Section 4: How Might Possible Benefits or Risks To Health From Conserved Lands Best Be Managed?

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4.1 Background

Historically, public health improvements arrived hand-in-hand with land development and economic progress as vector-borne diseases carried by insects were reduced when wetlands were drained for agriculture, rivers straightened for navigation and urban sewers sealed underground. Moreover, aggressive spraying of pesticides in the United States following WWII subdued the mosquito carriers of dengue and malaria while progress in medicine and public health eliminated human infections.

Today however, habitat fragmentation and hydrological disruption have fundamentally altered ecological dynamics, even as climate change and globalization are rapidly shifting species ranges. Since pathogens may originate directly in animals (‘zoonosis’) and may be transmitted by biting insects (‘vector-borne’), disease dynamics are heavily dependent on the ecological contexts surrounding insects and humans.

Central to this issue is the question: What are the risks to human health that may be posed by either more natural or more fragmented landscapes, particularly in the face of climate change?

Since landscape management and personal protection measures can greatly modulate personal risk factors, the conservation and health communities ought to be asking:

- How might natural areas either reduce or increase risks to human health?
- What are the resulting implications for management?

Answers to these questions may inform management of currently preserved areas, new park designs, and outreach strategies – and ultimately lead to new partnerships and collaboration among the land trust community, conservation funding agencies, public health officials and research scientists.
As we believe that other connections between land conservation and human health relating to such issues as water contamination, chemical pollution, or personal safety are well covered elsewhere, this section outlines a number of examples relating specifically to tick- and mosquito-borne diseases, which comprise the majority of infection risks posed to humans near conserved or fragmented lands. Given the scope and complexity of these issues, this section only presents a brief introduction to these topics.

4.2 How Might More Natural Areas Reduce Risks to Human Health?

The Millennium Ecosystem Assessment (MEA) highlights the protective services that intact and species-rich ecosystems can provide for human well-being (UNEP, 2005). The MEA synthesizes scientific findings that intact ecosystems may be less sensitive to invasion, buffer disease agents and resist the outbreak of infections. In their subchapter on “The Ecosystem Regulation of Infectious Disease,” Patz et al. (2005) describe how altered habitats, niche invasion and biodiversity losses drive changes in disease risk. These effects are visible both at the landscape scale in studies that describe the overall distribution and occurrence of disease, as well as in theories that seek to mechanistically explain changing dynamics.

On a global scale, the MEA offers a number of examples where land cover conversion creates new disease risks. For instance, deforestation has been linked to increased malarial risk in Africa and South America (Patz et al., 2005). As forests are cleared for agriculture, rates of water infiltration decrease and surface water may pool in ways favorable to the reproduction of the *Anopheles* mosquitoes that carry malaria.

In addition to changes in hydrology, deforestation promotes interaction between pathogens, vectors and hosts because it:

- Decreases wildlife habitat;
- Fragments the landscape into patches; and
- Increases the “edge-effect,” such that the borders between different habitat types increase in length and frequency (Patz et al., 2004).

In the United States, landscape characteristics such as forest fragmentation are also correlated with disease risk. A study by Brown et al. (2008) is widely cited as evidence that forest fragmentation in the context of urbanization increases human risk of contracting West Nile Virus (West Nile).

In the Northeast, the relative percentage of forested land to urban can predict incidence rates of West Nile. Specifically, counties in the lowest quartile of percent forested area relative to urban were shown to have a fourfold higher incidence of human West Nile infections than their more forested counterparts (Brown et al., 2008). Although this makes intuitive sense because urban areas concentrate human population, the dynamics of species within forested systems deserve closer investigation.
West Nile Virus

A relatively recent concern in North America, West Nile Virus was first described in 1937 in Uganda before it made the leap to New York City from Europe in 1999. Although four out of five people infected may show no symptoms, West Nile may cause fever and can ultimately cause severe neurological damage in elderly individuals or those with weak immune systems. New York State reported 13 cases of West Nile in 2012, leading to two deaths. As an arthropod transmitted virus (arbovirus), West Nile spreads when mosquitoes of the genus Culex seek a blood meal from an infectious host, such as a passerine bird (songbird) or a horse, and in turn transmit the virus from animal to human. For West Nile to persist in a landscape, conditions must be right such that mosquitoes encounter a host that has amplified levels of the virus. The ability of a host to support high viral load is often described as ‘competence.’

For more information see: http://www.cdc.gov/ncidod/dvbid/westnile/index.htm

The infection dynamics of species within forested systems respond to both forest fragmentation and land cover. While all passerine birds, including species as different as robins and crows, are susceptible to infection, these species prefer different habitat and exhibit greatly different competence to amplify West Nile. The American Crow (Corvus brachyrhynchos) easily succumbs to the virus and die-offs have been used to investigate the spatial and temporal dynamics of disease spread. Crow population declines from disease were most pronounced in urban settings that had less than 35% forest cover and exhibited warmer winter temperatures (LaDeau et al., 2011).

