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INSTITUTIONAL INTERVIEWS - 2009

July 2009

PDF

Zoological Society of San Diego

Third of three parts (Part 1 ¦ Part 2 ¦ **Part 3**)
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 236 papers cited a total of 1,609 times between January 1, 1999 and April 30, 2009. Their overall record in the database for this period includes 391 papers cited a total of 4,941 times.*

In the third and final part of this feature, ScienceWatch.com's *Jennifer Minnick explores the Zoo's dedication to the conservation of animals throughout the world and in our own backyards.*

Governments and Conservationists Work Hand-in-Hand to Save Species

Initiating and carrying out large-scale conservation projects are what the Applied Animal Ecology Division of the San Diego Zoo's Institute for Conservation Research—headed up by Dr. Ronald Swaisgood—is all about, usually devoted to the recovery of species that are particularly threatened or endangered. The Division's researchers use an arsenal of tools to bring these projects to a successful end, including applying behavioral and ecological studies to better enhance the recovery of any given species in its natural habitat. These studies are applied to both reintroduction—taking captive-bred species and returning them to the wild—and translocation—the relocation of wild animals from one area to another for conservation purposes.

One large-scale project Swaisgood has been involved in for years is the restoration of the black rhinoceros to its historical ranges. As a species, the black rhino has suffered huge declines in number, dating back to the 1960s and '70s, when the population dropped from 75,000 to about 1,600 in about a decade or so, primarily due to poaching.

A few countries—South Africa and Namibia being the most prominent—have the political and economic willpower to try to recover the species. The governments not only protected the rhinos in key reserve lands, but also tried to re-establish the population in the range from which they had been extirpated, once the populations in the reserves had increased enough to allow for translocation.

The problem was that quite a few rhinos were dying after being translocated. Because no one had closely studied what was happening after the rhinos were released, a team led by Dr. Wayne Linklater, a former postdoctoral fellow of the Zoo, radio-collared approximately 100 rhinos that were moved about southern Africa to monitor what they did after release and, in so doing, learned what would make a more successful

translocation program.

"One of the main factors that was causing problems was fighting, particularly by males directed at other males, or even at females and young," Swaisgood explains. "We found, for example, that you need a larger reserve to accommodate this kind of social conflict. They need to be at lower social densities in the post-release environment than in the environment from which they came. Rhinos living in a stable environment, even though they are solitary and aggressive animals, know their neighbors and develop relationships with them that prevent escalated fights. Throw a bunch of them together in a new area where they start encountering each other, they fight, they panic, they're under a lot of stress, and they take off running—they don't stay where they need to stay for their own self-interest. They run through the established boundary fences that were built—crash right through them. One rhino crashed through a fence and ran into an ecotourism lodge, fell into the swimming pool, and drowned."

Black rhinos (pictured) and white rhinos are the same color—they're both brownish gray!

One thing the research team found was that there was a critical threshold size—the reserve had to be about 11,000 hectares to accommodate the social conflict issues. At that size or larger, rhinos could do a pretty good job of keeping away from each other, and adjusted to their new habitats in relative peace.

Scent played a role in the rhino translocation project, similar to Swaisgood's work with the giant pandas. Because rhinos have an extremely keen sense of smell, the team established virtual scent territories in the new habitats by collecting the rhinos' dung and spreading it around the new site.

"The main idea behind this action was that even though rhinos are a solitary and aggressive species that has problems with fighting, when they're looking for a place to settle, they want to settle adjacent to another rhino. Not in their territory, but next to it," Swaisgood says, "This is called conspecific attraction, and the idea is that when an animal is naturally dispersing it needs to find good habitat, and the quickest, simplest way of finding good habitat is to find an area where their species is already living and thriving. Other studies with other species like lizards have shown that even solitary animals were attracted to settle next to other animals of their species."

Spreading the dung around worked really well in settling the rhinos' post-release dispersal problems—researchers were able to manage their settlement patterns, and the program is going much better now, as reported in the team's paper, "Reserve size, conspecific density, and translocation success for black rhinoceros" (Linklater WL and Swaisgood RR, *Journal of Wildlife Management* 72[5]:1059-68, July 2008).

