HABITAT RESTORATION AND ABUNDANCE ESTIMATION OF THE ENDEMIC SPECIES DAHL'S TOAD HEADED TURTLE (Mesoclemmys dahli)

Final Report to the People's Trust for Endangered Species - PTES
Presented by:
Turtle Survival Alliance and Wildlife Conservation Society

©German Forero/WCS

December 2015

people's trust for endangered species
Bringing the wild back to life

TSA turtle survival alliance
www.TurtleSurvival.org

Wildlife Conservation Society

Project Information

Project Head:
Germán Forero-Medina
Science Director
Colombia Program
Wildlife Conservation Society
Turtle Survival Alliance
Calle 2 #42 - 23
Cali, Colombia
(+57-2) 6831103
gforero@wcs.org

Institute:
Turtle Survival Alliance
Wildlife Conservation Society

Country Project is based in:
Colombia

Project Start date: October 2013
Project end date: September 2015

Date of Report:
December 2015

Species/habitat:
Dahl´s Toad Headed Turtle (Mesoclemmys dahli)
Tropical Dry Forest

Conservation Action:
Land/water management - Site/area management
Habitat & natural process restoration
Awareness & communications

Research Action:
Population size, distribution & trends
Threats
Conservation Planning - Species Action/Recovery Plan

Project Staff

Luis Eduardo Rojas, Biologist
Associate Researcher

John F. Gaitan, Zootechnician
Associate Researcher

Ruben Palacio, Biologist
Associate Researcher

Natalia Gallego, M.Sc.
Associate Researcher

Oscar Díaz Negrete, Engineer
Associate Researcher

Tomas Mejia
Field Technician

German Forero-Medina, Ph.D.
Science Director

Padu Franco, M.Sc.
Director
Widlife Cosnervaton Society – Colombia

Rick Hudson
President
Turtle Survivall Alliance

Table of Contents

Executive Summary

Dahl´s Toad Headed Turtle is and endemic and endangered species from northern Colombia, restricted to a small geographic area. In 2007 a study in one locality in Cesar, supported by the People´s Trust for Endangered Species (PTES), focused on abundance estimation, movement patterns and habitat preferences. In 2013, a second phase of the project begun, funded by PTES, Turtle Survival Alliance and Wildlife Conservation Society, with the aim of implementing restoration activities in the previously studied population and evaluating the species abundance across its range, in order to provide recommendations for conservation in other localities.

During this second phase, from 2013 to 2015, we developed a restoration model for the species habitat in the locality of Chimichagua, Cesar. This process included selecting reference ecosystems (riparian vegetation), rebuilding a nursery at a local school to provide treelings for the restoration activities, developing conservation agreements with the landowner and planting more than 1500 treelings of native species along the streams inhabited by *M dahli*, with the involvement of children from public schools. The agreement with the landowner involved building a fence around the area to be restored and building watering systems for the cows, as now they don´t have any access to the stream. These activities were concluded successfully and the first monitoring of the planted trees indicates high survival rates (>80%) despite a very long dry season, with intense water scarcity. The vegetation along the stream is starting to grow back, and there is no grazing from the cattle because of the fence. The process of recovering the vegetation and the habitat for *M. dahli* in the stream will take some years, but the initial phase was very successful and the landowner is committed to maintaining this area for the species.

The second objective of the project was to evaluate the abundance of the species across its range to provide recommendations for conservation. We sampled thoroughly more than 30 sites in the seven states included in the species range, using diverse methods. We captured more than 200 individuals and estimated relative abundances in five sites: Bajo Limón and Ceiba Pareja (Córdoba), Chimichagua (Cesar), Sincelejo (Sucre) and Bolívar. Relative abundance compared by the net method was higher in Ceiba Pareja and when compared by the hook method it was higher in Bajo Limón. Results from this study and previous studies in Cesar, indicate that these two localities in Córdoba along with Chimichagua (Cesar) have the highest abundances of the species across its range. On the other hand, the species was very rare at most of the sampled localities. This suggests that the global population of the species is very low and that conservation actions must be continued in Chimichagua and implemented in Córdoba to ensure persistence of the species.

1. Project aims and objectives

The project had two major aims, the first was to develop a model for restoration of riparian vegetation in one of the few known populations of the species. We hoped to develop a restoration model based on community organized nurseries, and implement a mechanism to evaluate its success for the improvement of the quality of the habitat of the species and its recovery.

The second aim was to confirm the presence of the species in several localities predicted by the distribution model, and evaluate its relative abundance at such localities to improve our understanding of its global abundance, determine threats to remaining populations and identify good areas for conservation of viable populations.

1.1 Objectives

- Restore the riparian vegetation of 2 streams in Cesar.
- Evaluate the effect of restoration in the quality of the habitat and abundance of the species
- Confirm the presence of the species in at least 15 localities covering the 7 departments predicted by the habitat models
- Estimate relative abundance of the species in at least 10 localities and estimate population size in at least 3 localities
- Develop a restoration model that can be applied in other sites identified to require such an intervention for the species.

