Interdisciplinary Approaches to Managing Health of Fish and Wildlife

May 1-2, 2018
Kimberley, British Columbia
Canada

Columbia Mountains Institute of Applied Ecology

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Columbia Mountains Institute of Applied Ecology

Box 2568, Revelstoke, British Columbia, Canada V0E 2S0

Phone: 250-837-9311 Fax: 250-837-9311

Email: office@cmiae.org

Website: www.cmiae.org

Table of contents

Acknowledgements

This conference was hosted by the Columbia Mountains Institute of Applied Ecology (CMI).

The CMI is proud to have worked with the following agencies in the development of this event: Canadian Wildlife Health Cooperative, BC Animal Health Centre – BC Ministry of Agriculture, BC Wildlife Health Program – BC Ministry of Forests Lands and Natural Resource Operations, and the BC Sheep Separation Program.

CMI extends our gratitude for the financial support provided by: Columbia Basin Trust, Wild Sheep Foundation, Fish and Wildlife Compensation Program, Vast Resource Solutions, and Wild Sheep Society of British Columbia.

We are appreciative of the fabulous work done by our conference organizing committee, and others who contributed expertise as the event developed. The members of the organizing committee were:

- **Jeremy Ayotte**, BC Sheep Separation Program
- **Ilsa Griebel**, University of Northern British Columbia
- **Doris Hausleitner**, Selkirk College
- **Glenna McGregor**, BC Ministry of Agriculture
- **Helen Schwantje**, BC Ministry of Forest, Lands and Natural Resource Operations and Rural Development
- **Craig Stephen**, Canadian Wildlife Health Cooperative
- **Harry van Oort**, BC Hydro
- **Hailey Ross**, Columbia Mountains Institute
- **Mia King**, Columbia Mountains Institute

We ***thank*** our conference volunteers, Ilsa Griebel, UNBC, Doris Hausleitner, Selkirk College, and Robyn Irvine, Poisson Consulting Ltd.

Our presenters and the people who brought posters and displays travelled from various communities in British Columbia, Alberta, Saskatchewan, Ohio, and Montana. We are grateful for your willingness to share your knowledge with us, and for the support of your agencies in sending you to our event.

Conference description

The expanding footprint of humans increasingly alters the complex dynamics of wildlife health and disease, which can threaten wildlife populations. An unprecedented rate of emergence and re-emergence of infectious disease has been enabled via transport of organisms, environmental degradation, and by other factors that compromise ecological stability, including climate change. In Western North America, population-threatening diseases are occurring in fish and wildlife at an increasing rate, presenting significant conservation challenges.

To ensure proactive conservation of wildlife populations, there is a need for cross-discipline sharing of information on current disease issues by governments, communities, scientists, wildlife managers, the agriculture industries, public health, and stakeholders from all sides.

This conference provided an opportunity for improved dialogue among experts: First Nations, veterinarians, academics, epidemiologists, wildlife biologists, stakeholders, managers, stewardship groups, and the public. Over the two days, speakers gave presentations on collaborative approaches to wildlife health management, monitoring and responding to disease outbreaks, incorporating community-based knowledge of wildlife health to make informed decisions, disease at the wildlife-livestock interface, implications of climate on wildlife health, and mutual concerns of human and wildlife health. Experiences with successful citizen science and disease-reporting tools were also shared. A poster session was held during the first afternoon, along with a networking social. Dr. Helen Schwantje gave an evening talk on May 1 which was open to the public with a crowd of about 110 people.

This conference was held in Kimberley at the Kimberley Conference Centre, May 1-2, 2018. Approximately 64 people attended the conference.

The summaries of presentations in this document were provided by the speakers. Apart from small edits to create consistency in layout and style, the text appears as submitted by the speakers.

The information presented in this document has not been peer reviewed.

About the Columbia Mountains Institute of Applied Ecology
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The Columbia Mountains Institute of Applied Ecology (CMI) is a non-profit society based in Revelstoke, British Columbia. CMI is known for hosting balanced, science-driven events that bring together managers, researchers, educators, and natural resource practitioners from across southeastern British Columbia. CMI's website includes conference summaries from all of our events, and other resources.

Summaries of presentations

A Walk on the One Health Wild Side: how wildlife health knowledge can help with human health

Glenna McGregor, Ph.D., BC Animal Health Centre – BC Ministry of Agriculture
Abbotsford, British Columbia
Glenna.McGregor@gov.bc.ca

The health of humans, animals and the environment are inextricably linked. A good understanding of wildlife health is important to human health in three key ways: one, wildlife can be sources of disease; two, wildlife can be sentinels for changes in pathogen prevalence and the presence of environmental contaminants that also have implications for human health; and three wildlife can serve as models for diseases that also affect humans.

A zoonosis is an infectious disease that can be spread from animals to humans. 60.3% of human emerging infectious disease events reported between 1940 and 2004 were caused by pathogens that originated in animals; 71.8% of those originated in wildlife (Jones *et al*., 2008). The number of emerging infectious diseases in humans caused by pathogens that originated in wildlife has increased over time, even when controlled for reporting effort. This increase is due to a number of factors including increasing human population density, improved diagnostic techniques and increased diagnostic effort increasing detection of novel pathogens, changes in climate, increased movement of people and animals and their pathogens, habitat loss and fragmentation, and increased human susceptibility to disease resulting from the HIV/AIDs epidemic and medical advances increasing the survival of people who are immunosuppressed.

The year 2016 marked the first detections of West Nile Virus in the Kootenays in 9 horses and 2 crows. West Nile Virus (WNV) is a well know zoonosis that is carried by birds, particularly robins and finches, and is spread to humans by mosquitoes. WNV originated in wildlife and was brought to New York in 1999 and then spread like wildfire across much of North America in the next 3 years. The factors that conspired to allow the establishment and spread of WNV in North America are numerous and complex. The factors that conspired to bring WNV to the Kootenays in 2016 are also likely equally numerous and complex and thus far unknown. Whether 2016 was an anomalous spike in cases or marks the beginning of increased WNV activity in the region remains to be seen.

Wildlife are ideal sentinels for infectious agents, contaminants or toxins in the environment that affect both animals and humans. They live much more closely with their environments and are less mobile than humans, so toxins from a particular environment often accumulate more rapidly and it can be easier to trace the site of exposure than in humans who generally travel widely and consume food from numerous sources. A BC example of this is the detection of *Cryptococcus gattii* on Vancouver Island and the Lower Mainland in both animals and humans in the early 2000s. *Cryptococcus gattii* is a fungus that causes pneumonia and/or meningitis in people and animals, with an almost 10% mortality rate. It is not contagious from animal to animal or animal to human, but is an environmental yeast primarily found in forests. Animals can act as a sentinel for infection because they are exposed by the same environmental sources that can serve as sources of infection for people.

An understanding of disease in wildlife can help us to understand and therefore treat or prevent similar diseases in humans. For example, epilepsy in sealions exposed to damoic acid, a neurotoxin produced by algal blooms that can produce memory loss, tremors, convulsions and death, is being used as a model to understand temporal lobe epilepsy in humans. Temporal lobe epilepsy is one of the most common forms of epilepsy in humans and currently has no cure. Treatments developed to treat affected sealions may also be helpful for affected humans.

The study and understanding of disease in wildlife species carries many challenges, but is well worth the effort, both for directing conservation efforts for wildlife and for helping to improve human health.

Back to Table of Contents

Bats: threatening or threatened? Bat health and how it may directly impact human health

Vikram Misra, Bat Zoonoses Laboratory, Department of Microbiology, Western College of Veterinary Medicine, University of Saskatchewan
vikram.misra@usask.ca

Bats are amazing animals. They are the only mammals capable of real flight. As a mammalian order, the Chiroptera are extremely diverse, making up a fifth of all mammalian species. They occupy diverse ecological niches everywhere on Earth, with the exception of the Antarctic and the northern reaches of the Arctic. Bats fulfil many ecological duties from insect control to pollination to seed dispersal. Yet, many find them threatening – as witnessed by their prominent presence in horror movies and Halloween costumes. This is not surprising – we are often wary of the unfamiliar and many bat species are nocturnal. Apart from seeing them flitting about on a summer night we rarely see them. There is, however, a more "real" reason to find them threatening. In the past few decades, several viruses have spilled over from bats to people and other animals causing serious and fatal disease. You have likely heard of Ebola; there about a dozen others. But, more about these a little later.

Bats are threatened as well. The needs of the ever-growing human population have resulted in the destruction of habitat needed by bats to survive. In some cultures they are an important source of protein and vast numbers are harvested for food. Closer to home, a little over a decade ago a new fungus was introduced to North America. This fungus is threatening some of our bat species with extinction. In the spring of 2009 people in the state of New York began to notice hundreds of dead bats near winter hibernacula. The dead bats looked emaciated and had a white furry growth around their faces and the skin of their wings giving the disease the name White Nose Syndrome (or WNS). The disease, caused by a fungus that grows in the near-freezing temperatures of caves and other bat hibernacula, has spread rapidly westward and now has reached the caves in Manitoba. WNS has killed millions of bats, driving some species to local extinction.

I would like to tell you about our work that suggests that there may be a connection between the perception of bats as threatening, especially as vectors of deadly diseases, and what we as humans do to threaten them.

First a bit about the role of bats as vectors of diseases. In recent decades several viruses that cause no pathology in their natural bat hosts appear to have spilled over to humans and other mammals causing severe and often fatal disease. For some of these diseases, such as Hendra and Nipah neurological and respiratory syndrome and Marburg haemorrhagic disease, the links with bats are well established. These viruses are present in bats and spillover to other animals can be traced. For others, such as severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS), porcine epidemic diarrhoea (PED), severe acute diarrhoea syndrome (SADS) and Ebola, the evidence is strong but circumstantial. Viruses very similar to those causing disease in other animals can be detected in bats but the actual culprits have not been found.

There are two important points about viruses that appear to have spilled over from bats: As I have mentioned earlier, none of these viruses harm bats. And, in general, bats seem to be particularly resilient to viruses. Even rabies, which is almost always fatal in other mammals, seems to behave in a less virulent manner in bats. The reasons for the benign relationship between bats and their viruses are not known. The other point is that although we now know a great deal about SARS, MERS and other spillover viruses, most of this information is about what they do in people and other spillover hosts or is from experiments in surrogate laboratory animals. Little is known about the relationship between the viruses and the bat hosts with whom they have co-evolved over millions of years.

The goal of our research team – the University of Saskatchewan Bat Zoonoses Laboratory – is to fill some of these gaps in our understanding of bat-virus relationships. We would like to answer the questions: Why don't viruses make bats sick? and, What happens when the apparently benign relationship between bats and their viruses changes? We try to answer these questions using North American prairie bats and their own viruses.

The Canadian prairies are home to two resident bats – the little brown bat, or *Myotis lucifugus*, and the big brown bat, also known as *Eptesicus fuscus*. They eat, mate and do whatever bats do to enjoy life in the spring, summer and fall, and hibernate in caves, old buildings and other convenient spaces during our long winters. Often the two species share the same roosts and hibernacula.

Noreen Rapin and Sonu Subudhi in my lab have detected, and in some cases isolated, unique viruses from little and big brown bats. These include a polyomavirus[1] (polyomaviruses in other species are known to cause cancers but the little brown bat polyomavirus does not seem to harm bats), a coronavirus[1,2] which resembles the SARS, MERS, PED and SADS causing coronaviruses, and a herpesvirus[3] which is related to the virus that causes Kaposi sarcoma in people (please note that there is no evidence that the human virus spilled over from bats). None of these viruses seem to harm their bat hosts and we can detect them, at low levels, in most bats, suggesting that they persist in their bat hosts for a long time. Bat antiviral defenses don't clear the viruses, the viruses are either silent or multiply at low levels and don't harm their hosts.

Why don't viruses make bats sick? Interestingly, what makes us and other animals sick from most virus infections is not what the virus does to our cells but, rather, an overzealous antiviral response by our bodies against the virus. When a virus infects our cells, they respond by turning on two defensive pathways – one that results in the synthesis of anti-viral proteins called interferons. These proteins protect other cells from viral infections and coordinate other defensive processes. The other response triggers inflammation. When interferons and inflammation are in a balance, the body successfully combats the virus infection. However, if there is too much inflammation the tissue near the site of virus infections is damaged. This is what happens in the severe pneumonia associated, not just with SARS and MERS but also with influenza. Inflammation is set in motion by a protein called TNFα.

My student, Arinjay Banerjee decided to ask the question – Do bat and human cells respond differently to virus infection? He treated bat and human cells with a chemical called poly(I:C) which is a surrogate of virus infection. He began his studies by using poly(I:C) instead of viruses because most viruses are very good at turning off anti-viral defences and Arinjay wanted to find out what the cells were capable of without viruses muddying the waters. He found that bat and human cells were fundamentally very different in their responses to poly(I:C). While both human and bats cells responded by making a lot of interferon, only human cells produced TNFα. Arinjay showed that not only did the bats cells not respond by producing TNFα, they have a very effective molecular mechanism for suppressing the synthesis of TNFα. Interestingly, it seems that many bats species share this mechanism for turning-off TNFα[4].

Arinjay next used the MERS coronavirus to infect bat and human cells. The virus has efficient mechanisms for suppressing interferon in human cells and so, as we expected, he found that human cells produced no interferon but lots of TNFα. Within, 24 hours the virus had multiplied in the cells and killed them. In contrast, the virus was not able to suppress interferon production in bat cells. Bat cells made interferon, no TNFα, produced low levels of virus and survived!! We can keep the MERS virus-infected bat cells alive and growing for months. All bat cells in the cell culture are infected with the virus but it does not kill them. The reason for this supposed harmonious co-existence is the inability of the virus to turn off the interferon response in bats cells. If we artificially turn off the interferon response, the bat cells behave like human cells and die. Our studies therefore suggest that bats don't get sick because they don't respond to viral infection with overblown inflammation and can resist the virus' attempts to turn off anti-viral interferon. It also suggests that events that may interfere with the interferon response in virus-infected cells may disrupt the virus-bat relationship, causing the virus to multiply more effectively, and the infected bat to shed more virus. What might these interferon-suppressing events be?

Can stress disrupt the bat-virus relationship? We got an opportunity to answer this question when White Nose Syndrome arrived in North America killing millions of our bats. In 2010, in a collaborative project led by Craig Willis from the University of Winnipeg and involving several international scientists and agencies, we began a study to find out if a fungus, with the tongue-twisting name *Pseudogymnoascus destructans*, isolated from dead bats, was the cause of the disease and, if it was, how did it kill hibernating bats. Much of the work was done at the Western College of Veterinary Medicine by two brilliant post-doctoral trainees – Lisa Warnecke and James Turner. Lisa and Jamie confirmed that the fungus was indeed the cause of White Nose Syndrome and that although the fungal lesions were restricted to the skin (mostly the skin of the delicate bat wings), its effects were also systemic and the bats died of starvation, severe fluid loss and shock[5,6]. So as not to waste bats sacrificed for the study, at the end of the experiment we archived for further study all tissues from both control and fungus-infected bats. Later we examined the archived tissues for virus as well as the bats' response to fungal and viral infections. Sonu and Noreen could detect coronavirus in the intestines of about a third of the bats, regardless of whether they were infected with the fungus or not. However, when they looked for how much virus was present (rather than just looking for whether the virus was present or not) they found that while the bats without fungus all had similar and very low levels of viral RNA, the levels in the fungus-infected bats varied considerably. Some of the fungus-infected bats had low levels of virus, like the bats with no fungus, while others had as much as a 100 fold more viral RNA. During our earlier experiment Trent Bollinger, a veterinary pathologist, had scored the bats, in considerable detail, for fungal pathology. We found that the levels of coronavirus RNA in the intestines of the bats correlated well with the extent of fungus-induced damage. The more severe the White Nose Syndrome the more viral RNA was in the bat intestines. Fungal infection seemed to be upsetting the bat-virus relationship.

We next asked if the fungus infection in the skin of bats had an effect on cells in their intestine, the very cells harbouring the virus. We found that fungal infection had a profound effect on the genes expressed in the intestine of bats. Several of the affected genes were involved in the animal's innate defences. The fungus in the skin of the wings appeared to suppress antiviral responses in the intestine. These results were exciting as they supported what we had found in cells persistently-infected with the MERS virus – suppression of innate responses in these cells allowed the virus to replicate to levels almost as high as seen in human cells.

Of course, much more work needs to be done before we are certain, but our work guides us into hypothesizing that *bats have evolved to have a benign relationship with their viruses. They don't eliminate the virus and the virus is maintained by slow growth without cell death. Stress, such as that from a deadly fungal infection, or other stressful events, upsets this balance releasing the virus to replicate more freely. This leads to increased shedding of the virus increasing the chances of transmission of the virus to other species*.

Thus, if you stress bats they are more likely to pass on deadly viral disease to people. Or, in other words:

If we threaten bats they will threaten us!

References:

1. Detection of polyoma and corona viruses in bats of Canada.
Misra V, Dumonceaux T, Dubois J, Willis C, Nadin-Davis S, Severini A, Wandeler A, Lindsay R, Artsob H.
J Gen Virol. 2009 Aug;90(Pt 8):2015-22. doi: 10.1099/vir.0.010694-0. Epub 2009 Apr 8.

2. A persistently infecting coronavirus in hibernating Myotis lucifugus, the North American little brown bat.
Subudhi S, Rapin N, Bollinger TK, Hill JE, Donaldson ME, Davy CM, Warnecke L, Turner JM, Kyle CJ, Willis CKR, Misra V.
J Gen Virol. 2017 Sep;98(9):2297-2309. doi: 10.1099/jgv.0.000898. Epub 2017 Aug 25.

3. Isolation, characterization and prevalence of a novel Gammaherpesvirus in Eptesicus fuscus, the North American big brown bat.
Subudhi S, Rapin N, Dorville N, Hill JE, Town J, Willis CKR, Bollinger TK, Misra V.
Virology. 2018 Mar;516:227-238. doi: 10.1016/j.virol.2018.01.024.

4. Lack of inflammatory gene expression in bats: a unique role for a transcription repressor.
Banerjee A, Rapin N, Bollinger T, Misra V.
Sci Rep. 2017 May 22;7(1):2232. doi: 10.1038/s41598-017-01513-w.

5. Inoculation of bats with European Geomyces destructans supports the novel pathogen hypothesis for the origin of white-nose syndrome.
Warnecke L, Turner JM, Bollinger TK, Lorch JM, Misra V, Cryan PM, Wibbelt G, Blehert DS, Willis CK.

Proc Natl Acad Sci U S A. 2012 May 1;109(18):6999-7003. doi: 10.1073/pnas.1200374109. Epub 2012 Apr 9.

6. Pathophysiology of white-nose syndrome in bats: a mechanistic model linking wing damage to mortality.
Warnecke L, Turner JM, Bollinger TK, Misra V, Cryan PM, Blehert DS, Wibbelt G, Willis CK.
Biol Lett. 2013 May 29;9(4):20130177. doi: 10.1098/rsbl.2013.0177. Print 2013 Aug 23.

Back to Table of Contents

Engaging citizens in disease surveillance and population monitoring - the BC Community Bat Program's citizen science initiatives

Presenter: **Leigh Anne Issac,** Kootenay Coordinator, BC Community Bat Program
info@bcbats.ca
www.bcbats.ca

Co-author (lead author): Mandy Kellner, Provincial Coordinator, BC Community Bat Program

Summary

Bats in North American are facing a conservation crisis beyond the scale of any previous impacts. White-nose Syndrome (WNS) is a fungal disease harmless to humans but responsible for the deaths of millions of insect-eating bats in North America. In Canada, three species of bats are federally 'Endangered' to-date, as a result of WNS in eastern Canada (Environment Canada 2015). Additional species in western Canada will likely be affected by the disease. In 2016, WNS made an unexpected jump to western North America, and was detected in Washington State in March 2016.

In spite of the magnitude of the impacts of this disease, protecting bats and bat habitat, including anthropogenic structures, is still important. It may promote healthy, resilient colonies, and provide secure habitat for any survivors to recover.

In order to plan for management actions and potential mitigation efforts, the BC Government would like to monitor the spread of WNS into and across BC. Unfortunately, bats are a difficult group to locate and survey. They are nocturnal, so are difficult to see. They fly, so track surveys are not useable. They use ultrasonic frequencies for echolocation, so we cannot hear them with an unaided ear. They are secretive, often roosting in inaccessible spaces such as soffits and roof flashing. They are similar-looking, with species often indistinguishable in the field even to bat biologists. And finally, unlike east of the Rockies, bats in BC do not hibernate in large congregations in caves where they may be counted. We are faced with many challenges when contemplating disease surveillance and population monitoring.

The BC Community Bat Program (CBP) has been involved in providing solutions to these difficulties in disease surveillance in bats. The CBP originated to promote the conservation of bats in anthropogenic structures such as attics, roofs, sheds, and bat houses. It is now a network of bat projects across BC, working with many regional stewardship and conservation organizations. When WNS showed up in western North America, less than 150 km from Vancouver, the CBP network was already in place and able to contribute to surveillance efforts.
The Community Bat Program is currently involved in three surveillance and monitoring efforts. Public participation and citizen science forms the basis of these efforts, which are:

1. Annual Bat Count – the only province-wide roost monitoring program

2. Winter surveillance – dead bats and unusual activity (November - May)
3. Spring guano sampling (April - June)

The Annual Bat Count is a visual exit count of bats leaving an anthropogenic roost site at dusk. It serves two purposes, to identify and monitor colonies and gather baseline data at bat colonies pre-WNS, and to engage and connect with landowners and roost stewards each year. Ideally two counts are done before pupping (June) and two after pupping (July/August). At count sites, the species of bat is confirmed with genetic analysis of DNA on guano. Acoustic sampling is also used, and may be particularly useful for identifying if a roost site may house multiple species.

The Annual Bat Count is similar to the UK bat monitoring program (Walsh et al 2001). This is a long-term monitoring program, including research into how many samples (roost sites) are needed for a statistically useful monitoring program. In the UK, most species required 5-9 years of data at 100 sites to detect a 5 % change in population size. However, in BC we will likely see a much large or catastrophic decline from WNS. In eastern Canada, populations declined by 30 – 99 % per year after WNS, so no statistics are really necessary, and many fewer sites are needed to identify changes in population sizes. However, detecting recovery will be challenging. Recovery will likely be slow, with many sites needed to detect small changes. At that point, information from monitoring and recovery programs in the UK will be more relevant and may provide guidance on monitoring targets.

The number of sites counted yearly in BC has increased from 2012 to 2017, with 470 counts done at 142 sites in 2017 (Kellner 2018). Sites are distributed across the province, although they are concentrated where there are larger, longer-running regional bat projects (Figure 1). Retaining volunteers and sites will be essential for developing a long-term dataset. Seven species of bats are monitored through Annual Bat Counts, with the majority of sites housing colonies of Little Brown and Yuma Myotis. More details about the Annual Bat Count can be found in Kellner 2018.

Because the Annual Bat Count is an extensive monitoring program, relying on large and widespread samples, this effort would be impossible without volunteer involvement. Regional coordinators work with naturalist groups, community groups, and keen individuals to do counts. In 2017, volunteers participated in a minimum of 90 % (418/470) of the counts.

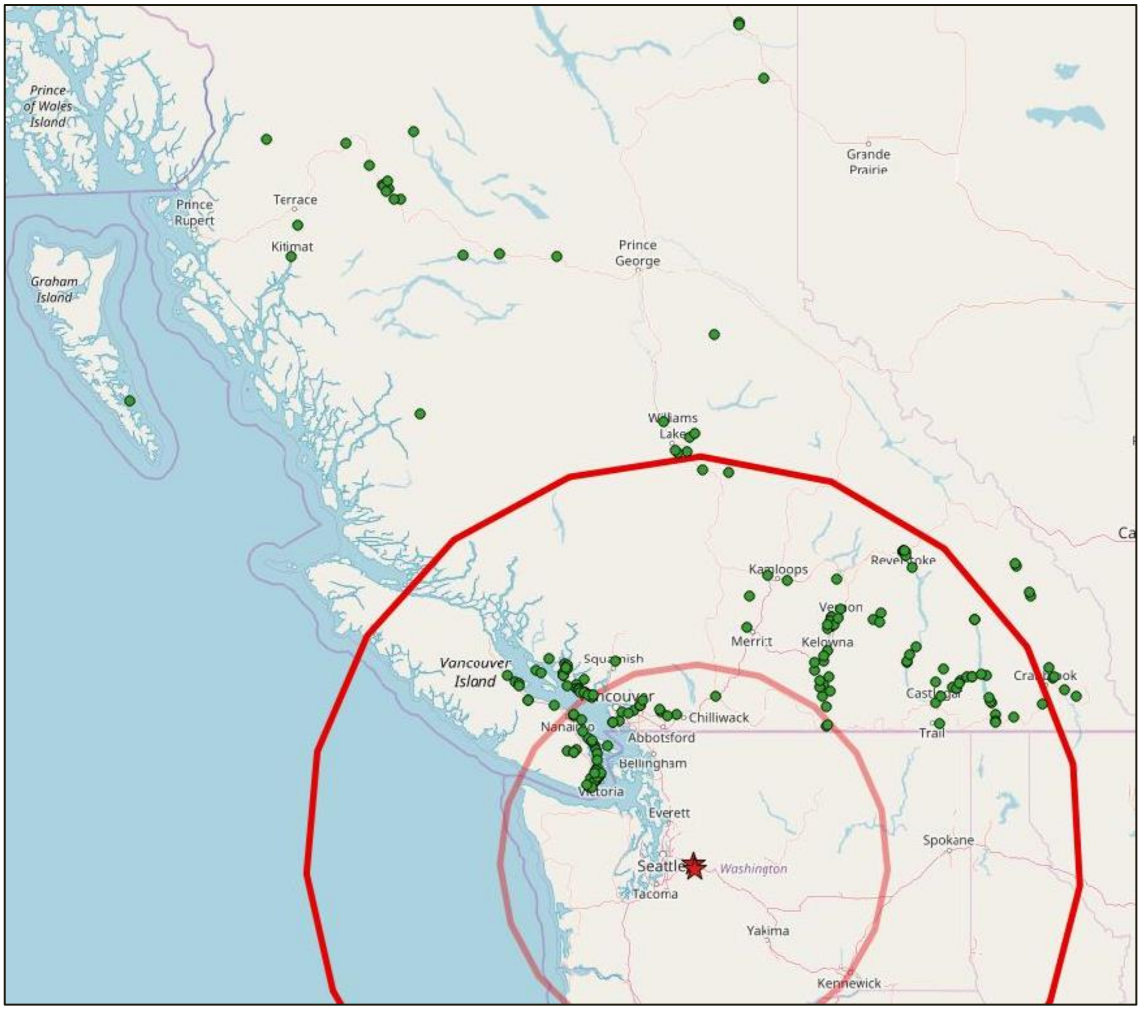


Figure 1. Annual bat count sites across BC. Green dots are roost sites where counts occurred. Red stars indicate WNS in Washington State, and the red 250-km and 500-km radius circles indicate where WNS is expected to first appear in BC.

The BC Community Bat Program is also involved in two surveillance methods to detect WNS and/or *Pseudogymnoascus destructans* (Pd), the fungus responsible for WNS. From November through May, we encourage public reporting and submission of dead bats for testing. By requesting public involvement, the number of 'eyes on the ground' can be increased, leading to more chance of detecting unusual mortalities. It was a public report that led to the initial WNS-positive bat found in Washington. We use press releases, presentations and social media to solicit reports of winter bat activity and dead bats. We then work with the BC government and Canadian Wildlife Health Cooperative lab in Abbotsford to collect, ship, and test these bats. In 2017, we assisted with the collection and submission of 32 dead bats. For 2018, bats are still being collected. The sample size of dead bats is small, however, and low population densities across much of BC leave many areas unsampled.

Pd can also be detected in spring, in guano. After bats emerge from hibernation, they groom off any fungal spores and excrete them. Collecting and testing spring guano may increase the sample size in the WNS/Pd surveillance program. In 2018, the Community Bat Program is targeting roost sites surveyed in the Annual Bat Count in southwestern BC. We rely in part on public roost stewards and volunteers to prepare the sites in late winter and collect guano in spring. Some sites are also being sampled by regional coordinators, BC Parks staff, and partner organizations. Year 1 (2018) is a pilot year, and this program may expand to increase surveillance efforts in coming years.

