Darwin Fellowship - Final Report

Darwin Project Ref No.	Round 19 Fellowship Funding Ref No: EIDPS036
Darwin Project Title	Planning wildlife corridors for La Primavera Biosphere Reserve, Mexico
Name of Darwin Fellow	Karina Aguilar Vizcaino
UK Organisation	The School of Geography, University of Leeds, UK
Your Organisation	Direccion de Conocimiento y Vida Silvestre del Area de Protección de Flora y Fauna La Primavera, Jalisco, Mexico.
Your role in your Organisation	Senior member of the La Primavera Biosphere Reserve Management team
Start/end date of Fellowship	July 2013- September 2014
Location	9 months in Guadalajara, Mexico and 6 months in Leeds,UK
Darwin Fellowship funding (£)	£ 10,600
Type of work (e.g. research, training, other, please specify)	1) Language training from July 2013 to March 2014. During the same period I got gather the data we need for design of the biological corridors. 2) GIS training from April to September 2014.
Main contact in UK Organisation	Prof Jon Lovett/Dr Steve Carver
Author(s), date	Karina Aguilar Vizcaino 11 September 2014

1. Background

Briefly describe your involvement in the Darwin project before the start of your fellowship.

As a senior member of the La Primavera Biosphere Reserve Management team, I had responsibilities for wildlife ecology, environmental education and coordinate researches about the forest. As part of the outreach activities of the management office I regularly publish articles on the reserve and I wrote a series of guides on natural history and mammals in the forest, also I coordinated some conservation projects, and collaborated with another ones. In particular I was responsible for establishing collaboration between the Darwin projects “Market Based Scheme for conservation in La Primavera Forest, Mexico” and the NGO Selva Negra, which resulted in implementation of the first biological corridor protected “Ahuisculco”.

Describe aim and objectives of the Fellowship, and programme of work.

Consolidate the work of DI project “Market Based Scheme for conservation in La Primavera forest, Mexico” by providing training and analysis in the selection, design and management of biological corridors that will be implemented in the reserve.

Training in GIS with a focus on tools for biological corridors, and design the best options to be implemented in the reserve. There are a number of other potential corridor sites and there is some urgency for developing these is a major road is planned around the La Primavera reserve which will create a major barrier to animal migration between the reserve and other adjacent forested mountains. The corridor routes need to be based on sound science so that the planning is well informed and an effective sustainable solution implemented.

Briefly describe the roles of the UK and Fellow's institutions.

I am currently working within the Wildland Research Institute (WRi) in the School of Geography in the University of Leeds. WRI aims to identify and elucidate the requirements, strategies and policies for a transition to a greater presence of wild landscapes within the wider land uses. The institute is at the forefront of developing and implementing wilderness and wild land mapping techniques utilising spatial information technologies. WRi has developed unique tools and software to help in this process including web-based participatory mapping tools, crowd-sourcing of perception data, real-time rapid viewshed assessment tools, remoteness models, recreation opportunity spectrum mapping, and multiple criteria and fuzzy modelling based approaches to wilderness quality mapping. WRi will provide advice and training on GIS and spatial analysis tools for planning biodiversity corridors in the La Primavera Biosphere reserve and adjacent areas.

Also I have been gaining experience in practical implementation of the CBD "Ecosystem approach" through contacts in Natural England and learning about ecosystem approach pilot projects that have been implemented in Wild Ennerdale (Lake District) and other places with which to compare the La Primavera management strategy.

If you have undertaken a formal course of training, please provide a brief explanation of the course and a link to the course website if available.

Introduction to Geographical Information Systems - Using ArcGIS (Raster Applications)

May 19-20, 2014

Organising Institution: University of Leeds (As part of TALISMAN, an ESRC funded project and NCRM node aimed at enhancing research methods across the UK)

Course description:

This is a 1.5 day course introducing Geographical Information Systems (GIS) using ESRI's ArcGIS version 10 software building on basic knowledge of data manipulation, mapping and analysis, introducing the Spatial Analyst extension. The emphasis of this course was working with raster data in the context of a variety of environmental applications by exploring surface geoprocessing tools within ArcGIS. Common raster data sources were used including Ordnance Survey terrain data and Centre for Ecology and Hydrology land cover maps (via Digimap). The course covered the basics of grid-based modelling (local, focal, zonal and global functions) and helped develop a wider understanding of the capabilities of ArcGIS and raster analysis in the context of terrain and hydrological modelling.

Instructor: Dr Stephen Carver

http://www.ncrm.ac.uk/training/show.php?article=4918

2. Achievements

Summarise the work undertaken during your Fellowship. What were the main activities undertaken. Highlight any work undertaken but not originally planned and explain why this happened. Highlight any problems encountered and how they were overcome.

After my arrival in Leeds at the end of March I was invited to meet two beautiful and significant areas of this part of the country so the landscapes represent the history of the place: Sutton Bank and the North York Moors National Park. This was the first time I realized the importance that the footpaths in the parks are as much for local inhabitants as for visitors, and the frequent use and well implemented management strategies that give them freedom of access at all times.

In April I attended some meetings and presentations of the different study groups of school geography, and I accompanied some groups in their field trips to Dalby forest, Spen Farm and Ennerdale which allowed me to better experience more protected areas of the country and how management is implemented in each of them depending on the use and purpose for which they have been assigned.

I was also worked with some members of staff with whom I could exchange ideas about the possibilities in the work to do. Here I met Fernando Sanchez Trigueros, and Gabriela Lopez Gonzalez, who helped me with the implementation of my survey in the Map-Me and with the search for a suitable posting my article.

During the month of May I was invited to give a presentation using my data in the class of one of the groups of Dr. Steve Carver, and attended a course of Arc GIS using raster that it imparted, and also I was fortunate to accompany him along with his team to the 1st conference of Digital Conservation at the University of Aberdeen, Scotland where many advances in science and technology as a function of the preservation of the natural environment and wildlife were presented. Interestingly, there was a marked touch of scepticism or controversy in some presentations which note that these advances could increasingly move us away from nature. I think the most interesting is the application of each example and how the research results can (or cannot) justify the means. This is pertinent to my own work as I am exploring the use of participatory surveys using the online Participatory GIS tool Map-Me. Although the social economic conditions of the site where this is being implemented are not ideally suited for getting a good response (many of the people living in the region of interest do not have a computer or also nor electric power), it is possible to obtain an idea of what is possible or probable to achieve given the rather high conflict regarding the potential use of the land.

I have also taken some lessons from academic course they offer on the University of Leeds to improve my writing and spelling in the English language.

In June I presented my work to the group Ecology and Global Change in Geography and I was also invited to present to the Latin American Society University of Sheffield on the 25th, where they gave me a credit for it.

During the months of July and August I was engaged in the preparation of a journal article about my work, and also had the opportunity to meet Dr. Jonathan Carruthers-Jones who was visiting Leeds for a few days. He is a specialist in the topic I'm working on which gave me some good recommendations to enrich my proposal.

During September, which is the last of my stay, I visited the Natural England offices in the city of York, and I meet with the expert Ruth Waters, an ecosystem service technician who works as a government adviser on environmental issues. They are responsible for providing practical advice, based on science, on how best to safeguard England's natural wealth for the benefit of all. Its mission is to ensure sustainable management of land so that people and nature can thrive and protect the environment for the enjoyment of future generations. They work with farmers and land managers; trade and industry; planners and developers; national and local government; stakeholders and local communities by helping to improve their local environment, so that these activities can be evaluated and the best aspects replicated in the State of Jalisco.

During December 2014 and January 2015 upon my return to Mexico I was involved in collecting data within local communities and surveying the knowledge of local people for use in the PGIS element of the work. Here I was collecting information on puma habitats, sightings and local opinion, knowledge and perceptions about possible conflicts with economic activity, etc.

The article being prepared for the journal Conservation Biology is attached in draft form. This is currently waiting to be accepted by them after receiving the corrections of my supervisors.

In summary and in regard to the objectives of the grant, I have acquired new knowledge in the area of GIS through the use of new programs and have been active in applying these and experienced gained from observing activities of nature and environment agencies in the UK to my own area of interest in the State of Jalisco and the La Primavera Biosphere Reserve.

What have been the main achievements of your fellowship? Key documents should be annexed to this report.

- I am currently writing my 1st academic journal paper (draft attached)
- I can use GIS better and know more about the different programs that can help me in the future research. (see the maps included in the paper)

- I am able to communicate much better in the English language, which is very important in allowing me to talk directly with experts in diverse topics related my interest.
- I met many very interesting people who are doing a good job in environmental projects, and I can share with them my own experiences.