2. Introduction

Dahl´s Toad Headed Turtle is and endemic species from northern Colombia, restricted to a small geographic area. For more than 40 years after its description (Zangerl and Medem 1958), it was only known from the region of the type locality, with all observations (< 10) restricted to the department of Sucre. It was later found to occur in the departments of Córdoba, Bolívar and Atlántico, and through the work funded by PTES it was confirmed to occur in Cesar and Magdalena.

The species is considered endangered because of its restricted distribution and the decline on the quality of its habitat, the tropical dry forest, which has been subjected to increasing destruction, fragmentation and alteration for human activities. Besides, the species is not formally protected across its narrow range (Forero-Medina et al. 2013).

As a response to the limited knowledge on the biology of the species and the urgent need to develop conservation strategies, we started a research project in 2007, in collaboration with the Universidad Nacional de Colombia, Fundación Caipora and the People´s Trust for Endangered Species. During a first phase of the project, we identified a previously unknown population in Colombia, and estimated its abundance and population structure. We have been monitoring this population for over five years. Additionally, in 2008 we studied the species habitat requirements and movement patterns using VHF Radio telemetry (Forero-Medina et al. 2011, Forero-Medina et al. 2012). These studies allowed us to understand some key aspects of the ecology of the species. Most importantly we learned the habitat requirements of the species and the patterns of use of space. The species is associated with first order streams (1 – 10 m width), with slow flowing (< 0.22 m/sg) and dark water (< 32 cm clarity). Within the streams where it occurs, the species is associated with locations that have considerable (> 82%) canopy cover. This highlights the importance of the riparian vegetation for the

species and the urgency to restore this vegetation in areas where it has been completely eliminated. Additionally, some individuals leave the water during the summer when the streams dry partially, and forage into the surrounding matrix, sometimes aestivating there for some months. This shows that they use these contiguous areas, and their home ranges can expand for nearly 30 hectares, indicating the importance of including these areas in protection strategies. We also worked with the community, particularly with kids in public schools to raise awareness about the endemic character of this species and the importance of preserving its habitat, the dry forest.

All this research allowed for a better understanding of the species distribution and habitat requirements. As a result we identified restoration of degraded habitat and evaluation of abundance across its range as priority actions for conservation and monitoring.

The second phase of the project, corresponding to this final report, had two main objectives. The first was to develop a model for restoration of riparian vegetation along the streams in one of the few known populations of the species. A restoration model based on community-organized nurseries, and mechanisms to evaluate its success on habitat quality improvement and recovery of the species. Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (SER 2004). The framework chosen for this project consists in a restoration strategy at the landscape level, where different elements are needed to generate physical and biological changes, known as HMP (*Herramientas de Manejo del Paisaje*, Lozano- Zambrano 2009). These tools aim to reduce the negative impacts over riparian remnants and at the same time to increase their connectivity, allowing the recovery of the habitat for Dahl's Toad-Headed Turtle.

The second main objective was to confirm the presence of the species in some of the localities predicted by niche models, and evaluate its relative abundance at such

localities to improve our understanding of its global abundance, determine threats to remaining populations and identify good areas for conservation of viable populations.

This is the Final Report, which summarizes the activities conducted from October 2013 to September 2015. During this period we restored a school nursery, planted more than 1400 treelings of native species along the stream San Fernandera where the species occurs, developed conservation agreements with the land owner to ensure persistence of the planted trees; sampled 30 localities for presence of the species and estimated its relative abundance at 5 sites. The project was very successful at initiating the recovery of the species habitat and identifying new populations, helping in the identification of the best candidate sites for conservation activities. We present here a detailed account of activities conducted and results during this two year project.

3. Habitat Restoration Activities

3.1 Election of the reference site for the restoration of streams

The reference site is the starting point as a model for the formulation, implementation, and monitoring of every restoration project. In the best case scenario the site is tangible with biophysical characteristics that can be described and documented. In our case, because of the bad ecological state and biological impoverishment of forest remnants in the region, we considered White & Walker's proposal (1997) to use multiple sources of information from sites and times that have both similarities and differences with the site to be restored.

In February 2014 we did multiple field trips to analyze forest covers and to assess the conservation status of the area. We visited multiple streams near Chimichagua, in order to have a complete picture of the riparian vegetation in the area in multiple contexts and generated a list of key plant species for restoration (Appendix 1). Some of these species have high conservation value as they are threatened or are useful plants for the community (Estupiñan-González *et al.* 2011)The two key species for restoration are the ñoli palm (*Elaeis oleifera*) and the caracolí (*Anacardium excelsum*).

We visited the following localities:

- *Guaraguau:* The stream in guaraguau is in a good conservation state, with lots of palms from intermediate to late succession (like *Elaeis oleifera*), also there are different plant groups associated with water like ferns and aroids.
- *La cabaña:* We found this site to be highly reliable in order to generate our reference site because it has different tree species close to the water in the stream and different palm species especially spiny palm (*Astrocaryum malybo*).

