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History of Deer Herd Reduction for Tick Control on Maine's Offshore Islands

by Susan P. Elias, Benjamin B. Stone, Peter W. Rand, Charles B. Lubelczyk, and Robert P. Smith Jr.

Abstract

The incidence of Lyme disease in Maine is associated with high abundance of blacklegged (deer) ticks, which in turn has been partly attributed to local overabundance of white-tailed deer. With evidence from Monhegan Island that the complete removal of deer reduced ticks and risk of contracting Lyme disease, nine other offshore communities initiated efforts to cull deer. We reviewed and summarized available histories of deer management on Maine's offshore islands. Concern about Lyme disease provided the overarching impetus for deer culls. Culls mostly occurred on islands that have no regular firearms hunting season, island communities have been challenged to control deer numbers, and social acceptance of deer culls varied. Integrated tick management (ITM) is the key to controlling ticks, but statewide ITM policy is lacking. Formation of vector control districts with statewide ITM policy would support all communities in Maine.

In addition to the agent of Lyme disease, blacklegged ticks in Maine can transmit the pathogens *Anaplasma phagocytophilum*, *Babesia microti*, Powassan virus, and *Borrelia miyamotoi* (Smith et al. [2014](#), [2019](#)). Cases of anaplasmosis and babesiosis in Maine have increased sharply since 2013; both can cause serious illness (and infrequently, death) in elderly, asplenic, or immune-suppressed persons (Elias, Bonthius et al. [2020](#); Smith et al. [2019](#)). Powassan (or deer tick) virus can cause a devastating encephalitis with a fatality rate of approximately 10 percent (Krow-Lucal et al. [2018](#)). Four cases of Powassan were recorded in Maine from 2000 through 2004 (Robich et al. [2019](#)), and at least eight during the 2013–2019 period (Peranzi and Robinson [2020](#)) including one 2013 fatality (Cavanaugh et al. [2017](#)). *Borrelia miyamotoi* can cause a relapsing febrile illness, with eight cases during 2016–2017 (Smith et al. [2019](#)) and 25 cases during 2018–2019 (Peranzi and Robinson [2020](#)).

INTRODUCTION

Several of New England's offshore islands—Monhegan in Maine, Martha's Vineyard and Nantucket in Massachusetts, and Block Island in Rhode Island—have recorded high incidences of Lyme disease going back to the 1980s (Krause et al. [2006](#); Piesman et al. [1987](#); Rand et al. [2004](#); Spielman et al. [1985](#)). Lyme disease is caused by the bacterial spirochete *Borrelia burgdorferi*, transmitted through the bite of an infected blacklegged (deer) tick (*Ixodes scapularis*) (Spielman et al. [1985](#)). Lyme disease was first recorded in Maine in 1986 with reports of individuals contracting the disease (Smith et al. [1990](#)). Since then, Lyme disease incidence has risen tenfold from 8.8 cases per 100,000 persons between 1992 and 2006 to 92.0 per 100,000 from 2016 to 2018 (Bacon et al. [2008](#); US CDC [2019](#)), with the spatial distribution of blacklegged ticks and Lyme disease incidence in Maine strongly correlated (Rand et al. [2007](#)). Lyme disease can cause fever, headache, fatigue, erythema migrans rash, and may involve the joints, the heart, and the nervous system; in some patients, arthritic and neurological symptoms may persist (US CDC [2019](#)).

From 2008 through 2019, the Maine Centers for Disease Control and Prevention (ME CDC) reported at least one Lyme disease case from 10 of Maine's 11 offshore towns, with Cranberry Isles the only island town with no cases reported during this period. Cliff Island, Great Diamond Island, and Peaks Island of Casco Bay are part of the city of Portland, so Lyme disease cases for the individual islands are not known. From 2014 through 2018, anaplasmosis was reported for Long Island, Islesboro, North Haven, and Vinalhaven, and babesiosis was reported for Long Island and North Haven.¹ In a 2016 survey of offshore island residents, respondents from most islands self-reported having acquired a tick-borne disease on the island: Lyme ($n = 10$ islands), anaplasmosis ($n = 4$ islands), and babesiosis ($n = 7$ islands) (Elias, Rand, et al. [2021](#)).

