QUANTOCK HILLS TICK RESEARCH PROJECT

FINAL REPORT

March 2008

Prepared for :

Quantock Hills AONB Service
Somerset County Council
Quantock Hills Office
Fyne Court
Broomfield
Bridgewater
Somerset TA5 2EQ

Prepared by :

Professor Roy Brown
R & D Associates
7 Lime Chase
Kirkbymoorside
York YO62 6BX

CONTENTS OF REPORT

MAP 1. Main Habitat types on the open Quantock Hills
MAP 2. Location of sample sites, tick densities and trends 1998 to 2007/08
Not included electronically. Hard copies can be obtained from the Quantock Hills AONB Service, Fyne Court, Broomfield, Bridgwater, Somerset TA5 2EQ

APPENDICIES

BIBLIOGRAPHY

QUANTOCK HILLS TICK PROJECT

KEY POINT SUMMARY OF FINAL PROJECT REPORT
March 2008

1. The Quantock Hills AONB (99km2) has large tracts of vegetation (heathland, bracken beds and woodland/scrub areas with dense undercover) which favour Sheep Tick *Ixodes ricinus* activity. There are abundant large hosts such as Red Deer (up to 1000 at certain times of year) and sheep. Recreational use on the Access areas is intense in some places, often corresponding with intense tick activity, and is moderate to high over much of the hill.

2. This study was commissioned by Somerset County Council in November 2007, funded by a grant from Natural England. Natural England is concerned about the possible conflict between human use of Open Access (CRoW Act) Land and tick activity in principle. The Quantock Hills AONB/SSSI provides a relatively small area where all the key factors of human use, tick and tick host activity come together. The purpose of this project has therefore been to investigate levels of tick activity and tick borne disease (TBD) on the Quantock Hills in relation to Human activity. There are potential issues over conflict between habitat management objectives and the promotion of recreational use. **In short, are ticks and tick borne disease a problem, if so is the problem becoming more serious and what can be done about it?**

3. The author has been working on ticks and TBD in the South West with special reference to the Quantock Hills since 1991. **This study draws on fourteen previous sampling periods and three within the contract period.** Data collected and analysed relates to tick population structures and distribution, the incidence of pathogens in ticks, tick-habitat relationships and tick-host relationships.

4. **Ticks** have been collected from vegetation by blanket dragging and disease data from these questing (starving) ticks and from engorged ticks collected from deer. **Habitats** have been characterised by vegetation type and management. **Key environmental data** relating to Air temperatures, wind speed and relative humidity have been collected from each site on each sampling occasion. Information on tick densities, population and life stage (Larva, Nymph, Male, Female) structure coupled with pathogen infection rates has been used to evaluate the relative importance and potential risks of disease transmission to people and (to some extent) sheep and other vertebrates on the Quantocks area.

5. Purposes of the study

A. Bring together and review all recent survey work on tick activity, habitats, hosts and disease patterns.

B. Conduct field surveys (November 2007 to February 2008).

C. Identify areas of intense activity ('hot spots') and/or reservoirs of potential TBD.

D. Produce advice on avoiding ticks and TBD with recommendations for management of habitats, host and tick populations directly to :
i. Habitat Managers to implement Management Techniques
ii. Access managers to develop educational awareness and advisory programmes for the public and health professionals

E. Identify the way forward for data collection, management, monitoring and additional resources.

6. The report provides a brief review of tick ecology, a discussion on Lyme Disease and an Appendix covering the range, recognition and management of tick borne diseases.

7. **Potential Tick Borne Diseases identified from the Quantocks include Tick Borne Fever (Cattle, Sheep, Roe Deer and People); Lyme Disease - [two strains of Borreliosis] (Red Deer and People); Louping Ill (sheep); Red Water Fever (Cattle and Deer); Tick Pyaemia/ Localised Infections (Sheep, Deer and People).**

8. The presence of the bacterial and viral pathogens in the ticks has been established using Polymerase Chain Reaction (PCR) which is a series of DNA determination techniques. The results from questing ticks are fully reliable, those from engorged ticks may be compromised due to primer interaction with host blood.

9. **The sites studied in detail over the years consist of 16 primary areas, which are Cothelstone Hill (3), Lydeard Hill (1), Crowcombe (2) , Weacombe (1), Thorncombe-Hurley Beacon (1), west Quantox Head - Staple Plain (3), Higher Hare Knapp (1), Great Bear Wood (2), Slaughterhouse Combe (2) as well as 17 secondary sites.**

10. Some habitats are particularly favourable for tick activity and tend to be small, densely vegetated and sheltered with much host activity. Five habitat groups have been identified in the study area. These are:

A. Dwarf shrub plateaux areas. These account for 71% of the sample area,

but only 5% of all tick activity.

B. Dense Bilberry cushions cover 3% of the area but returned 14% of the total tick sample, a classic example of 'hot spot' habitat.

C. Dense Bracken monocultures and Bracken-coarse grass complexes cover 8% of the hill and returned 68% of all recorded tick activity. These account for most of the 'hot spot' areas.

D. Coarse dry grassland occupies 2% of the area but return only 0.5% of tick activity.

E. Open Woodland/Scrub accounts 14% of the sample area and returns 10.5% of recorded tick activity.

Deer activity is a constant, but variable factor.

11. The **changes in tick density** over the years are variable. Some areas have shown only a slight increase over 15 years whilst others have increased substantially. This depends on location, habitat type and host availability. The significance of increase is related to initial density - a high percentage increase on a low density will make little difference, whereas a modest increase on a high density may result in many more ticks. **Percentage increases range from 85% to 475%,** but low percentage increases are often associated with high initial densities (eg. Aisholt). Changes in the rate of pathogen presence and breeding competence also have great bearing on the significance of tick activity for human and animal welfare. This also links into access. Thus Cothelstone Hill showed intense activity in 1991, has had a 55% increase over 10 years with high pathogen risk and high levels of visitor activity and is consequently a very high risk area. By contrast, parts of Thorncombe - Hurley recorded low densities in 1991, have remained virtually static, have always had a low pathogen presence and constitute a very low risk. Fortunately about 75% of the total hill area falls into the low risk category. **However, it only requires one bite from a tick infected with Tick Borne Fever to pass the disease on so caution and information are required all over the Quantocks**.

12. There has been a **marked increase in male to female ratio** on a number of areas, resulting in a greater fetilisation level and more dynamic population. The ratio has increased from less than 1.9 to over 2.1 in many places.

13. Data collected from questing and engorged ticks has been used to consider **large host competence as disease reservoirs.** Tick samples have been analysed from 10 culled female deer (7 Red and 3 Roe) shot as part of the normal management programme in February and March 2008. Ticks from **all 10 animals were carrying at least one Tick Borne Disease pathogen and/or infection *Staphyloccocus aureus.***

14. The **significance of deer as hosts,** both in terms of maintaining tick populations and as a means of controlling ticks by keeping the cycle within a large host species rather than fragmentation into smaller mammals and ground nesting birds is very high in the context of the Quantock Hills.

15. **Pathogen presence** in starving ticks is variable, but **over the 15 year study period there has been a marked increase in nymph ticks** (this life stage has been focussed on as being numerically important and capable of passing on disease) carrying one or more bacterial/viral infection. At Cothelstone Hill the rate has increased from 1.5% in 1991 to 16.8% in 2007. Aisholt was 1.5% in 1991 and 18.2% in 2007. Higher Hare Knapp did not return any pathogen carrying ticks until 2003 when a rate of 1.5% was recorded and this had increased to 5.8% in 2007. **There has been an increase in geographical range as evidenced by the Thorncombe, Weacombe and Higher Hare Knapp sites** (Table 2, main report). **It must be stressed again that viral/bacterial presence in a questing tick does not automatically mean infection** (the exception to this is TBF, see 11 above).

16. A **risk assessment** has been developed for a range of sites/habitats. Mean pathogen presence rates have been calculated across the main four habitat blocks (see 10 above). Woodland/scrub was sampled in 2007/08 only. The overall rate has increased from 2.47% in 1991 to 9.4% in 2007 which is a 380% increase. Habitat type risk has increased by 260% and **the corrected area risk rate has increased by 290%.** When these figures are considered alongside density changes it is apparent that while the geographical extent of tick distribution has not changed greatly over the last 10 years the densities have increased and breeding is more vigorous. Multiple infection rates have increased as has the the geographical range of pathogen carrying ticks. **Overall the risk of infection has increased between 200 and 300%.**

17. In other words the **mathematical liklihood**, assuming human activity levels and habitat structure have remained constant over the last 10 years, of being bitten by a tick on the Quantock Hills has increased almost threefold. In the same period the liklihood of being bitten by a tick carrying pathogenic bacteria and/or viruses is two to three times greater. As indicated before there is great variability in the pattern over the hill and these figures represent overall means.