More from the Field

Fred Bercovitch, the Institute's Director of Behavioral Biology, has some research findings newly in print and projects just getting underway that he's very excited about.

First up is his work with koalas in Australia, which was just published in *Behavioral Ecology and Sociobiology*: "Spatiotemporal dynamics of habitat use by koalas: the checkerboard model" (Ellis WAH, Melzer A, Bercovitch FB, 63[8]: 1181-8, June 2009). "What the article discusses," Bercovitch explains, "is a new model for how koalas use their environment. What we end up suggesting is that the animals can have overlapping home ranges, but not overlapping resource use. We speculate that this is because the koalas' social community is a lot more complex than people think, and that koalas navigate their environments in ways we're not clear about at this point."

"We also talk about how if you really want to design a conservation management plan, you need to think of more than just food resources. The big picture is that we need to include more things in our model than food use," concludes Bercovitch.

The team is also just getting started on a partnership for elephant conservation in Africa, which is planned for the area where Botswana, Zambia, Namibia, Angola, and Zimbabwe come together, as probably one-third to one-half of the elephants on the continent live in that area. The team is going to be looking at what determines elephant movements,

and how the behavior and activity of elephants in the collection compare to those in the field.

Koala

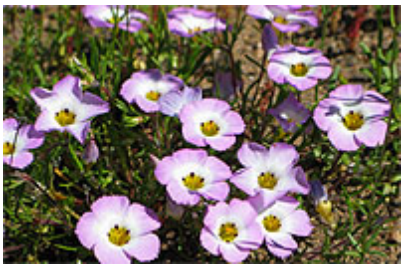
"Elephants need to walk and eat, so how do they know where they've been before, or where other elephants have been in terms of resources, etc.?" Bercovitch relates with enthusiasm. "Those are the questions we're trying to get at, and once we discover how they know where they're going and what it's like out in the wild, we'll can run a coordinated effort here with the elephants in the Wild Animal Park, and determine how to modify our colony management plan to give our elephants in captivity the best possible quality of life. The more we try to link the collection with the field the better the animals in the collection will have it. Nothing is static here; we keep changing things all the time. We can try to mimic the natural situation as best as possible, but are simply unable to duplicate it."

Plants Are Endangered Too

The Institute's Applied Plant Ecology Division focuses on "sustainability and restoration of native ecosystems, seed science, habitat monitoring and management, plant-animal interactions, and recovery programs for rare and endangered plant species," according to its mission statement. Founded in 2007 and headed up by Dr. Brian Endress, the Applied Plant Ecology Division focuses on habitat and plant restoration, not only for the sake of the plants themselves, but also for the animals that live in them or otherwise rely on them for survival.

One of the most challenging projects the Division has undertaken is that of the Seed Bank. This project is a partnership with Kew Royal Botanic Gardens in the UK, part of Kew's Millennium Seed Project, the goal of which is to collect seeds from 10% of the world's plants by the year 2010, focusing on areas of high biodiversity throughout the world. As San Diego County has over 2,000 native plant species—more plant species than any other county in the continental US—it is ideally suited for the project's purposes. And considering all the challenges to plant life at work in the county—including urbanization and increasing fire frequencies—the need to preserve seeds becomes even more apparent.

For their share of the project, Division researchers are trying to collect 20,000 seeds from each species—half of which are sent to Kew and the other half kept for the Division's research. Collecting seeds sounds easy, but it's really not. The seeds have to be hand-collected, from several different individuals within each target species to maintain the population's diversity. And they can only be collected if the target species is producing a viable volume of seeds to supply both the seed bank and the wild population. Since seeds have to be free of debris, pests, and fungi, many of them need to be cleaned and processed painstakingly by hand.



San Diego County is a recognized biodiversity hotspot with an incredibly diverse native flora. This diversity is under constant threat from habitat loss and fragmentation, particularly from intensive coastal development.

"It's a very high, high quality process to get a great product at the end," Endress explains. "We dry the seeds down to a low relative humidity to get as much of the water out as we can while still keeping a little bit in there for the embryo. Then they're put in the freezer. Every couple of years we need to take out samples to germinate, to make sure they're still viable, and some seeds don't handle that process as well as others, so we have to keep track of that and make sure all of our collection in the seed bank is still viable."

