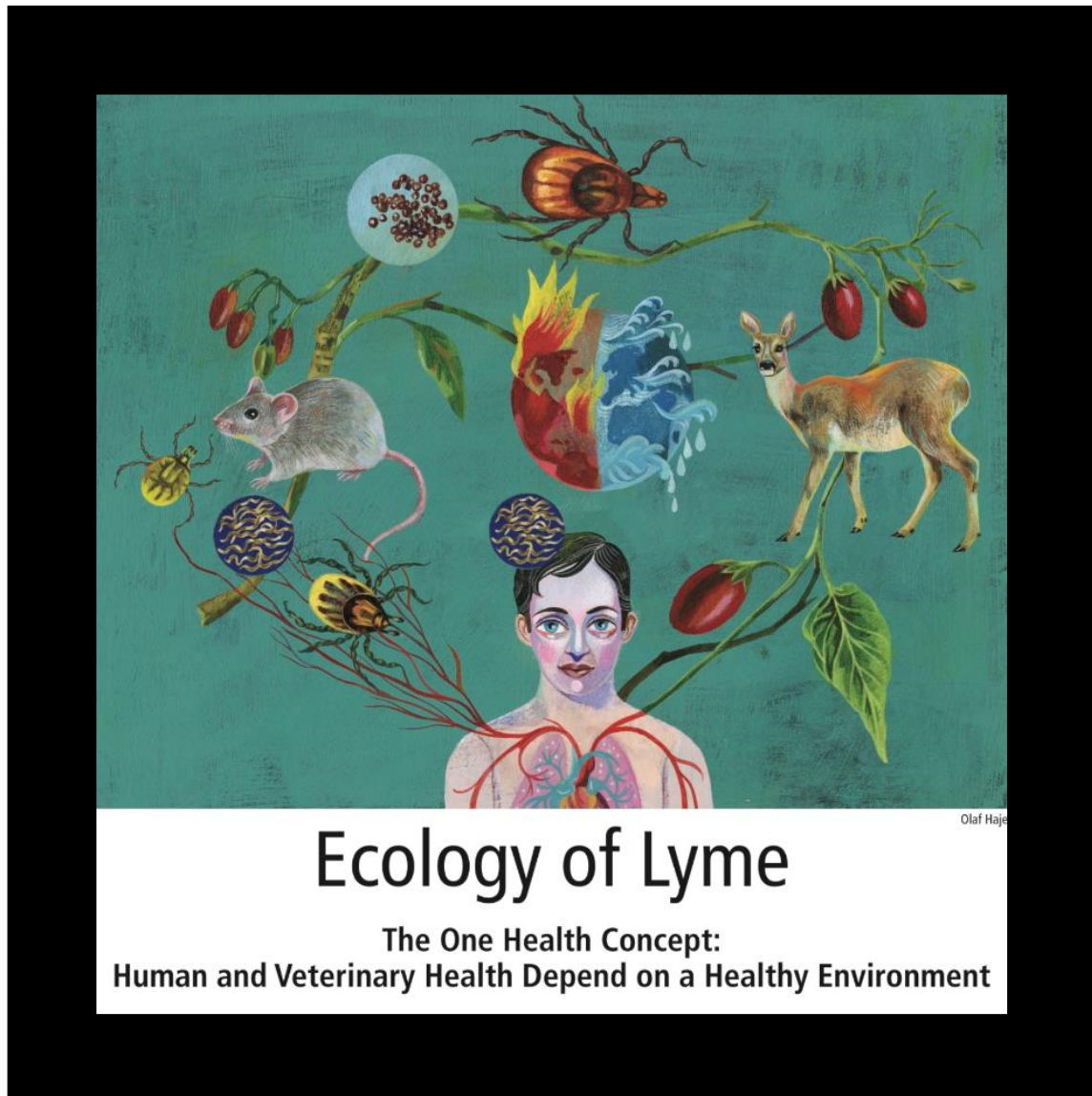


Reducing the harms of Lyme disease



Isabell MacInnes
Churchill Fellow 2018

Copyright © February 2020 by I. MacInnes. The moral right of the author has been asserted.

The views and opinions expressed in this report and its content are those of the author and not of the Winston Churchill Memorial Trust, which has no responsibility or liability for any part of the report.

All images by Isabell MacInnes unless otherwise specified.

Front cover image by Olaf. Ecology of Lyme (c) Olaf Hayek, 2017

Susan Elias at Maine Medical Research Institute as part of her PHD studies commissioned an artist to produce a drawing depicting Lyme disease. Hajek's colourful painting titled "Ecology of Lyme" includes multiple interconnected factors associated with the infectious disease — Earth being altered by a changing climate, a deer, a mouse, invasive Japanese barberry, and three stages of deer ticks. The painting also includes a person infected with Lyme bacteria.

CONTENTS

CHAPTER 1	4	
1.1 Acknowledgements		4
1.4 Introduction		7
1.4.1 Background to this project	7	
1.4.2 Why is it important	8	
1.5 Aims and Objectives of the Fellowship		9
1.6 Fellowship Approach		9
CHAPTER 2	10	
2.1 Tick collecting		10
2.2 Tick analysis		12
2.3 Mapping movement of tick across states/countries		14
2.3.1 Lone star tick	16	
2.4 Environmental		17
2.4.1 Mammals/Vegetation/ Habitat	17	
2.5 Management projects		20
2.5.1 Deer four posters	21	
2.5.2 Lyme shield for small mammals	22	
2.5.3 Impact of fire on tick abundance	23	
2.5.4 Land management projects	24	
2.6 Awareness raising and resources		25
2.6.1 Information posters	25	
2.6.2 Public information sessions	27	
2.6.3 Resources	28	
2.6.4 Western Isles promotion activities.	29	
2.6.5 Scotland's promotion activities	31	
2.6.6 Professional education	32	
2.6.7 Social research	33	
2.6.8 Online resources	36	
2.7 Healthcare		38
2.7.1 Tick testing for the general public	38	
2.7.2 Infectious disease clinic	38	
2.7.3 Lyme disease testing and treatment	39	
2.7.4 Surveillance	44	
2.8 National plans		46
2.8.1 Canada's Federal Framework	46	
2.8.2 France's National Plan	47	
CHAPTER 3	48	
3.1 Summary		48
3.2 Plans		49
3.3 Conclusions		50

Chapter 1

1.1 Acknowledgements

The Winston Churchill Memorial Trust Fellowship has given me the opportunity to spend six weeks meeting with professionals in USA, Canada and France who have extensive experience of researching ticks and tick-borne disease.

Undertaking this project has widened my professional perspectives and stimulated me to undertake academic research, which I hope, will add to the body of knowledge within the UK.

I would like to thank the organisations and staff that welcomed me and provided me with the opportunity to find out about the work they undertake in the different aspects that encompass Lyme disease.

United States of America and Canada



Maine Medical Centre Research Institute

Dr Rob Smith, Chuck Lubelczyk, Maggie Welch, Susan Elias, Libby Henderson, Danielle Cosenza and Rebecca Robich

The Connecticut Agricultural Experiment Station

Kirby Stafford, Megan Linske, Scott Williams, Mike Short, Goudarz Molaei, Doug Vuong, Alex Diaz

CDC Atlanta

Kathy Murray, Catie Peranzi, Sara Robinson

University of Maine in Orono

Allison Gardiner, Danielle Buttke

Public Health Risk Sciences Division at the Public Health Agency of Canada/University of Montreal in St Hyacinthe.

Dr Nicholas Ogden, Serge Olivier Kotchi, Catherine Bouchard, Erin Rees, Camille Guillot, Jules Konan Koffi ,Yann Pelcat, Ariane Dumas

Sandie Briand who works at the Institute National de Santa Publique de Quebec,

Robbin Lindsay and Antonia Dibernardo in Winnipeg.

Dr Ariane Adam-Poupart, Dr Alejandra Irace-Cima,

Ottawa

Rukshanda Ahmad, Michel Deilgat , Julie Theriault , Lindsay Colas, Annie-Claude Bourgeois , Karyn LaCroix , Anne Magnan who joined a conference call with me.

France



Sante publique France

Dr Julie Figoni, Sandrine Randriamampianina

Institute of Bacteriology, parasitology, and virology Strasbourg

Nathalie Boulanger, Pierre Boyer, Benoit Jaulhac, Laurence Filliaux, Marine Engel

Campus Veterinaire de Lyon

Karine Chalvet-Monfray, Magalie Rene Martellet

INRA Clermont Ferrand

Isabelle Lebert, Xavier Bailey, Maude Jacquat, Sylvian Dernas

Paris

Muriel Vayssier-Taussat

Vet-Alford in Paris

Sarah Bonnet

I would like to thank Dr Maggie Watts who encouraged me to apply for the fellowship and my employers NHS Western Isles who allowed me to take study leave to travel. Thank you also to my children Sarah, Joseph and Cameron and my extended family who coped very well without me for the two trips and finally my husband D.A. who travelled with me and drove me where ever I needed to go.

1.4 Introduction

1.4.1 Background to this project

I work as a Health Protection and Screening Nurse Specialist for NHS Western Isles. When I started working in Public Health in 2015, Graham Charlesworth a Vet in South Uist who is also my mother's neighbour told me "great you'll be able to do something about Lyme disease now!".

Since 2015 within my role as I have been working with my colleagues on Lyme disease, we looked at the recorded data and collated accurate figures, which confirmed the apparent high incidence reported in the Outer Hebrides when compared to the data from other areas in Scotland. Locally we produced resources including leaflets, posters, school education lesson plans and have undertaken health awareness activities to educate people on the risks and what actions they can take to reduce the risk of getting a tick bite as well as educate on how to remove an attached tick correctly. I participate on a group hosted by Health Protection Scotland, which operates to coordinate activities around tick borne disease for Scotland; this group has close links with Public Health England. Where I live on the Isle of South Uist is defined as a 'hot spot' for Lyme disease due to the higher than average amount of people that have been diagnosed with Lyme disease along with the population reporting an increasing incidence of tick bites. While this project was ongoing I began to look at the actions taken in other countries that reported a high incidence my manager Dr Maggie Watts who is a 'Churchill fellow' realised the opportunity overseas travel would give me to learn from other countries, her encouragement motivated me to apply.

The primary aim of my project was to understand how other countries have tackled the challenges associated with tick prevalence and the associated increase of Lyme disease. I hoped to explore the opportunities and messages used for raising awareness and the interventions used to reduce the risk of getting tick bites. I want to gain knowledge on the environmental, land management and ecological activities that undertaken to assess the risks and assess their applicability to our community. Through my travels, findings, and analysis I would like to be able to add to the knowledge that is available in the Western Isles, Scotland and the UK about ticks, Lyme disease and other relevant tick-borne disease.

1.4.2 Why is it important

Lyme disease is the result of an infection caused by the *Borrelia burgdorferi* bacteria, the bacteria is commonly found in ticks and people develop the disease following a bite from an infected tick (Public Health England (PHE) 2016). An early sign of the infection is an Erythema Migrans (EM) or 'bull's-eye' rash.



Erythema Migrans rash

Late Lyme disease is usually diagnosed when patients attend with symptoms such as fatigue, malaise, headache, myalgia, and arthralgia and subsequently Lyme disease is confirmed serologically. If untreated dissemination of bacteria to other tissues can occur leading to persistent clinical complications, these can include skin, neurological, cardiac, musco-skeletal and ocular manifestations. Lyme disease is the most common tick-borne disease in America and Northern Europe, with clinical presentations that range from acute to chronic illness. Most cases of Lyme disease can be treated successfully with a few weeks of antibiotics. However, despite the recommended antibiotic treatment a proportion of patients with Lyme disease report persisting non-specific symptoms of such severity that they influence the patient's daily life.

Similar to the Western Isles large increases in the number of human cases of Lyme disease are being reported across the world. In addition, considering the evidence of the impact Lyme disease can have on people's lives indicates it is a disease that merits further investigation.

1.5 Aims and Objectives of the Fellowship

- 1) To be able to add to the available knowledge in the Western Isles, Scotland and the UK about ticks, Lyme disease and other relevant tick-borne disease.
- 2) To utilise the evidence used by the countries I visit into our programs and actions; particularly in the areas of prevention and awareness raising, environment and land management.
- 3) To develop a surveillance tool that I can use to undertake a research study as part of a master's level qualification to gain a better understanding of the risks
- 4) To observe and learn from the models of the healthcare provision in primary and secondary care for people living with Lyme disease in Canada, USA, and France, identifying and applying relevant areas to Scotland and sharing these with the wider UK
- 5) To observe the current healthcare education, research, and training facilities and to use this knowledge to improve the education available to health professionals dealing with patients who have Lyme disease in Scotland.
- 6) To encourage and support original research into ticks and Lyme disease in Scotland
- 7) Dissemination and discussion of findings to various stakeholders and colleagues in the UK to aid the development of processes or pathways. This will include presentations to relevant conferences including the Scottish Public Health conference and the Five Nations (UK and Ireland) Health Protection conference

1.6 Fellowship Approach

While working on the local issues and devising an awareness campaign I looked for resources used in other countries this led to me reviewing some of the research and it became apparent that there is some discord with some aspects of tick-borne diseases. There is debate around the causes of the increase in tick bite reporting, regard to testing and treatment and those who suffer continuing symptoms.

Chapter 2

In this chapter I will give an overview of the work being undertaken in USA, Canada and France and identify how this relates to the work being undertaken within Scotland and the UK.

In all the locations I visited teams are dedicated to investigating the spread of disease carrying ticks and the disease agents they carry. The laboratories and professionals I met with have all been actively seeking to understand the environmental interactions of vectors, hosts, habitats, and climate with regard to Lyme disease. Monitoring the geography of risk and use the knowledge to increase public awareness of the threat they pose. Consistently the projects commence with analysis of tick abundance, location of ticks (peri-domestic or public areas) this information is then used to progress to testing management solutions as the project moves forward.