18. **Dogs are susceptible to tick burdens and some Tick Borne Diseases (TBDs).** This is very strong arguement for keeping them on leads and on paths on the hill. Even if these precautions are taken it is important to check the dog for ticks. Apart from the obvious risk to the animal there have been cases where a dog has taken a larval or nymph tick home. These have subsequently dropped off and gone to the next stage in soft furnishings and have then fed on and passed on disease to a human.

19. **Public awareness is a key issue.** A questionnaire study in 1992-93 indicated tick and tick borne disease awareness was limited and it is proposed to

reassess the situation by incorporating relevant questions into the next Summer Visitor Survey. The design and provision of on site and remote educational and information material for the public can be addressed acordingly. Information links for animal and human health professionals are also proposed.

20. A strategy of practical management has been proposed. This includes a. habitat management (bracken control or swaling); b host management (i. sheep - treating, excluding, shepherding and ii. deer - culling, possible treating, excluding); c. Information and Education; d. future implementation and necessary resources. **Interepetation Boards for the hill are currently being redesigned as simple, bullet point adice on tick safety should be incorporated as standard.**

21. The **study provides a template** for further studies in areas where ticks are a potential issue in Habitat and Access Management, particularly in relation to Open Access Areas.

22. **The overall conclusion is that the increase in levels of tick activity and Tick Borne Disease is a cause for concern on the Quantocks**. It is likely that the increasing trend will continue. Immediate habitat manipulation and education/awareness campaigns should be implemented and there should be continuing evaluation of potential host management, actual visitor/manager/medic awareness and the development of an appropriate strategy for the next 5 to 10 years.

23. It is recommended that a **one day conference/workshop** (formal report back on this work with maximum of 3 additional 'bullet point talks') is organised. This would be joint between Quantock Hills AONB and Exmoor National Park Authority land and recreation managers along with local medical and veterinary practitioners. The focus would be on recognition, safety, information exchange and practical management steps of both ticks/hosts and TBDs.

24. Recognition of TBDs and diagnosis are key issues and the possibility of a **regional diagnostic centre** with the facilities for accurate pathogen identification and disease confirmation should be explored with other relevant groups/authorities.

1. INTRODUCTION

Preamble

In November 2007 Professor Roy Brown of R & D Associates was commissioned to undertake a study of Sheep Tick *Ixodes ricinus* activity and associated disease risk to people (and incidentally domestic and wild mammals) on the Quantock Hills AONB with particular reference to the Open Access Areas (CRoW) within the SSSI. This study is on behalf of the Quantock Hills AONB Service with funding from Natural England as part of their Access Management Grant Scheme to local authorities to help manage Access Land. The issues of Public Enjoyment and welfare are high on the agenda of both Somerset County Council on Open Access areas in the County and Natural England in relation to Open Access areas Nationwide. This document reports the findings of the research and summarises key data and recommendations. The raw data sets (and those from previous studies by the author relating to the area) and background technical information has been produced as a series of electronic appendicies.

Background and Rationale

The Quantock Hills AONB covers about 99km2 and has large areas of dry heathland, bracken beds and woodland with dense groundcover (as well as an ample supply of large hosts such as Deer, Sheep and People!) where tick activity is intense. For many years the issue of high tick densities in the hills has lead to concern over public health.

The author has worked intermittently on tick activity on the Quantock Hills since the end of 1990 and has published various papers and reports relating to this and other areas within Somerset as well as the Exmoor National Park. This was done in conjunction with (and partially funded by) Somerset County Council and the Exmoor National Park Authority between 1991 and 2000. This work was carried out with a wider research remit and made a major contribution to the understanding of Tick Ecology and Tick Borne Disease (TBD) testing in general terms. The scale of the problems and the potential threats to human and animal welfare became apparent on the Quantock Hills and other key outdoor recreation areas so a 'risk assessment' excercise was carried out in 1998 - 1999. No direct action was taken on the assessment and its management recommendations at the time.

Data collected on an ad hoc basis from 2000 to 2007 confirmed ecological and disease patterns on the Quantock Hills and suggested increased activity and risk levels. In 2006 English Nature, the Countryside Agency and the RDS sections of DEFRA were amalgamated to form Natural England. This meant that within the same organisation there was responsibility for promoting access whilst at the same time physically managing areas for conservation purposes which might well encourage tick activity. There was a feeling amongst recreation and habitat managers that positive encouragement to the public to use areas that might

harbour high densities of ticks could create a negative image of the 'Countryside Experience' and lead to adverse publicity, as well as actual health issues.

Purpose of the Study

1. To bring together and review all the recent historic survey work on tick activity, habitats, hosts and disease patterns to form the basis for the current detailed assessment. This information to be analysed to determine trends in tick population density, distribution and potential tick borne disease patterns.

2. To conduct field surveys in key areas over a short time period (October 2007 - March 2008) into tick populations and the occurence of tick borne disease likely to affect humans and livestock in 'questing' ticks and ticks engorging on hosts on the Open Access Areas of the Quantock Hills.

3. To identify areas of intense tick activity (hot spots) and/or reservoirs of potential tick borne disease.

4. To produce advice for people on the treatment and avoidence of ticks and tick borne diseases and recommendations for the management of habitats, hosts and tick populations directly. This will enable :

a. Access managers to develop education campaigns and will raise awareness of issues associated with ticks in the public and healthcare professionals.

b. Habitat managers to implement land management techniques such as bracken control and host 'treatment' to control and reduce tick activity.

5. To identify the way forward in terms of future information gathering, monitoring and possible resourcing of long term management on the ground. In addition to Somerset County Council and Natural England, the National Trust and Forestry Commission have a vested interest as some of the key areas are within their ownership/management.

Outputs and Outcomes

1. Collection and collation of data on tick distribution and activity using a repeatable sampling framework and methodology.

2. Identification of tick population 'hotspots' and investigation of host activity.

3. Quantification of pathogen/disease presence and rates of infection (%) from sample areas.

4. Assessment of risk to public health related to habitats and specific areas.

5. Recommendations on habitat management.

6. Recommendations for information/education output and liaison networks.

7. Reports, Appendicies and specific briefing/information papers.

2. TICK ECOLOGY AND TICK BORNE DISEASES

Before discussing the methods and findings of the project it is useful to summarise the tick life cycle to understand the interactions with habitats, hosts and people.

Life Cycle and Habitat

Sheep Ticks *Ixodes ricinus* are small, hard bodied members of the mite and spider family which require three blood feeds at each of three stages of development from larva to nymph and then to adult female or male (which mates with the female but does not take a blood feed as she does). After mating an engorged female will lay up to 2000 eggs in coarse, sheltered vegetation. These hatch into tiny six legged larvae which need their first blood meal. They climb the vegetation to 'quest' for a passing host (they will climb up to 1m in the right vegetation, eg bracken fronds). They are indisciminate feeders and will attach to any thin skinned vertebrate (mamal, bird, reptile or even amphibian) which comes their way. They bore into the skin and draw blood from the capillaries. Many do not find hosts and die. Those that find a host will feed for 2 to 3 days before dropping off and may pick up viral or bacterial pathogens (if present in the bloodstream) from the host. When they drop off they need sheltered habitat where they can moult and pass to the next stage of the life cycle, the 8 legged larger nymph. The same process of questing and feeding occurs again with the nymph spending 3 to 5 days attached to the host. If the tick has picked up pathogens from its first host these may be injected into the second stage host and the nymphs may also pick up further virus/bacteria at this stage. The nymphs drop off into vegetation, moult and emerge as adult males or females. The males will quest to find hosts where they can mate with females but do not have a further blood feed. The females will engorge, spending 5 to 7 days attached and ending up the size and colour of a bean - hence another common name the Castor Bean Tick. If they mate (the ratio of male to female ticks is important and is discussed in the results below) they drop off and lay their eggs. The females may pass on any virus/bacteria they have picked up on their two previous blood feeds and may again ingest pathogens from their third host. There is evidence that *Borrelia* (the causative bacteria of the Lyme Disease complex) can be passed on transovarially (from female to egg) so that in some cases the larvae hatch carrying the bacteria without ever having had a blood feed.

The full life cycle may take two to three years, but may be less than 14 months in optimum conditions. Unfed adults may live more than one season if the habitat is right.

The nymph and female stages tend to feed on small mammals, ground nesting birds and larger hosts including hares, sheep, deer and people. The ability of the unfed female ticks to survive more than a year means that they often outlive their small mammal hosts and consequently become potential disease reservoirs.

Ticks therefore need a good level of hosts (of which the deer on the Quantocks are critical) to 'quest' for and get their blood feeds. They also need the right type of habitat in which to moult and which is physically sutable for them to quest in (they cannot tolerate high temperatures, dessication and high wind speeds which make it impossible for them to latch on to their prey). Other than the few days spent on hosts much of the tick's life cycle is spent in vegetation, particularly where it is coarse, undisturbed and where there is deep litter to buffer against extremes of temperature and humidity. Although unfed ticks have few natural predators engorged specimens at all life stages will provide chance meals for some omnivorous birds and small mammals if they are obvious. Once again the importance of the dense, sheltered habitats is emphesised. Heath, bracken, bilberry, wetter grass areas and woodland with good ground cover (as on the Quantocks) present ideal conditions.

