APPENDIX H

Mosquitoes and Other Perceived Pests

Jamie Vaudrey, Ph.D.
Department of Marine Sciences
University of Connecticut

Benefits & Public Health – Mosquitoes and Other Potential Pests

Two of the main concerns surrounding marshes in urban areas are the presence of mosquitoes and the attraction of "nuisance animals" to the area (Elmqvist, et al., 2015; von Döhren, Haase, 2015). While the presence of animals provides recreational opportunities such as fishing, bird watching, and nature watching of mammals, attraction of certain animals to marshes may be perceived as negative for humans in an urban setting (Bolund, Hunhammar, 1999; von Döhren, Haase, 2015). The study of environmental disservices, or "*functions of ecosystems that are perceived as negative for human well-being*," classifies the costs associated with these disservices into three general categories: financial (land, labor, capital), social nuisances, and environmental (Escobedo, et al., 2011; von Döhren, Haase, 2015). The presence of animals falls primarily into the social nuisance category, with concerns including refugia for vector-spread disease (Lyme disease, West Nile encephalitis, rabies), animal damage to structures and ornamental plants, wild animal attacks on pets and wild animal bites, disgust at presence of droppings, annoyance to humans, and generalized fear associated with encountering wild life (Douglas, 2012; Escobedo, et al., 2011). While such concerns are valid and must be addressed to the satisfaction of the local population, overwhelming evidence suggests that in cities in developed countries, ecosystem services provided by urban green and blue spaces far outweigh the disservices (Elmqvist, et al., 2015; Escobedo, et al., 2011; Lyytimäki, Sipilä, 2009; Lyytimäki, et al., 2008; Tzoulas, et al., 2007).

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Bird Watching, by Aniket Suryavanshi, https://www.flickr.com /photos/aniketsuryavanshi/16682781395, (CC BY 2.0).

The first step in addressing concerns regarding interactions with animals associated with a living shoreline is to identify the animals that might inhabit the area. Potential nuisance visitors to the marsh include mammals such as raccoons, opossums, and rats. Mice are often residents of marshes, but tend to be less visible. Other visitors may include deer, fox, and coyote, attracted by the abundant productivity of marsh settings. However, an urban surrounding is likely to keep these larger animals to a minimum unless they already have an established presence in the area. Species already adapted to urban settings, such as raccoons, will utilize the marsh. The presence of developed land and human activity around the marsh will discourage the presence of more sensitive species, such as the New England cottontail rabbit, which requires larger areas of habitat undisturbed by humans. Table 1 provides a range of

Raccoon at Stanley Park by Márcio Cabral de Moura, https://www.flickr.com /photos/ mcdemoura/15315572792, (CC BY-NC-ND 2.0)

habitat area required by mammals, reptiles, and amphibians found in New England saltmarshes. Comparing this list to the species known to inhabit the urban setting and factoring in the area of the marsh associated with the living shoreline, a list of likely inhabitants can be generated for a proposed living shoreline project. When evaluating the potential for nuisance animals, an important consideration is the preexisting presence of certain nuisance animals like raccoons, rats, and opossum within an area - does the marsh increase the potential nuisance by introducing a new species or increasing a population, or does the nuisance already exist? Once the potential for nuisance animals has been identified, development of a management plan prepares for a particular species becoming a nuisance in actuality.

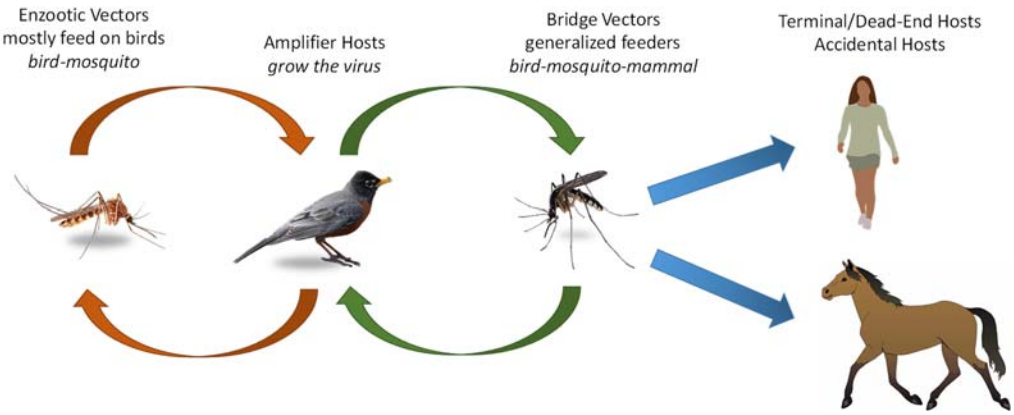
Table 1: Mammals, Reptiles, and Amphibians of New England Salt Marshes
The range of habitat area and diet of each species is listed, where the information were available. Data were obtained from a review of 35 sources specific to New England salt marshes (U.S. EPA, 2006). Mammals are sorted from smallest range to largest range.

