



One Mission

One Health

One Home

**Saint Louis Zoo Institute for
Conservation Medicine**

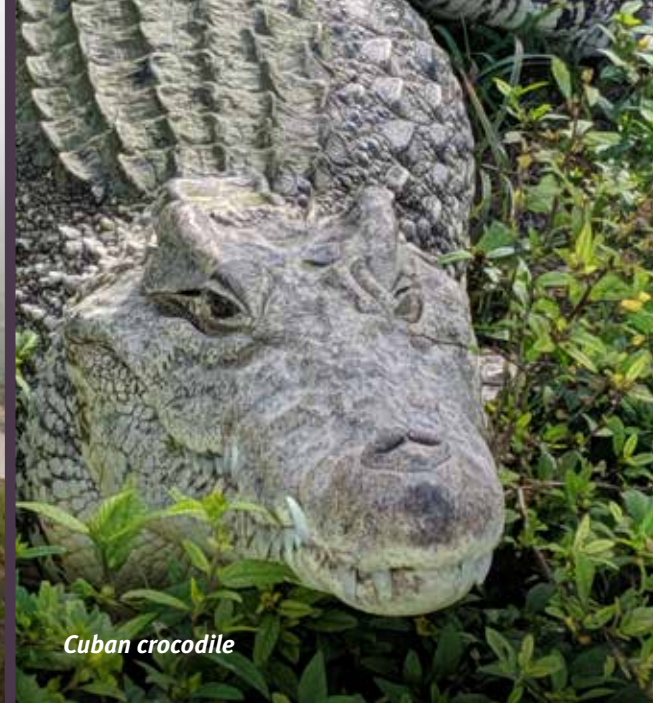
10-Year Report



 **Saint Louis Zoo**
Institute for Conservation Medicine™



Members of the Galapagos Tortoise Movement Ecology Programme team tracking tortoises on Alcedo Volcano, Galapagos



Cuban crocodile

In celebration of 10 years of the Saint Louis Zoo Institute for Conservation Medicine (ICM), we are happy to share this report highlighting the many accomplishments of the ICM during its first decade. **Launched in September 2011, the ICM was founded to expand upon the Saint Louis Zoo's internationally renowned successes in wildlife conservation and zoological veterinary medicine. When we first conceived of the ICM, the idea was simple — develop a department dedicated to health research that helps the conservation of wildlife and wildlands, and that is founded on a holistic approach to ensuring healthy animals and healthy people.**

In its first 10 years, what began as a department of one has grown to a team of nine that is now recognized as a leader, both nationally and globally, in conservation medicine and One Health. In fact, the ICM helped establish the groundwork for Association of Zoos and Aquariums institutions to be key players in One Health. The ICM now serves as a template for zoos and aquariums around the world as they seek to develop similar programs and departments within the growing conservation medicine and One Health movements.

As you will learn in the following pages, the ICM staff has conducted research, outreach and capacity-building programs in seven countries, including several based here in the U.S. At the same time, the ICM team has trained hundreds of undergraduate and graduate students and introduced One Health concepts to thousands of K-12 schoolchildren, from Missouri to the Galapagos Islands. The motivation behind all of this work has been to enhance wildlife conservation, human public health and environmental sustainability. The ICM's work has one purpose: to benefit the health of all life on Earth.

Reflecting on the first 10 years of the ICM has allowed us to appreciate how much we have accomplished to advance animal, environmental and human health. It has also made abundantly clear the work that lies ahead as the Saint Louis Zoo enters its second decade as a One Health leader working to ensure quality health for all who reside on this planet.

Sincerely,

Jeffrey P. Bonner, Ph.D.
Dana Brown President & CEO, Saint Louis Zoo

Michael Macek, BS, MBA
Director, Saint Louis Zoo

Sharon L. Deem, DVM, Ph.D., DACZM
Director, Saint Louis Zoo Institute for Conservation Medicine



Resident African white-backed vulture at VulPro in South Africa



Dr. Sharon Deem inspects a blood sample collected from a giant tortoise on Alcedo Volcano, Galapagos



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Dr. Sharon Deem examines a lemur in Madagascar



Adult red-eared slider at the Saint Louis Zoo WildCare Park

Our Mission

The Saint Louis Zoo Institute for Conservation Medicine takes a holistic approach to wildlife conservation, public health and sustainable ecosystems to ensure healthy animals and healthy people.

Our Vision

The Saint Louis Zoo Institute for Conservation Medicine continues to be a leader in global wildlife health and the conservation of biodiversity through a transdisciplinary One Health approach to ensure healthy animals, people and the planet.

What are Conservation Medicine and One Health?



• **Conservation medicine** is an emerging, interdisciplinary field to study the relationship between human and animal health and environmental conditions.

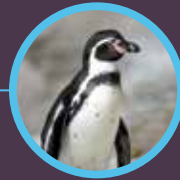
• **One Health** is an approach that recognizes that the health of people is closely connected to the health of animals and our shared environment. It is the collaborative effort of multiple disciplines, working locally, nationally and globally, to attain optimal health for people, animals and our environment. Relevant players in a One Health approach include professionals in:

- Human health (doctors, nurses, public health practitioners, epidemiologists)
- Animal health (veterinarians, paraprofessionals, agricultural workers)
- Environment-related fields (ecologists, wildlife experts)
- Human behavior-related field (sociologists, anthropologists)



Healthy Environments

The health of animals and humans is dependent on the environments that support all life. We need healthy land, water and air to ensure healthy animals and healthy people.



Healthy Animals

The health of animals is key to their survival and to ensuring healthy environments and people.



Healthy People

Public health is inextricably linked to the health and conservation of wildlife and wildlands. All aspects that affect animal and planetary health also affect human health.

Human-related environmental changes have escalated in recent years, threatening animal and human health as well as all ecosystems on Earth. On a global scale, the human population growth to 8 billion, with the associated habitat fragmentation and degradation, increased travel and trade, and climate change, has an impact on the health of all species. For example, as humans (and their domestic animals) move closer to wildlife populations and into wild lands, disease risks to wildlife, domestic animals and humans increase.

However, there is hope.

Using a transdisciplinary conservation medicine approach, we are finding solutions to some of these major conservation and health challenges. The Institute for Conservation Medicine plays a significant role in conservation medicine and One Health initiatives through conservation research, applied conservation, outreach and education.

Where We Work

We conduct scientific research, provide educational opportunities and perform conservation actions globally. From the many projects we lead right here in our home state of Missouri, to projects throughout South America and Africa, we work tirelessly to ensure good health for animals and people.



1. Native Turtles, Water Quality, Native Canids and Human Connections with Nature



2. Cuban Crocodiles



3. Galapagos Tortoises



4. Humboldt Penguins



5. Arbovirus Surveillance



6. Bolivian River Dolphins



7. Dromedary Camels



8. African Vultures



9. Lemurs & Tortoises



**A 10-Year
Timeline:
Saint Louis Zoo Institute
for Conservation Medicine
and One Health Events**

2011

ICM established with Dr. Sharon Deem as the first director



2011

The United Nations Population Fund designates October 31 as the day on which the world's population reached 7 billion people

2012

ICM and partners launch the St. Louis Box Turtle Project



2012

ICM hosts its first One Health Fair at the Saint Louis Zoo, which continues annually



2012

The largest West Nile virus outbreak in the U.S.; 5,674 cases worldwide

2012

Lonesome George, the last Pinta giant Galapagos tortoise, dies, rendering his species extinct



2012

The first case of camel-associated Middle Eastern Respiratory Syndrome (MERS) is reported in a person in Jordan

2012

ICM initiates the Dromedary Camel Health project in Kenya

2013

ICM joins the Galapagos Tortoise Movement Ecology Programme



2014

Chikungunya pandemic

2014 – 2016

The largest Ebola outbreak in history; the fatality rate reaches 70% in 2015-2019. Outbreak of measles in 24 states, the majority of cases occurred in unvaccinated individuals.

2015

ICM begins partnering with Dr. Lilian Catenacci on her arbovirus program in Brazil focusing on Zika, chikungunya, yellow fever and dengue viruses

2015

Dr. Deem and colleagues publish findings of MERS-CoV antibodies in dromedary camels in Kenya



2015

New species of Galapagos tortoise discovered through genetic testing



2015 – 2016

Widespread Zika virus epidemic erupts in Brazil and spreads throughout South America

2016

Warmest year on record to date

2016

Senator Al Franken of the Senate Health Committee introduces the National One Health Act of 2016, which calls for a “national, interagency One Health Program to address infectious diseases in animals and the environment, and to help prevent the transmission of known and emerging infectious diseases between animal populations and human populations”

2018

Dr. Maris Brenn-White joins ICM as the first ICM Research Fellow

2018

Establishment of the Center for Chelonian Conservation, Cuban Crocodile Program and the Canid Conservation Initiative through the Saint Louis Zoo WildCare Institute

2018

Dr. Deem begins co-teaching an undergraduate One Health course at Washington University in St. Louis, which has since been offered annually



2019

Dr. Deem co-authors the textbook, “Introduction to One Health: An Interdisciplinary Approach to Planetary Health”

2019-present:

SARS-CoV-2 pandemic appears in China in 2019 and spreads globally

2020

Tied with 2016 for warmest year on record

2020

Drs. Deem and Brenn-White host their commentary, “One Health – the Key to Preventing COVID-19 from Becoming the New Normal”

2021

10-year anniversary of the ICM

Our Team

The Saint Louis Zoo Institute for Conservation Medicine team is a group of professionals with a wide variety of expertise, including veterinary science, epidemiology, biology, education and engineering. In addition to the team in St. Louis, we also work closely with affiliates in Brazil and the Galapagos.

Sharon L. Deem
Director, DVM, Ph.D., DACZM



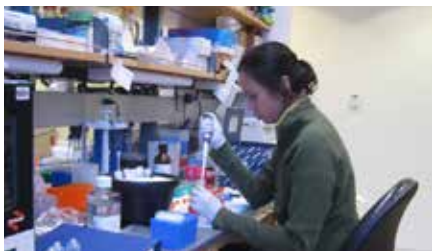
Sharon is the founding director of the ICM. She started with the Saint Louis Zoo in 2007 as the veterinary epidemiologist with the Saint Louis Zoo WildCare Institute Center for Avian Health in the Galapagos, then became the first director of ICM in September 2011. Prior to the Saint Louis Zoo, she worked for the Wildlife Conservation Society and Smithsonian National Zoo as both a clinical zoo veterinarian and an international wildlife veterinarian. A recognized expert in conservation medicine and One Health, Sharon is dedicated to training the next generation of One Health practitioners. She also co-authored the textbook, "Introduction to One Health: An Interdisciplinary Approach to Planetary Health." Her passion for conservation medicine has been the driver of her career, and she has worked on conservation medicine research projects in over 30 countries. Sharon has a special fondness for turtles, elephants and jaguars.

Jamie Palmer
Technician, M.S., B.S.



Jamie joined the ICM in February 2013 on a part-time basis and became full-time in 2020. She started at the Zoo in 2005 and has been a keeper in both the Zoo's Animal Health and Antelope Departments. Jamie's main research involves the movement and health of box turtles and health assessments of aquatic turtles in Missouri. Her expertise is in field and lab techniques, with a focus on reptile hematology. Jamie also is the co-director of the Saint Louis Zoo WildCare Institute Program for Crocodile Conservation in Cuba. Outside the U.S., she has worked in Galapagos, Peru and Cuba. Like Sharon, Jamie is particularly passionate about turtles!

Kathleen Apakupakul
Research Associate, M.A., M.S., B.A.



Kathleen joined the ICM in October 2015 with her first three years funded by Washington University School of Medicine. Before the ICM, she was a research scientist and lab manager at the University of California-San Francisco and Virginia Tech, and she also served with AmeriCorps.

Kathleen manages the ICM's molecular laboratory with a focus on infectious disease diagnostics. She is a strong proponent of capacity building and developed a mobile molecular lab for use at field sites outside the U.S., expanding our diagnostic capabilities and providing training for in-country researchers.

Keri Lammering
Conservation Education Liaison, B.S.



Keri has been the conservation education liaison with the ICM since 2014. She joined the Zoo's Education Department in 2004, and prior to that, she worked as a naturalist and a high school biology teacher. Keri's expertise is informal education (learning outside a structured curriculum). She loves to connect learners of all ages with the natural world. She leads ICM outreach projects, including our annual One Health Fair. Keri has built relationships with many local school districts, leading students in turtle safaris that take them into the woods to track box turtles. She is passionate about sharing the One Health message.