In the Northeast including Maine, blacklegged ticks feed on birds, rodents, and deer (Eisen et al. 2016). Migratory birds disperse tick larvae and nymphs over long distances (e.g., Smith et al. 1996). Locally, white-footed mice (*Peromyscus leucopus*) and some other rodent species are reservoirs of *B. burgdorferi* and transmit this pathogen to feeding blacklegged tick larvae and nymphs (e.g., Mather et al. 1989). However, blacklegged tick adults do not feed on mice. Indeed, the white-tailed deer (*Odocoileus virginianus*) is the most important host of adult blacklegged ticks by providing a mating site to adults and providing roughly 90 percent of female blacklegged tick blood meals (Wilson et al. 1990). A blood-fed, female blacklegged tick may lay approximately 2,000 eggs (Mount et al. 1997). Given the importance of white-tailed deer for completion of the blacklegged tick life cycle, and correlations between deer and tick numbers (e.g., Rand et al. 2003), high blacklegged tick density on New England's offshore islands has been attributed to overabundant white-tailed deer.

Accordingly, over the past three decades, New England island communities including several of Maine's—such as Monhegan and Islesboro—have debated and in some cases implemented the controversial task of reducing their deer herds in an attempt to lower risk of tick bites and tick-borne illnesses. Monhegan's history of deer removal is the best known example of community management of a deer herd on an offshore island in Maine. In the 1990s, concern about Lyme disease led the community to remove all deer, which resulted in a substantial decline in blacklegged tick density (Rand et al. 2004). Other Maine offshore island communities, facing locally burgeoning deer densities, began to cull (reduce) deer. Maine has 15 unbridged, offshore islands with year-round populations (Figure 1). The formation of town tick or deer control committees in some of these communities reflects the broader concept that betterment of public health sometimes hinges on community-initiated policies that improve environmental conditions (Deprez and Thomas 2016).

To suppress blacklegged ticks and Lyme disease, Telford (2017) suggested lowering the density of white-tailed deer to approximately 8–13 per square mile. The Maine Department of Inland Fisheries and Wildlife's 2017 *Big Game Management Plan* (MDIFW 2017) stated that maintaining deer at or below 11 per square mile may lower tick abundance and subsequently decrease risk of

tick-borne pathogens. Our intent is not to debate whether Lyme disease can be measurably reduced by lowering and maintaining deer density to 8–13 per square mile. Rather, we will summarize the efforts that Maine's offshore communities have made to control deer, while also assessing islanders' motivations. White-tailed deer are valued by Maine people for viewing, hunting, and the species' contribution to the economy, but overabundant deer have negative consequences beyond tick-borne disease, including vehicle collisions, orchard and landscaping damage, and reduced deer and forest health (e.g., Beguin et al. 2009; McShea 2012).

The history of efforts to reduce deer populations on Maine's offshore islands has been documented in a piecemeal fashion over time. To consolidate this history, we drew from scientific articles, Maine Department of Inland Fisheries and Wildlife (MDIFW) reports and biologists, and print and online news articles. Maine's news outlets have followed deer herd management across the decades, and reporters have solicited expert opinions from special permit hunters, MDIFW biologists, public health officials, and municipal personnel. Our aims were (1) to determine whether deer culls reduced and maintained deer density in the range of 8–13 per square mile; (2) to qualitatively assess motivations for and methods of deer herd reduction; and (3) to discuss the efficacy of deer herd management in the larger context of integrated tick management (ITM), social acceptance, and gaps in policy. We hope this article will serve as a reference for island and mainland communities and state agencies. These entities will benefit by understanding the motivations, magnitude, and effects of efforts to reduce deer herds and can use this knowledge to initiate or broaden ITM policies.