Disease Transmission

Sheep Ticks have been identified as vectors (transmitters) of various livestock and, more recently, human diseases via the biting and transfer process described above. There are up to 19 viral and bacterial pathogens which ticks may pick up and transfer. On the Quantock Hills Tick Borne Fever (Cattle, Sheep, Roe Deer, People), Lyme Disease (Red Deer, People), Louping Ill (sheep), Red Water Fever (cattle, deer) and Tick Pyamia/Local infection (Sheep, Deer, People) have been confirmed. The tick borne diseases found in the UK are discussed with symptoms in Appendix 1 of this report. The ticks generally pick up the pathogens from animal/bird hosts and pass them into the human chain, but different host species vary in their ability to sustain the bacteria/virus populations in their bodies and to magnify these up. In human terms on the Quantocks the Lyme Disease complex and Tick Borne Fever are the most important. It is important to note that individual ticks may end up carrying a cocktail of virus/bacteria (engorged female ticks from a Red Deer hind shoot on Exmoor in 2004 where carrying up to 7 distinct disease causing groups).

Lyme Disease

As perhaps the best known zoonoses (diseases transmitted by animals to man) Lyme Disease or Lyme Borreliosis is caused by bacteria injected into the blood stream from the bite of an infected tick. Lyme Disease is a complex which causes a range of symptoms as it is a multi-system, immune mediated inflamatory disorder. There are three species of spirochaete bacteria which have been identified as the causative agents of Lyme Borreliosis. These are *Borrelia burgdorferi* (North America and Europe), *Borrelia garinii* (Europe) and *Borrelia afzelii* (Europe and Asia). Each affects different body systems in different ways and the UK has all three present, although *Borrelia garinii* with its neurological symptoms is probably the most widespread. *Borrelia burgdorferi* and *B. garinii* have both been confirmed from questing (starving) nymph and adult female ticks on the Quantock Hills and Exmoor.

Lyme Borreliosis infection passes through three stages, localised infection, more disseminated infection and then a long term chronic stage if not treated.

Primary symptoms are often a ring like rash (Erythema Chronicum Migrans ECM) around the site of the bite and profound fatigue, fever, chills, headache, sore throat, sore and aching muscles and joints and swollen glands. The rash occurs in about 70% of cases and is considered diagnostically significant when it reaches a diameter of 5cm.

The second stage includes neurological complications and musculoskeletal pain that appears 4 to 6 weeks after infection. Neurological problems occur in 10 to 20% of patients. Symptoms include severe backache and stiff neck, facial paralysis, optical problems (even blindness), weakness and/or pain in the chest and extremities and coma. These symptoms can persist for weeks. Heart symptoms occur in 6 to 10% of Lyme Disease patients. The electrical conduction in the heart may be affected and inflammation of the heart muscle, or heart block, may occur. A skin condition called Acrodermatitis Chronica Atrophicans (ACA) may occur during the second stage to several years later. This is mainly caused by *Borrelia afzelii* and is chronic and progressive.

The third stage involves the onset of arthritis. Joint problems characteristic of rheumatoid arthritis generally occur within two months to two years after the onset of the rash. The attacks may last from a few days to a few weeks and mainly affect the large joints. This may be a repetative stage and some patients suffer loss of memory, mood swings and other upsets.

The condition is often complicated long term because a 'cocktail' of infections may be involved. Treatment with antibiotics at an early stage is normally effective and spontaneous recovery may occur. The disease often progresses if left untreated and whilst mortality rates are low long term disabilities from untreated Lyme Borreliosis are common. Diagnosis is a specialist action and advice should be sought if people feel unwell after a tick bite. The complex of diseases is treatable with antibiotics, especially in the early stages, and specialist advice should be sought as soon as possible.

In the UK *Ixodes ricinus* is the main transmitting agent. Wild species such as Hedgehogs, Rats, Mice, Voles, Deer, Red Grouse and other ground nesting birds as well as Seagulls (which can transport ticks over considerable distances) all provide suitable hosts for ticks. The competency of the various hosts to actually sustain the spirochaete is important in the disease cycle. Competent hosts, such as Red Grouse and some Mice, may be affected by the disease but will also become reservoirs on which 'clean ticks' might feed and hence agents for the transmission of the disease. If they are not competent hosts then they help to break the chain of transmission.

As with all tick bite transmitted diseases there are three levels of management in

terms of human health. The first is to provide people with advice which will enable them to avoid being bitten by ticks. The second is to provide information on how to deal with tick bites and seek appropriate advice. The third is to provide a framework for liaison and advice to health professionals, both medical and veterinary, in terms of diagnosis, treatment and support. Examples of the advisory approaches are summarised in Appendix 2.

Tick Borne Fever (TBF)

This increasingly widespread disease should not be confused with Relapsing Tick Fever (which is *Borrelia* related). The disease is caused by a number of varities of Ricketsia bacteria, known as ehrlichiae in the family Anaplasmatacea. For simplicity one species known as *Anaplasma phagocytophilium* which causes Human Granulocytic anaplasmosis (HGA) and also affects other mammals is used as the generic description in this report.

TBF affects cattle, sheep, horses, dogs and human beings and is carried by various other species of which Roe Deer are one of the main reservoir hosts. It is spread via infected Sheep Tick bite and once infected the tick is capable of passing it on at all subsequent feeds (if a larval tick is infected it will pass on at both the nymph and female feeding stages). In the case of many of the tick borne pathogens simply being bitten by an infected tick will not automatically result in a clinical condition but evidence suggests that TBF will always be magnified up in the affected host's body.

TBF is an infectous blood condition resulting in the reduction of cellular blood elements. The causitive organisms establish in the white blood cells (leucocytes) and result in damage to the lymphatic system, often ultimately affecting multiple organs and cell systems. The respiratory, circularatory and central nervous systems as well as the kidneys, brain, liver spleen and endothelial tissues specifically are involved. The main factor is that the damage to the white blood cells depresses the immune system which opens the body to secondary infections and other complications. In sheep, for instance, Louping Ill virus(*Flavivirus*) may be present in the blood but the vasculocerebeal immune barrier prevents the virus reaching the brain and therefore clinical manifestation. In the presence of *Anaplasam/Erhlichia* compromising the immune system the barrier is breached and the animal becomes ill. The same process occurs in other susceptible mammals, including human beings. The secondary infections do not have to be tick borne, but Louping Ill, Lyme Disease complex, *Babesia* and *Staphyloccocus aureus* are often present as co infections in the ticks.

Symptoms range from very mild, not requiring treatment, to severe and even life threatening. Common human symptoms are fever, headache, chills, muscular aches and pains and fatigue. There may also be sickness, diarrhoea, loss of appetite, respiratory problems, glandular involvement, confusion/delusion and even coma. Complications associated with the immune system failure may eventually involve kidney or respiratory failure.

No vaccines are available so caution is required. Even if symptoms are minor the fact that the immune system has been compromised and the body laid open to other infections is key, especially in people who already have immune mediated health problems. Treatment with the antibiotic Doxycycline is very effective except in end stages of the disease. Diagnosis is by testing blood samples for antibody titres to the different bacteria known to cause Ehrlichiosis and by identifying actual bacteria in the white blood cells.

The same approach identified for Lyme Disease should be adopted and further advice is given in Appendix 2.

3. METHODS

General

The basic methodology for collecting information on ticks in this study has been developed over a period of years. In the early 1990s questing (looking for a blood feed) tick populations were assessed from a series of random locations in different hill habitats in different parts of the country. The Quantock Hills was one of the main areas. At each random location the vegetation/habitat was described and 10 x 30m long blanket drags were carried out on each sample quardrat. The blanket used was 1m2. At every 10m on each drag the blanket was turned over and the ticks identified to life stage (larva, nymph, male, female), counted and collected for disease analysis (or at least a sample if numbers were high). At the same time a programme of live small mammal trapping was undertaken and ticks were collected from mice and voles by putting them in a warm high humidity chamber for a few days so that any ticks on them would complete their feeding cycle quickly and drop off, engorged with blood, into a warm water bath underneath them. The rodents were then returned to the wild. The collected ticks were again logged and subsampled for disease presence.

It very quickly became apparent that there were some areas where, for instance, there was extensive sheltered areas of bracken and often with a high level of host activity that numbers of questing ticks were high. In other areas, such as exposed old dry dwarf shrub habitats on the hill top tick activity levels were low even with host activity. On this basis the technique became more refined and areas of intense activity could be predicted. Sampling patterns were adjusted accordingly from the late 1990s and, where human use was an important factor, key areas for monitoring were defined. Factors such as Relative Humidity, Air temperature and Wind Speed as well as the relative shelter/questing importance of vegetation type and host availability have all been factored in and are now routinely recorded.