There are distinct benefits to involving the public and citizen scientists in our three approaches for WNS surveillance in BC. This approach allows surveillance efforts to be widespread, with extensive coverage across BC. It generates increased sample sizes, extending the sampling programs beyond what paid biologists could achieve. Finally, this approach has positive benefits to bats, with public engagement and education about bats ultimately contributing to bat conservation.

Acknowledgements
Thank-you to our many regional coordinators and volunteers, who form the basis of our WNS surveillance efforts and all aspects of our Community Bat Program. We also thank the Province of BC for their support, particularly O. Dyer, H. Schwantje, P. Govindarajulu, S. Willmott, and C. Nelson, and Glenna MacGregor of the CWHC lab in Abbotsford. Finally, thanks to our primary funders and many regional partners. Provincially, we are funded by the Habitat Conservation Trust Foundation, Forest Enhancement Society of BC, Habitat Stewardship Program for Species at Risk, and the Province of BC. Any questions about the BC Community Bat Program or our WNS surveillance can be sent to bcbats@gmail.com, or see www.bcbats.ca .

References

Kellner, M. 2018. British Columbia Community Bat Program Annual Bat Roost Counts (2012-2017). Update February 2018. 34pp. available from bcbats@gmail.com

Walsh, A., C. Catto, A.M. Hutson, P. Richardson, S. Langton, & P.A. Racey. 2001. The UK's national bat monitoring programme. Final report.

Back to Table of Contents

Preliminary baseline data for creating dynamic predictive models to characterize the risks of translocating free ranging mule deer (Odocoileus hemionus) from urban to non-urban habitats in the Kootenay

Amélie Mathieu (presenter), The Wilds
Cumberland, Ohio
amathieu@thewilds.org

Mark Flint, Department of Veterinary Preventive Medicine, College of Veterinary Medicine, Ohio State University, flint.71@osu.edu

Patrick M. Stent, British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development, patrick.stent@gov.bc.ca

Helen M. Schwantje, British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development, helen.schwantje@gov.bc.ca

Thomas E. Wittum, Department of Veterinary Preventive Medicine, College of Veterinary Medicine, Ohio State University, wittum.1@osu.edu

Summary

The provincial wildlife management agency, British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development, performed a translocation to control the urban mule deer (*Odocoileus hemionus*; uMD) overpopulation and supplement the declining non-urban mule deer (nuMD) population in the Kootenay region, British Columbia, Canada. The aims of this cross-sectional study were to evaluate the health of the urban and non-urban mule deer populations by comparing pathogen exposure, body condition scores (BCS) and pregnancy rates, to characterize the health risks associated with the translocation and to investigate the role of infectious diseases in the decline of the nuMD deer population. Two hundred free-ranging mule deer were captured in urban and non-urban environments in the Kootenay region from 2014 to 2017. BCS and morphometric examinations were performed for each deer. Blood samples collected from each deer were tested for exposure to selected pathogens and pregnancy status. BCS averaged 3.4 on a five-point scale, was greater in nuMD, and significantly differed between years. Antibodies were detected for adenovirus hemorrhagic disease virus (38.4% (uMD 43.7%, nuMD 33.3%)), bluetongue virus (0.6% (uMD 1.2%, nuMD 0%)), bovine respiratory syncytial virus (8.4% (uMD 4.6%, nuMD 12.1%)), bovine viral diarrhea virus (1.1% (uMD 0%, nuMD 2.2%)), bovine parainfluenza-3 virus (27.0% (uMD 27.6%, nuMD 26.4%)), *Neosporacaninum*(22.1% (uMD 24.4%, nuMD 19.7%)) and *Toxoplasma gondii*(8.2% (uMD 12.3%, nuMD 3.9%)).

No antibodies against epizootic hemorrhagic disease virus were detected. Pregnancy rates did not differ between the two deer populations (90.7% (uMD 90.6%, nuMD 90.9%)). Exposure to *N. caninum* was associated with a reduced probability of being pregnant. uMD were more likely to be exposed to *T. gondii* than nuMD.

Comparison of body condition scores, pregnancy rates and pathogen exposure of uMD and nuMD showed that the health of the two populations did not significantly differ, suggesting uMD translocations do not pose a severe risk of pathogen transmission between mule deer populations and that these selected pathogens do not factor in the decline of the nuMD population. However, inclusion of additional health indicators and creation of a robust predictive disease model are warranted to further characterize the health of mule deer and the health risks associated with uMD translocations. These results should be considered as part of a formal risk assessment for future uMD translocations in southeastern British Columbia.

Back to Table of Contents

First evidence of intracranial and peroral transmission of Chronic Wasting Disease (CWD) into Cynomolgus macaques: a work in progress

Stefanie Czub* (presenter), Walter Schulz-Schaeffer**, Christiane Stahl-Hennig***, Michael Beekes****, Hermann Schaetzl***** and Dirk Motzkus******

*University of Calgary Faculty of Veterinary Medicine/Canadian Food Inspection Agency; ** Universitätsklinikum des Saarlandes und Medizinische Fakultät der Universität des Saarlandes; *** Deutsches Primaten Zentrum/Goettingen; ****Robert-Koch-Institut Berlin; *****University of Calgary Faculty of Veterinary Medicine; ****** presently: Boehringer Ingelheim Veterinary Research Center; previously: Deutsches Primaten Zentrum/Goettingen

Abstract

This is a progress report of a project which started in 2009. 21 cynomolgus macaques were challenged with characterized CWD material from white-tailed deer (WTD) or elk by intracerebral (ic), oral, and skin exposure routes. Additional blood transfusion experiments are supposed to assess the CWD contamination risk of human blood product. Challenge materials originated from symptomatic cervids for ic, skin scarification and partially per oral routes (WTD brain). Challenge material for feeding of muscle derived from preclinical WTD and from preclinical macaques for blood transfusion experiments. We have confirmed that the CWD challenge material contained at least two different CWD agents (brain material) as well as CWD prions in muscle-associated nerves.

Here we present first data on a group of animals either challenged ic with steel wires or per orally and sacrificed with incubation times ranging from 4.5 to 7.4 years at post mortem. Three animals displayed signs of mild clinical disease, including anxiety, apathy, ataxia and/or tremor. In six animals wasting was observed, four of those had elevated blood glucose levels. All animals have variable signs of prion neuropathology in spinal cords and brains; and by supersensitive IHC reactions were detected in spinal cord segments of all animals. Amyloid seeding via real-time quaking-induced conversion (RT-QuiC) and PrP^{sc} by Western Blot further substantiated these findings. Bioassays challenging bank voles and transgenic mice with simian tissues are currently on the way. At present, a total of 11 animals are sacrificed and read-outs are ongoing. Preclinical incubation of the remaining 10 macaques covers a range from 7.1 to 8.9 years. Based on the species barrier and an incubation time of > 5 years for BSE in macaques and about 10 years for scrapie in macaques, we expect an onset of clinical CWD disease beyond 9 years post inoculation.

Back to Table of Contents

Managing for Northern Goshawk Populations impacted by both forestry and by our changing climate through black fly induced mortality of nestlings

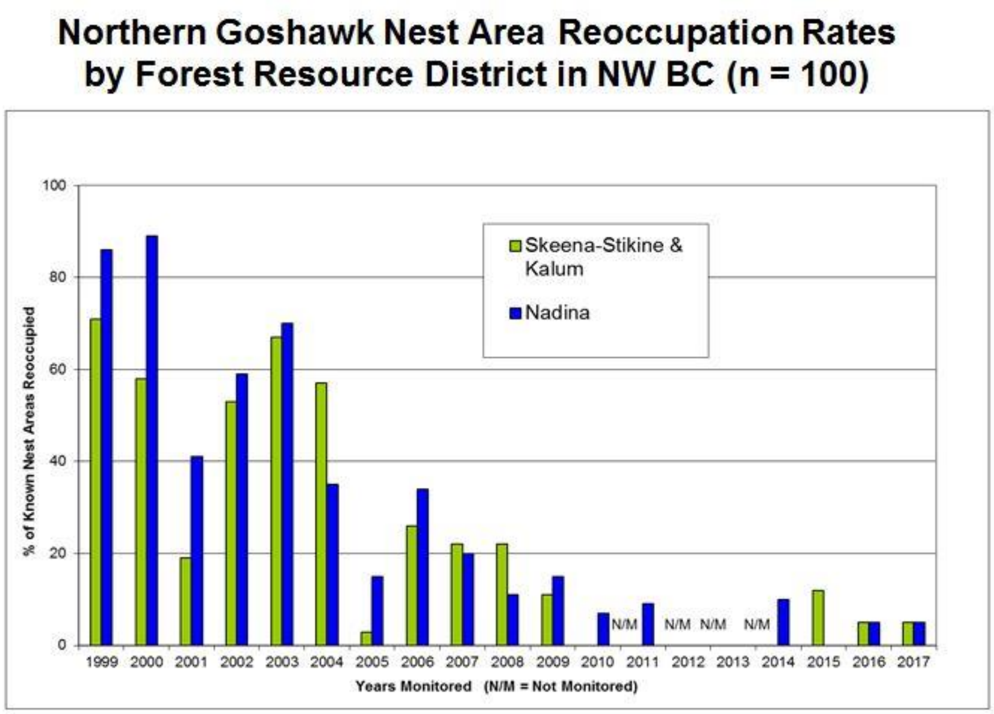
Frank I Doyle, Wildlife Dynamics Consulting
wildlifedynamics@gmail.com

Summary

This presentation focused on the dramatic collapse in goshawk populations in central and northern British Columbia (95% decline in the past decade) (Figure 1), and linked this decline to both forest harvesting and climate change. Goshawks are a large forest hawk that is adapted to breeding and foraging within landscapes dominated by mature-old growth forest landscape. They were once a common forest predator with breeding pairs regularly spaced 4-5km apart across our landscapes.

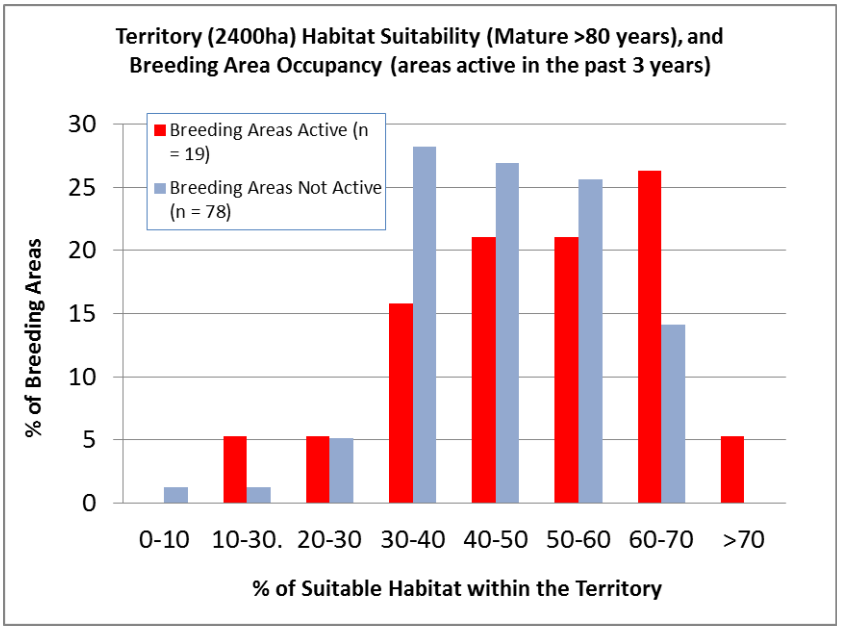
With large scale forest harvesting, we have seen both the loss of goshawk breeding and foraging habitat and many goshawk territories are now dominated by young seral forests and have been abandoned by the birds.

Figure 1. Northern Goshawk Annual Breeding Area Reoccupation rates (Doyle et al. 2017)



Forest harvesting has resulted in the loss of required mature – old growth forest habitat such that many goshawk breeding territories (~ 2,400ha) may no longer be capable of supporting breeding birds (Figure 2), with a greater area of mature forest associated with active territories.

Figure 2. Territory Area of mature-old growth Forest in Active Northern Goshawk Breeding Areas compared to inactive Breeding Areas.



However, even in occupied territories occupation rates at a time in peak prey abundance (2014-2017 peak in the snowshoe hare cycle) was only 30-40% in active territories, when historically during the previous hare peak (2002 – 2004) occupation rates of 40-60% were observed.

Our working hypothesis is that the low in occupation rates (overall and in relation to the area of mature forest), is being wholly or in part driven by climate change through attacks on the young, and brooding adults by blackflies. Black flies were first linked to the mortality of nesting owls and raptors as part of the Kluane Boreal Forest Ecosystem Project 1985-1996 (Krebs et al, 2001), when both Great Horned Owls and Red-tailed Hawks (Rohner and Hunter 1996, Rohner et al. 2000 & Doyle 2000) died as a result of black fly attacks, and both these studies and a study or Red-tailed Hawks (Smith et al. 1997), linked blood loss, falling from nests and a blood parasite (Leucocytozoon sp.) that is carried by the flies. This same blood parasite has also been seen in blood sample of goshawks nestlings (Jeffries et al. 2015). The Kluane study linked mortality to years with early warm spring temperatures and to a low in food supply (as the cyclic hare populations declined – fledged Great Horned Owls deaths due to black fly attacks were more prevalent in young with poor body condition).

Under present day circumstances with climate change, what if spring is early every year? Insect hatch in blackflies, like most insects, is based on temperature, when in contrast timing of breeding in birds is linked to light through day-length. Our hypothesis is that this has resulted in an earlier back fly hatch, with the flies then attacking and killing many of the raptor and owl nestlings, including goshawks. This is in part supported by several studies of well-studied species (Peregrine Falcons and Snowy Owls) that have recently observed mortality of nestlings and attacks on brooding females, in species with no prior history of black fly attacks (Solheim et al. 2013, Frankie et al. 2016).

In response to this observed decline, and the potential link with forest harvesting and black fly attacks, the Provincial Government has listed the Interior goshawk populations as species of Special Concern (Blue Listing). In addition, biologists, licensees, BC government and First Nations are working together to develop a landscape management strategy that maintains high quality (>60% mature-old forest within a territory), across the landscape, such that breeding birds will have a good food supply. With a goal of ensuring that if habitat alone is a driver, then we will have suitable territories across the landscape, and in addition if black flies are also a significant factor influencing survival, then the well fed nestling birds from these high quality territories may have a better chance of survival.

References

Doyle, F. I. 2001. Timing of reproduction by red-tailed hawks, northern goshawks and great horned owls in the Kluane Boreal Forest, Yukon.

Doyle, F. I., A. Coosemans, and L. Rach. 2017. Interior Northern Goshawk Management Strategy. Environment and Climate Change Canada, Habitat Stewardship Program—Prevention Stream. # HSP7539. Pp 1-74.

Franke, A., V. Lamarre and E. Hedlin. 2016. Rapid Nestling Mortality in Arctic Peregrine Falcons Due to the Biting Effects of Black Flies. ARCTIC. VOL. 69, NO. 3. P. 281 – 285.

Jeffries, M. I., R. A. Miller, M. D. Laskowski and J. D. Carlisle. 2015. High Prevalence of Leucocytozoon Parasites in Nestling Northern Goshawks (*Accipiter gentilis*) in the Northern Great Basin. Journal of Raptor Research, 49(3):294-302.

Krebs, C.J., S. Boutin and R. Boonstra. 2001. Ecosystem Dynamics of the Boreal Forest: The Kluane Project. Oxford University Press, New York.

Roar Solheim, Karl-Otto Jacobsen, Ingar Jostein Øien, Tomas Aarvak & Petteri Polojärvi. 2013. Snowy Owl nest failures caused by blackfly attacks on incubating females. Ornis Norvegica, 36:1-5.

Rohner, C. and D.B. Hunter. 1996. First-year survival of great horned owls during a peak and decline of the snowshoe hare cycle. Canadian Journal of Zoology. 74:1092-1097.

Rohner, C., C. J. Krebs, D. B. Hunter, and D. C. Curries. 2000. Roost site selection of great horned owls in relation to black fly activity: an anti-parasite behavior? Condor 102:950-955.

Smith, R.N., S.T. Cain, S.H. Anderson, J.R. Dunk and E.S. Williams. 1998. Black fly induced mortality of nestling red-tailed hawks. The Auk. 115(2):368-375.

Back to Table of Contents

The importance of local communities working together for the betterment of wildlife in rural British Columbia

Bill Oestrich, Tahltan Guide Outfitters Association
Dease Lake, British Columbia
timberlinehigh@hotmail.com
www.tgoa.ca

Our presentation was about the importance of communities working together in rural British Columbia (BC). First Nations, rural communities and Guide Outfitters are on the front lines of wildlife issues. These groups are often one and the same people. We share a unique lifestyle, experience and skills to access the land and observe animals in an intimate, yet educated manner. We have the historic and current knowledge of trends in wildlife populations and the ability to observe the health of live and harvested animals. In this age of environmental change it is critical that this knowledge is assessed and utilized to inform wildlife managers. With the goal of more adaptive and informed wildlife management, we now have new relationships and wildlife projects underway in northwestern BC.

1. The Tahltan Central Government (TCG), local communities and Tahltan Guide Outfitters Association (TGOA) identified a Stone's Sheep herd traveling from winter range to summer range near a heavily used industrial access road. This study will provide information on the vulnerability of the sheep by monitoring movements during peak migration, their habitat use and how human disturbance and predation affect the herd. In addition, for the first time, a standard health assessment model is being applied to all captured sheep and any mortalities to assess the health of this unique to BC species.

2. The health of other ungulate populations in the area is being assessed through a wildlife sampling program. Initially, the sampling program was focused on Northern Mountain caribou, but has expanded to include all harvested ungulates. Samples collected will provide information on wildlife health measures including parasite levels, infectious disease exposure, nutritional condition, stress levels and exposure to contaminants such as heavy metals.

3. The North West Round Table was formed as a forum to discuss current wildlife issues. Representatives of local First Nations, guide outfitters, resident hunters and the provincial government discuss aspects of wildlife health, habitat enhancement, scientific review, hunting regulations, adaptive management and

the effects of the changing environment. Round table discussions and recommendations are designed for the betterment of wildlife.

4. The TCG and the TGOA recognized the need to bring local community members, scientists and BC wildlife and resource managers together, but at a community level to present and discuss current management strategies and educate all parties about issues observed on the landscape. To date there have been two annual Northern Wildlife Symposiums that have informed and led to new approaches on how to better serve wildlife of the region.

5. The TCG, TGOA, and local communities of the northwest are working with the University of Calgary, and the province on a project to compile local knowledge to investigate health and behaviour in our northern caribou herds. Graduate student Naima Jutha is already active in communities interviewing community hunters, Outfitters and their assistant guides to establish their pictures of the trends and health of these important herds. Naima will also analyze the sample kits that have been collected over the last two years for more traditional measures of health.

Back to Table of Contents

The Local Environmental Observer (LEO) Network for surveillance of ecological changes

Thomas A. Okey[1,2], Linda Pillsworth[3], Dionne Sanderson[3], Michael Y. Brubaker[4], Michael J. Brook[4]

[1]Ocean Integrity Research, Victoria, British Columbia, Canada; Thomas.Okey@gmail.com; (250) 208-0677
[2]University of Victoria, British Columbia, Canada.
[3]First Nations Health Authority, West Vancouver, BC, Canada; Dionne.Sanderson@fnha.ca; Linda.Pillsworth@fnha.ca
[4]Alaska Native Tribal Health Consortium, Anchorage, AK, USA; mybrubaker@anthc.org; mjbrook@anthc.org

Abstract

Global environmental changes are outpacing the ability of scientists to estimate the extents of these changes. Citizen science is a promising type of solution to understanding ecological changes that manifest locally and across scales. Here, we introduce the Local Environmental Observer (LEO) Network to the fish and wildlife health community in western Canada. The LEO Network was designed by the Alaska Native Tribal Health Consortium (ANTHC) to help local and traditional people document, communicate, and manage unusual environmental changes. Observers use the LEO platform, either online at (www.leonetwork.org) or using the 'LEO Reporter' mobile app, to post observations of unusual environmental changes on an online map-based database with descriptions, photos, video, or audio information. Regional hub coordinators review observations, contribute additional information, and connect other experts on that topic. This brings local, indigenous, and scientific knowledge holders together in supportive working collaborations that integrate knowledge about the observed changes and help identify management solutions. The resulting collaborative and multi-media online posts (citable publications) are organized in a permanent and accessible map-based database with which informative trends can be examined.

Introduction

First Nations communities and other communities throughout British Columbia (BC) are experiencing accelerated changes in their physical environments, in the biological communities with which they interact and are embedded, and in their exposure to industrial and environmental hazards. These changes are being driven by both global environmental changes (e.g. climate change) and non-climate stressors such as development, exploitation of natural resources, other modifications to land and sea, and natural disasters. These changes are affecting local and regional socioeconomic and cultural systems and human and environmental health in profound and uncertain ways, and they are expected to continue accelerating.

Communications, political attention, planning, and solution-oriented actions related to climate change are limited in many First Nations communities and in many other communities, due in part to isolation and financial and human resource limitations. Other types of human communities (of practice) such as scientists, natural resources professionals, resource managers, and policymakers are in turn somewhat isolated and disconnected from these First Nations communities and other communities affected by these accelerating changes.

The LEO (Local Environmental Observer) Network (leonetwork.org) is designed to empower local people to apply their own expertise in the community and environment to detect and document conspicuous and unusual environmental changes. It also allows people to contribute these observations to a regional and global database; connect with communities of subject matter experts; facilitate the interpretation and discussion of observation postings; understand these observed changes in the context of regional or global trends; help design additional investigation and responses as appropriate; communicate these changes broadly; use the information in decision making; and access and connect with broad resources, communities, and other authorities for assistance with managing or adapting to these observed changes.

The LEO Network was developed in 2012 in Alaska by the Alaska Native Tribal Health Consortium (Brubaker et al. 2013) so that individuals in remote Native Tribal communities could share observations of unusual environmental change, connect with other experts to increase the understanding of those changes, and to increase their voice about issues of concern and potential responses and solutions. In Alaska, the LEO Network has already been very effective in engaging local communities in the surveillance of a wide variety of environmental changes, with over 1000 members from communities across the state. There are hundreds of examples of the LEO Network connecting those communities with experts, agencies, and other networks that can help them understand and communicate those changes so that appropriate planning, prioritizing, and actions can be taken at all levels of government and society.

The LEO Network has now expanded to British Columbia, Northwest Territories, and elsewhere in Canada in addition to some parts of the lower 48 United States, Northern Baja California, and elsewhere in Mexico. It has grown to include over 2,200 members affiliated with over 800 organizations within over 500 communities. Observations collected have begun to appear in the scientific literature revealing impacts of environmental change on terrestrial food security and on coastal marine ecosystems. Individual contributors and communities can determine what information to share given that the LEO Network database is intended for public information, with attribution to contributors.

Communities can set up private hubs, such as school classroom units that are being developed to support youth-elder dialogue on ecosystem change in which students can access and record knowledge of environmental changes that elders have witnessed in their lifetimes. These student posts stay within the private student hub, but individual posts can be promoted to the more public LEO map with agreement of all parties. In addition to documenting qualitative observations of unusual environmental changes, linkages can be made to other quantitative monitoring networks and information sources, and this can help to guide LEO observations in proximity to other monitoring or surveillance efforts.

Many news articles have featured the LEO Network (http://leonetwork.org/en/docs/about/news) and examples of applications are emerging in the academic literature (e.g. Hupp et al. 2015, Walsh et al. 2017, Okey in press).

The First Nations Health Authority and the LEO Network

The First Nations Health Authority (FNHA) is implementing the LEO Network in BC. The FNHA is the first province-wide First Nations-run health authority of its kind in Canada. In 2013, the FNHA assumed the programs, services, and responsibilities formerly handled by Health Canada. The First Nations Perspective on Wellness was established by BC First Nations to help guide FNHA health programming. This perspective includes the integral importance of the environment and lands in the health of communities.

The FNHA Environmental Public Health Services team supports communities in the awareness, identification and mitigation of health risks due to the environment. Concerns and observations about environmental change are often brought to FNHA staff. However, tools did not exist to document these stories. Access to experts has been dependent on individual professional networks and typically related to the mandate of FNHA programs. The LEO Network has proven to be a useful tool to help fill this gap of sharing, connecting, and understanding environmental change.

Methods: Exploring the LEO database for wildlife health terms

As an exercise to illustrate the usefulness of the LEO Network for surveillance of fish and wildlife health to the audience of the *Interdisciplinary Approaches to Managing Health of Fish and Wildlife Conference* in Kimberly, B.C., May 1-2, 2018, the 'Advanced Search' interface was used to query the LEO database, sequentially, with ten wildlife health search terms: algal, cyst, disease, domoic, infect, paralytic, parasite, pathogen, syndrome, toxic.

Results were summarized using stacked bar graphs of the frequency of hits of these terms in the 954 first-person observations and the 920 event-related news articles in the LEO Network database (as at April 24th, 2018). The news articles highlighted in the LEO database meet the criteria for location-based observations of unusual environmental changes and are included to complement first-person LEO observations. A map of the distribution of observations containing the search term 'Disease' (Figure 1) is used as an example of a map view of a query result.

We also downloaded a CSV file of the results for each of the searches from LEO's 'Advanced Search' interface. We combined these results into a single spreadsheet and removed duplicate observation records. We simplified the data into columns for production of tables of observation records organized by LEO categories to help readers to search for any patterns, themes, or topics that might inform the development of useful indicators of fish and wildlife health using the LEO Network. These tables can be provided upon request, or users can download data directly from the LEO Advanced Search interface.

In our presentation, and in the present summary, we highlighted a small number of observations as examples of the utility of the LEO Network in the topic of local-observer-based surveillance of fish and wildlife health.

Caveat relating to these wildlife health term searches in the LEO database

One potential limitation of these searches is that any given observation in the LEO Network can be tagged with multiple LEO Observation categories and can contain combined occurrences of the 10 search terms used in the present exercise. The instances of occurrence, therefore, do not strictly refer to separate observations, but rather are simply instances of association within the database that sometimes occur within observations. This should be recognized when interpreting the results.

Guide to advanced searches of the LEO database

The LEO online platform provides useful 'Advanced Searching' of the observation and article databases from the 'Advanced Search' screen, or from the main map. These searches can be especially powerful when using simple search operators. The following is a summary:

- Simple search for a term - e.g. gulls. This will search for inflections of the term, so searches for gulls and gull should return the same results.
- The | (vertical bar) operator searches for either term on either side of the bar, e.g. gulls | seagulls. Multiple terms can be searched simultaneously - e.g. gulls | seagulls | murres.
- The plus (+) sign searches for ALL terms - e.g. gulls + togiak. The + operator finds results that contain both terms in the same record.
- Complex queries are possible - e.g. (gulls | murres | seagulls) + togiak.
- Parentheses search for exact multi-word phrases, e.g. "paralytic shellfish poisoning". Phrases can be combined with other terms using other operators, e.g. "paralytic shellfish poisoning" | psp.

The results of any search can be used to add a whole search query result to a ‘My Map’, so it is possible to formulate a very precise query and then save the results for later examination or display.

Results A: LEO Network searches of ten wildlife health terms

Each of the wildlife health term searches produced a population of observations, such as that shown Figure 1, which indicates the locations of most of the 147 observations that contained the term ‘disease’ as of 24 April 2018.

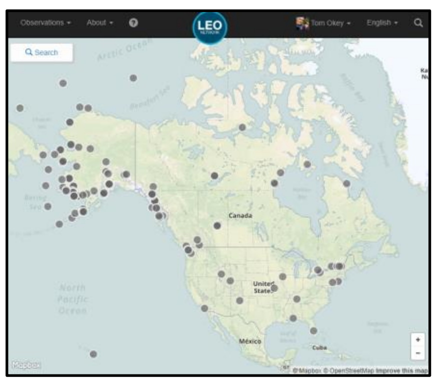


Figure 1. Most of the 147 locations of LEO Network observations containing the word disease as of 24 April 2018. These observations include first-person LEO observations and event-related news articles. Some locations in this search are not pictured in this figure, as they occur elsewhere throughout the world.