HISTORY OF DEER HERD MANAGEMENT ON OFFSHORE ISLANDS

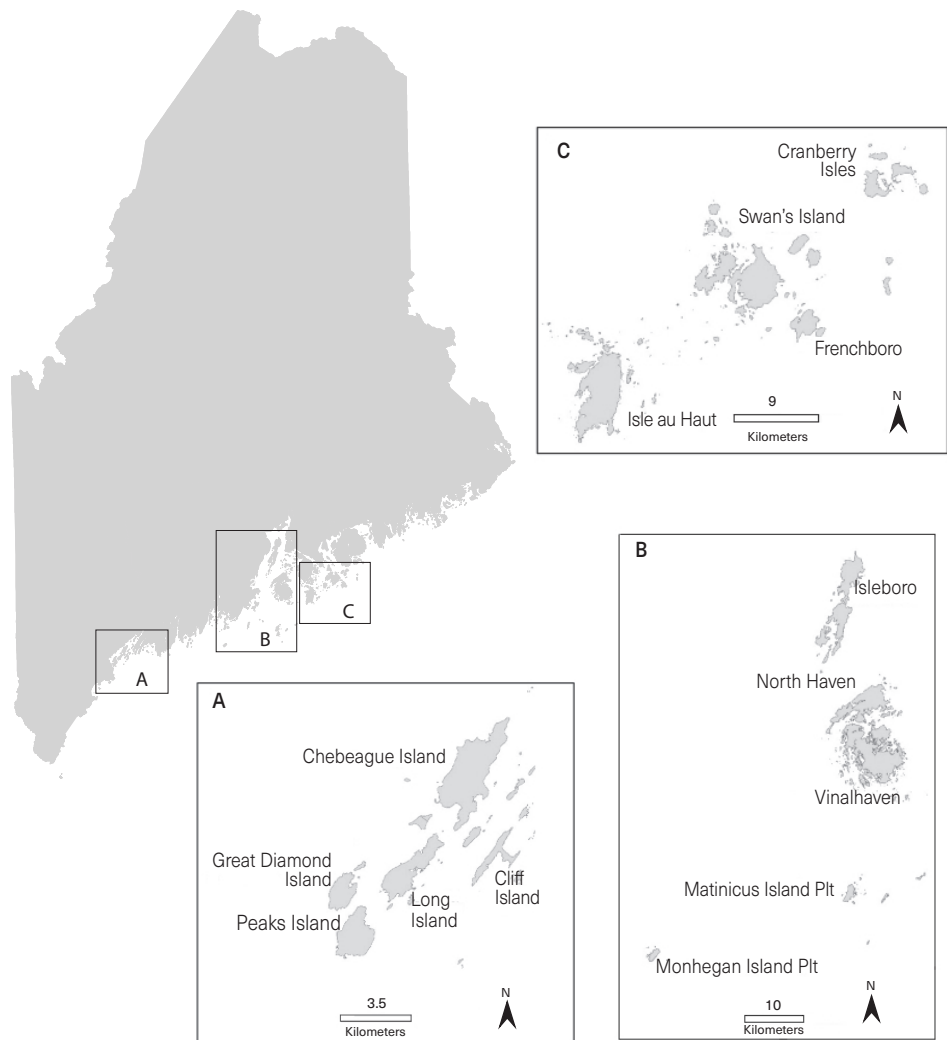
In Maine, white-tailed deer ranged from scarce around the turn of the 20th century to locally overabundant around the turn of the 21st century. Due to this scarcity, Maine's eight southern counties, which include all the offshore islands in our study, were closed to hunting from 1894 through 1902 (MDIFW 2017). Islesboro, North Haven, and Vinalhaven reinstated the regular firearms season in the 1950s (Moore 2002). Given safety concerns, other islands maintained hunting bans. In 2000,

the Maine State Legislature, responding to concerns over deer overabundance, granted authority to MDIFW to open islands previously closed by statute to deer hunting, which provided a formal mechanism for the agency and municipalities to coordinate controlled hunts (MDIFW 2017) in the absence of a regular fire-arms season. By the 1990s, deer densities ranging up to 100 per square mile exceeded island residents' tolerance for property damage and Lyme disease (Moore 2002), and between 1992 and 2014, removal or culls occurred on 10 of 14 islands with deer populations (Table 1).

Complete removal of all deer occurred only on Monhegan. In 1954, islanders successfully petitioned the state to bring approximately six white-tailed deer across 12 miles of water from the mainland (Rand 2017). By the early 1990s, however, Monhegan had between 105 and 108 deer, a density of 117–120 per square mile. The large deer population, presence of blacklegged ticks, and high percentage of cats and dogs with antibodies to Lyme bacteria (23 percent) raised residents' concern about Lyme disease (Rand et al. 2004; Smith et al. 1993). In 1995, a majority of islanders voted to remove all deer. In coordination with MDIFW, all deer were culled by sharp-shooting between 1997 and 1999. A long-term study by Rand et al. (2004) illustrates the dramatic change in blacklegged tick population between 1990 and 1996, collection rates of adult blacklegged ticks ranged up to 17 per hour, whereas

collection rates were around three per hour between 2001 and 2003, an 82 percent decline. Subsequently tick density remained low (less than 2 per hour, Elias et al. [2011]). During the Monhegan study, Isle au Haut, with its plentiful deer (25 per square mile), served as a reference island. There, collection rates of adult blacklegged ticks rose from 4 to 33 per hour between 1991 and 2003 (Rand et al. 2004). Upward trends in blacklegged ticks from the mid-1990s

FIGURE 1: Maine's Offshore Islands with Year-Round Residents



Adapted from *Ticks and Tick-borne Diseases* 12(2), Susan P. Elias, Peter W. Rand, Laura N. Rickard, Benjamin B. Stone, Kirk A. Maasch, Charles B. Lubelczyk, Robert P. Smith, "Support for Deer Herd Reduction on Offshore Islands of Maine, U.S.A." (2021), with permission from Elsevier.