- *El Pantano:* The vegetation here is strongly associated with floodplains and mangroves dominate. This is very different from the streams where our turtle has been found and therefore this is not a good reference site.
- *Las Peñas:* The vegetation has been highly perturbed, diversity is very low and succession is on initial states only. The structure and composition is very similar to San Fernandera, our restoration site.
- *La calera:* This site is probably the closest example of an undisturbed stream and is very close to become a reference site on its own. As a highlight, we found the complete skeleton of an adult female of *Mesoclemmys dahli* exposed freely in the ground.

Figure 1. Multiple localities visited with different vegetation and perturbation levels in order to choose our reference site.

3.2 Visit to local nurseries

We visited the nurseries property of CORPOCESAR, the nursery "Aula Ambiental" from the Educational Institute "Cerveleón Padilla Lascarro" and the commercial nursery belonging to Mr. Diomedes Arias.

The CORPOCESAR nursery is not in good shape, and we figured it would pose a problem to bring wáter to the plants. Besides, the nursery is the farthest away from the restoration site, and costs can get bigger. We decided then to not use this nursery for our project. The nursery "Aula Ambiental" has a good infrastructure and was in a pretty good shape, and we chose it as the site to propagate our native plant material. Finally,

we visited the private plant provider Diomedes Arias to check his nursery and we decided to buy from him plant material.

3.3 Identification of key local stakeholders

We identified the key stakeholders with direct or indirect relationship with the project and typified them in first, second or third level degree (Table 1).

Table 1. Stakeholder's identified for the restoration project.

Stakeholder	Type of stakeholder	Relation with the project	Action level	Type of Action	Importance
Orlando Palomino	Private	Direct	Local	Owner	1
Juan Robles	Academic	Direct	Local	Implementation	1
CORPOCESAR	Estate	Direct	Regional	Implementation	2
Germán Payan	Private	Direct	Local	Implementation	1
Tomás Mejia	Private	Direct	Local	Implementation	1
Institución Educativa "Cerveleón Padilla Lascarro"	Academic	Direct	Local	Implementation	1
Rogelio Gutierrez	Private	Direct	Local	Implementation	1
Diomedez Arias	Private	Direct	Local	Implementation	1
Osmelia Pedrosa	Community leader	Indirect	Local	Outreach	2

3.4 Divulgation and local participation

The project was socialized with Rodolfo Cabrales head of CORPOCESAR office in Chimichagua who was very glad to hear of restoration activities in the region. We also communicated the project to Osmelia Pedrosa, a spiny palm (*Astrocaryum malybo*) artisan leader and they are interested in planting the palm in the restoration area.

The project has engaged 150 students from the local institution, "Institutución Educativa Cerveleón Padilla" with ages between 14 and 18 years old, who have been helping our activities as volunteers, coordinated by their teacher Juan Robles. We have conducted multiple workshops with the students to make them more conscious about the Dahl's Toad-Headed turtle and the importance of restoring its habitat. The activities are integrated into their agricultural curriculum and the students volunteering at the project have learnt:

- How to obtain seeds and seedlings from the forest. - Native plant nursery techniques
- Tree planting
- Living fence implementation.

Figure 2. Researcher in a workshop with students of the institution "Cerveleón Padilla Lascarro"

3.5 Complete plant inventory for the restoration area

The diminished ecological state of the stream shows few vegetation cover and hence we were able to do a complete inventory of the plants in the restoration area (1.43 ha) and also to study the natural regeneration occurring in the area. We found 151 individuals in the left margin and 156 in the right margin for a total of 307 individuals belonging to 59 different species, with the most abundant species being *Attalea butyracea*, *Bixa orellana*,

Guazuma ulmifolia, *Tabernaemontana cimosa*, *Terminalia amazonia,* and *Triplaris purduei*.

These species are intermediate pioneers and most are fast growers and associated with disturbed sites. The palm Attalea butyracea is the most abundant species here and grows near the edge of the stream in the most deforested areas. We expect that with our restoration efforts this palm won't be able to grow near the water as the shade of other species will prevent its further development.

Regarding the natural regeneration in San Fernandera stream, we found that although there are seedling of most of the species, this seedlings aren't taller than 30 cm and there are no treelings. This means the stream, probably because of the action of the cattle, hasn't been able to recover itself.

3.6 HMP Implementation

We built a fence, a livestock watering system and fixed and rearranged a native plant nursery. A key aspect has been the financing of the HMP: We enabled the resources necessary for the project, and the landowner Orlando Palomino in the farm "Las Marías", although actively involved in every step of the process, didn't spend money for the restoration of the habitat of the turtle.

