Sand Dune Lizards (*Liolaemus multimaculatus*) are extremely cryptic. Surveys consist of multiple researchers walking transects across the dunes while counting the fleeting glimpses of lizards as they scurry away.

Natural History and Conservation of the Sand Dune Lizard (*Liolaemus multimaculatus*)

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Photographs by the author.

The day is dawning on the beaches of Buenos Aires. The sun's first rays caress the sand. As the temperature starts to rise, so too do the small inhabitants of this landscape. The Sand Dune Lizard (*Liolaemus multimaculatus*) starts its daily activities at a sluggish pace that will quicken with the warming rays of the sun.

This small saurian, a typical representative of these immense sand fields, has evolved for so many centuries in such close association with the landscape that it is unable to survive elsewhere. Its current conservation status is critical, primarily due to the irrational and excessive exploitation of these environments. Thus, this Argentinean endemic lizard is now categorized as a vulnerable species.

An overview of the dynamics of this ecosystem, as well as of its former and present use, is essential in understanding both the life history of this species and its current situation.

What is the Value of Coastal Areas?

Coastal environments represent about 8% of the Earth's surface, and they are considered among the most threatened environments on the planet. Most human-generated threats to biodiversity are exacerbated in these areas, mainly because human populations have always flourished along shorelines. Over half the world's population (about 3.2 billion people) live within 200 km of oceans and seas (only 10% of the earth's land surface). With this population distribution, increasing human numbers and mounting developmental pressures are taking a grim toll on coastal and near-shore resources. Sand dunes act as filters for water that allow the existence of aquifers (underground reservoirs of drinking water that supply nearby localities) and protect the coastline from erosion, ensuring the long-lasting existence of sandy beaches. In addition, coastal areas are attractive and offer great potential for tourism.

The marine coastal zone of Buenos Aires Province is particularly diverse in natural environments, including sandy beaches, cliffs, extensive sand dunes, and a large brackish lagoon (Mar Chiquita). These diverse ecosystems support numerous native plant and animal species that are threatened to varying degrees. Several of these species are poorly known, and some are in danger of extinction, as is the case with the Sand Dune Lizard.

From a historical perspective, urban development along the coast of Buenos Aires, which has been the most popular tourist destination in the country for about a century, has not involved adequate planning or resource management. Urban planning has not taken into account the risks of erosion when designing roads or drainages, or the impact of sand extraction on the sediment transport cycle. Furthermore, the current environmental impact legislation does not consider climate change, an extremely relevant factor in these highly dynamic systems. Other factors, such as pollution, overexploitation of resources (both fisheries and sand), use of 4 x 4 vehicles on the beaches and dunes, and the introduction of exotic plants for dune fixation,

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The Mar Chiquita Provincial Park lies along the Argentinian Atlantic coast

Sand Dune Lizards (*Liolaemus multimaculatus*) have evolved in such close association with these sandy habitats that they cannot exist elsewhere.

Sand Dune Lizards, such as this adult female, are small saurians, less than 70 mm from snout to vent, with a flattened body and a stout head.

represent additional disturbances. These problems seriously affect biological and geological aspects of the coastal fringe by altering its natural dynamics, modifying the landscape, and threatening the natural, paleontological, historical, and cultural heritage of the community.

The populations of endemic fauna and flora, that is, those species that evolved in and can only survive in coastal habitats, are the most affected by these activities, and they could be wiped off the face of the Earth within a few years. The Sand Dune lizard is one of these species, and its populations are already severely compromised.

Sand Dune Lizards

Five species of lizards occur in the coastal sand dunes in Buenos Aires province and the northern coastal region of Río Negro

Small size, body form, and color are all adaptations for life in the sandy dunes.

Juvenile Sand Dune Lizards may be distinguished from adults by the yellow lateral bands that disappear at maturity.