In the 954 first-person observations in the LEO Network database on 23 April 2018, the ten wildlife health search terms used in this exercise were associated with LEO observation categories in 258 instances. The frequency of these instances by LEO observation categories is shown in Figure 2.

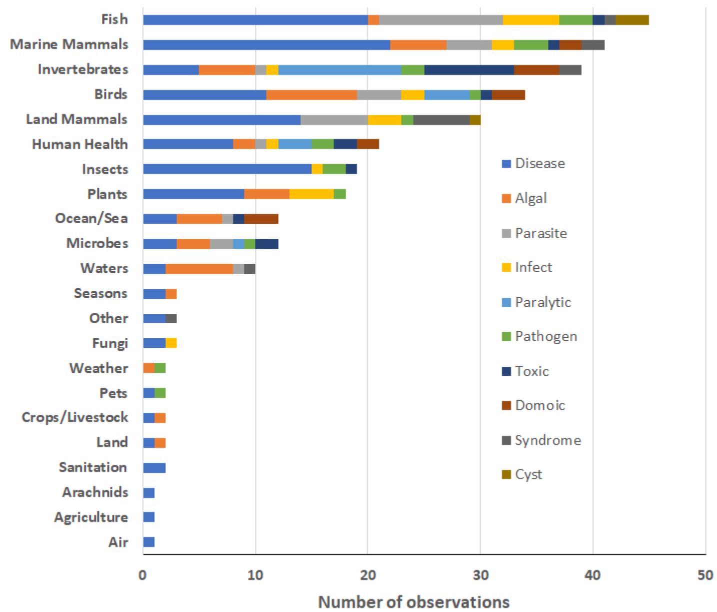


Figure 2. Stacked bar graph of the 258 instances of the ten wildlife health search terms in the 954 first-person observations in the LEO Network database (queried on 23 April 2018).

In the 920 event-related news articles that were in the LEO Network database on 24 April 2018, the ten wildlife health search terms used in this exercise were associated with LEO observation categories in 240 instances. The frequency of these instances by LEO observation categories is shown in Figure 3.

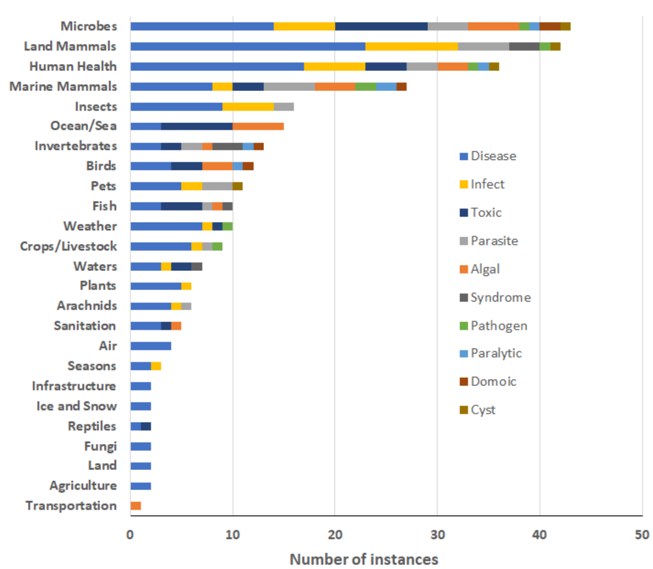


Figure 3. Stacked bar graph of the 240 instances of the ten wildlife health search terms in the 920 news articles in the LEO Network database, as queried on 24 April 2018.

Results B: Examples of LEO observations relating to fish and wildlife health

Here we feature examples of LEO Network observation posts that shed light on the usefulness of the LEO Network for surveillance of issues relating to fish and wildlife health.

Featured Observation 1. Growth on Sheefish Heart

Ms. Maija Lukin, National Park Service Superintendent of Western Arctic National Parklands in Kotzebue Alaska, shared an observation of parasites around the heart of a sheefish (*Stenodus leucichthys*) caught near Kotzebue, Alaska (Lukin and Ferguson 2016). She wrote, "This is the first time we have seen these around a Sheefish heart. Some people say these are similar to "cottage cheese crab" but it's the first time we have seen it in fish." Photo 1 shows the observed parasites.

Photo 1. The observer provided this photo and the following caption: "A photo of what was found around the heart of the Sheefish after cutting into it. The meat looked fine, but this was around the heart near the head. (Photo by Stephanie Stalker)"

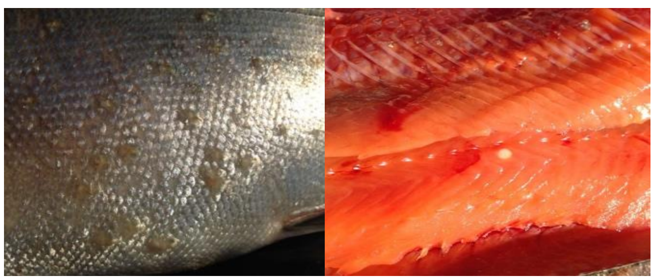
Dr. Jayde Ferguson, Pathologist with the Alaska Department of Fish and Game (ADFG), provided valuable background information and three links to related technical documents (Common Diseases of Wild and Cultured Fishes in Alaska, Black spot disease (*Neascus*), and *Diplostomulum*). She summarized her points about this observation as follows:

- *The parasite is a larval trematode (flatworm), which are common in wild fishes.*
- *It may be an undescribed trematode species; sheefish are greatly understudied.*
- *This parasite is not related to the "cottage cheese crab" disease.*
- *Follow FDA guidelines to kill parasites in fish prior to consumption (cook to internal temp. of 140°F or freeze at -4°F or below for 7 days).*

The LEO hub coordinator in Alaska presented some general information about sheefish and provided links to external documents with more information on sheefish life history. This observation and resulting consult provided clarification about the disease this fish was inflicted with and provided educational resources. It also presented an opportunity to reinforce public health messaging to ensure the required cooking and freezing temperatures are used to kill parasites in fish in order to avoid human illness.

Featured Observation 2. Coho Salmon with Parasites

Mr. Peter Gumlickpuk of the New Stuyahok Traditional Council shared an observation of sport-caught coho salmon *(Oncorhynchus kisutch)* with bumps between the flesh and the skin, and with bumps in filleted flesh (Gumlickpuk and Meyers 2014). Mr. Gumlickpuk shared that people in the community were wondering if fish with these bumps are safe to eat, see photos 2 and 3. They were also wondering what might be causing these bumps, and why the incidence and abundance of these bumps seem to be increasing.



Photos 2 and 3. The skin and filleted flesh of Coho salmon *(Oncorhynchus kisutch)* with myxosporidean cysts. The cysts under the scales are likely *Myxobolus squamalis* and those in the flesh are likely *Henneguya salminicola* (consult by T. Meyers, ADFG). Specimens were sport-caught in New Stuyahok, Alaska (Photos courtesy of Moxie Andrew Jr.).

Dr. Ted Meyers, State Fish Pathologist, Alaska Department of Fish and Game, stated that there are two different myxosporideans parasites that are present on and in these Coho salmon. Mr. Meyers mentions that "these are common parasites with prevalences that go up and down with no predictability". He notes that the juvenile fish are infected in freshwater and that "it is a complex set of variables that can influence parasite prevalences which may differ from one year to the next between or among any given watersheds". He mentions that the good news is that even though these parasites produce undesirable appearances on and in the fish, they do not pose a human health concern.

Mr. Gabe Dunham, Map Agent, SeaGrant Alaska Marine Advisory Program, replied that parasites are normal and "can occur naturally in wild plants, fish and animals." Mr. Dunham provides food safety information indicating that although these parasites are not harmful to humans, there are other parasites that can be passed to humans and he emphasizes the FDA guidelines for freezing and cooking to kill the parasites in any fish to be consumed (freeze fish at -4 degrees Fahrenheit for 7 hours, or cook to 145 degrees Fahrenheit for 15 seconds). Mr. Dunham provided links to Seafood Health Facts and more detailed information on parasites.

The information provided by the consults and the LEO hub coordinator in this observation gave valuable clarification to the questions and concerns asked by the observer and good references are available for all LEO Network members to learn from this important observation.

Featured Observation 3. Dead Birds on Spit Beach

Ms. Karis Porcincula from the Qagan Tayagunigin Tribe Environmental Department, shared an observation about ten dead birds that were found on Spit Beach at Sand Point, Alaska (Porcincula and Parrish 2016). She was not sure the species of birds but she noted that an unusual abundance of dead birds were washing up on Alaska beaches and that people did not know why. This observation links to a special LEO Project that illustrates the 2015-2016 trend of seabird die-off in Alaska.

Photo 4. One of many diseased specimens of the Common Murre (*Uria aalge*) on Spit Beach at Sand Point Alaska in 2015-2016 (Photo courtesy of K. Porcincula).

Dr. Julia Parrish, Executive Director of the Coastal Observation and Seabird Survey Team (COASST) suggested that the carcasses appear to be those of the Common Murre *(Uria aalge)*. She discusses how Common Murres have been washing up particularly in the Gulf of Alaska since 2015 and that the pattern of stranding occurrences has been odd. Dr. Parrish reports that "The COASST program, which collects monthly information on seabirds washing ashore on beaches throughout Alaska (and the lower 48 west coast), has seen an annual beaching rate of murres that is 150 times normal in the Gulf of Alaska. That's a huge difference and it adds up to many tens of thousands of murres." Dr. Parrish shared three alternate explanations for why the murres are dying:

- *The warmer than usual North Pacific Ocean, i.e. 'the blob', fundamentally shifted patterns of food production, including the forage fish that Common Murres consume;*

- *They may have been exposed to toxic compounds (e.g. domoic acid, saxitoxin) through the food-chain magnification of harmful algal blooms, also related to the warm anomaly;*
- *The fish that Common Murres consume may have taken deeper refuge than normal as they seek colder water, making the birds expend more energy to forage, thus shifting their energetic balance.*

Dr. Parrish also reports that people have “begun to report murres flying over the Kenai and the Alaska Peninsulas, and settling on rivers and lakes. I don’t believe this behavior has been observed by Western science. It would be very interesting to know whether there are community records or stories about murres inland.”

This observation demonstrates how the LEO Network platform can be useful in addressing complex and poorly understood patterns or problems, such as bird die offs. It highlights the value in collaborating and sharing all forms of knowledge whether it has Indigenous or Western scientific origins.

Featured LEO Project 1. Fish Illness

The Alaska Native Tribal Health Consortium is the lead organization ‘Fish Illness’ project on the LEO Network. The Project organizers, Mr. Mike Brubaker (ANTHC), Dr. Jayde Ferguson (ADFG), and Dr. Ted Meyers (ANTHC) point out that “Understanding unusual conditions in the health of fish is important for understanding sources of stress or impact on fish and the potential changes to local or regional environment....Observers are asked to provide information about the time and location...and the conditions of the fish, and possible contributing factors.”

Figure 4. Map of occurrences of observations that are included in the ‘Fish Illnesses’ project on the LEO Network.

Featured LEO Project 2: Ungulate Ticks

The Alaska Department of Fish and Game is the lead organization of the ‘Ungulate Ticks’ project on the LEO Network. The project organizers Drs. Kimberlee Beckmen, Bob Gerlach, and James Berner, described that the project’s purpose is to expand surveillance for invasive ticks in Alaska, with a focus on ungulates such as deer and moose. They ask observers to collect photographs of the tick as well as the geographic location.

Figure 5. Map of occurrences of observations that are included in the 'Ungulate Ticks'' project on the LEO Network.

Summary

The following 'take home messages' from our presentation at the *Interdisciplinary Approaches to Managing Health of Fish and Wildlife Conference* in Kimberly, B.C., May 1-2, 2018 summarize our chosen exercise and examples illustrating the value of the LEO Network in wildlife health surveillance:

- The Local Environmental Observer (LEO) Network was developed by the Alaska Native Tribal Health Consortium and is implemented in BC through the First Nations Health Authority.
- We searched the LEO database for ten wildlife health terms to illustrate its usefulness.
- A guide is provided for 'advanced searches' on the LEO Database.
- Maps of search results can be displayed and saved to personal 'My Maps' for examination.
- The frequency of wildlife health terms in first person observations was highest in observations about fish, marine mammals, invertebrates, birds, and land mammals, followed by human health.
- The frequency of wildlife health terms in event-related news articles was particularly high in observations about microbes, land mammals, human health, and marine mammals.
- The featured LEO observations focused on parasites on fish and mysterious mortality of birds:
    - Growths on a sheefish heart near Kotzebue, Alaska were identified by an ADFG pathologist as larval trematodes, which are killed following FDA guidelines.
    - Bumps on the flesh and skin of coho salmon in New Stuyahok, Alaska were identified by an ADFG pathologist as myxosporidean cysts--also addressed using FDA guidelines.
    - Dead Birds on Spit Beach at Sand Point, Alaska were Common Murres *(Uria aalge)*, which may have succumbed to a combination of low food

    - availability and harmful toxins related to the warm water anomaly in the Gulf of Alaska in 2014-2015.
- Two LEO Projects were also featured:
    - A 'Fish Illness' project illustrates numerous fish illness observations in Alaska.
    - An 'Ungulate Ticks' project exemplifies an effort to track northward tick expansion.

The present exercise demonstrates that the LEO network is useful for documenting fish and wildlife health issues. It provides a platform to support and feature a One Health approach to interactions with fish and wildlife, and the multi-directional connections between fish and wildlife health and human well-being. It provides a framework to support First Nations individuals and communities to actively inform dialogue and understanding relating to social-ecological health and change. The LEO Network in BC continues to be implemented through webinars and by engaging with communities and groups that might benefit from the added value of such a network.

In addition to first-person observations by adults who have the life experience and environmental knowledge to notice unusual ecological changs, LEO curricula are also being developed for school classrooms to engage youth in the surveillance of environmental changes. This includes a student-elder partnership approach that encourages youth to interview elders to learn and share stories of environmental and ecological changes that elders have noticed in their lifetimes. Such educational project sharing follow the guidelines of free and informed consent of contributors (e.g. Boutilier 2017), and these educational hubs and domains can be closed and private with public sharing only as deemed appropriate by communities and all involved contributors.

Acknowledgements

The members of the LEO Network in BC and elsewhere deserve primary acknowledgement for joining, contributing observations, and participating in webinars. We thank Mia King and the Columbia Mountains Institute of Applied Ecology for the invitation to the 2018 *Interdisciplinary Approaches to Managing Health of Fish and Wildlife Conference* in Kimberly, B.C. Additional LEO Network staff at the Alaska Native Tribal Health Consortium helped develop the LEO Network approach and platform, and supported implementation in BC. US Environmental Protection Agency provided much support for development of the LEO Network in Alaska. The Commission for Environmental Cooperation supported initial stages of British Columbia implementation, and was facilitated by Indigenous and Northern Affairs Canada. The First Nations Health Authority supports continuing implementation of the LEO Network in British Columbia.

Literature cited

Brubaker, M., J. Berner, and M. Tcheripanoff. 2013. LEO, the Local Environmental Observer Network: a community-based system for surveillance of climate, environment, and health events. International Journal of Circumpolar Health **72**:513-514.

Boutilier, S., 2017. Free, Prior, and Informed Consent and Reconciliation in Canada: Proposals to Implement Articles 19 and 32 of the UN Declaration on the Rights of Indigenous Peoples. West. J. Leg. Stud. 7, 22, 4.

Gumlickpuk, P., and T. Meyers. 2014. "Coho Salmon (*Oncorhynchus kisutch*) with Parasites." *LEO Network* (leonetwork.org). Observed 24 September 2014. Accessed 17 May 2018.

Hupp, J., M. Brubaker, K. Wilkinson, and J. Williamson. 2015. How are your berries? Perspectives of Alaska's environmental managers on trends in wild berry abundance. International Journal of Circumpolar Health **74**:28704-28704.

Lukin, M. and J. A. Ferguson. 2016. "Growth on Sheefish (*Stenodus leucichthys*) Heart." *LEO Network* (leonetwork.org). Observed 24 April 2016. Accessed 11 May 2018.

Okey, T. A. in press. Indicators of marine ecosystem integrity for Canada's Pacific: An expert-based hierarchical approach. Science of the Total Environment.

Porcincula, K. and J. K. Parrish. 2016. "Dead Birds on Spit Beach." *LEO Network* (leonetwork.org). Observed 28 March 2016. Accessed 22 May 2018.

Walsh, J. E., R. L. Thoman, U. S. Bhatt, P. A. Bieniek, B. Brettschneider, M. Brubaker, S. Danielson, R. Lader, F. Fetterer, K. Holderied, K. Iken, A. Mahoney, M. McCammon, and J. Partain. 2017. The high latitude marine heat wave of 2016 and its impacts on Alaska [in "Explaining Extreme Events of 2016 from a Climate Perspective"]. Bulletin of the American Meteorological Society **98**:S39-S43.

Back to Table of Contents

How do we meaningfully incorporate local and traditional knowledge in wildlife health surveillance and management?

S. Kutz, M. Tomaselli, S. Checkley, C. Gerlach, Fabien Mavrot

Abstract
Effective, accurate, and affordable wildlife health surveillance and population monitoring that relies solely on scientific methodologies is challenging, particularly in remote and/or resource poor settings. However, regular harvesters of wildlife hold a vast, and often untapped, knowledge about the animals that they harvest and the landscape in which they live (Berkes and Berkes, 2009; Brook et al., 2009). Capturing this knowledge in a systematic manner using standardized methodologies is essential so that it can be used to guide wildlife management decisions. We have been using a combination of qualitative research methods and participatory epidemiology techniques, together with hunter-based sampling of animals harvested for subsistence and through guided hunts, to assess the health status and demographic trends in caribou and muskoxen in the Arctic (Brook et al., 2009; Carlsson et al, 2016; Tomaselli et al., 2018). Our results demonstrate that this multi-faceted approach provides complementary information on population status and trends. In particular, hunter and guide knowledge not only informs on population trends, behavior, herd composition, body condition, disease, and mortality events, it also identifies emerging issues and provides plausible mechanisms for changing population demographics (Tomaselli et al., 2018). Importantly, systematic and regular collection of this knowledge may provide an early warning system for changes in population status and health. Finally, the use of robust techniques for capturing this information provides credibility to the process, and thus results, facilitating the use of data generated to inform wildlife management. We will discuss our research in the Canadian Arctic and how results have been used to guide species conservation and management plans.

Berkes F, Berkes M.K. 2009. Ecological complexity, fuzzy logic, and holism in indigenous knowledge. Futures 41(1):6-12.

Brook RK, Kutz SJ, Veitch AM, Popko RA, Elkin BT, Guthrie G. 2009. Fostering community-based wildlife health monitoring and research in the Canadian North. EcoHealth 6:266-278.

Carlsson AM, Veitch A, Popko R, Behrens S, Kutz SJ. 2016. Monitoring wildlife health for conservation and food security in the Canadian Arctic: a case study from the Sahtu Settlement Area in the Northwest Territories. Pages 132-151 in Cork SC, Hall DC, Liljebjelke K editors. One Health case studies: addressing complex problems in a changing world. 5m Publishing, Sheffield.

Tomaselli M, Kutz S, Gerlach C, Checkley S. (2018) Local knowledge to enhance wildlife population health surveillance: Conserving muskoxen and caribou in the Canadian Arctic. Biol. Conserv. (doi.org/10.1016/j.biocon.2017.11.010).

Back to Table of Contents

Predictors of survival of nestlings during harsh weather events in an aerial insectivore, the tree swallow

Presenter: **Ilsa Griebel,** Ecosystem Science and Management Program, University of Northern British Columbia
Prince George, British Columbia
griebel@unbc.ca

Co-Author: Russell D. Dawson, Ecosystem Science and Management Program, University of Northern British Columbia, russ.dawson@unbc.ca

Manuscript Citation

Griebel, I.A. and Dawson, R.D. Predictors of nestling survival during harsh weather events in an aerial insectivore, the tree swallow (*Tachycineta bicolor*). Can. J. Zool. In press.

Extended Abstract

Extreme weather events influence the population dynamics of wild animals. For organisms whose food source is affected by environmental conditions, such as aerial insectivorous birds, periods of inclement weather can have devastating effects. Here, we examine predictors of survival of individual nestlings and whole broods in tree swallows (*Tachycineta bicolor*) during an extreme, two-day harsh weather event in 2016, which resulted in the death of 49% and 86% of the broods at two field sites in central British Columbia. On June 15th, the temperature range was 4.1–9.1°C, with an average of 6.6°C, and on June 16th, it ranged from 4.3–10.9°C, with an average of 7.6°C (Environment and Climate Change Canada). Total precipitation was 25.7 and 20.3 mm on these two days, respectively. This harsh weather event co-occurred with an experiment reducing loads of ectoparasites at both the level of the individual nestling and the brood, using a broad spectrum, anti-parasite drug, ivermectin and heat treatment of nests, respectively. A curvilinear relationship existed between survival and brood age, such that middle-aged broods were least likely to survive. Middle-aged nestlings are beginning to thermoregulate, an energetically expensive activity, but have poorly developed feathers and a limited capacity to retain the heat they generate, which appears to make them particularly vulnerable to cold periods (Boyle et al. 2013). Survival of broods and individual nestlings was higher when raised by males with bluer plumage. This supports the ‘good parent hypothesis’, which predicts that females use ornaments displayed by males to select higher quality mates that provide better parental care (Hoelzer 1989). Specifically in our population, older male tree swallows were found to be bluer and brighter than younger males (Bitton and Dawson 2008). Thus, bluer males may be of higher quality and have more breeding experience, which could have improved the chance of their young surviving compared to younger, less experienced males with

greener plumage. Survival of individual nestlings was lower when female parents had brighter and more UV-reflective plumage, contradicting the 'good parent hypothesis' that predicts that male birds select a mate using female plumage ornamentation as a signal of the quality of parental care the female can provide (Owens and Thompson 1994; Johnstone et al. 1996). Female tree swallows with brighter, bluer plumage, however, have been shown to produce nestlings with lower body condition (Bentz and Siefferman 2013), supporting our results. Within broods, smaller nestlings had a lower chance of surviving than their larger siblings. With the fewest body reserves to generate heat and endure starvation, and the least developed feathers to retain body heat, the smallest nestling within a brood is often expected to be the first to die when conditions are poor (the 'brood reduction hypothesis'; Lack 1947; Howe 1978). Nestlings in broods where half of the offspring received ivermectin injections had significantly higher chances of surviving than nestlings from non-experimental broods, suggesting that parasite loads can influence survival during inclement weather. Following two field seasons of the ivermectin experiment, analyses found that nestlings from ivermectin-treated broods faced marginally lower parasite loads (number of larval blow flies per nestling) and had longer and faster growing flight feathers, higher haemoglobin concentrations, and greater fledging success than nestlings from control broods (I.A. Griebel, unpublished data). Fewer parasites in IVM broods may have meant nestlings had more resources available to endure starvation and, for older nestlings, to invest in thermoregulation. Our results identify several factors influencing resiliency of nestlings to harsh weather. Two of the key factors (age and plumage hue of the male) predicted survival at both the brood and nestling level, while the other factors only predicted nestling survival (relative size of the nestling, female brightness and UV chroma, and the anti-parasite treatments). Aerial insectivores are declining across North America (Nebel et al. 2010) and our analysis of survival during harsh weather may be important within the broader context of climate change. As climate change progresses, it is predicted that the frequency of extreme weather events will increase (IPCC 2014). Thus, the knowledge gained from this study, and research like it, may become crucial for understanding dynamics of aerial insectivorous bird populations in the future.

References:

Bentz, A.B. and Siefferman, L. 2013. Age-dependent relationships between coloration and reproduction in a species exhibiting delayed plumage maturation in females. J. Avian Biol. 44:080–088.

Bitton, P. and Dawson, R.D. 2008. Age-related differences in plumage characteristics of male tree swallows *Tachycineta bicolor*: hue and brightness signal different aspects of individual quality. J. Avian Biol. 39:446–452.

Boyle, W.A., Winkler, D.W. and Guglielmo, C.G. 2013. When and how do tree swallow chicks die during cold weather? In: SICB 2013 annual meeting abstracts, Jan. 3–7, 2013, San Francisco, C.A., pp. e22.

Environment and Climate Change Canada. 2017. Available from http://climate.weather.gc.ca/climate_data/daily_data_e.html?StationID=48370&timeframe=2&StartYear=1840&EndYear=2017&Day=20&Year=2016&Month=6# [accessed 5 May 2017].

Hoelzer, G.A. 1989. The good parent process of sexual selection. Anim. Behav. 38:1067–1078.

Howe, H.F. 1978. Initial investment, clutch size, and brood reduction in the common grackle (*Quiscalus quiscula L.*). Ecology, 59:1109–1122.

IPCC. 2014. Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (editors)], IPCC, Geneva, Switzerland.

Johnstone, R.A., Reynolds, J.D. and Deutsch, J.C. 1996. Mutual mate choice and sex differences in choosiness. Evolution, 50:1382–1391.

Lack, D. 1947. The significance of clutch-size. Ibis, 89:302–352.

Nebel, S., Mills, A., McCracken, J.D. and Taylor, P.D. 2010. Declines of aerial insectivores in North America follow a geographic gradient. Avian Conserv. Ecol. 5:1.

Owens, I.P.F. and Thompson, D.B.A. 1994. Sex differences, sex ratios and sex roles. Proc. R. Soc. Lond. B Biol. Sci. 258:93–99.

Back to Table of Contents

Wildlife Stewardship Council: To be a voice and Advocate for wildlife and the ecosystems that sustain all life

John Henderson, Wildlife Stewardship Council
wildlifestewardship@gmail.com
www.wildlifestewardshipcouncil.com/

Our Message

The time is now. What we do now, our children, our grandchildren and our great grandchildren will have to live with. The health of wildlife is intricately connected to the health of humans. When the animals are healthy, so too are we. Right now, many animal populations are suffering the impacts of a finite landbase and too few resources to go around.

Through our members, the Wildlife Stewardship Council (WSC) seeks new ways to support and to grow healthy wildlife populations. Together in partnership we find strength in each other's wisdom, experience and passion for wildlife. From these partnerships, everyone benefits, but no-one benefits more than the wildlife we cherish. Wildlife must come first.

Our Vision

- Our vision is to realize a sustainable system of wildlife co-management in which resource users inherit a management responsibility that comes with their use, activity and impact on the landbase.
- For resource users, there is a traditional, moral and ethical responsibility to harvest only what is required.
- Resource users will work together with respect for the ecosystem and for each other.
- We will work as partners to share management responsibility for shared wildlife and wildlife supporting resources

What We Do

The WSC operates on the First Nations "Seven Generations Principle" which considers future generations and the impact of our activities on those who are still unborn. This principle applies to all aspects of our organization including hunting activities, conservation efforts, and policy evaluation and recommendations. Our members are dedicated to putting conservation and responsible wildlife management before personal agendas and self-interest. We:

- Facilitate cooperation and respect between First Nations, stakeholders and government
- Contribute to the implementation of improved wildlife management practices in BC
- Advocate for responsible ecosystem and habitat management as a critical component to healthy wildlife populations
- Work to maintain and enhance nature's yield as a valuable resource for all
- Advocate for sustainable harvest practices as a valuable tool in wildlife management
- Undertake joint wildlife and habitat initiatives amongst WSC members and other partners
- Serve as a "clearing house" for information sharing between First Nations and stakeholder groups to build understandings between all parties
- Provide advice on issues relevant to sustainable wildlife management to government and other affected parties

History

In 2010, members of the Coastal British Columbia Guides Association became incorporated under the BC Societies Act. This association represented the best way to bring together and to focus on the best interests of wildlife, the coastal guiding industry, First Nations and our clients, filling an unmet need on the coast. The association, with high standards of wildlife stewardship, quickly outgrew the coastal constraints of its name and in 2014 adopted a new name, "Wildlife Stewardship Council", WSC. The new name better reflects the organization's emphasis on responsible wildlife management and removes geographic barriers. As a result, membership has broadened to include First Nations, guide outfitters and passionate individuals from other regions in the province.

Back to Table of Contents

From Bighorns to bats and everything in between: Year 25 of a wildlife vet's story

Dr. Helen Schwantje, BC Wildlife Health Program – BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development
Nanaimo, British Columbia
helen.schwantje@gov.bc.ca

Dr. Schwantje, the wildlife veterinarian for British Columbia and person responsible for the provincial Wildlife Health Program since 1992, gave a retrospective talk on her journey as a wildlife vet. This talk was presented during the evening of May 1, and was open to the public.

