Could you outline how your Federal Canada Research Chair position supported you in establishing the Natural Resources DNA Profiling and Forensic Centre (NRDPFC)?

I was able to secure three Canada Foundation for Innovation (CFI) grants matched by Ontario Innovation Trust grants of over CAD $10 million to acquire automated robotic DNA analytical equipment and initiate the construction of a 20,000 ft² building. The NRDPFC contains specialised infrastructure for research and laboratories, which provide DNA evidence for the enforcement of wildlife statutes. The equipment allows faculty and students to assess the genetic structure of threatened and harvested species across the landscape and the impacts of urbanisation and climate change on the genetics of species.

What is your relationship with the Ontario Ministry of Natural Resources (OMNR)?

We have performed all of the forensic DNA analyses for the Enforcement Branch of the OMNR for the last 25 years. We also perform genetic research on harvested and threatened species so we can estimate the probability of different animals sharing the same DNA profile for OMNR policy makers and managers. In return, the OMNR provides samples and field support for many graduate student research projects. This partnership has made important discoveries in the form of unravelling the nature of wolves and coyotes in North America. This allowed the identification of a distinct wolf species that has hybridised with grey wolves and western coyotes to form a range of forms that are termed ‘canis soup’ in Ontario.

Why are you conducting genetic studies in ruminants?

Goats provide much of the meat and milk consumed in developing countries. The number of kids born, their growth and future milk productivity determine whether farmers in these countries are at the subsistence level or can run a small business. We are working with a prominent local dairy goat farmer whose herd produces high volumes of milk as well as many multiple births. There is a regional economic initiative to export high quality goat genetics to developing countries, and we are genomically assessing the herd of dairy goats to identify the genes responsible for high milk production, especially under high temperature conditions.

Tracking past, present and future genes in wildlife

The Natural Resources DNA Profiling and Forensic Centre in Ontario, Canada, is helping to secure the future of endangered species and improve the techniques employed in conservation and landscape genetics with state-of-the-art DNA extraction and genomic profiling.

In Peterborough, Ontario, the Trent University Natural Resources DNA Profiling and Forensic Centre (NRDPFC) has collected DNA samples from 503 living and dead North Atlantic right whales over the last 25 years, including a sample from a whale that died in the 1500s. For individual whales, the NRDPFC DNA database holds the results of mitochondrial haplotype analysis, microsatellite profiles and sex; in some cases, the NRDPFC also houses information on whale paternity, pedigrees and many individual whales that are deceased.

The North Atlantic right whale population has continued to decline despite the elapse of more than 70 years since the ban on commercial whaling. Through analysis of the DNA profiles of ancient and modern whales, NRDPFC determined that the Basque whaling ‘golden age’ of the 16th and early 17th centuries did not, as had been previously proposed, account for the massive decline in numbers. Instead, results indicate that the species has likely always had small numbers and is now unable to reproduce at a rate sufficient to cope with population loss.

To explore the hypothesis that inbreeding might now account for the low number of new calf births each year, a further study matched the DNA
How does your laboratory make use of high-tech equipment?

For our research programmes, we analyse large numbers of samples per year. We use robotic equipment to extract DNA and develop DNA profiles to estimate population size and animal movements. Robots also allow graduate students to spend more time on experimental design and data analysis. For some projects within the private sector, robots enable us to monitor large numbers of samples quickly. This is especially important in areas such as food traceability using DNA markers.

Can you detail the latest studies underway at the Centre?

Some of our research involves collaboration with government agencies, such as Environment Canada. We are developing a DNA bioassay that will monitor the effects of mutagenic compounds released during oil extraction from the tar sands in Alberta. This takes advantage of next-generation DNA sequencing and our ability to sequence large stretches of DNA from many individuals.

DRDPFC is also collaborating with laboratories in the US to compare the sequences of three species of right whales. We are interested in the reasons for the low reproductive rate of North Atlantic right whales and are analysing genes identified as causing reproductive problems in Holstein dairy cattle. We have also been looking at the genetics of a number of species of animals in the Middle East, where there are issues with subspecies identity.

On the conservation of which species has your Wildlife Forensic DNA Laboratory had the greatest impact?

