INSTITUTIONAL INTERVIEWS - 2009

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Zoological Society of San Diego

First of two parts
A featured institution selection from *Essential Science Indicators*SM

Essential Science Indicators *from Thomson Reuters recently named the Zoological Society of San Diego a Rising Star in the field of Plant & Animal Science, meaning that the Zoo had the highest percent increase in total citations in this field from August to October 2008. The Zoo's current record in this field includes 228 papers cited a total of 1,545 times between January 1, 1999 and February 28, 2009.*

In this first of a two-part series, ScienceWatch.com's *Jennifer Minnick takes a virtual tour of the Zoo and its various research projects and conservation efforts.*

The Zoo was founded in 1916, and today consists of three main branches: the San Diego Zoo itself, the San Diego Wild Animal Park, and the Institute for Conservation Research. The Zoo proper sits on 100 acres of land, and houses more than 4,000 animals from more than 800 species and subspecies, many of which are rare or endangered. The Wild Animal Park houses over 3,500 animals from over 400 species and subspecies on 1,800 acres of land. The Institute for Conservation Research employs over 150 scientists, who participate in studies and projects related to the conservation of animals, plants, and their habitats in 35 countries worldwide.

Conservation Research at the San Diego Zoo is composed of eight research- and education-centered divisions: Field Programs, Applied Animal Ecology, Applied Plant Ecology, Behavioral Biology, Genetics, Reproductive Physiology, Wildlife Disease Laboratories, and Conservation Education.

San Diego Zoo

Heading up the whole shebang is Dr. Allison Alberts. Dr. Alberts came to the Zoo in 1991 and has never left, working her way up the ranks from postdoctoral research fellow to associate scientist, to division head, to her current title as the Zoological Society's Chief Conservation Officer and Benirschke Chair of Research.

Conservation Research has an extensive reach, far beyond the boundaries of the Zoo and Wildlife Park. Internally, there are currently over 100 research projects going on, either in the collection or out in the wild. In terms of external partnerships, the various divisions are involved in over 160 projects.

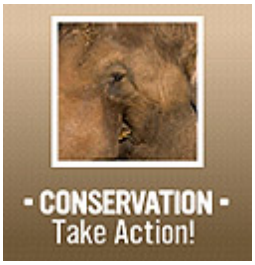
These projects range in size from small-scale, in which the Zoo's role is only one aspect of a bigger plan, to larger, strategic, long-term projects,

such as their many partnerships with the US Fish and Wildlife Service (FWS). The Zoo's relationship with FWS has its origins in the very successful project of recovering the California condor population, which started in the 1980s. More recently, the Zoo partnered with FWS to work on the long-term preservation of the desert tortoise.

Internal cooperation is a hallmark of the Zoo's work. "We've had a big push in recent years to work more collaboratively across divisions, and I can't think of any project that doesn't touch on at least more than one scientific discipline," Alberts explains. "We've found that working together is how we get our scientific innovations and our big breakthroughs. Everything's multifaceted and seems to involve almost everyone. When you talk about these large-scale recovery projects, like that for the California condor, we have every division contributing their piece of the puzzle to the whole, and I think that's why we've been as successful as we have."

When asked about a typical day in the life of an administrator, Alberts replied that there really isn't such a thing as a typical day, that each day is different, whether dealing with meetings on the various projects, raising awareness in the public, visiting in the field, etc.—her job is large of scope and high on variety.

San Diego Wild Animal Park



Institute for Conservation Research

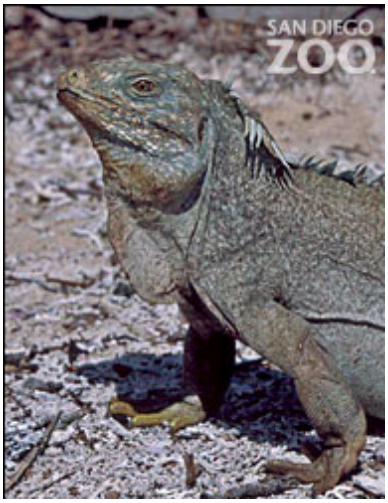
The Difference between Survival and Extinction

Even with administrative duties taking up much of her days, Alberts still makes time for her own research interests, which concern endangered reptiles ranging from the Caribbean and South Pacific to native California species. She finds reptiles fascinating. "They have a reputation for being ugly and not so intelligent," she says, "but when you begin to research them, you'll find that have amazing memories, terrific longevity, complex social structures, and are incredibly well adapted to their environments."