Dr. Schwantje's talk touched on many things including a veterinary's approach to wildlife management, networking towards One Health, and lessons learned throughout her 25 years as a wildlife vet. All of this was presented through many informational and engaging photos and stories of some adventures and experiences Dr. Schwantje has shared with both the wildlife and the incomparable people working with wildlife throughout British Columbia.

Back to Table of Contents

Risk assessment on the use of South American camelids for back country trekking in British Columbia

Presenter: **Tyler Stitt**, BSc, MPH&TM, DVM, Centre for Coastal Health
Nanaimo, British Columbia
tyler.stitt@viu.ca
www.centreforcoastalhealth.ca

Co-Authors: Theresa Burns, DVM, MSc, PhD, Centre for Coastal Health,
theresa_burns@hotmail.com

Stefan Iwasawa, BSc, Centre for Coastal Health, Stefan.Iwasawa@viu.ca

Carl Ribble, DVM, PhD, Director, Centre for Coastal Health, carl.ribble@gmail.com

Summary

South American camelids (SACs) are popular pack animals for back-country trekking and hiking excursions in many regions across North America, due in large part to their hardy nature and versatility. SACs include llama, alpaca, vicuna and guanaco of the Order Artiodactyla. Although they are not native to North America, llamas and alpacas are increasingly kept as domestic animals and often in co-habitation with domestic livestock. Stephen and Schwantje (2003) predicted that demands to allow SACs into wilderness areas in BC would increase, and set out to evaluate the risk of pathogen transmission from SACs to wild ungulates in the province. Although they defined criteria for high risk pathogens, they found no documented evidence for the transmission of any pathogen from SACs to wildlife. Citing the precautionary principle, they recommended that local, risk-based policies and practices be developed to manage disease risks to wildlife from SACs. A second risk assessment, following the guidelines set forth by the Canadian Wildlife Health Centre (CWHC) for "Health Risk Analysis in Wild Animal Translocations", (Garde et al., 2009), identified pathogens that can infect domestic SACs, sheep and goats and have the potential to negatively impact Dall's Sheep and Mountain Goats. The authors found no documented cases of pathogen transmission from SACs to wildlife. In 2015, Alaska National Park Service did not implement a proposed ban on llama and alpaca use in Alaska's backcountry due in part to a lack of evidence for pathogen transmission from SACs to wild ruminants. The BC government's recently proposed province-wide ban on SACs in backcountry areas suggested the need for an updated risk assessment.

To address knowledge gaps and update previous risk assessments, the Center for Coastal Health (CCH) was contracted by the governments of British Columbia and Alaska to 1)

identify emerging diseases of SACs, 2) describe and evaluate recent findings regarding the epidemiology, diagnosis and control of pathogens that affect both SACs and other ungulates, and 3) collect evidence about the risk of pathogen transmission from SACs to domestic or wild ungulates.

Risk is a composite measure that takes into account the probability of an event occurring, the magnitude or impact of that event, and an interpretation of the uncertainty around the criteria used to estimate probabilities and impact. As a tool, risk assessments aid in the systematic identification and description of risks, and allow us to weigh the evidence on those risks, address risk perceptions by different stakeholders, and enable decision-making and policy building. For this risk assessment, we performed a literature search and reviewed scientific publications as well as government, policy and grey literature reports. We interviewed experts in wildlife health and camelid infectious disease, evaluated available laboratory diagnostic data, and then collated, integrated and assessed the available information. Finally, we assigned uncertainty based on quantity and quality of information. Because the presence, prevalence and impact of many of the pathogens identified in our risk assessment on individual wild animals and herd health status is not completely known, we collated population and distribution information on BC's ungulates. Caribou, which are currently listed as extirpated, endangered or threatened in BC, may be more susceptible to newly introduce pathogens. Wild sheep, mountain goat, Roosevelt elk on Vancouver Island, and Northern Mountain Caribou are blue listed, or of special concern, and may also be susceptible to novel pathogens. Although yellow-listed species may not themselves be at risk for novel pathogens, it is plausible that they could act as a vector or reservoir for pathogens of concern for more at-risk ungulate species.

A full list of pathogens reported from llamas, Dall's Sheep, Bighorn Sheep, Stone's Sheep and Mountain Goat can be found in Garde (2009). In summary, the bacteria *Mannheimia haemolytica*, *Mycobacterium avium paratuberculosis* (Johne's disease), and *Pastuerella multocida,* along with parapox virus (contagious ecthyma), parainfluenza 3 and *Oestrus ovis* were considered of significance to the health of NWTs wild ungulates and have been reported from SACs. Since Garde's risk assessment, there have been a small number of case studies published that reported clinical disease in association with pathogens not previously associated with disease in SACs (i.e. parainfluenza virus 3, bovine leukemia virus), or that are of increasing significance to the health of SACs (i.e. bovine viral diarrhea virus, *Mycobacterium bovis*). There is high uncertainty about the probability of pathogen transmission from SACs to wild ungulates. We found no peer-reviewed publications documenting pathogen transmission from camelids to wild ungulates or to domestic sheep and goats for the identified pathogens. However, because there was almost no research examining the shedding and transmission dynamics for pathogens in camelid herds, or between camelids and other ruminants, a lack of peer-reviewed evidence should not be considered proof that transmission has not, or could not, occur. We are aware of anecdotal evidence that the introduction of trekking llamas near Atlin, Terrace and the Babine Mountains of BC (Skeena region) coincided with the first reports of contagious ecthyma in Mountain Goats (*Oreamnos americanus*) in these regions.

Overall, we assessed the composite disease risk posed to wild ungulates by SACs accessing backcountry areas as medium-high with medium associated uncertainty. This assessment was driven primarily by the high impact and the medium-high risk posed by the respiratory pathogens *M. haemolytica* and *Pasteurella* spp., the medium-high risk posed by contagious ecthyma, and the medium risk posed by Johne's Disease. Mitigation could be undertaken to partially reduce risk posed by respiratory pathogens, although mitigation for contagious ecthyma and Johne's Disease is much more challenging.

The full risk assessment is available online at
https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/wildlife-wildlife-habitat/wildlife-health/wildlife-health-documents/risk_assessment_use_of_camelids_for_backcountry_trekking_bc.pdf

References

Garde, E., Kutz, S., Schwantje, H., Veitch, A., Jenkins, E., & Elkin, B. 2009. Examining the risk of disease transmission between wild Dall's sheep and mountain goats, and introduced domestic sheep, goats, and llamas in the Northwest Territories. Manuscript Report No. 186. Environment and natural Resources Government of the Northwest Territories, Canada.

Stephen, C., & Schwantje, H. 2003. Communicable disease risks to wildlife from camelids in British Columbia. Nanaimo, BC.

Acknowledgments

British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development

Dr. Kimberlee Beckmen, Wildlife Health Veterinarian, Alaska Department of Fish and Game, Division of Wildlife Conservation, Wildlife Health and Disease Surveillance Program

Back to Table of Contents

The BC Sheep Separation Program: 18 years of collaborative management of respiratory disease transmitted from domestic sheep to wild sheep

Jeremy Ayotte, BC Sheep Separation Program Coordinator
Salmon Arm, British Columbia
Jeremy.ayotte@gmail.com

Summary

Respiratory disease transmitted from domestic sheep continues to remain the largest impediment to restoring and sustaining wild sheep across western North America. The mechanism of pathogen transmission from domestic to wild sheep may be relatively simple, but creating effective separation on private land to protect a public resource is not. This wildlife health issue has been historically contentious, with passionate wild sheep conservationists pitted against land owners who are well within their right to keep sheep on their own property. Changing farm practices to reduce risk to wildlife only happens through building trust and designing on-farm stewardship options that reduce risk to wildlife without increasing costs for the farmer. Successfully changing provincial legislation that limits or excludes domestic sheep on private land is achievable but it is a long-term goal and requires consistent and methodical pressure and support. BC is unique among jurisdictions with wild sheep range in its approach to this issue. We have the only dedicated program that works with all stakeholder groups toward a common goal of risk reduction to wild sheep while supporting a viable domestic sheep industry. The program is well-known and internationally respected.

With recent research by Dr. Tom Besser (Department of Veterinary Microbiology and Pathology, Washington State University) identifying Mycoplasma ovipneumoniae (M.ovi) as the primary pathogen that triggers bighorn sheep pneumonia outbreaks, wild sheep conservation efforts from New Mexico to Alaska are focussing efforts on protocols for testing and removing M.ovi from domestic sheep flocks as the most effective method to manage disease risk. The research also suggests that M.ovi free domestic sheep are more productive, where a 7% weight gain has been documented in M.ovi free lambs at slaughter. Consequently removing M.ovi from domestic sheep farms may provides a win-win solution and is in line with the original vision of BC's Sheep Separation Program to create healthy wild sheep in BC while supporting a viable domestic sheep industry.

While BC has led the process of initiating a multi-stakeholder separation program, developing the tools needed to create and maintain M.ovi free farm flocks (e.g., testing, sampling, segregating, and farm biosecurity) requires partnerships, collaboration and

coordination among veterinarians, Ministry of Agriculture staff, wildlife managers, farm owners, and wild sheep conservation groups. Ultimately success will be determined by good communication and program coordination. As we work together to develop these practical on-the-ground tools, the program coordinator is also tasked with maintaining open communication and collaboration within BC and across other jurisdictions that are working on similar issues (e.g., Alaska, Montana). The coordinator is also working to ensure specific research projects are connected to the overarching goal of creating a M.ovi Control Plan for BC that reduces the risk of disease outbreaks in wild sheep. Current research is focusing on the use of antibiotics to treat domestic sheep flocks that are M.ovi carriers.

The new research into M.ovi and its possible treatment marks a hopeful shift in the BC Sheep Separation Program efforts away from one-off mitigation projects that risk the creation of incentives to farm sheep in high risk areas (e.g., by providing "free" fencing to sheep farms), and more toward a focus on developing an overarching strategy that is defined through a M.ovi Control Plan. A provincial M.ovi Control Plan will be a planning document that defines the issues, actions, timelines, and accountability required to achieve the overall goal of sustainable health of wild sheep with minimal impact on domestic sheep farming. The plan will be developed with Ministry of Agriculture staff support so that projects directly link to and support policy development. Policy and regulations will be one important component of this strategy. The BCSSP has not had the benefit of a guiding strategy or plan such as this given that early efforts were focused primarily on physical separation as the only solution.

This long-term Wild Sheep Conservation and M.ovi Control program will continue the primary tasks of maintaining an engaged working group and finding novel ways to reduce immediate risks on new sheep farms that overlap with wild sheep range. The common ground that both the domestic sheep industry and wild sheep conservation groups share is to avoid another large scale die-off of our wild sheep.

[Back to Table of Contents](#)

Lessons learned from an interdisciplinary approach to managing bovine tuberculosis at a wildlife-domestic animal interface in southern Manitoba

Todd Shury (presenter), Wildlife Health Specialist, Parks Canada Agency
Saskatoon, Saskatchewan
todd.shury@pc.gc.ca

Paul Paquet, Raincoast Conservation Foundation and Dept. of Geography, University of Victoria, ppaquet@baudoux.ca

Doug Bergeson, Riding Mountain National Park, doug.bergeson@pc.gc.ca

Ryan Brook, Indigenous Land Management Institute & Department of Animal and Poultry Science, University of Saskatchewan, ryan.brook@usask.ca

Introduction

Bovine tuberculosis (TB) is a bacterial infection caused by *Mycobacterium bovis (M. bovis)*, a member of the mycobacterium tuberculosis complex, which includes the same bacterium that commonly infects humans (*M. tuberculosis*) and other host specific mycobacteria. It infects a wide variety of mammal species with cattle (*Bos Taurus*) a primary host, but also infects wildlife species, which can act as competent reservoirs of infection (Palmer, 2013; Thoen et al., 2014). Humans can become infected with *M. bovis*, although infections are rare in developed countries including Canada and the USA (Kaneene et al., 2014; Thoen et al., 2014). Zoonotic disease due to *M. bovis* is a major concern in other countries though (Thoen et al., 2014). *M. bovis* causes little or no adverse effects on wildlife populations, with rare exceptions, but is a concern for the livestock industry due to its potential to impact on international trade (Nishi et al., 2006; Palmer, 2013). Canada's livestock are considered bovine TB-free and loss of that status has potential for socioeconomic harm. Spillover from infected wildlife to domestic animals, as well as spillback from infected cattle to wildlife occur in many areas worldwide (Palmer, 2013). Canada has two major wildlife reservoirs of *M. bovis*; one in northern Canada in the region surrounding and including Wood Buffalo National Park where wood bison (*Bison bison athabascae*) are the reservoir species (able to maintain infection without reinfection by another host species), and another in southern Manitoba in the region surrounding and including Riding Mountain National Park (RMNP) where elk (*Cervus canadensis*) and white-tailed deer (*Odocoileus virginianus*) have been implicated as reservoir species (Nishi et al., 2006; Wobeser, 2009). The epidemiological situation and management strategies used have evolved considerably over the past two decades in this latter region. Lessons learned through this evolution will be described in hopes that other wildlife disease outbreaks may learn from the experience in and around Riding Mountain National Park.

The first *M. bovis* positive elk was discovered in 1992 (the first confirmed case in this species in the wild in North America) through a hunter submission south of RMNP and the first positive white-tailed in 2001 (Lees, 2004; Lees et al., 2003). Before this, two infected wolves were discovered in 1978 within RMNP (Carbyn, 1982), which subsequently turned out to be the same strain of *M. bovis* found in elk, deer and cattle in the current outbreak (Lutze-Wallace et al., 2005). Targeted surveillance programs have been ongoing annually since 1997, with no coordinated surveillance in wildlife prior to this. This surveillance comprises a mixture of hunter surveillance, blood testing samples and culled wild cervids (Shury et al., 2014). A surveillance and control zone (Riding Mountain Eradication Area [RMEA]) was created in 2003 by the Canadian Food Inspection Agency (CFIA) to allow intensive cattle testing and control cattle movement. A combination of management factors initiated between 2000 and 2003, as part of the Manitoba Task Group for Bovine Tuberculosis resulted in a major decrease in prevalence of *M. bovis* in elk and white-tailed deer between 2003 and present (Shury et al., 2014). This multi-jurisdictional initiative was formed to eradicate bovine tuberculosis from the Riding Mountain region via four goals: 1) to achieve and maintain bovine TB-free status in domestic cattle , 2) to eradicate bovine TB in wildlife that may pose a risk to agriculture, and 3) to minimize wildlife-livestock interactions in the RMNP region, and to, 4) minimize unnatural cervid herding behaviour that occurs where cervids feed on agricultural products, thereby minimizing the potential for disease transmission (Shury, 2015). Two provincial (Manitoba Sustainable Development and Manitoba Agriculture) and two federal government agencies (Parks Canada Agency and Canadian Food Inspection Agency) were involved with three major stakeholder groups (Manitoba Beef Producers, Manitoba Wildlife Federation, and Riding Mountain Biosphere Reserve) and four First Nations around RMNP to develop annual management plans through several oversight bodies and committees. Initial interactions between stakeholders and government agencies were highly combative and solutions being proposed were drastic (e.g. complete depopulation of elk and deer in RMNP, fencing the boundary of RMNP), but as knowledge was gained through scientific research and shared through extensive outreach efforts, positions softened somewhat over time leading to shared understanding and common objectives and goals.

A first important step was undertaking basic interdisciplinary research to understand the social and environmental factors that led to the creation of this *M. bovis* reservoir in wildlife. Social science was critical to understanding farmer and rancher attitudes towards elk and deer and explore potential solutions and barriers to progress (Brook and McLachlan, 2006, 2009). Understanding the scope and basic epidemiology and disease ecology of interactions among key host species was also critical to finding science-based solutions that would lead to control. A convergent finding in both of these areas indicated there were issues with baiting and feeding of elk outside of RMNP and significant access to stored hay bales by elk and white-tailed deer, which created a disease conducive landscape that allowed rapid transmission and maintenance of TB within elk, white-tailed deer and cattle in the 1990's and early 2000's (Brook and McLachlan, 2006 Brook et al., 2013; Gooding and Brook, 2014; Shury, 2015; Shury and Bergeson, 2011). A key recommendation was to ban baiting and feeding for the purpose of hunting in the RMEA, which was legislated in 2004 but took several years to adequately enforce. A key gap in monitoring was that no detailed monitoring data on baiting and feeding was ever recorded, so the role and importance of these activities remains poorly understood. Analysis of compensation payments to farmers for losses due to elk and white-tailed deer has been the only usable data to understand access of wildlife to hay bales and other agricultural crops and this research has shown this to be very effective at reducing wildlife-cattle interactions in the RMEA (Gooding and Brook, 2014).

The three objectives laid out by the Task Group have either been accomplished or are expected to be in the next 5 to 10 years. Elk density reduction and associated reduction in elk group size was another likely key factor in the switch of elk from reservoir to spillover host, as shown by a strong association between elk density and probability of finding culture positive elk on the landscape (Brook et al., 2013; Shury, 2015). WTD have likely always been a spillover host (unable to independently maintain infection) at densities at which they occur at within the RMNP region, and both cattle and WTD are likely spillover hosts (Shury, 2015; Shury and Bergeson, 2011). Disease transmission was likely reduced markedly as a result of efforts to prevent indirect contact between wild cervids and cattle over hay bales in winter, as there was a strong temporal association between reduced prevalence in wild cervids and fencing of hay storage yards around RMNP (Shury, 2015).

The combined actions describe above have resulted in a marked reduction in TB prevalence from approximately 10% in elk in 2003 to near zero presently. Only one positive elk has been found in the last five years of surveillance combined and the last positive white-tailed deer was found in 2009. The last positive cattle herd was discovered in 2008, despite intensive surveillance since that time in the RMEA.

M. bovis has likely been eliminated from both cattle and wildlife in the RMNP region, or is at a level that is undetectable with current surveillance methods. There is certainly potential for future latent cases in elk and WTD in the coming decade, but at current densities it is very unlikely that these species can maintain *M. bovis* infection independently (Shury, 2015). Current modelling indicates that additional surveillance will be required, with a strong focus on the core area over at least five to ten years to ensure a probability of disease freedom above 95% (Shury 2015). Although latent cases may still occur, further transmission is unlikely, if conditions remain similar to present and densities are not allowed to increase and contact between cattle and wildlife is maintained. Current biosecurity practices which include maintenance and use of barrier fencing for hay storage, use of guardian dogs, and strong legislation and enforcement of bans on baiting and feeding for hunting, will also need to be maintained. Ensuring adequate surveillance should be the focus of future management activities, as the conditions are now in place that have allowed eradication to occur. This has happened in other geographic locations in North America where sporadic *M. bovis* cases have occurred in the past, and the disease apparently no longer exists due to unfavourable conditions in wildlife reservoir hosts (Belli, 1962; Friend et al., 1963; Steffen et al., 1999; Ryan et al., 2006; Wobeser, 2009). White-tailed deer and elk densities where these isolated spillover events occurred were quite low and this is likely why these areas never developed into wildlife reservoirs (Wobeser, 2009). Cervid densities have generally increased throughout North America since the early part of the 20th century, concurrent with the development of wildlife reservoirs of *M. bovis* in several states and provinces (O'Brien et al., 2011; Palmer et al., 2012).

Lessons Learned

Lessons learned through experience with TB management in wildlife and domestic animals in this ecosystem include;

1) **Be truly adaptive.** There were many different advisory groups and oversight groups/committees which were created, evolved and changed over the 20 years of bovine TB management. Initially there was a management plan created by the four government agencies which was reviewed by major stakeholders. This eventually evolved into a Stakeholder Advisory Group, a Scientific Review Committee, a First Nations Wildlife Council and a Policy Steering Group. Recommendations ultimately came from the first three groups and were implemented by the latter group. A bovine TB Coordinator was also hired for the past six years to coordinate the many groups who eventually became involved in the process. This was critical to maintain momentum and keep government agencies on track. Parks Canada responded to initial concerns that elk within Riding Mountain National Park were not being adequately tested in the early phases of surveillance and trust was built and maintained with many local landowners when elk were tested and removed from the park in 2003 and found to be heavily infected. Another novel strategy (at the time) was for government agencies (Parks Canada and Manitoba Agriculture) to pay for capital costs of

installing hay barrier fences on private land outside the park to prevent contact between wildlife and cattle.

2) **Communicate & engage honestly.** A series of town halls was attempted to communicate with stakeholders initially, but this was not an efficient or useful form of communication, as it allowed vociferous individuals to grandstand, often with extremist views, resulting in confrontation and lack of progress. Indeed, many of the participants left the meetings more frustrated than when they arrived. Rigorous social science research and efforts to use local and traditional knowledge as part of social and ecological research facilitated more effective and informed discussions and found ways to more meaningfully engage local communities. Finding individuals to sit on the committees and groups that were reasonable and rational allowed sensible agreement to occasionally be achieved. Certain groups or individuals were often left feeling dissatisfied or disillusioned with the process, but it ultimately lead to finding solutions that were not only acceptable, but resulted in measurable success over time.

3) **Innovate.** Traditional tests for *M. bovis* require injection of purified antigens intradermally with recapture and retesting at 72 hours, precluding their use in free-ranging species. In collaboration with CFIA laboratory in Nepean, Ontario and several private companies in the US and overseas, several newer blood tests for *M. bovis* were developed and field validated for elk and white-tailed deer which proved very effective for diagnosis of the disease (Shury et al., 2014). Understanding the local context and what major stakeholder views were was an early and very effective strategy to both build awareness and to seek consensus views on acceptable strategies. Data and management strategies were shared with other wildlife agencies worldwide at conferences and symposia so that new knowledge could be incorporated and used quickly and efficiently (https://www.bcva.eu/system/files/resources/THURSDAY.pdf). On farm risk assessments developed specifically for the RMEA and targeted towards landowners in close proximity to Riding Mountain National Park were also an innovative strategy to maintain communication and understanding with local landowners (https://www.gov.mb.ca/agriculture/animals/animal-health/bovine-tb-prevention-program.html).

4) **Incorporate different knowledge types.** Scientific, local, and traditional ecological knowledge were equally important in understanding the drivers of the *M. bovis* outbreak around Riding Mountain National Park. This latter knowledge was held not only by First Nations around the park, but also local farmers and ranchers who provided critical understanding of elk and deer distribution and movement around the park. Local and traditional knowledge indeed formed the basis of some hypotheses for further disease ecology research. Kitchen table chats over coffee with hundreds of different individuals

allowed a deeper understanding of the diversity of opinion within the farming/ranching community as well as building a trust relationship that ultimately lead to effective monitoring and management over many years. A One health approach that considers domestic animal, wildlife and human health in an integrated manner is clearly required to successfully manage any wildlife disease.

5) **Favour reversibility.** A test and removal approach for wildlife using blood tests was initially favoured as it allowed removal of fewer individuals from the population that had a higher probability of being truly infected with *M. bovis*, rather than a depopulation approach that would have created a very long elk population recovery period. This approach does not work as well in domestic animal populations, because undetected, still infected animals may often still be present in herds, despite ongoing intensive testing. This approach was likely more costly (because more animals need to be tested over a longer period of time), but it was a compromise that appears to have been quite effective and was acceptable to most stakeholders and government agencies.

6) **Think long term (Persistence).** Diseases like bovine tuberculosis and chronic wasting disease are long-term, chronic infections that require long-term thinking to manage properly. Successes may not typically be realized even after 5 to 10 years of intervention. These facts must be communicated honestly to both stakeholder groups and policy makers when setting goals and objectives. Maintaining funding over long periods amongst several different levels of government is still one of the major challenges.
The disease management objectives that have resulted in the success realized within the RMNP region were only accomplished through an ongoing adaptive management framework with constant integration of new knowledge and acceptance of various groups of engaged stakeholders and First Nations. Of the management factors instituted by the Manitoba TB Task Force, the ones that *likely* had the greatest impact in prevalence reduction in wildlife were fencing of hay storage yards around RMNP, selective culling of elk and WTD within RMNP, and density reduction of elk and WTD which appears to have reduced populations to below a critical community size for maintenance of *M. bovis* in this wildlife reservoir. As a result, on-farm testing of cattle was recently suspended by the CFIA in 2017, something which had been ongoing annually since 2003 in the RMEA and live exports of breeding cattle without TB testing has recently been reinstituted by the US Department of Agriculture. Determining if elk and white-tailed deer are indeed free of *M. bovis* is the next challenge and that will likely take at least another 10 years of ongoing surveillance with no positives. However, the collaborative approach that has emerged suggests opportunities to continue this essential work and a capacity to address any surprises that may emerge along the way.

References

Brook, R. K., and McLachlan, S. M. (2009). Transdisciplinary habitat models for elk and cattle as a proxy for bovine tuberculosis transmission risk. *Prev Vet Med* 91, 197–208. doi:S0167-5877(09)00148-2 [pii] 10.1016/j.prevetmed.2009.05.021.

Brook, R. K., Wal, E. Vander, van Beest, F. M., and McLachlan, S. M. (2013). Evaluating use of cattle winter feeding areas by elk and white-tailed deer: Implications for managing bovine tuberculosis transmission risk from the ground up. *Prev. Vet. Med.* 108, 137–147. doi:10.1016/j.prevetmed.2012.07.017.

Brook, R., and McLachlan, S. (2006). Factors influencing farmers' concerns regarding bovine tuberculosis in wildlife and livestock around Riding Mountain National Park. *J. Environ. Manage.* 80, 156–166. doi:10.1016/j.jenvman.2005.08.022.

Carbyn, L. N. (1982). "Incidence of disease and its potential role in the population dynamics of wolves in Riding Mountain National Park, Manitoba," in *Wolves of the World: Perspectives of Behavior, Ecology, and Conservation*, eds. P. C. Paquet and F. H. Harrington (Noyes Publications), 106–116.

Gooding, R. M., and Brook, R. K. (2014). Modeling and mitigating winter hay bale damage by elk in a low prevalence bovine tuberculosis endemic zone. *Prev. Vet. Med.* 114, 123–131. doi:10.1016/j.prevetmed.2014.01.005.

Kaneene, J. B., Miller, R., Steele, J. H., and Thoen, C. O. (2014). Preventing and controlling zoonotic tuberculosis: a One Health approach. *Vet. Ital.* 50, 7–22. doi:10.12834/VetIt.1302.08.

Lees, V. W. (2004). Learning from outbreaks of bovine tuberculosis near Riding Mountain National Park: applications to a foreign animal disease outbreak. *Can Vet J* 45, 28–34. Available at: http://www.ncbi.nlm.nih.gov/pubmed/14992251.

Lees, V. W., Copeland, S., and Rousseau, P. (2003). Bovine tuberculosis in elk (Cervus elaphus manitobensis) near Riding Mountain National Park, Manitoba, from 1992 to 2002. *Can. Vet. J.* 44, 830–831.

Lutze-Wallace, C., Berlie-Surujballi, G., Barbeau, Y., and Bergeson, D. (2005). Strain typing of Mycobacterium bovis from a 1978 case of tuberculosis in a wolf (Canis lupis) from Manitoba. *Can. Vet. J.* 46, 502.

Nishi, J. S., Shury, T., and Elkin, B. T. (2006). Wildlife reservoirs for bovine tuberculosis (Mycobacterium bovis) in Canada: Strategies for management and research. *Vet. Microbiol.* 112. doi:10.1016/j.vetmic.2005.11.013.

Palmer, M. V. (2013). Mycobacterium bovis: Characteristics of wildlife reservoir hosts.

Transbound. Emerg. Dis. 60, 1–13. doi:10.1111/tbed.12115.

Shury, T. K. (2015). The epidemiology of bovine tuberculosis (Mycobacterium bovis) in the Greater Riding Mountain ecosystem. Available at: https://ecommons.usask.ca/handle/10388/ETD-2015-01-1966.

Shury, T. K., and Bergeson, D. (2011). Lesion Distribution and Epidemiology of Mycobacterium bovis in Elk and White-Tailed Deer in South-Western Manitoba, Canada. *Vet Med Int* 2011, 591980. doi:10.4061/2011/591980.