2.1 Tick collecting

The studies across all the research centres undertaken look at tick abundance, transmission hosts, and environmental factors and observe changes in these over the many years of data collection. This work helps to identify emerging pathogens within the ticks and how the environment or hosts have changed over the years. The importance of generating data over a number of years cannot be underestimated. The Vector lab in Maine has been carrying out field work in one particular area since 1994 that is 25 years' worth of knowledge. Nathalie Boulanger in Strasbourg has been involved in active field work since 2001. INRA in France is the world's second greatest producer of publications in the agricultural sciences, it was founded in 1946 and has 250 laboratories and 45 experimental units across 13 scientific divisions and 17 research centres and since the 2000's INRA has carried out research on Lyme disease.

The United Kingdom (UK) has started to undertake research studies more recently and there is evidence of coordination of the ongoing work. In Scotland, the James Hutton Institute in Aberdeen has undertaken ecological studies since 2010 and researchers and students at Glasgow University have tick- and tick-borne disease studies dating back to 2015. In 2014, the University of Liverpool's Institute of Infection and Global Health awarded funding to establish two Health Protection Research Units and one of these will be focusing on Emerging and Zoonotic Infections.

The development of the Health Protection Research unit in Emerging and Zoonotic Infections (HPRU EZI) has begun to bring together UK researchers and healthcare professionals across the UK by hosting conferences in 2017 and 2019, both of which I attended. The conferences offered the opportunity to review the work that is underway and discuss how to address some of the research gaps. UK studies are new when compared to the countries I visited but the conferences provide reassurance that knowledge is beginning to develop.

When reviewing published research it emphasises the importance of generating data through carrying out fieldwork and the researchers I met with have been involved in collecting ticks for many years, tick dragging activity is undertaken in a range of sites and includes parks frequently used by the public. When an area is being analysed the land is marked into transects and drags are generally performed each week through the project time. All the research sites I visited in USA, Canada and France used similar methods when tick collecting, this is a copy of the protocol used in questing tick surveys by Maine Medical Research Centre. This protocol was used in the studies of tick collecting in the Western Isles.

Maine Medical Research Centre Protocol for Questing tick survey

Materials

This method of surveying for ticks, at its most basic, does not require much in the way of technology. Much of the literature describes a tick flag or drag as being a piece of cloth attached to a pole and spread over the ground as the surveyor walks. Many studies record the use of either a heavy flannel or corduroy as the material to construct flags with. These two fabrics in many ways mimic the hair of a mammalian host that the tick might be seeking (flannel because of the fine hairs, corduroy because of the ribbing). In our studies, although we do occasionally use flannel, corduroy has proven to be more effective simply because it seems more durable in the field, especially after the fabric gets wet.

The general size of the flag is ~ 1-meter square.

Other items that are handy to have are a GPS unit for marking collections and a thermometer, which might be kept nearby for recording temperature while surveying.

Methods

To flag for ticks, one must first aim for collections on a day for good weather. Although the particulars for each tick species are different, these instructions, although general enough for common ticks, will focus on deer ticks, the vector of Lyme disease. Flagging for any species of ticks does not generally work during the rain or when temperatures are above 35c or below 10c. Likewise, days with lower wind generally produced better results. Higher winds desiccate ticks and lift the flag from the ground, where ticks might be found. Be sure to maximize the season to your advantage as well.



Dragging for ticks in Lyme, Connecticut and in St Hyacinthe, Canada

Many of the researchers I met with had personal experience of field surveillance and supervising students who carry out surveillance, so they are very knowledgeable on the results of previous sentinel surveys and the importance on monitoring the expanding edge of areas that have previously been recorded as demonstrating high tick abundance. It is beneficial to observe the situation in the areas out-with than to continually drag sites that are already recorded and known about. The data collection needs to continually expand further to check where the ticks are spreading to and collate information on the abundance of ticks in public sites and parks and also peri-domestic sites.

2.2 Tick analysis

The ticks collected during dragging are tested in the laboratories for the presence of *Borrelia*, more recently it has become routine to test for Myosotis, Babesiosis and Anaplasmosis and are looking at adding arbovirus into the panels. The laboratories infection prevalence in the different areas they collect ticks in the prevalence can range from 4-36%. Laboratories and researchers are improving knowledge on the presence of co-infections in ticks. Human studies have presented evidence of co-infections and there is acknowledgement that when they do occur it can lead to more severe and longer lasting disease than is seen with single infections. The continuous process involved in tick collecting and analysis allows the research centres to provide evidence of the bacteria's ticks carry.

PCR is used when detecting bacteria or viruses. It is a method widely used in molecular biology to make multiple copies of a specific DNA segment. Using PCR, a single copy of a DNA sequence is exponentially amplified to generate thousands to millions of more copies of the particular DNA segment. Maine medical Vector laboratory were looking at Powassan virus (Tick borne encephalitis in Europe), some of the ticks collected at a regular dragging location had tested positive relatively recently.

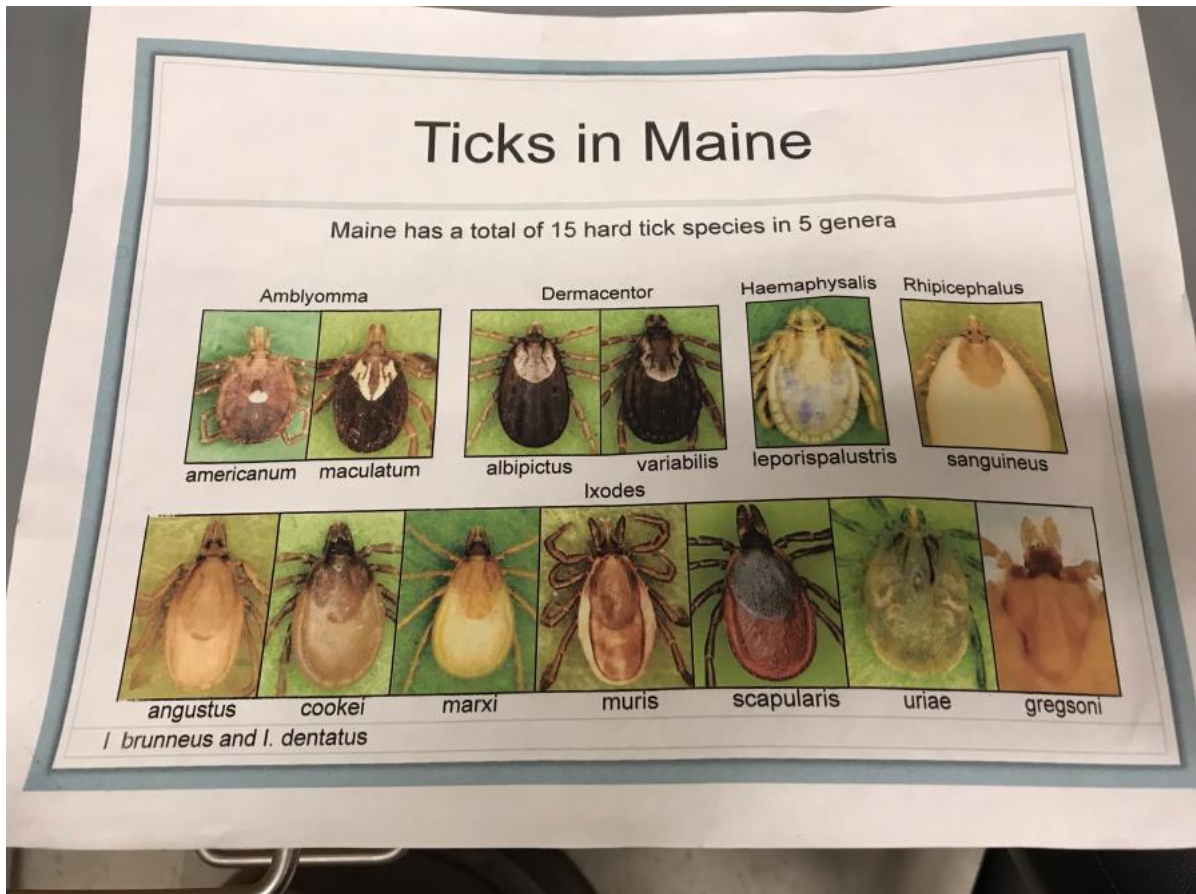
Powassan is a virus and is a +ve sense RNA virus. In humans we make RNA, which is single stranded and made in the nucleus, it can be turned into proteins within the body and fulfils its use within the body. Viruses or pathogens can be DNA or RNA; most vector borne viruses are RNA. DNA viruses integrate into DNA and can only be located in one host, RNA viruses do not enter the nuclei and can go from host to host which is true of tick-borne diseases. To start the PCR process the Powassan RNA has to be converted to double stranded cDNA, using reverse transcriptase and then the second step is to replicate it over and over again. Once replicated the cDNA is looked at alongside a control to identify the individual coding of each virus. Two different areas within dragging site had ticks positive for Powassan virus and the use of PCR allows for identification of the strains. This will demonstrate if it is the same strain at both sites and are they completely different strains. Once the PCR has identified the DNA code for the virus is matched onto a database where all codes are stored, this will allow for matching to any previously identified viruses. Once the PCR can identify whether the two groups of ticks carry the same DNA/RNA. If the DNA is different this type of information leads the research to look at other aspects such as the differences in vegetation or small mammal located at the sites and how these things impact on tick abundance and infection rates.

Host blood meal analysis would aim to find out which hosts the ticks are getting the blood meal from and organisations in USA are applying for funding to research this aspect more.

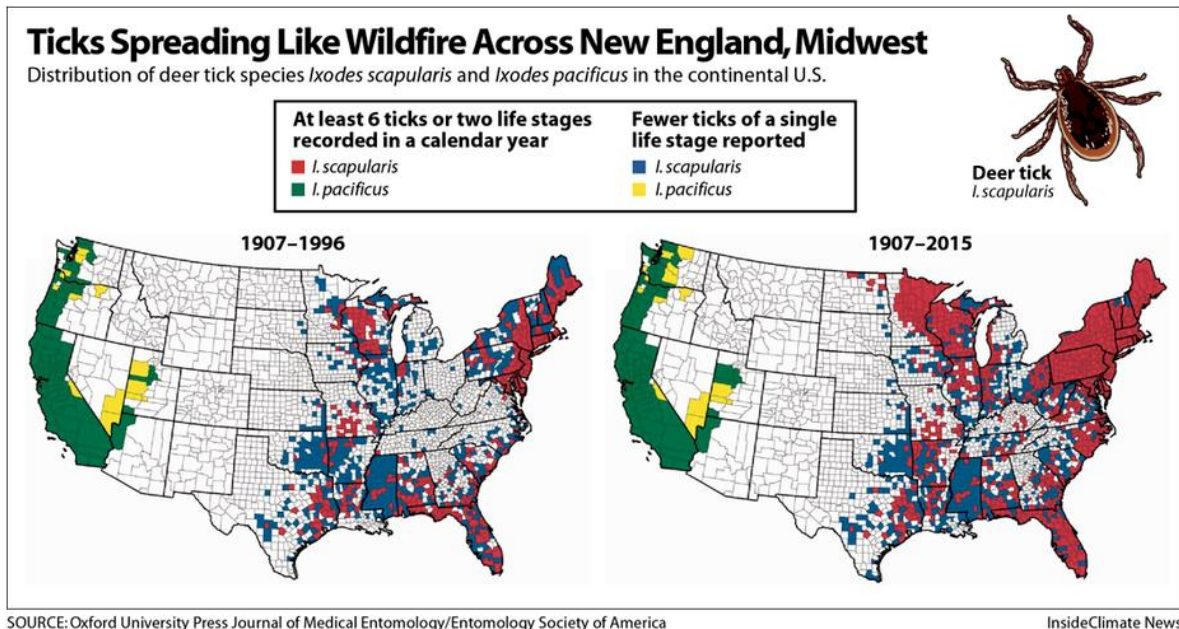
Tick ecology and surveillance is ongoing in the UK and when researchers identify that ticks are infected analysis to identify the bacteria takes place at the Rare and Imported Pathogens Laboratory (RIPL) at Porton Down in England. In 2019, National Services Scotland funded the development of a Scottish Lyme Disease and Tick-borne Infections Reference Laboratory (SLDTRL) within NHS Highland at Raigmore Hospital, Inverness. The aim of SLDTRL is to provide more comprehensive and standardised testing for Lyme disease and other tick-borne infections and to improve the epidemiological data provided to Health Protection Scotland (HPS). The laboratory in Scotland is predominantly use for identification of bacteria in human samples.

2.3 Mapping movement of tick across states/countries

Over many years the laboratory at Maine has collected ticks and identified the range of ticks that are found in Maine. The picture below shows the variety,



Ixodes scapularis (deer tick) is the most commonly associated with transmission of Lyme disease to humans in America, it is *Ixodes Ricinus* in Europe. The studies undertaken across the USA over the years have been able to map the movement of ticks along the country and identify any new species and strains of disease associated with the ticks.



In Canada Geographic Information Systems are utilised to map out disease, the authorities provide the data, which is then transferred onto maps, adding the information annually allows for easy visualisation of how a disease spread. The use of risk modelling has been able to predict the spread of Lyme disease and this has allowed for identification of high/low risk areas and could ensure surveillance activities were delivered in a targeted way.