3. Outcomes, lessons and Impact

Do you feel that the work undertaken during your Fellowship has improved skills that are relevant and important for your work in your organisation? How are you planning to apply those skills in future work?

The use of GIS is very useful in any environmental project, so now I am able to do some new proposals with better tools, and also I could show to other partners the best way to work with.

I was invited to join to work on a connectivity and participatory GIS project in La Primavera Biosphere Reserve to The Wildland Research Institute (WRi) aims to identify and elucidate the requirements, strategies and policies for a transition to a greater presence of wild landscapes within the wider land use continuum of Britain and Europe. The broad activities of the Institute combine social and natural sciences, as well as the arts and literary world, in leading-edge, interdisciplinary research, making this extremely relevant to my work.

The other important issue was met different places and projects here, to obtain an idea for others skills to do management in protected areas.

What arrangements have been made for your future involvement, what more could be done, what discussions have taken place with your original employer to ensure that your new skills are utilised?

The difficult thing was when my post with La Primavera Biosphere Reserve was terminated at the same time I started this Darwin Initiative post, but I am planning to apply the knowledge, skills and experience gained through the Darwin Initiative to new positions, with other new proposal to work allied to my wildlife and conservation interests when I will to return to Mexico.

Likely projects with different NGOs in my country it will be possible but I cannot be 100%certain as to what these will be. It is hoped that in the future there will be alternative opportunities to disseminate the information gained from the work among other organisations involved with puma habitat and conservation such as Conecta Bosques *es-* http://es.facebook.com/**conectabosques** with whom I have good relations. This will include presentations of my work, sharing of information, data and ideas, together with use of the skills and knowledge gained through the Darwin Fellowship.

Has the Fellowship helped to improve your capacity to solve practical problems related to the sustainable use and/or conservation of biodiversity in your country?

Yes, of course: I think is very useful.

I am able to present a new proposal of “rewild” and conservation in my country with a map that shows clearly the objectives of the proposal, also, the skills learned in English language I think offers me an excellent opportunity in my professional life, to improve my job with connecting people who trying to do a big change to do a better world.

In the other hand, I could meet some professionals (Geographers, Biologist, Environmental specialist) and increase my network of people to be interested in the same topic like me; something very useful when we trying to present an interdisciplinary work and participatory.

Have you had the opportunity to make contacts with other UK biodiversity institutions, intergovernmental organisations, NGOs or the private sector during your fellowship?

Will these contacts be useful for your future work, and how are you planning to maintain them?

Yes, I had the opportunity to make contacts with others universities in UK (Aberdeen, Sheffield, Cambridge), with some NGOs like National Trust, and official like the Forestry Commission and Natural England. Peter Welsh and Martin Davies from National Trust, Gareth Browning from Forestry Commission, Ruth Waters from Natural England all expressed great interest in my work and a desire to keep in touch. We have agreed to share documentation and contact details and will stay in touch over the remainder of the project and into the future. These contacts and the work they are doing in the UK will help inform my own work in Mexico and form the basis for exploring future partnerships. I am particularly interested in the parallels and differences between the institutional and land use/ownership issues viewed from both UK and Mexican perspectives and how these manifest themselves in the difficulties faced in terms of wildlife conservation and habitat modelling/planning. Working with members of the Wildland Research Institute from Leeds University, Including Steve Carver, Jonathan Carruthers-Jones, Alison Parfitt and Mark Fisher, has helped me a great deal not only in terms of training but also in developing a network of contacts in academia relevant to my work. To this end I have joined WRi as the member/principle contact for Mexico.

Any other issue emerging from your experience as Darwin Fellow that you would like to raise, or suggestions for improvements to the Darwin Initiative Fellowship scheme.

The difficult part in my time here was that being away in UK on DI funded training as being an opportunity for my employers to terminate my contract in La Primavera protected area in Mexico, so, when my period here it will be finish, I need to begin again looking some job related to rewilding, and connecting landscapes in my country.

The application of the PPGIS/Map-Me survey designed and developed as part of this research work has proved difficult to implement from the UK as it requires hands-on facilitated application in the field working with local people and experts. For this reason, this aspect of the work has not yet been completed to a satisfactory degree, although a trial survey has been completed. I am currently organising the survey now that I am back in Mexico, although the above mentioned termination of contract with La Primavera will hamper this situation. Recent connections with Conecta Bosques (ONG) might help. There are some funds unused from the main award (£1,213.21) that will be used to cover my costs (Travel and Subsistence) in carrying this work forward.

Activity	Budget	Actual Spend	Outputs
English Language Training Guadalajara			TOEFL score: 78/120 (reading 21, speaking 22, listening 18, writing 17) this has been much improved from Academic English language training and day-to-day conversational/written work.
Gathering data for corridor analysis La Primavera			GIS datasets collated and organised for La Primavera. Field Surveys in Tala region (community level data collection with local people for PGIS) (Food, Field Assistance/Security, Vehicle Rental, Fuel)
Travel to UK			Flight GDL-LBA £905.85, Tier 5 Visa £361.86, T&S Mexico City £65.26
Subsistence in UK			
Training in GIS corridor analysis			Attending Geog5060 GIS and Environment module, and one-to-one training with Dr Steve Carver and Jonathan Carruthers-Jones.
Bench fees:			
Analysis of La Primavera data			Data prepared for analysis. Model runs for designing wildlife corridors between la Primavera and adjacent protected areas. Design of PGIS survey. TALISMAN course “Introduction to Geographical Information systems Using ArcGIS (Raster Applications)
Finalising corridor design and report writing			Finalising model runs for wildlife corridor design including with/without Macrolibramiento Highway. Writing final report.
Writing of academic journal paper			Writing academic journal paper with Carver, Carruthers-Jones and Lovett.
Visits to agencies, individuals, conferences, etc. in UK			Attended Digital Conservation Interdisciplinary Conference, in University of Aberdeen. Visit to Natural England office in York for meeting with Ruth Waters. Visit to national Trust offices, Malham Tarn. Visit Wild Ennerdale and Scar Close in the Yorkshire Dales National Park. Vist to Spen Farm.
Develop dissemination strategy			Presentations to staff at Leeds University. Continuing with information/data sharing with Conecta Bosques.
Totals: *(Balance)*	**17100**	**16802.66** *(297.34)*	

Developing Sustainable Wildlife Networks for 21st Century Conservation: Planning, Participation and Resilience in Protected Area Design in Mexico

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Abstract:

Due to the increasing amount of economic infrastructure demanded by the growing population of the city and environs of Guadalajara, the pattern of natural ecosystems in the Jalisco region of Mexico is becoming increasingly fragmented. This has the immediate effect of increasing the isolation of the La Primavera Biosphere Reserve, Guadalajara's nearest protected area, with associated reduction in connectivity with other protected areas elsewhere across the region. Together with preserving suitable habitat for the few remaining large carnivores that still inhabit the region (and Puma in particular), there are many valid reasons to address the fragmentation problem and preserve a healthy environment. These include provision of ecosystem services such as clean air, water and recreational lands for human benefit. This paper proposes a system of management and connectivity for this important region for biodiversity in Mexico, centred on the La Primavera Biosphere Reserve that takes both spatial ecology and local opinion and knowledge into account.

This paper develops plans for an ecological network linking existing core areas and their associated conservation projects with the aim of increasing resilience to further fragmentation and human development. This is being used to inform possible plans for habitat restoration within the region, with associated benefits for all, including the human residents. The research tests a participatory GIS approach to collect local knowledge and opinion that is then used underpin and validate decisions made in implementing connectivity models.

Key words: fragmentation, connectivity, biological corridors, wildlife networks, conservation, resilience, participatory GIS.

1. Introduction

The aim of this research is to extend the current model for wildlife corridor design to the La Primavera Biosphere Reserve, Jalisco State, Mexico and augment this using participatory GIS techniques to build a more resilient and therefore sustainable habitat network, specifically for the region's top predator species; the puma (*Puma concolor*).

In the Mexican state of Jalisco, the human population continues to grow in an uncontrolled manner. There is a rapidly growing demand for housing, communications infrastructure and natural resources (especially land, water and timber) which has led to natural habitats becoming encircled and increasingly isolated. However, a carefully planned and implemented program aimed at creating a "Biological Corridors Network" can fulfil the function of connecting both natural and protected areas with particular

attention to the goal of restoring and increasing areas of native vegetation and forests. In addition to increasing the carbon sequestration and other ecosystem services, this network of natural corridors could contribute to the mitigation of the adverse effects of climate change in the region, help conserve biodiversity and contribute towards the general environmental health of the ecosystem. The proposal provides for human/social participation using GIS and a spatially explicit participatory mapping tool (Map-Me http://map-me.org) in the verification of corridors, the collection of local community-based knowledge about the puma, its habitats and other issues that will contribute to the identification, design and long-term resilience of the wildlife corridors.