Shury, T. K., Bergeson, D., Surujballi, O., Lyashchenko, K. P., and Greenwald, R. (2014). Field evaluation of three blood-based assays for elk (Cervus canadensis) naturally infected with Mycobacterium bovis. *Prev. Vet. Med.* 115. doi:10.1016/j.prevetmed.2013.11.003.

Thoen, C. O., Steele, J. H., and Kaneene, J. B. (2014). *Zoonotic Tuberculosis: Mycobacterium bovis and Other Pathogenic Mycobacteria: 3rd Edition*. doi:10.1002/9781118474310.

Wobeser, G. (2009). Bovine tuberculosis in Canadian wildlife: an updated history. *Can. Vet. journal. La Rev. vétérinaire Can.* 50, 1169–76. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2764465&tool=pmcentrez&rendertype=abstract.

Back to Table of Contents

From monkeys to salmon: harm reduction as an approach out of stagnation in wildlife health management

Craig Stephen, DVM, PhD, Canadian Wildlife Health Cooperative
cstephen@cwhc-rcsf.ca

The current unprecedented threats to health and sustainability are inspiring conversations on the need to change the way we address environmental harms. Problems like climate change, persistent pollutants and emerging pathogens are making it increasingly difficult to sustain healthy populations successfully and effectively. This paper explores the application of harm reduction concepts, used in public health to address problems with addictions, to programs aimed at promoting and protecting wildlife health.

The bulk of wildlife health research focuses on identifying the mechanisms or etiologic agent causing adverse pathophysiological outcomes. A very small proportion examines ways to develop and successfully deliver interventions to protect health under realistic social and environmental conditions. There is growing frustration in many fields that research is inadequately being used to inform decisions to improve outcomes. In particular there is a growing realization that to be ready for the onslaught of threats to wildlife health that accompany our rapidly changing world we need to shift from the reactionary principle to the precautionary principle by findings ways to reduce impacts on wildlife in the face of uncertain science and conflicting social values.

If one accepts that health is a cumulative effect of complex socio-ecological systems, one must conclude that scientific certainty is not only elusive in wildlife health research but also that multiple points of view are needed for evidence to be helpful. Because there are few options to remedy wildlife diseases, there is often a feeling of helplessness in efforts to eliminate their negative impacts. Most standard methods for disease control cannot be applied and rarely can the source of harm, whether a pathogen, pollutant or climate change, be eliminated from the environment. Furthermore, the reasons for failure or success of interventions to protect or promote wildlife health are usually social, rather than biological or physical factors. The decisions we make about environmental and resource management are affected by our values, economics, and politics. As we move from individual animals to the population and ecosystem level, the decision-making context becomes more variable, uncertain, and complex.

There is no wildlife health problem that does not cause multiple harms, have unresolved uncertainty and have conflicting social perspectives on the need for or nature of action. For example, chronic wasting disease harms individuals (ex. reduces survival or fitness of wild cervids), economies (ex. impacts agricultural trade of farmed cervid products), communities (ex. reduces income for hunting guides and outfitters), psychologies (ex. creates fear of consumption of wild venison), ecosystems (ex. alters functions as species decline), and politics (ex. creates policy and spending conflicts). Different but interconnected strategies are needed for each of these harms. Uncertainties over the nature of the CWD zoonotic risk, the means for its control and the future course of this wildlife epidemic further stymie decision makers looking for the 'right" way to manage this disease. While all these harms could be removed if the CWD prions could be eliminated or transmission can be stopped, neither of those options are plausible, socially acceptable, or feasible in the foreseeable future. Actions need to be taken in the present using what we know rather than waiting for a preferred future as the chosen management strategy. The inseparable links between the individual, social and ecologic levels of harm seen in wildlife health problems suggest that multi-level interventions are required to make increment gains in the health of wildlife communities and ecosystems.

Harm reduction is most often used to describe a set of public health and health promotion strategies intended to reduce the harmful consequences of addictive behaviours on individuals and society. It acknowledges that society is unlikely to eliminate substances like illicit drugs and that attempts at elimination have been insufficient to prevent the harms arising from addiction. Harm reduction programs aim to prevent or reduce the adverse consequences to all members of the community rather than only target the hazard and its users. Like illicit drugs, elimination of many environmental threats like climate change, pollutants or pathogens, is unattainable and unrealistic in the short-to-medium term.

There are six basic principles of harm reduction: (1) Focus on harm; seek interim actions to decrease the negative consequences of the hazard; (2) Be pragmatic; recognize hazard elimination is not always feasible and focus on helping populations cope within the current circumstances; (3) Be solution oriented; seek strengths, possibilities, and opportunities to reduce negative consequences rather than emphasizing discovery of the proximate cause of harms; (4) Use a multi-pronged approach, ranging from influencing policy to targeted biomedical interventions in high-risk settings to maximizes options for action; (5) Prioritizes achievable goals; seek incremental gains that can be built on over time by emphasizing actions that are feasible within the current circumstances and state of knowledge; and (6) Be people oriented; work to actively engage a diversity of players and not blame or judge the participants, in order to find pathways and control points that can be targeted to reduce harms across various perspectives, values and harms.

A review of current recommendations to recover declining Pacific salmon populations are consistent with the harm reduction approach, yet most policy and legislation stays focussed on defining and delivering health programs targeting specific infectious agents.

Many agencies involved in managing oceans activities remain concerned with managing a single species or a single activity. It remains no one's responsibility to integrate the social and ecological dimensions of salmon health nor to strive to coordinate efforts to reduce harms whilst debate over the attributable fractions of harm from specific etiologies remains. However, a recent external advisory committee report to the BC Ministry of Agriculture is promoting the harm reduction approach to encourage collaborative action on shared goals and reduce conflicts and stasis in actions associated with wild and farm salmon interactions. Additional policy research revealed how a holistic view of salmon health as the capacity to cope with change and a result of interacting social, physical and biological factors not only supports a harm reduction approach but also enables management agencies to more accurately identify entry points for salmon health problem solving and for build alliances to promote collective action. Ongoing research in St. Kitts managing human-monkey conflicts is providing an evidence base for adapting harm reduction processes and methods from human health to wildlife health.

A new approach to wildlife health is both timely and warranted. Harm reduction is a perspective and a set of strategies that applies to all the determinants of health and not merely problematic risks. It involves pragmatic, multidisciplinary, approaches to remove barriers to implementation of knowledge to protect health and promote sustainability. The harm reduction model is consistent with the precautionary approach that states that lack of full scientific certainty shall not be used as a reason for postponing measures to prevent environmental harm. Its goal is to help people make informed decisions and empower them to minimize harms by identifying ways to reduce negative impacts until a hazard can be moderated or eliminated. It promotes collaborative policy and action by discovering means for horizontal, cooperative approaches to protecting health in advance of serious, irreversible impacts. Adopting a harm reduction perspective is not a rejection of the current research paradigm but rather a call to expand our areas of inquiry to ensure that opportunities to lessen harms can be identified and acted on while we strive to directly prevent or avoid the negative consequences of environmental hazards.

This paper was based on the following research and publications:

Stephen C, Wittrock, Wade J. (2018). Using a Harm Reduction Approach in an Environmental Case Study of Fish and Wildlife Health. EcoHealth, 1-4.

Stephen C. (2016). Wildlife health research 2.0: Bridging the knowledge-to-doing gap. 2017 Journal of Wildlife Disease 53(1): 1-4.

Stephen, C. (2014). Toward a modernized definition of wildlife health. Journal of Wildlife Diseases, 50(3), 427-430.

Back to Table of Contents

Whirling disease in British Columbia

Stephanie Whyte, BSc, **Province of BC Whirling Disease Coordinator,** BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development
Cranbrook, British Columbia
Stephanie.Whyte@gov.bc.ca

In August of 2016, Canada's first case of whirling disease was found in Banff National Park. Since then, the disease has spread to include four watersheds in Alberta (the Bow, Red Deer, Oldman and North Saskatchewan), with the most recent declaration being made in March 2018.

The parasite that causes whirling disease, *Myxobolus cerebralis*, has two life stages and needs two different hosts to survive: a freshwater worm *Tubifex tubifex* (primary host) and a live salmonid (secondary host). The myxospore, found in the substrate, is ingested by the tubifex worm, where it develops into a triactinomyxon (TAM). While other species of invertebrates can ingest the myxospore, TAMs will only develop in the tubifex. TAMs are then released into the water column with the worms' feces until they either come into contact with a salmonid host or are destroyed by their environment. Once a TAM attaches to a fish host, it injects its sporoplasms into the fish where they make their way to the central nervous system and digest the cartilage in the spine and head, damaging the skeletal structure. This results in the physical symptoms of the disease. When the cartilage hardens to bone, it encases the spores which are released from the fish upon death and they cycle of myxobolus cerebralis starts again.

Infection rates can be higher in habitats that support high densities of tubifex; low elevation, slow moving water with muddy substrates with high densities of fish are considered hot spots for the disease. Peak TAM release occur when water is between 9 and 15 degrees; this coincides with the emergence of rainbow and westslope cutthroat.

British Columbia's waters are at risk of whirling disease transmission by anglers, recreationalists and even wildlife – anything that moves water or contaminated debris is considered a vector. All gear and equipment should be properly disinfected and dried and all watercraft should follow clean, drain, dry.

While all salmonids are susceptible to whirling disease, including salmon, trout and whitefish, there are varying degrees of infection between species; some species can even survive as asymptomatic carriers of the disease. Fish are most vulnerable from 2 day old alevin to 12 month old juvenile. Fish older than 12 months have had some time for their cartilage to harden to bone giving the fish some resistance to the disease. For the reason stocked fish are also less susceptible.

Symptoms of the disease include:

- Blacked tail
- Deformed head, shortened mandibles, indentations to the top of the head
- Deformed spine
- Swimming in a whirling pattern
- Possibly a lower growth rate
- Death

The whirling swimming pattern may only be evident in the most severe infections.

These symptoms are not specific to whirling disease and could be caused by various other influences. Diagnosis of the disease can only be made after lab testing.

After four watersheds being declared whirling disease positive in Alberta, both the Government of Alberta and Parks Canada have initiated long term monitoring plans and decontamination protocols.

Back to Table of Contents

Monitoring and evaluating health in the Vancouver Island Marmot (marmot vancouverensis)

Malcolm McAdie, DVM, Marmot Recovery Foundation and MSc. candidate at Thompson Rivers University
Nanaimo, British Columbia
malcolmmcadie@shaw.ca

Background and Current Status

The Vancouver Island marmot (*Marmota vancouverensis*) is a critically endangered species endemic to the insular mountains of central Vancouver Island (Nagorsen, 2005). This medium-sized, fossorial rodent naturally inhabits small, steeply sloped, south to west facing subalpine meadows between 1000 and 1500 metres elevation. Within recent historical times its range has extended from several mountains to the immediate north of Lake Cowichan (Latitude 48.94 N, Longitude 124.16 W) to Mount Schoen (Latitude 50.16 N, Longitude 126.23 W) which lies approximately 200 linear kilometers to the northwest (Bryant & Janz, 1996). Based upon the species' low numbers, limited available natural habitat, and restricted geographical range, it was first listed as endangered in 1978 by the newly formed Committee on the Status of Endangered Wildlife in Canada (COSEWIC 1979).

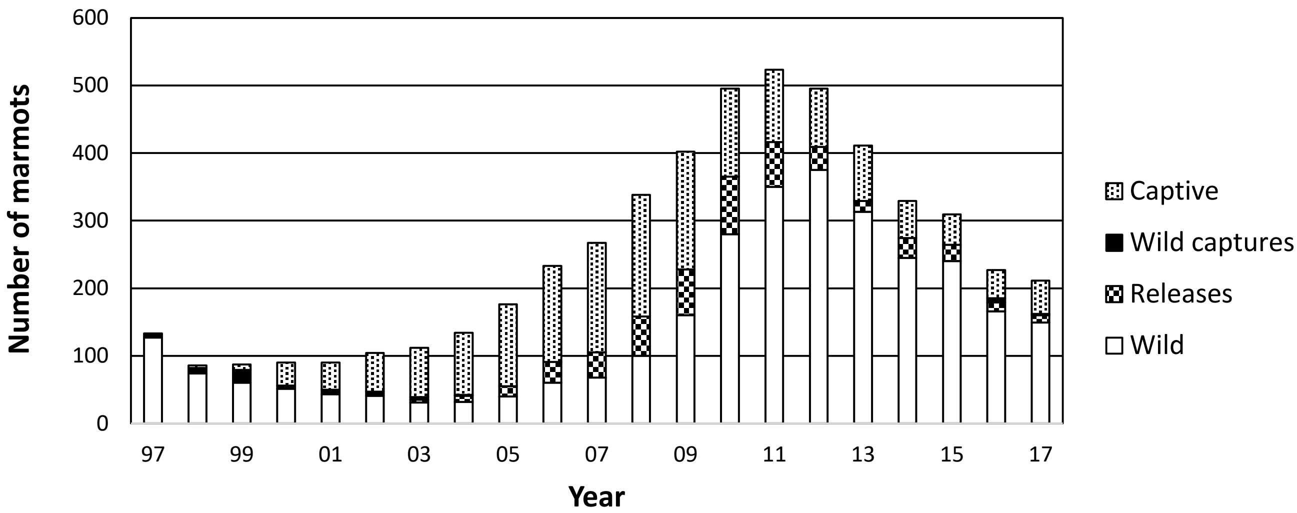
In the mid-1980s, there were an estimated 300 to 350 wild Vancouver Island Marmots (VIM). However, in the late 1980s and throughout the 1990s, marmot numbers demonstrated precipitous and progressive declines. There was a significant redistribution of the population from naturally occurring subalpine meadows to higher tracts of logged habitat. Rapid regeneration of conifers and alders (making the habitat unsuitable), and increased vulnerability to predation by naturally occurring predators (Wolves (*Canis lupus*), Cougars (*Puma concolor*), and Golden Eagles (*Aquila chrysaetos*)) resulted in declines at these artificial, ephemeral sites. Most were also close to natural colonies, which began to demonstrate parallel declines. It is possible that the logged areas disrupted colony connectivity, genetic exchange and "rescue" of natural colonies by intercepting young, dispersing marmots, thus interfering with the natural mechanisms that had historically perpetuated the metapopulation (Janz, et al., 2000). Altered predator-prey relationships on Vancouver Island, including declines in Black-tailed Deer (*Odocoileus hemionus*), may have also led to increased predation pressure that affected marmots in both natural and logged habitats. Limited historical data exists for Strathcona Park and the proximate causes of marmot declines in this protected area have not been well established (Bryant, 1998). There is compelling paleontological and archaeological evidence to suggest that this species was once more widespread on Vancouver Island and that its subsequent range contraction was not entirely related to modern anthropogenic influences (Nagorsen, Keddie, & Luszcz, 1996).

By 1998 marmot numbers had dropped below 100, and by 2003 there were fewer than 30 wild individuals at 4 colony sites. The National Recovery Plan for the Vancouver Island Marmot (2000 Update) stated that *"few animals exist for reintroductions or other management activities"* and that *"It is unlikely that wild populations will suddenly rebound of their own accord. Captive breeding and reintroduction present the only chance of increasing populations within a reasonable period of time and minimizing the risk of extinction"* (Janz, et al., 2000).

These concerns resulted in an intensive captive breeding and reintroduction program. Since its inception in 1997 this program has involved the participation of three Canadian zoological institutions, the Toronto Zoo, the Calgary Zoo and the Mountain View Conservation and Breeding Society (Langley, British Columbia). In 2001, a purpose built, quarantine and breeding facility, the Tony Barrett Mount Washington Marmot Recovery Centre, became operational at Mount Washington on Vancouver Island.

As of December 2017, there have been 660 marmots in the captive program, including 63 wild-born "founders" and 597 marmots that were born and weaned in captivity. A total of 501 marmots have been released to the wild. Releases of captive animals began in 2003, and by 2013 the wild population had grown to over 350 individuals at over 30 colony sites (Vancouver Island Marmot Recovery Team, 2017). As a result of this apparent success, there was a deliberate effort to reduce both the size of the captive population and the number of marmots being released to the wild. The captive population has gone from a high of 177 in 2008 to a current total of 49 individuals (with 14 scheduled for release in 2018). Subsequent to 2013, the wild population has shown evidence of a slow decline and it was estimated to be between 150 to 200 individuals at the end of the 2017 field season (Figure 1). Although recovery efforts have helped to increase the wild population from its low point in 2003, conservation of the VIM still necessitates a concerted program of *ex situ* management, reintroductions, and translocations (Jackson, C, *et al*, 2015).

Figure 1. Overall Vancouver Island Marmot (*Marmota vancouverensis*) population size (1997 to 2017).



Captive Management and Monitoring

Zoological facilities maintain eclectic collections of multiple taxa from a variety of sources, each with their own spectrum of microbial agents (Snyder, et al., 1996). In addition, captive facilities may inadvertently harbor pest species which provide an additional reservoir for introduction of exotic pathogens. The threat of novel infectious diseases in captive VIM cannot be fully quantified because it is not possible to determine the full extent of their susceptibility. Therefore, the marmots are managed to prevent disease exposure rather than dealing with it after the fact. Captive marmots are maintained under conditions of permanent quarantine, which includes strict biosecurity, limited exposure to other species, and no public display. The marmots have also been distributed to multiple facilities to minimize the impact of any catastrophic event or outbreak. Marmots which are moved between facilities or between captivity and the wild are subjected to additional quarantine measures. Captive marmots can be observed regularly, and their health is evaluated on a regular basis. This includes routine annual or biennial examinations, and clinical evaluation and sampling of individuals or the population in response to any potential health concerns. There is a thorough post mortem examination of all captive mortalities following standardized protocols.

Field Monitoring

Wild and captive-release marmots (= free-ranging) are surgically implanted with abdominal radio-transmitters. The pulse rate of these VHF transmitters is temperature responsive (i.e. low temperature = slow pulse), which prolongs battery life during hibernation, and serves as a mortality indicator during the period of marmot euthermia. Implant surgeries are performed at the Mount Washington facility or in the field. The health of captive-release marmots is evaluated prior to surgery, at the time of release following a period of convalescence from surgery, and opportunistically if individuals are subsequently recaptured for implant replacement or translocation. The health of wild marmots is evaluated prior to surgery, and opportunistically if they are subsequently recaptured for implant replacement or translocation. As much as logistically possible, free-ranging marmots are monitored in the challenging, mountainous terrain of Vancouver Island using telemetry and direct observation.

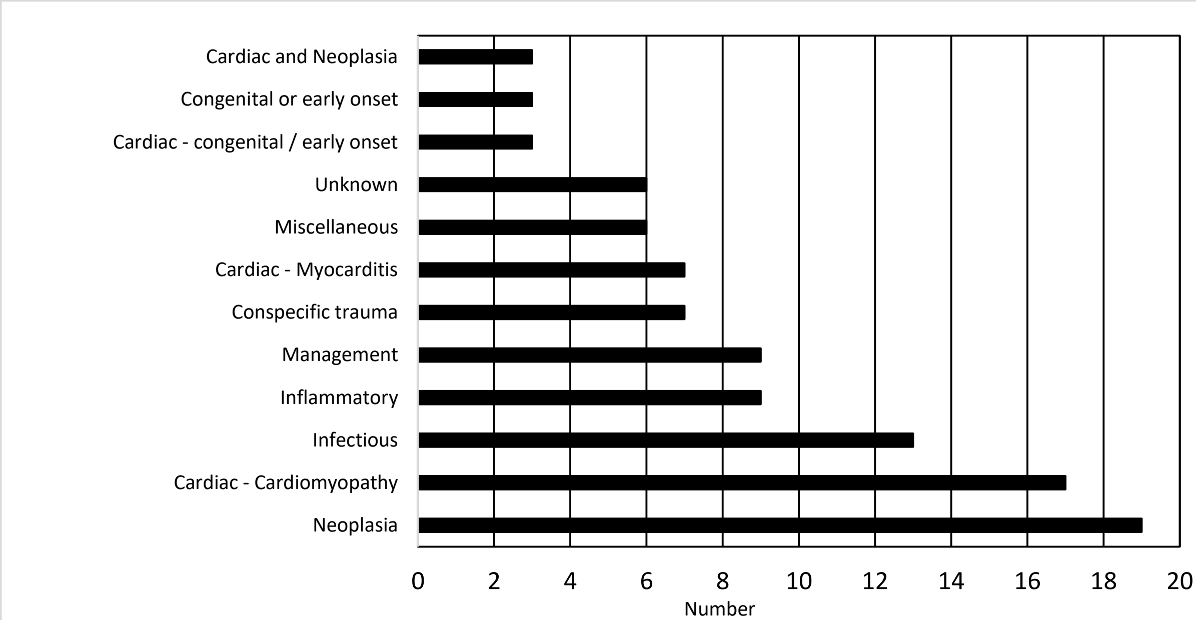
<u>Results</u>

Intensive observation, clinical evaluation, and post mortem examination of captive marmots has resulted in the identification of a number of health conditions which were not observed in any of the free-ranging marmots. Captivity is not entirely benign and artificial conditions have imposed a novel set of risk factors, particularly as management and husbandry practices were in their early stages of development. Nevertheless, captive marmots have increased longevity, allowing for the development of age-related problems such as cardiovascular disease and neoplasia. Several congenital defects, including cataracts, dental malocclusion, cardiac defects, and scoliosis were also identified in the captive population. It is possible that captive support may have prolonged the survival of young marmots suffering from these abnormalities. None of the individuals displaying congenital disorders were allowed to breed in captivity and no congenital problems have been been identified since 2011.

Overall, there was a paucity of health conditions identified in free-ranging marmots (both wild and captive-release) compared to their captive counterparts. In the late 1990s, the marmots at the Mount Washington colony showed pronounced alopecia and dermatitis which was associated with an intra-follicular mite. Suseptibilityto this mite may have been a consequence of inbreeding at this isolated site. In general, the lack of clinical disorders may be due to a fundamental lack of disease, or limited opportunities to observe or examine compromised marmots due to their reclusive behaviors or poor survival.

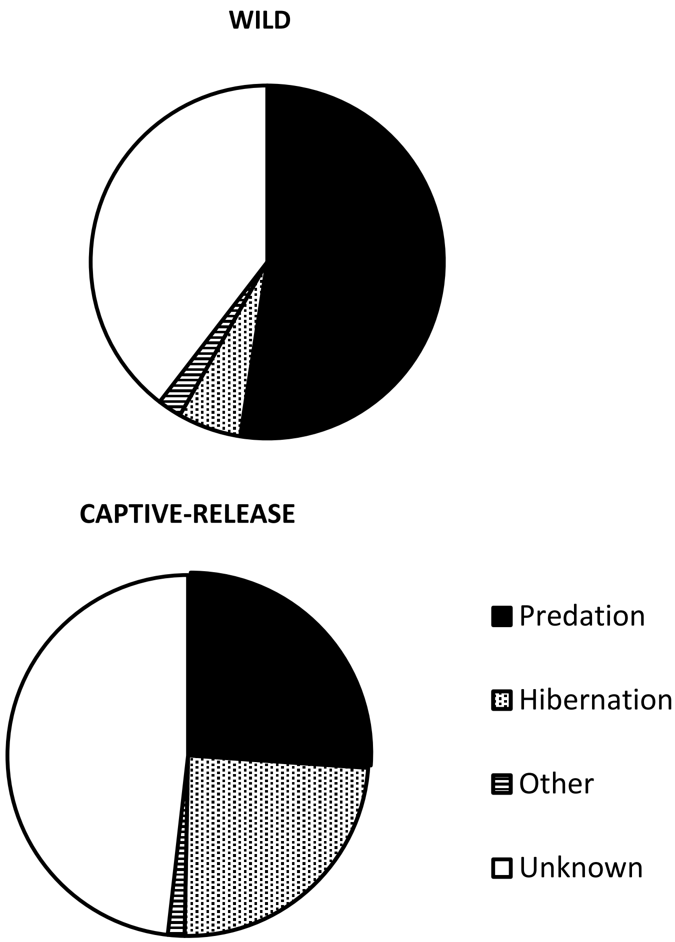
From 1997 to 2017, there were a total of 112 mortalities in the captive program. Pathologists were able to perform post mortem examination on 109 of these mortalities. (Figure 2).

Figure 2. Causes of mortality in captive Vancouver Island Marmots (*Marmota vancouverensis*).



From 1992 to 2017 a total of 928 implant surgeries were performed on 826 free-ranging individuals (329 wild, 497 captive-release) including 100 replacement surgeries. There have been 513 confirmed mortalities. Of these, only 8 of the wild mortalities and 24 of the captive-release mortalities have been recovered in a condition that is suffiently intact to allow for a post mortem examination. As a result, field determination of mortalities has often entailed consideration of other factors including the recent history of the marmot, location of the mortality, the pattern of consumption, and the presense of predator sign (feces, whitewash, feathers, etc.). In many cases, an unconsumed stomach and intestines full of ingesta indicated that the marmot had been actively feeding shortly before its death. Marmots that failed to emerge from their hibernacula (transmitters remained on slow pulse underground) in the spring were considered to be hibernation-related. The carcasses of a few, recently emerged, emaciated marmots were recovered intact. In the absence of other pathological findings, their deaths were also considered to be hibernation-related.

Figure 3. Presumed causes of mortality in wild (n = 167) and captive-release (n = 346) Vancouver Island Marmots (*Marmota vancouverensis*).



For wild and captive-release VIMs, predation represented the most common cause of identified mortality. Predation has been previously implicated as an important factor in the original population declines of the species and as a significant cause of mortality in captive-release marmots (Aaltonen, Bryant, Hostetler, & Oli, 2009; Bryant & Page, 2005). Predation appears to be a limiting factor in marmot population growth and recovery.

During the original population declines that occurred in the 1980s and 1990s, Cougars, Wolves, and Golden Eagles were identified as important predators of VIMs (Janz, et al., 2000). In recent years, Cougars appear to represent the biggest predation threat to free-ranging marmots.

Summary

1. There is a significant difference in our ability to monitor the health of the captive and free-ranging marmot populations. Captive marmots can be routinely observed and examined, and any mortalities can be promptly identified and evaluated. The challenging mountainous terrain of Vancouver Island (particularly in Strathcona Park) makes this much more difficult in free-ranging marmots.
2. Compared to free-ranging marmots, captive individuals appear to demonstrate greater overall longevity.
3. An increased number of clinical disorders have been described in captive marmots, including age-related, management-related, and congenital problems.
4. The first wild hibernation represents a significant time of mortality for marmots released from captivity.
5. Predation remains a major cause of mortality in both captive-release and wild marmots, and Cougars appear to currently represent the biggest predation threat.
6. Even though the wild population has shown encouraging growth from its low point in 2003, it may still be too small to overcome the inhibiting effects of ongoing predation pressure and stochastic events like bad winters or drought.
7. Like the original declining wild population, the current recovery population lacks autonomous sustainability and remains dependent upon captive augmentation to achieve defined recovery goals.

References

Aaltonen, K., Bryant, A. A., Hostetler, J. A., & Oli, M. K. (2009). Reintroducing endangered Vancouver Island marmots: survival and cause-specific mortality rates of captive-born versus wild-born individuals. *Biological Conservation 142*, 2181-2190.

Bryant, A. A. (1998). *Metapopulation ecology of Vancouver Island marmots (Marmota vancouverensis).* Victoria: University of Victoria.

Bryant, A. A., & Janz, D. W. (1996). Distribution and abundance of Vancouver Island marmots (Marmota vancouverenisis). *Canadian Journal of Zoology (74)*, 667-677.

Bryant, A. A., & Page, R. E. (2005). Timing and causes of mortality in the endangered Vancouver Island marmot (Marmota vancouverensis). *Canadian Journal of Zoology (83)*, 674-682.

Jackson, C.; Baker, A.; Doyle, D.; Franke, M.; Jackson, V.; Lloyd, N.; McAdie, M.; Stephens, T.; Traylor-Holzer, K.;. (2015). *Vancouver Island Marmot Population and Habitat Viability Assessment Workshop Final Report.* Apple Valley, MN: IUCN SSC Conservation Breeding Specialist Group.

Janz, D. W., Bryant, A. A., Dawe, N. K., Schwantje, H., Harper, B., Nagorsen, D., . . . Simmons, R. (2000). *National Recovery Plan for the Vancouver Island Marmot (Marmota vancouverensis) 2000 Update: RENEW Report No.19.* Ottawa, Ontario: Environment Canada.