Maris Brenn-White
Research Fellow, MPVM, DVM, B.A.



Maris joined the ICM in 2018 for a three-year research fellowship generously funded by an anonymous donor. As a wildlife veterinarian and epidemiologist, her broad experiences in conservation medicine and One Health have allowed her to merge her interests in global human health, conservation and wildlife populations. Maris has worked on projects as varied as HIV/AIDS prevention in Africa, mountain gorilla health, surveillance of avian influenza in gulls, and canine distemper spillover from domestic hunting dogs to jaguars in Nicaragua. Maris hit the ground running with the ICM in 2018, conducting research at the intersection of wildlife, domestic animal, human and ecosystem health, including camel health in Kenya, assessments of confiscated radiated tortoises in Madagascar, vulture poisoning in South Africa and infectious diseases in Missouri turtles. Her full-time fellowship position ends in 2021.

Kathy Zeigler
Program Manager, MBA, P.E., B.S.



After two years of volunteering with the ICM, Kathy joined the team as a part-time program manager in March 2019. Kathy is a chemical engineer, and prior to the Zoo, she was a remediation project manager at Medtronic, working collaboratively with regulatory agencies and local communities to develop solutions that met all stakeholder needs.

Kathy helps obtain research permits, manages the ICM budget, assists with grant writing and provides updates on ICM work through our newsletters and the Zoo website.

Ainoa Nieto Claudin
Wildlife Veterinarian, Galapagos, Ecuador; Ph.D. candidate; DVM; M.S.



Ainoa is a wildlife veterinarian currently leading the in-country tortoise health work for the Giant Tortoise Movement Ecology Programme in the Galapagos Islands, Ecuador. Her position is partially funded by the Charles Darwin Foundation and Galapagos Conservation Trust. After completing her DVM degree in Madrid, Ainoa worked with wildlife rescue centers in Costa Rica and Colombia before moving to Galapagos to work in one of the most pristine reserves in the world. In 2017, she joined the Charles Darwin Foundation and started her Ph.D. under Sharon's direction. She will complete her dissertation in 2022, after which she will continue working as a One Health practitioner.

Fernando Najera
Research Fellow, Ph.D., DVM, M.S.



Fernando joined the ICM in 2021 for a two-year postdoctoral position with the Saint Louis Zoo WildCare Institute Canid Conservation Initiative. He earned both his veterinary degree and Ph.D. in wildlife physiology in Madrid and completed an internship in zoological, exotic and wildlife medicine at Oklahoma State University.

Before joining the ICM, Fernando worked on conservation projects around the world, including the study of free-ranging Sunda clouded leopards in Malaysia, an *ex-situ* (off-site conservation) captive breeding program for clouded leopards and fishing cats in Thailand, wolf conservation in Idaho, and the reintroduction of Iberian lynx in Spain. Fernando is passionate about free-living canid medicine and conservation. While with the ICM, he will lead research on the ecology and health of the canid guild in ecologically distinct landscapes in the St. Louis region.

Lilian Catenacci
Adjunct Scientist and Professor, Ph.D., DVM, M.S.



As part of the Saint Louis Zoo Research Affiliate Program, Lilian has been an adjunct scientist with the ICM since 2020. She is also a professor of clinic and wildlife management at the Federal University of Piauí State, Brazil. Lilian was an extern at the ICM and the Biology Department at the University Missouri-St. Louis from 2015 to 2016. She specializes in wildlife management, conservation medicine and One Health approaches. Her focus is on arbovirus infections in wildlife and human populations in and around protected natural areas of north-eastern Brazil.

We have accomplished a lot in 10 years, but there is much more to be done. We look forward to continuing our research to address the challenges that threaten the survival of wild animal species and negatively impact human public health.



Juvenile red-eared slider at the Saint Louis Zoo WildCare Park



Zoo staff member Amy Niedbalski preps a participant for the Zoo's human health benefits study

Conservation Research



Jamie Palmer tracks a box turtle in Forest Park



Dr. Lilian Catenacci interviews an arbovirus study participant in Brazil

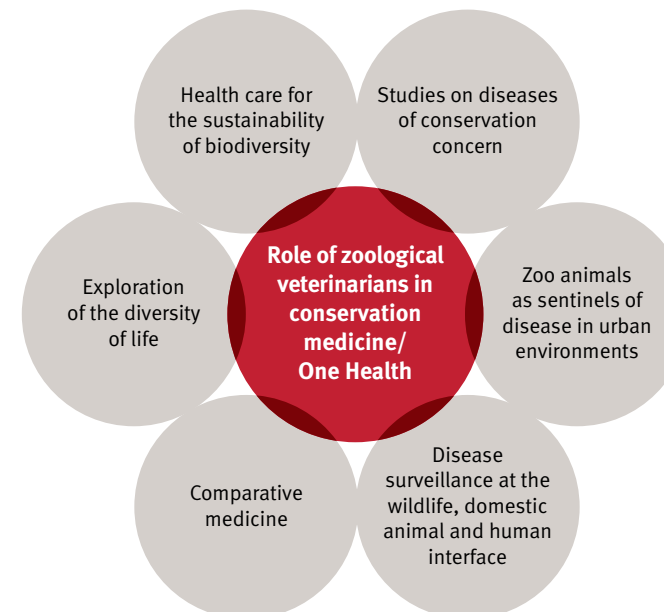
Conservation Research

The Role of Zoos in One Health

One Health is a collaborative and transdisciplinary approach — working at local, national and global levels — to achieve optimal health outcomes for people, animals, plants and their shared environments. Within this growing movement, the role of zoos in advancing optimal health outcomes for animals, humans and environments has become increasingly appreciated. This is largely due to the efforts of the Institute for Conservation Medicine.

Institute for Conservation Medicine Director Dr. Sharon Deem has been at the forefront of advocating for the role of zoos and aquariums in the One Health movement since she delivered her first presentation as ICM Director at the United Nations in Ethiopia: “The Role of Zoological Parks in One Health.”

Since that time, the ICM has published extensively on the importance of zoos and aquariums within One Health in scientific peer-reviewed publications, textbooks, magazines and more. Within a 2015 textbook on zoo and wild animal medicine, Sharon authored a textbook chapter entitled, “Conservation Medicine to One Health, The Role of Zoologic Veterinarians.” In the chapter, Sharon outlined the specific roles that zoological institutions can and should play in tackling health threats to the conservation of wildlife species and the resilience of wildlands, all while considering human public health (see below).



In the past six years, the ICM has added a new One Health role to this list through our studies demonstrating health benefits gained by visitors to the Saint Louis Zoo (see page 12). This work highlights the economic and recreational benefits that zoo campuses offer communities and individuals by supporting mental and physical human health. These benefits became all too clear during the COVID-19 pandemic when simply being outside and enjoying nature provided much-needed relief and restoration for so many of us.



Participants prepare to touch stingrays as part of a study on how a Zoo visit benefits human health

In addition to the many textbooks, scientific peer-reviewed publications and magazines that have featured our work regarding the One Health movement, our team has delivered nearly 1,000 presentations, webinars and university lectures on One Health. This includes the semester courses offered at the Danforth Campus of Washington University in St. Louis and in the Master of Public Health program at the University of Missouri-Columbia. Sharon’s TEDx presentations on One Health also showcased the importance of biodiversity and conservation within the One Health movement.

All of this advocacy and outreach has created positive change. In 2020, the ICM published a study entitled “Conservation medicine and One Health in zoos: Scope, obstacles, and unrecognized potential” that demonstrates the growth of conservation medicine and One Health programs within zoological institutions. Many of these programs were inspired by and based upon the Saint Louis Zoo’s example of how we, as zoo professionals, have operationalized One Health to ensure healthy animals and healthy people.

Human Health Benefits from Nature and Animals

One Health is not just a reminder of how humans and animals share infectious diseases, or how environmental health is a necessity if we want to have healthy humans and animals. One Health is also about the positive health connections of animals and humans. We know that people have an innate affinity for nature. We call this biophilia: “bio” for life and “philia” for love. This love of life is more than just a warm feeling, although that too is part of this affinity to other life forms. Studies are increasingly showing these human health benefits resulting from our relationship with nature, and that these benefits span our emotional, psychological, spiritual and even physical health. You may have heard of “forest bathing” as one example of how being in nature can make you feel physically and mentally healthier. And, we heal faster if resting in a hospital bed that faces a window with a park or forested area versus a building or a concrete wall.

The Institute for Conservation Medicine has added to these studies on the human health benefits of nature by demonstrating how a visit to the Saint Louis Zoo just might make you healthier. We show that a Zoo visit may reduce stress for our guests. These findings take on additional meaning in this age when humans are becoming increasingly disconnected from nature. Along with the Zoo’s Reproductive and Behavioral Sciences Department, the Education Department, and the Conservation Audience Research and Evaluation Department, as well as our partners from Washington University in St. Louis and the University of Missouri College of Veterinary Medicine, we have published two research studies that indicate several health benefits.



Dr. Sharon Deem with a human health study participant and her child

In one study, we found that people were less tense and more energetic after 10 minutes of touching and feeding stingrays at the Stingrays at Caribbean Cove presented by SSM Health exhibit. In the second study, we found a decrease in blood pressure and cortisol, as well as the same psychological benefits seen in the first study, resulting from a walk through the immersive River’s Edge exhibit. Taken through a One Health lens, these human health benefits from a visit to the Zoo are an example of an important role the Saint Louis Zoo plays in supporting public health in our community. These studies truly do show that visiting the Zoo may be just what the doctor ordered.

Turtles and Tortoises



Three-toed box turtle in Forest Park

Throughout our first 10 years, the Institute for Conservation Medicine staff has conducted chelonian — turtle and tortoise — health and conservation research globally. Turtles are cool creatures that play an important role in keeping the habitats where they live healthy. Unfortunately, turtle species are disappearing around the world due to factors that include infectious diseases, habitat destruction, environmental degradation and illegal wildlife trafficking. In fact, chelonians are the most threatened group of vertebrate species on Earth.

The ICM is advancing the science necessary to understand the threats to turtle and tortoise survival. We started by initiating the St. Louis Box Turtle Project in the spring of 2012, then becoming a collaborating partner in the Galapagos Tortoise Movement Ecology Programme in 2013. In addition to these initiatives, we work with



ICM Intern Sam Holmes conducts aquatic turtle surveys at the Saint Louis Zoo WildCare Park

aquatic turtle species in Missouri and radiated tortoises in Madagascar. Through these projects, we have introduced thousands of students of all ages to the wonders of turtles and the importance of ensuring their conservation for years to come.

Missouri Turtles

Missouri is home to 18 turtle species that live in our waterways, forests, prairies, backyards and even our city parks. As with turtle species around the globe, Missouri’s turtles are declining, but their conservation status is not well understood. In the spring of 2012, the Institute for Conservation Medicine launched the St. Louis Box Turtle Project to learn more about native box turtles and the conservation challenges they face.

The core of the St. Louis Box Turtle Project is a long-term study primarily of three-toed box turtles at two sites: Forest Park (a large urban park in the middle of St. Louis) and Washington University’s Tyson Research Center (a protected oak-hickory forest 20 miles outside the city). Through this project, we have met over 400 box turtles; followed the movements and survival of 52 box turtles using radio telemetry; and developed baseline health parameters for these understudied species, including known and previously undocumented diseases of conservation concern. By comparing the health, movement and ecology of turtle populations at both sites, we identify environmental factors impacting the turtles, other wildlife and humans alike. These box turtles have also served as ambassadors for native wildlife conservation to over 1,500 local school children (see page 29) and countless Zoo guests who have tracked box turtles with the St. Louis Box Turtle Project over the years.

During our population and health surveys in 2020, we sampled 283 aquatic turtles of eight species and found the first evidence of ranavirus in aquatic turtles in Missouri.

Inspired by an invitation from Forest Park Forever, we expanded our focus in 2017 to include native aquatic turtles. In preparation for the restoration of Forest Park’s waterways, the ICM was recruited to catch and move turtles from the restoration area. This was the beginning of catching, marking and performing health assessments on snapping turtles, red-eared sliders and other aquatic species in Forest Park. By studying the health of these turtles, we can learn about the health of the urban waterways they inhabit just as the box turtles teach us about the lawns, prairies and forests of Forest Park.

