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Karmen M. Hollis

University of Illinois

Christopher L. Anchor

Forest Preserve District of Cook County, IL

James E. Chelsvig

Forest Preserve District of Cook County, IL

Dwayne R. Etter

University of Illinois

J. P. Dubey

USDA, ARS, Parasite Biology and Epidemiology Laboratory, Beltsville, MD

See next page for additional authors

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Authors

Karmen M. Hollis, Christopher L. Anchor, James E. Chelsvig, Dwayne R. Etter, J. P. Dubey, Richard E. Warner, and Laura L. Hungerford

Radio-telemetry and geographical information systems to assess urban deer zoonoses

Karmen M. Hollis, University of Illinois, Department of Natural Resources and Environmental Sciences, 276 NSRC MC-637, 1102 West Peabody Drive, Urbana, IL 61801, USA

Christopher L. Anchor, Forest Preserve District of Cook County, 28W040 State Route 58, Elgin, IL 60120, USA

James E. Chelsvig, Forest Preserve District of Cook County, 28W040 State Route 58, Elgin, IL 60120, USA

Dwayne R. Etter, University of Illinois, Department of Natural Resources and Environmental Sciences, 607 East Peabody Drive, Champaign, IL 61820, USA

J. P. Dubey, United States Department of Agriculture, Agriculture Research Service, Parasite Biology and Epidemiology Laboratory, Beltsville, MD 20705, USA

Richard E. Warner, University of Illinois, Department of Natural Resources and Environmental Sciences, 1102 West Peabody Drive, Urbana, IL 61801, USA

Laura L. Hungerford, University of Nebraska, Great Plains Veterinary Educational Center, Clay Center, NE, 68933, USA

Abstract: Urban white-tailed deer (*Odocoileus virginianus*) populations can influence the epidemiology of many zoonotic diseases because they affect the distribution and abundance of pathogens and vectors. The risk of emerging zoonotic pathogens increases with human populations, as people have closer contact with wildlife in urban environments. We used radio-telemetry to study deer behavior and population dynamics in Chicago, IL. We monitored home-range use and habitat patterns for 43 radio-collared deer from 2 study sites, 1995-1999. Deer serology was conducted to test for various zoonotic diseases, such as babesiosis, encephalitis, and toxoplasmosis for 12 study locations. To analyze potential disease exposures for deer, we used Geographical Information Systems (GIS) to compare land cover characteristics for home-ranges and point location patterns for seropositive and seronegative deer. From our preliminary analysis of toxoplasmosis, we conclude that the combined use of epidemiology, radio-telemetry, and GIS tools appears promising for understanding zoonotic patterns and ultimately for predicting and minimizing disease to humans.

Key words: Chicago, deer, disease, Geographical Information System, home-range, Illinois, *Odocoileus virginianus*, radio-telemetry, urban, zoonosis.

Wildlife managers have underestimated the impact of disease on populations (Leopold 1933). The influence of wildlife diseases and parasites has

potential to affect the health status of wildlife, domestic livestock and pets, and human populations. Disease patterns and changes in incidence reflect changes in host-organism interactions, typically driven by environmental factors (Daszak 2000). For example, human and wildlife interactions increase as urban development encroaches on remaining wildlife habitat and influences the risk for disease transmission and outbreaks at various spatial and temporal scales.

Deer presence and density influence the risk of new and emerging tick-borne zoonoses (diseases transmitted to humans), because they affect the distribution and abundance of the pathogen's vector (Schultze et al. 1984, Wilson et al. 1990, Amerasinghe et al. 1992). The spectrum of infectious diseases is changing rapidly in conjunction with important social and environmental alterations. Factors present in northeast Illinois affecting deer densities include habitat alteration, artificial feeding, reduced mortality, reduction or elimination of predators, confinement of populations, and restricted animal movements (Etter et al. in press, Etter, unpublished data). Corridors within fragmented habitats increase the exposure of wildlife to humans and domestic pets, which can in turn facilitate disease contact (Simberloff and Cox 1987).

We used urban white-tailed deer (*Odocoileus virginianus*) from Chicago, Illinois as a sentinel for zoonoses during an extensive surveillance program. Radio-telemetry is commonly used to determine habitat patterns and delineate home-ranges of free-ranging animals (Cochran 1980, White and Garrott 1990). Geographic Information Systems (GIS) are computer-

based for automating, manipulating, analyzing, and displaying mapped information (Kitron et al. 1994). By combining these techniques with serology data, we provide a new approach for epidemiology research to understand disease patterns and zoonoses.