3.6.1 Fence

We built a fence in the side of the stream where the cattle comes to drink water. The fence is 400 m long and is located 10 m minimum away from the stream. This allowed the landowner to generate income from the start of the project as his employees were paid for this task. The other side of the stream was already partially fenced and there was no need for a new fence. The implementation of this fence was one of the most urgent measures to be taken for the conservation of Dahl's Toad-Headed Turtle, as it prevents cattle from entering the stream and to affect natural regeneration. The area inside the fence is our restoration area, about 1.43 ha.

Our aim is to make the fence a living fence in the future, and we have already planted *Pachira quinata* and *Bursera simaruba*, two excellent species for this purpose. The former is a spiny tree currently categorized as Endangered (Cárdenas y Salinas 2006) and the latter has been proposed as promising tool for the restoration of disturbed sites in tropical dry forests (Díaz-Martín *et al.* 2009).

Figure 3. Fence protecting cattle from entering the stream and delimiting the restoration area.

3.6.2 Livestock watering system

One of the key tenants of sustainable cattle production is: "cattle doesn't go to the water, the water goes to the cattle". By separating livestock from the stream we avoid erosion, damages in vegetation and feces contamination in the water (Calle, Z. *com.*

pers.). Because of the huge advantages, we built 2 watering systems of dimensions 6m x 1m x 0,5 m where the water is acquired from a deep pool that the owner of the property has in a nearby location. Now, about 150 cows are drinking from our systems.

Figure 4. Livestock watering system to replace the water that cattle was drinking from the stream.

3.6.3 Native plant nursery

We fixed and rearranged the nursery "Aula Ambiental" and protected a portion of it (60 m^2) in order to have 3000 seedlings ready for planting in the near future. A lot of essential tools were missing from the nursery and we bought and donated them to the academic institution. A major accomplishment was to improve the irrigation system for the nursery to ensure water for the plants when it's needed. Volunteer students participated thoroughly through the process to have the nursery in optimal conditions for native species arrivals.

Propagation in nursery to many plant species in tropical dry forests is the only alternative, due to low densities and few populations remaining. We relied on local guides to help us in the process of obtaining seeds and seedlings from nearby forests, ensuring the plants will be adapted to the local ecotype. The seedlings were planted in our restoration area when they grew to a minimum of 70 cm height, to ensure they were robust enough to survive on their own without further treatments. However, the high temperatures in the area required to manually water the plants during severe drought in 2015.

Figure 5. Students were engaged in different activities to repair and adequate the native plant nursery for a capacity of 3000 seedlings.

3.6.4 Planting of native species

First Planting

From the commercial nursery we bought and planted 600 trees corresponding to the following species: *Crateva tapia, Pseudosamanea guachapele, Tabebuia rosea, Astrocaryum malybo, Hura crepitans, Sterculia apetala*. These species are fast growers and tolerate high degrees of solar light. They were used as nursery trees to plant under them other species with higher requirements. Most of these seedling belong to timber species that will provide an economic benefit for the landowners in the future as long as he harvests them in a sustainable manner.

The plants were laid out at distances of 3 or 4 m without any type of spatial arrangement, following the dynamic and stochastic processes that occur in natural succession. Additionally, we enriched portions of the stream with some degree of plant cover by disposing seeds of multiple species gathered during our field trips. Also, we transplanted some nearby treelings inside the fence to enhance their survival and to speed up plant succession.

Figure 6. Planting of 600 native species in the deforested stream San Fernadera with the help of volunteer students.

Second Planting

During October 2014, we conducted the second planting of treelings, this time the plant material was coming from the local nursery that we previously repaired, adjusted and reactivated (Figure 7). The volunteer students in charge, with the coordination of their teachers, took proper care of the nursery and the plants, mainly watering the seedlings during the intense summer of July 2014. We are grateful to the volunteers who were highly motivated and understood the importance of taking care of Dahl's toad headed turtle (*Mesoclemmys dahli*) and its habitat.

Figure 7. The improved nursery at its current state, with treelings ready to plant.

The second planting was a highly technical endeavor that was properly supervised by our team, as we were dealing with species with particular requirements. Thus, a knowledge of the ecology of each species was necessary. Each species requires different shadow levels and it is important to plant them at different distances from the stream to optimize their development. We planted 887 individuals from 14 different species (Table 2), their initial height was recorded for further monitoring, using a sample of 30 individuals per species. Species with less than 30 individuals were assessed through a complete inventory.