Although the mechanisms are still unclear, landscapes with less forest cover appear to be consistently linked to higher disease incidence. Not all forest cover classes seem to behave the same, however. For instance, orchards were positively and preferentially associated with West Nile infection in robins, sparrows and horses. These effects also increased during times of drought (Crowder et al., 2013). Such results pose a number of interesting questions concerning the relation of habitat quality to species composition.

At the scale of individual forest fragments, patch size has indirect implications for disease risk – for example, smaller forests can be expected to have more ticks infected with Lyme disease. Based on the finding that woodlands smaller than two hectares support exponentially greater white-footed mouse (Peromyscus leucopus) populations relative to larger fragments, Allan et al. (2003) investigated the relationship between patch size, tick prevalence and rates of nymphal infection with the Lyme disease spirochete. Nymph infection density was found to exponentially decrease as patch size increased (Allan, Keesing, and Ostfeld, 2003).
An interesting question faced by European environmental restoration of pine plantations to more natural mixed forests is whether those changes are likely to increase Lyme disease risk. Tack et al. (2012) found that though restoration into semi-natural woodlands increased presence of deer beds and the regrowth of the understory increased tick habitat, prevalence of Lyme disease infection in nymphs was not found to be significantly different (Tack et al. 2012).

**Lyme Disease**

The U.S. Center for Disease Control confirms that Lyme disease affected between twenty and thirty thousand people in the United States each year between 2002 and 2011, with 96% of cases reported from 13 states in the mid-Atlantic, Northeast and Great Lake states (CDC, 2013). Lyme disease is caused by infection with the spirochetal bacterium Borrelia burgdorferi via the ixotid, or black-legged tick Ixodes scapularis (also by Ixodes pacificus in Western states). Typical symptoms include a bulls-eye rash, fevers, headache and fatigue. If left untreated, borreliosis can progressively cause joint pain and eventual neurological impairment. Other common co-infections include Babesia microti, Anaplasma phagocytophilum and encephalitis (Rickettsia sp).

For more information see: [http://www.cdc.gov/lyme/](http://www.cdc.gov/lyme/)

One hypothesis concerning disease relations to landscape, termed the ‘dilution effect,’ has been demonstrated in a number of settings ranging from vector-borne to purely zoonotic systems (Ostfeld and Keesing, 2012). In principle, biodiversity loss could either increase or decrease disease transmission depending on changes to the hosts, vectors or parasites that alter relative abundance, behavior and condition (Keesing et al., 2010).

However, increasing biodiversity modulates a number of factors that appear to ‘dilute’ pathogens and reduce their transmissibility. Such factors include:

- **Relative abundance:** the probability that an insect vector will encounter a host that is both a preferred blood source and a good reservoir is effectively decreased when an ecological community supports high species richness.

- **Behavior:** the probability of ‘horizontal’ (within species) transmission likewise reduces as encounters between individuals become relatively less frequent.

- **Condition:** genetically diverse populations are better equipped to fight disease on a population level due to variations in immunological competence.

The complex ecology of Lyme presents many opportunities to test the dilution effect. Ticks may feed on mammal, bird and reptile hosts in their development from larvae to nymph and adult life stages (LoGiudice et al., 2003; Schmidt and Ostfeld, 2001). Empirical re-
search shows that the ubiquitous white-footed mouse is comparatively poor at grooming off ticks and subsequently a good reservoir for propagation of the Lyme pathogen (Keesing and Ostfeld, 2012). By looking at the diversity of mammal species (including the deer that adult ticks hitchhike across the landscape on), measures of diversity and species richness can be correlated with overall disease burden.

The dilution effect has also been seen in diseases that can be transmitted directly. An experimental example in Panama demonstrated that removing non-reservoir species caused an increase in Hantavirus infection prevalence among host rodent species (Suzan, 2009). In other words, removal of rodents unable to contract Hantavirus increased rates of contact between susceptible individuals, leading to a spike in infection among reservoir species.

**Hantavirus**

Although viruses in the Hantavirus family are endemic to the Americas, they were relatively obscure in the U.S. until the 1993 ‘Sin Nombre’ outbreak. The United States reported 587 cases between 1993 and 2012 that exhibited an astronomical 30 percent fatality rate, making it a rare but especially fatal disease. Hantavirus pulmonary syndrome results from inhalation of dust particles originating in rodent urine and feces that contain the virus. Infection may progress swiftly and treatment options are limited to supporting the immune system fighting the infection. Zoonotic hosts of the Hantavirus include deer mice (living in woodlands across the US), cotton rat (shrubs and tall grasses in the Southeast), rice rat (marshy areas in the Southeast) and white-footed mouse (east of the Rockies). Outside the US, cases have been shown to cluster after unusual rains, bamboo flowering, human disturbance, or land use change.

