# Effects of habitat degradation on the monito del monte (*Dromiciops gliroides* Thomas) and its consequences on the seed dispersal interaction with an endemic mistletoe



Photo credit: Camila Dünner (2012)

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May 2013

**INTRODUCTION**

Plant-animal interactions play a central role in generating and maintaining biodiversity (Thompson 1994). Among them, pollination and seed dispersal mutualisms had been broadly studied since plants' reproductive success mainly depends on them. Seed dispersal may determine the natural forest regeneration potential, which is usually ruled by dispersal syndromes as product of a close interaction between the plant and the disperser (Lomáscolo *et al.* 2008). Although these mutualisms have been deeply studied since a couple of decades ago, its study in the context of habitat degradation is quite recent. Moreover, the study of the underlying eco-evolutionary dimension of ecological interactions in disturbed habitats remains as a little explored topic (Kinnison *et al.* 2007, Stockwell *et al.* 2003).

Anthropic habitat disturbance may change community's structure due to changes in the evenness and species loss. Also, the strength of the ecological interactions might be modified because of demographic and behavioural changes. Consequently, variations in frugivores' abundance might cause alterations on the selective forces (Kinnison & Hairston 2007), which they may exert on certain fruit phenotypic traits associated to seed dispersal. However, the possibility that intensity changes in frugivory might exert microevolutionary consequences on fruit traits remains unknown.

Dispersal mutualisms are particularly relevant at the Chilean temperate rainforest since many plant species of these forests depend on such mutualisms to

ensure their reproductive success (Aizen *et al.* 2002). In this biogeographic context, the interaction between the mistletoe (*Tristerix corymbosus*, Fig. 1) and the monito del monte (*Dromiciops gliroides*, Fig. 2) conforms a very particular study system, where a parasitic plant that totally depends on this marsupial for seed dispersal (Amico & Aizen 2000, Amico *et al.* 2011). Moreover, *T. corymbosus* provide food resources for many native species, and particularly for pollinating birds in winter, becoming a key resource in scarcity periods (Aizen 2003). It is known that habitat fragmentation reduces the mistletoe recruitment when the *D. gliroides* become severely reduced (Rodríguez-Cabal *et al.* 2007), but there is no formal assessment about the consequences of habitat degradation, where habitat quality is more critical than habitat quantity.

**PROJECT AIMS**

This project relied on three main aims:

**Aim 1:** To estimate *D. gliroides* abundances in degraded and non-degraded forest habitats.

**Aim 2:** To evaluate the effects of habitat degradation on frugivory, through quantifying visit and fruit-removal rates at both degraded and non-degraded sites.

**Aim 3:** To compare the magnitude, sign, and curvature of the selection gradients on the mistletoe (*Tristerix corymbosus*) fruit traits, related to the fruit removal by *D. gliroides*.



**Figure 1.** A mistletoe (Tristerix corymbosus) with flowers and fruits (photo credit: Francisco E. Fontúrbel, 2012)

**Figure 2.** *Dromiciops gliroides* walking through a small branch (photo credit: Francisco E. Fontúrbel, 2008).

**METHODOLOGY**

*Experimental design*

I have compared two spatially explicit situations: a) old-growth native forest stands without human disturbance and b) degraded forest stands with planted eucalyptus trees and secondary native vegetation in between. As degraded and non-degraded stands formed a complex habitat mosaic (Fig. 3), I have estimated the proportion of native habitat (as a proxy of the habitat degradation extent) within three non-overlapping buffers: 0-50 m, 50-100 m, and 100-250 m from each sampled mistletoe. The buffer distance was defines accordingly to the maximum movement distance recorded for the disperser *D. gliroides* (Fontúrbel *et al.* 2010). Habitat cover was obtained from aerial images of the study location and habitat quantification was done using ArcGIS 9.3 software (ESRI, Redlands CA).