With the establishment of the Saint Louis Zoo WildCare Park (the Saint Louis Zoo’s 425-acre property in north St. Louis County) we took this same approach to learn about the turtles on that property. During our population and health surveys in 2020, we sampled 283 aquatic turtles of eight species and found the first evidence of ranavirus in aquatic turtles in Missouri. Ranavirus is an infectious disease that causes serious epidemics in fish, amphibians and reptiles (especially box turtles), though some turtle species can be infected by the virus and never get sick. In 2021, we are conducting a multi-species study in amphibians and turtles, aquatic and terrestrial, to learn more about ranavirus at this site and understand how the Zoo can be the best possible stewards for the free-living animals at the WildCare Park as well as those that will be under human care when the WildCare Park opens.



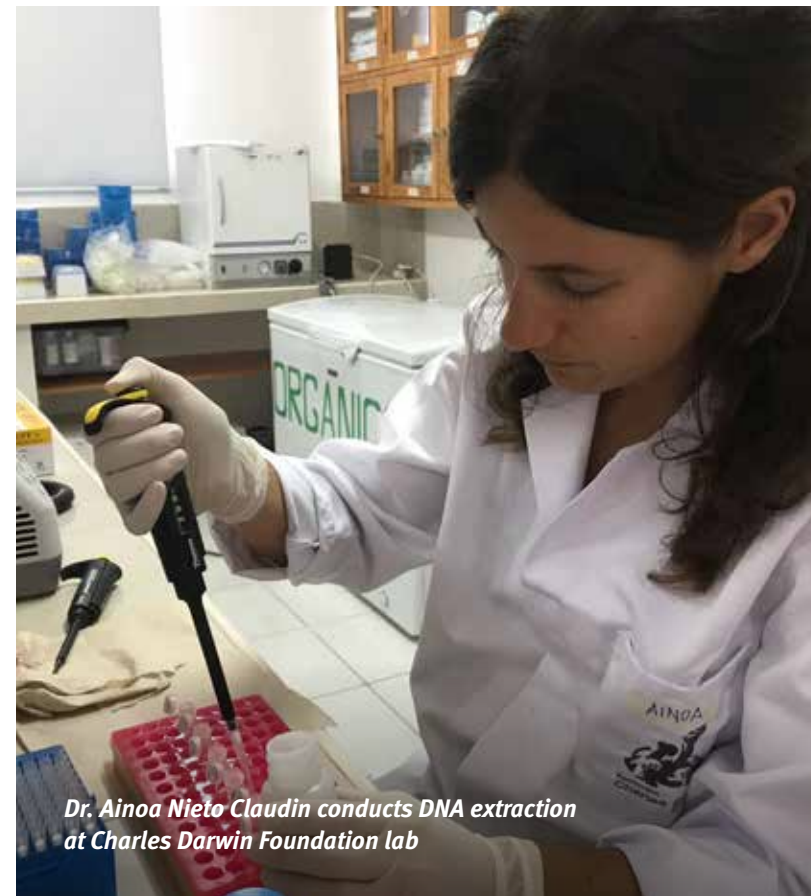
Giant tortoise on Alcedo Volcano, Galapagos

Galapagos Tortoises

In 2013, the Institute for Conservation Medicine joined efforts with the Charles Darwin Foundation, the Galapagos National Park Service and Max Planck Institute for Animal Behavior as a collaborating partner in the Galapagos Tortoise Movement Ecology Programme. This initiative began in 2009 with a scientist, Dr. Stephen Blake; a notebook; and a bicycle. At that time, the objective was to understand tortoise movement. Then starting in 2013, with the involvement of the ICM, we were able to bring a veterinary perspective to the Galapagos Tortoise Movement Ecology Programme and advanced health studies of free-living tortoises while also building capacity in One Health for local and international students and volunteers.

In the past eight years, the Galapagos Tortoise Movement Ecology Programme has performed physical examinations and collected biomaterials for laboratory diagnostics of hundreds of giant tortoises throughout the Galapagos. This includes the 100 tortoises with GPS tags that we monitor over time for movement and health. The health studies have varied over the years but all focus on understanding the health of different populations of giant tortoises in relationship to human presence in the archipelago. Studies range from determining best methods of hematological testing, plastic pollution impacts on tortoise health, reproductive fitness and health in relationship to movements, and hatchling survival.

In 2017, Dr. Ainoa Nieto Claudin joined the program to work on her Ph.D. dissertation. Through these studies, we have now described the first detection of antimicrobial resistance genes in Galapagos tortoises and how these differ based on human presence, as well as the presence of viruses of conservation concern. We lead the detection of pathogens of conservation concern for turtles and tortoises using our mobile laboratory at the Charles Darwin Research Station. We have now tested more than 400 tortoises from four islands and five species for diseases (including adenovirus, herpesvirus, ranavirus and mycoplasma).



Dr. Ainoa Nieto Claudin conducts DNA extraction at Charles Darwin Foundation lab

Radiated Tortoises

In 2020, the Institute for Conservation Medicine expanded its chelonian conservation programs to include Madagascar's critically endangered radiated tortoise. Over 24,000 radiated tortoises destined primarily for the illegal pet trade have been confiscated in recent years and are currently cared for by the Turtle Survival Alliance.



Free-living radiated tortoise in Madagascar

In preparation for the first large-scale release of these confiscated tortoises back into the wild, Saint Louis Zoo staff members Dr. Maris Brenn-White (ICM Research Fellow) and Jane Merkel (Zoological Manager of Animal Health), as well as veterinary staff from the Wildlife Conservation Society, performed veterinary exams on over 1,000 tortoises to ensure that healthy animals are selected for release. The team also performed a suite of standard bloodwork for 136 of these tortoises and 20 wild tortoises in the adjacent Ala Mahavelo Forest. Along with providing in-depth health screenings for a subset of the pre-release tortoises, we used these results to determine normal blood values and optimal field hematology methods for this species. This baseline biomedical information is a valuable tool for improving our understanding and care of radiated tortoises from confiscation to release and beyond. This work was the first project of a growing collaboration between the Turtle Survival Alliance, the Wildlife Conservation Society and the Saint Louis Zoo to support radiated tortoise conservation in Madagascar.

1,000

radiated tortoises confiscated from the illegal pet trade that received health assessments prior to release into the wild in Madagascar

Next we will focus on building capacity for diagnostic testing of radiated tortoises and other endangered chelonians in Madagascar. Having this capacity in-country will massively improve the speed and cost of health screenings for confiscated tortoises while redirecting financial and educational resources to Malagasy scientists. As soon as COVID-19 restrictions allow, ICM Research Associate Kathleen Apakupakul will travel to Madagascar to train students in molecular diagnostic techniques and get the needed tests up and running at Mahaliana. This is a laboratory, research, and training center founded by Dr. Fidisoa Rasambainarivo,

Turtle eggs incubated at male-producing temperatures are feminized if exposed to BPA during first stages in life. These studies add to our understanding of how EDCs can cause harm to animal and human health.

our collaborator for this initiative and affiliate scientist of the Saint Louis Zoo WildCare Institute Center for Conservation in Madagascar.

Impact of Endocrine Disrupting Chemicals

Working with our partners at the University of Missouri-Columbia, the United States Geological Survey and Westminster College, we have conducted several studies to explore the impact of endocrine disrupting chemicals (EDCs) such as bisphenol-A (BPA) on the reproductive systems and general fitness of aquatic turtles. These are true One Health studies since turtles are sentinels of the negative impacts of EDCs on other animals and humans, with these impacts affecting primarily the nervous and reproductive systems.

In our work, we demonstrate that when turtles in their first stages of life (in an egg) are exposed to BPA, their sex can change due to chemical exposure during incubation. How can this be, you ask? Many turtles have a temperature-dependent sex determination, with cooler temperatures during egg incubation resulting in males and warmer temperatures resulting in females. However, we have shown that eggs incubated at male-producing temperatures are feminized if they are exposed to BPA during this time.

These studies add to our understanding of how EDCs are causing great harm to animal and human health. With the increase in production of BPA and other EDCs, mostly tied to the increased use of plastics, we are just now unraveling the hidden health cost of these chemicals. They pose a risk to environmental health, wildlife conservation and human public health, a true example of a One Health challenge.

Molecular Lab

In addition to the education and field research work that is crucial to our programs, our current and future conservation work relies heavily on laboratory science and molecular tools. In 2017, we established the Institute for Conservation Medicine molecular research laboratory to open the door to the potential of developing our own research to diagnose new diseases and for advancing zoo science. In our vision, this laboratory takes two basic forms: as an in-house entity to conduct work on-grounds and as a mobile lab to make molecular diagnostics available for our field operations. We focus on molecular diagnostics of diseases of conservation concern, research and capacity building.



Kathleen Apakupakul processes a tissue sample in the ICM molecular lab



Kathy Zeigler and Dr. Maris Brenn-White conduct water quality tests

Diagnostic testing is imperative for determining prevalence and patterns of disease infection and spread. The ICM's first foray into molecular diagnostics focused on testing turtle pathogens of conservation concern for our Forest Park snapping turtles and St. Louis Box Turtle Project studies using established polymerase chain reaction (PCR) protocols. We have since expanded our molecular diagnostic portfolio, which now includes several infectious agent tests for various animal taxa and for environmental DNA (eDNA) testing of environmental samples (e.g., water or soil).

Along with diagnostic work at our Zoo laboratory, we also conduct research on-site. The ICM is unique in that our work involves wildlife, people, and animals in human care, and so we need the ability to identify novel diseases as they arise, which is important in order to deal with pathogen spread as well as for research purposes. Much of our molecular work can now be performed at field sites. We have developed a mobile lab, which allows us to bring the lab to the field. This obviates the need to acquire permits to export samples for testing and keeps all sample processing in-country, which also provides the added opportunity and benefit of training local scientists. In February 2018, we piloted this mobile lab at our field site in Galapagos. We transported laboratory equipment to the Galapagos, where ICM Research Associate Kathleen Apakupakul spent two intense weeks training wildlife veterinarian Dr. Ainoa Nieto Claudin in molecular diagnostic testing of Galapagos tortoises. Consequently, Ainoa has been able to transfer these skills to several of

her local students and volunteers. It is our hope that this skill acquisition will maintain locals as the stewards of the wildlife where they live, with less reliance on scientists from developed countries. Our next step is to travel to Madagascar to provide similar scientific capacity building training to our partners at Mahaliana Labs.

Only a few zoological institutions have supported the development of an internal molecular lab and research program. As the ICM works to develop One Health collaborations in the Midwest, we also strive to be the Midwest's leader in conservation medicine research among zoos, which includes the development of our own, autonomous, research lab.

Zoonotic Diseases

Zoonoses — diseases transmitted between human and non-human animals — are one of the central One Health challenges to ensuring healthy animals and healthy people. The COVID-19 pandemic has been a devastating experience of what can happen when a new zoonotic disease emerges and is only the most recent example of a number of emerging disease events.

The timeline on page 6 shows many of these emerging diseases amongst the key One Health events over the past 10 years. Inspired by the understanding that our interactions with wildlife play key roles in disease cycles that can place human health and conservation at risk, the Institute for Conservation Medicine has been working to understand and address zoonotic diseases since its inception. This means not only discovering diseases present in wildlife and domestic animals that may infect people, but also how humans drive zoonotic disease emergence when we disrupt intact ecosystems through unregulated wildlife



trade, deforestation, moving our livestock into natural areas and other pathways.

Equally important is drawing attention to the effects of spillover events that move in the opposite direction — from humans to wildlife — as highlighted in our systematic review of disease spread from humans to endangered great apes. In our commentary, “One Health – the Key to Preventing COVID-19 from Becoming the New Normal,” we argue that a transdisciplinary approach that considers the health and interactions of environments, humans and non-human animals is essential to stemming the tide of emerging zoonotic diseases. The ICM's zoonoses research program adopts this very approach so that we can leverage knowledge gained to prevent human and animal pandemics and develop sustainable solutions that acknowledge the interconnectedness of all life on our planet.