For more information see: http://www.cdc.gov/hantavirus/index.html

### 4.3 How Might More Natural Lands Increase Risks to Human Health?

Whether they are wetlands, meadows or forests, lands preserved from development will continue to provide critical habitat for a multitude of species – and anticipating future risks will be key to successful management. While the dilution effect has been demonstrated to reduce disease risk as reservoir species diversity increases, mathematical modeling shows that more diverse vector communities can also increase risk (Roche et al., 2013).

Over the past fifty years, more than half of all emerging infectious diseases (EIDs) originated with a zoonotic host. Of these EIDs, the majority, 71.8 percent, came from wildlife (Jones et al., 2008). Dr. Peter Daszak, president of the EcoHealth alliance, told *The New York Times*, “[a]ny emerging disease in the last 30 or 40 years has come about as a result of encroachment into wild lands and changes in demography” (Robbins, 2012 July 14).
The EcoHealth Alliance

The mission of the EcoHealth Alliance is to preserve biodiversity, conserve ecosystems and protect human health. Internationally active, the organization partners with local veterinarians and ecologists to promote nature preservation and actively track the threat of emerging infectious disease. Examples of work include “Project Deep Forest,” which tests the health protection effect of biodiversity in Malaysia, and the “PREDICT” program that seeks to identify geographic hotspots of potentially emerging diseases.

For more information see: http://www.ecohealthalliance.org/

OneHealth

A concept championed by the veterinary, ecology and conservation communities is the idea that human, animal and ecosystem health are inextricably linked. ‘OneHealth’ seeks to bridge disciplinary and departmental boundaries by uniting doctors, veterinarians, the CDC, USDA and National Environmental Health Association with the mission of reducing vector borne and zoonotic disease. For examples of OneHealth in action, see the Disease Detection and Response Team of the National Parks Service.

For more information see:
http://www.onehealthinitiative.com

One recent example of disease risk that may be exacerbated by human intrusion into natural areas is the Hantavirus, which is now receiving increased attention in the American West. Hantavirus presents an interesting case because ecological research has previously confirmed both a dilution effect and a forest-edge effect that mediate disease transmission. For instance, when they investigated a series of sites in Panama’s national parks and forest, Suzán et al. (2008) found that forest edges and disturbed habitat had higher prevalence of Hantavirus reservoir host species.

After news of a Hantavirus outbreak in Yosemite National Park hit media outlets in the summer of 2012, the National Parks Service was faced with the difficult task of tracking and communicating risk factors to the 230,000 odd visitors the park hosted since early June (Jaret, 2012). In a posting updated September, 2012, the CDC confirmed ten cases of Hantavirus that resulted in three fatalities (CDC, 2012). A retrospective look at the chronology of events suggests that most of the cases originated at the ‘Signature Tent Cabins’ in
Curry Village, with one case identified at ‘High Sierra Camps,’ as a result of close proximity of campers to mice living in the insulated platform tent walls. It takes contact with mouse droppings that are no more than three days old to transmit the virus, as dry conditions, ultraviolet light, and time deactivate the virus. In this case, it was the comfortable habitat provided in the campers’ living quarters that led to such a high rate of infection.

Exposure and Liability

In what case is a landowner or employer liable for illness contracted as a result of exposure to vector-borne diseases? In the 1993 case Grano et al. v. Long Island Railroad, rail employees were able to win damages after contracting Lyme disease while laying signal cable next to the tracks. In this case, liability was established as a consequence of Long Island Railroad’s neglect in controlling trackside vegetation, which was held to interfere with normal employee duties. Although strict liability may not be clearly applicable to private lands, it is instructive that the railroads are required to respond to tick-borne disease by providing their employees information, insect repellent and a vegetation management plan. As with many legal issues, case law is apt to change and a lawyer should be sought for true legal advice.

For more information see:
http://www.maurerlaw.net/Articles/Lyme-Disease-and-the-Risks-for-Railroad-Workers-By-Ira-M-Maurer-Esq.shtml

Though the earlier discussion of the potential health risks of natural areas focused on landscape-scale risk, the personal, individual risk faced by those encountering nature can best be determined as a function of time spent outdoors in areas where exposure is possible. Human epidemiological data suggests that actual cases of Lyme disease are correlated with exposure to natural settings. While both tick density and infection prevalence are higher in ticks occupying small patches in a fragmented landscape, human cases of Lyme disease were found to be correlated instead with large and isolated habitat patches (Brownstein et al., 2005). Why might this be true? Such a finding seems counterintuitive to the basic epidemiological model, where human infection events ought to correlate with the absolute number of infected ticks.