*Aim 1: Capturing protocols*

*Dromiciops gliroides* abundance was determined through live trapping. Custom made wire–mesh traps, baited with fresh banana slices, were operated in 5x5-trap grids at each plot. Capturing protocols were previously standardized (Fontúrbel & Jimenez 2009). Trap grids were operated for five consecutive days and checked every morning. Animal care, handling and marking will be conducted following the guidelines

of the American Society of Mammalogists (Sikes *et al.* 2011). Captured individuals were marked (using PIT Tags and hair marks), measured (length, weight, sex, and age), and immediately released.
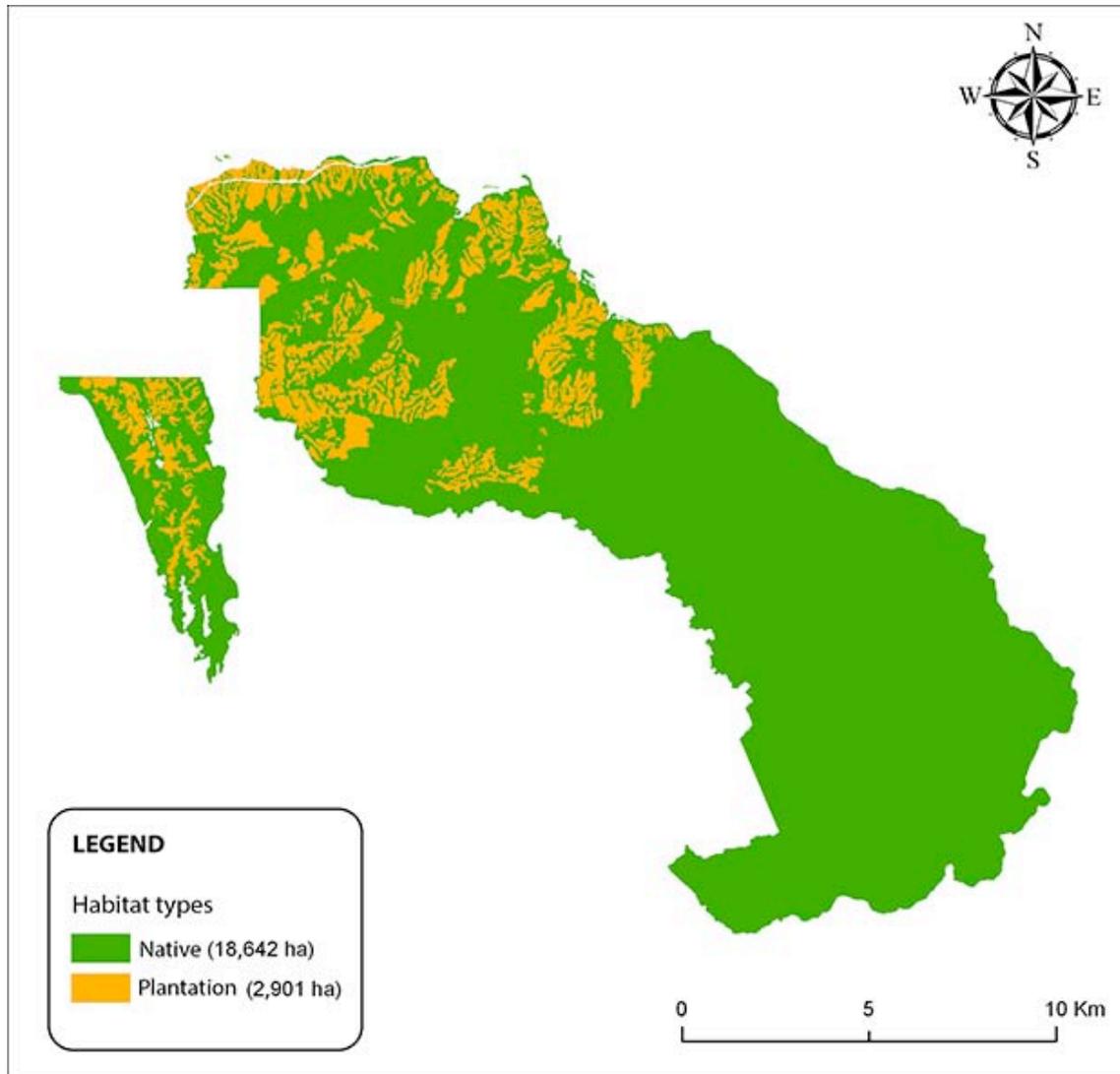


**Figure 3.** Native (non-degraded habitat) and eucalyptus plantation (degraded habitat) mosaic at the Valdivian Coastal Reserve.