In terms of collecting data on questing ticks the methodology has not changed greatly. The raw data for the blanket dragging sample sessions in this study is summarised in Appendix 3. In the current study no small mammal host work has been undertaken but greater account of deer as hosts has been built in. In conjunction with the Forestry Commission, who have been carrying out the normal winter culling programme over the four months of this study, sample engorged ticks, condition assessments and general tick counts have been collected from female Red and Roe Deer.

Ticks sent for disease analysis were processed using Polymerase Chain Reaction (PCR) a unique protien DNA determination. This work has been carried out in different laboratories and has evolved over the years. Much of the effort has gone into Lyme Borreliosis, but other viral and bacterial pathogens have also been determined especially TBF as it is widespread. Although all ticks of all life stages have been counted the focus for looking at population trends and

the incidence of pathogens has been on the nymph stage. This stage has been chosen as numbers are relatively high, nymphs are capable of piercing the skin of large and small hosts and they have often picked up pathogens on their first feed as larvae. They are also less easy to see than the females. In short, they pose the greatest risk. Figures for pathogen presence have been calculated as percentages of the total sample tested for both questing and engorged ticks.

Study Sites

The distribution of major habitat types on the open hill is summarised on Map 1. In the Quantock Hills project there are fourteen areas which have been sampled on a near annual basis since the studies started in 1991, with two new areas added as a result of the current study and a further 17 check sites where full habitat descriptions have not been undertaken but ticks have been sampled over several years. These are identified on map 2. The profiles of these sites in both habitat and tick activity terms has been applied to similar habitat areas on the Quantock Hills to calculate the total areas involved. In this current phase of the project emphesis has been placed on places where there is a high level of public interface and/or the areas have been established as 'hot spots' in terms of high levels of tick/host activity and/or pathogen presence in questing tick populations.

The sites and areas have been digitally mapped and key points referenced using GPS.

Cothelstone Hill (2 areas), Aisholt Common (3 areas), Lydeard Hill (1 area), Crowcombe (2 sites), Weacombe (1 site), Thorncombe-Hurley Beacon (1 site) and West Quantoxhead - Staple Plain complex (3 sites) have all been sampled since 1991. The sample years have been 1991, 1993, 1994, 1995, 1997, 1998, 1999, 2001, 2003, 2006, 2007 and 2008 (Jan - March). Higher Hare Knapp has been sampled since 1998. Great Bear Wood, Slaughterhouse Combe and a supplementary woodland area at Cothelstone Hill have been sampled in 2007 and 2008. With the check areas about 750ha of habitat have been described in detail amounting to roughly 10% of the open hill,scrub woodland edge area of the Quantock Hills.

Samples of questing ticks have been collected for pathogen analysis from Cothelstone Hill, Aisholt, Lydeard Hill, Thorncombe and Weacombe since the beginning of the research on the Quantock Hills with Higher Hare Knapp coming in from 1998.

Data Analysis

Vegetation/habitat characterisation was carried out using mean percentage cover values of the dominant species. For purposes of comparing tick densities between vegetation type and over time numbers were aggregated (within each

life stage) for each vegetation type and each year. They were expressed as mean numbers of ticks per drag per annum. A non-parametric multiple comparisons analysis (Kruskal-Wallis two-factor analysis of variance) was used to evaluate the significance of the differences observed.

The ratio of male to female ticks recovered from the questing population has been monitored for the successive years of monitoring. This is important in terms of evaluating the potential changing breeding dynamics of the tick populations.

Disease analysis has been discussed above and because of the limited nature of results there has been no attempt to apply rigorous statistical evaluation, although the trends are very clear. The risk assessment in terms of exposure to pathogen carrying ticks has been calculated for the key visitor sites and for the blocks of habitat as a whole. The calculation involves the area occupied by a habitat type, the % 'infection' rate for the habitat type, the % of the total sample of nymphs attributable to the habitat block and then habitat and area risk corrections based on combinations of the data.

4. RESULTS

Habitat

Earlier work in the South West of England (1995 to 1999) established that Sheltered dense bracken with deep litter and deer activity accounted for 40% of all questing ticks collected ; Dense bracken with dense litter for a further 32% ; Old, tussocky Purple Moor Grass for 12% ; Dense carpets of Bilberry (in summer) for 9% ; Bilberry and bracken mix 2% ; Bilberry established after bracken control 2% whilst Old dwarf shrub, mixed coarse grassland, waterlogged flushes, new growth Calluna/dwarf shrub and recently burnt Purple Moor Grass accounted for only 3% between them. This is even more significant when the fact that the last category accounted for over 75% of the total ground area is taken into account. In these studies (which included the Quantock Hills) scrub/open deciduous woodland was not included in the survey. The main habitat types are identified on Map 1.

The 2007/08 survey on the Quantock Hills confirms earlier findings that small 'hotspot' habitat areas account for a very large percentage of the total tick activity. The main sample areas have ranged through the dry heath hill tops dominated by Bell Heather, Ling, Gorse with Flying Bent Grass and smaller damp areas with Cross Leaved Heath/Purple Moor Grass mix, through Bilberry 'cushions', mixed grass/bracken/dry heath, dense bracken banks and slopes to open scrub woodland with a full range of the ground covers listed above and some small areas of wetland as well. Table 1 contains the summary of activity levels

Table 1

Habitat and tick relationships on the Quantock Hills in 2007/08

A. The dwarf shrub plateaux areas (excluding Bilberry) which accounts for 71% of the total habitat sampled, but accounts for less than 5% of all recorded tick activity.

B. Dense Bilberry cushions on the open hill which account for 3% of the area but 14% of recorded tick activity.

C. The dense Bracken monoculture and bracken/coarse grass/scrub complexes which account for 8% of the total area but 68% of all recorded tick activity.

D. Coarse, dry grassland which covers 2% of the area, but accounts for only

0.5% of recorded tick activity

E. Open woodland/scrubland with dense ground cover occupies about 14% of the total sample area and accounts for 10.5% of recorded tick activity.

Deer are a constant factor across all of the sample sites unless they have been excluded by fencing.

The significance of these distributions is discussed further in the context of specific sites and the distribution and risk assessment of tick borne diseases below, but the keypoint is that 29% of the area accounts for 95% of the tick activity.

Changes and trends in Tick Population distribution and densities 1998 to 2007/08.

Table 2 summarises some of the key trends in relation to specific areas with explanatory notes about the changes. Map 2 gives a graphic summary of the sample sites and changes in tick densities for the Quantock Hills SSSI. There have been marked changes in some habitats and areas, both in total numbers, range and in the composition of the life stage structure (eg male to female ratio) as well as potential exposure to pathogens (below). For ease of presentation only the data for the start (1998) and finish (2007/08) years of the comparison period are included here, but in many cases there are intermediate records and surveys going back to 1991. This data is all contained in the electronic appendicies and the summary of the raw data relating to this specific study is presented in Appendix 3. Where appropriate, reference is made to data outside the time box in the discussion below.

In terms of tick densities various levels have been defined. **Very low** indicates a mean annual density of 0 to 2 questing ticks of all life stages per 30m2 ; **Low** levels are 3 to 5 per 30m2 ; **Moderate** levels are 6 to 9 per 30m2 ; **High** levels are 10 to 39 per 30m2 ; **'Hot Spots'** are 40 per 30m2 plus. Table 1 shows that the dwarf shrub/dry coarse grass habitats occupy 73% of the physical area but account for only 7% of all questing tick activity recorded in this survey. By contrast the bracken, bilberry and open woodland communities occupy 27% 0f the area, but account for 93% of all recorded questing tick activity. This underpins the 'hot spot' function of the sheltered bracken and bilberry areas and the woodland. Deer are critical hosts in both hot spot and low activity level areas. The same is true of sheep, but intense concentrations of deer in certain areas have both physical consequences for the dwarf shrub habitat and the maintenance and transport of tick populations and the pathogens they carry. It is estimated that there are up to 1000 Red Deer on the Quantocks at certain times of year and on an area this size and habitat composition the maximum hind herd should be substantially less than this in terms of dwarf shrub quality and tick

population management. There is brief reference to the importance of the deer population in the recommendations section and the issue should be addressed in the near future.

Since the start of records in 1991 certain areas have seen large increases in tick densities. Bilberry 'cushion' areas at Staple Plain have recorded an increase of 475% ; Bracken areas on Aisholt Common 412% ; Bracken on Cothelstone 210%. By contrast other areas such as Crowcombe Park Bilberry/dense grasshave seen a modest increase in percentage terms (85%) overall, but actual numbers are high in any event and it is these figures which are key.