Endangered coastal dunes in Argentina act as filters for water that allow the existence of aquifers and protect the coastline from erosion, ensuring the long-lasting existence of sandy beaches.

province, Argentina. These are *Liolaemus multimaculatus*, *L. wiegmanni*, *L. gracilis*, *L. darwinii*, and *Stenocercus pectinatus*. All but *L. darwinii* are known as sand-dwelling lizards due to their preference for sandy biotopes. In addition, *L. multimaculatus* and *L. wiegmanni* are highly specialized for life in the sand, and are accordingly clustered in a monophyletic assemblage of "sand-dwelling lizards" within the genus *Liolaemus*. However, only the populations of *L. multimaculatus* occur exclusively in these habitats, whereas the other four species have wider geographic dis-

Six isolated patches of coastal dunes remain in Buenos Aires Province; all have been declared "Áreas Valiosas de Pastizal" (Valuable Grassland Areas). These patches are separated from each other by coastal towns catering to tourists, which block gene flow between lizard populations in each area.

The author and Ricardo Cañete, a park ranger at the Mar Chiquita Natural Reserve. Rangers monitor and enforce protective measures intended to preserve some of the few remaining natural areas. They also are providing logistical help with this study.

Males are larger than females and have scattered ventral spots that are not visible in this view.

tributions. Historically, this species could be found throughout the marine coast of Buenos Aires; now, however, it has become hard to find in areas where it used to be abundant. Its habitat specializations make this lizard an "indicator species." Indicator species reflect the "health" of the ecosystems they inhabit and are the first to disappear when faced with serious alterations of their habitats.

Liolaemus multimaculatus is a small saurian, less than 70 mm long from snout to vent, with a flattened body and stout head. Its dorsal coloration shows a somewhat irregular pattern of dark spots in transverse series on a brownish background. The spots are outlined posteriorly by white scales, which give them a sand-like appearance. These lizards show evident sexual dimorphism in size and ventral coloration (males are larger and have scattered ventral spots). They usually are seen on dunes with low or sparse plant cover as they scurry away; when not in motion, the lizards are virtually undetectable; their coloration and texture are a perfect match for the substrate. To burrow and "sand-swim," these lizards require loose sandy substrate, which does not occur in areas with abundant vegetation, such as the those planted with exotic species such as pines (*Pinus* sp.), acacias (*Acacia* sp.), or Tamarisk (*Tamarix* sp.).

What is Happening to the Sand Dune Lizard?

This species is highly adapted to life in the sand. Its sand-swimming ability and cryptic coloration attest to the close evolutionary ties between this lizard and the coastal dunes. Its situation is even more critical given the severe alterations experienced by the coastal habitats in Buenos Aires Province, because it cannot colonize and survive in other habitat types. Studies carried out in a dune sector called "Mar del Sur" have shown that this species is highly sensitive to habitat alteration; minor disturbances such as the establishment of a trail for 4 x 4 vehicles can seriously affect its natural populations, causing a critical drop in population density and eventually leading to localized extirpation. This situation is clearly evident in the dune sector situated between the

"Sand-swimming" involves axial oscillations of the trunk and tail, and can be performed only in substrates that are too loose to permit tunnel formation, which is not the case in areas with abundant vegetation, such as those planted with exotic species.

Spots are outlined posteriorly by white scales, giving these lizards a sand-like appearance and rendering them extremely cryptic.

towns of Villa Gesell and Cariló, where this lizard was abundant no more than 10 years ago; today it is practically impossible to find in that area.

Only six patches of coastal dunes remain in Buenos Aires Province, and they have been declared "Áreas Valiosas de Pastizal" (Valuable Grassland Areas) for South America. These patches are isolated and separated from each other by coastal towns catering to tourists, thus making it impossible for the lizard populations in each of them to interbreed. This factor prevents gene flow, thus reducing the genetic and phenotypic plasticity that allows greater flexibility in responding to abrupt environmental changes. In addition, these patches (with the exception of small portions that have been preserved as natural reserves) are not managed with a focus on the conservation of the habitats and species that live in them. On the contrary, the excessive and irrational exploitation that takes place in these areas disregards any environmental protection, and ultimately facilitates the disappearance of the original environment along with its native flora and fauna, including the Sand Dune Lizard.