Janz, D., Blumensaat, C., Dawe, N. K., Harper, B., Leigh-Spencer, S., Munro, W., & Nagorsen, D. (1994). *National Recovery Plan for the Vancouver Island Marmot. Report No. 10.* Ottawa, Ontario: Recovery of Nationally Endangered Wildlife Committee.

Nagorsen, D. W. (2005). *Rodents & Lagomorphs of British Columbia.* Victoria: Royal British Columbia Museum.

Nagorsen, D. W., Keddie, G., & Luszcz, T. (1996). *Vancouver Island Marmot Bones from Subalpine Caves: Archaeological and Biological Significance, Occasional Paper No. 4.* Victoria, British Columbia: Ministry of Environment, Lands and Parks.

Snyder, N. F., Derrickson, S. R., Bessinger, S. R., Wiley, J. W., Smith, T. B., Toone, W. D., & Miller, B. (1996). Limitations of Captive Breeding in Endangered Species Recovery. *Conservation Biology 10 (2)*, 338-348.

Back to Table of Contents

Advances in the treatment and management of psoroptes ovis in bighorn sheep: A highly collaborative approach to wildlife health

Adam Hering[1] , Andrew Walker[2], Helen Schwantje[2], Tasha Epp[1], Craig McLean[2], Aaron Reid[2], Sean O'Donovan[2], James Pepper[3], Cailyn Glasser[4], Murray Woodbury[1],

- [1]Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, SK.
- [2] British Columbia's Ministry of Forests, Lands, Natural Resource Operations, and Rural Development (FLNRORD), Penticton and Victoria, BC.
- [3] Department of Natural Resources, Penticton Indian Band, BC
- [4] Natural Resources Department, Okanagan Nation Alliance, Westbank, BC

Objective: Bighorn sheep (*Ovis canadensis)* populations in North America have shown significant declines after outbreaks of *psoroptes ovis*; a highly pruritic skin mite. This study aimed to identify a treatment for psoroptes that is effective and appropriate for use in free ranging bighorn sheep.

Design: A randomized, controlled, treatment trial was performed to test the efficacy of new treatment approaches for *Psoroptes ovis* in bighorn sheep.

Animals: Eighteen (18) naturally infected bighorn sheep were captured and housed in two purpose-built 5-acre enclosures.

Procedures: Two different anti-parasitic drugs (eprinomectin and fluralaner) were tested *in vivo* using injectable, oral, and topical routes of administration. Animals were monitored daily and sampled monthly to assess disease resolution through evaluation of clinical signs, microscopic skin crust analysis, and antibody titer testing.

Results: Eprinomectin and the topical form of fluralaner were ineffective at the dosages used. The oral formulation of fluralaner showed encouraging results at both tested dosages. All orally treated individuals were free of live mites one month after treatment, showed improvement in subjective clinical signs, and one individual was free of live mites for the entire three-month follow-up period, despite cohabitation with infected individuals.

Conclusions and Clinical Relevance: Orally administered fluralaner may be an effective treatment option for psoroptes in bighorn sheep however further studies should be performed to determine appropriate dosing and duration of protection. Due to a lack of host immunity, the simultaneous treatment of entire herds is essential for disease eradication. These findings could lead to new management options for the treatment of psoroptic mange in free ranging bighorn sheep through the use of medicated feeds, thus

enabling a cost-effective, low-stress option for the management of this disease in affected free-ranging bighorn sheep herds.

Back to Table of Contents

The impacts of human footprint on caribou populations may depend on migratory behaviour

Presenter: Jessica Theoret[1]
Co-authors: Maria Cavedon[2], Bridgett vonHoldt[3], Troy Hegel[4], Robin Steenweg[5], Helen Schwantje[6], Jan Adamczewski[7], and Marco Musiani[8]

[1]*Faculty of Environmental Design, University of Calgary, Calgary, Alberta*
Email: jltheore@ucalgary.ca
Phone Number: 403-554-3327
Postal Address: Biology, Univ. of Calgary, Lab 332, 2500 University Dr NW, Calgary, Alberta, T2N 1N4
Website: https://www.linkedin.com/in/jessicatheoret/
[2]*University of Calgary, maria.cavedon@ucalgary.ca*
[3]*Princeton University, vonholdt@princeton.edu*
[4]*Government of Yukon, troy.hegel@gov.yk.ca*
[5]*Government of Alberta, robin.steenweg@gov.ab.ca*
[6]*Government of British Columbia, helen.schwantje@gov.bc.ca*
[7]*Government of Northwest Territories, jan_adamczewski@gov.nt.ca*
[8]*University of Calgary, mmusiani@ucalgary.ca*

Landscape alterations, such as forest removal associated with seismic exploration or timber harvesting, can impact the dynamics of wildlife populations. Such impacts have been expressed in caribou (*Rangifer tarandus*) populations throughout Canada, where some populations are declining, and others have gone extinct (e.g. Dawson's, Haida Gwaii, and Banff [COSEWIC 2011, Festa-Bianchet et al. 2011, Hebblewhite 2017]). Habitat loss also may affect a species' ability to adapt to additional threats such as climate change and disease. However, differences in genetic and behavioural traits within the species may result in some individuals being more resilient than others. Therefore, recognizing variability in caribou genetics and behaviour could be integral to protecting intraspecies diversity and preserving population health.

In Canada, caribou have evolved from two distinct lineages: the primarily migratory barren-ground subspecies specialized for the tundra environment, and the primarily sedentary woodland caribou subspecies typical of boreal forest and mountainous environments. Crossbreeding between these two lineages following the last glacial period (approximately 14,000 years ago) is thought to have resulted in a Rocky Mountains hybrid swarm; genetically and behaviourally unique caribou that inhabit the Rocky Mountains and boreal forests today (McDevitt et al. 2009).

Preserving intraspecies biodiversity, a fundamental conservation goal, strengthens species adaptability. Current research focuses on concordance of ecological traits with genetic traits potentially of adaptive value. Migration, a varying trait among caribou populations (i.e. migratory, sedentary or partially migratory), may be genetically determined. My research therefore aimed to first classify migration in individuals according to their movement behaviour.

Telemetry data was collected from 125 primarily female radio collared individuals (Figure 1). Of the individuals, 59 were from 3 herds classified as barren-ground subspecies, and 66 were from 10 herds classified as woodland caribou. Due to variability in the capture frequency of the telemetry data, the data were normalized to at least one location every 7 days, and at most one location per day. Data were also required to be broken down into 'bursts' (i.e. sample years); that is, roughly equal amounts of time (in this case, 10 months to a full year) that would represent the animals full home range and capture a migration event if one were to occur. It was essential for each 'burst' to begin on or near a set start date. The start date was selected as April 15th as migratory caribou are thought to still be within their winter ranges during this time (Smith et al. 2000). There were 119 and 103 barren-ground and northern mountain caribou 'bursts' respectively, for a total of 222 trajectory 'bursts.'

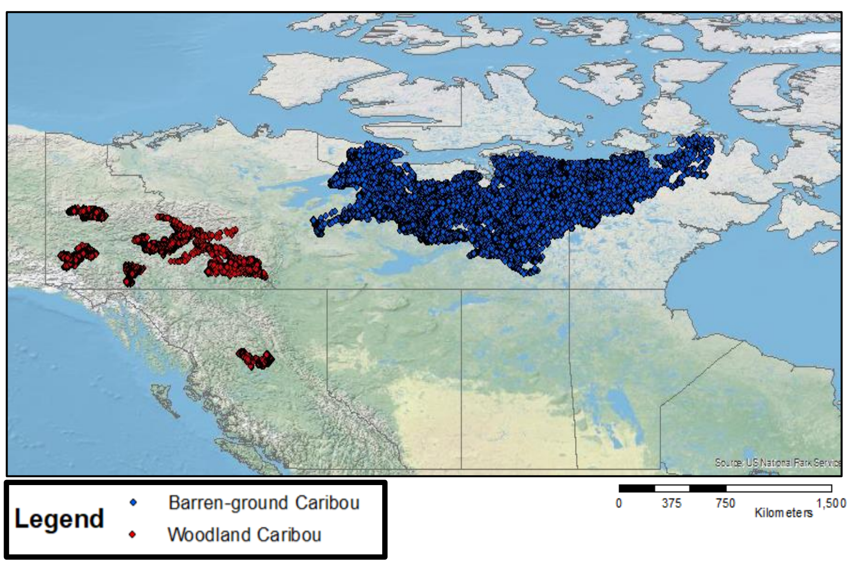


Figure 1. Telemetry points of 59 barren-ground caribou individuals (blue circles) and 66 woodland caribou individuals (red circles) projected on a partial map of Canada.

The telemetry data were analysed utilizing the ‘migrateR’ package developed for the open source statistical software R (Spitz et al. 2017). This package expands upon model-driven methods for classification of animal movement spearheaded by Bunnfeld et al. (2011), whom applied the statistical measurement of net squared displacement (NSD) to trajectory data for the purpose of identifying and distinguishing between migratory movement patterns. NSD is a measure of the linear distance between a starting location and each subsequent location in a given trajectory. Once the NSD for an individual’s movement path is obtained, it is graphed, and models representing different movement behaviours are fit to the NSD pattern (Figures 2 and 3). The ‘migrateR’ package attempts to fit 5 different movement models to the NSD plot, and evaluates their fit using Akaike information criterion (AIC). These models include: a resident (or sedentary) model, describing a telemetry that maintains a relatively stable annual range; a migrant model, indicated by a telemetry path moving away from and returning to the same location; a mixed migratory model, fitting a telemetry path that moves away, but returns to the same geographical area; a nomadic model adhering to a telemetry path that displays ‘random walk’ behaviour; and a dispersal model, characteristic of movement from an initial range to a new area. Trajectories classified as mixed migratory were considered migratory for simplicity, resulting in a total of 4 possible movement models in this analysis.

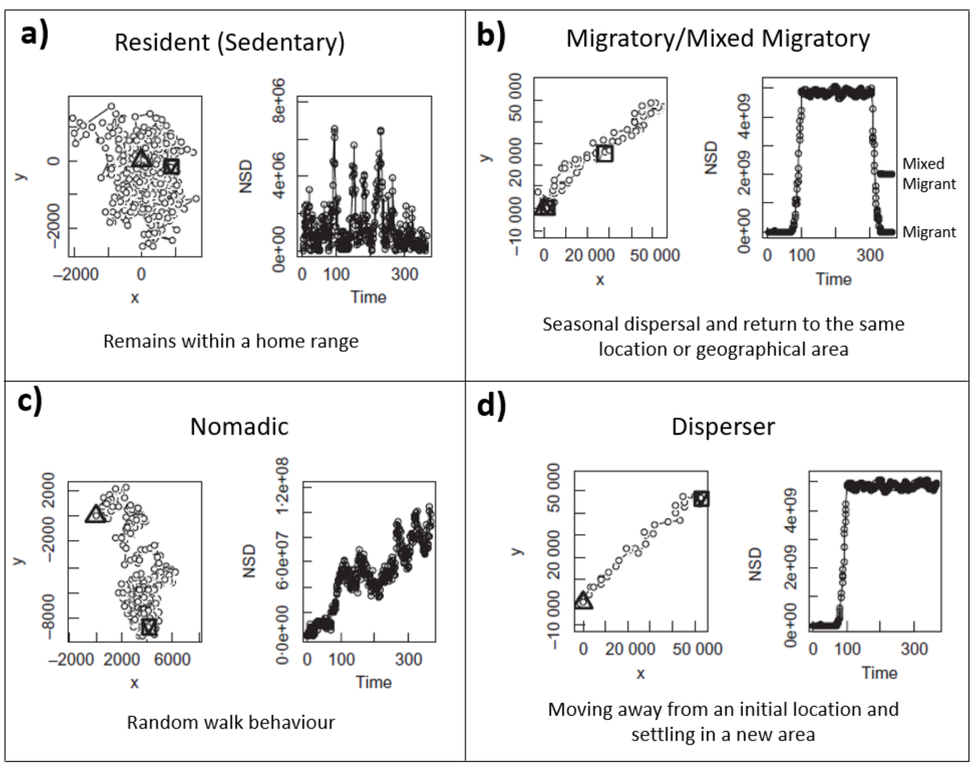


Figure 2. Examples of trajectory data mapped by coordinates (left of each quadrant) and associated net squared displacement (NSD) patterns (right of each quadrant) for a) an individual with resident or sedentary behaviour, b) an individual with migratory or mixed

migratory behaviour, c) an individual with nomadic behaviour and d) an individual with disperser behaviour (adapted from Bunnfeld et al. 2011).

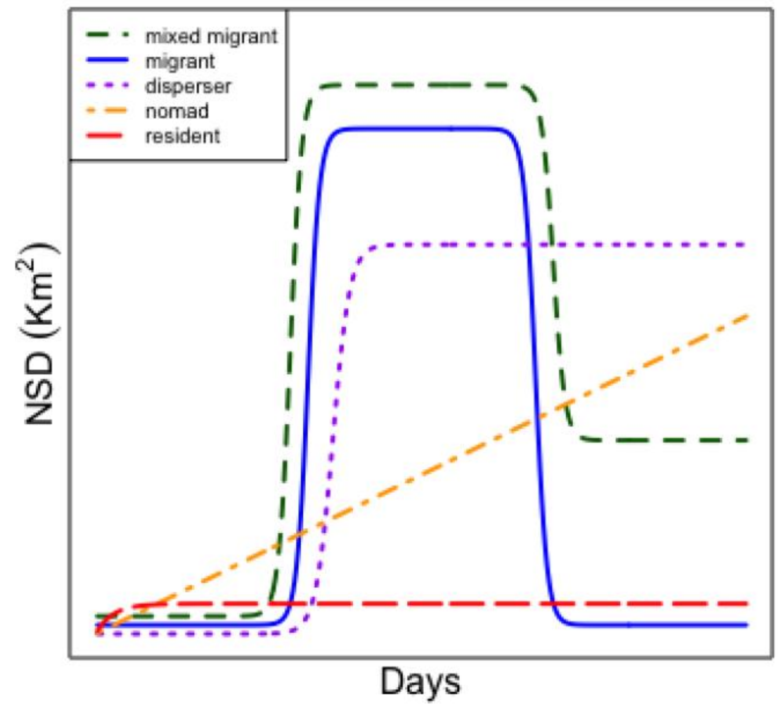


Figure 3. Theoretical examples of movement models fit to net squared displacement (NSD) patterns (taken from Spitz 2018).

There was evidence of all 4 movement behaviours in both the barren-ground and northern mountain subpopulations, with each subpopulation having at least one individual classified as each model type. Most notably, the majority of individuals were classified as migratory in both the barren-ground and northern mountain subpopulations (Table 1). Examples of NSD outputs fit with models can be seen in Figure 4. These results are preliminary, and adjustments may be required in the models or input data in order to improve model fit. Examples of adjustments that may improve model fit include: 1) adjusting the start date to ensure it is not after a migration event, 2) thinning out the input data by decreasing the frequency of the trajectory data, and 3) adjusting parameters in the model, such as defining a minimum occupancy time (e.g. 21 days) spent in a separate seasonal range for the behaviour to be considered migratory. Additionally, it is important to note that migration may be altitudinal as opposed to latitudinal. Populations of the northern mountain ecotype, for example, may migrate up mountains to avoid predation in summer, and down into valleys in search of resources during winter. Elevational migration will be evaluated with similar NSD methods as this research progresses.

Table 1. Percentage of trajectory 'bursts' best classified as migrant, resident, nomadic or disperser net squared displacement (NSD) models within the barren-ground and northern mountain caribou subpopulations.

	Best Model*			
Subpopulation	Resident (%)	Migrant (%)	Nomadic (%)	Disperser (%)
Barren-ground (n = 119)	3.4	81.5	5.9	9.2
Northern Mountain (n = 103)	2.9	83.5	5.8	7.8

*Best model fit was determined using Akaike information criteria (AIC).
Abbreviations: "n" is the total number of trajectory 'bursts' that were fit with NSD models; "%" is the percentage of trajectory 'bursts' fit with NSD models.

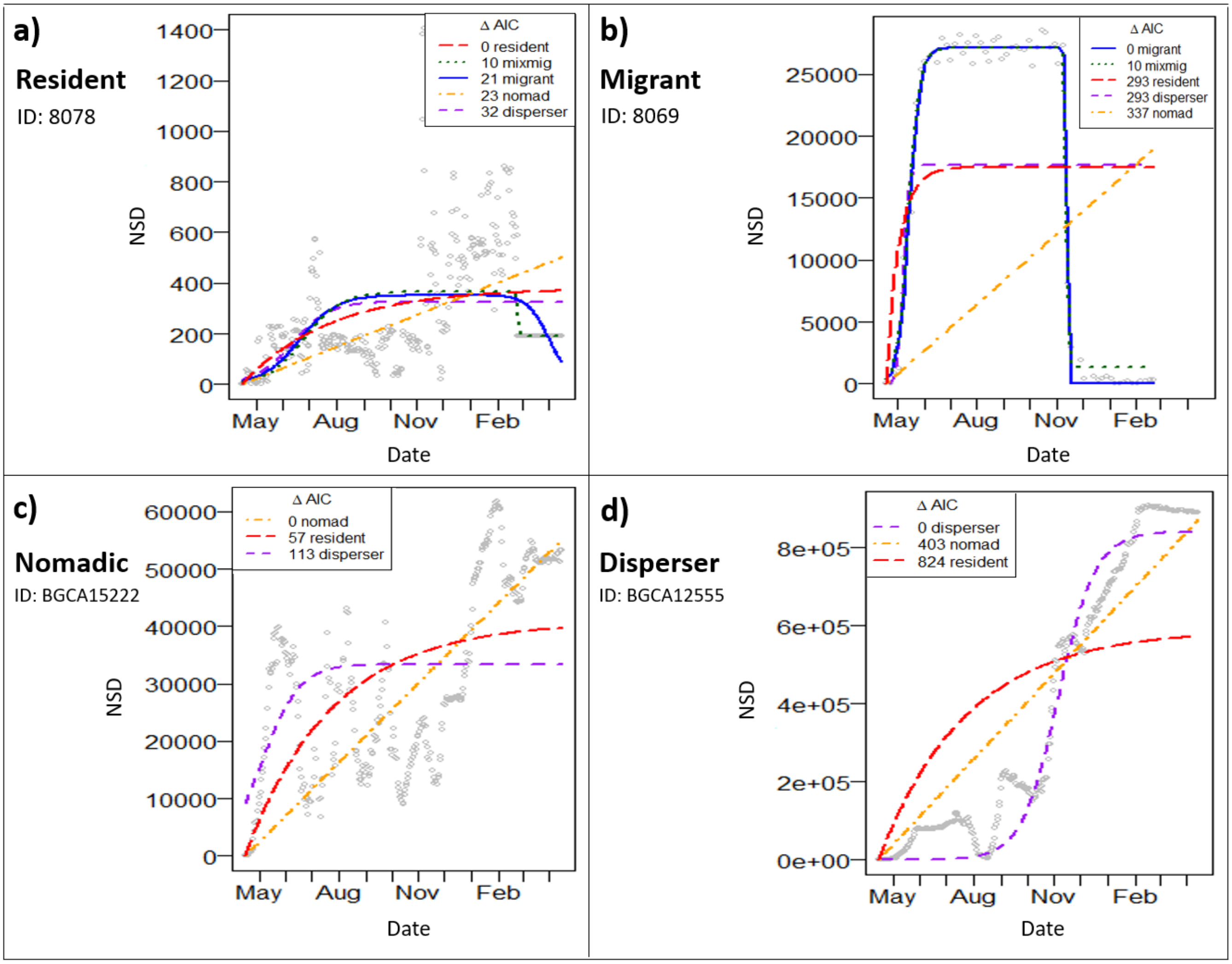


Figure 4. Example outputs of net squared displacements (NSD) for an individuals (ID) movement path where the top model fit was a) an individual with resident behaviour, b) an individual with migratory behaviour, c) an individual with nomadic behaviour and d) an individual with disperser behaviour, evaluated using Akaike information criteria (AIC).

Variability in movement behaviour within subspecies is significant, as each behaviour contributes to population health. Migration, for example, is essential for barren-ground caribou predator avoidance, and counteracts scarce resource availability in the tundra during the winter season. Resident or sedentary behaviour, on the other hand, relies on landscapes with relatively low spatial and temporal variation. Nomadic behaviour is notable, as this indicates that such an individual is flexible in terms of resources such as food, while dispersal can contribute to gene flow between herds. When faced with increasing human footprint and habitat fragmentation, nomadic and dispersal behaviours suggest plasticity in terms of resources and movement. However, when confronted with the same challenges, migratory and sedentary individuals may be less resilient; recent research suggests that migratory behaviours are at risk due to movement restriction (Tucker et al. 2018), and sedentary caribou are increasingly at risk of isolation (Gubili et al. 2017).

The results of this preliminary research challenge the traditional distinctions between barren-ground and woodland caribou primarily based on migratory behaviour, as the barren-ground subpopulation appeared not consistently or strictly migratory, while woodland (northern mountain) caribou were not primarily sedentary. Not only does this suggest that traditional methods of distinction be reconsidered, but also raises the possibility that diversity within subpopulations is underestimated, which could be contributing to intraspecies diversity loss and therefore decreased species adaptability.

References

Bunnfeld, N., L. Börger, B. van Moorter, C. Rolandsen, H. Dettki, E. J. Solberg and G. Ericsson. 2011. A model-driven approach to quantify migration patterns: individual, regional and yearly differences. *Journal of Animal Ecology*, 80, 466–476.

COSEWIC. 2011. Designatable Units for Caribou (Rangifer tarandus) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 88 pp.

Festa-Bianchet, M., J. Ray, S. Boutin, S. Côté, and A. Gunn. 2011. Conservation of caribou (Rangifer tarandus) in Canada: an uncertain future. *Canadian Journal of Zoology*, 89(5), 419-434.

Gubili, C., S. Mariani, B. Weckworth, P. Galpern, A. McDEvitt, M. Hebblewhite, B. Nickel and M. Musiani. 2017. Environmental and anthropogenic drivers of connectivity patterns: A basis for prioritizing conservation efforts for threatened populations. *Evolutionary Applications*, 10, 199–211

Hebblewhite, M. 2017. Billion dollar boreal woodland caribou and the biodiversity impacts of the global oil and gas industry. *Biological Conservation*, 20, 102-111.

McDevitt, A., S. Mariani, M. Hebblewhite, N. DeCesare, L. Margantini, D. Seip, B. Weckworth and M. Musiani. 2009. Survival in the Rockies of an endangered hybrid swarm from diverged caribou (Rangifer tarandus) lineages. *Molecular Ecology*, 18, 665–679

Smith, K., E. Ficht, D. Hobson, T. Sorensen, and D. Hervieux. 2000. Winter distribution of woodland caribou in relation to clear-cut logging in west-central Alberta. *Canadian Journal of Zoology*, 78, 1433–1440.

Spitz, D. 2018. Analysis of Animal Migration in R: the migrateR Package. MigrateR: Animal Movement Classification. R package version 1.0.6.

Spitz, D., M. Hebblewhite, and T. Stephenson. 2017. 'MigrateR': extending model-driven methods for classifying and quantifying animal movement behavior. *Ecography*, 40, 1–12.

Tucker, M., K. Böhning-Gaese, W. Fagan, J. Fryxell, B. Van Moorter, S. Alberts, … T. Mueller. Moving in the Anthropocene: Global reductions in terrestrial mammalian movements. *Science*, 359, 466-469.

Back to Table of Contents

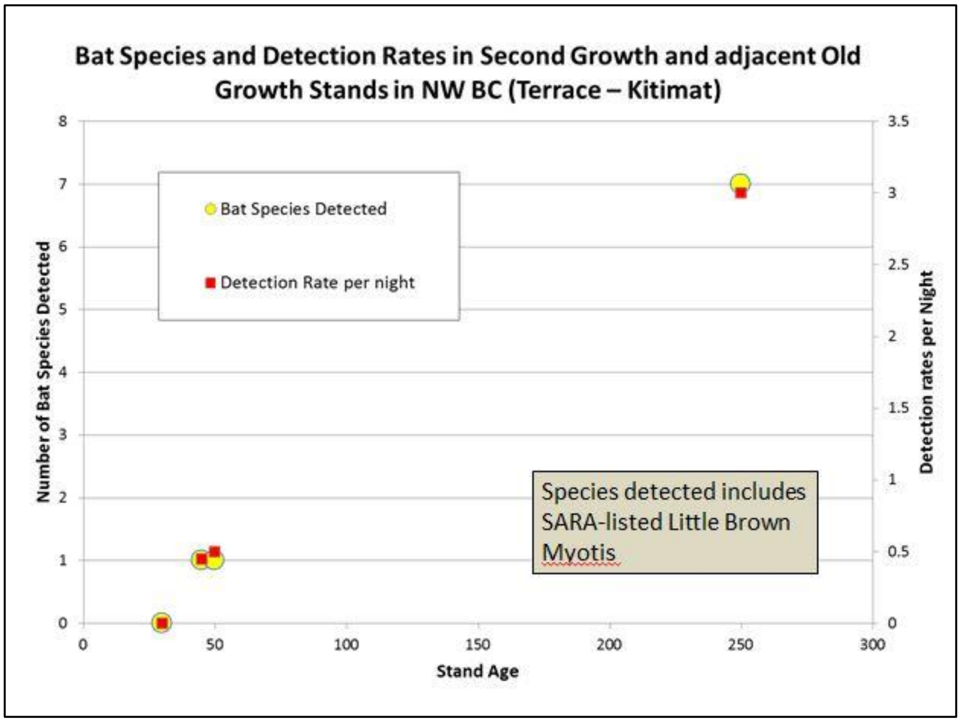
Building resilience of our bats to the impacts of white-nose syndrome

Frank I Doyle, Wildlife Dynamics Consulting. wildlifedynamics@gmail.com
Amanita Coosemans, Balanced Ecological Consulting balancedecological@gmail.com

This presentation highlighted the multiple threats to bats (white nose syndrome, habitat loss, climate change) in the context of the overall threats to many focal bird and mammal species within the "working" (harvested) forests of British Columbia. It then outlined a range of silviculture stewardship mitigation strategies that can be applied to help support overall ecosystem resilience to these cumulative threats, and how these strategies are now being adopted within second-growth forests in northwestern BC (Community Forests, First Nations and Licensees).

In northern BC, second growth forest stands (~40-50 years old) have significantly lower bat detection rates and lower species diversity than in adjacent and comparable old-growth sites (Figure 1; Doyle *et al*. 2015). This observation is not surprising given the lack of older forest attributes in second-growth stands—in particular, tree cavities that are a key requirement for many species of birds and mammals in British Columbia (Bunnell 2013). Eight of BC's northern bat species require such cavities, of which two (little brown myotis & northern long-eared myotis) are now listed as Endangered as a result of the threat from white-nose syndrome (SARA 2018).

Figure 1. Bat species and detection rates in second growth and adjacent old growth forest in 2015.



In the context of the accumulating threats to bats, but also in the context of the loss of old growth attributes required to sustain other focal species, a range of strategies (Table 1) are now being tested and applied within the working forest, in landscapes where the second-growth forest is now old enough to be commercially harvested (Doyle *et al*. 2015). Specific to the lack of maternity roosting sites for bats in second growth forests, and the imminent threat to bats from white-nose syndrome (BC Community Bat Program; Riis 2018), maternity bat boxes are being deployed to provide for the opportunity to support a heathy and resilient bat population across the landscape. In addition to these strategies, larger areas of second growth forest can be managed for these and other older forest attributes, through snag & coarse woody debris "feature" creation, small gaps-openings to allow for herb and shrub growth, commercial thinning and/or deferred harvest (Doyle 2006).

Table 1. List of focal old growth attributes, recruitment strategies, and associated focal species/groups being applied within second growth forests.