The forensic evidence we have supplied has been used by the Enforcement Branch of the OMNR in many poaching cases and is now regarded as a major deterrent. Once poachers know we can trace animals from illegal kill sites to their freezers they tend to stop poaching and illegally trading in meat and animal parts. This has helped sustain black bear and moose populations and the restoration of turkeys and elk in Ontario.

We analyse DNA in products such as sausages. Moose and deer are often sold as sausages labelled ‘spicy Italian’ or ‘honey garlic’, and DNA can identify the amount of illegal game meats. Our work on black bear gall bladders and seal penises has helped to reduce international poaching to supply products to the Asian medicine trade. We have also been working on jewellery made from endangered coral species to help reduce poaching of critical species.

Long-term research on the highly endangered North Atlantic right whale has provided a major resource for both US and Canadian governments (http://narightwhale.nrdpfc.ca). The genetic database and DNA bank contain over 75 per cent of the individuals that have lived in the last 25 years and recently helped identify the likely mating ground as the Great South Channel.

profiles of female whales and their offspring with photographic records of each whale’s distinctive callouses and markings. This revealed that for a pregnancy to be successful, the parents need to have very different genetic profiles. The calves’ DNA also indicated that at least 10 per cent of the male whales that had fathered offspring had not been sampled, and so were unknown: this gives hope for the future of the species as the gene pool is healthier than first imagined. The NRDPFC, in collaboration with the US National Marine Fisheries Service, is currently combining field data and DNA analysis to help locate the mating ground where the males may be found.

RESEARCH AND SERVICES

It is this type of research that sets the Centre apart from any other in Canada. It is dedicated to training, research and services in DNA profiling for wildlife conservation and statutory enforcement to aid agriculture and industry. Established by Dr Bradley White, Canada Research Chair in
INTELLIGENCE
DNA PROFILING INFRASTRUCTURE FOR CONSERVATION AND LANDSCAPE GENETICS LABORATORY

OBJECTIVES
• To provide DNA forensic evidence for the enforcements of wildlife statutes in Canada and internationally
• To carry out wildlife research in the conservation of harvested, threatened and endangered species
• To store large geographically referenced genetic databases and DNA banks for species
• To provide infrastructure for private sector research including goat genomics, chicken meat traceability and the effects of extracting Alberta oil sands on exposed wildlife DNA

PARTNERS
Marine mammal research: Canadian Department of Fisheries and Oceans • US National Marine Fisheries Service • New England Aquarium in Boston • Forensic services: Ontario Ministry of Natural Resources Enforcement Branch; Enforcement Branch of Environment Canada • Monitoring: Ontario Ministry of Natural Resources • Centre for Disease Control and Prevention (CDC) • US Fish and Wildlife Service

FUNDING
Canada Foundation for Innovation (CFI) • Ontario Innovation Trust (OIT) • Ontario Ministry of Natural Resources, Natural Sciences and Engineering Research Council of Canada (NSERC) • Department of Fisheries and Oceans • Canadian Wildlife Service • Parks Canada • Environment Canada • World Wildlife Fund for Nature (WWF) • Chicken Farmers of Canada • Ontario Goat Centre of Excellence

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BRADLEY WHITE is Director of the Natural Resources DNA Profiling and Forensic Centre (NRDPFC) and Professor of Biology at Trent University. He obtained his BSc in Botany at Nottingham University, UK, in 1967, before emigrating to Canada and obtaining his PhD at McMaster University in 1971. In 2009 he became Chair of Biology at Trent University to geographically unite the department in a new 40,000 ft² addition to the DNA Building.

Conservation Genetics and Biodiversity, NRDPFC represents a longstanding partnership between Trent University and the Ontario Ministry of Natural Resources (OMNR).

The NRDPFC infrastructure includes a state-of-the-art environmentally controlled greenhouse, animal necropsy facilities, ancient DNA laboratory, Level III biocontainment facility, an automation facility and other laboratories for genomics to allow for the successful analysis of DNA and the exploration of plant and wild animal disease. Additionally, it provides support to graduate student and faculty research, OMNR and other government agencies, as well as industrial research programmes. NRDPFC investigations span a wide range of species and topics: diseases that affect wildlife and how they develop; genetic profiling for conservation and recovery of small populations and endangered species; genetic shifts in populations of wild animals; the impact of landscape changes, such as road construction on animals’ behaviour and their interrelationships; and ancient or historic genes to aid conservation of plants and animals. The NRDPFC also provides services for the analysis of biological samples collected by private individuals, researchers, industry, law enforcement and develops new biotechniques to aid investigations.