This method allows us to include the opinions and advice of local people living within the affected communities, increasing their empowerment, and providing a valuable insight into how local people to can work together on issues of importance to conservation and livelihoods (Carver et al. 2009; Huck, 2104). Thus, the proposal represents an overt attempt to use local ecological knowledge to assess and evaluate the possibilities of continuing conservation projects for wildlife and livelihoods in the study area. The approach makes use of fuzzy spatial patterns and descriptions from participants allowing their views, opinions and comments to be integrated into the spatial modelling processes thereby validating the corridor designs.

We propose a working approach to the recovery of the affected areas, allowing a comprehensive management of these natural environments and improving ecosystem resilience in the centre of Jalisco State. With the puma still being present within the region, this large carnivore provides a natural focus for conservation with efforts focusing on maintaining and improving habitats and connectivity for this iconic apex predator species and preventing its threatened extinction within the region.

2. Study area

The study area is located in the west-central region of Mexico, at the confluence of the Sierra Madre Occidental and the Neo-Volcanic Axis Transverse, where they join the Nearctic and Neotropical bio-geographical regions. This gives the region its high and important level of biodiversity (see Figure 1).

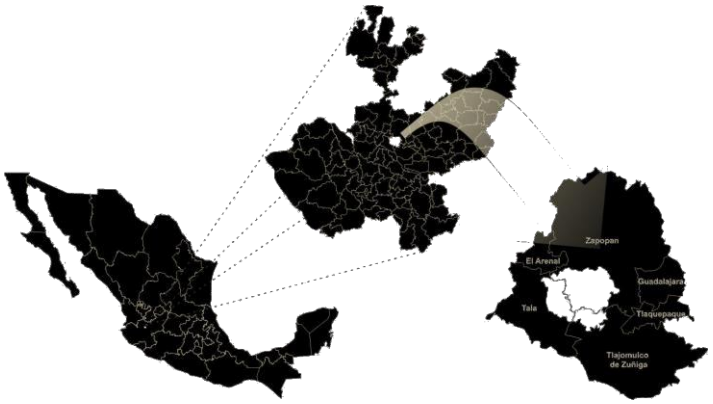

Figure 1. Location of study area: Mexico, Jalisco, and Bosque La Primavera

The main types of vegetation are oak forest, oak-pine forest, pine and tropical deciduous forest as well as some plant communities associated with rivers, rocks and roads (Rzedowski 1978). Local rural residents are today largely engaged in agriculture

with the production of tequila agave, corn and sugar cane being the main activities. They also raise cattle. The average education level in this region is only to the level of basic schooling.

The degradation of ecosystems has led to the generation of proposals to safeguard natural resources in Jalisco, one of which is the State Law on Ecological Balance and Environmental Protection (LEEPA, 2007 Decree Number 13596.- Title 1, Chapter 1, Article 2do) where it is considered:

> *III. The care of the necessary sites to ensure the maintenance and improvement of genetic resources and wild flora, fauna and fish, against the danger of serious deterioration or extinction; and*
>
> *IV. The establishment of buffer zones to safeguard, by reason of the presence of activities affecting or likely to affect the balance of ecosystems. (p.1).*

In Mexico, natural protected areas are considered to be areas in which the original environments have not been significantly altered by human activity, or are areas that need to be preserved and restored. The aim of establishing these protected areas is to preserve representative natural environments of all the different bio-geographical environmental regions and associated fragile ecosystems, to ensure balance and continuity of evolutionary and environmental processes, and to help preserve the genetic diversity of the natural flora and fauna.

In Jalisco there are 19 such natural areas protected by federal and state regulations, but this only represents a small percentage of the territory. In addition, many are in a state of high environmental fragility due to the continuous process of isolation, degradation and pressure from agriculture and urban expansion (see Figure 2). This has led to a reduction in patch size within the dynamic regional landscape scale and this is perhaps the main cause of the loss of connectivity between the natural forest environments. (Figueroa y Sanchez-Cordero, 2008).

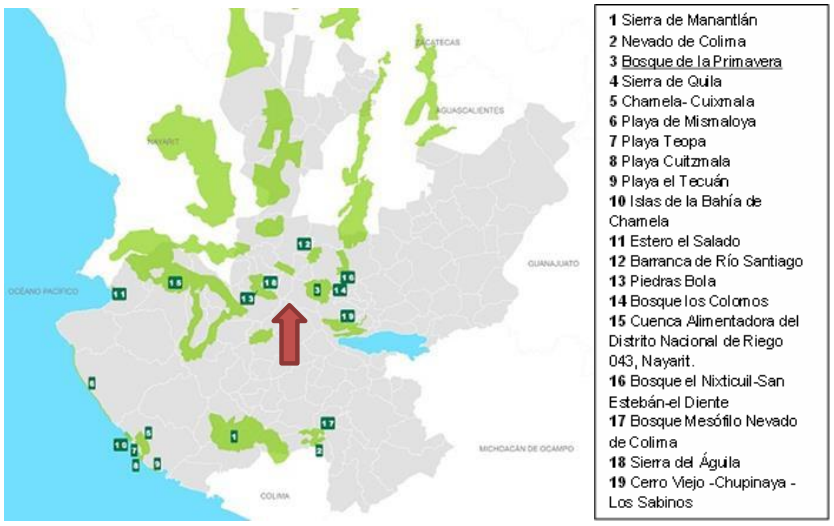

Figure 2. Protected areas in Jalisco with Bosque La Primavera highlighted (source: http://semadet.jalisco.gob.mx/medio-ambiente/biodiversidad/areas-naturales-protegidas)

In 1980, El Bosque La Primavera (which as an indicator of biodiversity contains 346 species of vertebrates) was declared an Area of Protection of Flora and Fauna. In 2006, La Primavera joined the global network of forest reserves of the MAB-UNESCO

biosphere, the second in the State of Jalisco. Under this recognition, one of the priority actions is "the ability to link Biosphere Reserves with biological corridors to help achieve regional integration" (1ª Conferencia Iberoamericana de Reservas de Biosfera. Red de Comités MAB e IberoMaB. Declaration of Puerto Morelos, Mexico, 2010).

The model of biosphere reserves proposed under MAB-UNESCO is distinguished by a roughly concentric zonation structure where only the small central areas or cores are "protected areas". Nonetheless, the scheme provides a much larger area of conservation wherein the objectives of the biosphere are to bring together surrounding landscapes and associated human activities (settlement, agriculture, forestry, tourism and recreation) in a transition area separated from the core protected area by a buffer zone (see Figure 3).

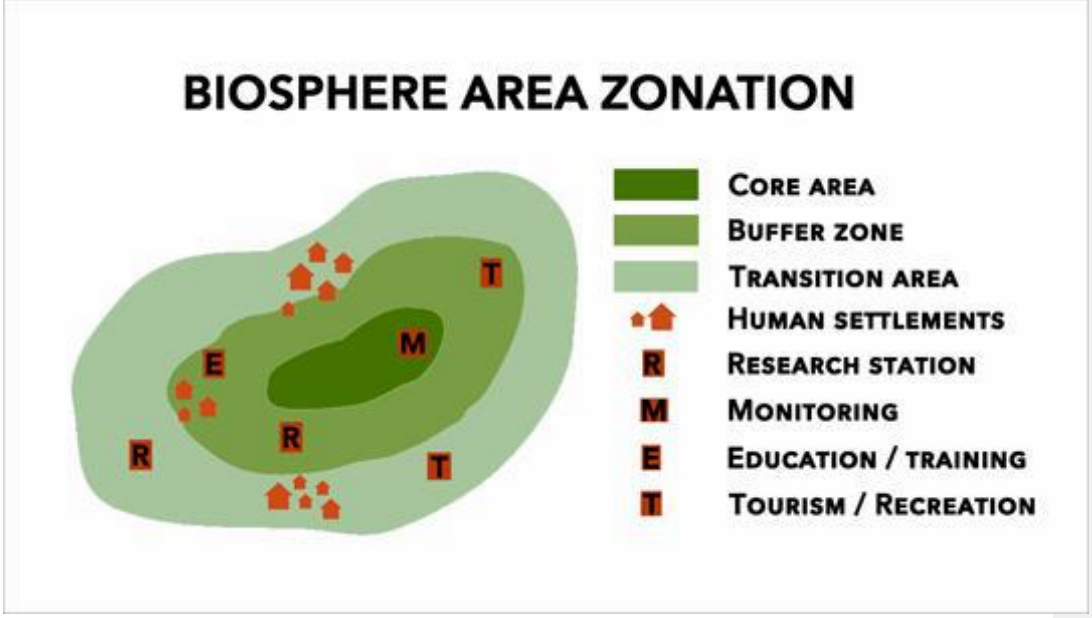

Figure 3. Biosphere Area Zonation (After Netherlands National Commission for UNESCO)

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3. The Puma (*Puma concolor*) and La Primavera Biosphere Reserve

Despite the fact that the Guadalajara metropolitan area (the second largest in Mexico with over 4.4 million inhabitants – *INEGI 2010*) exerts enormous pressure on Bosque La Primavera through urban expansion, it has been shown, through the use of camera traps (see Figure 4) that the largest carnivore in the region – the puma - still survives, with at least 6 individual pumas inhabiting the Bosque La Primavera in a total area of 30,500 ha.