Dromedary Camel Health in Kenya

As climate change has made parts of Kenya hotter and drier, dromedary camels have rapidly become the “new cow” due to their ability to thrive in drought conditions and still produce plentiful, nutritious milk. As camels expand into new parts of the country, so does the risk of transmission of camel-borne diseases to people and wildlife that encounter camels. Understanding this risk and ensuring camel health is a key part of ensuring healthy food for Kenyans and protecting Kenya's rich and diverse wildlife. These goals are at the heart of the Institute for Conservation Medicine's Dromedary Camel Health program, which focuses on: 1) improving camel husbandry, health and welfare; 2) researching the epidemiology of important camel diseases; and 3) training conservation medicine practitioners.

Our study of the Mpala camel herd revealed high levels of exposure to Q fever (Coxiella burnetti), an emerging infectious disease of people in Kenya.



Dr. Kisa Juma Ngeiywa helps with the Camel Health and Welfare Workshop in Kapiti, Kenya

The program was initiated in 2012 with a review of husbandry practices and health assessments of the camel herd at the Mpala Research Centre. Mpala is home not only to working livestock herds but also to many threatened and endangered wildlife species including black rhino, African elephant and Grevy's zebra, making it an ideal location for this conservation medicine research.

Our study of the Mpala camel herd revealed high levels of exposure to Q fever (*Coxiella burnetii*), an emerging infectious disease of people in Kenya, and laid the foundation for development of a camel husbandry and medicine manual for local herders. Based on these findings, we began larger scale studies on the epidemiology of Q fever in camels to understand the role they may play in cross-species transmission between livestock, wildlife and humans in the region.

Shortly thereafter, camels were identified as the likely reservoir species for Middle Eastern Respiratory Syndrome coronavirus (MERS-CoV), which emerged in a series of epidemics throughout the Middle East. Turning to Kenya, we found that 46.9% of our study camels had evidence of exposure to MERS-CoV. Fortunately, the Kenyan strain appears distinct from the Middle Eastern strain and

currently has low zoonotic potential. Despite the warning of MERS-CoV, many zoonotic diseases of camels remain understudied in Kenya and elsewhere. To identify and draw attention to these, we and our Smithsonian colleagues published a systematic review of the zoonotic pathogens of dromedary camels globally that will help guide future research efforts of camel health.

Arboviruses in Brazil

Brazil's forests are home to amazing biodiversity that includes animals, plants and microbes. When healthy themselves, these species help to keep rural populations of humans safe and healthy. However, with recent and ongoing deforestation, urbanization, and drastic environmental change, the human population has become exposed to infectious agents, in particular, zoonotic pathogens that may lead to clinical disease. In Brazil, zoonotic arboviruses (diseases transmitted by mosquitoes) such as dengue, Zika, yellow fever and West Nile viruses have become a significant concern for conservationists. For example, the yellow fever outbreak in 2019 caused great suffering for humans but also affected more than 15 primate species, 11 of which were already endangered.



A veterinary student collects samples for Dr. Lilian Catenacci's studies in Brazil



Dr. Lilian Catenacci examines a three-toed sloth in Brazil. The forests in this country are home to biodiversity that includes animals, plants and microbes. When healthy themselves, these species help keep rural populations of humans healthy.

To learn more about these threats and to help mitigate the negative impacts they may have on Brazilian wildlife, Dr. Lilian Catenacci, students from the Federal University of Piauí State (Brazil) and the Institute for Conservation Medicine team are evaluating the prevalence and the risk of arbovirus infections in the unique ecosystems of Brazil.

Our primary study sites are the Bahia Atlantic Forest and Caatinga Biomes. In the last five years, we have sampled more than 10,000 mosquitoes, 300 primates, 400 wild birds, 350 horses and 11 human rural communities for arbovirus testing. To date, we have discovered 15 arboviruses circulating in rural communities, 11 of which are common to both people and wild animals.

With these data, we were able to demonstrate that rural communities that exist nearest the forest in which free-living monkeys live experience less infection by viruses than those that live farther away, suggesting that primates living in the forest may have a role in reducing viral loads in human communities. This goes to show how the forest, and the animals that call it home, may protect humans.

Bolivian River Dolphins

Institute for Conservation Medicine Director Dr. Sharon Deem has been fortunate to work in Bolivia starting in 1999, and she has conducted a number of conservation medicine projects in the country on a variety of wildlife species. Therefore, she was ready to contribute when contacted in 2016 by colleagues in Bolivia when asking for assistance with the safe movement of trapped endemic river dolphins. Dolphins in Bolivia and other Latin American countries are increasingly becoming trapped in shallow lagoons due to the fragmentation and over-use of river water for



Bolivian river dolphins trapped in lagoon

agriculture. In partnership with Dr. Ellen Bronson with the Maryland Zoo in Baltimore and the National Museum of Bolivia, the ICM has helped to move trapped river dolphins and to train local Bolivian biologists and veterinarians to assist with future translocations. The team had one successful trip in 2018 when we were able to move six endangered river dolphins back to the Rio Grande. The dolphins were safely captured using nets and transferred to a kiddie pool on the shore. We measured and weighed each dolphin, inspected their eyes and teeth, listened to their breathing, and collected specimen samples. Ultrasounds were performed to determine whether female dolphins were pregnant. The vets also analyzed

Conservation Research

blood and blowhole samples to look for signs of anemia, toxins and parasites. These six dolphins are the first ever of this species to have health assessments conducted with our makeshift lab in the forest. Three of the dolphins were tracked for a month post-relocation via GPS devices that we placed during handling. This tracking confirmed that the dolphins resumed normal movement patterns and were able to use the river well after being placed back into their river home. Unfortunately, subsequent trips have been on hold, first due to climate change-induced wildfires in the region, and then due to the COVID-19 pandemic. However, the ICM is hopeful for a return trip in early 2022 to move additional dolphins and to continue with training on proper dolphin handling, welfare and health. We have been able to do this work through an American Association of Zoo Vets Wild Animal Health Fund and a generous donation from an anonymous donor.

African Vultures

Vultures are nature's clean-up crew, and they are essential to healthy ecosystems. The important role that vultures play is under threat throughout Africa, where vulture populations have declined by 62% over the last 30 years. In January 2020, Research Fellow Dr. Maris Brenn-White traveled to VulPro, a South African vulture rehabilitation and breeding center, to assist with health assessments on 153 of the center's resident endangered Cape and African white-backed vultures. Ensuring that these vultures are healthy contributes to their welfare and breeding success and ultimately increases free-living vulture populations as the offspring of these resident vultures are released into the wild. Maris and zoo veterinarian Dr. Sarah Woodhouse also used this opportunity to pilot-test a new portable blood analyzer that may allow



Resident wild Cape vulture at VulPro in South Africa

rehabilitators and poison-response teams to identify pesticide-poisoned vultures in the field. Poisoning with commercially available pesticides is a primary threat to African vulture species. Rapid detection of poisoning events would improve treatment of affected vultures and help conservationists target outreach and monitoring efforts.

In the last five years, we have sampled more than 10,000 mosquitoes, 300 primates, 400 wild birds, 350 horses and 11 human rural communities for arbovirus testing in Brazil.



Participants and teachers at the Camel Health and Welfare Workshop in Kapiti, Kenya



Wild radiated tortoise in Madagascar



Moving trapped Bolivian dolphins to the Rio Grande River

10 things to know...

1. We are at the forefront of advocating for One Health at zoos and aquariums.
2. Visiting the Saint Louis Zoo may be just what the doctor ordered! Guests who participated in our study had a decrease in blood pressure and cortisol during their Zoo visit.
3. We gather data to help understand, and mitigate, threats to turtle and tortoise survival. They serve as the "canary in the coal mine" for human health threats from a changing environment.
4. We conduct turtle and tortoise research in Missouri, the Galapagos Islands and Madagascar.
5. We work to minimize health and conservation impacts associated with the illegal trade in wildlife.
6. Our EDC studies show impacts of plastics on reproduction and fitness in turtles. This research could help inform of the potentially negative impacts of EDCs on other animals and humans.
7. Our molecular laboratory tests for infectious diseases of conservation concern.
8. Our camel studies in Kenya address climate change, food security and emerging infectious diseases challenges such as Q fever and MERS.
9. Our work to return Bolivian river dolphins to rivers will help ensure their long-term survival.
10. We are working to conserve and understand baseline health values of African vultures.

Collaborations



Health assessments of Humboldt penguins in Punta San Juan, Peru



Dr. Fangqiong Ling of Washington University in St. Louis meets her first box turtle



Lemur with a radio collar in Betampona, Madagascar



Jamie Palmer teaches laboratory skills in Cuba

Collaborations

Saint Louis Zoo WildCare Institute Collaborations

Since its launch in 2011, the Institute for Conservation Medicine has collaborated extensively with several WildCare Institute centers, programs and initiatives. From the beginning, ICM staff have worked to ensure healthy animals and healthy people at several WildCare Institute field sites, spanning the globe from Missouri to Cuba, Madagascar and Peru. In addition to providing veterinary, epidemiological and molecular diagnostic consultations, we have also provided veterinary services such as the safe immobilization of free-living lemurs in Madagascar with the Center for Conservation in Madagascar and health evaluations of Humboldt penguins as part of the Center for Conservation in Punta San Juan, Peru.

In addition to these collaborative efforts, three new conservation efforts were established in 2019 through the WildCare Institute. Building upon the ICM's history of turtle and tortoise conservation work in Missouri and the Galapagos Islands, the creation of the WildCare Institute Center for Chelonian Conservation provides a hub in which to solidify the Zoo's efforts in turtle conservation. The Program for Crocodile Conservation and Research in Cuba, co-directed by ICM Research Technician Jamie Palmer, is also an example of a new WildCare Institute conservation program in which the One Health approach is instrumental to its success. Lastly, the newly launched Canid Conservation Initiative promotes research into disease threats from pathogen sharing at the domestic/wild canid interface, a major challenge to wild canid conservation. These collaborative efforts truly embody the transdisciplinary nature of One Health work and are exemplary of the various conservation forces of Saint Louis Zoo teams working together to save species.

Crocodile Conservation and Research in Cuba

The Cuban crocodile is arguably the most morphologically, ecologically and behaviorally distinct species of crocodile in the world and has the smallest known range of any living crocodylian. The Institute for Conservation Medicine partnered with Lauren Augustine, Curator of Herpetology at the Saint Louis Zoo, in 2017 to study Cuban crocodiles at the Zapata Crocodile Farm in Matanzas, Cuba. Home to over 4,000 genetically pure Cuban crocodiles, the Zapata Crocodile Farm breeds crocodiles in part for reintroduction into the Zapata swamp, one of only two sites where Cuban



Baby Cuban crocodile

crocodiles are found in the wild. We work with Zapata Crocodile Farm staff to study Cuban crocodile behavior, health and nutrition. ICM Research Technician Jamie Palmer leads the health portion of this work.

In 2019, the Saint Louis Zoo WildCare Institute began supporting our work as the WildCare Institute Program for Crocodile Conservation and Research in Cuba.

90 Cuban crocodile health assessments performed at Zapata Crocodile Farm, Cuba

In 2018, we performed the first-ever health study at the Zapata Crocodile Farm, collecting samples from 43 adult crocodiles, with a follow-up sample season in 2019. Our first peer-reviewed paper to come out of this work will be submitted in 2021 for publication. We hope to continue our work with the team at the Zapata Crocodile Farm and other Association of Zoos and Aquariums institutions once travel resumes.



Canid Conservation Initiative participants place camera traps at the Saint Louis Zoo WildCare Park

Canid Conservation Initiative

In October 2018, a Saint Louis Zoo-led project, the Canid Conservation Initiative, was launched to identify and address critical issues in conserving free-living species in the dog family, such as foxes and coyotes. Those working on this initiative include representatives from the Saint Louis Zoo (Institute for Conservation Medicine, Saint Louis Zoo WildCare Institute, and the Zoo's Carnivore, Animal Health, and Reproductive and Behavioral Sciences Departments) as well as long-time collaborators at the Endangered Wolf Center and Washington University in St. Louis. This group brings together substantial local expertise in canid health (both for animals in the wild and in human care), management, reproduction and ecology.

Through our early discussions, we identified interactions of wild canids with humans and with domestic dogs and cats as two major threats to wild canid conservation. A particular area of concern is the risk of disease transfer from domestic dogs and cats to wild canids.

We are conducting a study of carnivores at the Saint Louis Zoo WildCare Park in north St. Louis County and Tyson Research Center in the St. Louis metropolitan area east of Eureka. This includes all the native canids in both areas,

which are coyotes and grey and red foxes. Surprisingly little is known about these species in Missouri, but most especially the grey fox.