The human use patterns of natural areas may bear closer scrutiny in this case, as one answer may be that recreational users simply spend more time in large isolated habitats, eschewing fragmented landscapes. It is also possible that urbanites, fleeing to forested areas for recreation, acquire the disease while recreating, but do not discover it until they are back in their home cities. In support of this hypothesis, Pepin et al. (2012) found a negative correlation between Lyme disease risk predicted by nymph infection and cases actually reported in Massachusetts.
It is important to overlay patterns of human activity that mediate disease transmission risk on the overall quality of landscape. Brownstein et al. (2005) argue that suburbanization decreases overall human risk because the number of properties adjacent to suitable habitats is inversely correlated with development. Suburban real estate may, in this theory, be crowding out the microhabitats that harbor deer, mice and ticks.

Once again, how humans use their landscapes matters. If your average suburbanite spends most of their time indoors, this will affect the number of infection cases reported, as ecology is uncoupled from daily exposure. On the other hand, suburbanites may find themselves facing greater exposures around their property as woodpiles, stone walls and leaf piles make excellent habitat for mice and ticks, and many mosquitoes thrive in lushly irrigated suburban yards.

The decline of top predators may also influence disease outbreaks. Population losses for predators such as owls, bobcats, coyotes and foxes due to habitat destruction and forest fragmentation have had far reaching consequences on the population of prey species like white-footed mice that today may act as disease reservoirs. Even mid-size predators require a scale of habitat not often preserved in contiguous remnants and they have suffered major population declines. As a result, natural rodent control is lacking precisely in those places where people and animals meet (Levi et al., 2012).

### 4.4 How are the Benefits and Risks of Natural Lands Likely to Shift Under Climate Change?

As climate change drives insects adapted to warmer climates further north and into preserved natural areas adjacent to human settlement, the risk of insect borne disease may increase. Scientists have thoroughly described the thermal tolerance of mosquitoes, but insects are cold blooded and some may exhibit a nonlinear response to temperature change. Tick range, for example, could shift North by 200km by 2020 and 1000km by 2080 (Patz et al., 2008).

According to the Intergovernmental Panel on Climate Change AR4 report, climate change is expected to increase rainfall in wet areas, such as the Northeastern US, and worsen drought in dry areas, like the Southwest (IPCC, 2007). Flooding from excess rainfall and storm surges have recently captured attention after the great damages caused by hurricanes Irene (2011) and Sandy (2012). As we extend the built environment, runoff patterns will change, altering the prevalence of breeding grounds for mosquitoes and possibly displacing subterranean rodents. By way of example, rat sightings have increased following hurricane Sandy, raising health concern in a New York City experiencing changing climates (Peeples, 2013a; Peeples, 2013b).
Changes in water availability can also change the way that animals interact with one another. Similar to West Nile Virus, St. Louis Encephalitis is spread by bird-biting *Culex* mosquitoes. Early spring drought drives *Culex* mosquitoes into dense, moist hammocks of vegetation cohabited by wild nesting birds, meaning land surface wetness changes will change animal-insect interaction rates (Shaman, 2013). Hydrological models that can predictively describe mosquito occurrence provide a key tool for identifying areas of potential disease outbreaks. Shaman et al. (2006) developed an ensemble seasonal prediction method that couples data on hydrologic conditions and human encephalitis outbreaks in order to predict infection risk two to four months in advance.

Emerging diseases linked to climate changes are not limited to novel pathogens but, indeed, also include old foes such as dengue fever (Florida Department of Health, 2012). Since establishment of a disease requires both the presence of the specific mosquito species able to transmit the pathogen and the arrival of an infected host, the probability of epidemic outbreak only increases if mosquitoes can overwinter in northern cities.

Across the nation, cities such as Philadelphia are seeking to meet their Clean Water Act requirements by increasing the number of green acres in an attempt to soak up and attenuate rainfall before it floods storm drain systems (Philadelphia Water Department and USEPA Region III, 2012).

While critics of the ‘green infrastructure’ approach may say that promoting runoff-capturing tree pits, bioswales and even stormwater wetlands might increase mosquito habitat if they fail to drain according to their design specifications, research suggests that reducing combined sewer overflow (CSO) events could in turn decrease ephemeral habitat for West Nile-carrying mosquitoes.

In a study conducted in Atlanta, Georgia, authors Vazquez-Prokopec et al. (2010) found a strong spatial clustering of West Nile cases in humans, blue jays and crows around streams affected by CSO events. The mosquito *Culex quinquefasciatus* breeds in polluted water and was found to have significantly higher rates of West Nile infection in streams affected by CSOs. By restoring the infiltrative capacity of natural areas in an urban setting, green spaces have the potential to reduce this particular source of West Nile risk.
Beyond Infectious Disease: Could There Be Other Threats to Health?