*Aim 2: Visit rate and fruit removal evaluation*

Infrared camera-traps were placed in front of 70 fruiting plants in order to quantify visit rates, for a total of 48 hours of continuous monitoring per plant. Fruit removal was quantified through randomly marking 10 fruits per plant and counting the number of fruits removed or fallen at 5 days after marking. During daytime, bird censuses and camera trapping were conducted in order to identify potential pulp consumers. Besides, seed germination was determined in a fruit sub sample of each focal plant.

*Aim 3: Selection coefficients assessment*

The following fruit traits will be measured at each plot: number of fruits per plant (= crop size), fruit size, seed mass, and sugar contents. As a fitness proxy, we will use the proportion of fruits removed per plant (quantitative fitness) multiplied by seed viability (qualitative fitness). Hence, directional, quadratic, and correlational selection gradients will be calculated using the Lande & Arnold's equations (Lande & Arnold 1983). The proportion of native habitat within the three ring buffers defined was included as a covariate in linear and non-linear selection gradient equations.

**RESULTS**

*Aim achievement*

**Aim 1** was accomplished only partially. Despite having a capturing effort of 1,490 trap-nights, I have captured only six *D. gliroides* individuals, thee at the non-degraded habitat and three at the degraded habitat. The capturing protocol was the same used in a previous field research (Fontúrbel & Jimenez 2009, Fontúrbel 2010), yielding captures rates up to 11% (with 81 captures corresponding to 69 different individuals in one summer season), and also were tested in other Chilean locations and in Argentina (Fontúrbel *et al.* 2012). Low capture rates found here might be related to the abundant food resources present in the environment (15–200 fruit per $m^2$ on average), probably making the individuals being not interested into entering the traps because there were many other food resources outside the traps. However, taking advantage of the trap-cameras bought for the frugivory monitoring, I have set cameras in photo mode (in order to extend the batteries life and enhance the monitoring period) and placed them at the same capturing plots, obtaining 520 photos from December 2011 to April 2012 (each camera monitored 98.5 days on average, during the spring-summer period) and from November 2012 to March 2013 (each camera monitored 100 days on average). Despite cameras are unable to provide other valuable information (such as gender, age, and body condition) as live traps did, and also did not allow the individualization of each animal photographed, this technique provides a good relative activity proxy (i.e., the rate of photos per day at each site) without any human interference and without introducing any environmental bias (i.e., a baited trap) into the environment. Considering that my trap-cameras use infrared LED technology to take night shots, they are able to make pictures without emitting a bright light that may disturb the animals or induce behavioural changes. Relative activity levels were similar between habitats across time (repeated measures ANOVA, $F_{1.6,69} = 1.24$, p = 0.24).

Further, trap-camera monitoring showed a higher relative activity at the degraded habitat (i.e., the eucalyptus plantation) during the early summer, but at the late summer the activity was more intense at the non-degraded native habitat (Fig. 4).
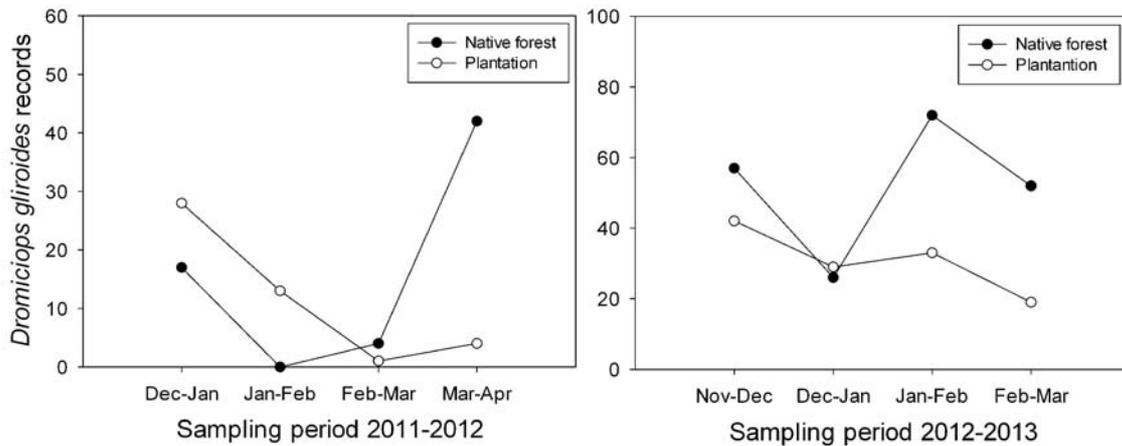