In terms of rates of change in density an **increase of <10%** is classed as **Static**, **11 to 25% Slight Increase, 26 to 35% Moderate Increase, 36 to 49% High and 50% pus Very High.**

The trends on sites over the last 10 years show varying profiles.

1. The three sites at **Aisholt** have shown about a 50% increase with actual numbers varying between habitat types. However the dense bracken areas have seen an increase from very high to hotspot status and also a significant change in male to female tick ratio indicating clear potential for further increases. Fortunately public use is moderate as this is and has continued to be a high risk area for tick borne disease.

2. Quantox Head/Staple Plain sites show a range in increase from 56% to over 200% in the period, but the area of high increase has low numbers to start with. Increases in absolute numbers are high in Bilberry hot spot areas, there is a high pathogen presence, the male to female ratio has increased dramatically and there is intense public use.

3. **Crowcombe Park** has shown some of the lowest percentage increases 7% to 36% and, although densities are high/hotspot level in places the pathogen occurence has increased only moderately and there is no increase in male to female ratio. This is a heavily used access area, however.

4. The hotspot areas of **Cothelstone Hill** record intense tick activity and have shown over a 55% increase in the last 10 years. There is a very high pathogen risk, the male to female ratio has increased greatly and there is intense public use making this the single area of greatest concern on the Quantocks Hills.

5. **Lydeard Hill** has shown about a 50% increase and a marked increase in the male to female ratio, but pathogen levels are not high and actual tick densities are moderate-high. There is, however, intense recreational use.

6. **Higher Hare Knapp** has low to moderate tick numbers and although %

increases have been as high as 50+ the pathogen levels are low, male to female ratio is low and not increasing and visitor activity levels are moderate only.

7. **Thorncombe,** representing much of the dry dwarf shrub area of the hills, has low densities, is virtually static in density terms, has a low and non increasing male to female ratio and visitor activity is moderate but tends to be confined to set pathways.

Ratio of Male to Female Ticks and implications for population change

Earlier publications by the author (references in bibliography) established the differences in male to female ratios in different habitats. Table 3 summarises the figures for the North York Moors in 1993 and the Quantocks in 1993 and 2007. A high male to female ratio is critical to successful breeding and this fact must be taken into account in analysising existing tick populations and predicting trends. The North York Moors data has been presented to reflect the consistency in ratios between different habitats in different geographical regions of the country.

Table 3

Male to Female Ratios in different habitats in different geographical areas

Location	**North York Moors National Park**	**Quantock Hills AONB**	
Date	**1993**	**1993**	**2007**
Habitat	**Male : Female**	**Male: Female**	**Male: Female**
Bracken	**2.00 : 1.00**	**1.83 : 1.00**	**1.95 : 1.00**
Bilberry	**2.40 : 1.00**	**1.85 : 1.00**	**2.10 : 1.00**
Heather (Calluna)	**0.80 : 1.00**	**0.70 : 1.00**	**0.80 : 1.00**

The key points to emerge are the consistent low ratios in dwarf shrub and high ratios (which have increased on the Quantock Hills in the last 15 years) in bracken and bilberry areas. This is related to micro climate as well as host availability. In the Quantocks there has been a significant increase in the ratio in Bilberry 'cushion' habitats confirming the dynamic situation in tick populations on a number of the key habitats/areas on the hills.

The importance of Hosts and Disease Profiles in Engorged Ticks

Deer and sheep are the main 'top hosts' for ticks. In general terms an untreated ewe may carry 300 to 500 ticks of all life stages at any one time if heavily infested. By contrast, a Red Deer hind will routinely carry 1500+ and figures of 8 to 12000 are not uncommon. Stags may carry an even higher burden at certain times of the year (overall 'records' are just over 18000 from a stag and 22000

from a hind, both from North East Scotland in different years). It is important to maintain deer populations as a means of keeping tick populations within a host cycle which can be managed. This applies particularly to the final Female stage. The same principle applies to sheep, but both numbers of ticks carried and the current organophosphate/synthetic pyrethroid/vaccination treatments policy make them 'secondary hosts'. A population of deer, even if not actively managed to control levels of tick activity, has the effect of concentrating questing ticks on a few large hosts so that transmission onto smaller hosts (such as microtine mammals and ground nesting birds) is restricted.

It is much easier to manage a few heavily infested hosts than large numbers of small hosts, each carrying a relatively small number of ticks. There is thus a need to balance the impact of too many deer concentrating on vulnerable vegetation areas with the need to contain tick activity. It is also important to remember that relatively high tick burdens on small mammals and birds particularly can cause physical stress without disease transmission and greatly reduce general body condition, breeding and overall ability to survive.

Details of deer tick samples collected in the current study are summarised in Appendix 4. A sample of feeding (except for males) ticks was collected from Hinds shot as part of the normal annual control programme in February and March 2008. A total of 10 deer (7 Red Hinds and 3 Roe Does) were sampled to give an indication of levels of pathogen presence in engorged ticks. Of the 7 Red Deer 3 returned ticks with TBF, 2 with Borrelia (Lyme Disease complex), all 7 with Staphyloccocus aureus and 2 with Flavivirus (Louping Ill). All 3 Roe returned ticks with TBF, none with Borrelia, all 3 with Staphyloccocus aureus and 2 with Louping Ill.

Appendix 4 shows the total number of ticks collected from deer and it should be noted that numbers retrieved increased from early February to early March, although no attempt was made to count all ticks off, and the increase in Male and larval activity indicates the Spring Rise of ticks had started by the time the last deer was shot.

Analysis of disease presence was also carried out by life group (eg all the female ticks taken from one deer were treated as one group) giving a total number of 26 groups. Only one larval sample was recovered and this was Borrelia positive ; there were 10 samples (groups) of nymphs of which 4 had TBF, 2 had Borrelia, 9 had Staphyloccocus and 2 had Louping Ill ; there were 8 female samples of which 3 had TBF, 1 had Borrelia, 7 had Staphyloccocus and 3 had Louping Ill. Males are non feeders and any pathogens they carry are from an earlier stage and will not be passed on. One male sample returned TBF and one returned Staphyloccocus.

The pattern was as predicted with all deer returning ticks testing positive for one or more pathogen/infection and all tick life stages recorded with one or more Tick Borne Disease pathogens. Deer are universal over the Quantock Hills, although

some sites are restricted, and the results of this survey confirm the importance of deer as hosts and, in some cases disease reservoirs in the area.,

Disease Profiles in Questing Ticks

The profiles for different habitats and sites since the start date on the area concerned are presented in table and graph form in seperate electronic appendicies. This section summarises the key points in relation to pathogen presence and trends in general terms. The main virus and bacteria groups assayed using the PCR and culture techniques described above are **Borrelia** spp (Lyme Borreliosis), **Flavivirus** (Louping Ill), **Anaplasma**/**Ehrlichia**/**Ricketsia** (Tick Borne Fever, Spotted Fever Groups) and **Staphyloccocus aureus** (Pyaemia, localised skin infections). **Babesia** (Red Water Fever) has been confirmed from recent samples.

The general implications for human health have been discussed in some detail elsewhere in this report and Table 4 summarises some of the key findings and trends from the main study areas of the last 17 years.

Table 4

Trends in rates of infection (%) in questing nymph ticks on the Quantock Hills

A. Cothelstone Hill (Dense bracken 'hotspot' area)

Samples from all 12 data collecting years since 1991. Ticks carrying pathogens recorded from year 1 (1991) onwards. Dramatic and consistent increase in pathogen presence over the period (1.5% in 1991 ; 16.8% in 2007/08).

B. Aisholt (Dense bracken 'hotspot' areas)

Samples from all 12 data collecting years since 1991. Ticks carrying pathogens recorded from 1991. Similar pattern to A, as on much of the sheltered bracken areas on the whole hill. Pathogen presence 1.5% in 1991 ; 18.2% in 2007/08).

C. Lydeard Hill (Bilberry/Grass site)

Samples from all years (12) since 1991. Ticks carrying pathogens recorded from year one. Marked increase in pathogen presence (3.3% in 1991 : 15.2% in 2007/08).

D. Thorncombe (Bilberry/Grass Site)

Sampled in all 12 collecting years since 1991. Pathogens in ticks first recorded in 1995 indicating increasing range of disease. Moderate increase in pathogen presence over time (3.3% in 1995 ; 12.0% in 2008).

E. Weacombe (Dwarf shrub - also some damage from deer)

Sampled in all 12 collecting years since 1991. Ticks carrying pathogens first recorded in 1994 again indicating an increasing range. Tick numbers low, but increase in pathogen

presence from 2.25% in 1994 to 12.60% in 2008).

F. Higher Hare Knapp (Controlled Bracken/Grass/dwarf shurb complex).

Samples collected in each sample year from 1998 onwards. Ticks carrying pathogens first recorded in 2003 again indication increasing range. Levels of tick activity have remained low and pathogen presence is increasing very slowly (1.5% in 2003 ; 5.8% in 2007/08).

