticides in the environment (Kabat, 2017; Metcalf, 1993; Peterson, & Higley, 1993; Slovic, 1987). This concern extends to the use of adulticides to protect public health, including ground or aerial applications to prevent arboviral disease transmission (Cohen, 2003; Ziem, 2005). Even in the face of epidemic transmission of WNV in an area, some residents oppose spraying for adult mosquitoes (Haley, 2013).

The primary focus of NWMAD is the reduction of the two WNV vector mosquitoes, *Culex pipiens* (Linnaeus) and *Cx. restuans* (Theobald) (Hamer et al., 2008; Hayes et al., 2005). Both species are peridomestic in nature and thus are more likely to be found in urban settings (Spielman, 2001; Vinogradova, 2000). Most of the mosquito disease vectors in the world, including in the U.S., are peridomestic and live near dwellings (Weaver, 2013). Data from historical NWMAD mosquito trapping show that *Cx. pipiens* and *Cx. restuans* are more likely to be

found in urban and residential areas than in rural or FPD locations. The FPD locations, however, still produce WNV vector mosquitoes. Analysis of a 6-year data set of gravid trap collections on FPD land revealed capture of an average of approximately 17 *Cx. pipiens* and *Cx. restuans* per trap night, compared with 21.6 for all district gravid traps (unpublished data, 2018).

We also evaluated WNV infection rates in these mosquitoes by examining a 6-year average of the percentage of WNV positive samples (*Culex* mosquitoes that are pooled from gravid traps) and found that FPD traps are positive 10% of the time over the season compared with the district average of 14%. The FPD land in Cook County is heavily used by residents who might be exposed to infected mosquitoes during their visits. In 2011, it was estimated that the 68,000 acres of FPD land has approximately 40 million visits (University of Illinois Chicago Library, 2021). Not spraying FPD lands could put visitors at risk, as infected mosquitoes are prevalent in these areas.

Beginning in 2015, NWMAD made it a priority to work with beehive owners located within the district. As of October 2018, there were 71 hive locations. After contacting the hive owners and explaining the district's mosquito adulticide program and the potential risk it posed to their bees, an additional 25 properties were added to the DNS list (Pokhrel et al., 2018; Rinkevich et al., 2015; Table 3). In some cases, due to hive location, it was recommended by district personnel that the property not be sprayed. Not all beehive locations, though, were added to the DNS list; this example highlights the importance of mosquito control districts conducting outreach and education to residents.

It is possible that the district would have more flexibility to treat all areas within its boundaries if a public health emergency for WNV or other vectorborne disease occurred. Since the introduction of WNV into Cook County and Illinois, however, there has never been a public emergency declared. Even in the WNV outbreak years of 2002, 2005, and 2012—when Cook County had 302, 135, and 174 reported human cases, respectively—a public health emergency was not declared (K. Beamis, personal communication, April 17, 2018)

The impact of residential DNS parcels extends far beyond each household; the DNS decision of 137 residents negatively affects 2,147 other residential homes that thereby receive reduced or no adulticide treatment. The number of parcels affected by the buffer is highly dependent on the size of the parcel. While some townships have a larger number of residential DNS parcels, most of the residential DNS acreage falls within the Barrington and Hanover townships. These townships have larger residential parcel size and more agricultural land, which increases the untreated area. Only 15% of the NWMAD total population live in these two townships. The number of individuals affected by DNS parcels increases proportionally with the number of individuals residing within each home.

NWMAD is observing an increasing trend in the number of people requesting to be placed on the DNS list. Between 2015 and 2018, 65 people requested to be added to the NWMAD DNS list, which represents a 42% increase since 2014. Discussions with other MADs suggest this trend might be due to the proliferation of social media neighborhood apps. Residents who live within a defined neighborhood can interact with their neighbors through online message boards and in this manner might be spreading information about the DNS list. Additionally, some social media sites have become the platform for the sharing of pseudoscience, which could contribute to misunderstandings of science, and by extension, mosquito control operations (Del Vicario et al., 2016). Without surveying these residents, we can only assume these are some of the reasons for the requests to be put on the DNS list. These assumptions might be inaccurate, however, or not representative of all MADs with DNS lists. If the frequency of residents requesting to be placed on the DNS list continues to increase, it could adversely affect the district's ability to manage the mosquito population and prevent human WNV transmission.

