Applications of GIS and Remote Sensing in Herpetological Conservation

Herpetological conservation focuses on reptiles and amphibians. These organisms, apart from being some of the oldest existing vertebrate clades aside from fish, are an integral part of every extant ecosystem type on earth save for the polar ice caps. Much like many living things on this planet rapid climate change and habitat loss is adversely affecting these ectotherms. Amphibians in particular are suffering heavy losses in numbers. Their biology makes them particularly susceptible to waterborne toxins and pollutants and many are being besieged by a cadre of increasingly common parasitic organisms, such as the chytrid fungus, that lead to often fatal diseases. In either case endangered amphibians and reptiles are becoming more common and must be conserved for future biosphere integrity.

Conservation often begins with understanding. It’s impossible to protect any species without first knowing its ecological roles and needs, its behavior, how anthropogenic factors affect them and a slew of other factors. A daunting task which requires an array of effective tools and methodologies. One such set of tools are GIS and Remote sensing. Apart from several forms of interpolation, which is not an uncommon procedure in GIS modeling, no single method or sensor seemed to stand out in the scientific articles reviewed for this overview. This would seem to be less a mark inefficiency of these tools in herpetological studies and more an indicator of their versatility and range which is necessary to tackle such complex subject matter. However, some trends in basic use did appear.

Firstly, remote sensing allows researchers to study animals in conditions too vast, dangerous for direct human observation. Case in point, a study by Richardson, et al. (2013) on the behavior of a population Green sea turtles in Sri Lanka. The migratory and feeding behavior of this particular group had not been well documented in the past but since sea turtles travel vast distances underwater direct observation was obviously out of the question. The solution was satellite tracking receivers attached to the turtles when they nested in the Rekawa Sanctuary. With this the location data was used to analyze the different subjects’ movements. As a result, the team found that this group exhibited a higher than expected behavioral plasticity or adaptability.

Remote sensing is also used when subjects aren’t physically inaccessible but must be observed under natural conditions without human intervention. Pille et al. (2018) studied a group of translocated Hermann tortoises released to reinforce a population ravaged by fire. Each subject had a radio transceiver affixed to them in order to track their movement and behavior over several years. Human presence during the study would have marred the results otherwise and luckily the subjects did seem to eventually integrate into their new home.
GIS offers some powerful advantages as well. Arguably one of the most pertinent is its sheer modeling flexibility. Many variables can be observed and analyzed together for a number of important perspectives on a given ecosystem and its inhabitants. Density maps of nesting sea turtles (Lopez, G., et al. 2015), the suitability of a habitat after grazing for sand lizards (Wouters et al. 2012), Loggerhead sea turtle bycatch hotspots (Cambie et al. 2013) and the distribution of mountain stream salamanders (Escalera-Vázquez et al. 2018) are but a handful of examples of the resulting maps we can make according to the data needed. These last two studies actually bring attention to another important component of GIS, interpolation.

As researchers we have to face the reality that we may not have the time, energy, resources or manpower to study a population as extensively as we wish. Luckily interpolating new information using mathematical algorithms and enough existing information can be a viable alternative if done right. Cambie et al.’s paper on loggerheads used information gathered by local long line fisherman, GPS trackers on said fishing lines and complex spatial analysis along with Kriging interpolation to form their bycatch hotspot models. The kriging would help fill in any gaps and also provide information on the validity of said interpolations. The paper on Michoacan stream salamander’s by Escalera-Vázquez et al. used interpolation to predict the distribution of the endangered creatures. Very useful considering their small size highland distribution. With information regarding historical and modern locations coupled with data on habitat variables conducive to their survival it was unfortunately predicted by the model that their distribution could be greatly reduced and that these animals are more endangered than originally known. However, if these interpolations were not available who knows how long it would have taken to identify this dangerous trend using traditional methods. The damage would be far grater if not irreversible.

All in all, remote sensing and GIS are powerful research tools for herpetological conservation. Given the range and variation of these animals we need far reaching and efficient means to study them and their complex associations with the biosphere. Given the sheer breadth of the subject it’s difficult to pick a data source that’s more useful or valuable than all the others. A better term would be the most basic data source needed and in almost any conservational plan that would be an organism’s habitat needs. How could we protect something without knowing what it needs to survive and whether or not those conditions are altered in some way?

I’m quite sure these applications will grow, adapt and be refined as time goes on. The need for better data will push technology forward as it ever has. UAV’s could be used to study arboreal tree frogs in rain forest canopies. Thermal imaging could be used to study thermo regulation in basking Nile crocodiles. There are many possibilities and that is only assuming most of those ideas haven’t been recently in play. This is but a handful of the existing literature after all and were going to need all we can learn to care for these ancient denizens of our world.
Annotated Bibliography:


This paper by Cambie et al. tackles the issue of the bycatch of endangered turtle species by attempting to develop a method for estimating sea turtle bycatch hotspots via density map. Specifically, for smaller-scale longline fisheries, a scale which hasn't historically had the necessary research put into it. In order to create such a sophisticated model several variables were voluntarily provided by participating Italian fishing crews over a two-year period and also tracked with GPS sensors attached to the line’s buoys. These include area covered by the main lines, the number of hooks per line, the position of hooks that produced bycatch and soak time of the lines. The data was compiled in a GIS database as several polygon sets which, via a spatial analysis procedure and the kriging method, were eventually interpolated into the desired density map. As a result, this study provided the scientific community with a standardized, accessibly low cost and reproducible method to calculate bycatch density maps at finer spatial resolutions. This is invaluable given it can apply to multiple turtle species across the small-scale fishing industry. Its repeatability is paramount due to the fact hotspots change with time as turtle populations inevitably shift. All the better to quickly and effectively avoid them.