Methods

The study was conducted on >26,000-ha of public land in the Forest Preserve District of Cook County (FPDCC), 1995-99. We collected data from 12 preserves throughout the county. We obtained blood samples from deer culled during the annual FPDCC deer removal program. We collected age, sex, location, body and reproductive condition, and tooth cementum aging data (Gilbert 1966, Ransom 1966, Kistner et al. 1980). We captured 85 deer from 2 study sites (Des Plaines and Palos) using drop-nets (Ramsey 1968) or remote-dart guns (Kilpatrick et al. 1997) from December through April, 1995-98. For captured deer, we aged by tooth wear and replacement, sexed, and collected body length, hind foot, and chest girth measurements (Severinghaus 1949). We collected blood via the jugular vein, separated sera, and froze at -20 C. We marked deer with 2 numbered plastic ear tags, 2 metal ear tags with agency information, and fitted random females ($n = 60$) with radio-collars equipped with a motion sensitive mortality signal (Advanced Telemetry Systems, Inc., Isanti, MN). The United States Department of Agriculture (USDA) Research Center in Beltsville, MD tested sera samples for toxoplasmosis using serum agglutination (Dubey and Desmonts 1987). Agglutination (Dubey and Desmonts 1987) and sera dilutions included $\leq 1:25$,

1:50, 1:500, and ≥ 500 . Less than or equal to 1:25 was considered negative. All others were classified as positive. The University of Illinois' Laboratory Animal Care Advisory Committee (LACAC) reviewed and approved all methods (Protocol #V5R246).

We used prevalence ratios to analyze levels between age, sex, and site (Rothman 1986) in EpiInfo (USD, Inc., Stone Mountain, GA). We used Cochran-Mantel-Haenszel (CMH) adjusted prevalence ratios and chi-square statistics to examine relationships between areas (Fleiss 1981). Statistical significance determined at $P < 0.05$. We collected telemetry locations at least 1 day/week. We mapped removal locations in the field and transferred points into ARCVIEW (Environmental Systems Research Institute, Inc., Redlands, CA). We obtained GIS land stat images (28.5 x 28.5-m resolution) from the Illinois Natural History Survey. We constructed 95% minimum convex polygon (MCP) home-ranges using computer software CALHOME (United States Forest Service, Fresno, CA). We created polygons in ARCINFO (Environmental Systems Research Institute, Inc., Redlands, CA) and overlaid on GIS

land cover maps using ARCVIEW to analyze habitat characteristics.

Results and discussion

Prevalence of toxoplasmosis for all deer was 48.8% ($n = 966$), relatively high compared to rural deer studies. Herbivores sampled in Missouri and Kansas found seroprevalence levels of 11% (Smith and Frenkel 1995). The role of wildlife in the transmission of *Toxoplasma gondii* to humans is not well known, but believed to be due to contaminated water resources, raw or rare meat, or through direct fecal contact. An outbreak, 1995, in British Columbia, Canada was due to contaminated water distribution systems (Eng et al. 1999). There was a significant difference in prevalence for toxoplasmosis between the 2 live deer study sites ($n = 480$, Des Plaines Prev = 67%, Palos Prev = 38%, $p < 0.001$, Figure 1).

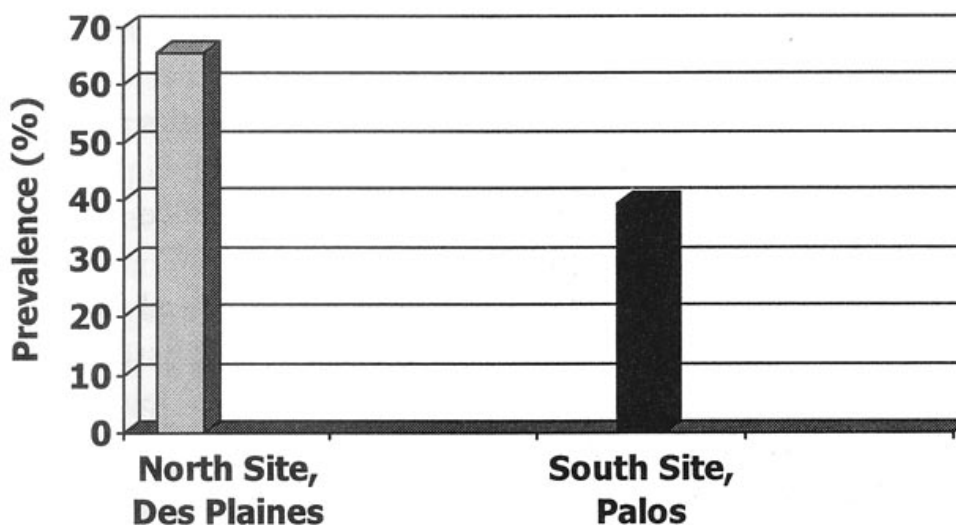


Figure 1. Prevalence of Toxoplasmosis in urban deer from Des Plaines and Palos study sites, Chicago, IL.