Urban communities face many health challenges posed by air quality problems. Soaring asthma rates, especially among inner-city youth, has led many to fear vegetation, like ragweed, as they are regularly implicated in seasonal allergies. Although urban trees have been shown to increase air quality and reduce asthma rates, someone with severe seasonal allergies may view every green leaf with suspicion. They would not be heartened to learn that pollen production is often higher in urban environments than in natural areas, likely as a strange result of increased CO2, nitrous oxides and other air pollutants in urban areas (Zielo et al., 2012). Artificially raised CO2 levels have been shown to hasten and increase pollen production in pine (LaDeau and Clark, 2006) and warmer temperatures are expected to both speed ragweed growth and dramatically increase pollen output (Ziska et al., 2009). Tracking public perceptions through research programs like the Baltimore Ecosystem Study of The Long Term Ecological Research Network will be critical for engaging communities in the future.

For more information, see: http://www.beslter.org/.

4.5 Implications for Managing Potential Health Risks from Natural Areas

If natural areas could increase human health risks, as in some instances they may – what might land managers do to help mitigate or avoid health problems from conserved lands? The many pathogens currently present (and likely to arrive) on natural lands present a complex challenge for management.

As will be discussed, for any long-term management strategy to be effective, it should be implemented with the cooperation of professionals such as officials from the local Mosquito Control District, medical entomologists and others with epidemiological expertise.

Monitoring and Mapping

Many state mosquito management programs and county mosquito control districts throughout the US have implemented sophisticated monitoring programs in order to target integrated pest management efforts more efficiently. For instance, Connecticut has established an extensive system of light traps baited with carbon dioxide that are used to collect mosquitoes weekly, June through October, in order to test them for the presence of arboviruses. Additionally, state-controlled wetlands are sampled for larvae in an effort to identify where larval insecticide application would be most effective and where landscape-scale management would be appropriate (CT DEEP, 2013).
Data Tools on the West Coast

Risk maps and real-time data feeds from state agencies provide a valuable tool for monitoring the threat of disease. “Fight the Bite” is the public face of a campaign that coordinates data between the California Department of Public Health, the UC Davis Center for Vectorborne Diseases, the California Department of Food and Agriculture, and the Mosquito and Vector Control Association of California. By providing a county-level count of West Nile Virus activity (defined as positive tests from humans, horses, dead birds, mosquito pools, sentinel chickens, and squirrels), “Fight the Bite” provides an informational platform and hotline for coordinating vector-borne disease information in the west.

For more information see: http://westnile.ca.gov

Public Education

Public perceptions of disease risk matter. Among a variety of things they can influence personal vigilance and willingness to spend time outdoors. Preventative behavior may play a large role in regulating final disease transmission risk, as insect repellent and long sleeves followed by a thorough self-inspection can dramatically decrease infection risk from mosquitoes and ticks respectively.

From a managing agency perspective, three key prevention strategies have been identified by Piesman and Eisen (2008) to combat tick-borne diseases:

- Encourage avoidance of habitats at the peak season of insect activity;
- Spread objective information about risk (maps, risk factors); and
- Educate about personal protection measures (clothing, repellents).

Innovative outreach can greatly improve the impact of ecological and epidemiological risk mapping. A team at the Yale School of Public Health led by Dr. Durland Fish has developed an interactive iPhone app to help users identify whether they are in endemic lyme disease territory, screen for and remove ticks, and, should they need, identify local physicians with relevant expertise (Yale School of Public Health, 2013). Their source map on human infection risk is based on a 2012 publication that is the most accurate eco-epidemiological assessment to date (Diuk-Wasser et al., 2012).

In the Northeastern U.S., peri-domestic exposure is cited as the leading cause of infection, whereas recreational activity is responsible for most exposure in the West. While personal protection is the most effective way of ensuring personal safety, people may be reluctant...
to use chemical repellents (e.g., DEET & permethrin) due to perceptions of possible toxicity. Although a number of natural alternatives derived from eucalyptus, catnip, geranium, lavender and cedar oils have been tested as alternative insect repellents, researchers have only described them as ‘somewhat effective’ and ‘show[ing] potential’ to date (Piesman and Eisen, 2008).

**Pesticide Application**

The classic example of a landscape historically feared as unhealthy comes from our perception of wetlands. Conditions that promote mosquito breeding, such as pooling or ponded water, puddles, drainage ditches and abandoned swimming pools increase the likelihood of disease transmission. The requirement for water in the mosquito life cycle has great implications for wetland restoration, but also for patterns of development that intrude upon intact wetland habitat. For instance, both proposed ‘green infrastructure’ solutions to the storm surge faced by NYC and the new wetland mitigation banking developments in New York State could face intense scrutiny for their effects upon public health (Feuer, 2012; Mascia and Brett, 2013).