One of Alberts's projects involves a "headstarting" program for Caribbean rock iguanas, laid out in the paper "Behavioral considerations of headstarting as a conservation strategy for endangered Caribbean rock iguanas" (*Applied Animal Behaviour Science* 102[3-4]: 380-91, February 2007). These iguanas are highly endangered. On island ecologies, introduced species can spell disaster for native species, which have no natural defenses against these new predators.

Although the iguanas are the largest native vertebrate still alive today on the islands, when they're babies, their small size—maybe six to eight inches long—makes them vulnerable to introduced predators on the islands like cats, dogs, and mongooses. "You can go to certain islands in the Caribbean a month after the breeding season takes place, and you won't be able to find a baby iguana; they're just all gone," Alberts laments.

The solution? The "headstarting" program. Under this program, the babies born on the islands are brought into captivity and reared there until they are three to four years of age, when they're large enough that they're no longer vulnerable to the introduced species. Then they are released back into the wild to give the population a boost.



Caribbean Rock Iguana

This project is conducted in-country with the full and enthusiastic cooperation of the island people and local governments and conservation groups. The baby iguanas are raised at centers on the islands, rather than being brought to California. Keeping them on the island just makes sense, because moving them to the Zoo would bring unnecessary stress and increase the potential for introducing exotic diseases.

For four out of the nine species of Caribbean iguanas, the headstarting programs have meant the difference between survival and extinction. "It's really kind of a Band-Aid approach, though," Alberts stresses. "It's not going to solve the problem forever and you can't headstart animals forever, but it buys you time to be able to deal with the introduced-species problem in the wild."

The fact is, such Band-Aid approaches are completely necessary, and not just with Caribbean rock iguanas. As Alberts says, "Some species do already live only in captivity, and if you look at what's happening globally, unfortunately, at least in the near term, that number's only going to increase, but hopefully in the long term, we can change that by taking captive-bred animals and reintroducing them to the wild once we get a handle on the environmental problems there." The captive breeding and reintroduction of the California condor over the '80s and '90s is one of the Zoo's better-known success stories, but there are many other such projects on the Zoo's roster.

The Case of the Disappearing Frogs

Captive breeding programs are now being considered for the frogs of the world. All over the world, many species of frogs and salamanders have been falling prey to a fungal skin infection, chytridiomycosis, or chytrid for short, caused by the fungus *Batrachochytrium dendrobatidis*. Dr. Rebecca Papendick, Senior Scientist in the Wildlife Disease Laboratories division, has been involved with the global frog crisis from almost the start.

"It's one of those serendipitous stories," she relates. "I was doing my residency in pathology at the University of Florida at the time. My husband is a herpetologist, and one of his grad students, Dr. Karen Lips, was doing her dissertation research in Costa Rica. She encountered mass die-offs of frogs. It was known that frog populations were on the decline, but I think Karen was one of the first to get her hands on some fairly freshly dead frogs. My husband called me up and asked me to take a look at the specimens and see if I could figure out what was killing them. I found the organism that is now known as the chytrid, but I had no idea what it was and didn't realize the significance of it—and neither did other people at the time."

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African clawed frog being tested by scientists for chytrid fungus (this is part of a new procedure that San Diego Zoo scientists have developed to screen for the disease).

But discovering the cause of the disease is only a small part of the battle. Today, chytrid is still a serious cause of population decline and species extinction worldwide. The Wildlife Disease Laboratories and other people within the Zoo are currently very involved in trying to develop protocols and standards for creating survival assurance colonies.

"This is a last-ditch effort to bring some of these animals that are on the verge of extinction into captivity, raise them in a chytrid-free environment, and keep the species going while we try to figure out what else can be done, how to help in the wild," Papendick explains. "Is there something we can do to help the frogs fight it off; can we find species that are immune? But we need to do what we can to preserve the species that we have right now. So that's a big push of our division at this point. It's a two-pronged approach, to save the species in captivity while trying to figure out what's going on with them in the wild. We can't wait until we know more because they're disappearing now."

Frogs aren't Papendick's only focus. As a board-certified veterinary diagnostic pathologist, she works on animal diseases throughout the Zoo and Wildlife Park, as well as in the Conservation Research programs around the world, and for various external partners.

Looking After Our Feathered Friends

Papendick and Dr. Bruce Rideout, the Associate Director of Conservation Research and head of the Wildlife Disease Laboratories, are also very involved in research dealing with avian mycobacteriosis (more commonly but less accurately known as avian tuberculosis). This project, though still in progress, has been groundbreaking in its discoveries so far.