Removal point locations were spatially clustered on habitat maps because deer were harvested over baited sites (Figure 2). Removal point locations for Des Plaines were coded positive and negative for toxoplasmosis and home-ranges for live deer were overlain on land cover maps to examine relationship differences in prevalence (Figure 3). Our examination of potential disease distributions indicate deer in the narrow and fragmented Des Plaines site have home-ranges that overlap with urban residential developments (Piccolo et al. in press). This was not the case in Palos where forest preserves were larger and bordered by low density human developments (Figure 4).

Deer may have increased exposure to contaminated cat feces in Des Plaines due to browsing in backyards. We continue to investigate factors related to differences in disease prevalence among study locations. Other possible influences might include soil type, cat numbers, deer behavior and densities, human demographics, habitat type,

and weather. GIS analyses will assist with data questions associated with overabundant deer ecology and epidemiology. For example, GIS has been used to extract environmental variables associated with deer and tick abundance (Glass et al. 1994). The risk of emerging zoonotic pathogens is increasing with human populations, as people are in closer contact with wildlife in urban settings. Monitoring and recognizing disease manifestations are critical for controlling potential outbreaks.

Management implications

Infectious diseases increasingly threaten public health and contribute to the escalating costs of health care (Centers for Disease Control 1994). GIS and wildlife technology applied to wildlife management and epidemiology can enhance our understanding of habitat, animal behavior, and monitoring for species and zoonoses. GIS images provide powerful tools to examine environmental factors in surveillance programs at the landscape level.

When we understand the ecology of a disease we can identify vulnerable links between affected species, the disease agent, environmental risks, and human transmission (National Wildlife Health Center 1998). Knowledge about wildlife diseases are vital for conserving our natural resources and human health (Hess 1996, Nettles 1996).

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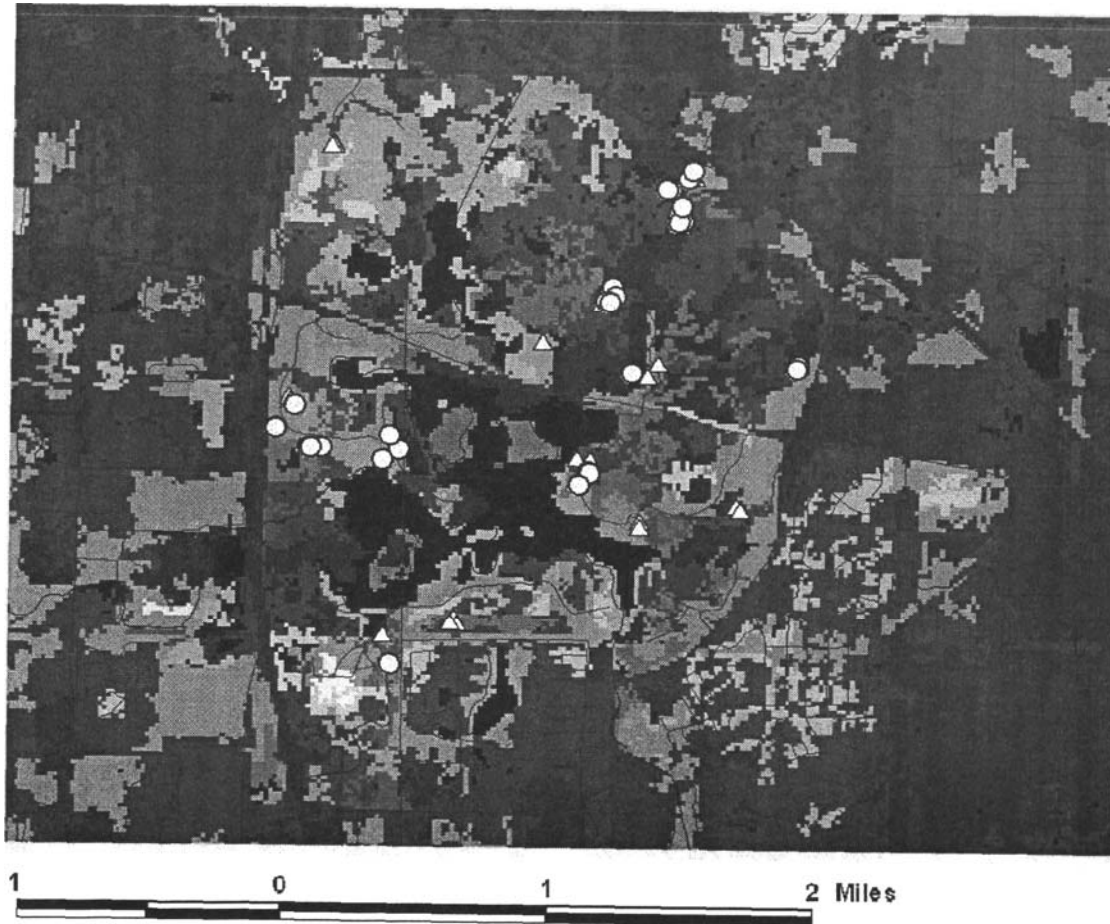