Table 2. Species planted during the second event and their number of individuals

Family	Species	Common name	Individuals planted	Initial height (cm)
Anacardiaceae	*Anacardium excelsum*	Caracolí	274	55
Anacardiaceae	*Astronium graveolens*	Gusanero	28	69.5
Arecaceae	*Oenocarpus minor*	Maquenque	3	11
Arecaceae	*Elaeis oleifera*	Ñolí o corozo	44	13
Arecaceae	*Astrocaryum malybo*	Palma estera	20	10
Esterculiaceae	*Sterculia apetala*	Piñón	2	41
Bignoniaceae	*Tabebuia rosea*	Roble	311	72
Apocinaceae	*Aspidosperma spruceanum*	Tomasuco	5	53
Lauraceae	*Nectandra cuspidata*	Laurel amarillo	8	57
Lauraceae	*Nectandra turbacensis*	Laurel prieto	21	55
Sapindaceae	*Melicoccus bijugatus*	Mamón	3	41
Fabaceae	*Jacaranda caucana*	Gualanday	165	73.5
Fabaceae	*Inga sp.*	Guamo	2	37
Moraceae	*Ficus sp.*	Higuerón	1	150
		Total	887	

We hired local workforce since September 26 to prepare the land near the stream for the planting and to perform the necessary tasks to have everything arranged before the volunteers arrived. We had to cut down aggressive grasses, make the holes for the plants, and bring the individuals a day before to the stream, so the volunteers could plant in the first hours of the morning, avoiding the intense heat that starts at about 10 am. We were lucky, as the weather conditions on both days of the plantings were optimal for both the plants and the volunteers.




Figure 8. Volunteer team that helped us with the plantings, a close-up of a student leader and a plant of tolú (*Pachira quinata*) growing to start converting the fence into a living fence.

On October 3, we planted the treelings with volunteers from SENA institution who are currently studying environmental management and are associated with CORPOCESAR, the regional environmental authority. We worked with them specially to plant our two key species for the restoration of Dahl's toad headed turtle hábitat: ñoli palm (*Elaeis oleífera*) and caracolí (*Anacardium excelsum*) both planted in the nearest parts of the stream where they naturally grow. On October 4, we continued the work with volunteer students of the institution "Cerveleón Padilla Lascarro", a local school, and two accompanying teachers, finishing the planting with success.

3.6.5 Monitoring of treelings

After the second planting event, we had planted a total of 1784 individuals, belonging to 32 species from 17 families. During February of 2015 we estimated survival of the planted treelings and found that 779 individuals had survived, corresponding to a survival rate of 43.7%. Some individuals were damaged by pigs from the land owner, goats from neighboring lands and an herbivory from insects (Lepidoptera), which was controlled using plague controllers. The two key native species from the project had very good survival rates. In fact, for the *ñoli* palm (*Elais oleifera*) 85.6% of the individuals survived and are in good condition. The *caracoli* trees have also survived and grown successfully.

From September 2014 to December 2015 we hired a technician in charge of the general care of the plants. This was very important as it has reduced mortality from water deficit because plants were watered every afternoon and the soil around their stems was cleaned to avoid competition from grasses. The technician also re-planted some treelings that were damaged during a flood.

Figure 9. Some of the treelings that have established and are growing at the restoration site, slowly improving the quality of the habitat for *M. dahli*.

During this time the technician monitored the growth of the plants and with the help of the land owner repaired the drinking tanks for the cattle, which had some issues (Figure 10). These drinking tanks are essential to keep the cattle away from the stream that *M. dahli* inhabits.

Figure 10. Field technician monitoring the plants (left) and repaired water tanks for the cattle (right).

3.7 Protocol for long-term monitoring of the restoration

A protocol for long-term monitoring of the restoration process – One of the most important activities was the development of a working document (in spanish) for the monitoring of the restoration process (Appendix 2). Our activities in the field involved the geo-referencing and mapping of all the restoration area and the original vegetation cover represented by trees. We also took reference pictures with their coordinates and pictures of the most important treelings in the area to help the volunteer team in their identification. The protocol describes all the steps, materials and logistical activities to perform the monitoring in an integral way, not only to describe changes in the

vegetation but also to assess if the indicators of success (attributes of a restored ecosystem) as well as the objectives of the Project.

4. Distribution and Abundance Estimation for Dahl´s Toad-headed turtle

From January to October 2014 we visited localities in the departments of Córdoba, Sucre and Bolivar to search for populations of the species and identify sites for mark-recapture. We sampled these localities using baited traps and nets, the latter resulting in the most effective method for capturing individuals of the species (Figures 11, 12). We confirmed the presence of the species in eight localities, but only two of them had a significant number of captures (Ceiba Pareja and Bajo Limón), and appeared as good candidates for abundance estimation (Figure 11). Confirmation of the presence of the species in Bolivar was a highlight as there were very few records from this state in the literature.

Figure 11. Working team capturing *M. dahli* using nets in Bajo Limón, Córdoba.

From October 2014 to June 2015 we visited an additional 15 localities in the departments of Atlántico, Bolívar, Sucre, Cesar, Cordoba and Magdalena to search for populations of the species (Table 3) and conduct recapture samplings (Table 4). The number of individuals recaptured was very low and there were only recaptures in Córdoba. This confirms that the species is not very abundant at the localities where it occurs.

The number of individuals captured at each site, confirm previous models conducted by the team (Forero-Medina et al. 2012), which predict that the core of the distribution is in the department of Córdoba (Table 3, Figure 13). This has important implications for conservation, as it suggests that probably this department has great potential for the conservation of viable populations of the species.