Studying and Conserving the Sand Dune Lizard

In 2004, as part of a Ph.D. research program, a study of the population dynamics of this lizard was initiated under the direction of Jorge Williams (La Plata University). Due to its restricted distribution in dune islands, as well as its high degree of specialization for this particular type of environment, this species is an excellent model organism for basic ecological studies. Later, after considering the problems that affect this species, the project was expanded to include new aspects related to the protection of its relictual populations. The main goals of this project are: (1) Locating, assessing, and monitoring the status of wild populations, and (2) providing the general public with clear information about its circumstances, and taking action to promote conservation strategies for this species in particular and the sand dunes in general. This is accomplished by means of two interrelated programs.

Even when their approximate location is known, finding and catching these lizards is difficult.

Gala Sanchez Velíz, an advanced biology student at La Plata University, measures a lizard.

The Scientific Research Program

The goal of this program is the study of basic aspects of population dynamics (spatial arrangement, population density, survival, and mortality), autoecology (habitat use, home range), and elements that allow us to assess the status of wild populations, such as the study of fluctuating asymmetry (a bioindicator of environmental stress that is expressed in populations subject to primarily anthropic impacts producing size differences between left and right body sides) and any decreases in genetic variability due to population isolation. Knowledge of the basic ecology of a species is essential for establishing management guidelines and initiating conservation action. The study is intended to encompass all of the coastal dunes that remain in Buenos Aires Province. However, due to the lack of effective and sustained financial support, the project has been restricted largely to research in specific sectors, mainly the natural reserves at Mar Chiquita and Faro Querandí and neighboring areas. The results of these studies will permit the identification of priority areas for monitoring and conserving wild *L. multimaculatus* populations, as well as for ongoing assessments of their conservation status. To optimize fieldwork, volunteers from around the world have been solicited to help with this project. Thus, a relatively large group of people are available during the most intense stages of the project (e.g., during the reproductive season in spring and summer, when these lizards are most active, given that they hibernate and are inactive during the winter. Volunteers perform different research-related tasks, and some also participate in activities that promote public awareness.

Volunteers from around the world have helped with this project. The 2007 Sand Dune Lizard work group in the field (from left to right): Gala Sanchez Velíz (La Plata University), the author, Gianluca Guaitoli (an Italian naturalist), Alberto Rafael (La Plata University), Cristiano Liuzzi (an Italian wildlife technician), and Alejandro Molinari (La Plata University).

Once in hand, individuals are measured and marked prior to release at the original site of capture.

Blood samples are taken for genetic studies that will allow researchers to assess the effects of isolation on individual populations. The author (right) is assisted by volunteers: Javier Caimi (center) and Paula Lourenco are biology students at La Plata University.

Public Awareness Program

The goal of this program is to provide clear and understandable information about the severe threats affecting the Sand Dune Lizard and the coastal dunes. Results of the research program are conveyed to the local community in an effort to create a greater awareness about these issues. Using a conservationist approach, we emphasize information about the benefits of conserving the coastal natural resources. This program is part of a larger team effort, the "Coastal Conservation Workgroup" ("Grupo de Trabajo para la Conservación de las Costas" or GTCC) integrating researchers from the Universidad Nacional de la Plata, Universidad de Buenos Aires, and Fundación de Historia Natural "Félix de Azara," all of whom share a mutual interest in the conservation of coastal environments. To achieve the project's stated goals, conferences are organized and brochures and posters are distributed in several coastal towns. Results of this work also have been presented at meetings and in scientific journals in Argentina and internationally.

Information about preservation efforts is diseminated in public education programs and at scientific meetings; here, the author (right) and Cintia Celsi present a poster at a meeting of the Grupo de Trabajo para la Conservación de las Costas (GTCC = Coastal Conservation Workgroup).

What Can We Do?

Gaining knowledge is the first stage of a process that can lead to a greater awareness of the difficulties faced by this species in particular and its environment in general. The second stage is the initiation of definitive actions that promote rational and sustainable use of these habitats at personal, institutional, and governmental levels. These natural habitats can be enjoyed without altering them or affecting the plants and animals that have coexisted for such a long time. These goals can be realized if humans become aware of the current situation and sensitive to other realities beyond our own. The preservation of the natural world is our responsibility.

The coast grows dark, and as the sun moves into the sea to hide beyond the horizon, a lizard burrows in the sand under a large tussock where it has chosen to spend the night, escaping the cold and nocturnal predators. The Sand Dune Lizard rests from its forays, recovering its energy for what we hope will be many new tomorrows.

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