Figure 2. Point locations for deer harvested from Busse Forest Preserve overlaid on land cover maps.

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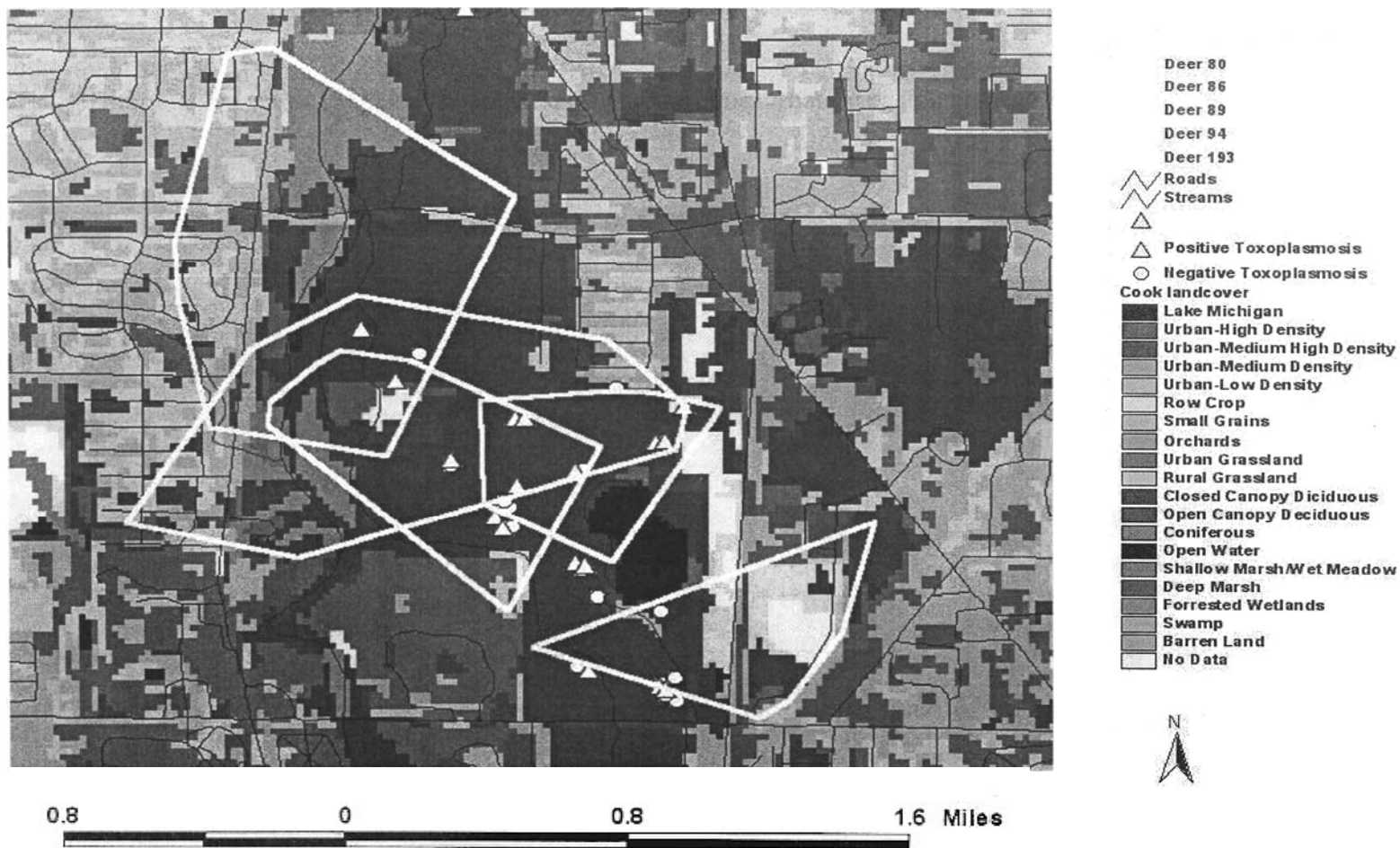


Figure 3. Toxoplasmosis seroprevalence (positive and negative) and urban deer homeranges overlain on land cover maps for Des Plaines forest preserve, Chicago, IL.