Attribute	**Strategy**	**Target Wildlife Species/Group**	**Reference(s)**
Cavities - nesting	Tree Girdling (for snag creation) (larger trees >30cm dbh)	Primary and Secondary cavity nesting birds and mammals	Harris 2001, Walter and Maguire 2015
Cavities - bats	Maternity Bat Boxes	Little brown myotis, Northern (long-eared) myotis	BC Community Bat Program; Riis 2018; SARA 2018
Denning Sites - mammals	Coarse Woody Debris (CWD) Piles	American marten and other furbearers.	USDA 2011
Decaying Coase Woody Debris	CWD creation: thinning (immediate source of CWD), & girdling (CWD recruitment).	Small mammals and furbearers, Invertebrates - biodiversity.	Sullivan [n.d.]
Openings - shrubs and herbaceous plants	Small patch harvest to provide light that supports seed and berry production.	Small mammals, invertebrates - biodiversity	Coates and Burton 1997

This presentation highlighted stewardship opportunities that may be readily incorporated to partly mitigate our impacts on the natural landscape.

References

BC Community Bat Program. *www.bcbats.ca*

Bunnell, F. L. 2013. Sustaining Cavity-Using Species: Patterns of Cavity Use and Implications to Forest Management. Hindawi Publishing Corporation. Volume 2013, Article ID 457698, 33 pp., http://dx.doi.org/10.1155/2013/457698

Coates, K.D., and P.J. Burton 1997. A gap-based approach for development of silvicultural systems to address ecosystem management objectives. Forest Ecology and Management. 99:337-354.

Doyle, F.I. 2006. When do naturally regenerating and pre-commercially thinned second-growth forests attain attributes that will support Northern Goshawk (*laingi* subspecies) and Marbled Murrelets on Haida Gwaii? Prepared For: Cascadia Forest Products Ltd. Gwaii Haanas National Park Reserve and Haida Heritage Site. Pp 1-32. (Obtainable on request: wildlifedynamics@gmail.com)

Doyle, F. I., R. S. Saimoto and A. Coosemans 2015. Forceman Ridge Waste Management Facility - An Environmental Mitigation Plan for impacted Wildlife Habitat, Huckleberry/ Blueberry Harvest, and Trap line Territories: Enhancement of Wildlife Habitat Diversity in second growth forests as mitigation for lost habitat associated with the clearing of old growth forest. Unpublished report prepared for the Regional District of Kitimat-Stikine. Pp 1-56. (Obtainable on request: wildlifedynamics@gmail.com)

Harris, B. 2001. Observations on the use of stubs by wild birds: A 10-year update. BC Journal of Ecosystems Management. 1 (1): pp.19-23.

Riis, D. 2018. https://www.cedarbatboxes.com/

Species at Risk Public Registry: Bats and White-nose Syndrome in Canada. https://www.registrelep-sararegistry.gc.ca/default.asp?lang=En&n=073dc653-1 (Accessed 10th May 2018)

Sullivan, T. P. [no date]. Woody debris, wildlife habitat & biodiversity. FIA (Accessed 12th Dec 2014) www.appliedmammal.com/content/brochures/WoodyDebrisBrochure.pdf

United States Department of Agriculture 2011. Natural Resources Conservation Service. Environmental Quality Incentives Program, http://smallforestowner.blogspot.ca/2013/08/wildlife-slash-pile-construction-for-nrcseqip.html (Web: Accessed 9th February 2015)

Walter, S. T. and C. C. Maguire 2005. Snags, Cavity-Nesting Birds, and Silvicultural Treatments in Western Oregon. The Journal of Wildlife Management, Vol. 69, No. 4 (Oct., 2005), pp. 1578-1591.

Back to Table of Contents

White-nose syndrome survivorship modelling and probiotic management strategies to conserve bats in British Columbia

Cori L. Lausen, Wildlife Conservation Society Canada; clausen@wcs.org; P.O. Box 606, 202 B Ave; Kaslo, BC V0G 1M0;
Sarah H. Olson, Wildlife Health Program, Wildlife Conservation Society, 212 South Wallace Avenue, Suite 101, Bozeman, MT, 59715 USA
C. Reed Hranac, Molecular Epidemiology and Public Health Laboratory, Hopkirk Research Institute, Massey University, Private Bag, 11 222, Palmerston North 4442, New Zealand
Naowarat Cheeptham, Department of Biological Sciences, Faculty of Science, Thompson Rivers University, Kamloops, BC

Abstract

Since its discovery in eastern North America in 2007, white-nose syndrome (WNS) has been rapidly spreading westward across the continent, leaving hibernating bat populations decimated in its wake. Thus far, few effective management strategies have been implemented and most are designed to reduce the rate of disease spread. In 2013, we began a collaborative project designed to create a mechanistic model of species-specific survivorship for western bat populations facing the imminent expansion of WNS. As species susceptibility to WNS-related mortality depends on host physiology, the pathogen, and the hibernaculum environment, this survivorship model will help identify species of management concern by indicating which western species are most susceptible. This research will then be combined with species distribution models using data from monitoring projects like NABat to inform WNS management strategies in response to a range of climate change scenarios. From here, we aim to supplement the current management strategies with the development of a probiotic cocktail of natural bat wing bacteria that inhibit the growth of the fungus that causes WNS, *Pseudogymnoascus destructans* (Pd), and thereby reduce rates of WNS-related mortality. So far, we have isolated several bacteria that offer suitable anti-Pd properties and are preparing to test dispersal methods that will alter the bat wing microbiomes to include a higher proportion of these protective microbes. The next step is to test exposing bats to the probiotic cocktail as they enter or leave their maternity roosts. When deployed in the fall, before bats travel to hibernacula, this probiotic cocktail is intended to inhibit the growth of Pd on these bats over the winter hibernation period. Using information from the survivorship modelling to identify the most vulnerable species and hibernacula types, our research will offer powerful tools to enhance the survival of bats facing WNS.

Introduction

White-nose syndrome (WNS), an invasive fungal disease of bats has caused unprecedented mortality (>90% for some species) in hibernating bat populations in eastern North America. The pathogen, *Pseudogymnoascus destructans* (Pd), has spread from a single site in New York in 2006 to 36 states and seven Canadian provinces and continues to spread (USFWS 2018a). WNS was discovered in the Pacific Northwest in spring 2016 (Washington Fish and Wildlife Service 2017), announcing the entry of this devastating disease into the species-rich bat communities of western North America. The susceptibility of western bats to WNS is largely unknown, in part because many bat species in the west are not found in eastern North America. Additionally, to date, most proposed chemical or biological 'treatments' for WNS involve spraying bats or substrates with some anti-fungal agent within WNS-affected hibernacula (Cheng et al. 2016) and have not yet proven to be effective tools to treat WNS (USFWS 2018b). The winter ecology of most bat species in the Pacific Northwest of North America remains poorly or completely unknown; they hibernate in scattered locations over expansive areas, most of which have not been identified. This challenges the prospects and opportunities for treatments of infected bats at hibernacula (Tobin et al. 2017), but positions a prophylaxis approach at summer roosts as a promising alternative. Opportunities remain for such proactive interventions that may mitigate impacts when WNS arrives; however, effective application will require understanding the range and vulnerabilities of bat populations.

WNS Survivorship Modelling Project: A mechanistic energetic model was developed by Haymen et al. (2016) using rates of energy consumption, *Pd* growth and hibernation conditions over the length of winter to predict differences observed in WNS mortality. These models rely on parameters from well-studied bat populations living at relatively low latitudes in eastern North America. Little is known about the ecology and physiology of bats hibernating in northwestern latitudes. Our goal is to fill these critical knowledge gaps to parameterize a WNS survivorship model and develop population-specific predictions of the impact of WNS on northwestern bat populations. Understanding the potential of bats of different species and hibernation strategies to persist, recover, and re-populate WNS-affected areas after *Pd*-invasion is a critical, as there is preliminary evidence that some bats survive the winter with WNS.

We are testing the hypothesis that not all northwestern bat species will be equally susceptible to WNS mortality during hibernation. Based on measurements that we have made of key parameters related to hibernation physiology and behavior of three species of British Columbia bat species, we have begun to model population-specific WNS-survivorship for Californian myotis (*Myotis californicus*), Yuma myotis (*M. yumansensis*) and silver-haired bat (*Lasionycteris noctivagans*) to inform conservation actions. All three species are found free-flying on the landscape well into autumn months, before they enter into hibernacula for winter (C. Lausen, unpublished data).

Hibernacula for Yuma myotis are not known, but Californian myotis and silver-haired bat are found hibernating throughout many southern B.C. and coastal locations and are easily captured free-flying during winter months when bats naturally arouse. We targeted bats for bioenergetics measurements in both autumn and winter, comparing metabolic rates of both Californian myotis and silver-haired bats in autumn versus winter to determine if significant seasonal differences are detectable.

Probiotic Management to Reduce WNS Severity Project: There has been progress in development of chemical and biological treatments for WNS that could be applied to bats during winter. However, such treatments could be counter-productive, especially if some proportion of bats survives the winter without treatment. If some bats survive and possess physiological traits that favor survival, then the most urgent priorities for management should be actions that support reproduction by these survivors. By understanding survival potential of bats, management priorities can be established and limited resources appropriately allocated.

Maternity roosts represent a promising yet unstudied WNS treatment target for many western bat species. Whereas relatively few hibernacula are known, we know the locations of numerous maternity roosts across the west, particularly for species using anthropogenic structures such as Yuma (western species) and little brown myotis (*M. lucifugus*, continent-wide species). An alternative prevention strategy is needed that could target maternity colonies in the west for which many locations are known, especially for building-roosting bats (e.g., www.batwatch.ca Canadian database; BC Community Bat database). At minimum, the intervention would need to protect bats into the hibernation period and slow infection by Pd enough to reduce mortality risk during winter. There is mounting evidence that naturally-occurring microbes on bats' wings may confer levels of resistance to WNS by inhibiting the growth/reproduction of Pd (Hoyt et al., 2015; Cheng et al., 2016; Lorch et al., 2016; Buecher et al., 2017; Ghosh et al., 2017). There is also precedence in other animals that altering skin microbial interactions through introduction of antifungal bacteria can prevent morbidity from lethal diseases (e.g., treatment of chytrid in frogs; Harris et al., 2009). A probiotic-type of WNS treatment has a serious chance of providing a long-lasting solution for managing the disease, unlike many proposed chemical treatments to date that require ongoing treatment (Cornelison et al., 2014), and thus should be tested as soon as possible.

Without treatment/prevention, WNS is poised to devastate bat populations of many bat species in western Canada. B.C. has the highest species richness in Canada, with 14 species that hibernate, making them all potentially susceptible to die-back from this disease. Two species hit hardest by WNS in eastern Canada are also found in B.C. -- northern myotis (*M. septentrionalis*) and little brown myotis. Both species are SARA-listed as endangered (Government of Canada 2014a,b); the latter will be included in this probiotic treatment project along with Yuma myotis, a species that typically shares summer roosts with little brown myotis.

Methods and Materials

WNS Survivorship Modelling Project

Using HOBO microclimate dataloggers, we recorded hibernacula conditions where the silver-haired and Californian myotis bats could be located during winter. Our study areas consisted of one mine site and several tree and rock crevice roosts in the Beasley area of West Kootenay. We captured free-flying bats using mistnets at mine entrances (3) and at building roosts (2). We used morphometric measurements, and used flow-through respirometry and temperature-sensitive radiotelemetry to measure pre-hibernation mass, metabolic rates, and arousal rates. Logged pulse rates of the temperature-sensitive transmitters quantified torpor and arousal patterns during the coldest winter months, January - February.

We measured respirometry to determine torpid metabolic rates at 0, 2, 4, 6, 8, 10^{o}C for three test species: Yuma myotis, Californian myotis, and silver-haired bat. Respirometry was conducted in the months of Sept and Oct. (autumn rates) for all 3 species, and in late November through to mid-December (winter rates) for the latter two species only. We ran a linear model of all respirometry data for Californian myotis and silver-haired bats to examine the effects of season (fall and winter), and species on metabolic rates. These parameters were then fed into the mechanistic energetics survivorship model and the potential impacts of WNS were evaluated.

The survivorship model incorporates species-specific parameters describing overwinter fat stores, metabolic rates, evaporative water loss, and duration and frequency of arousals during hibernation in addition to Pd fungal growth rates (Haase et al. 2018). By comparing model results of uninfected, and bats infected with *Pd* we can make informed estimates of how a species will fair when it is colonized by *Pd*.

Probiotic Management to Reduce WNS Severity Project:

The following activities are in progress for this component of the project:

i. Culture swabs from healthy bats in western Canada to identify bacteria/fungi that inhibit growth/reproduction of Pd.
ii. Sequence candidate microbes and culture in combinations.
iii. Apply probiotic cocktail on captive bats that continue to fly normally (flight chamber).

iv. Frequently swab wings of bats that are temporarily held in captivity for trial application of cocktail to ensure that after 3 or more weeks they have wing microbes that match those of the cocktail. Swab pre- and post- inoculation.

v. PIT-tag and/or band bats for individual identification. Radiotrack bats to determine behavioural patterns and identify satellite roosts. By doing this prior to treatment, it can be determined if changes occur post-inoculation.

vi. Locate additional building colonies in Vancouver that do not share membership with the 'test' colony. Having other roosts to compare to will provide a baseline, which will be critical if WNS appears in Vancouver during the course of this study.

vii. Design an application mechanism (applicator) for the probiotic cocktail and test that it can result in live microbes being transferred to the bat wings.

viii. Install applicator at building/bat-box roost so that bats are not impeded when entering or exiting roost, but rub against a surface that will transfer microbes successfully.

ix. Periodic capture of bats at test roost (in Vancouver) with wing swabbing followed by lab culturing to ensure that microbes present in the cocktail are in high density on the wings. Monitoring and swabbing will continue in spring when bats return from hibernation; this will determine overwintering longevity of application.

Results

Survivorship Models – We tested the effect of season (fall vs winter) on metabolic rates for the two species of bats for which we had samples from both seasons: Californian myotis (64 fall metabolic rates, all temperatures combined; 29 winter metabolic rates) and silver-haired (47 fall; 12 winter). We found no effect of season (p= 0.49; full model results not presented here) and thus pooled fall and winter metabolic rates for each species for survivorship modeling.

The hibernation energetics model was run for each species using species specific parameters across a range of ambient hibernacula temperatures (-5 - 20 ^{o}C) and relative humidity (60-100%) with a maximal winter length of 12 months. Microclimate survival maps were created fo each of the species (Figures 1-3) and illustrate how long silver-haired bat (Figure 1), Californian myotis (Figure 2), and Yuma myotis (Figure 3) may survive winter hibernation without (A) and with (B) WNS. Here survival is defined as having enough energy at the end of winter hibernation to arouse and live 24 hours at euthermic body temperature. A microclimate survival map is also presented for little brown myotis (Figure 4), based on eastern data; as this species has experienced extreme mortality due to WNS and provides an important reference point. The black boxes represent the winter microclimate ranges that we know bats use in the West Kootenay.

Note that to date we do not know the temperature and humidity conditions that Yuma myotis use during hibernation.

Our survivorship models are preliminary continue to be revised as parameter estimates are updated and metabolic intricacies are included. Currently, our survivorship model results suggest a significant difference in survivorship of western bat species to WNS. Even when infected with WNS, silver-haired bats (Figure 1) could hibernate far longer than required, but only within in narrow microclimatic ranges and hibernacula microclimates that are too cool result in maximal hibernation of only a couple of months regardless of infection status. Californian myotis infected with WNS (Figure 2) could hibernate up to ~6 months if they roost within a narrow range of temperatures and humidity (~5^{o}C in almost 100% humidity), however this species is known to use a wide range of roost microclimates (unpublished data). This suggests that most Californian myotis are likely to be impacted by WNS, potentially surviving only a couple of months in hibernation. Nowhere in B.C. have we documented roosting conditions of Yuma myotis in winter as we currently do not know where Yuma myotis hibernate in the province. However, no matter what conditions this species uses in winter, its maximal hibernation time with WNS is expected to fall short of the length of winter in western B.C. Hibernation microclimates for little brown myotis are not known in B.C. (there is only one cave found to house this species in winter in B.C. and it has yet to be genetically confirmed; M. Davis, BatCaver Coordinator, pers. comm.), cave microclimates in Alberta and Northwest Territories where this species hibernates in large numbers, is known and thus presented on Figure 4 (black box).

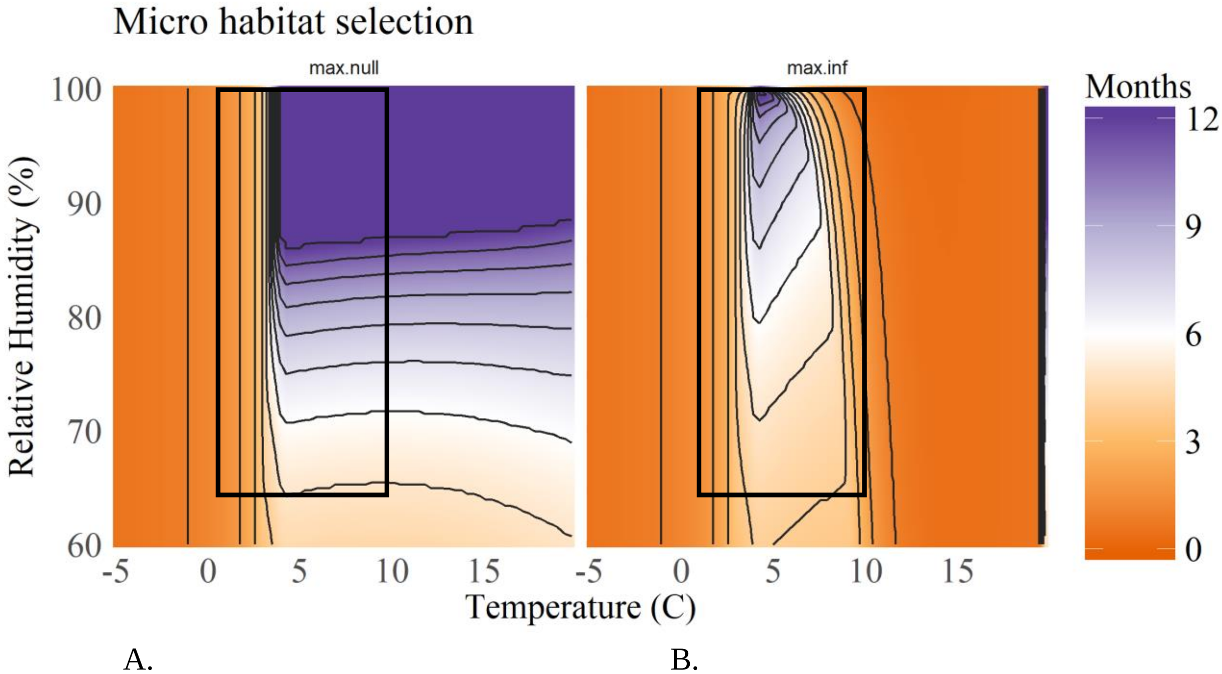
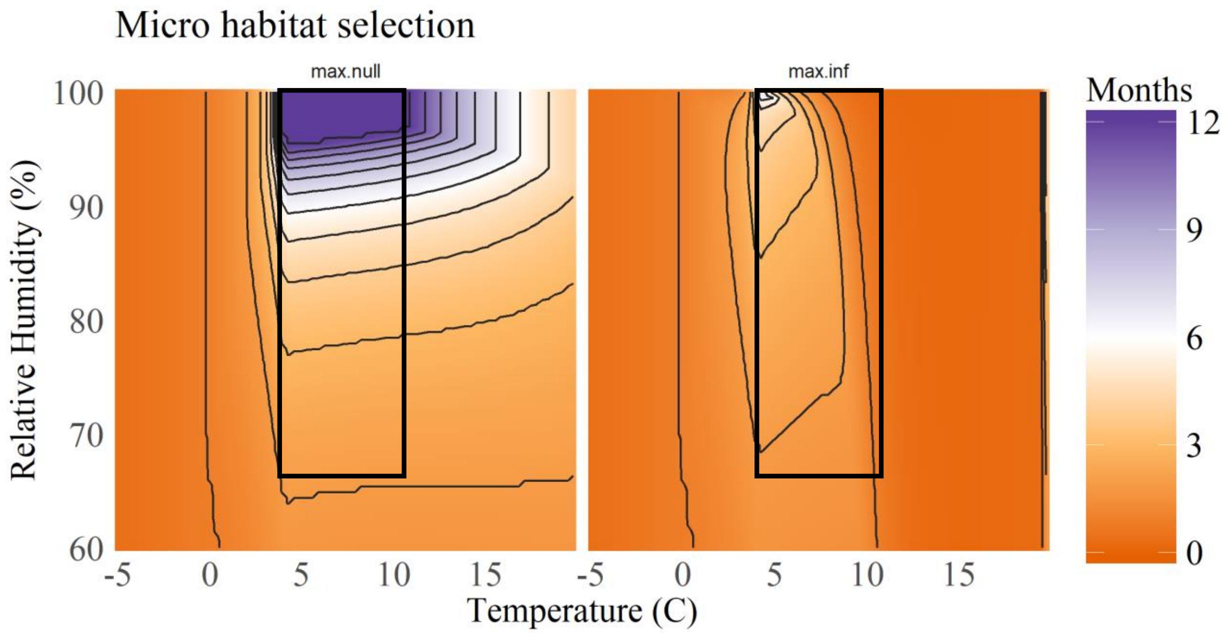


Figure 1. Silver-haired bat microclimate survivor map under normal (A) and WNS infected (B) conditions. Purple areas indicate under what conditions the bats would be able to hibernate more than 6 months based on their typical fat reserve, and orange is the combination of microclimate conditions under which this species would survive less than 6 months of winter. White is ~6 months of winter. Each contour line represents one month. The black box outlines the RH and temperatures in which this species has been found hibernating in West Kootenay. In this area, hibernation length is generally 4-5 months.



A. B.

Figure 2. Californian myotis microclimate survivor map under normal (A) and WNS infected (B) conditions. Purple areas indicate under what conditions the bats would be able to hibernate more than 6 months based on their typical fat reserve, and orange is the combination of microclimate conditions under which this species would survive less than 6 months of winter. White is ~6 months of winter. Each contour line represents one month. The black box outlines the RH and temperatures in which this species has been found hibernating in West Kootenay. In this area, hibernation length is generally 4-5 months.

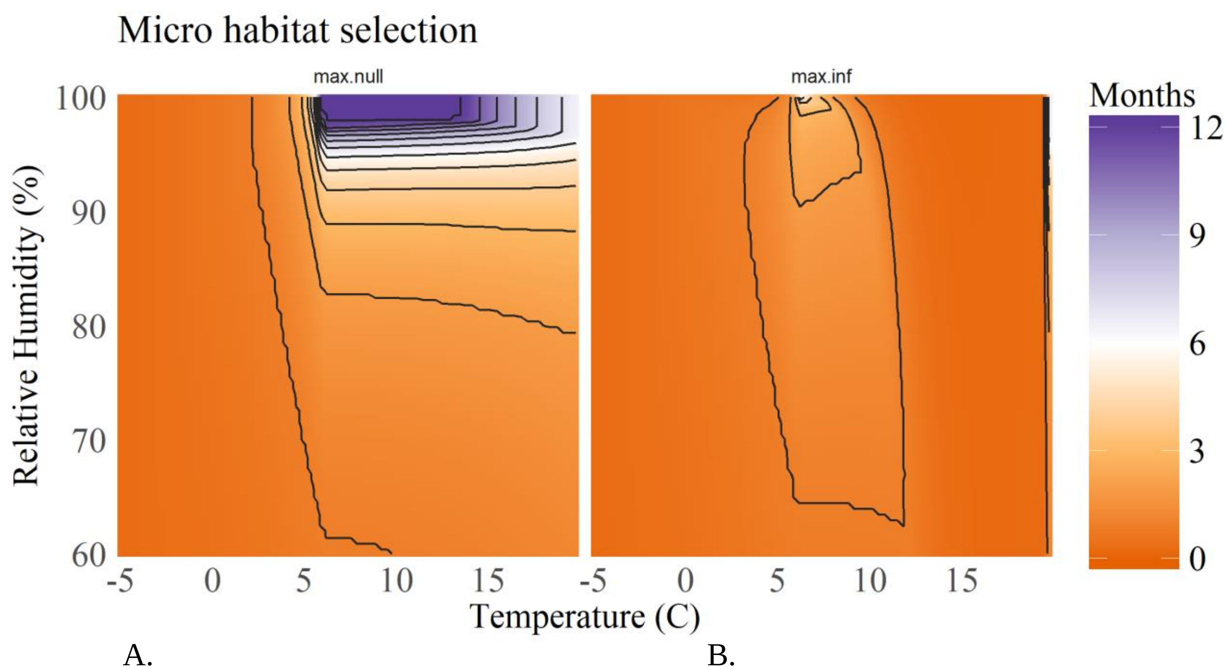
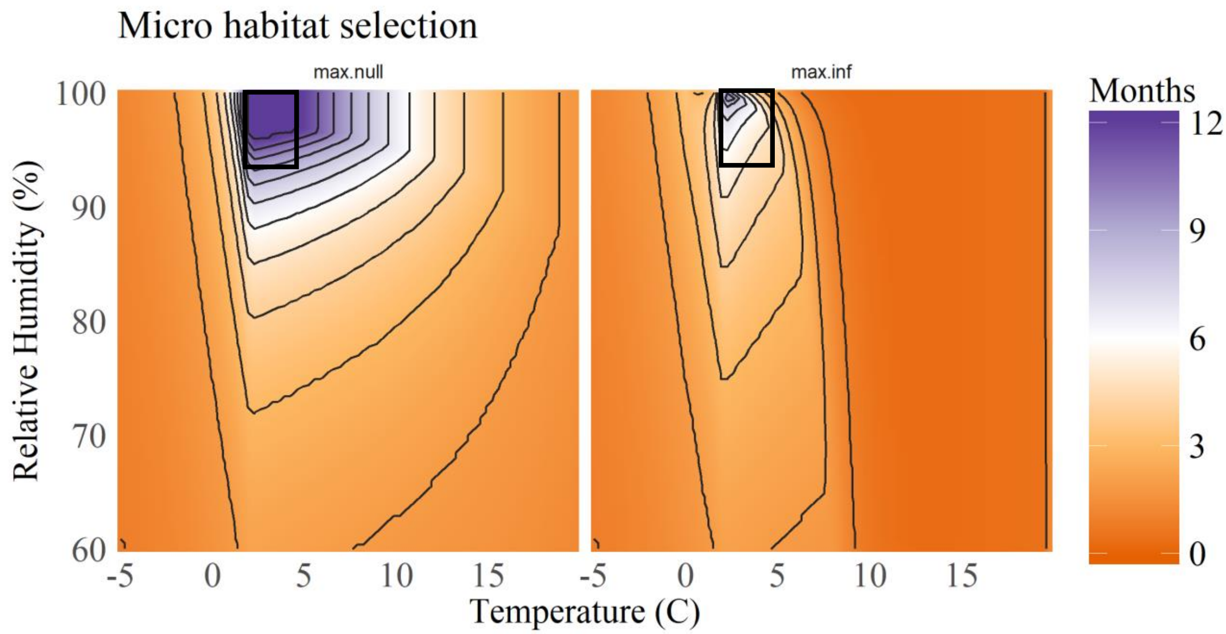


Figure 3. Yuma myotis microclimate survivor map under normal (A) and WNS infected (B) conditions. Purple areas indicate under what conditions the bats would be able to hibernate more than 6 months based on their typical fat reserve, and orange is the combination of microclimate conditions under which this species would survive less than 6 months of winter. White is ~6 months of winter. Each contour line represents one month. In the West Kootenay area, hibernation length is generally 4-5 months.



A. B.

Figure 4. Little brown myotis microclimate survivor map under normal (A) and WNS infected (B) conditions. Note that these figures represent models of survivorship for eastern little brown myotis. They have been included here only as reference. Purple areas indicate under what conditions the bats would be able to hibernate more than 6 months based on their typical fat reserve, and orange is the combination of microclimate conditions under which this species would survive less than 6 months of winter. White is ~6 months of winter. Each contour line represents one month. The black box outlines RH and temperature of microclimates that this species is known to use in Alberta and Northwest Territories.

WNS Prevention through Probiotic Application -- This project has just begun and thus no results are currently available. A preliminary probiotic cocktail is being developed for a small captive bat trial in late summer 2018.