Figure 12. Juvenile of *M. dahli* captured during the sampling events in Córdoba. Photograph: Luis E. Rojas

Table 3. Number of individuals of *M. dahli* captured at different locations across the species potential range.

Department	Number of Localities visited	Number of individuals captured
Atlántico	2	-
Bolívar	12	4
Cesar	5	7
Córdoba	2	168
Magdalena	2	1
Sucre	6	31
Total	**29**	**211**

Table 4. Number of individuals of *M. dahli* marked and recaptured at different sites across the species range.

Department	No. of marked individuals	Localities	Recapture events	No of recaptures
Atlántico	-	-	-	-
Bolívar	4	-	-	-
Cesar	7	3	2	-
Córdoba	94	2	3	11
Magdalena	1	-	-	-
Sucre	25	3	1	-

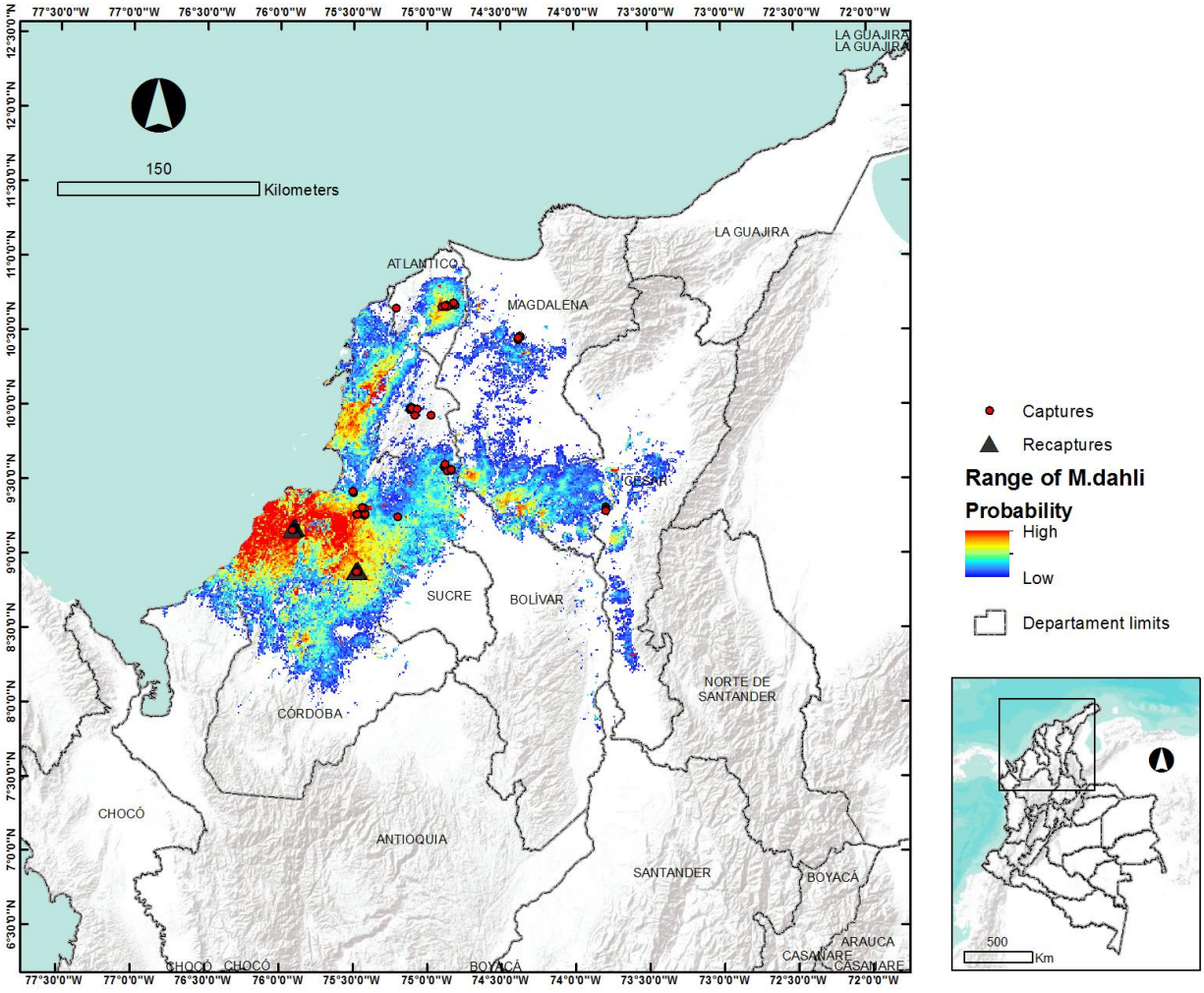

Figure 13. Sites with captures and recaptures of *M. dahli* across its potential distribution.