That's another reason to take so many samples—they don't just put the seeds in the freezer and walk away. "We conduct important conservation experiments on them, such as what are the best ways to germinate them," says Endress. "It's all well and good to collect the seeds and put them in the freezer, but if you can't germinate them or figure out how to get them back out into the wild there's no point—you're treading water or worse."

Habitat for Humanity—and the Animals

The Division has also undertaken a unique conservation and cultural preservation project in conjunction

with the Conservation Education Division: Native Seeds for Native Americans, which aims to "renew a connection between native plants and tribal people." So far, under the aegis of the project, a plant propagation shade house has been built on the San Pasqual Reservation, more than 100 native trees and shrubs have been delivered to the La Jolla Band of Luiseño Indians for use in post-wildfire restoration, and an ethnobotanical field guide of culturally significant plants, their native names, and traditional uses has been published.

Working within a socioeconomic or cultural frame of reference is something that the Institute's researchers do often. The Applied Plant Ecology Division is currently working to establish the first formal study on palm harvesting in Mexico and Central America. The rationale behind the project is to study a few representative palm species to see how they respond to harvesting, and hopefully, to be able to make some recommendations about palm conservation in general, so that palms can be sustainably managed, while still allowing the local people who rely on palms for their way of life access to the resources they need, and to help ensure healthy habitat for any animals that live in or otherwise utilize the palms. "Working with local communities is really important because they're the ones who use these palm populations, and oftentimes they know more about palm ecology than even the scientists because they live among them and know them quite well," Endress explains.

Another project the Applied Plant Ecology Division is working to get off the ground is in Vietnam, conserving the forest habitat of the Tonkin snub-nosed monkey, one of the rarest primates in the world. "In January, we went over there to assess the situation for the Asia programs, the Vietnamese government, and other organizations that are trying to figure out ways to promote and preserve these monkeys. A lot of the focus is on plants, because these fairly decent-sized (50-60 pounds) primates eat leaves—specifically leaf stems. They have a really peculiar diet and their habitat is restricted to these high mountain forests that there are very few of left in Vietnam," Endress relates.

"The trip was pretty interesting, and again ties in the people aspect because the monkeys and the local communities in this part of Vietnam both rely on the forest. Hunting is not a problem; the local communities also rely on the forest for firewood and a lot of other subsistence and economic reasons," Endress continues. "We have to find ways to maintain healthy habitat for the monkeys while also providing resources for the communities. So, much like the palm studies, we're trying to work out how we can work with people so we have a win-win situation for them and the monkeys." The locals are quite enthusiastic about saving the monkeys, and so Endress has high hopes for this particular program.

Backyard Conservation

Though known far and wide for their conservation efforts in the exotic species like pandas and tigers, the Zoo does a great deal of work in Southern California itself. As the Institute's Director Dr. Allison Alberts says, "Southern California is what you call a 'biodiversity hotspot'—it's an area incredibly high in biodiversity, but it's also very threatened with extinctions. For example, there are more species of threatened plants here in San Diego County than in any other county in the continental US. What's threatening them is development and urbanization, the expanding human population, competition for water and resources, things like that. We do a lot of work with local species, right here in our own backyard: everything from the burrowing owl to the Pacific pocket mouse to the coastal cactus wren, and the list goes on. And I would love to see us become as well-known for that work as we are for our global work. People don't tend to think of conservation as something in their own backyard, but we have some pretty incredible biodiversity right here in San Diego County."

Speaking of the coastal cactus wren, one of the other projects the Applied Plant Ecology Division is involved in is the preservation and restoration of coastal scrublands, the habitat for this particular species of wren. The wren lives in sage scrub that contains a high abundance of prickly pear cactus, and prefers to roost in cacti that are at least three feet tall. The San Diego Wild Animal Park's land is host to about 900 acres of coastal sage scrub natural habitat, but that habitat is in danger even at the Park, due to the increasing frequency of wildfires.