common name	*scientific name*	range	primary diet (secondary diet)
MAMMALS			
Meadow vole	*Microtus pennsylvanicus*	0.01 – 0.4 ha	Grasses (forbs)
Meadow jumping mouse	*Zapus hudsonius*	0.1 – 0.4 ha	Forbs (insects)
Eastern cottontail	*Sylvilagus florianus*	0.9 – 2.8 ha	Forbs (grasses)
Woodland vole	*Microtus pinetorum*	1.1 ha	Grasses (forbs)
Virginia opossum	*Didelphis virginiana*	4.65 – 23.5 ha	Insects (carrion)
Norway rat	*Rattus norvegicus*	7.8 ha	Forbs (small mammals)
Long-tailed weasel	*Mustela frenata*	16 – 160 ha	Small mammals (birds)
Black-tailed jackrabbit	*Lepus californicus*	20 – 140 ha	Forbs, succulents
Raccoon	*Procyon lotor*	49 ha	Invertebrates
Muskrat	*Ondatra zibethicus*	50 – 200 ha	Aquatic plants (fish)
New England cottontail	*Sylvilagus transitionalis*	50 – 200 ha	Grasses (forbs)
White-tailed deer	*Odocoileus virginianus*	59 – 520 ha	Grasses (forbs)
Least shrew	*Cryptotis parva*	170 – 280 ha	Insects (crustaceans)
Striped skunk	*Mephitis mephitis*	200 ha	Insects (small mammals)
Mink	*Mustela vison*	600 – 5600 ha	Fish (small mammals)
Fisher	*Martes pennanti*	900 – 1300 ha	Small mammals (birds)
Coyote	*Canis latrans*	1000 – 4900 ha	Small mammals (crustaceans)
Red fox	*Vulpes vulpes*	1450 – 2000 ha	Birds (fish)
Masked shrew	*Sorex cinereus*	--	Insects
River otter	*Lontra canadensis*	--	Fish (crustaceans)
REPTILES & AMPHIBIANS			
Common snapping turtle	*Chelydra s. serpentine*	--	Insects (crustaceans)
Diamondback terrapin	*Malaclemys t. terrapin*	--	Crustaceans (insects)
Green frog	*Rana clamitans melanota*	0.01 ha	Insects (crustaceans)
Northern water snake	*Nerodra s. sipedon*	--	Amphibians (fish)
Painted turtle	*Chrysemys picta*	--	Insects (crustaceans)
Spotted turtle	*Clemmys guttata*	--	Gastropods (insects)

Mosquitoes have always presented a nuisance by biting, but since 1999, concern over the spread of the virus causing West Nile encephalitis into Connecticut has made the potential consequence of mosquito bites more serious (Kilpatrick, et al., 2006). West Nile virus is transmitted between animals and humans (a zoonotic pathogen), with the mosquito as the vector. Birds are “amplifier” hosts, meaning they can grow the virus rapidly and transmit it to mosquitoes; humans and other mammals are “dead-end” hosts

or “terminal" hosts, we do not return the virus to mosquitoes. A mosquito bites an infected bird and later passes the virus to humans and other mammals.

Multiple species of mosquitoes are capable of transmitting the disease. A study conducted in New Haven, Connecticut in 2004 evaluating West Nile virus vectors in an urban setting identified nineteen species of mosquitoes with four species accounting for 91.7% of the individuals caught (Brown, et al., 2008). The mosquito species *Culex pipiens* and *Culex restuans* largely feed on birds (enzootic) and are thought to play a larger role in the bird-mosquito transmission portion of the cycle. *Culex salinarius* is a more generalized feeder, biting both birds and mammals, and is more likely to be involved with transmission of the virus to humans, termed a “bridge vector”. *Aedes vexans* is locally abundant in Connecticut, aggressively bites mammals, and is frequently infected with West Nile virus; *Ae. vexans* was thus identified as a likely bridge vector. The mosquito populations in New Haven were spatially segregated, with the two species which feed primarily on birds (*Cx. pipiens* & *Cx. restuans*) located in moderately vegetated areas where trees provided the resting locations for both the birds and mosquitoes. The bridge vectors (*Cx. salinarius* & *Ae. vexans*) were found in residential areas with higher vegetation values, with *Cx. pipiens* & *Cx. restuans* also present. The authors noted that threshold values of the bird-mosquito vectors (especially *Cx. pipiens*) may be required for an outbreak to occur. The question becomes, how much of an additional threat do living shorelines pose in regards to risk of exposure to mosquitoes?