In an urban population center such as New York City, the prerogative to protect public health and prevent a human epidemic often outweighs other public goods arguments. Manhattan was sprayed with the pesticide ‘Anvil’ as recently as the summer of 2012, in an effort to control mosquitoes that could carry West Nile Virus (CBS New York, 2012). Notwithstanding this, the application of pesticides is generally unpopular among many citizen groups, not the least of which are organizations charged with protecting the vitality of local ecosystems.

For example, the Massachusetts Audubon Society (Mass Audubon) has presented a comprehensive position on mosquitoes and mosquito-borne disease (as of May 2012) that is generally against widespread pesticide application. They make efforts to educate property owners on how to exclude themselves from nuisance control spraying but acknowledge that, in a declared public health emergency, even its own property holdings may be sprayed (Massachusetts Audubon Society, 2013).

In contrast to mosquitoes, ticks are rather more difficult to control through the use of pesticides because the nymphal stage is entirely terrestrial and hidden among forest vegetation. This did not dissuade Soviet pest-control experts from broadly applying DDT between 1965 and 1971, successfully reducing tick-borne encephalitis in the Soviet Union by 2/3rds (Piesman and Eisen, 2008). However, after the phase-out of DDT it took only two decades for encephalitis to rebound.
Fire Island: A Case of Applied Tick Management

Home to both a National Seashore and a year-round population that numbers in the low hundreds, Fire Island is a barrier strand off the southern coast of Long Island that provides a clear example of compromise between nature preservation and public health intervention. Complaining of extremely high risk of Lyme disease, communities embedded in the park have advocated for landscape-level vector suppression through pesticide application. This clashes with the mission of the National Park Service to preserve “unimpaired the natural and cultural resources and values of the national park system” – and especially with designation of Fire Island as a ‘Wilderness Area.’

Rather than broadcasting pesticides, a highly targeted strategy was deployed. As a result of multi-year research and collaboration with state agencies and Cornell University, the island is now home to a number of ‘4-poster’ devices that apply the pesticide permethrin to deer lured-in by grain dispensers. This targets ticks on their favorite carrier and limits application of pesticides overall. Proactively controlling ticks has been shown to decrease overall vector occurrence in the surrounding area.

Another popular method of tick control involves placing pesticide-soaked cotton balls in tubes around the base of a resident’s home. Foraging mice use the cotton fluff to build their nests and in so doing eliminate many of the nymph-stage ticks that both bite mice and propagate great disease risk to humans. This method has been investigated since the late 1980s, showing significant reductions in ticks in suburban settings (Mather et al. 1988).

A key prerequisite to any effective management plan is proper categorization of disease risk by a qualified medical entomologist. For a thorough risk analysis that considers climate suitability, host occurrence and actual reported human cases, see the comprehensive science synthesis paper written by Dr. Howard Ginsberg from the USGS Patuxent Wildlife Research Center at the University of Rhode Island.

For more information see:
http://wildlifecontrol.info/tickstudy/pages/default.aspx
http://www.nps.gov/aboutus/mission.htm
Landscape Management

The ‘Working Group on Land Use Change and Disease Emergence’ authored a research meeting report titled “Unhealthy Landscapes: Policy Recommendations on Land Use Change and Infectious Disease Emergence” (Patz et al., 2004). This policy analysis recommended a number of actions that may improve land management and public health, including:

- Bringing land use into public health policy discussions; and
- Promoting more research on deforestation and infectious disease, including:
  - Collecting more baseline data.
  - Improving disease and land relationship models.
  - Designing health-relevant decision support tools for land managers.

Smart design of parks, restoration of wetlands, and even routine landscaping create an opportunity to reduce the chance that disease vectors contact people or eliminate these vectors outright. Dr. Ginsberg comments that the ecologically and visually compelling ‘Sunken Forest’ on Fire Island had been an ideal habitat for ticks to lie in-wait for hiking visitors until the Parks Service built an elevated boardwalk, which both protected sensitive vegetation and reduced encounters with health risk (Ginsberg, personal correspondence, 2013 April 4).

Vegetation management is reported to be an effective means of reducing tick populations. Piesman and Eisen (2008) note that the controlled burns traditionally practiced by Native Americans across the East Coast consequently controlled both understory vegetation and tick populations. A number of leaf litter removal, brush management, cedar mulch and controlled mowing techniques may be more appropriate for heavily used properties, but can present a challenge for conserved lands. Increased sunlight, frequent mowing, wood chip, mulch or gravel perimeters all present a barrier to tick migration.