Avian mycobacteriosis has been a huge management problem in captive situations for decades. To begin with, diagnosis in a living bird is almost impossible to obtain, because as a whole animals tend to hide problems. It's a survival instinct: sickly animals can be kicked out of their social groups or picked off by predators. Because of what is known about human tuberculosis, which is highly contagious, when a bird in an enclosure was diagnosed (usually post-

mortem) with mycobacteriosis, it would set off a panic—a rush to quarantine and test other birds that had been housed with the infected bird. Elaborate clinical workups of living birds—involving blood chemistry panels, fecal analyses, and sometimes liver biopsies—were not only expensive but also extremely stressful to the bird, especially since Zoo birds aren't trained to be handled by humans.

The Wildlife Disease Laboratories groups, including Rideout, Papendick, epidemiologist Carmel Witte, and others, decided to explore the transmission of the disease. "As it turned out, all of the dogma about avian mycobacteriosis being contagious was just that—dogma. We were able to show that in the vast majority of cases studied, the birds acquired the disease from the environment, not from other birds," Rideout states.

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California condor flying free in Northern California.

Although the team is still looking into what environmental factors cause avian mycobacteriosis—whether water, soil, or food—and is also exploring better ante-mortem diagnostic techniques, just the discovery that avian mycobacteriosis isn't contagious has been an enormous step in the right direction, and it has great practical significance.

"When you talk about these large-scale recovery projects, like that for the California condor, we have every division contributing their piece of the puzzle to the whole, and I think that's why we've been as successful as we have." ~Allison Alberts

First of all, infected birds don't need to be quarantined, but are instead carefully monitored in their regular enclosure, causing less stress. "Now when we diagnose a bird with the disease, people don't go into a panic," Papendick says. Even more valuable, Rideout points out, if a particularly endangered bird gets infected, it can still be a part of a breeding program without worrying about infecting its mate.

The Wildlife Disease Laboratories are also investigating Johne's disease in exotic hoofed animals, as well as West Nile virus in California condors. Because of the long-term commitment to the reintroduction of condors into the wild, the populations are carefully monitored and managed. When they are tested for lead poisoning (a well-known problem, stemming from ingesting lead-shot carcasses), they also get tested and vaccinated against West Nile.

Rideout is also involved in other key projects with birds, both in captivity and in the wild. In captivity, he and his team helped to show that the antiparasitic drugs fenbendazole and albendazole, which are widely used in veterinary medicine, have a much narrower margin of safety than previously imagined. "What happened," Rideout relates, "is that I noticed a cluster of a few cases of cormorants that looked like they had viral enteritis, but when I investigated them I couldn't find any viruses. Then we had to backtrack and think of what other things cause intestinal lesions that might look like a virus but are actually something else. One of the things that can do that is drugs and toxins. So then we started looking back in the history of the birds, and found that in all the cases, they had been treated in previous weeks with these drugs."

"What made it difficult for people to realize this connection earlier," Rideout continues, "is that it takes weeks for this effect to happen. You treat the birds for the parasites, which clear, and things seem to be going great, then two to four weeks later, the bird dies. And nobody made the connection that the birds are dying two to four weeks after this drug treatment. So we did the work to show there actually was a connection and to try to alert vets all over the world. The drugs can still be used, but because of the much narrower margin of safety, we recommend that much lower doses of the drugs be employed."

"Interestingly," he adds, "after we published on this, other people started looking at similar effects in other species, and found that these drugs also have a much narrower margin of safety in other species—they caused toxicity problems in dogs and cats and other exotic animals."

In the wild, Rideout has worked on projects investigating veterinary-drug poisoning in vultures in Asia and toxoplasmosis in the Hawaiian crow, the 'Alala. In both cases, the bird populations were in severe decline, but the underlying problems as well as the solutions in these cases were vastly different.

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Sign at the entrance of the San Diego Zoo.

In the past decade, the vulture populations in Asia have declined by upwards of 98%, with some species on the verge of extinction. This decline was a dramatic change for birds that were once abundant across Asia. Rideout was invited to be part of a team put together by The Peregrine Fund, led by a colleague at Washington State University, to discover why the vultures were dying out.

"We took a very systematic approach to our investigation and kept a much more open mind than a lot of other groups, and the end result was that we were able to show that the cause of the decline was the overuse of this veterinary drug, diclofenac," Rideout explains. "It's sold over the counter all across Asia and it has this amazing ability to take cattle that are sick for whatever cause and make them feel really good, so they'll stand up and appear to be better. It seems like a miracle drug, whereas it doesn't cure anything. Ultimately, these cattle will die and they'll have high levels of this drug in their bodies. Across most of Asia, when cattle die, they're just left out for the vultures. So then the vultures eat the carcasses and get a toxic dose of the drug themselves."