"A lot of us are interested in doing cactus scrub restoration to help the coastal cactus wren populations, which are really declining," Endress says. "The problem is when you go around asking what the best method to restore prickly pear cactus habitat is, there hasn't been a lot of research. So we're trying to fill that need."

Of the 1,800 acres that comprise the Wild Animal Park, 900 are undeveloped, consisting largely of pristine coastal sage scrub.

The Division is currently undertaking an experiment to determine the best way to propagate prickly pear cactus. Cacti can be propagated by pulling off a pad, drying it, and planting it, but the question is whether cacti can be planted right there in the field, or if they would benefit from a year of growth in a carefully monitored shade house? The latter method is more expensive, but is it better for the cacti in the long run? Which method will be best for helping the cacti attain the heights needed to sustain the coastal cactus wren? This is what Endress and his team hope to find out.

The lands of the Wild Animal Park, particularly the coastal sage scrub, are also being used to study fire-recovery rates of native flora and fauna. "We have some great information on what animals are here and the abundances, and with the fires of 2007 we were given a terrific opportunity to look at the relationship between abundances of native animals within the plant habitats and structures," Endress says.

Endress and his team are working on a coordinated effort with Ron Swaisgood and the Applied Animal Ecology researchers to examine the degree to which active restoration helps habitats in 20 plots of land that were affected by the 2007 fires. "Basically," Endress explains, "we divided up the plots into two groups: one we're going to let naturally recover, and we have native plants coming back but we also have quite a few exotics moving in, and in the other, we're doing a combination of herbicide applications to give native plants the advantage. What we're looking at is how the restoration succeeds from a plant point of view, then also working closely with Applied Animal Ecology to see how that translates to better-quality habitats for the animals."

Swaisgood's team is also deeply involved in the restoration of the Pacific pocket mouse and the Stephen's kangaroo rat in Southern California, in partnership with the Fish and Wildlife Service. Just as with the larger, more exotic animals, the principles of using ecological information and behavioral biology for a more successful project apply.

Interestingly, the case of the Stephen's kangaroo rat paralleled that of the black rhino, in that the team, led by Dr. Debra Shier, used scent to mark the rats' new territory. The particular population of rats were in the path of development and needed to be moved to a safer but still suitable habitat. "Phylogenetically, the rats and rhinos are far apart, but behavior-wise, they're both solitary and territorial. In terms of the behavioral ecology there were some similarities, and they also both rely on scent for communication, so we thought it might work with the rats as well," Swaisgood relates, and they were right. The team collected and spread scent around for some of the rats, but not others, because they really weren't sure if it would work or not, and they found a higher post-release survival in the rats for which scent had been used.

More than just the rhinos and the rats can benefit from these studies, Swaisgood points out. "So what we're trying to do is use a series of studies like this to develop an optimal translocation strategy for species—and once we figure out which of these different theories apply to different species we can put together protocols for how best to translocate individuals of that particular species."

Kangaroo rats and pocket mice (pictured) are considered keystone species that influence ecosystem processes in desert, shrub, and grassland ecosystems.

The other thing the team took into consideration with the kangaroo rats was the cost of social disruption when moving wild animals. Swaisgood says this cost needs to be taken into account, but often isn't. "You might think of it with a group of monkeys because we all know how social they are, but you might not think of it for an animal like the kangaroo rat. But again, they have relationships with their neighbors. And in a translocation there are many competing needs: they have to find a new place to settle, to be on the lookout for predators, and if you add one more cost to them—that of forcing them to develop new relationships with new neighbors—you might actually hinder that effort. And we found that that was the

case. So what we did was translocate groups of kangaroo rats that were neighboring at the source population and were already familiar with each other and released them next to each other. We found that those animals thrived better when released this way rather than random release."

The project on the Pacific pocket mouse is currently in a holding pattern. The team intended to do a similar project to what they did for the kangaroo rat, but they ran into the unfortunate obstacles of the 2006 drought in Southern California—the mouse population had crashed to such an extent that they didn't want to risk capturing more mice from the source population to move them. Unlike the kangaroo rat, the habitat for the pocket mice was in no immediate danger—rather, the plan for the project was to extend the natural range of the mice. While the relocation aspect of the project is stalled, the conservation partners are looking into the possibility of a captive breeding program. "The mice haven't been bred in captivity before but because the population has become so critically low, the feeling is that we might want to establish an insurance colony just in case something happens to that small population," Swaisgood explains.