Relative abundance was estimated as: a) the number of turtles captured per hook-hour and b) the number of turtles captured per flushing event (in the net). This is because a combination of the two techniques was used to capture animals in most sites. The locality of Bajo Limón (Córdoba) had the highest relative abundance for the hook method (Table 3). However, Ceiba Pareja had the highest relative abundance when comparing by the net method, with three turtles per flushing occasion, followed by Bajo Limón. This confirms that Ceiba Pareja and Bajo Limón, in Córdoba, are the localities with the highest relative abundance of the species across tis range, along with Chinichagua

(restoration site). In other localities where the species was confirmed, there were not even enough captures to estimate relative abundances. Only in the localities in Table 3 were there enough captures.

Only two localities had recaptures, Bajo Limón and Ceiba Pareja. We estimated population sizes for these two sites, using the Jolly-Seber open population method (Krebs 199). However, because of low number of recaptures, confidence intervals were huge, making the estimate uninformative and not useful for monitoring purposes. Population estimate for Bajo Limón was 105 turtles (95% confidence limits 26 – 822) and Ceiba Pareja was 92 turtles (95 confidence limits 20-864). Nonetheless, a continued mark-recapture study, with increased effort, may lead to improved estimates in these two localities, which are recommended for monitoring purposes.

Table 3. Relative abundance of *M. dahli* in localities across its range with more than one individual captured.

Locality	Turtles/hook-hour	Turtles/flushing event (net)	Total hook captures	Total net captures
Sincelejo (Sucre)	0.0721	1.0909	17	12
Bajo Limon (Córdoba)	0.395	1.6364	29	18
Ceiba Pareja (Córdoba)	NA	3.1	NA	62
Chimichagua (Cesar)	0.0578	0.087	5	2
Bolivar	NA	0.1905	NA	4

The number of captures and relative abundance of the species in Chimichagua, where we conducted the restoration activities was low. However, previous studies there have indicated there is a population of approximately 150 turtles in these streams, but this abundance may vary over the year considerably. We believe the sampling events in this locality did not have the best timing, and there might be an effect of the increased intensity and extent of the summers in the region, which have translated into extended periods when the streams are dry. This may have affected the behavior of the species, which may be spending more time on land.

Results from this study indicate that, although distributed across the Caribbean region, populations of the species are much localized and it is very rare in most sites. Only three sites have been identified where it can be continuously sampled and there are resident animals. Considering the least conservative estimates, the upper limits of population estimates at these three sites (Chimichagua, Bajo Limon and Ceiba Pareja), these sites do not even have 2000 individuals of the species together, and may have many less, probably less than 1000. This suggests that the global population of the species is quite low, and that conservation actions like this restoration program must be continued in Chimichagua, Cesar, and should be implemented in Córdoba, where there is a high chance of success, as the species is locally abundant at particular streams in this locality.

5. Literature Cited

Cárdenas, D. y Salinas. 2006. (eds.) Libro Rojo de Plantas de Colombia. Especies maderables amenazadas. I parte, La serie Libros rojos de especies amenazadas de Colombia. Instituto Amazónico de Investigaciones Científicas SINCHI, Instituto de Ciencias Naturales- Universidad Nacional de Colombia, Ministerio del Medio Ambiente, Bogotá.

Díaz-Martín Ruth; Castellanos-castro, Carolina y Bonfil Consuelo (2009). Propagación y establecimiento de dos especies de bursera como herramienta para la restauración de bosques tropicales secos en México. Grupo de Restauración Ecológica, Universidad Nacional de Colombia – GREUNAL. I Congreso Colombiano de Restauración Ecológica & II Simposio Nacional de Experiencias de Restauración Ecológica.

Estupiñán-González, A.C., N.D. Jiménez-Escobar, M.P. Cruz, N. Sánchez, G. Galeano y E. Linares. 2011. Plantas útiles del complejo cenagoso de Zapatosa. En: J.O. Rangel-Ch (de) . Colombia Diversidad Biótica. Publicación Especial No. 2. Guía de campo. Grupo de Biodiversidad y Conservación, Instituto de Ciencias Naturales, Universidad Nacional de Colombia- CORPOCESAR. Bogotá, D.C. Colombia. 77 pp.

Forero-Medina, G., Y Joppa, L. 2010. Representation of global and national conservation priorities by Colombia's Protected Area Network. PLoS ONE 5(10): e13210.

Forero-Medina, G., Cárdenas-Arevalo, G., y Castaño-Mora, O.V. 2011. Abundance, Home Range, and Movement Patterns of the Endemic Species Dahl's Toad-Headed Turtle (Mesoclemmys dahli) in Cesar, Colombia. Chelonian Conservation and Biology 10(2): 228-236

Forero-Medina, G., Cárdenas-Arévalo, G., y Castaño-Mora, O.V. 2012. Habitat modeling of Dahl's Toad-Headed Turtle (Mesoclemmys dahli) in Colombia.