Puma was believed to have been extirpated from the area during and since the 1970's. Studies show that pumas can exist only when extensive and suitable natural habitats are available (Markovchick-Nicholls et a. 2008; Burdett et al. 2010). The presence of pumas in La Primavera confirms the importance of wildlife and habitat preservation as a "priority factor" in management plans.

The puma is considered to be an "umbrella species" because pumas provide indirect protection to the ecosystem they since their presence is crucial for the maintenance of the food chain and thus makes them an important driver of trophic cascades. This is much the same case as seen with the wolf in studies carried out in Yellowstone National Park, between 1995 and 1996, where a total of 31 wolves were reintroduced

with subsequent readjustments to the ecosystem and biophysical processes operating therein (Fortin et al. 2003; Smith et al. 2005). In La Primavera, the puma requires the ability to move to other areas of suitable habitat. Careful consideration of these needs is both urgent and required, as the four juvenile pumas that have been registered in La Primavera will have to migrate in order to find their own territory.

Figure 4. Camera trap evidence of puma in La Primavera (taken during 2011)

While pumas can tolerate a certain amount of human presence and often live in regions that are already quite populated, they always need good hiding places and craggy areas or deep ravines for denning, hunting, travel, etc. In temperate areas, pumas feed primarily on deer and where deer abound, pumas can kill an average of one per week, thus helping to control deer populations (Whitaker 1980). Pumas can reproduce every two years with most births occurring shortly before the rainy season. In temperate areas, the average litter size is three cubs. These remain with their mother for about 15 months before they separate and look for their own territory (Aranda and March 1987; Eisenberg 1989).

Pumas can cover large distances often travelling between 5 and 40 km per day. Their population densities are highly variable, with the highest densities occurring in pine and pine-oak forests (Ceballos and Galindo 1984), though they are also found in other natural vegetation types. Pumas can live from sea level to 3500 meters, but it is generally present at altitudes between 1500 and 2500 meters. The normal territory for a puma varies from 66-685 km^2 for females and 152-826 km^2 for males (Bailey 1974; Berg 1981; McCord and Cardoza 1982; Zezulak and Schwab 1981; Sendell 1989). The males' territorial ranges normally overlap with that of one or more females.

As the top predator in the food chain in temperate areas of Mexico, the puma's relationship with other species should be considered important for its effect on prey populations and because their presence is clear evidence of good conservation status of the local ecosystem. Pumas are often thought to be harmful to cattle populations, however, there are no formal studies that reinforce these complaints. Anecdotal evidence would suggest that most of the injuries to cattle could be attributed to feral dogs. In Mexico, the puma is classified as a species requiring special protection (SEDESOL 1994, SEMARNAT 2002), but despite this it is still considered a game species and can be hunted with a special permit. While every hunter may contemplate the killing of a male puma during the official season, the real problem is from poachers and farmers acting outside of the law. However, it remains a poorly studied species in Mexico, so the true status of their population is unknown in several states although according to CITES and IUCN some subspecies are classified as "endangered".

It is evident that the puma and its habitat are under threat within the Jalisco region. Taking the trophic cascades model into account, then if we can protect the puma as the top level predator, we can also obtain additional environmental benefits from associated ecosystem services at each of the trophic levels beneath it. This demands that the issue of permanence and protection be urgently addressed and in doing so consolidate the critical forested areas and limit the use of these areas solely as “urban parks” for nearby human populations. In the Neovolcanic states, the situation is critical with appropriate measures for their protection being urgently required.

Elsewhere, the figures are just as alarming. In southern California, USA for example, one study indicated that 35 monitored pumas died by being hit by cars in just 2 years (Harris and Gallagher 1989), while on the east coast of USA, the leading cause of mortality for the Florida Puma is also seen to be road accidents (Beier and Barrett 1991). Fragmentation of landscapes by roads and human modified ecosystems is therefore of concern in regard to puma conservation. Despite their ability to live in close proximity to urban areas, road/traffic related mortality is a problem for puma populations especially when migrating from one habitat patch to another.

Recent thinking in conservation biology for key stones predator species has focused on the so-called "Cores, Corridors and Carnivores" model (Worboys et al. 2010), wherein the aim of landscape scale conservation is to maintain connectivity of protected areas through a network of biotopes that serve as thoroughfares (stepping stones and permeable landscapes) or linear corridors linking habitats in the form of an ecological network (See Figure 5). Where an area is fragmented by roads, the most threatened species tend to be the larger mammals, including carnivores and ungulates that regularly move over great distances and so are forced into crossing roads in the process. It has been suggested that the adverse effects of habitat fragmentation by roads might be mitigated by constructing wildlife, or conservation, corridors and "eco-bridges" (Soule, 1991) which connect otherwise isolated patches of habitat on opposite sides of roadways (Saunders and Hobbs1991; Beier and Loe 1992).

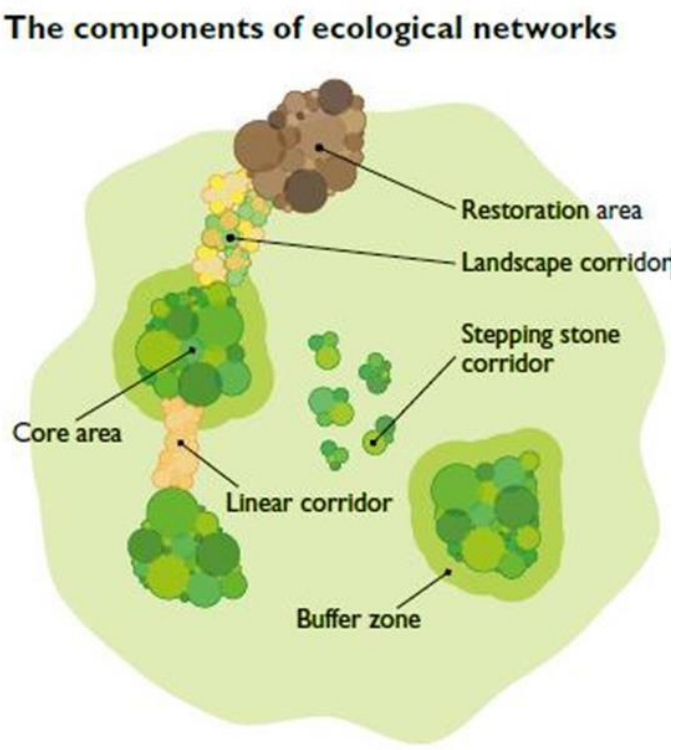

Figure 5. Connectivity: reversing the trend with cores, corridors and carnivores (Source: http://www.tverc.org/cms/content/ecological-network).

Local monitoring in the La Primavera area carried out in 2011 revealed 33 deaths of different animals (both wild and domestic) during a one-month period along the "*Circuito Sur*" highway. With the imminent construction of Guadalajara's *Macro-Libramiento*, a high speed road that cuts through three natural forest corridors of La Primavera to the south and west of the reserve, it has been suggested the specialised wildlife corridors are included during the planning and construction phase of this road-building project as a mitigation measure to limit the number of road-kill and maintain connectivity between La Primavera and other protected areas of puma habitat. These should include, not only those underpasses listed as part of road construction, but at least three wider overpasses or "eco-bridges" covered with vegetation and built with the standards characteristics that have success in other countries. It is known that each species has a particular behaviour, and they can choose the best place to cross. (Clevenger, A. P *et al.* 2009). Using this knowledge together with spatial modelling can help us identify the best places to construct these bridges.