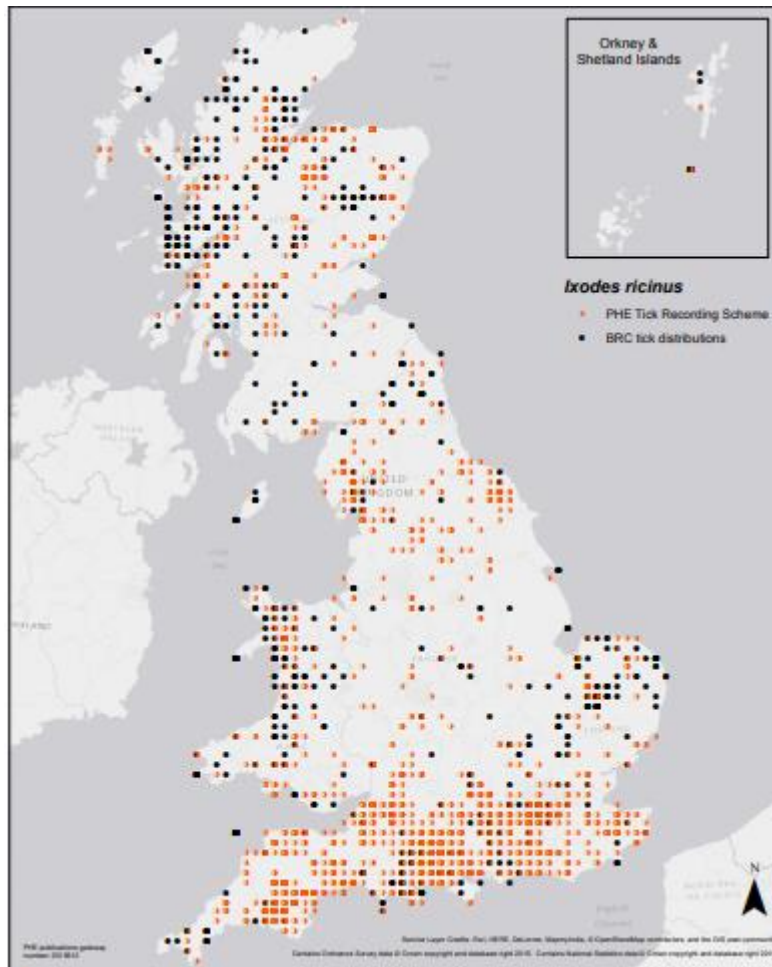
In France a multi-centre project has been building a tick risk map for France, the researchers are looking at the suitability for the presence of ticks. It looks at the landscape index, density of ungulates, density of humans and the climatic indicators.

The mapping clearly demonstrates the advancement of ticks into the countries, this information is achieved by the researchers who drag for ticks and record the findings. The availability of the information is the useful for warning people of where the high-risk areas are.

Mapping has commenced in the UK and Public Health England have a tick surveillance scheme and they use the Biological Records Centre data. The map outlines where *Ixodes ricinus* ticks have been found up to the end of 2015. Each point on the map represents a location at which this tick species has been recorded. Areas with no data do not necessarily represent areas of tick absence, but simply that no records have been received for that location. The main aims of the scheme are to

- Promote the surveillance of ticks in the UK
- Monitor tick distribution and seasonality on a nationwide scale
- Determine the diversity of ticks infesting humans and animals
- Detect non-native (imported) or rare UK tick species

The scheme relies upon members of the public, health practitioners, veterinary practitioners, wildlife groups and others to submit ticks to the scheme. The mapping is relatively new and not widely promoted. To improve data collection the scheme needs to be disseminated more widely and promoted with people to increase submissions.



Ixodes ricinus is the predominant species that bites humans across the UK. The Lyme disease bacteria are known to be carried mainly by small mammals, such as mice and voles, and birds, though larger mammals can also carry it. Ticks feeding on these animals pick up the Lyme disease bacteria and pass them on to the next animal they feed on. The principal tick that attaches to humans is the sheep tick, *Ixodes ricinus* but the hedgehog ticks *I hexagonus* and the fox or English dog tick *I canisuga* can sometimes attach too.

2.3.1 Lone star tick

Many people I have spoken to in the USA speak about this Lone star tick *Amblyomma americanum*, it is the most common tick in the south eastern USA and it has started to move through the states it has not been detected in Portland Maine yet but is abundant in Connecticut. The female is distinctive with the dot on its body-picture included



Test tube full of *Amblyomma americanum* collected by CAES.

Ticks seeking a host for a blood meal will wait on a blade of grass for a host to brush past, the tick will then take the opportunity to move onto the host and attach to the skin, the lone star tick seeks out hosts, it will move toward movement and sound.

The bite of the lone star tick is associated with an allergy to red meat. A delayed anaphylaxis develops in individuals that have previously consumed red meat without difficulty, this appears to be due to sensitisation to galactose- α -1, 3-galactose (alpha-gal), a sugar carbohydrate found in beef, lamb and pork but not humans. After a tick bite people may develop antibodies to alpha-gal and can have an allergic reaction upon subsequently eating red meat. The reaction occurs 4-8 hours after consuming the meat and may consist of itching, hives, swelling of the throat and anaphylactic shock.

2.4 Environmental

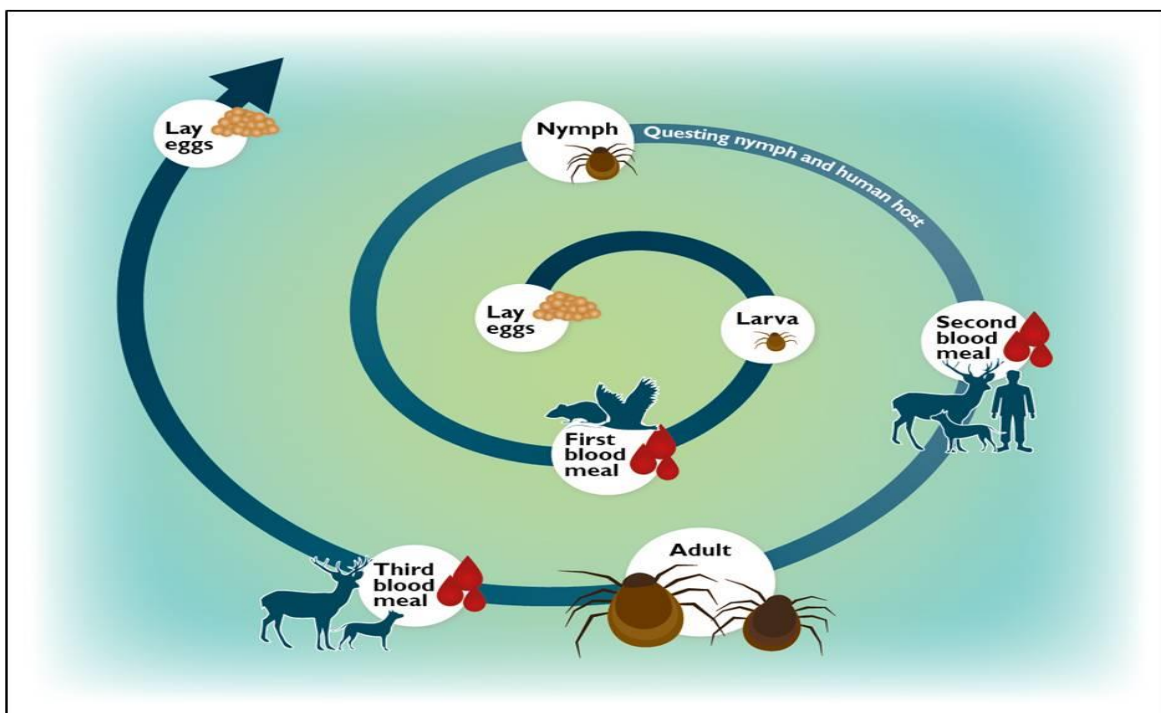
2.4.1 Mammals/Vegetation/ Habitat

While the techniques of tick dragging are used to collect ticks, researchers are also looking at the environmental factors that can affect tick abundance. Factors such as the presence of different types of vegetation, the evidence of which transmission hosts are located in the areas that are examined and the continual projects allow observation of factors over the years of data collection.

There are many examples of projects that have been used across research sites to look at how ticks cope and thrive in different environments. Projects look at host density and diversity; centres use motion sensitive cameras to record the mammals dwelling in areas and then comparing residential areas with woodland areas.

Sherman traps are used to humanly trap small mammals such as rodents, mice and voles, these animals are then examined for the presence of ticks, skin and blood samples can also be taken. These interventions allow for identification of the infections carried by the mammals.

The researchers acknowledge deer have a role to play in the increasing levels of ticks and Lyme disease. Deer are a large mammal that can host a lot of ticks which allow ticks to complete their life cycle.



There is acknowledgement within environmental studies that where deer dung is found there are high levels of tick populations and deer are also allowed to roam freely, other animals such as sheep, cattle, and horses are fenced into areas and owners use tick treatments regularly.

Data is also kept on the type of vegetation at any sites where ticks are collected this allows for inclusion in the analysis of the impact different types of vegetation can have on tick populations. In the USA two of the centres I visited were collaborating on a project that was monitoring the microclimate effects on tick survival. This collaborative project has been active since 2015. Ticks are placed in the ground in pots in a random block design, with mobile data and temperature loggers, throughout the winter the pots are kept in one of four combinations: Leaf and snow removal.

No leaf removal and snow removal; Leaf removal and no snow removal and No leaf, no snow removal, the study is looking to identify how the ticks cope in each of the combinations.

Studies have also identified the invasive plant and tick associations; ticks are predominately found in the thick undergrowth and this plant (shown below) Japanese Barberry which is non-native provides a cover for lots of tick habitat. It is one of many non-native species causing problems. More information available at: <https://wildseedproject.net/2017/07/invasive-plants-maines-ecological-puzzle>



In 2007-2016 CAES were involved in management of Japanese barberry, looking at ground cover estimates, dragging for adult scapularis ticks and trapping rodents as well as looking at the use of treatments to kill the plant.

The researchers have recognised the significance of forests in maintaining tick populations, there are two pictures following this paragraph, both pictures are taken one to the left and the other to the right of a path within a large forested area. On the left side there are lots of tall trees more tightly packed together with minimal amounts of ground shrubs this area is less friendly to ticks, while dragging the site I did not collect any ticks. However, on the right side of the path there are much more ground shrubs and the trees appear more spaced with more sunlight getting in this type of vegetation is very tick friendly and we successfully collected ticks on the drag.



In Scotland studies have identified that some management activities could lead to an increased risk of Lyme disease by increasing the habitat available for wildlife hosts and the tick vector. Activities such as woodland regeneration and biodiversity policies which increase the amount of forest bordering open areas as well as urban greening were proposed as factors. A suggestion was made that managing deer populations alongside the woodland regeneration projects, could reduce tick populations and therefore reduce the risk of Lyme disease. Studies at the James Hutton Institute in Aberdeen have demonstrated that deer are often key to maintaining tick populations, but do not become infected with the bacteria. The research provided evidence of a clear relationship between deer densities and tick abundance in Scotland, the research continues by testing for Lyme disease risk at a lot of sites with widely varying deer densities to test the impact of deer densities on Lyme disease risk.

It is acknowledged that management activities can potentially teach a lot about how changes to the environment can affect the chances of humans coming into contact with ticks and with the pathogen's ticks transmit. It would make sense that monitoring ticks and pathogens should accompany conservation measures such as woodland regeneration and urban greening projects. Thus, allow for appropriate guidelines and mitigation strategies to be developed, while also helping the development of a better understanding of the processes leading to higher Lyme disease risk.

2.5 Management projects

In this section I will discuss some of the examples of management strategies that I observed on my travels. Kirby C. Stafford the chief Entomologist at the Connecticut Agricultural Experiment Station (CAES) has published a Tick Management Handbook which is an integrated guide for homeowners, pest control operators and public health officials for the prevention of tick associated disease.

On my visit to CAES I found out about some of the projects that are discussed in detail in the handbook.

Food and shelter are essential requirements for wildlife and residential areas can be particularly attractive to deer and conducive to small mammals such as mice both species being recognised as important hosts in the prevalence of ticks and tick borne infections therefore managing their activity in your gardens.

Deer fencing is recognised as an effective method to control deer access to property, there are many types of deer fencing and selection will depend on the area to be protected, the site characteristics and the frequency and amount of deer invade your property. Deer fencing does not inhibit small mammal movement and management of stone walls, woodpiles, and dense vegetation as well as proper disposal of waste will help to reduce suitable habitats for rodents.

Deer reduction and management schemes through regulated hunting or controlled hunts are used to reduce the problems associated with deer overabundance. There are questions around how low deer densities should be, there are studies that demonstrate the incremental removal, reduction or elimination of deer has clearly been shown to substantially reduce tick abundance.

Passive treatment systems have been tested for deer and mice; I was able to observe both systems being placed in yards as part of an ongoing project.

2.5.1 Deer four posters

Four Posters- deer feeding/treatment method

A device termed a '4-poster' was designed for the application of topical acaricides to white tailed deer to prevent the successful feeding of adult ticks. It consists of a feeding station with four paint rollers that hold the pesticide. Deer self-treat themselves when because of the design, they are forced to brush against the rollers as they feed on the corn kernel.



Mike Short (research assistant) setting up the four posters

There are restrictions that have to be adhered to when setting up the four posters, they have to be 100 yards or more away from houses. Children and pets should not be allowed near them. The sites were selected when the team sent mailers to all the homes in the community they were targeting for initiatives. The homeowners who volunteer their area have to also take some responsibility for keeping people away from the site. Warning notices are also displayed.