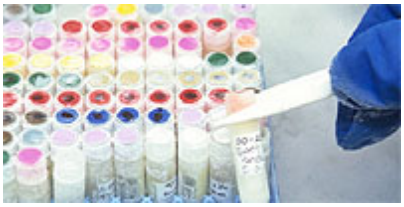
A similar debate occurred years ago, with the California condor breeding program, Swaisgood mentions by way of precedent in favor of the breeding program for the mice. "Many years ago we were down to 22 animals—we started a breeding program and now there are over 300. We've done the same thing with the San Clemente Island Shrike, another local species that lives off the coast of San Diego," he adds. "We've bred and released several hundred of those birds, and the wild population today is comprised almost completely of animals that we bred in captivity or their offspring."

Applying Genetics to Conservation

Leading the Institute's Genetics Division, including the part of the Frozen Zoo® that encompasses frozen tissue samples and DNA banks as well as an extensive living cell collection, is Dr. Oliver Ryder, who has been with the Zoo since 1975. "The success of this enormous collection," Ryder asserts, "lies in the fact that we've been able to preserve this material so that when new technologies become available, we're in a position to help undertake studies or to undertake them ourselves using new techniques but drawing on the samples that we've banked, including the living cell collection."

Studies in the Genetics Division include a wide variety of topics, from filling in the phylogenetic tree to DNA barcoding to helping unlock the mysteries of the human genome. These studies address such questions as: how different is the Przewalski's horse from the domestic horse? Or the black rhinos of southern Africa from the black rhinos of eastern Africa? Why are some animals not breeding—could this be due to a cryptic speciation in chromosomal differences?

The Zoo's most-cited paper in the *Essential Science Indicators* database comes from the Genetics Division: "Molecular phylogenetics and the origins of placental mammals," (Murphy WJ, *et al.*, *Nature* 409[6820]: 614-8, 1 February 2001). "This study was the most ambitious undertaking to look at the molecular evolution of the placental mammals," Ryder says. With the advent of DNA sequencing technology, Ryder and his co-authors were able to use DNA sequencing information to evaluate the evolutionary tree of the placental mammals.



The Frozen Zoo®

"Some very unexpected relationships were found," Ryder relates. "There's a group of animals called the Afrotheria, which showed that tenrecs, which are little hedgehog-like animals from Madagascar, and elephants and aardvarks and hyraxes and manatees were all closely related—were on the same branch, in fact, even though they had diverged enormously in terms of their morphology. Understanding the systematics, the evolutionary relationships of species, is really crucial to managing their conservation efforts."

Another key project for the Division is DNA barcoding. This project came about in part due to situations that would arise in the field, leading researchers to realize that having reference DNA banks could be an extremely useful tool. Thanks to tissue samples collected from gorillas in zoos and studies performed in the field in Africa, Ryder's team was well-positioned to help the government of Rwanda with the identification of some orphaned gorillas: the team was able to tell, though genetic comparisons, whether the orphans were mountain gorillas or eastern lowland gorillas.

Similarly, field workers often request help in identifying the origins of bush meats. Subsistence hunting has been giving way to wholesale commercial overexploitation of wildlife in many parts of the world. Conservation workers can use DNA barcoding technology to track this illegal trade. "Because we have the Frozen Zoo®," Ryder says, "we're involved; we have many of these species already documented, so we

can build up this reference database, and we also have the laboratory facilities to undertake this work and to train people so that they can learn how to do it. We've trained high school students, who've gotten on fire about all this, producing documentaries and traveling to Africa and training wildlife officials about this technology. We're bringing people from other countries to learn how to utilize these techniques in our laboratories."