4. Aims and Objectives

The work described here develops a landscape-scale perspective to modelling puma habitats and connectivity around the La Primavera Biosphere Reserve and uses the knowledge gained to better inform plans for maintaining and improving connectivity between protected areas in the region. This work is deemed important because while we know everything is connected within natural ecosystems, the development of urban areas, rural land use and transportation infrastructure within the region has adversely impacted on puma's ability to survive as the key stone species. As a result, we need to

study and redesign some of the most heavily impacting developments and reinstate some of the lost connectivity within the landscape mosaic. This will inevitably impact negatively on human activities within the region and so it is suggested here that plans need to take account of local peoples' views if they are to have any chance of succeeding. Thus, listening to the people, and taking care to increase the value of natural lands for the benefit of both the wildlife and our own future are considered an essential element in planning for more resilient landscapes. The objectives of the research are therefore to:

- Identify and design various functional connectivity options to form the "Western Wildlife Network" between the protected areas and puma habitat areas in the Jalisco region.
- Using a participatory GIS approach ("Map-Me") design an online survey for the collection of 'fuzzy' spatial data on local public knowledge and opinion about puma habitats, sightings and conservation measures.
- Propose and develop options for mitigating the adverse ecological effects of habitat fragmentation, and assess the limitations of the various models as regards landscape connectivity.
- Make recommendations for developing policies and management approaches to implementing the "Western Wildlife Network" to improve connectivity and ensure conservation.

5. Methods

5.1 Selection of data sets

Social, economic, physical, and biological data relevant to the proposed area of biological corridors information are collected from existing sources. These include vector and raster data for spatial analysis together with the regional base map. These data are summarised in Table 1.

Information		Data
Vector data:	**Basic (infrastructure and topography):**	**Toponyms, electrical substations, power transmission lines, waterfalls, electricity generating plants, communication facilities, sports facilities, radio beacons, high structures, cemeteries, roads and highways, roads, earthworks, sheds toll railways, tunnels, bridges, tracks plane, streets, blocks, villages, land subject to flooding, archaeological features, industrial facilities, facilities and diverse infrastructure, state and local political division.**
	Physical environment:	**Material banks, dams, hydrological regions, watersheds, hydrological watersheds, hydrological micro-basins shallow hydrography temporary, permanent surface hydrography, bodies of water, contours (10m, 20m, 100m), hypsometry, temperatures, ranges moisture isotherms, rainfall,**

		evapotranspiration, climates, soil, slope, exhibition.
	Living Environment:	**Dense vegetation, land use and vegetation 1998, 1999, 2011 and 2012 Land Cover of Mexico, ecological zones, and utilization management units, priority sites for conservation in Mexico, mastogeographical regions and provinces, priority terrestrial regions, priority hydrologic regions, biogeographic provinces, terrestrial eco-regions, floristic divisions, protected areas, areas important for the conservation of birds, mammals registration, records of birds, wildlife hit record on roads, National Forest Inventory 2004-2007, resampling the 2013 national forest inventory, forest germplasm-producing units, forest Inventory University of Guadalajara, Arturo Balderas' forest inventory, forest inventory for his project corridors 2014, forest fires, Program and land ecological state of Jalisco, Management Programme eco of Tala, Santa Ana and San Agustin suburbs.**
	Social landscape:	**Boundaries properties, "ejidos", communal areas and rural groups, private property, government property, Census of Population and Housing 1990-2010.**
Raster data:	**Imagery data:**	**9 satellite images Landsat 7 ETM + 1999-2007 30-meter resolution in GeoTIFF format with its corresponding spectral layers files, 2 satellite images Landsat 7 ETM + 2000 and 2003 at 30 meters resolution ECW format combined false color (5,4,3), 1 image 2012 combined satellite SPOT 6 meter resolution, 2 digital elevation models at 5 and 10 meter resolution in TIN format, raster 2 models 5 and 10 meters resolution in TIFF format, 2 digital shaded models 5 and 10 meter resolution.**
	Terrain data:	**2 digital elevation models at 5 and 10 meter resolution in TIN format, raster 2 models 5 and 10 meters resolution in TIFF format, 2 digital shaded models 5 and 10 meter resolution.**
Programs and software:	**Corridor Design"** **http://corridordesign.org/**	**Majka, D., J. Jenness, and P. Beier. 2007. CorridorDesigner: ArcGIS tools for designing and evaluating corridors.** **McRae, B.H. and D.M. Kavanagh. 2011. Linkage Mapper Connectivity Analysis Software.**
	"Linkage mapper" and "Circuitscape" **http://www.circuit**	**Dr. Steve Carver (University of Leeds) Dr. Jonny Huck (University of Lancaster)**

	scape.org/linkage mapper	
	"Map-Me" survey http://map-me.org/	
Surveys and Trails:		**With reference to the area's largest carnivore, distribution, habitat use and activity pattern was analysed to create a map of suitability of Puma (Puma concolor), informal interviews with people who have had encounters with the cat were performed, and obtained traces as well as photographic records multiple camera traps.**
Sources:		• **National Institute of Statistics and Geography (INEGI)** • **National Commission for the Knowledge and Use of Biodiversity (CONABIO)** • **National Forestry Commission (CONAFOR)** • **University of Guadalajara (UDG)** • **Government of the State of Jalisco Institute (spatial information of Jalisco - IITEJ)** **United States Geological Survey / Global Land cover Facility (USGS / GLCF).**

Table 1. Data sources

Comment [KA2]: Needs figure heading and make sure we cross reference in the text

The data selected for use in any biodiversity analysis should be evaluated in the light of the specific research goal (Williams *et al.* 2002). The basic practical criteria used for data selection is that it is up-to-date, freely-available and that it offers complete and uniform coverage for the study area. A key consideration is whether it can be processed during the timeframe of the research project in order to test connectivity in the region. Considering the size of the study region in combination with the type of research objectives specified, GIS compatible data are identified and collected from a range of sources for further assessment. These datasets are listed in Table 1.

5.2 Processing data for use in corridor modelling

A Geographical Information System (GIS) (ESRI ArcGIS 10) is used to represent the study area using the data sets listed in Table 1. All required data layers for the corridor modelling are standardised and projected onto the same local projection system (WGS_1984_UTM_Zone_13N) and clipped to the same extent for the project area.

5.2.1 *Creating a habitat suitability model*

A habitat suitability model (HSM) is created for puma using knowledge of puma habitat preferences (Burdett et al. 2010). This is built using the following layers: Land cover type, distance from nearest water course or surface water body, distance from nearest road, topography and elevation. These were reclassified into habitat suitability classes based on expert knowledge about puma habitat preferences as shown in Table 2. Each

Comment [KA3]: Describe the five layers and justify in the context of Puma hábitat requirements / cross reference to section 4 and reference Tables x.2

layer is weighted according to the level of importance for puma habitat before running the HSM sub-model in the Corridor Design model (Beier et al. 2011). The resulting HSM layer is reclassified to identify patches of suitable puma habitat in the study region based on HSM value and area of land available.

Classification

LAND COVER TYPE	Land cover description	SUITABILITY CLASSIFICATION
1	Human settlements	0
2	Pine-oak forest	100
3	Oak forest	95
4	Oak-pine forest	100
5	Open water	0
6	Rainwater-fed permanent agriculture	40
7	Rainwater-fed semi-permanent agriculture	35
8	Mesquite forest	45
9	Natural pasture	30
10	Mesquite forest	45
11	Improve pasture	30
12	Irrigated permanent agriculture	14
13	Irrigated permanent/semi-permanent agriculture	20

Water distance (m)

0	100	100
100	500	72
500	5309	28

Topography

1	Canyon bottom	100
2	Flat-gentle slope	27
3	Steep slope	98
4	Ridgetop	95

Comment [SC4]:

14	Irrigated semi-permanent agriculture	25		Road Distance (m)	
15	Deciduous forest	85	0	100	5
16	Temporal agriculture	20	100	500	30
17	Temporal permanent agriculture	25	500	7397	100
21	Secondary shrub in pine forest	30		Elevation (m)	
22	Secondary trees in pine forest	50	560	1000	23
23	Secondary shrub in oak forest	35	1000	1500	47
24	Secondary trees in oak forest	60	1500	2000	89
25	Secondary shrub in oak-pine forest	25	2000	2950	100
26	Irrigated semi-permanent agriculture	40			
27	Secondary shrub in deciduous forest	30			
28	Secondary trees in deciduous forest	45			

Table 2. Habitat preference classifications used in the HSM

5.2.2 Resistance surface

The resulting HSM is used a resistance layer in identifying suitable migration corridors. It is recommended when using a least-cost surface modelling approach that the data range for cell values stretches from at least 1-100 or even 1-10000 such that the model better distinguishes between resistance values across the full range from high to low (Beier *et al.* 2011). Here the cell values in the puma habitat suitability model raster layer are stretched to a new scale of 1-10000 using the equal interval method in the standard 'Slice' tool in ArcGIS 10. The polarity of this layer is then reversed using the 'Raster calculator' tool to create a resistance scale where low values equal low resistance and

high values equal high resistance as required by the Linkage Mapper Toolbox model (see section 5.3).