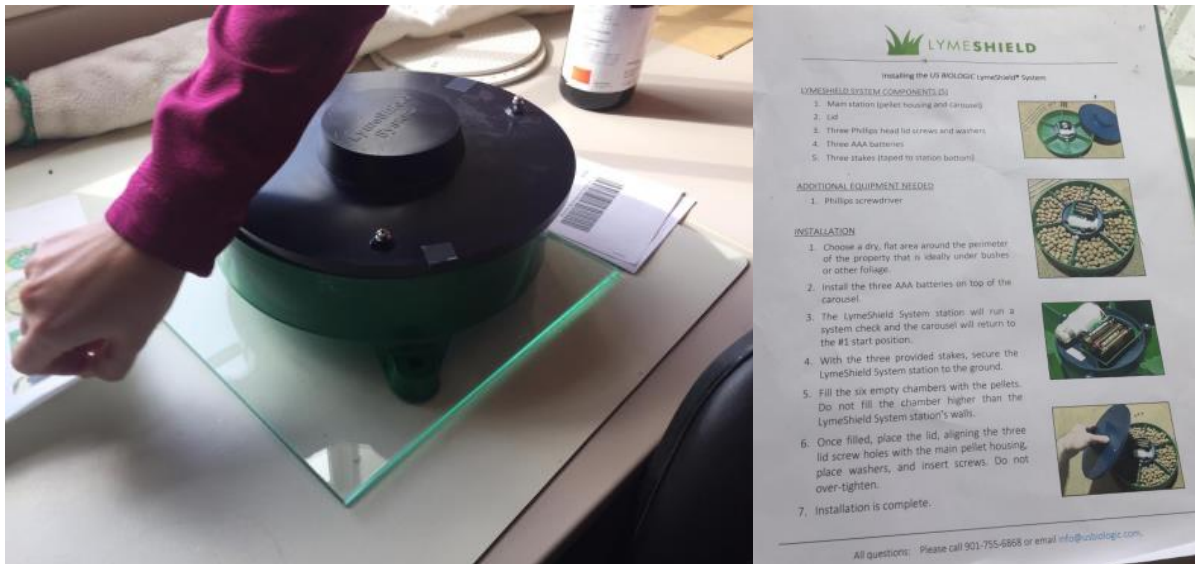
The evidence collected while the 4-posters were used demonstrated high usage by deer however when alternative food sources were available such as with heavy acorn mast or ample vegetation availability in the summer making it a device that is only effective in the winter. Maintenance of the system is labour intensive due to the need to replace the acaricide and the corn however the evidence suggested it was an effective alternative to area wide application of acaricides or drastically reducing the deer population.

2.5.2 Lyme shield for small mammals

Researchers had identified that the white footed mouse is the principle animal carrying the pathogens that cause Lyme disease. Habitats such as dense vegetation, stone walls, tree cavities and wood piles offer mice opportunities to nest and they will then stay within close range of the nest.

The first rodent targeted product tested was a cardboard tube full of cotton wool balls impregnated with the insecticide permethrin. The product was aimed at larvae and nymphs feeding on white footed mice.

The effectiveness depended on the nice collecting the cotton wool as nesting material, some projects demonstrated a successful reduction that other projects did not. Similar in principle to the 4-posters the Lyme shield is small bait boxes used to attract small mammals the projects were used to attract the mice in for food and in the process have to rub against sponges impregnated with tick treatment. This was found to be a very effective method and the prevalence of infection dropped dramatically in the first year and the population of nymphs substantially reduced after two years.



2.5.3 Impact of fire on tick abundance

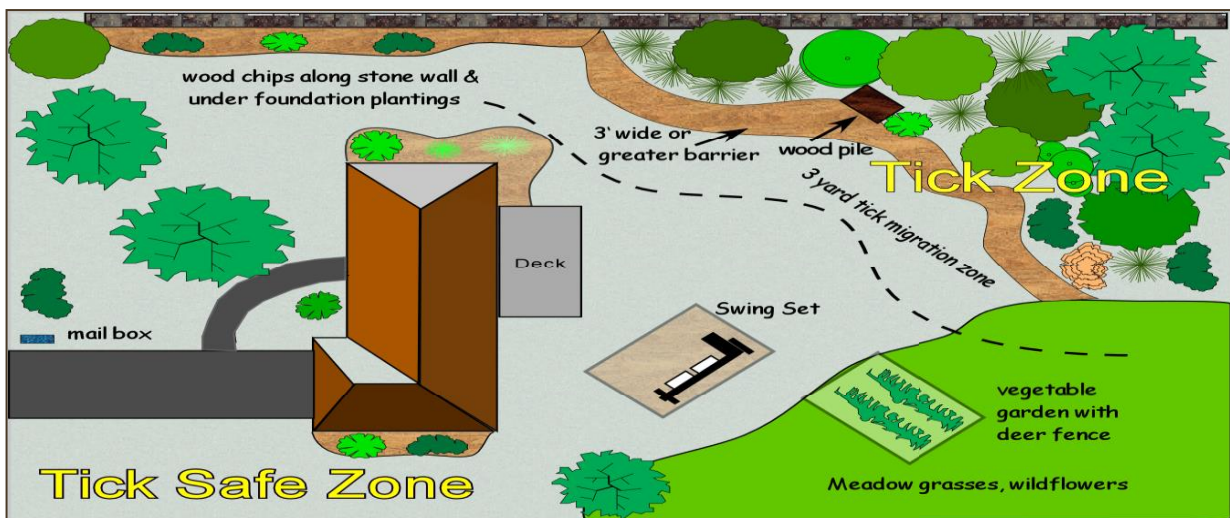
Muirburn in Scotland is the practice of burning off old growth on a heather moor to encourage new growth with the added suggestion that it will kill off ticks. This is a process that I hear people recommending as a tool to reduce the tick problem.

One of the researchers I met with mentioned a project that is underway to look at the tick abundance in Acadia national park. There was a large fire in the park in 1947 and the preliminary findings of current research into the prevalence and distribution of ticks in the park are demonstrating higher tick abundance in the parts that were affected by the fire. The study by the University of Maine will try to establish associations between where they see high densities of ticks and various environmental variables. The project is also going to observe habitat and vegetation changes in areas that have been burned in the last five years as the park use burning as a tool to manage vegetation. Previous evidence has demonstrated an initial drop in tick numbers following a burn but in the following years the numbers are higher than ever. It will be interesting to await the finding of this study to inform practice in Scotland particularly with muirburn.

2.5.4 Land management projects

Area wide chemical control of ticks has been tested where homeowners applied acaricides targeting lawn and woodland edges and perimeter areas near tick hot spots. The measures provide consistent control, but it has to be applied at the right time of the year. There are many restrictions to adhere to and many states have banned the use of pesticides in certain areas.

The properties I visited did not use fences to define areas/yards and many homes particularly in Connecticut are built very close to forested areas, the image below was within a leaflet to advise householders to develop an area around their plot to separate the garden from the forest with woodchips and this helps to inhibit ticks as the layer is dry and not hospitable to ticks. Deer fence is recommended around vegetables are planted and where children play.



A good example of the barrier between gardens and forests is seen in the picture below. Vegetation is cleared keeping the barrier dry and tick free.



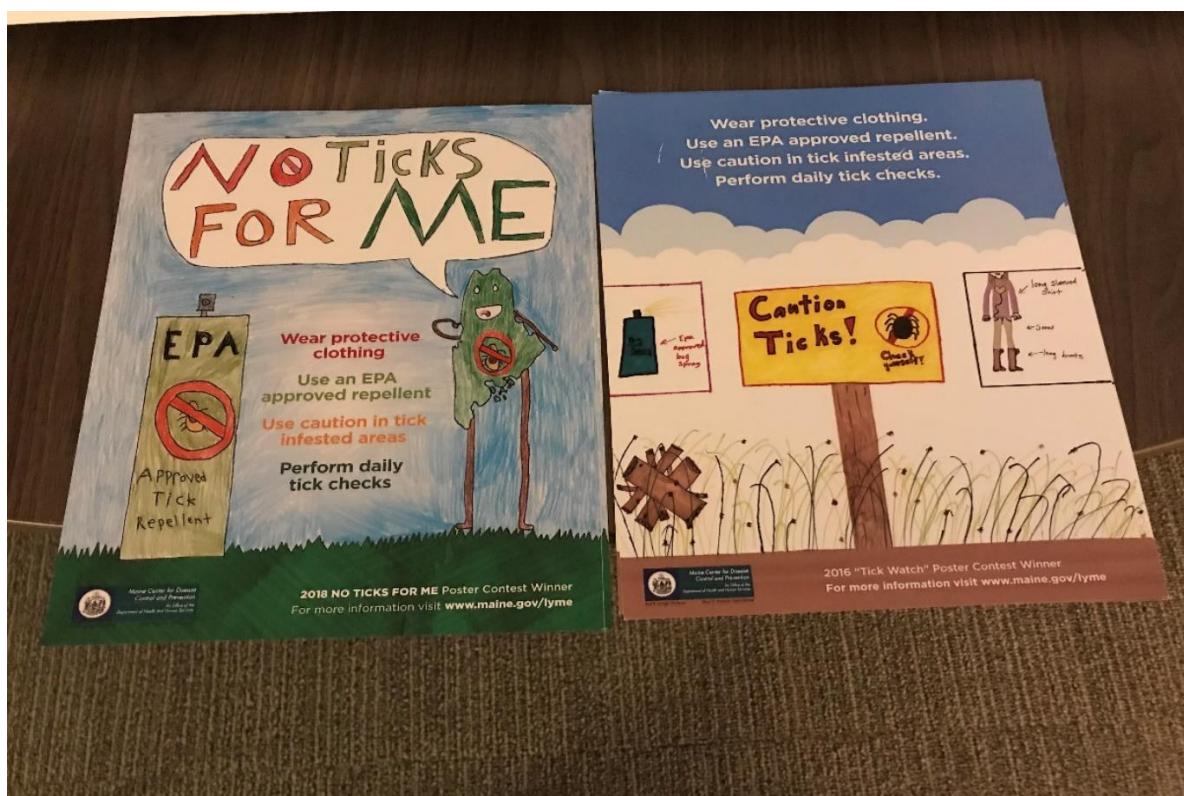
2.6 Awareness raising and resources

One of the main aims of my trip was to identify how other people manage awareness raising within the communities impacted by ticks and Lyme disease. All the researchers had a role with raising awareness by sharing the knowledge gained from studies, publishing findings, and speaking to the communities living in the areas where tick and Lyme research is undertaken. In USA, the Centers for Disease Control and Prevention (CDC) take the lead in producing resources, In Canada it is the Public Health Agency of Canada (PHAC) and in France Sante Publique. Examples of resources from the three agencies will be shown within the next few pages.

The main aspects discussed were producing and distributing resources and speaking to the public at formal and informal events.

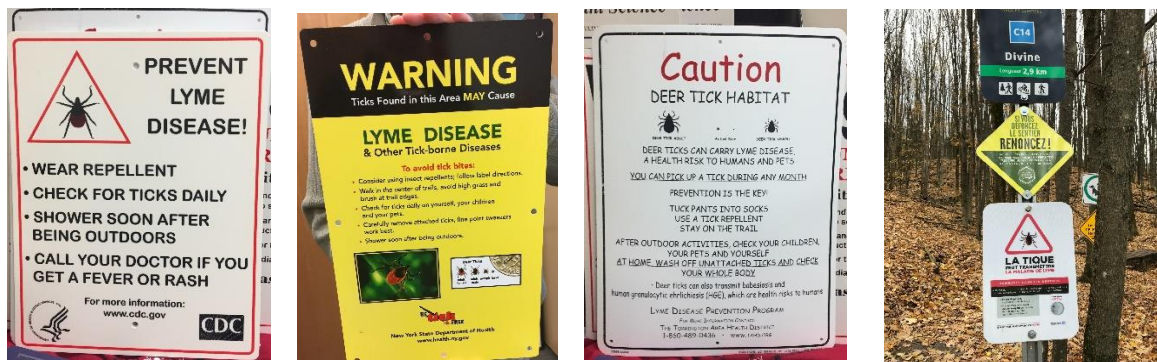
2.6.1 Information posters

CDC hosts an annual poster competition for local school children this is a good way to get families to consider the risks and the precautions that can be taken. The winning posters are then distributed widely for the next year. Here are two of the 2018 winning posters.

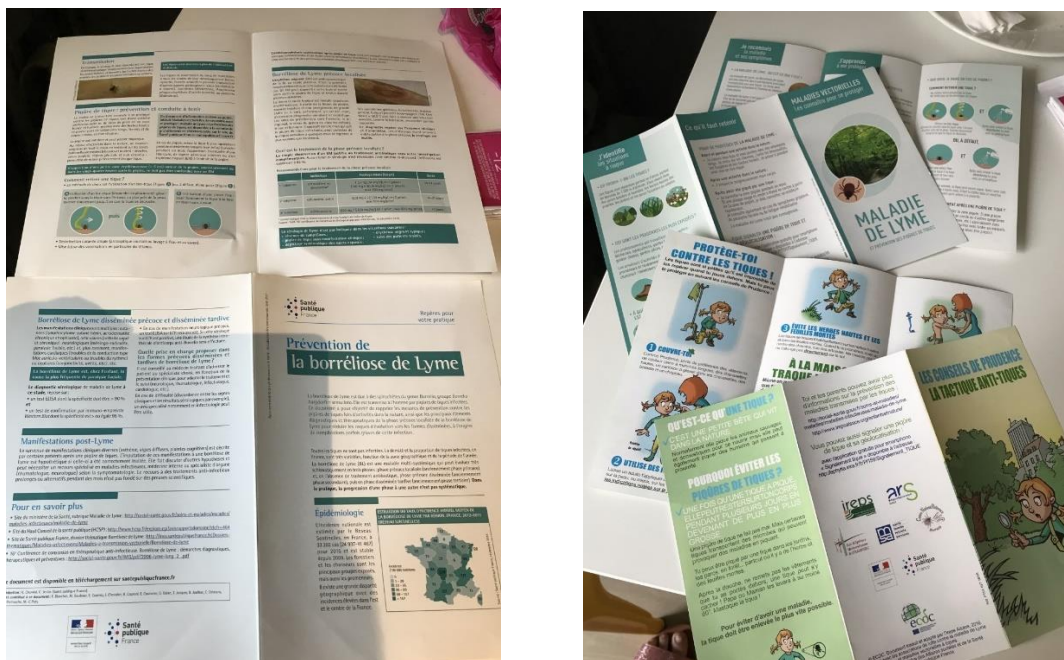


Participating in the competition is a good way to educate children of the preventative actions that can be taken to avoid tick bites. Activating a generational shift in attitudes and behaviours to tick and tick bites is important to address the increasing incidence being reported of tick-borne disease.