G. Great Bear Wood (Deciduous woodland/scrub edge)

Sampled in November 2007, late December 2007 and early February 2008. Small sub-samples were tested for disease. A total of 18 ticks in November, 21 in December and 20 in February 2008 were used. Pathogen presence was 6.8% in November, 7.6% in December and 8.1% in February.

H. Slaughterhouse Coombe (Deciduous wood/bracken/intense deer activity)

Sampled in late December 2007 andagain in February 2008. The sample number was small in December, but the pathogen present percentage was high (14.5%) and even higher (15.1%) in February 2008.

The implications for potential human exposure are clear and are discussed further in the context of risk assessment below. In order to indicate the long term variations Table 5 summarises the changes in pathogen presence from 6 of the key sites since the study was commenced in 1991.

Table 5

Changes in detection rates of pathogens in questing nymph ticks on the Quantock Hills between 1991 and 2007/08
Figures are % of ticks carrying at least one pathogen

Location	A.Cothelstone	B.Aisholt	C.Lydeard	D.Thorncombe	E.Weacombe	F.Hare Knapp
Date						
1991	1.5	1.5	3.3	0	0	-
1993	3.3	3.3	6.2	0	0	-
1994	8.3	3.3	5.8	0	2.25	-
1995	5.8	3.3	3.3	3.3	2.25	-
1997	7.4	4.5	4.1	4.4	3.8	-
1998	7.9	6.8	5.7	5.0	5.9	-
1999	8.1	7.1	8.9	6.8	7.0	0
2001	8.6	9.6	10.1	7.8	7.9	0
2003	7.6	14.2	12.6	8.4	9.4	1
2006	11.1	16.1	13.2	9.6	9.8	1.25
2007	17.2	18.5	15.6	11.7	12.4	1.5
2008	16.8	18.2	15.2	12.0	12.6	5.8

The table confirms the fluctuating but progressive increases on all sites.

Risk Assessment

Whilst it might be possible to calculate a risk assessment (the chances of being bitten by a pathogen carrying tick - not necessarily resulting in the contraction of a Tick Borne Disease - TBD) for individual sites eg. Cothelstone Hill it has been considered more constructive to apply this to the major habitat types. The risk assessment in relation to Lyme Disease bacteria in nymph ticks is summarised in Table 6.

Five key groups of habitat are identified in Table 6. These are the dense bracken areas, which occupy 8% of the total habitat sampled, the Bilberry 'cushion' areas occupying 3% of the area, Dwarf shrub accounting for 71% of the habitat, Coarse grassland covering 2% and Woodland accounting for 14%. The table compares the risk factor of 1998 with that of 2008 and works on the basis that the physical areas have not changed. Woodland was not included in the 1998 survey and the figures are adjusted accordingly. To carry out the calculations the % infection rate in nymph ticks is recorded for each habitat block in each year. The % of the total nymph sample collected from each habitat type is calculated for each year. The general habitat risk is calculated by multiplying infection rate by proportion of nymph sample for each habitat. This is not an absolute measure, but an indicator the significant threshold value of which is set at 10. The area risk, ie the weighted significance of each habitat type is calculated by multiplying the general habitat risk by the % area occupied by the habitat type. Again the threshold is indicative with anything above 100 being regarded as significant.

Earlier data sets have shown the relative importance of different habitat types in relation to tick distribution/densities. This table confirms the overwhelming significance of the bracken areas. More importantly it shows how this factor has increased dramatically, mainly driven by the change in pathogen incidence between 1998 and 2008. Bilberry shows a proportionally high significance and dramatic increase over the 10 year period and although no comparison is possible the woodland area shows a high level of risk significance. The dry dwarf shrub, which occupies the bulk of the sample area, constitutes a low risk area, but even this has shown a significant increase over the 10 year period and the same cautious approach to public information applied to high risk areas must also be applied here. Only the small areas of dry grassland fail to reach significant levels overall, but even here there has been a marked increase in the rate of pathogen presence.

In summary the mean infection rate across the four comparable habitat blocks (woodland sampled in 2008 only) has increased from 2.47% to 9.4% a 380% increase. The habitat risk mean has increased from 108.6 to 283.52 (significant threshold 10) a 260% increase and the corrected area

risk has increased from 809.45 to 2339.2 (significant threshold 100) almost a 290% increase.

When these figures are considered alongside the density changes it is clear that the general pattern of tick distribution has remained the same over the last ten years, but the densities have increased, the life stage structure has militated towards more vigorous breeding, the distribution (and multiple infection rate) has increased considerably and the overall rate of infection has increased between 200 and 300%.

Public Awareness

An earlier published study by the author based on a 2003 interview survey indicated that the public was largely unaware of the problems of ticks, tick borne disease, steps to avoid being bitten, how to recognise TBD problems and the best ways of getting diagnosis and treatment. The current study through contact with health professionals suggests that both Physicians and Veterinary Surgeons (whilst some of the latter especially are very well clued up !) are generally not as aware as they could be. This is especially important in the light of changing tick ecology and the highly increased risk of being bitten by ticks and the need to re-assess public awareness (and then develop an appropriate information strategy) and to form information exchange structures with local clinicians (human and animal) are two of the key recommendations of this study.

5. RECOMMENDATIONS

A series of detailed recommendations have been made within the following framework.

1. Habitat Management

A. Acaricides - application on the ground. This is not an option on the Quantock Hills.

B. Selective land management such as bracken control (hotspot reduction) and carefully managed swaling (rotational burning) on dwarf shrub and grass areas to reduce the tick habitat. This will be a major tool on the Quantocks and detailed proposals should be developed as an overall tick habitat management plan.

Bracken management will need to be integrated, bringing together chemical and physical control methods. Swaling of targetted dwarf shrub and grass areas is important, but the current practice of burning areas of bracken is not helping. The effect of burning a bracken bed is to raise the base status of the soil in general terms, which encourages new growth from spores, and potassium in particular which encourages further growth of the established rhizome/root/frond system. Burning also has only a limited effect on ticks as at best it will damage the top 1 to 3cm of the dense bracken litter and active ticks frequently shelter deeper in the litter where the temperature is hardly raised by a top burn and the humidity within the system is not compromised. The burning approach needs to be linked into the 5 to 10 year plan and there needs to be close liaison with the graziers over effective bracken management.

Based on previous surveys and the significance of the bracken 'hot spots' it is recommended that about 30ha of bracken are controlled in each of year 1 and 2 of a five year programme; 30ha of primary control in year 3 plus up to 10ha follow up on year 1; 20ha of primary in year 4 plus 15ha of follow up on year 1 and 2 areas; 20ha of primary control in year 5 plus 20ha of follow up on years 1,2 and 3 areas; 20ha of primary in year 6 plus 20 ha of follow up on years 1,2,3 and 4; 25ha of follow up in each of years 7, 8 and 9 on the primary areas treated in years 1 to 6. This gives a total of 150ha of primary and 140ha of secondary/follow up over the 9 year period. This is not a full bracken control programme it is designed to reduce and contain 'hot spot' areas only.

C. Agricultural Rotations - in this context the management and movement of domestic species such as ponies, cattle and (most importantly) sheep. Maintaining sheep as large tick hosts has been discussed above, but shepherding and controlled exclusion will be as important as vaccinating the sheep and treating them with Organophosphate and Synthetic Pyrethroid

preparations. This has some significance to the Quantocks situation and possible development with commoners/farmers should be explored.

D. There is a need to consider the impacts on other invertebrates and animal groups. This applies to the simplification of habitats as other species may be disadvantaged. eg some ground nesting birds.

E. Funding for practical management may be an issue and liaison with appropriate charities and trusts should be established.

2. Hosts

A. Vaccines. Vaccines are possible for sheep, especially in relation to Louping Ill, but these do not necessarily help with reducing overall levels of tick activity. There is also clear evidence that other tick borne diseases may be as important eg. Tick Borne Fever and Pyaemia.

B. Acaricides. Treatment of sheep with synthetic pyrethroids and organophosphate dips, pour ons etc is well established. However, it will be important to try to treat wild hosts - specifically deer and the sheep treatments are not an option. New, more environmentally neutral treatments may soon be available and it is recommended that these are considered as the programme is rolled out over the next few years. This approach may well become available for sheep as well. This should be explored with graziers as part of the ongoing tick management programme

C. Host removal, such as excluding sheep from the ground, will be limited because of the permanent presence of large wild hosts (deer). In relation to deer management removal through further culling, combined with 2B above, should be explored. The importance of maintaining an albeit reduced deer herd as a means of managing tick activity has been discussed above.

D. The need to consider other small wild hosts, such as foxes, hedgehogs, voles, mice, squirrels and ground nesting birds as hosts must not be overlooked and should be factored in. This will be less of a problem if 'top' large hosts are properly managed.