5.2.3 Reinforcing roads

An additional version of the resistance layer is also built incorporating motorways and trunk roads as maximum resistance value barrier elements due to their influence on puma movements and mortality from road traffic collisions. Whilst these are considered in the original resistance layers they do not appear as absolute barriers in the final raster layer. This is done by merging the infrastructure layers into a combined vector layer and converting this to raster format. The resulting infrastructure raster cells are then weighted and reinforced using best practice guidelines to avoid gaps and ensure their suitability for cost-distance modelling (Adriaensen *et al.* 2003). This layer is then combined with the original resistance surface to produce a new puma infrastructure resistance layer.

5.2.4 Puma Patch

Based on the literature review and the Corridor Design tool, puma patch habitat is defined as follows: minimum patch area of 100ha and minimum distance from water, preference for difficult terrain (canyon bottoms, steep slopes and ridge tops), maximum distance from road, higher elevations, and more natural land cover types.

A minimum size criterion is implemented in ArcGIS to select only those Puma patches with an area greater than or equal to 100ha. Selecting sites of size greater than 100ha is in line with other similar large scale analyses where it is considered a large enough area to act as a stepping stone.

Comment [KA5]: Ref?

5.3 Puma linkage modelling

An analysis is conducted for the whole study region and then for smaller subsets to determine the impact of key configuration parameters for the 'Build Network and Map Linkages' tool from the *Linkage Mapper* modelling toolbox (LMT) (McRae and Kavanagh 2011). The modelling process which is implemented by this tool is shown in Figure 6.

Optimum runs are then made using this tool for the various permutations of nodes and resistance surfaces in the smaller subset regions. The cost-weighted distance raster output maps from these modelling runs are then individually processed and symbolised in ArcGIS to display the natural linkage corridors. These corridors represent the normalised cost-weighted distance between nodes allowing linkages to be compared on the same map. The normalized least-cost corridor between habitat core areas (HCA) *A* and *B* is calculated as follows:

$$CWDA + CWDB - LCDAB$$

Where:

CWDA is the cost-weighted distance from HCA *A*

CWDB is the cost-weighted distance from HCA B

LCDAB is the cost-weighted distance accumulated moving along the ideal (least-cost) path connecting the HCA pair

(After Washington Wildlife Habitat Connectivity Working Group 2010:39)

The width used to clip and extract these linkage corridors from the underlying cost surface produced by the modelling run is based on those values within the first quartile (below 25%) of cost-weighted distance range for the underlying cost-surface. This is considered to capture the majority of viable least-cost paths within the landscape (Theobald 2006).

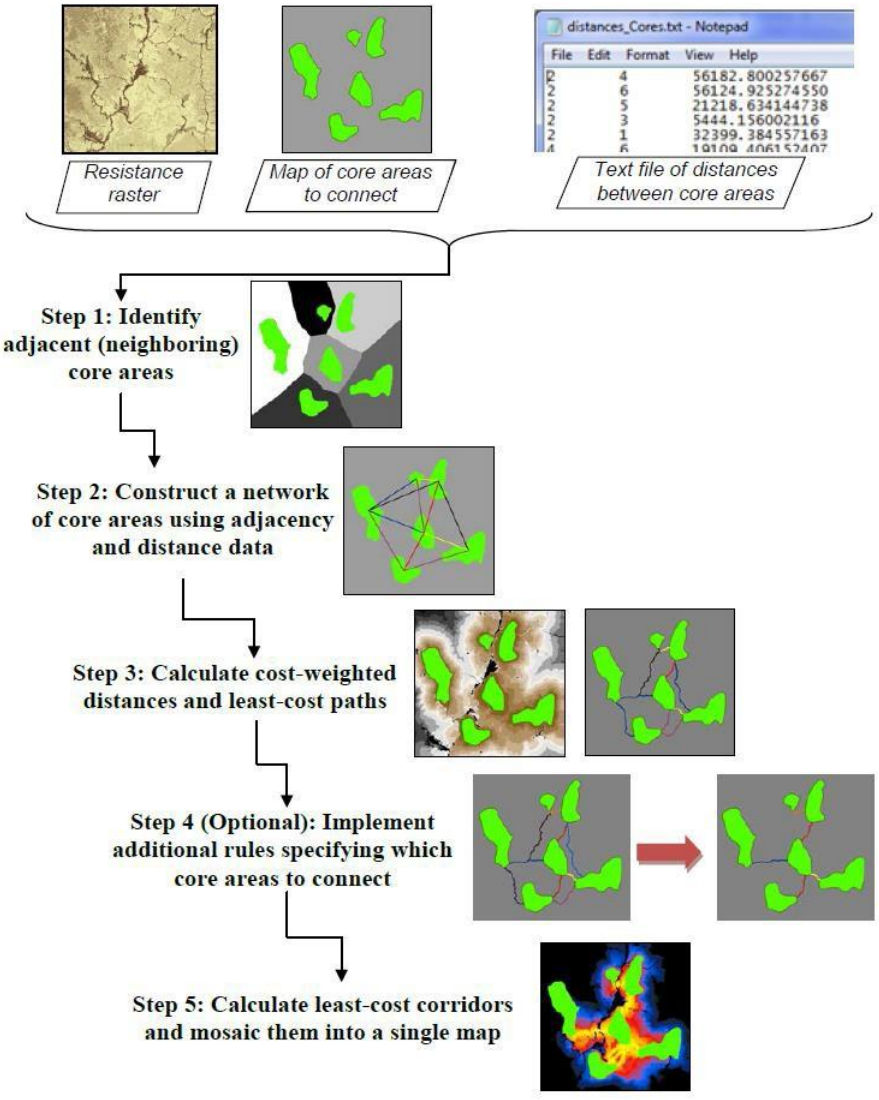

Figure 6. Modelling process implemented by the 'Build Network and Map Linkages' tool (Adapted from McRae and Kavanagh 2011)

5.4 Identifying pinch points & barriers

Experimental runs are made, based on the supporting documentation, for the "Pinchpoint Mapper" tools to ascertain which configuration gives optimum results (McRae 2012a; McRae 2012b; McRae 2012c). This tool is then used to run additional analyses on the natural landscape linkages raster data for the specified modelling runs in order to highlight critical points within these natural landscape linkages.

The output of these analyses was then symbolised in ArcGIS to spatially represent the data on linkages and pinch points. This is shown in Figure 7.

Comment [KA6]: JCJ's nice map!

5.5 Participatory GIS

While the use of state-of-the-art corridor modelling tools has enabled detailed modelling of habitat suitability and potential wildlife corridors and pinch points between protected areas and puma habitat, there is still a great deal of uncertainty surrounding the validity of these results. Our knowledge of puma habitat preference and behaviour is limited to field observations and surveys, while the models themselves are limited by the quality of the data and assumptions made in generating output. While the outputs shown below in figures 7-9 are very detailed and are based on the best available tools, there is still uncertainty as to whether they accurately represent true puma habitat preferences and behaviour. This paper presents additional analyses based on participatory GIS surveys of local people to try to validate the HSM and corridor modelling outputs.

A web-based participatory GIS (PGIS) system "Map-Me" is used to carry out surveys of residents of the area for a month to collate information on puma sightings and signs, livestock predation and the likely influence of land use, people and infrastructure on puma behaviour, disturbance and mortality. Map-Me is a fuzzy PGIS which uses a spray-can interface over a Google Map base that allows users to spray "paint" on the areas of the map that they wish to comment on in regard to questions posed in the survey (e.g. "Please spray on the map areas that you have seen puma or puma signs") and then comment on the areas defined in response to specific contextual questions using free-format text boxes (e.g. "When did you last see a puma or puma signs in this area?") (Huck et al 2014). The spay patterns are stored as point shapefiles (each blob of paint in a separate point) such that large amounts of data on spatial patterns can be collected in a relatively short period of time. The answers to the contextual questions are also stored but crucially linked to the spray patterns such that these can be used to generate a rich picture of local knowledge about various aspects of puma behaviour and habitat.