Through strategic trapping, GPS collars, sample collection, and testing for pathogens of conservation concern, we will answer foundational questions about the health of these species, and importantly, potential disease risks to more threatened species that may share their habitat such as the endangered American red wolf.

Additionally, by incorporating camera trapping with the above measures at the WildCare Park, we can assess potential risks to animals in the Zoo's care before these animals arrive to their habitats on campus. What we learn through this research will help us develop a model for responsible co-existence with wild canids in the region. Field studies started in 2020 but were limited to camera trapping due to the COVID-19 pandemic.

Hands-on work will begin in the fall of 2021, led by our new post-doctoral scientist, Dr. Fernando Najera, as he starts his two-year position helping move the Canid Conservation Initiative conservation and research work forward.

Lemur Health in Madagascar

Lemurs, primates endemic to the island of Madagascar, occupy a unique position within the primate evolutionary tree. However, many species of lemurs are critically endangered due to habitat loss, fragmentation and hunting. Bushmeat consumption and human encroachment into lemur habitat also increase the chances of pathogen spillover. In order to better understand the potential health threats to lemurs and contribute to their conservation, the Institute for Conservation Medicine team has worked in Madagascar within the Saint Louis Zoo WildCare Institute Center for Conservation in Madagascar to explore threats to the long-term conservation of lemurs, including possible infectious disease concerns. Our work also has been in collaboration with the Madagascar Fauna and Flora Group and scientists at the Washington University School of Medicine in St. Louis.

We have tested lemurs both at the Saint Louis Zoo and in Madagascar. One of the ICM's first projects on lemurs in 2012 and 2013 involved working with an international group of veterinarians and conservation professionals to gather data on the ecology and health of lemurs in the



Betampona Nature Reserve, a 5,639-acre protected lowland forest. These field trips involved tracking free-living lemurs and safely immobilizing them in order to collect samples for studies on health, disease threats and genetic relatedness. We placed radio-collars on some of the lemurs to allow us to collect long-term behavioral and ecological data.

In addition to these studies, ICM conducted a number of pathogen detection studies. Our efforts supported the research of Saint Louis Zoo veterinary resident Dr. Amy Alexander. She analyzed fecal samples from lemurs at both Betampona Nature Reserve and Ivoloina Zoological Park in Madagascar, as well as domestic carnivores from villages around Ivoloina. Additionally, our team, in collaboration with Washington University in St. Louis colleagues Drs. David Wang and Efreim Lim, discovered a variety of novel viruses in different species of lemurs. This includes the discovery of the first anellovirus in a free-living lemur, two novel picornaviruses and the first described exogenous virus in lemurs. We suspect that these discoveries are just a small subset of the infectious agents that exist within lemurs.

In addition to conservation and animal health work, public health concerns and the lack of basic livelihood security for the 22.9 million people of this island nation have led Zoo staff to work within a One Health framework. Through our commitment to endangered species conservation, we continue to use sound science and effective management efforts to improve the lives of local people and protect the species found only in Madagascar and nowhere else on Earth.

32,000+

Photos of wildlife captured by 15 cameras at Saint Louis Zoo WildCare Park

Our team and partnering colleagues discovered a variety of novel viruses in different species of lemurs. This includes the discovery of the first anellovirus in a free-living lemur, two novel picornaviruses and the first described exogenous virus in lemurs.

Humboldt Penguins in Peru

The guano fields that overlook the ocean in Punta San Juan, Peru, are an ecosystem hard to describe in words. Seemingly barren at first glance, this biodiverse marine reserve is home to the Peruvian Humboldt penguin. Since 2007, the Saint Louis Zoo has worked with partners to conserve the ecosystem and the penguins that live there.



Humboldt penguin colony in Punta San Juan, Peru

In June 2016, Institute for Conservation Medicine Director Dr. Sharon Deem and ICM Research Technician Jamie Palmer traveled to Punta San Juan to work with Humboldt penguins as part of the Saint Louis Zoo WildCare Institute Center for Conservation in Punta San Juan, Peru. Humboldt penguins are threatened in Peru due to anthropogenic factors, including guano (excrement) harvest, tourism, invasive species, mining, industrial fisheries and habitat degradation. Health assessments are one part of conservation efforts. Sharon and Jamie spent six days in the field performing health assessments on nesting penguins along the rocky cliffs and in the lab each evening processing samples. Downtime at the reserve was spent often discussing the challenges we face trying to conserve these wild places that are so heavily threatened by the human world around them. In a true conservation medicine approach, conversations always turned to the same question, "how do we work together to find a balance?"



We are proud collaborators with the Washington University in St. Louis Living Earth Collaborative and are partners on five grants involving a One Health emphasis.

Washington University in St. Louis Living Earth Collaborative

The Institute for Conservation Medicine has been an active and enthusiastic participant in the Living Earth Collaborative since the Washington University in St. Louis-led initiative was founded in 2018. Most notably, ICM staff have been awarded five Living Earth Collaborative seed grants as co-principal investigators. These projects are titled:

- “Quantifying Effects of Parasites on Ecosystem Nutrient Cycling”
- “Reducing Human-Wildlife Conflict in East Africa Using Participatory Action Research”
- “Using iDNA to Increase the Protected Status of the Djeke Triangle and Enhance Disease Surveillance in the Congo Basin”
- “Going Wild in Forest Park: Tracking the Movement of Biodiversity in an Urban Food Web”
- “Expanding the Toolset for Chelonian Conservation: Understanding the Diversity, Distribution and Dynamics of Terrapene Microbiomes”

Each of these five projects has a One Health emphasis that aims to develop solutions to ensure wildlife conservation, human public health and environmental stability.

Two of our newest grants — “Going Wild in Forest Park” and “Expanding the Toolset for Chelonian Conservation” — are focused in Missouri. These two local studies will help us better understand anthropogenic impacts on urban wildlife movements and health and, more importantly, provide new information to guide management recommendations to best care for wildlife species in our own backyards.



Dr. Stephen Blake of Saint Louis University places a telemetry device on a snapping turtle



Dr. Sharon Deem in Madagascar with field team working on lemur conservation



Moonscape of Punta San Juan, Peru



Health assessments of Humboldt penguins

10 things to know...

1. True to the One Health approach, all of our science, education and conservation actions are collaborative.
2. We work for the conservation and health of Cuban crocodiles, coyotes, grey and red foxes, lemurs, and Humboldt penguins, in collaboration with our Zoo colleagues and partners.
3. We are proud collaborators with the Washington University in St. Louis Living Earth Collaborative and are partners on five grants involving a One Health emphasis.
4. We have performed health assessments of endangered lemurs.
5. We have discovered a variety of novel viruses in different species of lemurs. This includes the discovery of the first anellovirus in a free-living lemur.
6. We performed the first full health evaluations of the critically endangered Cuban crocodile.
7. We are part of a team that will address critical conservation issues facing canids. A major threat is disease transfer from domestic dogs and cats to wild canids.
8. Through our work on canid research at the Saint Louis Zoo WildCare Park, we can assess potential disease risks to animals in the Zoo’s care before these animals arrive to their habitats on campus.
9. Our work at the WildCare Park provided opportunities for staff from five different Zoo departments to work on field based conservation.
10. Conservation takes collaboration!



Dr. Paulo Colchao meets his first giant tortoise



Community outreach science event in Brazil

Education and Outreach

K-12 Education

In 2012, the Institute for Conservation Medicine team and partners developed the St. Louis Box Turtle Project. From the beginning, this project received National Science Foundation funding to develop teacher workshops and field trip opportunities to take students into nature to track box turtles at both the rural research site of Tyson Research Center and the urban research site of Forest Park. The program gained the attention of local K-12 educators, and it grew in popularity to the point that our team needed assistance to grow the program to meet the demand.

The St. Louis Box Turtle Project includes a classroom visit to introduce conservation issues that box turtles face and to prepare students for their field experience. To date, the team has taken over 1,500 students into natural areas to track box turtles using radio telemetry. Many of the students are from underserved, urban schools near Forest Park. For many students, this is their first time exploring nature and seeing a turtle in the wild. Students not only gain experience using scientific equipment alongside a field biologist, but they also gain a better understanding of their connection to nature, a fundamental part of One Health and the foundation for developing conservation mindfulness.

Education and Outreach



Elementary science teacher Chris Hwande uses box turtles to engage students

In 2016, the Ferguson-Florissant School District reached out to ICM and asked to expand the project to include their site, Little Creek Nature Area. This 98-acre natural area is owned and managed by the school district. This expansion has allowed the team to collaborate with teachers and administrators to use the St. Louis Box Turtle Project as a part of the district's STEM curriculum and experiential learning opportunity.



ICM summer interns at Tyson Research Center



Keri Lammering educates next-generation conservationists

The truly unique aspect of this program is that students contribute to a local conservation research project. In 2014, Conservation Education Liaison Keri Lammering joined the ICM team to expand the outreach efforts while allowing the ICM scientists time to focus on their research. Nine years later, this program has grown to become a flagship STEM (Science, Technology, Engineering and Mathematics) program for the Saint Louis Zoo.



Ferguson-Florissant students on a turtle safari at Little Creek Nature Center



Teaching about the benefits of forests in Brazil

One Health Education for College Students

Institute for Conservation Medicine Director Dr. Sharon Deem has co-taught a fall semester One Health course at Washington University in St. Louis since 2018. The course is based on the textbook, “Introduction to One Health: An Interdisciplinary Approach to Planetary Health,” which Sharon wrote with Drs. Kelly Lane-deGraaf and Elizabeth Rayhel of Fontbonne University. This is one of only a handful of semester-long One Health courses offered for undergraduate students at any U.S.-based university, and we are proud to be training the next generation of conservation medicine and One Health professionals.

86 College students who have been interns, externs or preceptors with ICM since 2011 (and two more start in October 2021)

One Health Education Beyond St. Louis

Arbovirus Research in Brazil

The ICM’s Brazilian adjunct scientist, Dr. Lilian S. Catenacci, developed an outreach education program that trains professionals at zoos and animal rescue/rehabilitation centers, undergraduate students, and Brazilian health care workers about the importance of protecting biodiversity as a strategy to prevent zoonotic diseases. Lilian has developed education materials that explain how non-human primates have a fundamental role in preserving their forest habitat, such as dispersing seeds to regenerate new plant



Dr. Sharon Deem with participants from the Conservation Medicine Course in Santiago, Chile

growth, and in turn keep people who rely on the forest healthy as well. The networks that have been developed during these outreach efforts are instrumental in the implementation of local preventive actions to protect both people and animals and has been shared with regional health and environment departments to facilitate data-driven policy and decision-making.

Galapagos Tortoise Movement Ecology Programme

In addition to our contributions within the scientific community, the education and outreach component of the Galapagos Tortoise Movement Ecology Programme has been hugely successful through experiential learning/



Professional Training Spotlight: Dr. Paulo Colchao

Paulo is a Peruvian veterinarian. We met Paulo during a field trip to Punta San Juan, Peru. At the time, Paulo was a field assistant at Punta San Juan and worked with us during a Humboldt penguin health assessment in 2016. An excellent field biologist with a strong interest in conservation medicine, Paulo became part of our team in 2017 when he was able to study with the ICM for an 18-month period through a WildCare Institute Field Conservation grant. During this time, Paulo expanded his research and veterinary training at the Saint Louis Zoo, Brookfield Zoo in Chicago and the Maryland Zoo in Baltimore. This additional training made it possible for Paulo to conduct research on wild Amazon pink river dolphins in Peru. Paulo also obtained a M.S. in wild animal health in London and then went back to Punta San Juan in 2020 as field coordinator. Paulo now works to address the conservation and health of wild animals in Peru.

Intern Insights:

“Working on projects with the Institute for Conservation Medicine has taught me immeasurable life skills, prepared me for a career in wildlife and conservation medicine, and gave me experiences and friends of a lifetime. Thank you, ICM!”

Julie Sheldon, M.S., DVM, DACZM

Clinical Assistant Professor of Zoological Medicine
University of Tennessee, College of Veterinary Medicine

“During my time at the Institute for Conservation Medicine, I was able to make valuable connections, strengthen my research skills, and most importantly, increase my knowledge of the One Health concept. The rewarding experiences I had at ICM have shaped me into a better public health professional and ultimately helped me realize which area of public health I wanted to pursue post-graduation.”