One way to address the growing trend of DNS requests is to conduct direct outreach to the residents currently on the DNS list. Educational outreach by NWMAD could alleviate fears based on inaccurate information about adult mosquito control. By having a discussion about our adult mosquito control operations and listening to resident concerns, we might be able to remove some residents from the DNS list. Further, a routine contact survey of these

TABLE 3

Beehive Do Not Spray (DNS) Areas Within the Northwest Mosquito Abatement District (NWMAD)

Area	Acreage (Hectare)	% of NWMAD Acreage	Total # of Parcels	% of Parcels in NWMAD
NWMAD (total)	149,632.88 (60,554.28)	100	213,796	100
Beehive DNS parcels	58.22 (23.56)	0.04	25	0.01
Non-DNS parcels completely within DNS buffer	20.04 (8.11)	0.01	83	0.04
Non-DNS parcels partially within DNS buffer	102.63 (41.21)	0.07	294	0.14
Total loss from beehive DNS parcels	211.09 (85.43)	0.14	402	0.19

TABLE 4

Total Impact of Do Not Spray (DNS) Areas Within the Northwest Mosquito Abatement District (NWMAD)

Area	Acreage (Hectare)	% of NWMAD Acreage	Total # of Parcels	% of Parcels in NWMAD
NWMAD (total)	149,632.88 (60,554.28)	100	213,796	100
Total loss from FPDs and NPAs	18,941.52 (7,665.36)	12.66	–	–
Total loss from residential DNS areas	1,621.25 (656.09)	1.08	2,284	1.07
Total loss from beehive DNS areas	211.09 (85.43)	0.14	402	0.19
Total loss from DNS areas in NWMAD	20,773.86 (8,406.88)	13.88	2,686	1.26

Note. FPDs = Forest Preserve Districts; NPAs = Nature Preserve Areas.

residents will be essential to ensure that any new residents at these addresses are not placed on the DNS list due to the request of the previous owner. Enacting a medical professional exemption requirement as other MADs do would further contribute to DNS list removal—but could damage relationships with residents if educational programs are not proactive.

Conclusion

The amount of area that might be excluded from adult vector control due to opt-out poli-

cies, natural areas, organic farming, and beehives can be significant and negatively affect the ability to control mosquito-borne diseases. Currently, NWMAD has almost 2,300 residential parcels receiving no or reduced adult mosquito control due to DNS requests. Factoring in FPD and NPA areas, approximately 14% of our district get reduced or no adult mosquito control. Through educational outreach programs and surveys addressing concerns and reasons for DNS list requests, plus resident verification, future studies can

TABLE 5

Do Not Spray (DNS) Areas by Townships Located Within the Northwest Mosquito Abatement District (NWMAD)

Township	Township Acreage (Hectare)	# of DNS Parcels	% of DNS Parcels	DNS Parcel Acreage (Hectare)	% of DNS Acreage	% of Township Acreage
Barrington	23,118.10 (9,355.56)	13	8.02	642.13 (259.86)	60.62	2.78
Elk Grove	18,367.35 (7,433.00)	33	20.37	8.79 (3.56)	0.83	0.05
Hanover	21,469.29 (8,688.31)	7	4.32	315.96 (127.86)	29.83	1.47
Maine	16,858.08 (6,822.22)	16	9.88	8.02 (3.25)	0.76	0.05
Northfield	3,839.72 (1,553.88)	9	5.56	4.16 (1.68)	0.39	0.11
Palatine	23,102.56 (9,349.27)	21	12.96	33.48 (13.55)	3.16	0.14
Schaumburg	19,775.31 (8,002.78)	9	5.88	6.44 (2.61)	0.61	0.03
Wheeling	23,102.46 (9,349.23)	54	33.33	40.25 (16.29)	3.80	0.17
NWMAD (total)	149,632.88 (60,554.28)	162	100	1,093.88 (442.41)	100	–

analyze the origin of DNS list requests and compare the impact of those programs on DNS list removals and new requests to show the benefit of adulticiding operations. 🐞

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