I looked for examples of warning posters to be displayed in the environments where ticks were found. I saw many examples as shown below.

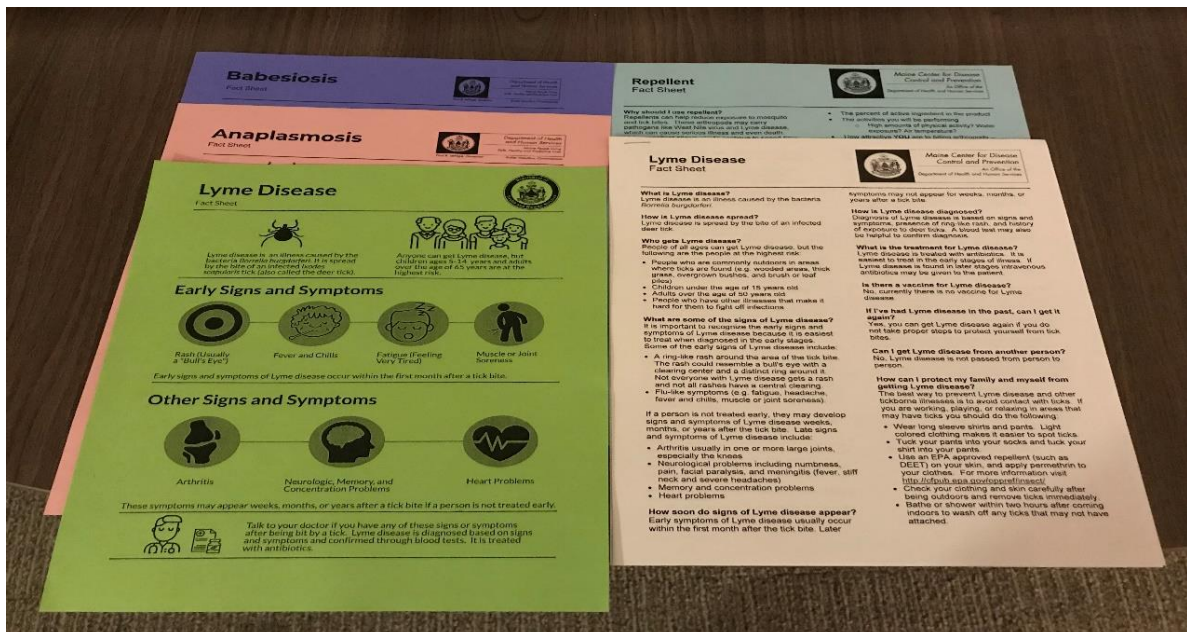


Information leaflets and posters are available in all the countries but a striking feature of them all was the large amount of text and lack of images used, most were structured using text. Sante Publique used cartoon images in a leaflet (shown below) which would be likely to encourage people to absorb the contents.



Catie Peranze at CDC told me her MSc project on health literacy, and she has spent time improving the resources available across CDC. The next picture demonstrates how she has improved the Lyme disease information sheet. The right-hand leaflet is the older form which was all words and not likely to encourage people to read it all on the left is Catie's new version in an easy to read format with plenty of pictures.

Both contain the same information and I think it offers a very good example of the importance of making resources as person centred as possible and consideration should be given to health literacy when producing patient facing materials.



2.6.2 Public information sessions

Health educators work across many programmes and ticks and Lyme disease is one of the areas they are involved in. In USA May is Lyme disease awareness month and many events are organised throughout the month as well as an active media promotion. In 2018 the retailer LL Bean who specialise in Outdoor clothing and resources had a home and Garden event where CDC staff hosted tables with information for the general public and distributed tick removers and literature.

I attended the annual open house event at Maine Medical Research Centre. The event is open to the general public and schools and universities are invited to bring students along. The aim of the event is to inform people on the scope of research being undertaken and give the opportunity to speak to the departments to find out about their projects. The Lyme and Vector Lab had a stall at the event.



Dr Rob Smith and Isabell



Dr Rob Smith and Susan Elias

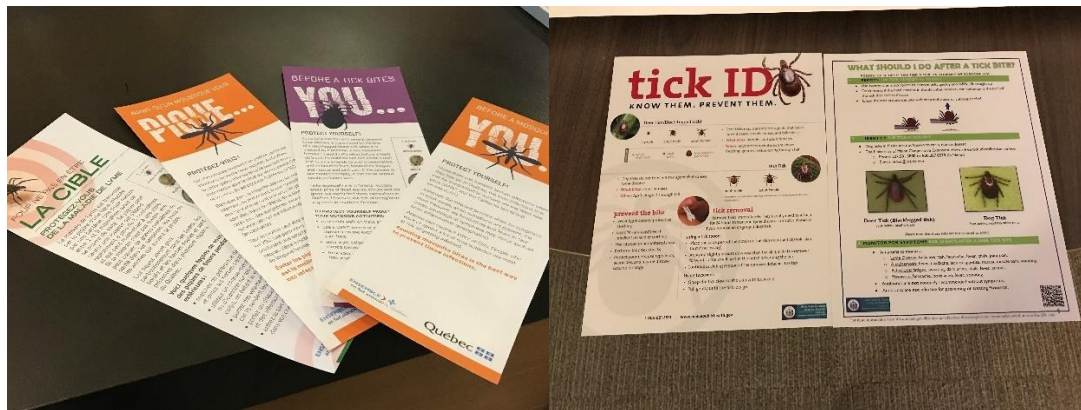
2.6.3 Resources

While at CDC staff shared with me some of the resources she uses in school, cards, magnets, leaflet, and tick remover tools. Kathy, Catie and I discussed tick removal tools. Catie had looked at my fellowship blog before our meeting and noticed that in the Western Isles we encourage use of the twisting tool for tick removal, we chose to recommend this tool as it was accessible locally (through the Vets) and it was easy to use. We did not recommend tweezers as we know people do not own the fine point tweezers and it would encourage people to use the blunt end type. CDC promote the use of fine point tweezers and it is a resource that they provide free to the general public at events, they also give out spoons both are pictured below.



The discussion we had agreed that there was not enough evidence to decided which is the best tick removing tool to use we all agreed it would be good to find a study that identifies which is the best tool to use.

The CDC, Sante Publique and PHAC produce the literature and purchase tools that they offer free to organisations that raise awareness of ticks and Lyme disease. Posters, cards, bookmarks, and information leaflets are distributed every year to National parks and emergency rooms and on a rotational basis to other departments last year they sent information to all elderly/geriatric services.



Posters and notices and local media information are sent to parks and areas where people undertake outdoor activities. This information is available in the high-risk areas and the distribution is done in the spring/summer seasons when there is a higher risk of exposure. Emphasis is placed on the precautions that can be taken to prevent tick bites and how to remove ticks.

2.6.4 Western Isles promotion activities.

In response to the acknowledged high incidence of cases of Lyme disease identified in the Western Isles, we identified the importance of developing a broad public health response to raise awareness in the local community and for those who visit these islands about precautions against being bitten by ticks and 'Tick awareness'.

NHS Western Isles developed and implemented an awareness raising campaign, producing, and promoting resources and education on 'Tick awareness'. We launched the materials at an event in South Uist on 30 March 2017. Following this, materials have been distributed for display to local shops, businesses, GP practices and a range of other venues across the Western Isles.

Leaflet:

How can you prevent tick bites?

Ticks don't jump or fly, but wait until an animal or person brushes past to climb on. Some simple steps to avoid coming into contact with ticks:

- Keep exposed skin to a minimum, wear long sleeves and tuck trousers into socks.
- Wear light coloured clothing so ticks are easier to spot and brush off.
- Walk on paths, avoid brushing against vegetation.
- Avoid take more care in areas with dense vegetation.
- You can use insect repellents containing DEET.

Reminder

Please remember to be tick aware.

- You could be exposed to ticks whenever you are outdoors and enjoying the countryside, even in your garden or the local park.
- Take extra care in, or avoid altogether, areas of dense vegetation.
- Ticks attach themselves to animals to feed and sometimes this can irritate people.
- You can prevent tick bites by walking on clearly defined paths, using insect repellent containing DEET and performing regular tick checks.
- Check yourself for ticks in the days after being outdoors.
- Some tick bites can result in infection so it is important to remove ticks as soon as possible.
- Ticks can be removed safely with tweezers or a tick removal tool.
- Do not squeeze, twist or squash the tick.
- If you have been bitten or recently spent time outdoors and start to feel unwell, contact your GP.

Further information and help

For further information please contact the Health Protection Team:

Email: wha@hpa.gov.uk
Tel: 01851 708033 or 01870 603366
or visit: www.lymediseaseaction.org.uk

We are listening - how did we do?

We welcome your feedback, as it helps us evaluate the services we provide. If you would like to tell us about your experience:

- speak to a member of staff
- visit our website www.whis.scot.nhs.uk/feedback or share your story at: www.patient@nhs.uk or 0800 122 31 35.
- Tel: 01851 704704 (ext 2438) on a Tuesday and Friday afternoon between 1pm and 5pm.

Date produced: January 2017 Review date: January 2019
Produced by: Health Protection Team, NHS Western Isles
Disclaimer: The content of this leaflet is intended to augment, not replace, information provided by your clinician. It is not intended for use as a substitute for professional medical advice. Reading this information does not create a medical relationship or any other health care provider. It is not a substitute for professional medical advice. If you are unsure, please contact your GP or other health care provider. © NHS Western Isles, 2017. All rights reserved.



Bòrd SSN nan Eilean Siar
NHS Western Isles
Health Protection Team

Ticks and Lyme Disease



Important health advice and basic precautions to help you and your family avoid tick bites

Ticks can transmit bacteria and viruses that cause diseases such as Lyme disease.

Although not all tick bites result in disease, it is important to know how to avoid tick bites and to take action if you or your family get bitten. Removing the tick as soon as possible reduces the chance of infection.

What are ticks?

Ticks are small, blood-sucking creatures which feed on many different types of birds and animals, including humans. During feeding they can cause infections that may lead to diseases. They are found in grassland, moorland and garden areas and are most common from April to October, but can be found at any time of year.

Ticks have a four stage cycle: the minute egg that hatches into a 0.5 mm, six-legged larva followed by a 1 mm, eight-legged nymph and finally the 10 mm engorged female. Larvae and nymph feed for 2 to 3 days then drop off into vegetation, where they develop and moult, ready for their next blood meal. Adult females feed for 10 days before laying eggs deep in the undergrowth.

Nymph is most likely stage of tick from which humans contract Lyme disease.



Image © Shutterstock

What diseases do ticks carry?

Ticks carry many infective agents that can affect animals or humans or both. In Scotland, Lyme disease, also known as Lyme borreliosis, is the most common human disease transmitted by ticks.

There are also other tickborne diseases which in the UK mostly affect animals, but which on very rare occasions can affect humans.

Tick check

Make it a habit to carry out a tick check - an easy way to make sure you haven't picked up any. Look over your clothes and body for any ticks to brush off.

When you get home, carry out a thorough check by removing your clothes and having a good look and feel for any ticks. Best practice is not to remove clothes in the bedroom, as ticks could remain on carpets/bedding.

Ticks prefer warm, moist places on your body, especially the groin area, armpits, behind the knee and along hair lines, so look out for anything as tiny as a fleckle or a speck of dirt.

Young children are more commonly bitten on the head/neck so they need to be carefully checked around the neck, behind the ears and along the hairline. Although it should be noted animals to animal/human transfer is very unusual, checking pet bedding is a good idea. A 60°C wash cycle does NOT kill ticks, so it is recommended to wash clothes after a tick check in a 60°C wash cycle (please check clothing temperature recommendations first).

Please note
If, following a tick bite, you feel unwell or develop a rash around the site of attachment please consult your GP.

What to do if you are bitten?

Infected ticks spread disease because bacteria and viruses can pass from the tick during the time they are attached to the animal/human.

If you do get bitten, removing the tick quickly and correctly can help reduce any potential risk.

- DO:
- remove the tick as soon as possible BUT ensure the tick is safely removed by using a pair of fine tipped tweezers, or tick removal tool.
 - grasp the tick as close to the skin as possible.
 - pull upwards slowly and firmly, as movements left to the skin can cause a local infection.
 - apply antiseptic to the bite area, or wash with soap and water and keep an eye on it for several weeks for any changes.
 - contact your GP if you begin to feel unwell with flu-like symptoms, joint pains, headache or fever and you were bitten by a tick or have recently spent time outdoors.

- DO NOT:
- squeeze, twist or squash the tick.
 - cover the tick with oil, lotions, chemicals or petroleum jelly.
 - try to burn the tick with a lit cigarette end or match head as these may increase the likelihood of the tick passing on a disease.

PLEASE NOTE:
Lyme disease responds well to treatment with antibiotics and is better when treated early. If you do visit your GP their intention will be to tell them you have been bitten by a tick.
There is no need for antibiotics or to see your GP if you have been bitten but have no other symptoms.
A rash which spreads out from the bite, resembling a bull's-eye could be the initial sign of Lyme disease.

Poster:



Ticks and Lyme Disease

Important health advice and basic precautions to help you and your family avoid tick bites

What are ticks?

Ticks are small, blood-sucking creatures which feed on many different types of birds and animals, including humans.

During feeding they can cause infections that may lead to diseases. They are found in grassland, moorland and garden areas and are most common from April to October, but can be found at any time of year.