One corollary to this is that white-footed mouse density decreases as a function of distance into open space like old fields and it has been demonstrated that the density of nymphs and nymphal infection prevalence negatively correlates with distance from the forest edge (Horobik, 2001). In fact, in one study cited in a report from the Connecticut Agricultural Extension “Managing Ticks on Your Property,” 82 percent of deer ticks were found within nine feet of the forest edge (Stafford, 2005). On a broader scale, categorization of landscape features on residential properties in Westchester County, New York, showed that the abundance of nymphs decreased with the proportion, frequency and area of lawn (Frank, Fish, and Moyn, 1998).

Invasive plants can also tip the ecological balance in favor of unwelcome animal communities. Controlling invasive ornamentals may prove effective at removing niches that shelter disease vectors. For instance, Japanese Barberry is a landscape ornamental that has become a notorious invasive because deer eschew the shrub in favor of less spiky vegetation. As a result, thickets of barberry abound in deer-heavy environments, providing a particular safe haven for the white-footed mouse.
Control of the invasive barberry may well then have a positive effect on reducing suburban risk of Lyme disease. Land trusts would do well to pay even closer attention to the question of invasives removal, as one Connecticut homeowner asked in an online forum: “If someone has a conservation easement on part of their property that forbids removal of trees & shrubs, can they remove invasives like Japanese Barberry from the easement?” (Henderson, 2012 April 18; Musante, 2012 August 22).

Wildlife management and proper fencing can greatly reduce tick hitchhiking and overall population size. The explosion of white-tailed deer in suburban America is a familiar example of an animal thriving on both natural and peri-urban lands. Deer exclusion fencing reduced tick larvae, nymphs and adults between 74 and 100 percent in an area 300 feet from an electric fence (Stafford, 2005).

While certain backyard practices to “enrich habitat” may raise concerns about changing animal behavior and increasing disease exposures, Townsend, Ostfeld and Geher (2003) found no correlation between bird feeders and prevalence of Lyme disease, to allay one fear at least.

### 4.6 Possible Questions for Discussion

- Should land managers try to interpret and apply the results of statistical epidemiological models to improve public health? Are there significant barriers to this work or opportunities for collaboration?
- Does land conservation increase the amount of time people spend outdoors during peak insect activity?
- Would access restrictions and visitor registration policies improve epidemiological tracking?
- Are we doing enough to track the spread of invasive species? Does the answer to that question vary by region of the country?
- To what degree are insect control measures the responsibility of land managers and where should heavy pesticides be considered? Can we identify areas where pesticide use should be strongly avoided? Strictly limited?
- What liabilities do organizations acquire when they inform their members of specific health risks?

### Some of the Organizations Doing Interesting Work on this Topic

- U.S. Center for Disease Control and Prevention (www.cdc.gov)
- One Health Initiative (http://www.onehealthinitiative.com)
- EcoHealth Alliance (http://www.ecohealthalliance.org/)
- Cary Institute of Ecosystem Studies (http://www.caryinstitute.org)
- Yale University School of Public Health (http://publichealth.yale.edu/index.aspx)
improving human health by increasing access to natural areas: opportunities and risks

· Baltimore Ecosystem Study LTER (http://www.beslter.org/)
· California Department of Public Health (http://westnile.ca.gov/)
· National Parks Service Fire Island National Seashore (http://www.nps.gov/fiis/)

Works Cited / Useful Readings


4.7 Examples, sources of information and other key points from the discussion

Some of the examples, sources of information and key points from the discussion included the following:

- Participants noted that land trusts and other conservation organizations are already coordinating with local, state, and federal public health organizations/agencies to assure the safe use of natural areas for health promotion and better stewardship.
  - In its report From Fitness Zones to the Medical Mile, the Trust for Public Lands presents a number of new programs and places where efforts are being made to “maximize a park’s ability to promote physical activity and improve mental health.” This is discussed more in Appendix 2. For more information see: www.tpl.org/research/parks/economic-health-benefits.html
Participants noted that public perceptions of health risks from exposure to nature or time spent outdoors do not often line-up with realities. People will generally over-estimate the risk from rare events, like exposure to exotic pathogens, while underestimating real and preventable risks, like dehydration. There is plenty of work to be done — and partnerships to be forged — in the effort to change public perception of risk, both to lower real risks and to get more people outdoors.

- The One Health Commission is a great example of an organization doing such work. This non-profit organization was formed to further the mission of the One Health Initiative by establishing new communication programs and demonstration projects that can “transform the way human, animal, and ecosystem health-related disciplines and institutions work together.” Couched at Iowa State University, the Commission has key collaborations with diverse organizations including the American Medical Association (AMA), American Public Health Association (APHA), American Veterinary Medical Association (AVMA), among others. For more information see: https://www.onehealthcommission.org/en/resources/one_health_commission/

Unique Partnerships to Reduce Risk – Cornell Department of Communications and the National Park Service

In the effort to improve public perceptions of health risks from nature, the Cornell Department of Communications has partnered with the National Park Service (NPS) to fine-tune the messaging around the One Health Initiative (described earlier in section 4).