Forero-Medina, G., Castaño-Mora, O.V., Cárdenas-Arevalo, G., y Medina-Rangel, G.F. 2013. Mesoclemmys dahli (Zangerl and Medem 1958) –Dahl's Toad-Headed Turtle, Carranchina, Tortuga Montañera. En: Rhodin, A.G.J., Pritchard, P.C.H., van Dijk, P.P., Saumure, R.A., Buhlmann, K.A., Iverson, J.B., y Mittermeier,R.A. (Eds.). Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs No. 5, pp. 069.1–069.8, doi:10.3854/crm.5.069.dahli.v1.2013, http://www.iucn- tftsg.org/cbftt/.

Lozano-Zambrano, F.H. (ed). 2009. Herramientas de manejo para la conservación de

biodiversidad en paisajes rurales. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt y Corporación Autónoma Regional de Cundinamarca (CAR). Bogotá, D.C., Colombia. 238 p.

Society for Ecological Restoration (SER) International, Grupo de trabajo sobre ciencia y políticas. 2004. Principios de SER International sobre la restauración ecológica. www.ser.org y Tucson: Society for Ecological Restoration International.

White, P. S. and Walker, J. L. 1997. Approximating Nature's Variation: Selecting and Using Reference Information in Restoration Ecology. Restoration Ecology 5: 338–349.

6. Budget

Category	Item	Number items	Cost	Total
Staff costs	Workers for nurseries (per month)	6	200	1200
	Field guides (x8 months)	2	1000	2000
Field equipment				0
Laboratory equipment				0
Travel	Ground transportation (sampling populations) etc.	12	320	3840
	Airfare	5	300	1500
Subsistence	Per person (x6 months)	2	3000	6000
Consumables	Materials for fences, for refurbishing the nursery, etc.	1	3000	3000
Report production	Presentation of the project to the community (before and after)	2	500	1000
Administration				0
Insurance				0
Other				0
TOTAL				**18540**

APPENDIX 1. LIST OF POTENTIAL PLANT SPECIES FOR THE RESTORATION OF STREAMS ASSOCIATED WITH DAHL'S TOAD-HEADED TURTLE (*Mesoclemmys dahli*)

Species	Family	Local Name	Habit
Vitex capitata	Verbenaceae	Aceituno	Tree
Anacardium excelsum	Anacardiaceae	Caracolí	Tree
Aspidosperma spruceanum	Apocinaceae	Tomasuco	Tree
Samanea saman	Fabaceae	Campano	Tree
Albizia niopoides	Fabaceae	Guacamayo	Tree
Terminalia amazonia	Combretaceae	Guayabo león	Tree
Bulnesia arborea	Zygophyllaceae	Guayacán	Tree
Astronium graveolens	Anacardiaceae	Gusanero	Tree
Pseudosamanea guachapele	Fabaceae	Iguamarillo	Tree
Pseudobombax septenatum	Bombacaceae	Majagua	Tree
Enterolobium cyclocarpum	Fabaceae	Orejero	Tree
Byrsonima crassifolia	Malpigiaceae	Peraleja	Tree
Sterculia apetala	Esterculiaceae	Piñón	Tree
Tabebuia rosea	Bignoniaceae	Roble	Tree
Tabebuia chrysantha	Bignoniaceae	Polvillo	Tree
Tabebuia ochracea	Bignoniaceae	Cañaguate	Tree
Pachira quinata	Bombacaceae	Tolú	Tree
Cordia gerascanthus	Boraginaceae	Solera	Tree
Bauhinia hymenaeifolia	Fabaceae	Bejuco cadena	Vine
Desmoncus orthacanthos	Arecaceae	Matamba	Palm
Oenocarpus minor	Arecaceae	Maquenque	Palm
Elaeis oleifera	Arecaceae	Ñolí o corozo	Palm
Sabal mauritiformis	Arecaceae	Palma amarga	Palm
Astrocaryum malybo	Arecaceae	Palma estera	Palm
Bactris guineensis	Arecaceae	Uvitaelata	Palm
Bursera simaruba	Burseraceae	Resbalamonos	Tree
Licania arborea	Chrysobalanaceae	Garcero	Tree
Parinari pachyphylla	Chrysobalanaceae	Pergüétano	Shrub
Cedrela fissilis	Meliaceae	Cedro	Tree
Machaerium capote	Fabaceae	siete cueros	Tree
Peltogyne paniculata	Fabaceae	Tananeo	Tree
Casearia sylvestris	Flacourtiaceae	Jobo Macho	Tree
Triplaris purdiei	Polygonaceae	Varasanta	Tree
Senna reticulata	Fabaceae	Majagüito	Shrub
Spondias mombin	Anacardiaceae	jobo	Tree
Brosimum alicastrum	Moraceae	Guáimaro	Tree
Crateva tapia	Capparaceae	naranjuelo	Tree
Coccoloba acuminata	Polygonaceae	Maizcocho	Tree