What was so significant about this study is that no one had ever shown that a veterinary drug could cause such a widespread decline in a free-ranging species. Rideout emphasizes that what the study really revealed is the close connection between human activities and wildlife, analogous to the DDT work done in the '60s.

As for what's being done about the problem, policymakers are working with the governments to have diclofenac removed from the market. Other teams are also researching new drugs that might be safer. "It's always best that instead of just taking something away from people you give them something to replace it with," Rideout remarks.

In the case of the 'Alala of Hawaii, the solution was more immediate and more drastic. These birds were part of a reintroduction program on the islands. A big problem for Hawaiian forest birds is becoming infected with malaria or pox viruses, thanks to mosquitos, which had been introduced to the islands in the 1880s. Many of the forest birds live at higher elevations, above the mosquito line, but not the crows. They were found to be able to survive pox and malaria infections, but the populations were still dying.

The team outfitted the birds with radio transmitters that came equipped with a mortality signal so that they could do post-mortem exams, which revealed that the birds had toxoplasmosis from *Toxoplasma gondii*. The disease vector was found to be feral cats—the crows would forage in the cats' feces, even treating the feces as a food item.

The solution here was to bring all the birds back into the captive breeding centers in order to beef up their numbers, and the plan is to reintroduce them to the wild once scientists can figure out a way to do so safely, without the birds being exposed to toxoplasmosis.

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Tiger cubs at the Wild Animal Park.

"It's a two-pronged approach, to save the species in captivity while trying to figure out what's going on with them in the wild. We can't wait until we know more because they're disappearing now."
~Rebecca Papendick

Tending to the Big Cats

Rideout doesn't just deal with birds. In a June 2007 paper, he and his coauthors discuss a health problem in tigers that, through their case studies, they discovered is more common than originally thought (Sykes JM, *et al*., "Oral eosinophilic granulomas in tigers [*Panthera tigris*]—a collection of 16 cases," *Journal of Zoo and Wildlife Medicine* 38[2]: 300-8, June 2007). "No one really knows what the cause is. Tigers develop these raised lesions in their mouths, and sometimes they can ulcerate. The animals won't want to eat because their mouths are sore. They can get secondary infections. It's not usually a life-threatening disease in itself, but it can really cause a lot of impact on the animals. It's a very frustrating disease to treat," Rideout relates.

Though no closer to finding the cause, the paper explored potential treatments, the most promising of which is corticosteroids. The fact that steroids work may indicate an immunologic root of the problem. However, steroid treatment is not without risks, particularly in terms of secondary infections.

Next Month: Behavior, Reproduction, and Education

The health of the collections at the Zoo and Wild Animal Park, as well as in the wild, is paramount to the

scientists at the Institute for Conservation Research. But the mental well-being and health of the animals are also important for both keeping them engaged and stimulated and for aiding in captive breeding programs. Next month, we'll talk with the teams who are focused on animal behavior and reproduction, as well as the education efforts of all the teams.

Zoological Society of San Diego's current most-cited paper in *Essential Science Indicators*, with 515 cites:

Murphy WJ, *et al.*, "Molecular phylogenetics and the origins of placental mammals," *Nature* 409 (6820): 614-8, 1 February 2001. Source: *Essential Science Indicators* from Thomson Reuters.

Additional Information:

The Zoological Society of San Diego was a Rising Star in Plant & Animal Science in March 2009.

KEYWORDS: ZOO, CONSERVATION, ECOLOGY, WILDLIFE DISEASES, CAPTIVE BREEDING, HEADSTARTING, FIELD PROGRAMS, ENDANGERED SPECIES, EXTINCTION, CARIBBEAN ROCK IGUANA, FROGS, PATHOLOGY, POST-MORTEM EXAMS, CHYTRIDIOMYCOSIS, AVIAN MYCOBACTERIOSIS, DIAGNOSTIC TECHNIQUES, DISEASE ETIOLOGIES, WEST NILE VIRUS, CALIFORNIA CONDORS, LEAD POISONING, VACCINES, DICLOFENAC, ASIAN VULTURES, JOHNE'S DISEASE, HOOFED ANIMALS, FENBENDAZOLE, ALBENDAZOLE, VETERINARY MEDICINE, PIGEONS, DOVES, TIGERS, ORAL EOSINOPHILIC GRANULOMAS, 'ALALA, HAWAIIAN CROW, TOXOPLASMOSIS, DISEASE MANAGEMENT, COLLABORATIONS, PARTNERSHIPS, CONSERVATION ORGANIZATIONS, CONSERVATION EDUCATION.

PDF

back to top

Institutional Interviews : 2009 : Zoological Society of San Diego

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