**Figure 4.** *Dromiciops gliroides* relative activity measured as number of photos per habitat and month. Two sampling periods are presented.

**Aim 2** was successfully accomplished by the means of using the trap-cameras in video mode, taking 15-second footages (see an example on YouTube: http://www.youtube.com/watch?v=D-I0tflVZNE) when detecting activity for 48 hours of continuous monitoring for each mistletoe plant (a total of 3,360 video hours during the fieldwork, obtaining 83 records with evidence showing *D. gliroides* consuming fruits). The monito del monte appeared to be the sole mistletoe's seed disperser agent at this location, since no other species was recorded consuming fruits, despite being recorded four generalist frugivorous bird species (*Mimus thenca*, *Elaenia albiceps*, *Columba araucana*, and *Turdus falcklandii*), which are abundant all over the study location. Regarding interaction intensity, mistletoes at the non-degraded habitat received about four times more visits than those mistletoes at the degraded habitat (2.73 vs. 0.70 visits per plant, respectively), despite having smaller crop sizes. Contrasting visit rates to the proportion of native habitat in a buffer of 250 m around each plant, there were a positive but marginally significant trend of increasing visits (negative binomial GLM, estimate = 1.57 ± 0.97, p = 0.10) as long the native habitat becomes dominant.

**Aim 3** was successfully accomplished as well. From the 70 monitored mistletoes, I have collected fruit samples and frugivory-related traits were measured, the results standardized and fitted to the Lande and Arnold (1983) equations for

estimating linear ($\beta_i$) and non-linear selection gradients ($\gamma^2$ and $\gamma_{ij}$). Regarding linear gradients ($\beta_i$), significant selection gradients have been found for seed dry mass (positive), and sugar content (negative). Further, regarding the non-linear selection gradients ($\gamma$), a marginally significant stabilizing selection was detected for sugar content, and no correlational selection gradient was significant. Those results show that *D. gliroides* is consuming the mistletoe fruits in a non-random way, selecting some traits associated with seed size and sugar reward. In all cases, the proportion of native habitat (used as a proxy for quantifying habitat degradation effects) had no significant effect on the natural selection gradients irrespective of the spatial scale of the buffer ring considered, meaning that *D. gliroides* seems to be selecting the same fruit traits at both degraded and non-degraded habitats. However, analysing native and plantation data separately, I found that seed dry mass was significantly selected in native forest stands, with a positive linear gradient and a significant disruptive non-linear gradient (i.e., bigger seeds are favoured by natural selection), whereas sugar content was significantly selected at the plantation stands, with a negative linear gradient and a stabilizing non-linear gradient (i.e., fruits with intermediate sugar contents are favoured). These stress the importance of the habitat context for natural selection in this highly specialized mutualistic system.