This paper by Escalera-Vázquez, Hernández-Guzmáz, Soto-Rojas, and Suazo-Ortuño focuses on interpolating the distribution of endangered Michoacan stream salamanders in Mexican Highlands. In this case historical location data for the species was pulled from the Herpetology Collection of the California Academy of Sciences, the Global Biodiversity Information Facility and local scientific literature. These were combined with surveys conducted in the wet and dry seasons from 2013 to 2015 to reverify populations in historical locations and collect new data. Preferred habitat conditions were analyzed to further add to the distribution model. These included environmental variables from the WorldClim-Global Climate Data Project, correlated using statistical Program R software, and with land use and elevation data from the National institute of statistics and geography. All these sets were analyzed in a Geographic Information System to produce a potential landscape distribution model for the species. From said model the researchers found that Michoacan stream salamanders may have a smaller distribution range than previously studies had concluded, possibly due to habitat loss, and may require a higher threatened conservation status. Immediate attention to and verification of these findings is needed to prevent irreparable damage to the species.

The next paper by Lopez et al. studies several species of sea turtle nesting along the Bahia coastline of Brazil. Its main purpose is two-fold, first the creation of a sensitivity map for the coastline. Second the creation of a Map guide incorporating the prior mentioned sensitivity map in order to be used as a guideline for safe coastal development. The data incorporated came from local patrols of beaches and in situ nest monitoring following codes established by the Brazilian National Sea Turtle Conservation Program. The GIS designed map took into account the density of nests per kilometer of the coast assigning a relevance to certain amounts of nest sites. The higher the relevance, the more vulnerable the location. Once completed it was compiled into the sensitivity map guide along with protective guidelines based on internationally recognized best practices for nesting ground protection corresponding to the level of relevance for each site. As a result, not only were more vulnerable areas focused on for conservation efforts, the Guide is implemented in standard procedures for the environmental licensing of beach side projects. As a healthy side effect, developers looking to build on the coast without facing legislative pressures to set back their projects are more often considering the measures of the guide to mitigate impacts on sea turtle nests. It should be noted this paper is a bit sparse on its exact GIS methodologies and could use more information for the sake of repeatability of the process in other contexts.


The paper by Pille et al. studies the effectiveness of translocation as a supplement to population reinforcement in conservation. This practice is controversial due to cases where animals taken to new territories tended to die out or spread too far from the intended territory. Thus, providing no genetic reinforcement to the ailing target population. However, the proponents of this paper argue that with proper planning and long term monitoring it’s a viable method. To evaluate this, they remotely monitored with radio transmitters the movements and mortality rates of rescued Hermann turtles released into a population in the National Nature Reserve of France. This original control population had suffered member loss due to fires in the areas. Overall their mortality wasn’t any more pronounced than the control populations and despite not settling rapidly their movement patterns eventually became indistinguishable from that of local turtles. This behavior indicates settlement and most crucially the increased possibility of the translocated tortoises aiding resident recovery. It should be noted the use of rescue animals is an ingenious way to provide further conservational value to these types of projects.


The study by Richardson et al. looks at the behavior of endangered Green sea turtles satellite tagged at Rekawa Sanctuary in Sri Lanka. Although many turtle populations can exhibit similar travelling behaviors, they may reveal plasticity that leads to undocumented trends. The Rekawa population had not been studied yet in this regard and it was hoped that understanding their travel ranges could help in future conservation efforts. The tagged animals provided data on their nesting
activities in and away from the sanctuary, inter-nesting or foraging periods, migrations and site residency. With this information the Sri Lankan population was found to have very plastic or in other words adaptable behaviors. Several strategies abounded either farther migration routes, hunting grounds at deeper than expected waters or differently localized territories. In the end this is but the beginning of a possible research set that will help determine not only what nesting areas must be protected but also what oceanic routes must be monitored for their protection. Perhaps further study could reveal the triggers for the heretofore poorly understood behavioral changes.


The paper by Wouters et al. studies fascinating perspectives between Sand lizards in the Netherlands and their coastal dune environment. This study means to interpret how changes in vegetation composition and configuration after grazing affects habitat suitability for these animals. Grazing as a conservation method is traditionally thought to prevent plant type homogenization. This in turn should hypothetically benefit sand lizards due to their dependency on heterogenous plant cover. Interestingly enough, studying the coverage from the lizard’s perspective actually allows us to use them as an indicator for the success of the conservation method. To test this compositional data was collected remotely and extracted from high res, geo referenced aerial photos of the area taken over 16 years, specifically three pictures taken between disturbance and grazing events. Namely in ArcGIS, using moving window analysis, each pixel of the coverage map took into account an area equivalent to a lizard’s daily home range and, depending on the coverage and known behavior, scored its suitability for the lizards, giving us a useable model. From said model we see overall suitability didn’t change over the whole area but at smaller scales good areas degraded while poor areas improved, leading to the neutral net effect. This tells us that at the overall scale grazing isn’t as effective as was originally thought. Also, it tells us the lizards aren’t the indicators of large-scale heterogeneity change, but they are useful at monitoring small local disturbances.