TABLE 1: **Deer Cull History (Where Known) and Deer Herd Management Methods on Maine's Offshore Islands, 1992–2019**

Island	Area of island (mi ²)	Pre-cull history		Cull history			Current status (through 2019)		
		Approx. # deer	Approx. # deer/mi ²	Cull year(s)	Cull method(s)	# deer removed	Approx. # deer	Approx. # deer/mi ²	Management
Region A									
Chebeague	3.0			none					regular
Long	0.5			1999 ^a	shotgun	<10 ^a	20–30 ^b	40–60 ^b	special
Cliff	0.7			2003 ^c , 2004 ^d	sharpshooter	25 ^c	25 ^d	53	special
Great Diamond	1.3			1992–1995 ^{d,e} , 1999–2001 ^a	sharpshooter	?; 37 ^a	25 ^d	38	special
Peaks	1.2	274	100 ^c , 200 ^{d,f}	1999–2001 ^e	sharpshooter	223–234 ^{c,f}	25 ^d –30 ^e	21 ^d –25 ^e	special
Region B									
Islesboro	14.1	846	60 ^g	2012–2014 ^g	shotgun	124 ^g	690	50 ^g	special
Matinicus	1.3	0	0	not applicable			0	0	n/a
Monhegan	0.9	105–108	117–120 ^h	1996–1999 ^h	sharpshooter	114 ^h	0	0	n/a
North Haven	11.3			none					regular
Vinalhaven	22.5			none					regular
Region C									
Isle au Haut	12.6	315 ^h	25 ^h	none					no hunting
Cranberry Isles	1.6	133–156	85–100 ^f	1999–2001 ^e	archery, shotgun	100 ⁱ	15–20 ^j	10–13 ⁱ	restricted
Frenchboro	3.9			2001 ^f	archery, shotgun				restricted
Swan's Island	12.5			2001–2003 ^e	archery, shotgun	270 ^j	188 ^k	15 ^k	regular and special

Note: Hunting under special regulations means the island is not open to the regular firearms season. Restricted hunting means regular hunting with modifications. Special regulations for some islands can be found in Maine's Statutes: <https://www.mainelegislature.org/legis/statutes/12/title12sec11402.html>.

Sources: ^a Bieber N., personal communication, December 17, 2018; ^b Groening (2015); ^c Leath (2004); ^d Billings (2016); ^e MDIFW (2007); ^f Moore (2002); ^g Fleming (2017); ^h Rand et al. (2004); ⁱ Leven (2014); ^j Edgecombe (2003); ^k Unpublished data based on a 2018 deer pellet count (lower and upper 95% confidence limits 11.3, 18.0/mi²)

through the mid-2000s have been documented on the mainland as well (Elias, Maasch et al. 2020).

Among the nine offshore islands that culled deer (Table 1), the first cull was conducted from 1992 to 1995 on Great Diamond Island, and the most recent was from 2012 to 2014 on Islesboro. Pre- and post-cull estimates of deer density were available for just three islands: Cranberry Isles (reduced from around 85 per square mile to 10–13 per square mile); Islesboro (reduced from 60 per square

mile to 50 per square mile); and Peaks Island (reduced from around 100 per square mile to 21–25 per square mile). Permitted, special regulation hunts to control deer currently occur on six of the islands. We found no records of deer culls on Chebeague, North Haven, and Vinalhaven (each having a regular firearms season), and Isle au Haut. We found no records of deer on Matinicus Isle Plantation, 23 miles offshore, nor have we found an established deer tick population in our repeated surveys on this remote

island. MDIFW biologists from each region found our summary of cull histories sound given the information at hand.²

Among the negative impacts associated with overabundant deer, Lyme disease has apparently been the key motivator for deer control on the islands, as noted in state agency reports (MDIFW 2007, 2017) and media reports (Fleming 2017; Leath 2004). Initially, island residents may have grown accustomed to fencing in gardens (or not having gardens) and gradual changes in vegetation due to heavy deer browse on many islands, but the emergence of Lyme disease focused attention on deer overabundance (Moore 2002; Billings 2016).