In summary, my results suggest that both *D. gliroides* and the mistletoe *T. corymbosus* are more resilient to habitat disturbance than we previously thought (Fontúrbel *et al.* 2012). Indeed, Hershkovitz (1999) have described *D. gliroides* as a habitat specialist restricted to old-growth forest stands dominated by *Nothofagus* spp. and *Araucaria araucana*, and as we currently know the mistletoe is only dispersed by this marsupial at that latitude (Amico & Aizen 2000, Amico *et al.* 2011), the mistletoe recruitment would be limited to such forest stands as well. Conversely, the empirical evidence gathered here show that both species have plastic responses and are able to thrive in degraded habitats, on which the original vegetation was replaced by eucalyptus trees (with a commercial purpose), but after The Nature Conservancy (the protected area administrator) bought that area for conservation purposes, natural regeneration processes have operated and now we have a so-called 'novel ecosystem' that results from the mixture of the eucalyptus plantation, the native vegetation regenerated in between (dominated by rapid-growth, opportunistic and shade intolerant shrub and tree species with abundant fleshy fruits), and some invasive species (*Ulex europaeus*, *Ribes magellanicum*, *Rattus rattus*) shaping a 'degraded' form of the original habitat, but that could be a potential habitat surrogate for my target species. However, this resilience patterns observed should be interpreted with caution, since

the frugivory rate results show a contrasting scenario: mistletoes at the degraded habitat receive only one quarter (25%) of the *D. gliroides* visits than those received at the non-degraded habitat, which probably is imposing an important recruitment limitation because of the diversity of fleshy-fruited plants are competing with the mistletoe (and perhaps the mistletoes are also competing intra-specifically) for attracting seed dispersers. Moreover, plants at degraded habitats might be facing other costs such as increased herbivory and reduced gene flow, related to the high plant aggregation patterns found at those stands, but further studies are needed to adequately establish those less evident consequences of habitat degradation on this system.

*Notes on methodology*

As happens in many projects, my methodology needed few adjustments during the project's execution. First of all, live trapping do not yielded good results at this area, but the methodology employed showed to be appropriate at other locations. As discussed above, perhaps the large amount of available food resources for *D. gliroides* at both degraded and non-degraded habitats is responsible for such low capture rates, since camera-traps confirmed that this species it is present and active at the sampling plots. From the original number of marked mistletoes, I was able to sample only 63 since many plants do not have fruits or are inaccessible for sampling. However, despite those inconvenients, my methodology was sound and appropriate for answering my research questions. Also, it is repeatable in time and space. The methodological procedures that I have implemented here could be easily repeated for gathering new data in the next years, and could be also used for sampling other locations within *D. gliroides* distribution area. As live trapping is not always that effective, but it is time and effort consuming, I recommend to use camera-trap monitoring which allows to monitor large areas for long time periods with less field effort, and has the advantage of being less biased than trapping.

*Project contribution*

The empirical evidence obtained attains to two main subject areas: (1) the contribution to the ecological knowledge of *D. gliroides* and the species that interact with, and (2) the restoration ecology. About the first subject, this research contributes to understand how *D. gliroides* respond to anthropogenic habitat modification. Based on previous studies (see Fontúrbel *et al.* 2012 for a complete review) and this research, there is enough evidence to correlate *D. gliroides* presence in disturbed habitats with the retention of certain key environmental variables such as shrub cover,

the presence of mosses, vines, and a tick litter layer, and the presence of the native bamboo *Chusquea* spp. (Rodríguez-Cabal & Branch 2011). On those degraded habitats, *D. gliroides* is probable playing an outstanding role into promoting the natural forest regeneration by dispersed at least 11 native plant species (Amico *et al.* 2009, Mora & Soto-Gamboa 2011) besides the mistletoe *T. corymbosus*. As long as the remaining forest stands are able to maintain a minimum habitat quality (based on the structural elements mentioned above) as well as the forest fragments could be somewhat connected by wooden corridors, the persistence of *D. gliroides* is likely, also benefiting other species with similar habitat requirements (e.g., Rhinocryptids) and many native plant species (Fontúrbel & Jiménez 2011).

Moreover, this project may significantly contribute to conduct habitat restoration in degraded areas, such as found at the Valdivian Coastal Reserve (VCR), by the means of promoting the establishment of plant-frugivore interactions. Currently, The Nature Conservancy is undertaking an ambitious restoration plan at the VCR aiming to eradicate the eucalyptus at the long term, and hence restoring the Valdivian latifoliate rainforest that once have covered those areas. Chilean fauna is depauperate and rich in endemisms because of the island-like biogeographic context. Consequently, a reduced subset of species is driving most of the ecological interactions. Plant-animal mutualisms are particularly important on those forests since many plant species depend on pollinator and seed disperser animal vectors to ensure their reproductive success (Aizen *et al.* 2002). For those reasons, *D. gliroides* and a few other avian frugivores are responsible for most of the seed dispersal services, and consequently for the natural regeneration process. By the means of understanding how native species respond to habitat disturbance, we were able to conduct a proper habitat management that allows enhancing seed dispersal in degraded areas for promoting natural regeneration and preventing alien species (such as the shade-intolerant legume *Ulex europaeus*) to invade.