The cycle of West Nile virus; arrows represent the movement of the virus among hosts. Certain mosquito species tend to feed mostly on birds and are key in the movement of the virus between birds, though these mosquitoes may also bite mammals. Birds are the reservoir host or amplifier host, allowing for the growth of the virus, and capable of receiving and transmitting the virus to mosquitoes. Other mosquito species are bridge vectors, feeding on both birds and mammals, thus transferring the virus to mammals. Mammals are dead-end or terminal hosts, incapable of transmitting the virus back to mosquitoes. Images provided under Creative Commons licenses: American robin (Turdus migratorius) by Janet Hill, https://www.flickr.com/photos/45055378@N00/33708186893, (CC BY-NC-SA 2.0); http://pngimg.com/download/18149 & http://pngimg.com/ download/18165, (CC 4.0 BY-NC); http://clipartfans.com/post/human-clip-art-15.html & http://clipartfans.com/post/horses-clip-art-2.html).

While many species of mosquitoes utilize marshes and we have some understanding of the preferred habitats of species in large marshes, less is known about the distribution of mosquitoes in urban marshes (Roiz, et al., 2015). One study in an Atlantic coast marsh concluded that wooded areas adjacent to marshes can be a main source of the biting mosquitoes typically attributed to marshes, indicating the mosquitoes typically associated with the marshes were more closely linked to the wooded areas (Leisnham, Sandoval-Mohapatra, 2011). Research in an urban setting in New Haven, Connecticut identified moderately vegetated areas in the city as the target areas for the most effective mosquito

control; these areas are resting locations for both the main carrier-mosquito (*Culex pipiens)* and the main host-birds for West Nile virus, the American Robin (Brown, et al., 2008). *Culex pipiens* has a limited flight range of less than one-quarter mile while other species such as the saltmarsh mosquito (*Ochlerotatus sollicitans*) may fly up to 40 miles from their birth place (CTDEEP, 2017). The American Robin is an occasional year-round forager on saltmarshes, preferring the high marsh and upland border (U.S. EPA, 2006). Use of the saltmarsh by urban birds may increase populations by providing additional sources of food, however, very few urban birds will utilize saltmarshes for nesting or roosting areas. The impact of a living shoreline and the associated saltmarsh habitat on mosquito populations and on the bird populations involved with hosting West Nile virus is unclear due to a lack of available research; but what is available indicates the presence of a saltmarsh is unlikely to drastically increase the risk of mosquito-borne disease.

Many birds resident in urban settings are common visitors to saltmarshes (U.S. EPA, 2006):

occasional year-round visitors		***occasional year-round visitors***	
American crow	*Corvus brachyrhynchos*	Northern flicker	*Colaptes auratus*
American robin	*Turdus migratorius*	Northern mockingbird	*Mimus polyglottos*
Bonaparte's gull	*Larus philadelphi*	Red-shouldered hawk	*Buteo lineatus*
Canada goose	*Branta canadensis*	Red-tailed hawk	*Buteo jamaicensis*
Cedar waxwing	*Bombycilla cedrorum*	Rough-legged hawk	*Buteo laopus*
Common grackle	*Quiscalus quiscula*	Song sparrow	*Melospiza melodia*
European starling	*Sturnus vulgaris*		
Gray catbird	*Dumetella carolinensis*	***occasional summer visitors***	
Great black-backed gull	*Larus marinus*	American goldfinch	*Carduelis tristis*
Herring gull	*Larus argentatus*	Bank swallow	*Riparia riparia*
House sparrow	*Passer domesticus*	Barn swallow	*Hirundo rustica*
Mourning dove	*Zenaida macroura*	Chimney swift	*Chaetura pelagica*
Northern cardinal	*Cardinalis cardinalis*	Tree swallow	*Tachycineta bicolor*

The presence of animals, including mosquitoes with the potential to carry disease, are one aspect of concern for some stakeholders when considering the installation of a living shoreline. Fears over the adverse impacts can be exacerbated by anecdotal evidence and sensationalized stories. While comprehensive research addressing the specific impacts of urban living shorelines on nuisance animal encounters is lacking, the research conducted to date clearly indicates the negative effects are outweighed by the positive impacts of increasing green and blue spaces in an urban setting. The evidence presented in this summary leans towards indicating no notable increase in negative impacts over the preexisting conditions associated with urban wildlife; in other words, the negative interactions people may have with animals in a living shoreline habitat are the same negative interactions they are already having with wildlife in the parks and alleys of their city – the living shoreline should not bring an additional hazard into play. The scientific literature provides a number of reviews of negative impacts of green and blue spaces on urban dwellers, but these interactions are typically in low-latitude and low-income cities, places where extreme poverty results in sanitation issues, making green spaces toxic to residents (Barua, et al., 2013; Douglas, 2012). In developed countries and in temperate latitudes, the disservices exist but are greatly offset by the benefits gained by increasing the resident's exposure to a natural environment (Elmqvist, et al., 2015; Lyytimäki, Sipilä, 2009; Lyytimäki, et al., 2008; Tzoulas, et al., 2007).

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