Sara Wilton, MPH

Epidemiologist
Jefferson County, Missouri Department of Health

Intern Insights:

“My summer working with the Institute for Conservation Medicine has been the most formative experience of my career to date. The opportunity to work with this incredible team on a project that landed right at the intersection of conservation and public health was a perfect example of a One Health initiative. The skills that I developed working with ICM included laboratory work, field work, communication and collaboration between institutions, clinical skills, manuscript preparation, and presentation of our findings at an international conference. I will always be grateful for this experience and opportunity and the impact that it had on my professional and personal development.”

Tess Rooney, DVM, MPH

Zoological Medicine Fellow, Binder Park Zoo, Michigan

Education and Outreach



Anne Guezou, educator in Galapagos, with local elementary schoolchildren

teaching, traditional media outlets, and social media. We have taken hundreds of school-aged children on “tortoise safaris” in Galapagos. These safaris offer real hands-on experience with field work and scientific data collection, as well as provide didactic science-based learning opportunities using tortoises as ambassadors that connect kids and youth to nature. We have designed specific activities to introduce local students to One Health, using tortoises as an example of the human-animal interface. Students have had the opportunity to share a day in the lab with our veterinarians, learn about tortoise anatomy and physiology, and understand how daily habits such as antibiotic use may have an impact on tortoise health and conservation.



We have taken hundreds of school-aged children on “tortoise safaris” in Galapagos. These safaris offer real hands-on experience with field work.

Camel Health and Welfare in Kenya

After a few years of our Dromedary Camel Program in Kenya (see page 17), the Institute for Conservation Medicine moved into addressing veterinary training gaps in dromedary camel health and welfare. We delivered a five-day course at the International Livestock Research Institute’s Kapiti Research Station. The course was one of the first of its kind in Kenya, bringing together 16 veterinary practitioners from throughout the country for hands-on training in the diagnosis, treatment and control of high-priority camel diseases. This immersive experience helped create a lasting and active support network and community of veterinarians that are better prepared to protect the health of Kenya’s livestock, wildlife and people. The course was held in collaboration with the International Livestock Research Institute and the Smithsonian Institute Global Health Program.

Professional Training and Advancement

We value training opportunities for the Institute for Conservation Medicine team, but we also prioritize post-graduate training of U.S. and international professionals to help them move into their careers in conservation medicine and One Health. During the first 10 years of the ICM, we have hosted long-term training opportunities for five veterinarians:

- Dr. Lilian Catenacci (2015)
- Dr. Paulo Colchao (2017-2018)
- Dr. Ainoa Nieto Claudin (2016 - 2022)
- Dr. Maris Brenn-White (2018-2021)
- Dr. Fernando Najera (2021-present)

Each of these young professionals joined us for some part of their Ph.D. research or fellowship/post-doc studies. Maris and Ainoa remain on the ICM team as staff, and Lilian is an adjunct scientist. Paulo continues to stay in touch as he pursues his love of conservation medicine.



Dr. Lilian Catenacci and giant tortoise



Our alumni have gone on to a wide variety of careers. Many are practicing veterinarians or currently pursuing masters, Ph.D.'s or DVM degrees, while others have followed career paths into research, teaching and human medicine.

Student Internships

The Institute for Conservation Medicine has a robust training program for future conservation practitioners. Our interns, externs and preceptors range from undergraduates to fourth-year DVM, M.D. and Ph.D. students. While many of our students are in veterinary medicine or public health programs, conservation medicine doesn't stop there. We host students in biology, environmental studies, pre-medicine, ecology, conservation medicine and One Health degree programs. We also occasionally host high school students through exchange programs with local school districts.

Regardless of their backgrounds, most students work on our Missouri-based projects, notably the St. Louis Box Turtle Project; however, a number of students have worked internationally in Ecuador, Kenya, Brazil and Madagascar. Each student also develops an independent project during their time with us that involves research, presentations or

outreach. It goes without saying that our 2020 interns learned a lot about One Health with the pandemic, underscoring how the health of animals, humans and the environment are all interconnected.

Our alumni have gone on to a wide variety of careers. Many are practicing veterinarians or currently pursuing masters, Ph.D.'s or DVM degrees, while others have followed career paths into research, teaching, biology/ecology, and human medicine. Examples of where past interns work include the California Department of Food & Agriculture, National Forest Foundation, United States Department of Agriculture and the Omaha Zoo.

Since 2011, 86 students have worked with us at the ICM and are now located throughout the world. We are proud to have been a part of their One Health journeys.

**Professional Training Spotlight:
Dr. Bennett Lamczyk**

Bennett is an Institute for Conservation Medicine alum who graduated veterinary school in the top 10% of his class from the University of Illinois in May 2021. During the summers of 2016 and 2017, he worked with the ICM and learned about public health and conservation medicine, which have significantly influenced his career goals. He joined ICM for one more rotation during vet school and helped mentor three undergraduate interns during the summer of 2020.



Cape vulture in South Africa



2020 summer interns at the Saint Louis Zoo WildCare Park



Children meet a box turtle on a turtle safari in Forest Park

10 things to know...

1. We conduct K-12 education in Brazil, Galapagos, and of course, in Missouri!
2. We spread the One Health message to thousands of professionals through virtual presentations.
3. Past ICM interns now work throughout the United States, Europe and South America.
4. Over 1,500 students have tracked box turtles in Forest Park with us, experiencing nature up-close while learning about turtle conservation.
5. Hundreds of school-age children have gone on giant tortoise safaris with us in the Galapagos, where they experience field work and data collection.
6. The St. Louis Box Turtle Project, headed by our team, is a flagship STEM program for the Saint Louis Zoo.
7. ICM interns have a variety of majors. People with different professional backgrounds working together epitomizes the One Health approach.
8. The very first graduate from Washington University in St. Louis with a One Health major spent two full summers with us.
9. We provided five veterinary professionals with long-term training during their Ph.D. or fellowship/postdoctoral studies.
10. We provided hands-on training in the diagnosis, treatment and control of camel diseases for veterinarians throughout Kenya.

Volunteers and Partners



Kathleen Apakupakul and Dr. Maris Brenn-White sampling frogs at the Saint Louis Zoo WildCarePark

“I am eternally grateful for the year and a half that I volunteered in ICM and consider those days as the best work with the best people. I am certain that I will never find a more devoted, collegial, passionate and welcoming group of professionals-turned-friends. I experienced a great deal of growth in ICM and gained a new awareness and insight into its vital mission and work. ICM, you set the standard for collaboration, teamwork, dedication, excellent work for the global good, friendliness, cooperation and fun. I am very proud to have worked with the ICM team.”

Karen Jordan, Institute for Conservation Medicine Volunteer

Volunteers

Over the years, our team at the Institute for Conservation Medicine has been very fortunate to have volunteers who are interested in conservation medicine research and share our passion for One Health.

These volunteers help us complete numerous tasks our small team wouldn't be able to accomplish otherwise. With their varied backgrounds, our volunteers have also been wonderful emissaries for ICM by participating in events and helping us educate the public about One Health issues.

- Aline Booz-Holtz – Neurologist
- Carol Gronau – Medical Textbook Editor
- Jose Iturrizaga – Ecologist
- Karen Jordan – Research Librarian
- Annette Kelly – Engineer
- Lynn Marsden – Photographer
- Helen Porter – Animal Nutritionist
- Hasmik Sarukhanyan – Veterinarian
- Kathy Zeigler – Engineer

We are immensely grateful for their willingness to donate their time and talents to the ICM.

Partners

We at the Institute for Conservation Medicine are so proud of our long-lasting collaborations with local and international partners who share our dedication to a One Health approach to conservation research.

Abaxis - VetScan
Captain Elementary, Clayton School District
Charles Darwin Foundation
Complutense University of Madrid, Spain
Critter Cam
Detroit Zoological Society
DigitalGlobe
Ecology Project International
Enterprise for the Conservation of Zapata swamp
e-obs Digital Telemetry
Ferguson-Florissant School District
Fontbonne University – Center for One Health
Forest Park Forever
Galapagos Conservation Trust
Galapagos National Park
GenStat
Houston Zoo
International Livestock Research Institute
Little Creek Nature Area
Living Earth Collaborative
Mahaliana
Maryland Zoo in Baltimore
Max Planck Institute for Ornithology
Mola Mola Ecological Club, Galapagos
Mpala Research Centre
Noel Kempff Mercado Natural History Museum

Principia School, Town and Country
Saint Louis University Department of Biology
Saint Louis University School of Medicine
Smithsonian Institute's Global Health Program
State University of New York, College of Environmental Science and Forestry
Turtle Survival Alliance
Tyson Research Center, Washington University in St. Louis
United States Geological Survey
University of Florida College of Veterinary Medicine
University of Illinois College of Veterinary Medicine
University of Missouri Columbia College of Veterinary Medicine
University of Missouri Columbia School of Health Professions
VulPro
Washington University in St. Louis
Washington University School of Medicine
Westminster College
Wildlife Conservation Society
Wildlife Rescue Center – St Louis

“Volunteering with the staff at the ICM has been a gift. It provides me with the opportunity to learn new things from a brilliant group of women. Hopefully my volunteering gives a little value back to them.”

Annette Kelly, Institute for Conservation Medicine Volunteer

In Memoriam



Left to right: Carol Gronau with friends Janet Jackson and Senior Vice President, External Relations, Cynthia Holter

Carol Gronau Institute for Conservation Medicine Volunteer

We met Carol because of her passion for conservation and science and are so grateful to have known her.

Carol started volunteering at the Zoo in 1993 as a docent and had been a Marlin Perkins Society member for 23 years.

She traveled to numerous

countries with the Zoo and met her late husband, Axel, on a Zoo trip to Kenya. Carol had a master's degree in English and enjoyed a lengthy career as a medical textbook editor. In addition to volunteering with the Institute for Conservation Medicine, Carol was active in various other organizations including Reading is Fundamental, St. Louis Children's Hospital and her church.

In 2015, Carol purchased an imaging system for the ICM molecular lab, which helped make infectious disease testing possible. It was during a visit to the lab to see her money in action that Carol decided to dedicate her time and talents as an ICM volunteer.

Carol was a cherished member of our team and brought her editing and language skills to tasks such as editing fact sheets and research updates for our website. She also helped organize thousands of photos and blood slides, all the while asking questions about our projects and advocating for our work. She was also a lot of fun to be around! Every time Carol came in to the office, we had interesting and lively conversations on topics from A to Z. She always had a witty remark about current events.

We also are thankful to Carol for her enormously generous gift to our endowment. Through her support, her love of the Zoo will live forever. We will continue to be inspired by her love of words, science and animals. Our team also will be forever grateful for this ongoing stream of support to help further our mission.

We were saddened of Carol's passing on June 2, 2021. She was a wonderful friend and will be dearly missed.

Grants



Dr. Sharon Deem processes tortoise blood slides, Alcedo Volcano, Galapagos

Washington University St. Louis – Living Earth Collaborative

\$29,592 awarded to Ling, F., Brenn-White, M., Apakupakul, K., Deem, S.L. “Expanding the toolset for chelonian conservation: understanding the diversity, distribution and dynamics of Terrapene microbiomes.” 2021 – 2022.

Washington University St. Louis – Living Earth Collaborative

\$30,000 awarded to Dell, A., Blake, S., Braude, S., Deem, S.L., Winkler, D., Witt, A., and Knouft, J. “Going Wild in Forest Park. Tracking the movement of biodiversity in an urban food web.” 2020 – 2021.

Washington University St. Louis – Living Earth Collaborative

\$33,923 awarded to Sanz, C., Deem, S.L., Fischer, P., Brenn-White, M., Hellmuth, H., Leendertz, F., Patrono, L., Mayoukou, W., and Morgan, D. “Using iDNA to Increase the Protected Status of the Djeke Triangle and Enhance Disease Surveillance in the Congo Basin.” 2020 – 2021.

Saint Louis Zoo – WildCare Institute Field Conservation

\$9,939 awarded to Apakupakul, K., Rasambainarivo, F., and Brenn-White, M. “Building scientific capacity in Madagascar and advancing the conservation of radiated tortoises (*Astrochelys radiata*) through molecular diagnostics training of Malagasy scientists.” 2020 – 2022.