*Long term monitoring*

The next step in this research line is to establish the actual costs of habitat degradation for mistletoes and dispersal limitations for *D. gliroides*. The southern South America forests are highly variable in space and time, consequently I considered appropriate to have at least two-year data in order to capture a greater temporal variability of the system components and their interactions. In the mid-term, I expect to be able to conduct molecular analyses that allow us to test whether degraded habitat imposes gene flow restrictions by limiting the disperser's movement and / or behaviour.

I expect that The Nature Conservancy may implement the findings of this work and the forthcoming results for restoring the degraded areas based on the knowledge of plant-frugivore interactions. Considering that the VCR has about 51,000 ha of extension, making it one of the largest continuous Valdivian forests remnants, this protected area are might be holding one of the greatest *D. gliroides* population. The VCR is interested into conducting long-term monitoring for this species, which is easier and less expensive using trap-camera technology (as I did in this project), and also allows making extensive monitoring than using live trapping. My results showed that there is an opportunity for *D. gliroides* and *T. corymbosus* at degraded habitats, but also stresses the need of conserving certain level of habitat quality and connectivity for allowing both species to persist in the long-term. If other private or state institutions would adopt this monitoring protocol to conduct regular assessments of *D. gliroides* populations, multi-year data at a broad geographic range may provide reliable information to update this species IUCN category, and hence to design appropriate conservation and management actions.

*Information dissemination*

The results of this research funded by the PTES contributed to gather the data for my PhD dissertation, which is finished (in final draft form) and dissertation is expected by August 2013. My thesis document is composed by four core chapters: the first chapter assess the multi-scale effects of habitat transformation (from native forest to pine plantation) on plant-animal mutualisms; the second chapter examines how mutualistic effectiveness landscapes change along a habitat disturbance gradient; the third chapter examines the consequences of native forest replacement on *D. gliroides* and local avifauna; and finally the fourth chapter assess the importance of habitat context on frugivore-mediated evolution. Also, I expect to publish four papers in edge-leading journals (one per chapter), to give a talk at a national congress (Ecology Society Meeting, November 2013), and another one at an international congress (to be defined). Besides scientific publications and meetings, I have conducted extension activities to get the society involved in this topic. In this sense, I conducted two workshops with 10-12 years old children at the rural elementary schools of Chaihuín (Figure 5) and Huape (Figure 6), towns neighbouring the Reserve. Children were receptive and showed high interest in learning about wildlife, but they were not aware of many local species of animals that are characteristic of that region. Two additional workshops were made, one with young scouts that were visiting the Valdivian Coastal Reserve (Figure 7), and another with park rangers and the administrative personnel of

the protected area. Complementarily, I have designed and printer an educative poster (intended for children and people with no scientific knowledge; Figure 8) aiming to help retaining the workshop information and expecting to inform adult population as well. For detailed and updated information (project updates, field photos, videos, activities), please visit my website: http://sites.google.com/site/ecoevolutionary



**Figure 5.** Workshop with 10-12 year-old children at the rural elementary school of Chaihuín (November 2012).



**Figure 6.** Workshop with 10-12 year-old children at the rural elementary school of Huape (November 2012).

**Figure 7.** Workshop with young scouts (January 2013).


**Figure 8.** Educative poster produced.

**BUDGET IMPLEMENTATION**

The following table summarizes the original budget requested to the PTES, and the actual budget expenditure made. Differences in budget execution are explained below. Figures are expressed in sterling pounds.