3. Ticks

A. Biological Control in the conventional sense (eg irradiated males) is not a practical wide scale option. However, an application which prevents attached ticks from completing their blood feed is being trialled elsewhere and may be an option worth exploring in the near future.

B. The need for properly structured control trials in the context of the Quantock

Hills agricultural and access management regimes should be factored in to the management programmes for the next 5 to 10 years.

4. Human Involvement

A. Public awareness of risk. Re - evaluation of public awareness of ticks and tick borne disease by including a sub questionnaire in the next visitor survey.

B. Development of a management strategy based on information from 2008 and earlier surveys to make people using the access areas aware of the potential risk, give on the ground advice about specific risks and advice on avoiding tick bites and how to seek help at all stages including diagnosis and early treatment of disease. A network of simple 'on site' information notices is needed at key access points and all high risk locations, with more extensive information resources at main centres and also dedicated, easy to use, web pages.

C. Liaison with GPs, Community Physicians, Specialists and Veterinary Surgeons to establish information and advice networks and to develop a strategy for delivery.

D. Vaccines for certain forms of TBD exist, but are not appropriate here and are not considered further.

E. Current diagnostic facilities are limited, eg. the need to differentiate between the 3 strains of Borrelia, and the possibilities of developing a regional laboratory service should be explored. The Acurus Laboratory already exists at Bristol for Veterinary use and the human diagnosis services need to be considered, again looking for potential funding as part of the process.

F. Information relating to tick problems on Open Access Land on the Quantock Hills should be incorporated into the Interpretation Boards which are currently being redesigned and are due to be replaced. Development of Web Sites with interactive information exchange is another development for the near future.

G. Information on the problems should be put across to staff, volunteers and occupation groups at risk through an intensive briefing day for managers who will then be able to disseminate the information. Briefing packs should be prepared.

H. A one day joint conference/workshop involving the land and recreation managers from the Quantock Hills AONB and the Exmoor National Park Authority should be organised for late summer 2008. This will be based on the findings of this report and a maximum of three additional presentations. Local Medical And Veterinary Practitioners should be invited so that a general briefing and information exchange protocols can be established and relevant interest groups can exchange information.

I. A Tick Monitoring 'Tool Kit' should be prepared and given out to Local Authorities and other interested groups (4G and 4H above).

5. Resources

A. Additional funding issues.

B. Staff resources - implementation of management and education on the ground
- ongoing monitoring requirements
- additional research and evaluation.

C. Equipment and Materials

6. Future Application of this project

A. Development of a template to be applied to other Open Access/SSSI areas to assess risk levels and potential management strategies. This will be modelled on the current study to help inform Natural England on other sites.

B. Establishment of a small working group relating to the Quantocks Hills AONB to draw in additional resources (avoiding double funding) for the proposals and to monitor and insure their implementation.

C. Developing a host management strategy as a means of tick control.

D. Formation of a small informal grouping involving the County Council/AONB officers with other interested parties to develop a resource/funding strategy to support a long term (up to 10 years) input into tick/disease/habitat/host/people management.

RWB 16/03/08

Appendix 1

TICK BORNE DISEASES
(SYMPTOMS, DIAGNOSIS AND MANAGEMENT)

Not included electronically. Hard copies can be obtained from the Quantock Hills AONB Service, Fyne Court, Broomfield, Bridgwater, Somerset TA5 2EQ

Appendix 2

TICKS AND TICK BORNE DISEASES
(ADVISORY AND EDUCATIONAL MATERIAL)

1. A Resource Pack has been produced and is lodged with Somerset County Council (Quantocks Hills AONB) and Natural England.

2. The leaflet on 'Ticks and Lyme Diseae' produced a number of years ago by Somerset County Council, Mendip Hills AONB, Quantock Hills AONB Service and Blackdown Hills AONB contains sound advice.

3. BADA -UK (Borreliosis & Associated Diseases Awareness UK) is a useful point of contact.

Web site www.bada-uk.org and email bada-uk@hotmail.co.uk.
BADA -UK (Information service)
PO Box 70
North Walsham
NR28 0WX

4. ILADS (International Lyme and Associated Disease Society) has produced comprehensive guidelines and can be contacted via:

PO Box 341461
Bethesda
Maryland
USA
20827-1461

Web site http://www.ilads.org and email lymedocs@aol.com

5. The Quantock Hills AONB Service can be contacted at :

Quantock Hills AONB Service
Fyne Court
Broomfield
Bridgewater
Someset TA5 2EQ

Web site www.quantockhills.com and email quantockhills@somerset.gov.uk

Appendix 3

QUESTING TICKS

(RAW DATA COLLECTED FOR CURRENT STUDY)
(October 13 - 15 2007; December 30 - 31 2007; February 11 - 13 2008)

Not included electronically. Hard copies can be obtained from the Quantock Hills AONB Service, Fyne Court, Broomfield, Bridgwater, Somerset TA5 2EQ

Appendix 4

SUMMARY OF TICK RESULTS FROM DEER CULLED ON THE QUANTOCKS IN FEBRUARY AND MARCH
(NB Engorged Samples collected for TBD testing, not total tick counts)

Location	Species	Date Culled	Sex	Weight	Tick Life Stage (pathogens in brackets)			
					Larva	Nymph	Female	Male
1. Quantocks	Red	11/02/08	F	36kg	0	2 (A C)	4	0
2. Quantocks	Roe	11/02/08	F	14.5kg	0	5 (A C)	0	0
3. Quantocks	Red	11/02/08	F	46kg	0	6 (C)	0	0
4. Quantocks	Red	18/02/08	F	49kg	0	4 (B C)	6	5 (A*)
5. Quantocks	Roe	18/02/08	F	12kg	3	3 (A C D)	6	1
6. Quantocks	Red	20/02/08	F	60kg	4	4 (C)	8	2
7. Quantocks	Roe	20/02/08	F	15.5kg	4	4 (A C)	9	1
8. Quantocks	Red	07/03/08	F	65kg	4	4 (B)	16	2 (C*)
9. Quantocks	Red	07/03/08	F	50kg	2	2 (C)	9	1
10. Quantocks	Red	10/03/08	F	48kg	2 (B**)	14 (C D)	26	12

A = Tick Borne Fever B = Borrelia spp (Lyme Disease group) C = Staphyloccocus aureus (scabbing etc) D = Flavivirus (Louping Ill)

*** Males do not feed and the pathogens detected must have been aquired at the larva or nymph stage**

**** First blood feed so either aquired from blood of deer (but note no Borrelia in either nymph or female stage) or passed transovarially**

Appendix 5

INFORMATION FOR INTERPRETATION BOARDS

- **Sheep ticks are widespread on these hills particularly in dense bracken areas, in coarse damp grassland, in scrub woodland with dense undercover and in cushions of dense Bilberry. These habitats are often tick 'hotspots'.**
- **Ticks of all sizes from the tiny 6 legged larva, through the 8 legged nymph to the large female, which looks like a bean when full of blood, can pierce the skin and can spread disease putting you and your dogs at risk. The dark coloured free living male tick does not bite.**
- **Wear sensible clothing, cover your legs and arms and tuck trousers into shoes or boots. Open shoes and bare legs are not recommended. Keep you dogs on a lead and do not go into tick 'hotspot' vegetation.**
- **Check for ticks when you go home - they attach anywhere on thin, sheltered, hairy or moist skin areas. If you find ticks remove them as quickly as possible but do not 'shock' them. It is best to twist them out carefully with a pair of twezers.**
- **If you develop a rash or feel unwell up to three weeks after a tick has attached to you get medical advice**
- **Further information on Ticks and their management on these hills is available at www.....**

Appendix 6

TICK ASSESSMENT AND ACTION PLAN
(SUMMARY)

TICK ASSESSMENT AND ACTION PLAN
(SUMMARY)

Professor Roy Brown
01 December 2007

There are several species of hard bodied tick found in the British Isles. One *Ixodes ricinus,* the Sheep or Castor Bean Tick, occurs widely on birds and mammals (including human beings) and dominates in terms of distribution, numbers, range of hosts and habitats. These parasites require three blood feeds on different hosts to complete their life cycle and may create major problems in terms of sheer population densities and, increasingly, transmission of disease to wild and domestic birds and mammals. With increasing focus on public access to areas which, by virtue of their habitat structure and diversity are often favourable tick habitats, the risk of human exposure is increasing dramatically.

This note is intended as an outline guide to issues and solutions based on over 30 years experience of tick ecology, habitat and host management. It is intended for use at any scale, but most of the applications have been at Estate/Farm level (5 to 29000ha), or at SSSI level (0.6 to 19000ha) and even whole area level (eg. Exmoor National Park, North York Moors National Park, Quantock Hills AONB).

1. Is there a tick problem?

Ticks are not a problem in all access areas and the scale of the problem should be assessed before committing resources. This can be judged from simple habitat counts (blanket dragging) and forensic examination of ticks and hosts.