In a description of the collaboration the Cornell Center for Wildlife Conservation says: “Poorly crafted risk messages could decrease public support for species conservation, lessen tolerance for wildlife, or – in extreme cases – initiate backlash against certain species.” “Well-crafted risk messages,” meanwhile, “may be able to connect the concept of One Health and zoonotic disease risk to garner support for biodiversity and species conservation.”

Cornell professors with expertise in communications, ecology, entomology, and natural resource management are working with scientists and project leads at the NPS to craft new, accessible educational media for public consumption.

For more information see: ccwc.cornell.edu/index.cfm/group.show/Riskcommunicationwiththeo.70.htm

- In the urban environment better stewardship of existing open spaces can lead directly to public health gains. One workshop participant noted the success that a regional initiative in California’s San Joaquin Valley is having as they seek to improve community safety and children’s health simply by keeping school playgrounds open after school. Without requiring new infrastructure or transportation alternatives, such initiatives can expand access to open space almost overnight.
For a great source of information on the latest science of the benefits of nature in urban areas see the Green Cities: Good Health web portal, which forms a collection of good, recent peer-reviewed literature. See: http://depts.washington.edu/hhwb/Thm_ActiveLiving.html

San Joaquin’s Joint Use of School Grounds

In the neighborhoods of California’s San Joaquin Valley childhood obesity is a growing concern and open space, where children can safely pursue active recreation, is limited.

In response to these related issues, school officials and neighborhood residents have partnered with a public health organization, the Central California Regional Obesity Prevention Program (CCROPP), to easily expand open space in a surprising way: helping schools keep their park grounds and recreation areas open before and after school.

These school green spaces are already built and spaced across the community - but many barriers keep them closed after school hours, including liability and vandalism concerns. “When it comes to using school space … the liability issue can be a show-stopper,” one of the project leads noted in a review of the program.

Through creative collaborations and strong community engagement this initiative has already had some success, helping keep a number of school grounds open longer and later. For more information see: www.partnershipph.org/gallery/story/san-joaquins-joint-use-school-grounds-pixley

Participants also noted that there are many new resources from public health institutions detailing health risks from disease vectors in natural landscapes and, increasingly, management strategies for how to limit these risks.

Emerging Diseases from Natural Landscapes: More Resources

A number of new resources are available on the nature of risk from infectious diseases emerging from natural lands. Howard S. Ginsberg, workshop participant and a scientist at USGS Patuxent Wildlife Research Center, provided some information on where to turn for details on how to identify or manage health risks from some of the most common vector-borne diseases acquired in America’s natural landscapes:
Tick-borne

An excellent general resource for tick-borne diseases is the CDC website which has a page specifically devoted to tick-borne diseases (www.cdc.gov/ticks/). To determine which tick-borne diseases might be a problem in your area, consult the distributional maps on page 4 in the CDC publication Tickborne Diseases of the United States (www.cdc.gov/lyme/resources/TickborneDiseases.pdf).

Another useful online resource for information about ticks and about risk and management of tickborne diseases is the tick encounter website (www.tickencounter.org).

A valuable resource for information about ticks and the pathogens they carry, and practical information about tick management and tick-bite prevention (especially in the northeast), is the Tick Management Handbook by Kirby Stafford, published by the Connecticut Agricultural Experiment Station (www.ct.gov/caes/lib/caes/documents/publications/bulletins/b1010.pdf).

Mosquito borne

The major mosquito-borne pathogens in North America are arboviruses (arthropod-borne-viruses), with the most common being West Nile Virus (WNV), which causes one to several thousand cases per year. Other mosquito-borne viruses include Eastern Equine Encephalitis Virus, Western Equine Encephalitis Virus, St. Louis Encephalitis Virus, and Lacsrosse Encephalitis Virus.

These viruses typically present most risk to humans in late summer and early fall, and have distinctive geographical distributions. Maps of their distributions are available at the disease maps website (diseasemaps.usgs.gov).


Information about mosquito-borne diseases in general is available at websites of the CDC (www.cdc.gov/ncidod/dvbid/arbor/arbdet.htm) and the Association of State and Territorial Health Officials (ASTHO) (www.astho.org/Programs/Environmental-Health/Natural-Environment/) under the heading ‘Vector-Borne and Zoonotic Diseases’.

In cases where you are specifically concerned about vector-borne diseases at a given locale, I suggest contacting local or state health departments and mosquito control districts for specific information and guidance.”

– Howard S. Ginsberg, Ph.D., USGS Patuxent Wildlife Research Center

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