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| Item | Cost | Other funds | PTES req. | PTES spent |
|---|---|---|---|---|
| Field assistant x 4 | 96 | | 120 | 96 |
| IR cameras x 20 | 2740 | 1370 | 1250 | 1370 |
| Memory cards x 20 | 26 | | 100 | 26 |
| Traps x 150 | 1024 | 512 | 525 | 512 |
| Ladder x 1 | 71 | | 100 | 71 |
| Notebook x 1 | 1280 | 256 | 1000 | 1024 |
| Calliper x 2 | 60 | 60 | | |
| Refractometer x 1 | 55 | 55 | | |
| GPS x 1 | 110 | 110 | | |
| PIT Tag reader x 1 | 305 | 305 | | |
| Small field eq x 1 | 300 | 300 | | |
| Petri dishes x 100 | 130 | 130 | 130 | 0 |
| Tetrazolium | 55 | | 0 | 55 |
| Bus tickets x 8 | 660 | 177 | 120 | 483 |
| Truck rental | 1300 | 1300 | | |
| Fuel | 600 | 600 | | |
| Food in field x 11 months | 380 | | 660 | 380 |
| Desk supplies | 50 | | 50 | 50 |
| Consumables | 100 | | 100 | 100 |
| Office and lab use | 2400 | 2400 | | |
| Desktop computer | 700 | 700 | | |
| Health insurance | 1080 | 1080 | | |
| SIG software | 223 | | 305 | 223 |
| Books | 235 | 165 | 0 | 70 |
| **TOTAL** | **13980** | **9520** | **4460** | **4460** |

*Notes to budget implementation*

- Initially I have asked for four field assistants, but I had two undergraduate students in practice that assisted in field as part of their academic program, reducing the assistant payments to about the half.
- Most trap-cameras came with a free SD card; hence, the saved SD cards money was used to pay the international shipment and customs charges of importing the trap-cameras.
- As there were new Chilean customs regulations to import custom-made materials (such as the live capturing traps), it was not possible to buy the traps in Argentina. Consequently, I had to buy them in Chile at a higher price (but also with a better

quality), and that is why I only have bought 55 traps instead the 75 originally planned to acquire.

- My advisor provided me the Petri dishes. Consequently, I re-assigned this part of the budget for buying the Tetrazolium reagent.

- I had to travel a lot more than expected from Santiago to the field site, which resulted in an increased expense on bus tickets.

- I have got a student special price on GIS software (from 305 to 223 GPB). I have used the remaining for buying specialized books in statistics.

**FURTHER FUNDRAISING**

Considering that this is a two-year project, I have also applied to other funding sources. From those applications, three agencies (American Society of Mammalogists, Cleveland Metroparks Zoo, and Rufford) have also provided funding for supporting the purchase of additional equipment, renting a 4x4 vehicle, and fuel expenses. Idea Wild also granted field equipment. Also I have obtained funds of the Chilean Government, through the National Foundation for Scientific and Technologic Research that covered 2012-2013 fieldwork expenses. Additionally, such extra funding allowed me to create a sub-project for offering an honours dissertation for an undergraduate student (which is in its final draft form), as well as two undergraduate research units.

**LESSONS LEARNED**

After the first year of leading this project, I have learned some lessons:
- Species respond to habitat disturbance in a complex and sometimes unpredictable ways. When I stated my research hypotheses I assumed that any situation but the original would have adverse effects on the seed dispersal mutualism between *Dromiciops gliroides* and *Tristerix corymbosus*. However, both species showed plastic responses to habitat structure changes and were able to thrive at the degraded habitat as well.

- A field technique that works well at one place may not be useful at another one. That happened to me with live capturing. I have sent a lot of time, efforts, and money in operating trapping grids with so few results. Conversely, trap-camera monitoring resulted optimum for this situation and such technique gave valuable data for an extended monitoring period, being less time and resource consuming.

- More not always means better. Mistletoes at the degraded habitat had greater crop sizes, those plants thriving in between of the eucalyptus trees and the secondary

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vegetation were displaying thousands of fruits, giving a first impression of a greater success at the degraded habitat. However, when examining the visit rates a trade-off shows up: those plants receive only one quarter of the visits that the mistletoes at the non-degraded habitat receive. Those plants are making a great energy and resources investment in producing larger crop sizes, but *D. gliroides* resulted to be a limiting factor for the seed dispersal process of those plants.