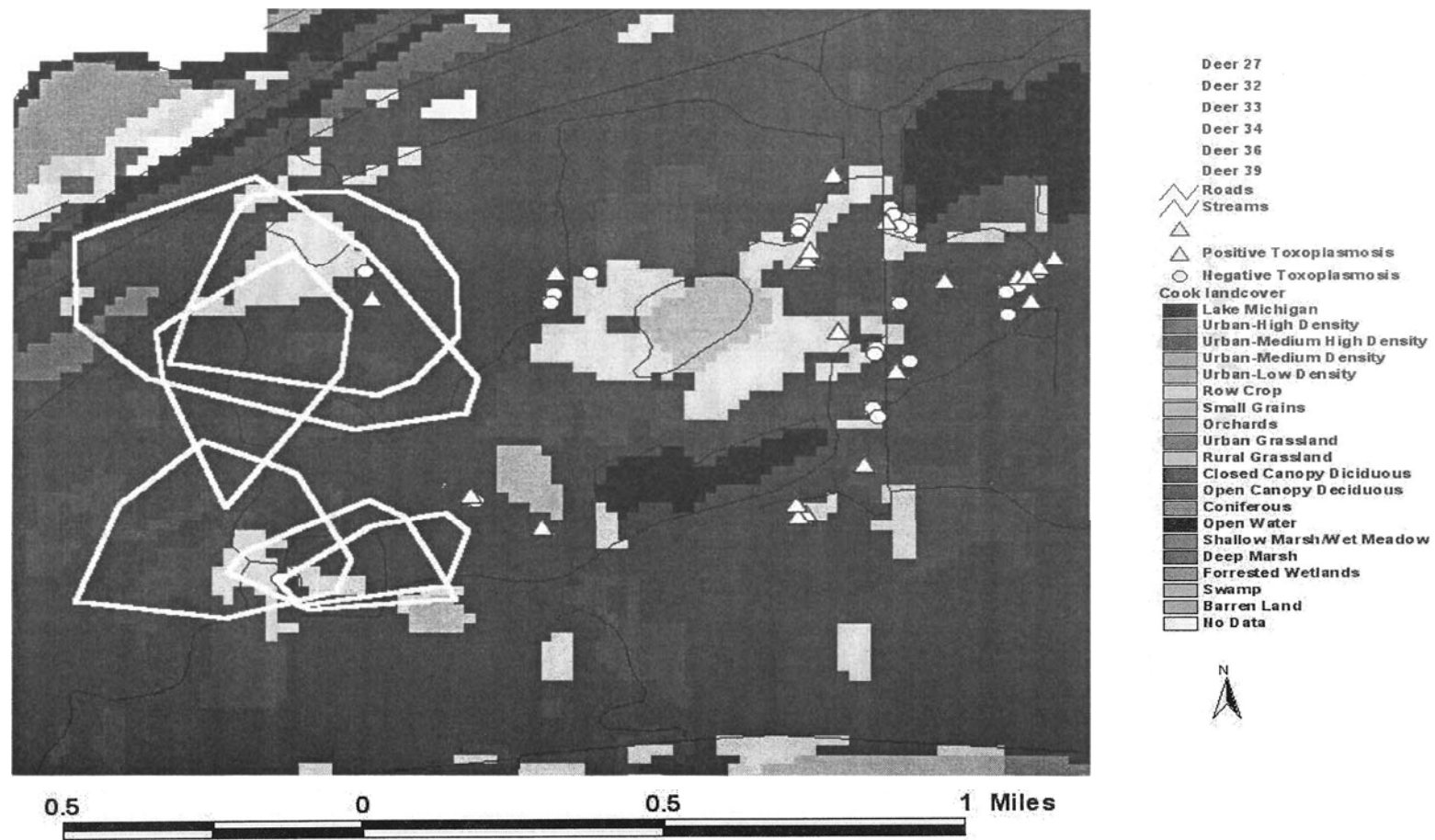


Figure 4. Toxoplasmosis seroprevalence (positive and negative) and urban deer homeranges overlain on land cover maps for Palos forest preserve, Chicago, IL.

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