Whether through regular or special hunts, it appears that on most islands with histories of deer culling, the communities have been challenged to control deer numbers effectively. Among islands with density estimates for their deer populations, the 8–13-per-square-mile criterion was met only by the Cranberry Isles (Table 1). In Casco Bay (Region A, Figure 1), Long Island and the city of Portland islands (Cliff, Great Diamond, and Peaks) have maintained regular special hunts to reduce deer numbers, but densities ranging from 21 to 60 per square mile (Table 1) suggested goals have not been met. On Swan’s Island, the 2001–2003 cull took approximately 270 deer (Edgecombe 2003). On the basis of our field surveys on Swan’s Island, we noted more blacklegged ticks after the cull than before (1 tick per hour pre-cull vs 26 ticks per hour post-cull; Elias, unpublished data). This is likely due, at least in part, to a rebound in deer numbers since the 2001–2003 cull. In 2018, Swan’s Island held a special hunt to reduce the deer population, but only two deer were taken (Curtis 2018).

The diverse deer management histories of the islands likely reflect the unique physical characteristics and human communities of each island. For example, Monhegan is too far out to sea for deer to reach via island-hopping and swimming, and deer were introduced to the island within collective memory of its residents. These factors likely led to the eventual (albeit controversial) consensus to eliminate all deer. In contrast, Islesboro is a much larger community and closer to shore, and in 2016, community members reached a stalemate over the policy to reduce the deer herd. In the mid-2000s, a group of Islesboro residents formed a deer reduction committee. In 2012, the town spent \$20,000 to census deer, which estimated deer density at 60 per square mile. A cull program from 2012 to 2014 was

not successful at reducing the deer population substantially, and in 2014, a group consisting mostly of summer residents (Concerned Citizens of Islesboro) offered \$350,000 towards hiring a sharpshooter to cull deer.³ At a special town meeting in 2014, the sharpshooting article was rejected by a margin of nearly two to one. In 2016, the town voted against switching to a regular firearms season from the current expanded archery season. The community became polarized on this issue, and the deer reduction committee was dismantled (Fleming 2017). Islesboro’s newer Tick-borne Disease Prevention Committee focuses on education on how to avoid tick bites (Sullivan 2019). In 2019, Isle au Haut citizens discussed what would be—if our historical summary is correct—its first cull. In October 2019, by unanimous approval of town voters, Isle au Haut approved a five-year program to cull deer on the portion of the island not part of Acadia National Park (where hunting is prohibited by federal statute). This program would monitor both the abundance of blacklegged ticks and the regeneration of forest plants, which is expected to improve when there is less browsing pressure from overabundant deer (D. Stevens, personal communication, November 9, 2019).

Maine’s offshore islands have unique histories of deer herd management, with communities collectively concerned about impacts of deer overabundance, particularly the presence of blacklegged ticks and Lyme disease. In the Northeast, deer reduction has had mixed results in terms of lowering blacklegged tick populations (Kugeler et al. 2016). With partial deer management histories and scant pre- and post-cull data on blacklegged ticks, it was difficult to assess the effectiveness of deer culls on Maine’s offshore islands. In our review, it was clear that most islands that have culled deer have found it difficult to keep deer numbers reduced. Furthermore, on most Maine’s offshore islands, tick-borne disease and damage caused by deer to vehicles, landscaping, and forests remain a concern (Elias, Rand, et al. 2021).

NEED FOR INTEGRATED TICK MANAGEMENT IN MAINE

The history of deer management on Maine’s offshore islands raises points pertinent to all communities in Lyme-endemic areas. First, integrated tick management is essential; second, consensus on managing deer herds is

difficult to achieve; and third, creation of state- or district-level vector control districts would support community ITM.

ITM is the key to tick control; it targets tick hosts (e.g., deer, mice), tick habitat, and the ticks themselves. ITM is a toolbox from which communities can select the best tools to suppress ticks based on the ecological and sociological characteristics of their communities. As per Telford (2017), we recommend pairing long- and short-term strategies to maximize the return on the investment in ITM. A cull, followed by commitment to maintain lower deer density through regular or special hunts, is a long-term strategy and should be paired with at least one short-term strategy. The idea is that following deer reduction there will be a two- to three-year period where there are more ticks in the environment as they seek blood meal hosts, so short-term strategies will kill a substantial proportion of these questing ticks. One short-term strategy is to target mice via bait stations that contain bedding material or food with an acaricide (a tick-killing substance), antibiotics, or oral vaccine (e.g., Dolan et al. 2011; Eisen and Stafford 2020; Williams et al. 2018). Other short-term strategies include reducing tick habitat by removing brush and leaves in yards (Stafford et al. 2017).⁴ Another short-term strategy is to apply synthetic, botanical, or fungal sprays around homes, but we note that synthetic sprays that kill ticks are unlikely to be adopted on a community-wide scale where livelihoods depend on lobstering and other fisheries (Pearce and Balcom 2005). While appealing in name, botanical acaricides have not shown clear results as a control method for blacklegged tick (Benelli et al. 2016), and their effects on nontarget organisms are mostly untested (but see Elias et al. 2013). For more detail on ITM, we recommend *Tick Management Handbook* (Stafford 2007).