• Degraded forests are not biological deserts. Those degraded stands at the study location have many native plant species that have naturally regenerated after the disturbance, and are sustaining an important native fauna diversity as well. Those stands provide habitat for many bird species, many of them very common and abundant, but also some disturbance-sensitive species like Rhynocriptids are able to inhabit those forests. And the greatest surprise: *D. gliroides*, which was assumed to be restricted to old-growth native stands, is also able to exploit degraded habitats with activity levels similar than those of the native forest.

• Biodiversity loss drivers have differential effects. Habitat fragmentation showed to have profound negative effects on the mistletoe recruitment by the means of reducing *D. gliroides* abundance even to local extinction (Rodríguez-Cabal *et al.* 2007). Conversely, degraded but non-fragmented stands are capable to maintain this mutualism, allowing both species to persist even when habitat structure has been modified.

**SUMMARY**

Plant-animal mutualisms are key to maintain biodiversity at the temperate rainforest of South America, but the effects of habitat degradation on them has been not assessed. Aiming to fill this gap, I tested whether habitat degradation disrupts the seed dispersal mutualism between a marsupial (*Dromiciops gliroides*) and a keystone mistletoe (*Tristerix corymbosus*). Live-capturing yielded only six captures (with 1,250 trap-night effort). However, photo monitoring with camera-traps yielded 520 photographic records, and showed similar activity levels between non-degraded and degraded stands. Camera-traps were also used for monitoring 70 fruiting mistletoes, registering an interaction rate of was 0.70 visits / plant at the degraded habitat and a rate of 2.73 visits / plant at the native forest. By conducting bird censuses and video monitoring, I have identified four potential avian frugivores, but they were not registered consuming mistletoe fruits. As the sole seed disperser, *D. gliroides* imposed significant selection forces of seed mass and sugar contents, being context-dependent at degraded and non-degraded sites. The evidence obtained so far suggest that *D. gliroides* and *T.*

*corymbosus* seems to be more resilient to habitat disturbance than we previously thought, being the degraded forest a potential suitable habitat surrogate. However, the ecological interaction results show a more critical scenario: at the degraded habitat mistletoes are offering twice more fruits but they are ~75% less than consumed than those from the native habitat. Such scenario suggests a disperser limitation at the degraded habitat. As take-home message, this project showed that native species respond to anthropogenic biodiversity loss drivers in complex ways. Finally, I recommend conducting extensive monitoring within *D. gliroides* range in order to have more and better ecological data, as well as to understand the real costs that plant thriving in degraded habitats are facing.

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**PHOTOGRAPHIC APPENDIX**

I attach a few photos of the fieldwork, with their respective credits and captions. Full
resolution Images could be downloaded from Dropbox:

https://www.dropbox.com/s/bs99u1qbm70qzcl/PTES_pics_Fonturbel.zip



One of our camera-traps installed at native forest. Photo:
Francisco E. Fontúrbel (2011).



A *Dromiciops gliroides* individual captured at a degraded
habitat stand. Bushnell Trophy Cam shot.



Mistletoe with ripening fruits. Photo: Francisco E.
Fontúrbel (2012).



A *Dromiciops gliroides* captured at a native forest habitat.
Photo: Camila Dünner (2012).



Mistletoe seedlings into a eucalyptus branch. Photo:
Francisco E. Fontúrbel (2012).



My students (Javiera Malebrán and Daniela Salazar) and
I during a rainy fieldwork day. March, 2012.

Ripening mistletoe fruits. Photo: Alina Candia (2012).


Defecated mistletoe seeds found at a seed collector: Photo: Alina Candia (2013).


A branch of *Aristotelia chilensis* with many mistletoe saplings. Photo: Javiera Malebrán (2013).


Valdivian Coastal Reserve overview. Photo: Javiera Malebrán (2013).


Searching for dispersed seeds. Photo: Javiera Malebrán (2013).


Mistletoe seed germination trials. Photo: Francisco E. Fontúrbel (2013).