SMALL POPULATION
The scope of NRDPFC activities extends beyond Canadian borders. For example, White, along with former student Dr John Wang and their team of Trent undergraduate and graduate students, helped to ensure that the pink dolphins of the Eastern Taiwan Strait (ETS) were designated protection against extinction. Wang discovered a small group of up to 100 Indo-Pacific humpbacks in the ETS. After three years of investigation, the group confirmed that the dolphins in the Strait were indeed distinct from populations on the coast of China, such as those around Hong Kong. The analysis led to a Critically Endangered status, which encourages Taiwan to impose restrictions on economic activities that may harm its future survival. Additionally, it gave the evidence base for the small population of dolphin, species designated into threat levels of landscape changes, such as road construction on animals’ behaviour and their interrelationships; and ancient or historic genes to aid conservation of plants and animals.

A more recent project, led by Dr Kaela Beauclerc, addressed the question of genetically rescuing an inbred captive population of the Critically Endangered Puerto Rican crested toad (the first amphibian to be included in the American Association of Zoological Parks and Aquariums’ Species Survival Plan) by mixing toad lineages and the decline in Pelee Island populations of the Blanchard’s cricket frog. Toronto Zoo has established a breeding colony as part of the multi-agency Canadian Blanchard’s Cricket Frog Recovery Plan. In support, the NRDPFC is developing genetic profiles of historic Pelee Island frogs alongside those of frog populations that still exist in parts of the US, like the Puerto Rican crested toad, to determine genetic variation and divergence. The objective is to ensure the preservation of the new frog population through captive breeding and habitat creation by improving gene pool diversity.

WILDLIFE DNA FORENSIC LABORATORY
The forensic laboratory uses automation to extract, isolate and profile DNA using a range of molecular markers. The facility consists of a compact next-generation genome sequencer, two high-throughput sequencers, four automated liquid handlers, storage freezers and numerous thermal cyclers to apply quantitative polymerase chain reactions (PCRs). Thus, the laboratory can deliver DNA isolation, real-time quantification and sampling, as well as DNA profiling and sequencing. The Centre also offers a high-yield DNA extraction service for genomics applications.

Though markers may differ between species and objectives, procedures are standardised, automated and developed to improve efficiency, sensitivity and reliability. These include fluorescent labelling for detection, identification and assessment of variation at functional and neutral DNA regions such as microsatellite loci.

The laboratory undertakes analyses to provide agencies with information on the number and distribution of animals. The emphasis is on non-invasive means of obtaining samples. Describing work with the OMNR to monitor the black bear population, White explains: “We extract DNA from bear hairs that are taken by wire traps baited with sardines and from furs harvested by licensed trappers that are sold by large auction houses”.

From analysis of DNA in the scat of wolves and coyotes, White and his team recently identified that the coywolf was a hybrid, part eastern wolf, part western coyote; having originated in south western Ontario and expanded south of Algonquin Provincial Park, the coywolf can now be found as far away as Cape Cod and Newfoundland. Other analyses of wolf scat and hair found in the Park showed that pack formation behaviour disturbed by hunting were restored following a ban.

The laboratory has processed more than 1,000 statutory enforcement cases to date for the OMNR and other Canadian and international agencies, such as the Royal Canadian Mounted Police, Environment Canada, the International Fund for Animal Welfare and the US Humane Society. Cases have included illegal hunting of moose, black bear, rainbow trout and white-tailed deer, and pinpointing the source of ingredients in certain products used for alternative Asian medicines.

Trent University’s ethos of ‘challenge the way you think’ rings true at its Centre for Natural Resources DNA Profiling and Forensics. With new premises and a wealth of technology at its fingertips, the Centre and all those who frequent it stand at the leading edge of discovery, helping to conserve species and improve the knowledge base of the global scientific community.