Ticks have a four stage cycle: the minute egg that hatches into a 0.5 mm, six-legged larva followed by a 1 mm, eight-legged nymph and finally the 10 mm engorged female. Larvae and nymph feed for 2 to 3 days then drop off into vegetation, where they develop and moult, ready for their next blood meal. Adult females feed for 10 days before laying eggs deep in the undergrowth.

Nymph is most likely stage of tick from which humans contract Lyme disease.

Be tick aware

Please remember to be tick aware.

- You could be exposed to ticks whenever you are outdoors and enjoying the countryside, even in your garden or the local park.
- Take extra care in, or avoid altogether, areas of dense vegetation.
- Ticks attach themselves to animals to feed and sometimes this can irritate people.
- You can prevent tick bites by walking on clearly defined paths, using insect repellent containing DEET and performing regular tick checks.
- Check yourself for ticks in the days after being outdoors.
- Some tick bites can result in infection so it is important to remove ticks as soon as possible.
- Ticks can be removed safely with tweezers or a tick removal tool.
- DO NOT squeeze, twist or squash the tick.
- If you have been bitten or recently spent time outdoors and start to feel unwell, contact your GP.

Prevent tick bites

Ticks don't jump or fly, but wait until an animal or person brushes past to climb on.

Some simple steps to avoid coming into contact with ticks:

- Keep exposed skin to a minimum, wear long sleeves and tuck trousers into socks
- Wear light coloured clothing so ticks are easier to spot and brush off
- Walk on paths, avoid brushing against vegetation
- Avoid take more care in areas with dense vegetation
- You can use insect repellents containing DEET.

Useful Information

NHSinfo: www.nhsinfo.com

NHS 24: Freephone 111 www.nhs24.com

Lyme Disease Action www.lymediseaseaction.org.uk

Please note:
If, following a tick bite, you feel unwell or develop a rash around the site of attachment please consult your GP.

For further information contact the Health Protection Team
Tel: 01851 708033 or 01870 603366. Email: wha@hpa.gov.uk
Normal opening hours: 9.00am - 5.30pm. Out of Hours: Via Western Isles Hospital, tel: 01851 704704

Banner:

We devised a large banner which has a large easy read display using images with a small amount of text. The banner is circulated around GP practices, the local library, the ferry terminals, and cafes, and will be displayed at events across the islands to broaden the reach of the messages to locals and visitors alike.



Information packs have been delivered along with a tick removal tool and guidance to all schools, nurseries, and GP practices across the Western Isles. Local businesses were also invited to request a pack.

2.6.5 Scotland's promotion activities

The Scottish Health Protection Network Lyme Borreliosis group have co-ordinated the production of resources and also developed information pages on the easily accessed 'NHS Inform' webpages. NHS Inform is an online tool, used by the general public to access a range of health information.

The NHS Inform link: <https://www.nhsinform.scot/illnesses-and-conditions/infections-and-poisoning/lyme-disease>

The page has easy to read information on:

- Signs and symptoms of Lyme disease
- When to see your GP
- How you get Lyme disease
- Who is at risk and where are ticks found?
- Treating Lyme disease
- Preventing Lyme disease

- How to remove a tick
- Chronic Lyme disease

Further information is also available at: nhsinform.scot/bugs-and-germs

[file:///C:/Users/DA/Downloads/1_tick-lyme-disease-infosheet-20170810%20\(1\).pdf](file:///C:/Users/DA/Downloads/1_tick-lyme-disease-infosheet-20170810%20(1).pdf)

[file:///C:/Users/DA/Downloads/2_tick-lyme-disease-poster-20170810%20\(1\).pdf](file:///C:/Users/DA/Downloads/2_tick-lyme-disease-poster-20170810%20(1).pdf)

2.6.6 Professional education

Kathy works as the Manager for the Integrated Pest Management for schools programme in Maine and within her role she actively works with school nurses to support schools to manage the problems associated with pests such as cockroaches, mice, bed bugs, head lice and off concern to a lot of nurses ticks.

CDC arrange annual meetings with Dr's, Nurses and Pharmacists in regions- the intensity of information does depend on the risk in the area. Maps demonstrate not all areas are affected so it is important to target activities that are relevant.

A project is being developed by the University of Maine which will collaborate with private landowners looking at tick borne risk. The project will look at the impact a range of land management practices have on tick borne disease. The project will look particularly at the impact of timber harvesting and forest management and compare to other areas that are just left with no management at all. The project is in its infancy and plans include dragging for ticks, mammal trapping and how the burden of ticks' changes depending on the land management practice in the areas. It is hoped the project will generate recommendations for the best practices. Others aspects to the project are to collate information on landowners knowledge on tick borne disease and what actions do they take to protect themselves as well as educating and encouraging landowners to undertake tick dragging on their own land to monitor for tick burden and how that changes.

The Ministry of Health in Canada area involved in awareness raising activities, this includes distribution of notices to parks, projects with outdoor workers and their employers to increase awareness, developing E-learning videos and educating workers to collect data in their own parks. They are also developing a 'train the trainers' event and extend the range of parks they work with and widen the project to include public education. Some other ideas being considered are offering free bug spray (insect repellent) with the hand gel in parks.

In all countries online resources are available to aid health professionals with diagnosis, testing, and treatment and with the identification of ticks.

Health Protection Scotland in collaboration with NHS Education for Scotland have developed a resource for professionals to access- below is the link to the resource.

https://www.nes.scot.nhs.uk/media/4167645/ticks_and_lyme_disease_in_scotland_revised_july_2018_slides_with_notes.pdf

2.6.7 Social research

A theme in all the countries was the importance of engaging with the general public to collect information of behaviours and actions with regard to ticks and tick-borne diseases. Many studies have been published about risk factors and action that can be taken yet it appears these recommendations are not being adhered to. There are studies which have looked at the interaction the general public have with any research findings, an example is a National Park in USA which has a high incidence of ticks that are positive for borrelia with a positivity rate of about 30%. A high number of visitors go to the park each year with a subsequent high level of visitors going on to report they have Lyme disease following a tick bite in the park. An initial survey looked at how visitors think climate change will impact on the park, the survey had not been looking at tick borne disease initially, but it turned out to be one of the most common themes in the responses. This led to the opportunity to look at tick borne disease and combining social research as well as environmental research.

In the three countries I visited many tick collecting projects are undertaken in national parks or areas frequently used by the general public, some of the larger parks have over 70 different sites being sampled by blanket dragging for ticks and small mammal trapping to identify the areas with higher tick abundance. The information will be used to develop a risk map for the area, this information will be combined with the social research aspect which is to look at where visitors go in the park and the activities they undertake and the two sets of data will be combined with a view to targeting risk messages for the area's most used by visitors and most affected by tick burden.

One of the research projects used questionnaires to collect information from visitors to a national park, the aim was to understand visitor's knowledge and the preferred prevention behaviours they used. Researchers attend the park with the survey and directly asked people the questions and one of the most noticeable findings was people would say they knew to tuck trousers into socks as a method to reduce risk but on looking at the person they had **NOT** taken the precaution (not tucked trousers into trousers). This has led to consideration for activities that prompt people to look for ticks before they leave the park, ideas being explored are signs at the trails with magnifying glasses and pictures of ticks or making one of the toilet cubicles a tick checking area with mirrors

Danielle Butteke works with national parks to prevent and manage human, animal, and environmental health issues. She helps the U.S National Park Service take a holistic approach that is needed to understand, protect, and promote the health of all species –the concept of One Health– because human and animal health are inextricably linked. There is a lot of discussion around how the general public perceives Lyme risk and recognises the importance of sharing the knowledge of tick abundance with those in the areas affected. It has been suggested that the sharing of this information needs to improve as many people are not aware of the risks. However as with the example above people know the risks, they choose not to take the precautions. Research has identified that people attending the parks know a lot about ticks and tick-borne disease but not everyone was clear about tick removal and when this is discussed there are still many people who remove ticks incorrectly, some of the examples given were removing the tick by squeezing it between their fingers, covering the tick with Vaseline or a plaster or covering it with alcohol. All of these methods increase the likelihood of the tick regurgitating into the blood stream of the person it is attached to making it more likely that bacterial transmission will occur. Therefore, these responses will be used to develop areas of education; there was a suggestion that at the exit point of parks tick checking booths could be set up where people have access to magnifying glasses and tick removing tools to check themselves and remove ticks if any are found.

Prior to the development of the national plan in France a population study looking at knowledge, attitudes and behaviour was undertaken. 65% of respondents had heard of Lyme disease 1 in 4 people had been bitten and 1 in 5 thought they were at risk of exposure to ticks. The study demonstrated that it did not present as high an issue as other public health matters such as vaccine preventable disease like meningitis. It is therefore important to find the correct balance of the actual disease burden when compared to other conditions but to also ensure people are aware of the risks particularly in the acknowledged high-risk areas. Actions should be appropriate and should not be alarmist it is imperative that people continue to enjoy the environment and participate in outdoor activities. This was also discussed with me in France the suggestions that Lyme disease has been portrayed to everyone as a disease to be fearful of is thought to be of social construction as the perception of the illness is thought to be made worse through publicity and through media. Another French study was developed to look at peoples fear with the hope the results could be used to modify public health policies to help the prevention policies against ticks. The researchers wanted to gain an understanding of how people view the risks for themselves and their families and how they view the media constructions of the risk. Many social approaches were used within the study and in the rural areas of Clermont Ferrand where cases of Lyme disease have been recorded for approximately 50 years, discussing ticks was not new to the resident population there. Contact with ticks is expected and the people know how to cope, and they do not fear them.

Generally, people integrate the management of ticks into their life, they see it as normal, they do know many people with Lyme disease, but they do not see it as a big problem. Their view is that climate change is a factor causing the increase in the problem.

In the study in cities the results are very different, generally people have no experience of ticks and their knowledge is based on the information provided by the media which has been seen as scaremongering. The study found that people interpret the media messages as 'ticks make you ill' and 'you should avoid forests/trees', people link forests and mountains with tick risk. This understanding is a public health problem as it is causing people to stop taking part in outdoor activities.

The study identified that people need to be informed going out and speaking to people to provide information and challenge peoples interpretation of the media messages. Using the knowledge from published papers on tick risk, and the precautions that can be taken as they are key in prevention of Lyme disease. Social conflict theory demonstrates that information such as in the media can be taken at face value- people do not find out any other information or explore other views on the topic. This study found that speaking to people and explaining the risks can lead to people changing their mind. Although not everyone responds to this method, many farmers in France have Lyme disease and behaviour change education has been targeted but they are not willing to change. Health professionals, students and the general public especially those with children are very open to the behaviour change messages.

It is imperative that professionals help the public to have a better understanding of tick's and tick-borne disease people have become afraid of ticks and the risk they pose. There is acknowledgment that 10% of people with Lyme disease will have prolonged impact from the disease, the media will offer a lot of publicity to this group of patients when discussing Lyme disease. The arguments are not balanced by speaking to the 90% of patients who have tick bites, developed Erythema migrans received the correct treatment in a timely manner and once the treatment is complete and they suffer no further ill effects. These opinions can be changed by giving the correct information, clarifying that there are actions that the public can take to reduce risks of bites and then ensuring people recognise when they are developing symptoms that require to be treated.

At a recent conference I attended in Liverpool it was evident that there is a distinct lack of research evidence across the UK in the behavioural aspect of ticks and Lyme disease. Access to this knowledge would help target public messages and evaluate their impact, this has been acknowledged as a priority area for future studies across the UK.

2.6.8 Online resources

The expansion of tick across countries has encouraged researchers to look at methods to inform the general public about risks. An online resource is in the early development stages in Scotland at the moment, so it was useful to find out about some of the online resources that exist in other countries.

Ecocast

In the US staff at Maine are involved in a group looking at Innovations in Science and they are scoping a resource similar to weather forecasting for ticks. The jelly fish forecast tool operated by bigelow has expanded to include tick and it is generally used to record where the general public encounter ticks. The tool can be accessed: <https://eco.bigelow.org/>.



The staff at Maine are looking at a resource that includes more information such as adding prevention information with the risk messages being adapted to differentiate between different areas, this requires the public to add information and details this can also include pictures of the ticks. The group want to engage with relevant partners to promote the page.

Tickencounter

Another public engagement online site is from Rhode Island University 'Tick: ncounter.org'. The site can be accessed with this link: <https://tickencounter.org/>. This site has lots of information provided by people, but it also includes a link for people to send ticks for testing.

etick.ca

This is a public platform for image-based identification and population monitoring of ticks in Canada. The site has been developed in recognition of the emergence of Lyme disease and the rapid geographical range expansion of certain tick species in Canada are important issues for public health authorities and the public in general. Following tick populations on such a large territory is also expensive and logistically challenging.

The citizen science project *eTick.ca* therefore invites the public to participate in the monitoring of ticks in Canada by submitting tick photos on *eTick.ca* for identification by a professional. The identification results combined with other data such as collection date and locality can then be consulted and mapped so that all users may visualize the information related to any/all species for any given year and/or geographical area. Access to *eTick.ca* is free and it is not necessary to contribute data in order to consult the database. The site can be accessed with this link: <https://www.etick.ca/en/>.

The University of Montreal in collaboration with other organisations are currently looking at a project to develop a tick app. If funding is secured it will be an integrated tool for tick borne disease prevention and public health surveillance. Tick and Lyme risk is different across the regions of Canada therefore the risk communication messages would have to be adapted - the traditional communications activities delivered through websites and media would not be able to differentiate the messages for the changing risk areas.

Freqrando project

This project is looking at the human use of walking trails in Metropolitan France. It is hoped the information provided by those hiking will make it possible to estimate the human exposure to tick bite, to identify the risk of bites and to propose preventative measures. Hikers are asked to register the area they are hiking by providing GPS co-ordinates and completing a questionnaire. It can be completed online, and it is promoted widely. This is the link to the reporting portal- if you open it in Google chrome the settings should translate it into English <https://www6.ara.inra.fr/epia/Sites-Web/FREQRANDO>. The reporting portal also includes information on ticks and tick removal.