Saint Louis Zoo – WildCare Institute Field Research for Conservation

\$9,925 awarded to Brenn-White, M., Deem, S.L., Rakotoarisoa, N.A.T., and Palmer, J. “Establishing hematology and biochemistry reference ranges to improve treatment, rehabilitation, & reintroduction of confiscated radiated tortoises (*Astrochelys radiata*).” 2019 – 2020.

Saint Louis Zoo – WildCare Institute Field Conservation Program

\$6,312 awarded to Lammering, K. and Brenn-White, M. “Using Box Turtles to Enhance Conservation Education in the Ferguson-Florissant School District.” 2019 – 2021.

Washington University St. Louis – Living Earth Collaborative

\$35,000 awarded to Millich, K., Lesorogol, C., Deem, S.L. “Reducing Human-Wildlife Conflict in East Africa Using Participatory Action Research.” 2019.

American Association of Zoo Veterinarians Wild Animal Health Fund

\$10,000 awarded to Deem, S.L., Nieto Claudin, A., and Apakupakul, K. “Assessing the health of the critically endangered Eastern Santa Cruz Galapagos tortoise (*Chelonoidis donfasutoi*).” 2019 – 2020.

Microsoft AI for Earth Grant

\$14,230 awarded to Leard, S., Sagan, V., Deem, S.L., Brenn-White, M., Paheding, S., and Apakupakul, K. “Connected conservation and applied remote sensing for One Health at the intelligent edge in Kenya and Madagascar.” 2018 – 2019.

Conservation Grants Fund – Association of Zoos and Aquariums

\$18,536 awarded to Augustine, L., Torregrosa, K., Deem, S.L., Miller, K. “Collaborating to Improve Conservation Efforts for the Critically Endangered Cuban Crocodile.” 2018 – 2019.



Washington University St. Louis – Living Earth Collaborative

\$30,000 awarded to Koltz, A., Deem, S. L., Ezenwa, V.O., Penczykowski, R. “Quantifying Effects of Parasites on Ecosystem Nutrient Cycling.” 2018 – 2019.

Saint Louis Zoo – WildCare Institute Field Research Conservation

\$10,000 awarded to Nieto Claudin, A., Deem, S.L., Palmer, J., Apakupakul, K., and Esperón Fajardo, F. “Assessing the health of endangered free-living Galapagos Tortoise species occurring in human-modified landscapes and protected areas.” 2018 – 2019.

Saint Louis Zoo – WildCare Institute Field Conservation

\$9,983 awarded to Zimmerman, D., Fèvre, E., Gluecks, I., Tobin, K. and Deem, S.L. “Protecting Kenya’s Wildlife Through Capacity Building and Biosecurity Training.” 2018 – 2019.

American Association of Zoo Veterinarians Wild Animal Health Fund

\$10,000 awarded to Bronson, E., Colchao, P., Deem, S.L., and Venegas, C. “Health Status and Welfare in Translocated Bolivian River Dolphins (*Inia boliviensis*) Experiencing High Anthropogenic Disturbances.” 2018 – 2019.

Saint Louis Zoo – WildCare Institute Field Research Conservation

\$5,000 awarded to Hassells, J., Murray, S., Fèvre, E., Zimmerman, D., Deem, S.L., Ogada, D., Murn, C., and Njenga, K. “Exposure of vultures to anthrax in Kenya, and their role as sentinels for a lethal bacterial zoonosis in endangered wildlife, livestock and humans.” 2017 – 2018.

Cleveland Metroparks Zoo – Scott Neotropical Fund

\$5,000 awarded to Nieto Claudin, A., Deem, S.L., and Esperón Fajardo, F. “The endangered Galapagos giant tortoise: assessing their health and the potential impact of humans and livestock on their wellbeing.” 2017 – 2018.

Dromedary camels are the “new cow” in Kenya due to their ability to thrive in drought conditions and still produce milk. As camels expand into new parts of the country, so does the risk of transmission of camel-carried diseases to people. Protecting camel health is a key part of ensuring healthy food for Kenyans.

Saint Louis Zoo – WildCare Institute Field Research Conservation

\$10,000 awarded to Catenacci, L.S., Deem, S.L., Travassos da Rosa, E.S., Vasconcellos, P.F., Alcântara, B.N., Osório, D.B. “Zika virus, chikungunya, dengue and yellow-fever virus: are they real threats for wild animals in the Americas?” 2017 – 2018.



Dr. Sharon Deem and Dr. Julie Sheldon place a telemetry device on giant tortoise

Grants

Saint Louis Zoo – WildCare Institute Field Research Conservation

\$3,610 awarded to Novak, L., Deem, S.L., Allender, M., and Palmer, J. “Comparison of Leukocyte Quantification Methods in Free-Living Eastern Box Turtles (*Terrapene carolina carolina*) and Three-toed Box Turtles (*Terrapene carolina triunguis*) both before and after transportation and handling.” 2016 – 2017.

Saint Louis Zoo – WildCare Institute Field Conservation

\$9,998 awarded to Deem, S.L., Macek, M., and Colchao P. “Field Veterinary Capacity Building for Punta San Juan, Peru.” 2016 – 2017.

Saint Louis Zoo – WildCare Institute Field Conservation

\$4,967 awarded to Tieber, A., Palmer, J., and Lammering, K. “Saint Louis Zoo Box Turtle Project Outreach and Training in the Cypress Swamp.” 2016 - 2017.

Saint Louis Zoo – WildCare Institute Field Conservation

\$10,000 awarded to Catenacci, L., Deem, S.L., Travassos, E.S., Vasconcellos, P.F., and Vianez, João. “A One Health Approach to Arbovirus Surveillance in the Atlantic Forest, Brazil.” 2016 – 2017.

American Association of Zoological Veterinarians

\$10,000 awarded to Catenacci, L., and Deem, S.L. “A One Health Approach to Arbovirus Surveillance in the Atlantic Forest, Brazil.” 2016 – 2017.

National Science Foundation Research Experience for Teachers

\$14,900 awarded to Gibbs, J., and Deem S.L. “How Environment, Physiology and Life History Interact to Determine Pattern in Animal Migration.” 2016 – 2017.

Saint Louis Zoo – WildCare Institute Year End Funds

\$5,000 awarded to Deem, S.L., Wang, D., and Lim, E.S. “Discovery of Novel Lemur Viruses.” 2015.

Disney Conservation Fund

\$21,300 awarded to Deem, S.L., Blake, S., Palmer, J., Lammering, K., Flowers, S., and VanLinn, P. “St. Louis Box Turtle Project.” 2015 – 2016.



Dr. Maris Brenn-White conducting a veterinary exam on a dog

Weiss Foundation

\$11,000 awarded to Deem, S.L. “Pathogens of zoonotic and wildlife conservation concern in dromedary camels in Kenya.” 2014 – 2015.

Disney Conservation Fund

\$23,950 awarded to Deem, S.L., Blake, S., Palmer, J., Lammering, K., Flowers, S., and VanLinn, P. “St. Louis Box Turtle Project.” 2014 – 2015.

Mizzou Advantage Award – University of Missouri-Columbia

\$249,996 awarded to Rosenfeld, C., Tillitt, D., Bhandari, R., Deem, S.L., Holliday, D. “Endocrine Disruption of the Epigenome Across Taxa.” 2014 – 2015.

Saint Louis Zoo – WildCare Institute Field Research Conservation

\$10,000 awarded to Rasambainarivo, F., Parker, P., Porton, I., and Deem, S.L. “Leptospirosis at the interface between domestic animals and wildlife of the Betampona Natural Reserve, Madagascar.” 2014 – 2015.

Saint Louis Zoo – WildCare Institute Field Research Conservation

\$10,000 awarded to Lim, E., Deem, S.L., Porton, I., and Wang, D. “Discovery of Novel Lemur Retroviruses.” 2014 – 2015.

Conservation Endowment Fund – Association of Zoos and Aquariums

\$20,834 awarded to Deem, S.L., Bradshaw, L., Niedbalski, A., and Johnson, R. “Human health benefits associated with visiting zoological institutions.” 2013 – 2014.

Saint Louis Zoo – WildCare Institute Field Research Conservation

\$9,600 awarded to Deem, S.L., Kinnaird, M., Browne, A.S., Fevre, E., and Wang, A. “Health monitoring of dromedary camels in the arid and semi-arid lands of Northern Kenya: implications for human health and wildlife conservation.” 2013 – 2014.

National Science Foundation

\$600,000 awarded to Gibbs, J., Blake, S., Deem, S.L., and Frair, J. “How Environment, Physiology and Life History Interact to Determine Patterns in Animal Migration.” 2013 – 2016.

Saint Louis Zoo – WildCare Institute Field Research Conservation

\$4,500 awarded to Porton, I., Deem, S.L., and Rasambainarivo, F. “The health of four lemur populations in Betampona Natural Reserve: *Indri indri*, *Propithecus diadema*, *Varecia variegata* and *Eulemur fulvus albifrons*.” 2012 – 2013.



International Elephant Foundation

\$9,900 awarded to Miller, M., Olea-Popelka, F., Deem, S.L., and Schmitt, D. “Disease risk analyses for tuberculosis detection and prevalence in elephants.” 2012 – 2013.

Mazuri

\$7,250 awarded to Deem, S.L., Duncan, M., Schmidt, D.A., Junge, R.E., and Fischer, M. “An epidemiologic study of rumenitis in exotic ungulates.” 2011 – 2012.

Novus International

\$14,500 awarded to Deem, S.L., Dierenfeld, E., and Kinnaird, M. “Health monitoring of dromedary camels in the arid and semi-arid lands of Northern Kenya: implications for human health and wildlife conservation.” 2011 – 2012.

Connecting with communities and understanding their needs is an important aspect of conservation. In Madagascar, Dr. Sharon Deem shows some children photos of themselves on her camera.

Friends of the Saint Louis Zoo Institute for Conservation Medicine

“The Saint Louis Zoo Institute for Conservation Medicine is committed to understanding, preserving, and caring for animals and environments locally and around the world. They teach us how our health and the health of the entire planet is so very dependent and interconnected with the health of animals and the environment.”

Dr. Virginia Herrmann



Dr. Virginia Herrmann is greeted by a California sea lion

In addition to funding from the Saint Louis Zoo, grants and partners, we receive significant philanthropic support from our wonderful group of donors.

We would not have accomplished so much in the last 10 years without the generous support from those who understand that the health of animals, people and the environment are all interconnected. Our donors understand our mission and know their funds are used wisely by our dedicated team. Some donors are most interested in scientific research projects such as evaluating antibiotic resistance in giant tortoises or studying ranaviruses in Missouri reptiles. Others focus on applied conservation efforts such as rescuing Bolivian river dolphins trapped in

lakes created by human activities or conducting health assessments on tortoises confiscated from the illegal pet trade. Many of our supporters are passionate about educating the next generation and have made a wide variety of outreach activities possible over the last 10 years. We value our ability to teach children about nature and the species with which they share the planet, and the financial support we’ve received has made it possible to a degree we would not have been able to otherwise.

We are deeply appreciative of our many supporters. Their generosity to the Institute for Conservation Medicine helps our scientific research and outreach continue so we can help ensure healthy people and healthy animals.

\$100,000 and above

Anonymous
Dr. Virginia M. Herrmann

\$99,999 – \$50,000

Ms. Elizabeth L. Green
Wendy Knudsen & George Farrell

\$49,999 – \$10,000

Anonymous
Ms. Carol S. Gronau
Ms. Gentry Ashmore Hoit
Mark R. & Becky Humphrey
Mr. Steve King
Novus International, Inc.
William E. Weiss Foundation

\$9,999 – \$5,000

Dr. & Mrs. John Bermingham
Peg Cooper
Sue Dexter
Dr. Todd Margolis

\$4,999 – \$1,000

AAZK – St. Louis Chapter
Carolyn Cray
Diana L. & John Deem
Michael Deem & Elizabeth Ickes
Eastern States Veterinary Association, Inc.
Elena Gorman
Mrs. Richard A. Hamilton
Mr. & Mrs. Kenneth A. Johnson
Diane & Dane Kull

“Over the years, our support of the Institute for Conservation Medicine has been one of the first and most personally fulfilling donations we make. The ICM brings worldwide scientific research on the crossover of diseases from animals to humans to the forefront of concern, supporting the One Health initiative.”