This information was used to develop a better understanding of local people's perceptions about puma and about how the construction of underpasses and eco-bridges under/over the new highway could affect the conservation of wildlife. The spray patterns are mapped used kernel density filters to show the overall pattern and frequency of local knowledge (see Figure 11).

6. Results

Using the methods described a number of potential corridors have been identified. The corridors identified around the Bosque La Primavera are:

- To the northeast Tepopote hill (where recently the construction of a new subdivision was approved), which connects this hill with Los Bailadores and Huentitan Canyon.
- On the east side is the connection to the hills of Tequila, (where the new road is more polygon next to the protected area).
- To the south is the Ejido Ahuisculco, (where we have a promising long-term comprehensive project to rescue the biological corridor by the NGO Selva Negra and proceeds from the mitigation ecological footprint from the rock group Maná during their last world tour) which would connect with the Sierra del Aguila and then the Sierra de Quila.
- In the southwest, is "Cerro Viejo-Chupinaya-Los Sabinos", the latest of protected areas in the state, where despite the *Macro-libramiento* runs all along its northern edge, and the fragmentation of agricultural land is wide in that area, also to been possible to record the presence of Yaguarundi (*Herpailurus yagouarondi*) species recorded in the official Mexican standards (NOM-059-SEMARNAT-2010) as "threatened", which tells us that there are still good quality habitat in the area (See Figures 7-10).

The identification and estimation of a network of ecological corridors is performed by the study and analysis of habitats and distribution. Thus, data from existing maps are selected to determine elements that can function as connectors two or more places of interest for biodiversity spaced apart so that the dispersion of living beings is also facilitated. As a result we have some patches called stepping stones; isolated biotopes that function as biological connectors can provide habitat, shelter and other resources for many species. This suggests focusing attention to increase forest coverage and maintain the natural wealth.

Comment [S7]: Will need to reference these figures directly and interpret them in relation to local geography.

Once we have carefully mapped corridors, a proposal tailored to different local conditions can be developed. We worked with the CCC model (Core, Carnivores, Corridors) in GIS with good design techniques, that provide diverse possible roads to connect, and with every option we could design alternative plans, to work beside the farmers in function to conserve special places for the secure mobility of the carnivores in the area. PGIS tools are used to collect local knowledge about puma habitat and sightings and map these. These maps are used to verify the HSM, corridor, linkage and pinch point analyses and provide "ground truth" justification for the planned puma corridor and eco-bridge construction in the project area and especially in mitigating against the barrier effects of Guadalajara's new *Macro-Libramiento* highway.

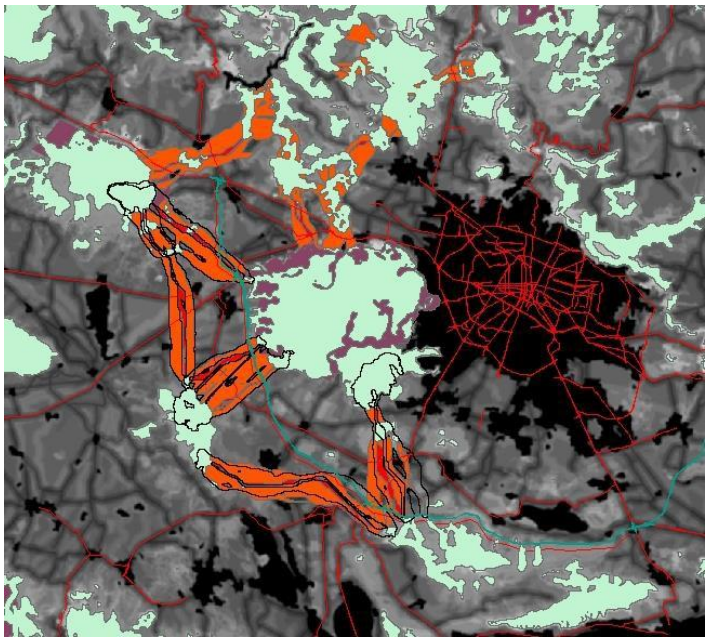

Figure 7. Map from *CorridorDesign* with all the options to connect.