Fleatickrisk

This is an online tool I heard about while in Lyon, it is a forecasting model that uses meteorological data to predict activity in different climates. Weekly updated maps show the risk of infestation by ticks, fleas, mosquitoes, and sand-flies in Europe to adapt pet's treatment to protect them from parasites. This site can be used by people to check the area they are visiting for tick risk. The site can be accessed with this link: <http://www.fleatickrisk.com/>

Climatik

This is a multi- site project across France. It started in 2014 and each area is collecting ticks to observe the changes. Each site uses the same protocols and tick collecting is undertaken each month. The ticks are analysed to identify the pathogens they carry.

OHTICK

This project is a one health approach to identify the pathogens transmitted by ticks, pathogens that could be responsible for the unexplained syndromes suffered by many people particularly in those where Lyme disease has been excluded. The project follows on from a previous online collecting tool that had been piloted in France called citique. OHTICK is a multi-disciplinary project combining veterinarians, doctors, scientists, and sociologists who will work collaboratively to better characterise the diseases that are transmitted by ticks.

The project objectives included detecting, identifying, and isolating the microorganisms collected from patients and animals that have been bitten by ticks, demonstrate the ability of ticks to transmit these agents and to provide elements for better management of tick-borne diseases. The project is over four main sites in France and is projected to last for two years. Here is the link to read more about the project: <https://www.ohticks.fr/en/ohticks-2/>.

2.7 Healthcare

2.7.1 Tick testing for the general public

In CAES the general public are offered the opportunity to bring ticks that have bitten them to the Lab for testing. In the height of the summer they can have up to 100 ticks taken in every day. 2017 saw around 5000 ticks tested, we were at the Lab on 24th October 2018 and 3 ticks had been handed in.

The ticks are tested for Borrelia, Babesiosis and Anaplasmosis and if the tick is positive for any of the bacteria's the laboratory staff commit to contacting the person to inform them that the tick was positive and that they should seek medical advice with regard to receiving appropriate treatment if required.

Being bitten by a tick does not always mean a person will contract Lyme disease, if the tick is removed quickly (within a few hours) and correctly (without squeezing the body of the tick) there is less likelihood of the bacteria being transmitted and treatment with antibiotics should not be required.

2.7.2 Infectious disease clinic

The Maine Medical Research facility lab is unique in that it is clearly linked to the hospital and has been part of the hospital research structure from the beginning, this is essential when looking at human disease, infectious diseases are a significant threat to human health and are emerging at an alarming rate. Successful medical research is a complex process requiring the close collaboration of scientists, physicians, epidemiologists, and data analysts.

Being able to offer patients the best available evidence-based medicine requires physicians to adopt a rigorous, scientific approach and look critically at all the efforts to understand transmission, diagnose, and treat Lyme disease. This collaboration is achieved within Maine and is advancing the available knowledge.

I was privileged to be able to attend an Infectious disease clinic where patients with Lyme disease had been referred. This gave me an idea of the care people receive and their treatment options and expectations. The clinic I attended was at an Inter-Med facility <https://www.intermed.com/about/about-intermed/>. There is no other Infectious disease clinic facility in Portland so all patient requiring specialist input are referred here.

It was apparent that primary care physicians are very informed on Lyme disease with regard to recognising and treating patients, patients have had preliminary tests which include blood panels for Borrelia, Babesiosis and Anaplasmosis and the patients have been prescribed the recommended 2-3 weeks course of antibiotics. Those with persisting symptoms which the primary care physician has investigated and found no cause are referred for specialist input.

There is a two-tier level of testing, these tests are most reliable a few weeks after an infection episode and after your body has had time to develop antibodies. The test used to detect Lyme disease; the enzyme linked immunosorbent assay test looks for antibodies to Borrelia. If antibodies are detected a further blot test is completed, the blot test is used to look at outer surface protein antibodies, some of these proteins will be present due to other conditions. Skilled physicians will interpret the antibody/blot results and consider the history of tick bite, patient's health and symptoms and the evident patterns with the patient's illness, prior to making any treatment recommendations.

Without doubt many patients fear that they have a chronic debilitating illness and are concerned that they are not being treated appropriately, for these patients it is important to use the best evidence-based information to give the most appropriate treatment. At the appointment, the opportunity was taken to educate patients about reducing the risks of further bites and giving guidance on tick removal.

2.7.3 Lyme disease testing and treatment

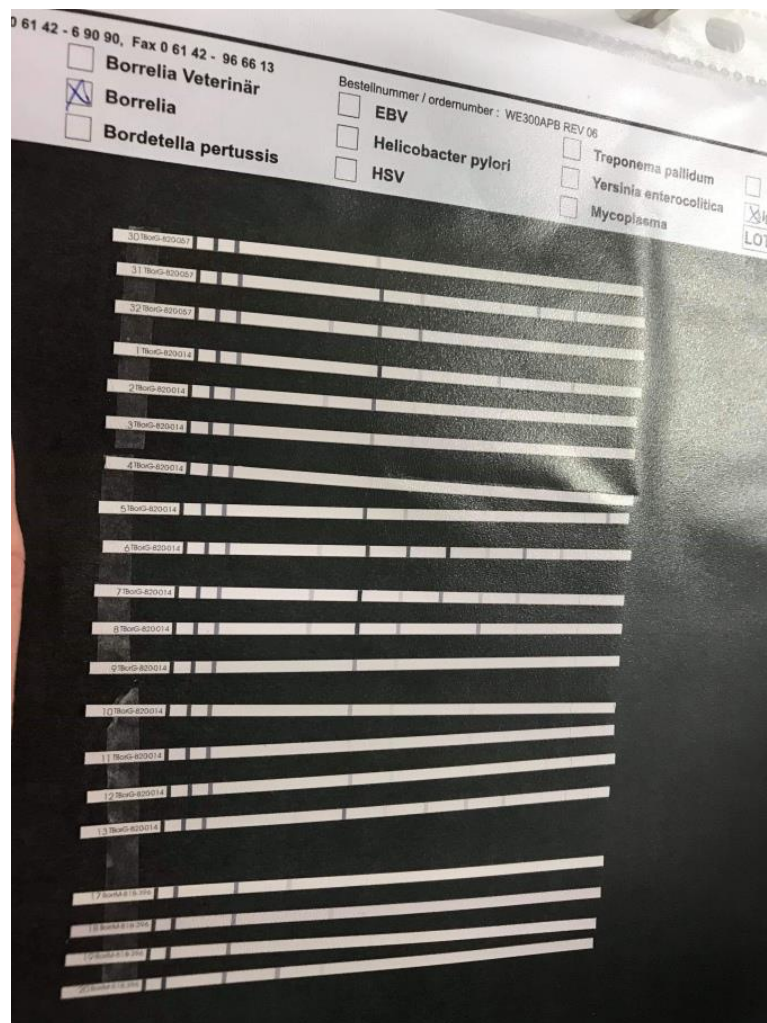
There is much debate about the scientific evidence regarding the treatment of Lyme disease. In USA the Infectious Disease Society of America (IDSA) is responsible for issuing evidence-based guidance for the diagnosis and treatment of Lyme disease, they were last published in 2006 and are being reviewed and updated at the moment.

Three aspects are subjected to particular criticism the sensitivity of serological testing, the presence of symptoms after completion of the standard treatment and the continuing presence of non- specific symptoms following completion of treatment.

Serological testing is undertaken using a two-tier testing protocol

1-Enzyme immunoassay test which is looking for the presence of class specific IgM and IgG antibodies to *Borrelia Burgdorferi* if no antibodies are detected the result is negative, if there are antibodies detected the test is equivocal or positive and is sent for further analysis using western blots

2-Western Blot test- this also tests for antibodies against *Borrelia Burgdorferi*, it looks for specific protein patterns, the interpretation of the bands requires the patient history of tick bite/symptom development to conclude the result



A very simple explanation of interpretation of the Western Blot result is the 3 strips on the left are the controls and the strips further on the right have to present darker than the controls to offer a positive result, if the strips further to the right are lighter in colour than the controls the result is negative, if the reaction is darker they are positive, the colours change in reaction to IGG and IGM in the samples being tested. IGG and IGM reactions can be detected in many inflammatory processes and when diagnosing Lyme disease specific patterns need to be evident on the Western Blot and that information is then evaluated along with the patient history of tick exposure or known tick bite and symptom development. Reaction on one band of the Western Blot is not sufficient to diagnose a person with Lyme disease.

Polymerase chain reaction (PCR) is used to evaluate people with persistent Lyme arthritis or nervous system symptoms. It is performed on joint fluid or spinal fluid.

The Scottish Lyme Disease and Tick-borne Infections Reference Laboratory (SLDTRL) was established in 2019 is provided by NHS Highland at Raigmore Hospital, Inverness. The aim of SLDTRL is to provide more comprehensive and standardised testing for Lyme disease and other tick-borne infections and to improve the epidemiological data provided to Health Protection Scotland (HPS). Below is a link to information about the laboratory, the service it will provide and the plans they are developing to improve knowledge of Lyme Borreliosis in Scotland.
<https://hps.scot.nhs.uk/media/1458/sldtrl-user-manual-2019.pdf>

The Rare and Imported Pathogens Laboratory (RIPL) is now incorporated into the functions of Public Health England (PHE), which was established on 1 April 2013. Previously, RIPL operated within the Health Protection Agency's (HPA) Microbiology Services Porton and was known until November 2011 as the Special Pathogens Reference Unit (SPRU). RIPL provides a clinical diagnostic service for rare and/or imported pathogens such as pathogenic arboviruses, haemorrhagic fever viruses and a number of Hazard Group 3 bacterial pathogens including rickettsia, Coxiella burnetii and Bacillus anthracis. The Lyme disease testing service was transferred from HPA Southampton to RIPL on 1 June 2012.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/880003/RIPL_User_Manual.pdf

Standard treatment is prescribed for patients with Erythema migrans or positive serology, antibiotics for 14 /21 days and in the overwhelming majority of patients are successful, additional antimicrobial therapy has not been proven to be helpful, and in a world concerned by the overuse of antibiotics and the increase of antibiotic resistant infections caution should be advised with prescribing extended courses.

Continuing symptoms as is the case with many infections, some or all of the patient's symptoms may continue even after the infection has been microbiologically cured, bacterial debris may still be present in the body but this does not necessarily mean that the bacteria is still active. The symptoms attributed to Lyme disease often do not resolve immediately and you can readily understand why patients may feel that they have not had enough treatment. It is recognised that patient can suffer from prolonged neurological, cardiac, or arthritic symptoms following a Lyme disease diagnosis.

The clinicians I met with spoke extensively about the diagnostic accuracy of serological tests which are frequently criticised and emphasises should be placed on the facts that the results cannot be interpreted in isolation, history, symptoms and the patients presentation have all to be considered when forming conclusions about a diagnosis. If the conclusion is that it is not Lyme disease other investigations should be undertaken. A study published in 2018 in France that demonstrated only 10% of patients with ongoing symptoms had Lyme disease the study also reflects the concerns that exist around over-diagnosis and over treatment of Lyme disease.

PhD students are supervised by many of the researchers I met with. In Strasbourg, a student was working on proteomics and one aspect of the study is looking at the proteins in skin biopsy samples which could help to improve diagnoses and testing in non-typical Erythema migrans rash. Within this laboratory there was interest in research of the skin and the area around the tick bites which is the main interface between tick and host.

There is also another aspect to a Lyme disease diagnosis managing continuing prolonged symptoms when the patient has never tested positive for Lyme disease, but the patient is utterly convinced that they have Lyme disease.

In the USA insurance companies meet the costs for treatment and will pay for the treatment in the recognised guidance only, this has led many people to seeking support from clinics that are set up to treat Lyme disease only and the patient has to meet the expense themselves, patients are paying up to and beyond \$10,000 for treatment which includes extended courses of antibiotics, and many other medications such as anti-inflammatory, anti-fungal, anti-emetics and gastro-oesophageal medication.

I met with a Lyme disease patient and she spoke about the profound effect the disease had on her life and how it impacted on her physically, socially, and emotionally. Sandy attended a clinic that specialised in Lyme disease and was prescribed a treatment regime that included a large amount of medication and lasted for three years. She had to meet the costs of this treatment herself. She has stopped the medication but continues to suffer symptoms of fatigue, joint pains, and fibromyalgia.

Post exposure prophylaxis

The use of post exposure prophylaxis in tick bites is recommended in USA and Canada.

In Canada the recommendations are made for regions where the proportion of infected ticks is higher than 20%, the tick has been attached for more than 36 hours, it is an adult or nymph *Ixodes scapularis* and prophylaxis commences within 72 hours of tick removal. Therefore, it is not simply a case of you have had a tick bite and prophylaxis is required.

The Infectious Diseases Society of America (IDSA) do not generally recommend antimicrobial prophylaxis, although in 2016 they made an exception for patients who meet the following criteria; the tick can be identified as *Ixodes scapularis*, the estimated time for tick attachment is less than 36 hours; the antimicrobial will commence within 72 hours of tick removal; Lyme disease is common in the county or state the patient lives in or has travelled to and the patient has no contra indications to doxycycline. The protocol is marred by the frequent calls that it is a misuse of doxycycline with its effectiveness being called sub optimal by medical professionals.

Post exposure prophylaxis is not recommended in the UK

Lymesnap project in France

Researchers at INRA spoke about a project called Lymesnap, the project wanted to collect information on episodes of Erythema migrans (EM). The project was developed in collaboration with the hospital in Clermont Ferrand, and people were recruited to participate in a study where they took photographs of the EM rash and completed a questionnaire and they were offered counselling on Lyme disease. When a picture was submitted, they were reviewed to decide if they were EM and the discussion included whether the person had received appropriate treatment. The project was promoted throughout the region in the media, newspapers, visits to local businesses and at GP and Hospitals. The project is completed, and analysis of the work continues.