Becky & Mark Humphrey

“I feel what the ICM does is absolutely necessary, not only for the health of our fauna, but also for the planet as a whole. I especially believe the St. Louis Box Turtle Project has been extremely helpful to local public-school students by encouraging them to take part in turtle safaris at various times of the year and on multiple levels, so they may learn about science and the natural world while connecting with nature that is close to home.”

Elizabeth Green

Ms. Melissa J. Ma
Carolyn L. Prowse Manning & Mark Fainmel
Dr. Eric Miller & Dr. Mary Jean Gorse
Jane Feigenbaum Morris
Angie & Ken Nettleton
Joe & Patty Nicoloff
Kei & Susan Pang
Christopher Sheffield
St. Augustine Alligator Farm & Zoological Park
SWKT, Inc.
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Patricia Vaughan
Washington University in St. Louis
Webster Groves Nature Study Society
Westminster College
Kathy Zeigler

\$999 – \$500

Cristi & Jimi Cook
Mr. & Mrs. J. Philip Hellwege
James L. & Mary H. Kroll
Dr. Lisa Puscheck
Mr. & Mrs. David J. Saltman
Mr. & Mrs. Michael A. Saltman
Dr. & Mrs. Robert R. Schlueter
Mr. Justin A. Smith
Truman State University

Up to \$499

Sharon & Pete Abel
Asian Pacific Island Organization
Association of Avian Veterinarians (AAV)
Dr. Jill & Andrew Barnholtz-Sloan

Brett M. & Norene Bennett
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Girl Scouts of Eastern MO, Troop #1844
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Leonard E. Opdycke
Mrs. C. Lynn Outman
Keith F. & Beth A. Petti
Principia School
Linda M. Schulte
Ms. Cindy Schwartz-Hafemeister
Lynne Scott
The Andy Stewart Family
American Association of Zoo Veterinarians - Student Chapter
Richard & Nancy Tebeau

“The dignified box turtle is such an interesting creature that faces so many challenges today. Dr. Deem and the ICM team’s research produces a wealth of information that helps to sustain these vulnerable creatures. That’s why I support the ICM and the St. Louis Box Turtle Project.”

Steve King

Technology Investors Network
Mr. Brandon Thornberry
Patricia Vaughan
Mrs. Constance V. R. White
Michele & Tom Wolford
Mr. & Ms. Rene Zar
Leisa J. Zigman

Saint Louis Zoo Institute for Conservation Medicine Funding

The Institute for Conservation Medicine is funded through several sources, including the Saint Louis Zoo’s annual operating budget, contributions from various donors and partner institutions, and in coordination with the Saint Louis Zoo WildCare Institute. Without the support from these numerous sources, the vital work performed by the Institute for Conservation Medicine team would not be possible. For more financial information, please refer to the Saint Louis Zoo annual reports located on the Zoo’s website, stlzoo.org.



Wendy Knudsen visits the Asian elephants at the Saint Louis Zoo

Media, Awards and Accolades

18

Saint Louis Zoo blogs featuring the ICM



Awards & Accolades

The St. Louis Box Turtle Project is part of the 2017 Conservation Federation of Missouri's Wildlife Conservationist of the Year Award that was awarded to the Saint Louis Zoo WildCare Institute for its five centers conducting Missouri-based conservation.



Awards & Accolades

The University of Missouri's Gamma Eta Chapter of the Delta Omega Public Health Honorary Society selected Dr. Deem as a 2018 Honorary Inductee.

40

Print media articles authored by or that feature ICM team members

Awards & Accolades

Dr. Deem, Jamie Palmer and Emily Dunay (ICM intern) received St. Louis City Hospitality Heroes Awards for their work with Forest Park Forever on a snapping turtle rescue (2017).

"Turtle Dogs" Go National

In April 2021, the Saint Louis Zoo published a blog and video regarding seven turtle-detecting spaniels to help the ICM retrieve box turtles at the Saint Louis Zoo WildCare Park. The video was posted to the Zoo's social media and picked up by local and national media outlets.



Ebola and Human/ Wildlife Health (St. Louis Post-Dispatch)

Between 2014 and 2016, a deadly Ebola outbreak affected West Africa. In October 2014, Dr. Deem co-authored an opinion article in the St. Louis Post-Dispatch about Ebola and the link between human and wildlife health.

Awards & Accolades

On April 6, 2017, Dr. Deem received the St. Louis Science Academy Trustees Award in recognition of work she does in One Health and her studies on animal, human and environmental health.

25

Radio and TV interviews by ICM team members



500+

Lectures, presentation and webinars by ICM team members

Association of Zoos and Aquariums "Ask Me Anything" Twitter Event

Dr. Deem participated in the Association of Zoos and Aquariums' "Ask Me Anything" Twitter event. Following the event, Dr. Deem spoke to an AP journalist about COVID-19, animals and zoos. Over 1 million people were reached through this event.

TEDx Talks: "The Ties That Bind"

In April 2018, Dr. Deem gave a TEDx talk at The Sheldon Concert Hall in St. Louis regarding One Health.



Dr. Deem Weighs in on COVID-19 Outbreak

The local NBC affiliate in St. Louis, KSDK, interviewed Dr. Deem and did a segment covering both One Health and the COVID-19 pandemic in February 2020.

Awards & Accolades

Dr. Deem was awarded the 2018 Lifetime Achievement Alumni Award at The Virginia-Maryland College of Veterinary Medicine, her veterinary alma mater.

Publications

Our scientists with the Institute for Conservation Medicine are leaders in both conservation medicine research and applied conservation. In our first 10 years, we have published 67 peer-reviewed articles in esteemed scientific journals ranging from Journal of Zoo and Wildlife Medicine and Frontiers in Veterinary Science to Zoonoses and Molecular Frontiers. Our articles cover a wide array of research on wildlife, diseases, ecosystems and human health. We've also published commentary and scientific explanations of why a One Health approach is critical to protect animal, human and environmental health. In addition, Dr. Sharon Deem has co-authored a textbook, "Introduction to One Health: An Interdisciplinary Approach to Planetary Health," published in 2019.

Lamczyk, B.A., Palmer, J.L., Kozłowski, C.P., Blake, S., and Deem, S.L. No difference in corticosterone concentrations between Missouri three-toed box turtles living in an urban and a rural site. *Human Wildlife Interactions* (in press).

Apakupakul, K., Deem, S.L., Maqsood, R., Sithiyopasakul, P., Wang, D., and Lim, E.S. 2021. Endogenization of a prosimian retrovirus during lemur evolution. *Viruses*. 13, 383. <https://doi.org/10.3390/v13030383>

Bronson, E., Deem, S.L., Patino Westermann, L.C., Angulo Alpíre, S., and Emmons, L.H. 2021. Field anesthesia of the maned wolf (*Chrysocyon brachyurus*) in Bolivia. *Journal of Wildlife Diseases*. 57: <https://doi.org/10.7589/JWD-D-20-00033>

Catenacci, L.S., Ferreira, M.S., Fernandes, D., Padda, H., Travassos-da-Rosa, E.S., Deem, S.L., Vasconcelos, P.F.C., and Martins, L.C. 2021. Individual, household and environmental factors associated with arboviruses in rural human populations, Brazil. *Zoonoses and Public Health*. <https://doi.org/10.1111/zph.12811>.

Cianfagna, M., Bolon, I., Babo Martins, S., Mumford, E., Romanelli, C., Deem, S., Pet-tan-Brewer, C., Figueroa, D., Velasquez, J., Stroud, C., Lueddeke, G., Stoll, B., Ruiz De Castañeda, R. 2021. Biodiversity and Human Health Interlinkages in Higher Education offerings: A first global overview. *Frontiers in Public Health*. <https://www.frontiersin.org/articles/10.3389/fpubh.2021.637901/full>

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The Next 10 Years of the Saint Louis Zoo Institute for Conservation Medicine



We hope you enjoyed this report highlighting the first 10 years of the Institute for Conservation Medicine. While writing it, we were able to reflect on the past decade and think ahead to what the next 10 years will hold for the ICM.

In the coming years, we know that wildlife conservation and human public health challenges will continue. This is abundantly evident today with record-breaking heat over much of the world, and during a time we are just emerging, hopefully, from the tragic COVID-19 pandemic. These two challenges to our shared One Health, along with many others that include the loss of species and habitat degradation, will continue to threaten the health of people, animals and environments. Of this we are certain. It is because of this certainty that we will continue our commitment to gaining a better understanding of these conservation and health challenges.

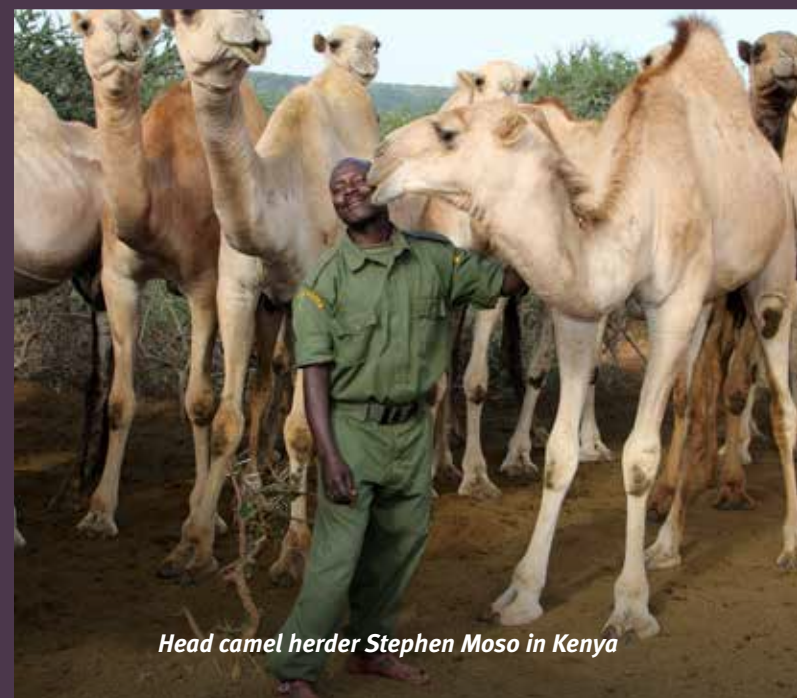
More importantly, we remain committed to our search for solutions that will ensure the health of the animals in our care, people with whom we share the planet, and the ecosystems on which all life is dependent. We make this promise based on our continuation of sound scientific research, high-quality educational opportunities, and performance of conservation actions demonstrated by the ICM that will ensure healthy animals and healthy people. We will expand on already-strong partnerships and programs that advance One Health around the world. And we will stay flexible so that we may rapidly address the changing landscape of conservation and public health challenges.

As is true of all the conservation efforts of the Saint Louis Zoo, we cannot do this alone. Starting with daily behaviors that have a global reach, we invite you to be part of the One Health movement.

We thank you for your support of the Saint Louis Zoo over the years and your belief in the Saint Louis Zoo Institute for Conservation Medicine. We are optimistic that, together, in the ICM's second decade, we will continue our work to save species while providing optimal health of animals and people.



Saint Louis Zoo WildCare Park aquatic turtle health assessments



Head camel herder Stephen Moso in Kenya



One Health Fair at the Saint Louis Zoo

Ways to Give

How You Can Help

The COVID-19 pandemic has brought new awareness, to billions around the world, of the ties that bind the health of animals, humans and ecosystems. The challenges that threaten wildlife conservation and human public health are more evident today than 10 years ago when the Institute for Conservation Medicine began.

As you have seen through this report, the ICM has accomplished a tremendous amount during our first 10 years. Our research, outreach and conservation actions have been possible through staff expertise, passionate donors, and collaborations with other individuals and organizations who share our enthusiasm for One Health. We could not have done it without you — and we are just getting started!

Together, we have the chance to make a lasting investment in wildlife conservation and planetary health. By using the enclosed response envelope, you become an advocate for the One Health approach as we find solutions to some of our most pressing conservation issues.

The ICM offers you an opportunity to support our programs in a number of ways. You can:

- Support our ongoing conservation research or outreach programs;
- Create an endowed staff position to allow our department to retain our high quality professionals; or
- Provide an unrestricted gift to be used where our need is greatest at that time.

Your gift to the ICM will make a difference today and for future generations. For more information on contributing to the work of the Saint Louis Zoo Institute for Conservation Medicine, please visit stlzoo.org/icm or contact the Zoo's Development Office at (314) 646-4691.

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