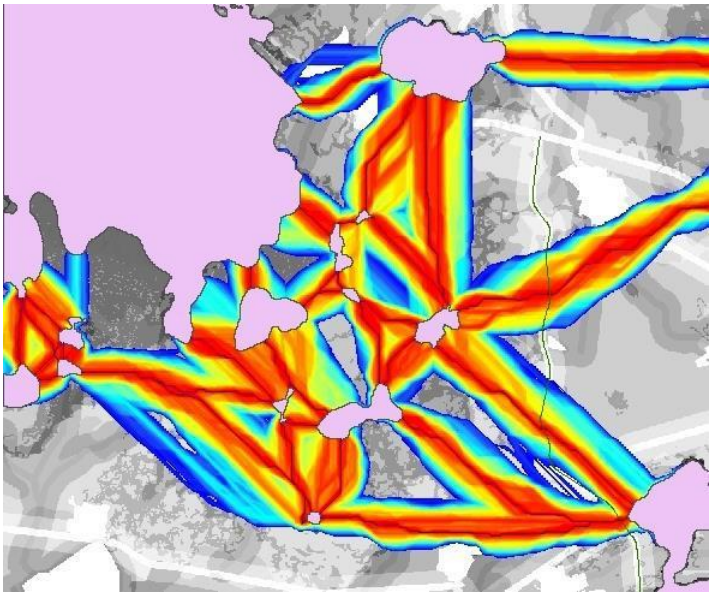

Figure 8. Details with LinkageMapper and Circuitscape for Tequila

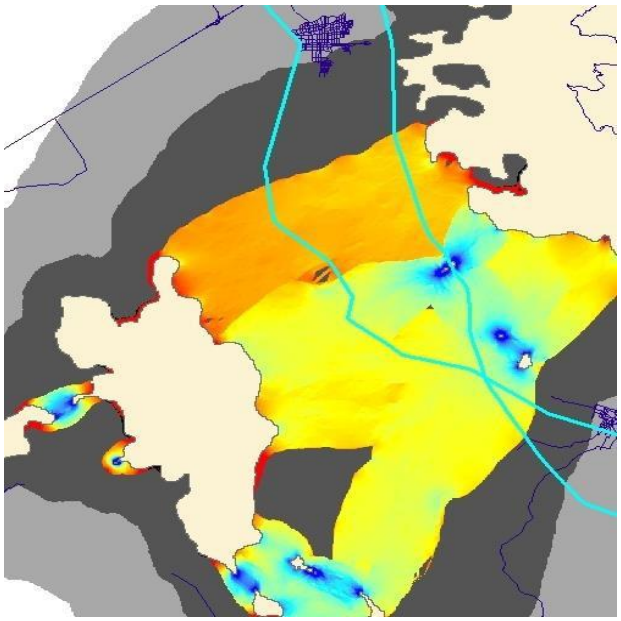

Figure 9. Details with LinkageMapper and Circuitscape for Ahuisculco

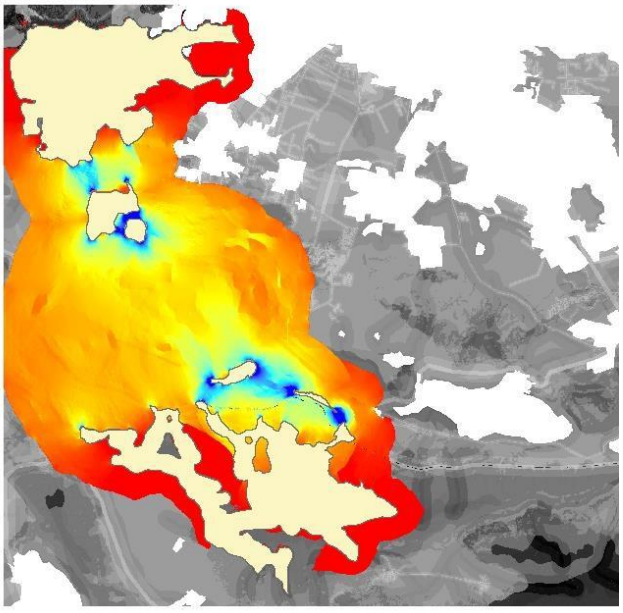

Figure 10. Details with LinkageMapper and Circuitscape for Cerro Viejo

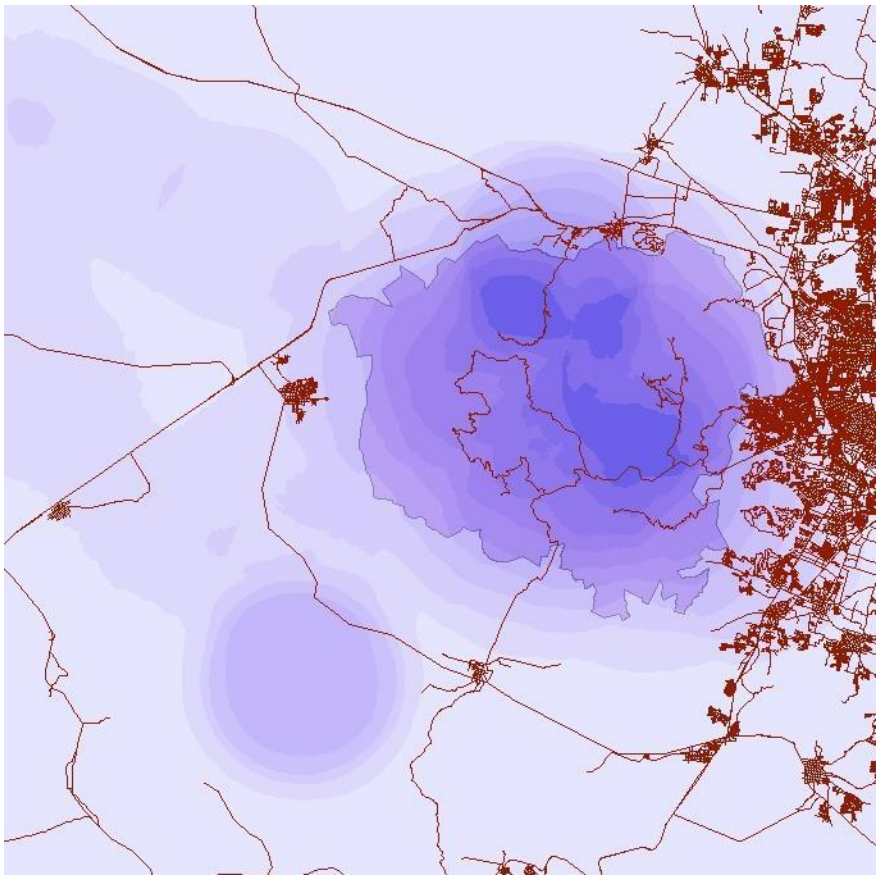

Figure 11. Map-Me outputs showing local knowledge of puma sightings and signs

While the patterns in Figure 11 remain at this stage necessarily vague due to their broad scale, and further work is perhaps required to add further local detail based on further field surveys of local knowledge and opinion, it can be seen that that there some distinct patterns linking the outputs from the corridor design work and the knowledge of local people. The core of the biosphere reserve shows up very clearly as core puma habitat according to local people and reserve employees. There are also “satellite” cores apparent in Ahiusculco and Tequila together with connecting “corriddors” between these two areas and La Primavera. While there are no data supporting the presence of local knowledge of puma presence and habitat in Cerro Viejo and Tepopote this is likely to be due to lack of response from people in these areas because of political and personal reasons. Further studies are required to ensure a full response from these areas. Nevertheless, at the scale of the whole of La Primavera and its surrounding protected areas it can be seen that information gathered using PGIS can be useful in validating and confirming the presence and pattern of puma habitats and probable migration corridors, thereby supporting the spatial analysis presented above. Just how good these models are at identifying the detailed location and pattern of corridors and associated pinch-points on the ground is open for debate. It is suggested here that further field surveys with local people, land managers and conservation professionals is essential in validating the detail of the models and therefore better support decisions regarding the best placement of capital expensive infrastructure such as wildlife bridges and underpasses, especially where funds for these are limited and it is essential to build these in the best possible place.

7. Discussion

For the design and planning of the corridors to become functional, it should be based not just on the biophysical landscape but also on social perceptions, local knowledge and the "grounded" realities of those human communities that inhabit the area. Additional support from the education sector and widespread promotion of the economic benefits to all involved could help win over the cause of puma conservation. Resilient plans can only be achieved by integrating the views of local people into the planning process and use these to verify or change the design of the wildlife corridors before proposing actions which involve greater human-wildlife conflicts than solutions allow. Thus, local people might reasonably be considered the key partners in any conservation planning process.

Using the latest wildlife corridor mapping tools we have obtained a network of possibilities that may correspond, more or less, to the functional behaviour of the species in question, and its territorial use. Richard Noss (1991) distinguishes different types of connectors within habitat biodiversity conservation networks. For the regional scale, he proposes the "network of reserves," which corresponds to the protected areas at the landscape level including the buffer zones surrounding both the reserves as well as the corridors that connect them.

The method with the best result obtained in the methods and results described above was "Circuitscape". Circuit theory views the landscape as if it were a large electric circuit in which all parts of the landscape are part of the same circuit board. Something that distinguishes this from other methods is that while the circuit approaches can be used to delineate the single least-cost routes, it is often more useful to analyse and describe connected habitat patches that have multiple options running either direction. This gives more than one option or result, which can be more functional and also more accurately approximates the way in which organisms move across the landscape in reality. This approach is particularly useful when connectivity between large sets of habitat patches is modelled and where such integrated schemes must function to support decision-making, management, or implementation.

8. Conclusions and recommendations

The conservation, design and maintenance of connected landscapes is a priority in maintaining biodiversity conservation. The proposed network described here is intended to cover the central part of the State of Jalisco and eventually to spread to other areas so as to connect to protected areas in the neighbouring states of Nayarit, Colima, Michoacán, Guanajuato, Zacatecas and Aguascalientes. This will require verification and testing of the efficacy of the corridor linkages at each stage, breaking through regional and national boundaries, integrating economically viable human needs with wildlife, and elimination of conflicts caused by the competition between human land use and wildlife movements.

Consideration of the design of the network of ecological corridors should not only correspond to a theoretical design principles as laid out in the literature, but must also be based on a thorough knowledge of the environment as well as its connection with the complex integration of different habitats, species, human land use and local communities. Furthermore, an integrated conception of territory makes us see that the interest exceeds the purely municipal level; it being more realistic to consider a systemic view of ecological processes. Ultimately, we can arrive at a network of ecological corridors, where each is considered by its certain functionality within the whole.

Follow-up and monitoring of programs are essential if we are to have reliable indicators of effectiveness of such adaptive management. Local field studies, as performed in the Bosque La Primavera, are essential to improving connectivity models. While society may give a certain level of priority to the conservation of biodiversity, this is still at a very low level when compared those priorities attached to meeting immediate production needs (food, fuel, water, etc). In countries where economic and social conditions have not yet passed the basic requirements for human survival it is harder to promote environmental issues that do not directly involve human well-being or may seem contrary to these. This anthropocentric vision of "human needs first" has so many times before led to conservation actions coming too late to protect and conserve the larger predator species such as the puma. The real challenge ahead, therefore, is to shift attention towards a global or landscape scale conservation, in which the future of most of the world's biodiversity can be assured.

This is not the time to put such actions in the hands of a single institution. One of the best alternatives to traditional systems is to seek public-private partnerships. This involves a major legal and institutional challenge for national policy and social will. However, practice has shown not only is it viable, but connectivity between areas does not necessarily imply the strict preservation of the territories that would operate as brokers. Many of them could play a role in lessening the impacts of shocks and generate productive activities on protected areas. It is enough that certain practices such as clear-cutting exclude the replacement of native vegetation and exotic forest plantations, more compatible with conservation, and responsible ecotourism activities are encouraged and biological conservation criteria are incorporated into the productive land use, as maintenance of live trees or snags, riparian vegetation and forest patches in the middle and at the edges of fields, as well as more environmentally friendly farming practices like permaculture is successful for the purpose intended.

8.1 A Proactive Agenda:

- Promote research programs and programs for monitoring biodiversity.
- Manage the state "Integrated Network of Protected Areas and Biological Corridors".
- Include the category of “protected corridor” within future legislation to help to ensure long-term preservation.
- Development and / or monitoring of recovery plans and conservation of vulnerable or endangered species.
- Maintain native vegetation cover and initiate recovery activities for the patches without vegetation and diverse natural reforestation.
- Together with NGO’s and civil-society, seek additional incentives for land-owners incentives to continue advance their involvement in conservation.
- Information dissemination on elements of wildlife and conservation benefits that come from the corridors.

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And finally to all who like to "connect" - to build bridges, partnerships and cooperatives… to all those who believe in preservation... we're on the same side of life.

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Comment [KA8]: Check references that Jonathan has made in methods section here… see his dissertation

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