A. Sheer numbers
- Hosts :
    i. 5 nymph/female ticks on a grouse, curlew or small mammal.
    ii. any female ticks on a small mammal.
    iii. >30 ticks at any life stage on sheep, deer or ponies.
- Habitat :
    i. average number of nymphs/female ticks per m2 of blanket dragged ground > 3.
    ii. Disease Presence - Viral or Bacterial

Disease causing pathogens detected either in questing or engorged ticks. Look for signs in birds, livestock, small/medium size mammals or deer. There are up to 19 possible bacterial or viral pathogens which can be passed (to people and other mammals) via tick bite in Europe but the following are most common.

a. Tick Borne Fever	***Erhlichia (Anaplasma) phagocytophilia*.**	**Mainly cattle(and People)**
(often with)		
b. Red Water Fever	***Babesia divergens*.**	**Cattle, Deer, Dogs (and People)**
c. Tick Borne Fever	***Ricketsia* (mild unless complicated by d or e)**	**Sheep (and People)**
d. Louping Ill	***Flavivirus* i. acute ii. sub acute**	**Sheep(and People)**
e. Tick pyaemia	***Staphyloccocus aureus***	**All - skin, joint**
f. Lyme Disease	***Borrelia burgdorferi* (and two other strains)**	**All - variable**
g. Tick Borne Encephalitis	***Flavivirus***	**All**
h. Tick paralysis	**Toxins in saliva, impact in UK unknown**	

Infected ticks often carry a 'cocktail' of more than one infection.

2. Occurence and Tick Distribution

Preferred habitats on open ground for the all important nymph stage (excluding open woodland with good ground cover which is also an important habitat but is discussed seperately) include dense bracken with deep litter cover (especially where deer are active), rank tussocky Purple Moor Grass, Bilberry (Blaeberry) and Bilberry mixed with bracken, some drier coarse grass areas.

Heather (any life stage/management condition), coarse dry grassland in general, wet flushes and recently burnt Purple Moor Grass (within last two years) carry very low numbers of nymphs and larvae.

In all cases of higher density activity the 'hot spot' concept is a critical one. Even in favourable areas the combination of sheltered, warm locations with constant humidities, shelter in the form of deep litter for the between active tick stages, good questing conditions and a supply of hosts will give rise to places of intense tick activity. These tend to be on the edge of more uniform areas and generate a high percentage of the total tick activity. This is discussed further below.

Summary of percentage distribution by habitat (excluding woodland) of nymph and larval tick densities in upland habitats of England. Female numbers are relatively low and constant between different habitats and it is the nymph stage which is most critical in the disease cycle.

Dense bracken with dense litter and deer activity	**40%**
Dense bracken with dense litter	**32%**
Purple Moor Grass (tussocky and old)	**12%**
Bilberry	**9%**
Bilberry and Bracken	**2%**
Bilberry after bracken control	**2%**
Old Heather	**1%**
Mixed, coarse grassland	**1%**
Waterlogged flushes/Juncus, new growth Heather/ dwarf shrub, recently burnt Purple Moor Grass	**1%**

3. Key Factors

Tick Lifecycle requirements include :

a. Habitat
   i Vegetation/Litter - Cover between feeding stages
   ii Questing support
   iii Environmental Factors (Windspeed, Temperature, Relative Humidity)
   iv Management Practices with stock and vegetation
b. Hosts
   i Mammals - Large (Deer, Sheep, Ponies); Medium (Hares); Small (Mice and Voles)
   ii Birds - Ground nesting and migratory (especially Gulls and Waders
c. Optimum conditions (Ai above). Remember, only sheltered areas will support viable tick populations at a high level for long periods of time, even if hosts, preferred vegetation cover and other factors such as temperature (> 16 C), Relative Humidity (> 75%) and windspeed (< 5 kph) would encourage intense periods of activity. Once again high levels of activity and survival (even if environmental conditions are sub-optimal) are associated with dense bracken and tussocky Purple Moor Grass in particular.

Percentage of activity under optimal and sub optimal conditions in different open habitats

Habitat	**Optimal (>16 C; RH > 75%; WS <5kph)**	**Sub optimal (<16 C; RH <75%; WS >5kph)**
Bracken	**60**	**40**
Old Purple Moor Grass	**50**	**50**
Bilberry	**80**	**20**
Calluna/Deer	**90**	**10**
Calluna/Bracken	**70**	**30**
Grass/Herbs	**100**	**0**
Calluna (grazed)	**90**	**10**
Calluna (mature)	**75**	**25**
Purple Moor Grass (recently burnt)	**95**	**5**

4. Action

a. Survey.
    i Tick distribution - on hosts (animals and birds) - in habitatsB.
    ii Disease presence determinations from.
        ii. mammals/birds;
        iii. engorged ticks;
        iv. questing ticks on the ground.
    iii Habitat survey to pinpoint 'hotspots', including assessment of potential activity/availability.
    iv Generate isopleth maps and risk assessments.
b. Produce three to five year Management/Action Plan with built in monitoring routine.
c. Implement Management Elements.
    i Stock Management, including shepherding, density manipulation and dipping/treating.
    ii Other vertebrate management (deer and Mountain Hare). Potential new herbal systemic treatment, culling where essential (mainly for habitat rather than tick control reasons), possible deer fencing in some circumstances where populations are high.
    iii Burning Programme - locations/habitats (heather, Purple Moor Grass) - optimum burning times within permitted code (spring burns best).
    iv Bracken control (where appropriate and subject to constraints eg. butterfly conservation).
    v Other vegetation manipulation (eg. glyphosating Purple Moor Grass prior to burning ; heather reseeding on bracken control areas on dense litter).
    vi Develop specific Education/Information Programmes including information for Health Professionals (Veterinary and Human)

Prof Roy Brown. November 2007

07879040543
profbrown@btinternet.com

BIBLIOGRAPHY

1. Supervised Studies, Conference and Unpublished Reports (Chronological rather than Alphabetical)

Brown, R W (1991). The Countryside is Bad for your Health. Keynote Lecture. British Association for the Advancement of Science, University of Plymouth 1991.

Holloway, S M (1994). Bracken (Pteridium aquilinum (L) Kuhn) Stand Characterisation on the North York moors : A study of the Rhizome and Frond system with regard to a large scale control programme. Ph.D Thesis, University of Plymouth 1994.

Sheaves, B J (1995). An Investigation of certain human health problems associated with Bracken Fern (Pteridium aquilinum) Environments in the UK. Ph.D Thesis, University of Plymouth 1995.

Brown, R W (1995). The Ecology of Lyme Disease : An interim report on work carried out between 1990 and 1995. 14pp. Professor Roy Brown, Director of Research, Bishop Burton, University of Lincoln and Humberside.

Brown, R W (1998). Tick and Lyme Disease Survey 1998 to 1999, Somerset. Interim Report for Somerset County Council. Prof.Brown Manchester Metropolitan University and R & D Associates.

Brown, R W (1998). Exmoor National Park Tick and Lyme Disease Study. Final Report for Exmoor National Park Authority. Prof. Brown Manchester Metropolitan University and R & D Associates.

Brown, R W (1999). Tick and Lyme Disease Survey 1998 to 1999, Somerset. Final Report for Somerset County Council. Prof. Brown Manchester Metropolitan University and R & D Associates.

Between 2002 and 2008 there have been a large number of specific reports on Tick Ecology, Control and Management including : North York Moors (4); Perth Area (8); Inverness (12); Braemar (7); Islay (9); North of England (4); South West England (3); Testing and Diagnosis (3) ; General (5).

2. Referred and other Published Output (Chronological)

Brown, R W (1993). Ticks and Lyme Disease. *Biologist* 40(1),4

Brown, R W and Sheaves, B J (1993). Breaking the cycle : environmental control of Borrelia. *Annals of Rheumatic Diseases*; 52: 407

Brown, R W (1995). Bracken and the Ecology of Lyme Disease. In 'Bracken : An Environmental Issue'. Eds R T Smith and J A Taylor, proceedings of the IBG 1995. p 116 - 119.

Brown, R W (1995). Regeneration options on bracken control sites : In ' Bracken : An Environmental Issue'. ... p 160 - 165.

Holloway, S M (1995). The Control of Bracken in the North York moors National Park with specific reference to the rhizome system in ' Bracken : An Environmental Issue'. ... p 148 - 154.

Sheaves, B J and Brown, R W (1995). A zoonosis as a Health Hazard in UK Moorland Recreational Areas : A Case Study of Lyme Disease. *Journ. of Env. planning and Management,* Vol 38, No 2 p 201 - 214.

Sheaves, B J and Brown, R W (1995). Densities of Ixodes ricinus ticks (Acari : Ixodidae) on moorland vegetation communities in the UK. *Experimental and Applied Acarology,* 19 p 1 - 9.

Brown, R W (1998). Environmental change and Lyme Disease. *The Globe*, 42 p 6 - 8.