Even if all community members have a clear understanding of ITM and the importance of deer herd management as an ITM tool, community consensus for and commitment to ITM is difficult to achieve and maintain. Deer culling is unpalatable and not broadly socially acceptable. People variously want to save the deer, object to hunting or deer management, or are unhappy with deer for damaging vehicles and landscaping and elevating risk of Lyme disease. Participants in these debates include elected

officials, hunters, representatives of animal rights and welfare organizations, and experts on deer biology, tick ecology, and deer treatment or removal methods (Kirkpatrick and Turner 1997; Sterba 2012). It is not surprising that many community debates end in no action, or ineffective deer management actions. It is notable, however, that Maine's offshore island communities have striven over the years to manage persistent deer overabundance.

Currently in Maine, ITM is implemented at the individual or community scale, but the whole state would benefit from state- or region-wide policies and vector control districts. Rochlin et al. (2019) and Eisen (2020) suggested that regional tick management programs could be partly modeled after, or merged with, existing mosquito control programs. Organizations such as the American Mosquito Control Association and the Northeast Mosquito Control Association strengthen ties between research and the mosquito control industry. Although there is no analogous association for ticks, a link between mosquito- and tick control programs could stimulate industry to invest in new solutions for tick control (Eisen 2020; Eisen and Stafford 2020). Maine does not have mosquito control districts on which to pattern tick control, but tick control is a high-priority need for the state in the context of adaptation to climate change. Range expansion of the black-legged tick is partly attributable to warmer winters and longer growing seasons (Elias, Gardner, et al. 2021). Additionally, warming climate is likely encouraging the arrival of the lone star tick (*Amblyomma americanum*) in southern Maine (Molaei et al. 2019). The lone star tick transmits the agents of diseases such as tularemia and human monocytic ehrlichiosis, causes alpha-gal syndrome (red meat allergy), and relies on the white-tailed deer as a primary blood meal host (Paddock and Yabsley 2007). As a strategy to mitigate entomological risk, the Public Health Subgroup of the Maine Climate Council recommended in 2020 that the Maine CDC create vector control districts at the municipal, county, or other district level, and develop policies for tick and mosquito control.⁵ We support this recommendation. Well-organized and -funded vector control districts can provide essential infrastructure for community-specific ITM programs and facilitate acceptance of area-wide, long-term deer herd management.

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NOTES

- 1 Data on cases of tick-borne diseases come from the ME CDC Maine Environmental Public Health Tracking Program, which is available on the following website: <https://data.mainepublichealth.gov/tracking>.
- 2 N. Bieber, personal communication, December 17, 2018; K. Kemper, personal communication, December 31, 2018; S. Lindsay, personal communication, January 2, 2019; S. Bard, personal communication, January 20 and February 20–22, 2019.
- 3 More information about deer reduction on Isleboro is available on the town website: <http://townofislesboro.com/committees/deer-reduction>
- 4 Removing non-native Japanese barberry (*Berberis thunbergii*) from landscapes (e.g., Ward and Williams 2011) and other plants associated with ticks might be considered a long-term strategy, since, as with deer removal, it takes ongoing effort to suppress these invasive plants.
- 5 More information about the Maine Climate Council's concerns about tick control is available in the report *MCC Public Health Subgroup Strategies*, which is available here at https://www.maine.gov/future/sites/maine.gov/future/files/inline-files/PublicHealthSubgroup_FinalStrategyRecommendations_June2020.pdf. The Maine Climate Council Scientific and Technical Subcommittee report, *Scientific Assessment of Climate Change and Its Effects in Maine*, is available at <https://climatecouncil.maine.gov/reports>.

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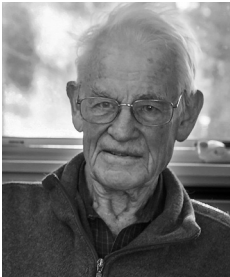
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