Co-infections

Co-infection is thought to be generally uncommon but depends on the species of tick and on the geographic area. In the US *Ixodes scapularis* is the vector for *Borrelia burgdorferi* and has also been recorded as carrying the protozoan *Babesia microti*, the bacterium *Anaplasmosis phagocytophilum* or *Borrelia miyamotoi*. Researchers in France have been looking at *Bartonella* and the studies were able to demonstrate that ticks were able to transmit *Bartonella*, this was relevant for patients with persistent symptoms, particularly where Lyme disease is negative. It has been suggested that co-infection should be considered in a patient without a rapid improvement after 48 hours of the correct antibiotic.

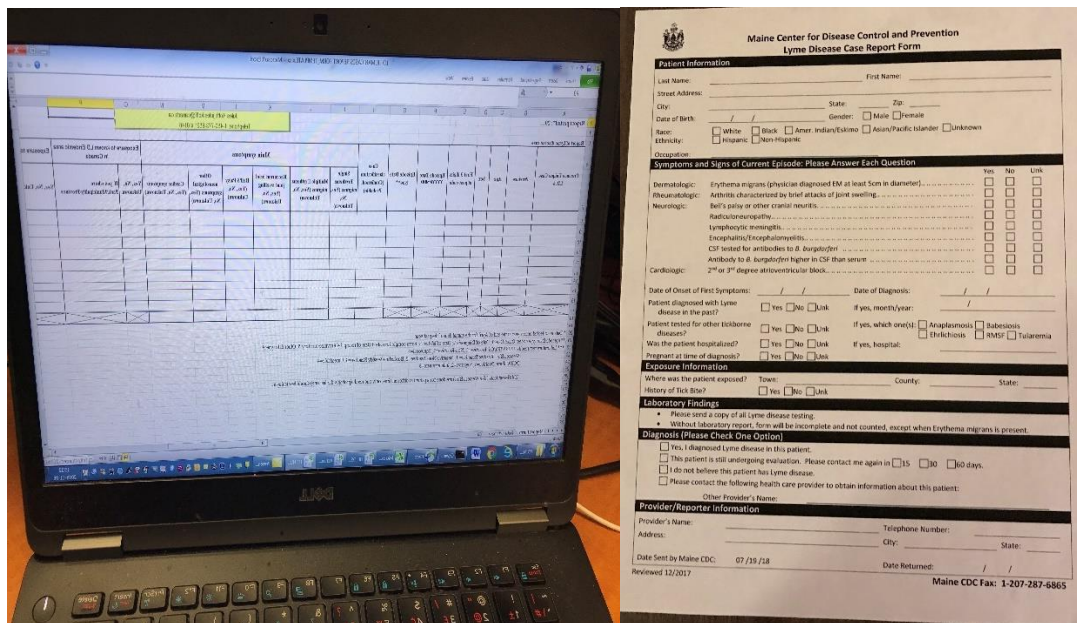
The ticks being collected in areas should be tested for other bacterium and it would begin to provide evidence of the presence or absence of co-infections in ticks.

2.7.4 Surveillance

Monitoring and surveillance are inextricably linked. Both are used to collect, analyse and interpret health data, this is in order to track the state of people's health and the way in which it is changing. While at CDC Atlanta I met with Sara who discussed her role with regard to surveillance of the many notifiable diseases. Lyme disease is a reportable condition in the USA and the department have extensive data which maps the increase of disease across the states. Primary Care Physicians (PCP) are asked to report cases and about 50% of practices return the form.

The form looks quite detailed but apparently it does not take too long to complete. The question is what is the benefit to continuing with the surveillance? It is widely known and accepted that the prevalence of Lyme disease is high in the area, the form takes time for the PCP to complete and return and then for the CDC department to review. It is acknowledged that only 50% of practices complete the reporting form, this suggests that the data would not be complete along with the suggestion that Lyme disease is under reported in general as people do not attend the doctor.

Data is also analysed through real time monitoring which is taking place through some health care providers, these analyses is looking at the burden placed on health services by people attending a centre stating that they have Lyme disease, the data is recorded when the patient registers at the health centre. This data is helpful to determine how much resource is taken up by patients who think they have Lyme disease. The system also records how many people attend centres for tick removal. Once a patient is seen by a PCP their eventual diagnosis is also noted and the data comparison will allow for identifying the number of people who think they have Lyme disease and those that are subsequently diagnosed. Two examples of the information asked for in surveillance forms is shown in the next two pictures.



The Public Health Agency of Canada (PHAC) are involved with developing an online Lyme disease surveillance system, there is a national notifiable surveillance system for a range of disease and there is a second enhanced surveillance system for Lyme disease. Lyme disease is reported from the Doctor - Regional Government-Provincial Government -Federal Government. Currently it is a paper system which requires the data to be transferred onto online systems, 9/10 of the provinces in Canada currently input data for the process. The process of validating and checking the data is time consuming but it is necessary before the data can be released as the national statistics. The working group can be put under pressure from Lyme advocacy groups about the release of the data, but the process is adhered to strictly to ensure the data going into the public domain is correct.

Many researchers have been involved in passive and active surveillance and there are many challenges associated with these methods, particularly when the territory under surveillance is very large and available resources are limited.

France has been collating data since 2009. Three main methods have been used; volunteer GP practices complete sentinel surveillance which is considered to reflect the incidence of Lyme disease across France with regional and seasonal differences being noted, the second data set comes from patients admitted to hospital where cases are reviewed by hospital staff, GP's, staff at Sante publique and the Lyme reference laboratory to ensure the diagnosis is validated and the third data set is being collected from a study looking at the sero-prevalence of at risk populations such as forestry workers. There are plans to undertake sero-prevalence testing of blood donations to establish if there is any correlation between the number of identified cases of Lyme disease and the prevalence in the general population.

Each of the countries acknowledge that surveillance is important, however it is recognised that surveillance practices can alter the perceived features of the disease through under reporting and detection bias. Interpretation of the data is also complicated by the existence of clinically similar diseases, the concerns around the serological testing and the different methods of surveillance practices across countries. Another factor that alters results is the focal distribution of disease, pockets of intense transmission may exist in some areas, but when aggregated by country it can cause complicated comparisons. Nevertheless, despite these difficulties it is apparent that the incidence of Lyme disease continues to increase in many countries, geographic distribution demonstrates the disease is escalating in Europe and North America and the risk of infection is substantial in some areas.

2.8 National plans

2.8.1 Canada's Federal Framework

The document called 'Lyme Disease in Canada a Federal Framework' acknowledges that Lyme disease is an emerging infectious disease in many parts of Canada, and the Government of Canada recognizes the impact that it has on Canadians and their families. The document is centred on three areas, surveillance, guidelines and best practice and Education and Awareness and includes the establishment of a Lyme disease research network. As an emerging disease it is recognised as important that researchers come together with an evidence-based approach, and address knowledge gaps through further research.

The Public Health Risk Sciences division in collaboration with others are at the forefront of progressing research being undertaken. In response to the Federal framework a Canadian research network has been proposed, a multidisciplinary, patient-centred research program, from discovery to implementation, with the ultimate vision of reducing the impact of Lyme disease on the health of Canadians. The network will integrate researchers, patients, health care providers, public health and non-researcher stakeholders into the planning, advisory, and oversight capacities of all research activities to create short and long-term outcomes that are specific, measurable, accountable and transparent. Solutions and strategies will be developed by facilitating engagement across stakeholder groups. Patient engagement will be guided by provincial Strategy for Patient Oriented-Research (SPOR) units and patient/citizen engagement experts. Training and development of highly qualified personnel will be integrated across all research areas.

It has been suggested that many critical knowledge gaps exist in Canada including: conflicting views on the natural history of disease, including the impact that Lyme disease strains have on the effectiveness of current diagnostic tests and on disease clinical presentation and patient outcomes, and lack of evidence on prevention/intervention strategies to reduce risk and long-term sequelae.

Further, training and education of healthcare providers is required to improve awareness and understanding of Lyme disease.

2.8.2 France's National Plan

The national plan was driven by the ministry of health and involved a wide range of groups, professionals, and patients, and it identified actions on Epidemiology, diagnosis, treatment, and prevention. Aspects of the plan remain disputed by some of the groups involved but work continues to improve the knowledge available in France.

Since the national plan was published in 2016 there has been a large increase in the amount of people working on different aspects of ticks and tick borne disease and in particular on Lyme disease, this work has only been possible by the increase in money that was made available to allow research to be undertaken.

France is combining science, medicine, and education to create a multi-level awareness, prevention and treatment initiative that treats Lyme disease as a major public health problem. The strategy includes stepped-up surveillance of ticks, detailed data on infection rates and investment in research to create better diagnostic tests treatment protocols.

Chapter 3

3.1 Summary

With this report I have provided evidence of research projects that have been tested, the results of programs and actions that have been utilised particularly in the areas of prevention and awareness raising, environment and land management.

One of the most important messages from my trip is you cannot act on one aspect of ticks and Lyme disease. The poster 'Ecology of Lyme' using the image by Olaf shows the importance of considering all the aspects that are involved when trying to manage Ticks and tick-borne disease, you cannot act on one aspect alone. All the experienced researchers I met with recognised health is dependent on the health of the landscape and humans, animal and ecological health are inextricably linked, and this is a subject that needs to be studied and managed holistically.

There are no doubt ticks are increasing on the landscape and there is much historical and newly acquired data, which can be used to predict hotspots. Once the tick hotspots are identified decisions can then be made about the most effective interventions. Land and host management practices have been shown to provide excellent tick control

Public engagement is key to managing tick-borne disease and researchers have to be willing to share their knowledge and be available to attend events to answer questions about tick borne disease. Sharing the acquired knowledge helps to build relationships and trust, the public need to be informed of study findings ensuring people have the correct information but also that they begin to realise that they have a role to play in the reduction and prevention of tick-borne disease.

I saw good examples of awareness raising materials; resources need to be produced, disseminated, and displayed particularly in high risk areas. Activating a generational shift in people's behaviour to ticks in the environment is very important. If children are brought up 'tick aware' it will embed the actions of taking appropriate precautions, checking for ticks and removing ticks correctly into their outdoor routine and this will pass on into the next generation and could help to see a reduction in cases of Lyme disease. When resources are produced health-literacy has to be considered but recognising also that resources have to be engaging to encourage people to read them.

Lyme disease is a very emotive topic and there is much publicised about the patients who suffer with long term effects but that needs to be balanced with those who get bitten by a tick and don't get Lyme disease, those who present with Erythema migrans receive the correct treatment and recover completely and those who go out in the environment regularly and never get bitten.

90% of people with Lyme disease recover following appropriate treatment and that message also needs to be conveyed.

Without any vaccine the control of Lyme disease relies on managing tick bites and methods to reduce the tick population or the prevalence of the infection of ticks. Prompt recognition of infection and early access to treatment can prevent more serious manifestations of the disease therefore education is important in preventing or managing disease.

Having visited organisations undertaking extensive studies, all areas spoke about the financial constraints which impact on the ability to undertake studies and this subsequently restricts the actions that can be taken and finally some studies have provided evidence of actions that can benefit but there is no money to allow the utilisation of these methods. Governments in the United Kingdom have to recognise tick-borne disease as an increasing threat and money has to be spent on research and awareness raising, making finance available will allow for an increase in the knowledge and understanding of the progression of ticks and tick-borne disease across the UK.

3.2 Plans

I will share the knowledge gained from my Churchill fellowship travels by preparing a presentation and offer to speak at events and meetings. As I am writing this report, I have already given a talk locally to my Public Health colleagues in the Western Isles and I have also presented to the Health Protection Nurse Network in Scotland which is attended by Nurses from all NHS Boards in Scotland. I have also spoken to members of the Scottish Health Protection Network Lyme borreliosis group about some of the research I heard about.

I have been nominated to represent NHS Western Isles who are a partner agency involved in supporting a PhD student undertaking research across the Western Isles to look at the role of deer and non-native hosts in tickborne disease emergence in the Western Isles. As part of the introduction to the studies I spoke about some of the environmental work I observed and aspects such as the tick dragging protocol and small mammal trapping are incorporated into the study.

I will be reviewing the promotional materials we developed in the Western Isles previously and will make amendments and consider some of the suggestions I received from the people I met with, I particularly liked the book marks, which can be given to school children and also consider health literacy when preparing materials for the general public.

As a member of the Scottish Health Protection Network Lyme borreliosis group I hope to be able to influence the direction the group takes with regard to improving people's knowledge from the public to health professionals.

On return from my Churchill fellowship travels I resumed my master's studies and developed a project looking at the impact of Lyme disease on the quality of life of people who have had Lyme disease in the Western Isles of Scotland. I have presented the study findings at a UK conference in Liverpool and while the findings were well received it was a stark reality that the UK lacks research knowledge on how ticks and Lyme disease affects people. The conference clearly identified the need for behavioural science studies to determine how public health messaging about ticks and Lyme disease is received. With the knowledge gained from my fellowship travels I feel determined to continue to educate people and to undertake more research that will help to build on the currently available knowledge.

3.3 Conclusions

- The 'One Health Concept' is essential- Health is a collaborative, multisectoral, and transdisciplinary approach, working at the local, regional, national, and global levels with the goal of achieving optimal health outcomes recognising the interconnection between people, animals, plants, and their shared environment.
- Public engagement is essential to bring people together to address the issues surrounding ticks and tick-borne disease ensuring the public follow the advice to reduce the incidence of Lyme disease and other tick-borne disease.
- Funding has to be available to progress the knowledge and actions that can be taken to manage ticks and tick-borne disease. The amount of funding and resources committed to tick borne disease will directly affect the development, quality and services related to increasing the knowledge and understanding and deliver management strategies.