The Genetics Division is also aiding the National Institutes of Health on the Human Genome Project. "As you know, the human genome was sequenced in 2003, but in order to better understand the human genome, researchers need to expand their understanding of the genomes of other species. For instance, mice and humans are on the same branch of the mammalian tree, something we know from the Murphy paper," Ryder explains, "so we need to sample from all the branches."

+enlarge

Sign at the entrance of the San Diego Zoo.

"And so the NIH in its effort to understand the evolution of the human genome is involved in determining the genome sequences of other species," Ryder continues, and the Frozen Zoo® has been a source of many of these studies. For instance, the elephant genome that has been sequenced is a female from our Wild Animal Park, and the gorilla that's being sequenced is also a female from the Park. We're very happy to participate in those studies because we're able to help design them in a way that is both beneficial to the goals of their study but in ways that also contribute to our conservation mission in that we would like to know more about the genetic variations, for example, of endangered species of zebras."

Ryder goes on to discuss the value of these studies for the Institute. "For instance," he says, "I'm sure you're familiar with the 'out of Africa' hypothesis for humans, and the 'mitochondrial Eve.' Humans aren't the only species that have that story, so understanding how the zebras or elephants or rhinos are distributed across their range and how the gene pool is partitioned is really important for conservation. Knowing this can help you set up reserves or understand what historical patterns of migration or population growth were. All of those processes can leave a kind of a signature on the genome, in terms of its genetic diversity, and having that information can be very useful for conservation efforts."

Another current project Ryder's group is working on is using genetics in the field to aid the continuing restoration of the California condor. "The condor's gene pool is really small," he says, "and condors are susceptible to a genetic disease called chondrodystrophy. We're trying to apply the same methods to help condors as we use for understanding genetic diseases in humans. We're trying to map a deleterious gene to try to understand what went wrong, and identify carriers so that we can better manage our breeding program. Five years ago, the only genetic map for a California condor was whether it was male or female, and now we have a genetic map with hundreds of markers on it. Next year we hope to make it have almost 1,000—we're going to embark on a condor genome sequence so we can better understand the biology of condors not only in terms of their diseases but also with regard to their historic population sizes and as they face new threats in the environment, threats like West Nile virus, that they weren't previously exposed to."

Summing up this study as well as the work of his Division, Ryder concludes, "The tools that we use to understand other species are, increasingly, genetic and genomic analyses. We feel that this is just a responsible way to ensure, as best we can, the future these species, as part of our overall efforts."

Teaching Future Generations

Because all the Zoo's efforts would be in vain if future generations didn't learn the value of conserving worldwide biodiversity, the Zoo runs a variety of education programs through the Institute for Conservation Research. These programs touch the regional, national, and international levels. The Institute hosts postdoctoral researchers and student interns both in San Diego and at the various field programs worldwide.

The Institute works with students and community groups, teaching cooperation and sustainability. It also runs a seminar series with diverse topics such as the effects of dolphin shows on conservation awareness and their impact on dolphin behavior, elephant distribution and home ranges in Botswana, the reproductive biology of the giant panda, as well as more local conservation issues such as monitoring

the coastal California gnatcatcher populations, and the impact of urbanization on bobcats in Orange County.

The Arnold and Mabel Beckman Center for Conservation Research

All the staff at the Institute for Conservation Research are dedicated to getting the word out about their projects. For instance, Fred Bercovitch talks about putting his and Matt Anderson's bioacoustic research into a context zoo visitors can understand, by playing the recorded vocalizations. "If a child has ever heard a baby grey squirrel make its high-pitched shrieking noise, we can say to the kids, 'Remember that noise? Well, some endangered animals do that too!'" Bercovitch says.

As the mission statement of the Institute for Conservation Research says, the various divisions are "Committed to generating, sharing, and applying scientific knowledge vital to the conservation of animals, plants, and habitats worldwide." From as far off as Africa to as nearby as San Diego County, the Zoological Society of San Diego is doing its level best to meet these goals on a daily basis.

Zoological Society of San Diego
Institute for Conservation Research
Escondido, CA, USA

Zoological Society of San Diego's current most-cited paper in *Essential Science Indicators*, with 530 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:

Zoological Society of San Diego three-part interview: Part 1 ¦ Part 2 ¦ Part 3

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

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