Discussion

Survivorship Models – Because white-nose syndrome infected bats show more frequent arousal rates (Reeder et al. 2012), it is likely that fat consumption throughout the winter period plays a key role in survival. How much fat a bat goes into hibernation with, how high its torpid metabolic rate is during hibernation, and how often it arouses from hibernation, all determine how much fat a bat will have when it emerges from hibernation. If this fat is depleted before the end of winter, mortality is likely to occur due to lack of insect prey in cold winter conditions. To determine whether a bat will survive winter requires knowing its normal metabolic rates under disease-free conditions, how much stored fat it would typically enter hibernation with, how often it would normally arouse from hibernation and for how long, and the rate of evaporative water loss the bat experiences while in torpor and euthermic. We measured these parameters for 3 species of bats in B.C. – silver-haired bat, Californian myotis, and Yuma myotis. Also important to modelling disease susceptibility is the prediction of how well Pd will grow on bats in their roosting micro-environments. We measured temperature and humidity within known winter roosts of silver-haired and Californian myotis bats. It is known that bats roosting at temperatures too cool and dry for optimal *Pd* fungal growth are less impacted by WNS (Langwig et al. 2012).

Using novel physiological and morphological measurements of western bats in B.C., we expanded upon a developed WNS survivorship model (Haymen et al. 2016) that allows us to make predictions on how three species of bats will respond to WNS infection. In the West Kootenay, bats in low elevation locations typically hibernate mid-Nov – end of March (~4.5 months), suggesting that most silver-haired bats are likely to survive WNS (Figure 1). This species has also been reported to use a wide range of hibernation temperatures and humidities (unpublished data). Our model predictions suggest that most Californian myotis are likely to be impacted by WNS, potentially surviving only a couple of months in hibernation. Nowhere in B.C. have we documented roosting conditions of Yuma myotis in winter as we currently do not know where Yuma myotis hibernate in the province. However, no matter what conditions this species uses in winter, its maximal hibernation time with WNS is expected to fall short of the length of winter in western B.C.

While almost nothing is known about little brown myotis hibernation in B.C., it is known that in Alberta and Northwest Territories large cave hibernacula of little brown myotis roost at temperatures 2 – 3^{o}C with almost maximum air saturation (unpublished data – S. Irwin, D. Hobson, A. Kelley). While it has been observed that little brown myotis experiences high mortality rates in eastern parts of its North American range, it is not yet known how WNS will affect this species in the west, but it is hypothesized that this species will be similarly affected by WNS across its range (Government of Canada 2014a). WNS has been reported in both Yuma and little brown myotis species in the west (Tobin et al. 2017). Based on our survivorship models, winter survival of little brown myotis infected with WNS is expected to be more than 6 months, but this is not long enough in many places of its range to successfully overwinter. While length of hibernation period of this species in B.C. are not known, this species typically leaves maternity roosts in mid-Sept., and in many areas of B.C. it is not back at maternity roosts until mid-May (B.C. Community Bat Program, unpublished data). Therefore, it is possible that this species hibernates longer than other Myotis in the province, and may in fact spend more than 6 months in hibernation typically. If this is the case, and if this eastern-based survivorship model holds in the west, this species will be impacted by WNS in western reaches where the hibernation period extends longer than 6 months.

In summary, silver-haired bats are likely to be less impacted from WNS than little brown, Californian and Yuma myotis. Silver-haired bats have been found to be *Pd*+ but no WNS has been reported to date (USFWS 2018a). We do not yet know the microclimates used by Yuma myotis during winter, but the narrow zones of survival on the hibernation microclimate maps for infected Yuma myotis, and the ecologically similar little brown myotis (Adams 2003), suggest that WNS poses great risk to this species.

All of these models are built off the most aggressive fungal growth parameters we have (Chaturvedi et al. 2010), so any reduction in fungal growth (whether it be through prophylaxis or local fungal adaptation) could reduce disease severity.

Management Implications

These projects have direct management implications. Conservation of bats through slowed WNS progression from prophylaxis inoculation will be an immediate result and if successful, this approach can be applied over a broader geographic scale, well beyond B.C.

Our prophylaxis approach also has the potential to be self-propagating, with bats returning in spring to roost surfaces that may have retained the beneficial anti-Pd microbes over winter, reducing the need to re-inoculate cocktail applicators. Determining the longevity of anti-Pd microbes remaining on roost surfaces and the need to re-inoculate cocktail applicators will require ongoing monitoring for several years. If this method is self-propagating over time, it will be highly cost-effective and not labour intensive for the long term conservation of building-roosting bats.

Given that there are at least 14 species of bats hibernating in northwestern North America, WNS survivorship models, as they continue to include more western species will elucidate which species are of higher conservation concern due to WNS. Such species may be candidates for mitigation approaches such as the probiotic application that we describe here.

Literature Cited

Adams, R. 2003. Bats of the Rocky Mountain West – Natural History, Ecology, and Conservation. Boulder, University Press Colorado.

Buecher, D., Hamm, P., Caimi, N., Northrup, D., Winter, A., Valdez, E., and Porras-Alfaro, A. 2017. Monitoring western bats in the face of white-nose syndrome. Western Bat Working Group Biennial Meeting, Fort Collins, Colorado, Oral Presentation (Unpublished work).

Chaturvedi, V., Springer, D. J., Behr, M. J., Ramani, R., Li, X., Peck, M. K., ... & Butchkoski, C. M. 2010. Morphological and molecular characterizations of psychrophilic fungus Geomyces destructans from New York bats with white nose syndrome (WNS). PLoS One, 5(5), e10783.

Cheng, T.L., Mayberry, H., McGuire, L.P., Hoyt, J.R., Langwig, K.E., Nguyen, H., Parise, K.L., Foster, J.T., Willis, C.K.R., Kilpatrick, A.M., and Frick, W.F. 2016. Efficacy of a probiotic bacterium to treat bats affected by the disease white-nose syndrome. J Appl Ecol. 54(3): 701-708.

Cornelison, C.T., Gabriel, K.T., Barlament, C., and Crow, S.A., Jr. 2014. Inhibition of *Pseudogymnoascus destructans* growth from conidia and mycelial extension by bacterially produced volatile organic compounds. Mycopathologia 177, 1-10.

Ghosh, S., McArthur, R., Grand, S., Mubarak, W., Kam, G., Lauriente, T., Wong, A., Lausen, C., and Cheeptham, C. 2017. Examining potential biological controls exhibiting anti-*Pd* activity: bee propolis, viral proteins, and microorganisms from caves and other environments, mistletoe and bat wings. White Nose Syndrome Workshop. 23-25 May, 2017. Nashville, TN. (unpublished data).

Government of Canada. 2014a. Species at risk public registry. Little Brown Myotis. http://www.registrelep- sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=1173

Government of Canada. 2014b. Species at risk public registry. Northern Myotis. http://www.registrelep- sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=1175

Harris, R.N., Brucker, R.M., Walke, J.B., Becker, M.H., Schwantes, C.R., Flaherty, D.C., Lam, B.A., Woodhams, D.C., Briggs, C.J., Vredenburg, V.T., and Minbiole, K.P. 2009. Skin microbes on frogs prevent morbidity and mortality caused by a lethal skin fungus. ISME J 3, 818-824.

Haase, C.G., N.W. Fuller, D.T.S. Hayman, C.R. Hranac, L.P. McGuire, S.H. Olson, R.K. Plowright, and K.A. Silas. 2018. Incorporating Evaporative Water Loss into Models of Hibernation Energetics and Implications for White-Nose Syndrome. White-nose Syndrome National Meeting. Tacoma, Washington (oral presentation, abstracts available: https://www.whitenosesyndrome.org/sites/default/files/wns-meeting-2018-abstracts_20180607.pdf)

Hayman, D.T.S., J.R.C. Pulliam, J.C. Marshall, P.M. Cryan, and C.T. Webb. 2016. Environment, host, and fungal traits predict continental-scale white-nose syndrome in bats. Science Advances 2: e1500831–e1500831.

Hoyt, J.R., Cheng, T.L., Langwig, K.E., Hee, M.M., Frick, W.F., and Kilpatrick, A.M. 2015. Bacteria isolated from bats inhibit the growth of *Pseudogymnoascus destructans*, the causative agent of white-nose syndrome. PLoS One 10, e0121329

Langwig, K. E., Frick, W. F., Bried, J. T., Hicks, A. C., Kunz, T. H., & Marm Kilpatrick, A. 2012. Sociality, density‐dependence and microclimates determine the persistence of populations suffering from a novel fungal disease, white‐nose syndrome. Ecology letters, 15(9), 1050-1057.

Lorch, J.M., Schmidt, K.Z., Vanderwolf, K.J., and Blehert, D.S. 2016. Fungal skin communities in hibernating bat species that are susceptible and resistant to white-nose syndrome White-nose Syndrome Workshop Denver, CO. Oral presentation (unpublished data).

Reeder DM, Frank CL, Turner GG, Meteyer CU, Kurta A, Britzke ER, et al. 2012. Frequent Arousal from Hibernation Linked to Severity of Infection and Mortality in Bats with White-Nose Syndrome. PLoS ONE 7(6): e38920. https://doi.org/10.1371/journal.pone.0038920

Tobin, A., Haman, K., and Anderson, C. 2017. Understanding the impacts of white-nose syndrome on Washington's bat population Western Bat Working Group Biennial Meeting, Fort Collins, Colorado, Oral Presentation (unpublished data).

United States Fish & Wildlife Service (USFWS). 2018a. "Whitenosesyndrome.org." A Coordinated Response to the Devastating Bat Disease. https://www.whitenosesyndrome.org.

United States Fish & Wildlife Service (USFWS). 2018b. White-nose Syndrome National Meeting. Tacoma, Washington. Abstracts: https://www.whitenosesyndrome.org/sites/default/files/wns-meeting-2018-abstracts_20180607.pdf

Washington Fish and Wildlife. 2017. White-nose syndrome. http://wdfw.wa.gov/conservation/health/wns/

Acknowledgements

We thank our funders: US National Fish and Wildlife Foundation (2015-6 F15AS0018) and National Fish and Wildlife Foundation – Bats for the Future Fund (2017-9: #57614); FightWNS – Micro Grants for MicroBats; B.C. Habitat Conservation Trust Foundation; Forest Enhancement Society of British Columbia; Mitacs; TRU/UBCO Tri-Universities Grant; TRU Internal Grants -- TRU UREAP (Robyn McArthur, Julianna Bissonnette, Brandon Hayashi) and TRU IRFSST (Cheeptham); BC Ministries of Forest Lands Natural Resource Operations and Rural Development/Min. of

Environment and Climate Change – Land Based Investment Strategy; Columbia Power Waneta Terrestrial Compensation Program.

We thank our collaborators and partners: David T.S. Hayman; Drs. Kingsley Donkor, and Norm Reed, Thompson Rivers University (TRU); Dr. Cynthia Ross Friedman, TRU; Dr. Glenna McGregor, Animal Health Centre, British Columbia Ministry of Agriculture; Dr. Helen Schwantje, B.C. Ministry of Forests Lands Natural Resource Operations and Rural Development; Orville Dyer and Dr. Purnima Govindarajulu, B.C. Min. Environment and Climate Change ; Dr. Craig K. R. Willis, University of Winnipeg; Dr. Francois-Joseph Lapointe and Virginie Lemieux-Labonté, Université de Montréal; Dr. Julian Davies, UBC Microbiology & Immunology; Patrick Burke and other members of South Coast Bat Conservation Society, Vancouver, BC; John Saremba, Burke Mountain Naturalists; Robyn Worcester and Markus Merkens, MetroVan Regional Parks; Adrienne Clay, BC Wildlife Park, Kamloops; BC Parks; Stanley Park Ecological Society; Margaux Resources; Dr. Karen Hodges, University of British Columbia Okanagan; Leah Rensel, MSc Candidate, University of British Columbia; Dr. Yvonne A. Dzal, University of Winnipeg; Dr. Brandon Baerwald, Nokomis, SK; Karen Vanderwolf and Dr. Don McAlpine, New Brunswick Museum; Dr. Catherine G. Haase, Montana State University; Dr. Nathan W. Fuller, Texas Tech University; Dr. Liam P. McGuire, Texas Tech University; Dr. Meredith L. McClure, Conservation Partners; Dan Crowley, Montana State University; Dr. Raina K. Plowright, Montana State University.

For significant contribution to field work we thank: Yvonne Dzal, Brandon Baerwald, Jason Rae, Heather Gates, Leigh Anne Isaac, Nick Hindley, Tara Robinson, Elodie Kuhnert, Alexis Heckley, Rhiannon Kirton, Emma Kunkel, Doug Burles, Aimee Mitchell, Chris Currie; many additional members of the BC and Alberta Bat Action Teams.

Back to Table of Contents

Development of eDNA monitoring tools and protocols for assessment of Western Painted Turtles (Chrysemys picta bellii) in British Columbia

Presenter: **Amanda Baxter,** MSc candidate Natural Resource Environmental Studies, Biology, University of Northern British Columbia
Prince George, British Columbia
abaxter@unbc.ca

Co-Author and supervisor: Dr. Brent Murray, Associate Professor, University of Northern British Columbia, brent.murray@unbc.ca

The environmental DNA (eDNA) method is a relatively new approach that uses DNA-based identification to detect species from residual genetic material that organisms leave behind in the environment. The eDNA method of sampling is non-invasive and has great potential for detecting rare or cryptic species such as the Western Painted turtle (*Chrysemys picta bellii*). The Western Painted turtle population is endangered along the Pacific coast of British Columbia due to anthropogenic effects such as major wetland habitat loss, vehicle-related mortalities, and introduction of non-native species. Although eDNA methods have successfully detected species at low densities, the method is difficult to standardize due to differences in target species and ecosystems. Western Painted Turtles may benefit from this sampling method as this species can be difficult to detect. This project will expand on previous research which deals with standardising a reliable sampling procedure for quantifying the sensitivity needed to detect Western Painted turtles via the DNA found in their environment. To meet these objectives, environmental variables (such as water temperature and pH) were documented at each sampling site, and two water processing methods will be compared (filtration vs. precipitation). Within the filtration method, several filter types and pore sizes were used to further compare the detectability of the filters. The results from this project will help determine what method is most sensitive for detection of the target species, thus leading to better conservation planning and management for this endangered species.

Back to Table of Contents

Using local knowledge and hunter-based sampling to inform woodland caribou conservation

Presenter: **Naima Jutha,** DVM, BSc, MSc candidate at University of Calgary, Faculty of Veterinary Medicine – Department of Ecosystem and Public Health
Calgary, Alberta
naima.jutha@ucalgary.ca

Co-authors: Susan Kutz, DVM, PhD, Professor – University of Calgary, Faculty of Veterinary Medicine, skutz@ucalgary.ca

Helen Schwantje, DVM, MSc, Wildlife Veterinarian – BC Wildlife Health Program, BC Ministry of Forests, Lands, Natural Resource Operations, and Rural Development, helen.schwantje@gov.bc.ca

Bill Oestreich, Vice President – Tahltan Guide & Outfitter Association, superguides@hotmail.com

The Northern Mountain Population of woodland caribou (NMPC) occurring in northwestern British Columbia are of great cultural, economic, and ecological significance to the local first Nations, BC recreational hunters, the guided hunting industry, and Canadians in general. These caribou face the increasing threats of a changing landscape and climate, and considerable concerns have been raised by local land-users of declining numbers and erratic herd behaviours. Despite this, there is insufficient information on the NMPC to understand current health status, predict future population trends, and ultimately support informed and adaptive management. This proposed research intends to establish past and current NMPC health status and trends using guide-outfitter sampling and knowledge and to evaluate the contribution of the guided-hunting industry towards a community-based caribou health surveillance framework. Biological samples collected from harvested caribou by locally practicing guides and outfitters will be analyzed for various markers of health including condition, bacterial, viral, and parasitic disease exposure, contaminant levels, trace minerals, demographics, and stress; these metrics of individual health are staged to best inform health in populations. Drawing from established methodologies, systematic interviews of guide-outfitters will be conducted to gather local knowledge pertaining to observations on caribou health, population status, and trends. This research will address the difficulties of implementing effective wildlife health monitoring initiatives in remote regions of northern Canada. Taking a multi-disciplinary and participatory-action research approach will complement and enhance conventional quantitative methods of health

surveillance, and support the refinement of a locally-driven wildlife health monitoring program for the species and regions that need them most.

Back to Table of Contents

Evaluating potential health implecations of maternal penning in a threatened population of northern caribou

Presenter: **Janie Dubman,** Wildlife Infometrics
Mackenzie, British Columbia
evgenia.dubman@wildlifeinfometrics.com
www.wildlifeinfometrics.com

Co-Authors*:* Dr. Scott McNay, Wildlife Infometrics,
scott.mcnay@wildlifeinfometrics.com

Dr. Bryan Macbeth, Ministry of FLNRORD – Wildlife Management,
bjm197@mail.usask.ca

Population recovery measures will be necessary to restore BC's declining caribou herds, and while some approaches have shown short-term success (e.g. maternal penning, predator control), the long-term implications of these recovery actions on overall health is poorly understood. Understanding such implications presents a two-fold challenge. First, published health data for caribou is lacking across much of the province, despite two decades of intensive study of the species. Second, health samples from population management projects such as the maternal pens (Revelstoke and Klinse-Za) and translocations (Telkwa) have not yet been systematically collected and analyzed.

Over the past 4 years, the Klinse-Za maternal pen project has resulted in improved calf/cow survival. However, capturing and penning wild caribou may have direct and indirect health consequences and the overall health status of the Kilnse-Za/Scott East caribou herd is currently unknown. We are in the data collection phases of a study that has two specific wildlife health objectives:

1. Characterizing baseline health parameters within the Klinse-Za/Scott East herd
2. Evaluating potential effects of penning on caribou health

Objective #1 will be achieved by collecting and analyzing biological samples from live-captured and free-ranging caribou to evaluate four key health determinants: a) exposure to, or infection with, selected diseases and parasites, b) body condition, c) physiological stress and 4) diet. We will run the following lab assays to address these areas, respectively: a) fecal pellets (parasitology) and blood (exposure to viral and bacterial pathogens), b) bone marrow (fat content) and blood (trace minerals), c) hair (cortisol), fecal (cortisol) and blood serum (cortisol), and d) fecal (nitrogen). Results will be summarized by sex and age of individual, and compared to the outcomes of other contemporary caribou research programs.

Objective #2 will be achieved by tracking health determinants in samples collected from penned caribou, and comparing results with samples from wild individuals where possible. We will address the same four areas of health as 'objective #1', above, but using a more focused dataset. Specifically, we will be using fecal pellets collected during the 2017 and 2018 penning season (March – July) to evaluate pathogen loads, stress, and diet, as well as weigh scale data from the maternal pen in 2017 and 2018 (to evaluate body condition). Results from the fecal pellet analysis will be compared between penned and wild individuals, as well as throughout the penning period, while the body weight results will be tracked within the penned population throughout the penning season.

Collecting and analyzing baseline health parameters from the Klinze-Za/ScottE herd will help expand understanding of population-level caribou health, which currently only includes boreal caribou herds. Sampling a mountain herd may reveal currently unknown pathogens, and will help define the range of the known ones. These results could also be used to test possible relationships between land-use practices, climate change and caribou population health, which may be applied to developing best management practices in the future.

Back to Table of Contents

Current status of chronic wasting disease in wildlife in Alberta

Presenter: **M.J. Pybus,** Alberta Fish and Wildlife
Edmonton, Alberta
margo.pybus@gov.ab.ca
http://aep.alberta.ca/fish-wildlife/wildlife-diseases/

Co-author: Mark Ball, Alberta Fish and Wildlife, mark.ball@gov.ab.ca

Alberta began monitoring chronic wasting disease (CWD) in wild cervids in 1998. Ongoing surveillance relies heavily on heads from hunter harvested cervids (primarily white-tailed and mule deer), supplemented with diagnostic, clinical, and opportunistic samples. We tested over 68,000 wild cervids and detected CWD in 920 animals (1^{st} case in 2005). Overarching patterns include: predominance of CWD in mule deer and males, focal distribution of CWD within landscapes, and association with specific watersheds in eastern Alberta. CWD prevalence is increasing in local populations and the disease continues to spread westward.

Back to Table of Contents

If you build it will they come? Snake use of artificial habitat within a commercial scale vineyard

Presenter: **Valerie Law,** BNRS, Thompson Rivers University
valerie-law@hotmail.com

Co-author: Dr. Karl Larsen, Thompson Rivers University, klarsen@tru.ca

The Okanagan region of British Columbia (BC) has been subjected to large-scale agricultural expansion due to a land base and climate optimal for agriculture. The subsequent conversion of the native shrub steppe habitat directly impacts snake populations endemic to the area. Finding ways to enable snakes to use vineyards for hunting has obvious benefits to both snakes and vineyard protection, though reduction of prey levels. However, for venomous rattlesnakes, this can be a great challenge, requiring ways to ensure the safety of both snakes and vineyard workers. This study is investigating a novel way to approach this situation, through the creation of artificial pockets of habitat ('refugia'). Eight refugia, consisting of subterranean chambers, artificial rock piles, and native flora were built within a vineyard in Oliver, BC and monitored over the spring/summers of 2015-2017. Internal chambers have become cooler, likely due to the addition of vegetation, than ambient conditions and provide stable temperatures below the voluntary maximum of snakes. Wildlife cameras within the chambers reveal relatively higher levels of visits by snakes (rattlesnakes, gophersnakes, and racers) in refugia near the periphery of the vineyard. Rodents (snake prey) also utilize the refugia quite extensively. However, analysis of snake use of refugia revealed no significance between snake use, rodent use, or ambient air temperature. Behavioural analysis of camera footage suggests snakes are predominantly utilizing these spaces for their foraging opportunities rather than thermal properties. Spaciousness of chambers was identified as a factor that may reduce suitability for snake use.

Back to Table of Contents

Chronic wasting disease surveillance and management in Montana

Emily Almberg, Montana Fish, Wildlife, and Parks, ealmberg@mt.gov, 406-994-6358, 1400 S. 19th Avenue, Bozeman, MT 59178, fwp.mt.gov/cwd

Jennifer Ramsey, Montana Fish, Wildlife, and Parks, jramsey@mt.gov

John Vore, Montana Fish, Wildlife, and Parks, jvore@mt.gov

Keri Carson, Montana Fish, Wildlife, and Parks, kcarson@mt.gov

Justin Gude, Montana Fish, Wildlife, and Parks, jgude@mt.gov

In 2017, Montana Fish, Wildlife and Parks (FWP) renewed their surveillance for chronic wasting disease (CWD). Employing a weighted surveillance strategy aimed at detecting 1% CWD prevalence with 95% confidence among mule deer in southcentral Montana, FWP tested over 1,300 samples during the general hunting season. Through these efforts, FWP detected CWD in mule deer and white-tailed deer in southcentral Montana and in a mule deer near Chester, Montana, south of the Alberta border. Special late-season hunts were called within both of these areas, yielding an estimated prevalence of 2% (95%CI: 1-4%) in mule deer and 1% (95%CI: 0-3%) in white-tailed deer in the southcentral hunt area and 0.8% (95%CI: 0.1-4%) among mule deer in the hunt area adjacent to Alberta. Within the southcentral hunt area, infections were clustered to the south, closer to the Wyoming border; the prevalence in the southern portion of this hunt area was 8% (95%CI: 4-16%). FWP is developing long-term CWD management plans for these affected areas, which may include increased harvest, especially of antlered deer, targeted removal in limited areas around CWD detections, efforts to minimize large groupings of deer by removing or fencing highly localized attractants or through hazing or dispersal hunts, and carcass transport restrictions. FWP will also develop a long-term monitoring plan to assess management efficacy.

Back to Table of Contents

Migration and parasitism: Wildlife health on the move

Presenter: **Dr. Stephanie Peacock,** Biological Sciences, University of Calgary
Calgary, Alberta
stephanie.peacock@ucalgary.ca

Co-authors:
Dr. Mark A. Lewis, Biological Sciences/Mathematical and Statistical Sciences, University of Alberta
Dr. Susan Kutz, Ecosystem & Public Health, Faculty of Veterinary Medicine, University of Calgary
Dr. Péter K. Molnár, Biological Sciences, University of Toronto Scarborough

Many wildlife populations undergo arduous migrations to track seasonal changes in resources, find mates, or avoid predation. These mass movements have important consequences for disease dynamics. It has been proposed that migrations may facilitate the spread of pathogens and increase transmission at high-density stopover sites. Alternately, migration might improve population health by allowing hosts to escape infection hotspots (*migratory escape)* or culling infected animals from the population (*migratory culling*). This diversity of potential outcomes makes it difficult to determine how migration and changes to migratory patterns affect wildlife health.

We developed a mathematical model of host-parasite dynamics in migratory animals in order to explore the characteristics of the host, parasite, and environment that give rise to these different phenomena. Simulations of the model revealed the biological parameters that lead to migratory escape and migratory culling. We also found that under certain conditions a positive feedback between transmission at infection hotspots and reduced migratory ability of hosts can lead to *parasite-induced migratory stalling* – a previously undescribed outcome that may have dire consequences for host populations.

Our approach is interdisciplinary in that it bridges ecology and mathematics, blending data and theory in order to understand the potential outcomes of parasitism for migratory host populations. The quantitative framework we developed is general, and applications to species from salmon to caribou are discussed. Future work will extend the model to include temperature-dependent parameters in order to understand how climate change will impact health of migratory caribou in Canada.

Back to Table of Contents

Summary of forum evaluations

There were ~64 people at the forum, and 23 evaluation forms were returned.
Not all forms had a response for each question.

1. **How well did the conference meet your expectations?**
   a. Exceeded **x12**
   b. Fully met **x9**
   c. Met most **x3**
   d. Met only a few **x0**
   e. Did not meet any **x0**
2. **Key things learned that will have an impact on your work/things you will be doing differently in the future**
   a. Forestry stewardship project ideas
   b. Forest harvest & management activities
   c. Bat immunology & further research
   d. Learning about caribou migration in different ecotypes (barren-ground vs. mountain) **x2**
   e. Importance of respectful, genuine collaboration **x2**
   f. Concept of harm reduction/using harm reduction model **x7**
   g. True collaboration and community engagement/listening to local knowledge **x10**
   h. LEO network – **x3**
   i. Translocation pros and cons for mule deer
   j. I was mostly here to network and this was a fantastic setting for that
   k. Focusing on social ideas for driving changes forward
   l. Significance of bats; I want to help set up bat roost monitoring
   m. As a woodlot owner, I will promote habitat diversity when we log an area
   n. As a future DVM student, I'm excited about opportunities in wildlife health
   o. Appetite exists for pro-active management approaches
   p. Possible health correlation between camelids and mountain goats
   q. Incorporating knowledge of First Nations & other stakeholders creates more "buy-in"
   r. Interaction between stress and WNS
   s. How blackflies affect goshawks **x2**
   t. Successes of working with local community and First Nations
   u. Importance of health in cumulative effects
   v. Ecology plays a big role in wildlife disease

3. **Anything you hoped to learn that you didn't**
   a. No – **x10**
   b. Yes
      i. I was hoping to hear more about the provincial moose health program and discuss possible techniques that might be carried over to caribou
      ii. More about fish **x3**
      iii. Climate change impact strategies
      iv. I thought there might be more info about local large mammals such as bear, elk and deer (but most of the large mammal focus was on caribou and bighorn)
      v. Would be great if you had a workshop connected to the conference that we could attend for professional development
      vi. Greater focus on supporting resilient populations
4. **If we run a sequel to this event, what topics would you like to see included?**
   a. Habitat management/stewardship/enhancement to support wildlife health
   b. More about fish **x2** (especially since "Fish" was in the conference title)
   c. Adaptive management
   d. Population ecology & "herd health" in wildlife
   e. Conservation biology
   f. A section on native bees/pollinator friendly habitat
   g. Info on other local large mammals including bear, elk and deer
   h. Follow up on ongoing projects
   i. Habitat enhancement in a world/landscape of significant change: what works? What should we try?
   j. Less citizen science
   k. Science communication/how to connect science with community **x2**
   l. More on linkages of anthropogenic and natural disturbance to health
5. **Any other comments about the event?**
   a. Good balance of talks and breaks **x5**
   b. Appreciate the size of the room and having just single and not concurrent sessions
   c. Careful monitoring of talk length (not allowing speakers to take others' time)
   d. Great diversity of speakers/topics **x5**
   e. Important to focus on actions/strategies and what we can do
   f. More interesting than I expected

Back to Table of Contents